United States
Environmental Protection
Agency

Region V
230 South Dearborn
Chicago, Illinois 60604

November 1979

Water Division

EPA

Environmental Impact Statement

Draft
Appendices

Alternative Waste Treatment Systems For Rural Lake Projects

Case Study Number 5
Ottertail County Board Of Commissioners
Ottertail County, Minnesota

VOLUME II

DRAFT ENVIRONMENTAL IMPACT STATEMENT

ALTERNATIVE WASTEWATER TREATMENT SYSTEMS FOR RURAL LAKE PROJECTS

CASE STUDY No. 5: OTTER TAIL COUNTY BOARD OF COMMISSIONERS

OTTER TAIL COUNTY, MINNESOTA

Prepared by the

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION V, CHICAGO, ILLINOIS

AND

WAPORA, INCORPORATED

WASHINGTON, D.C.

Approved by:

John McGuire
Regional Administrator
U.S. Environmental Protection Agency

November 1979

VOLUME II

A P P E N D I X E S

APPENDIX A

SOILS

SOIL FACTORS THAT AFFECT ON-SITE WASTEWATER DISPOSAL

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

SOIL LIMITATION RATINGS FOR SEPTIC TANK ABSORPTION FIELDS

Item affecting use	Degree of soil limitation		
	Slight	Moderate	Severe
Permeability class[1/]	Rapid[2/], moderately rapid, and upper end of moderate	Lower and of moderate	Moderately slow[3/] and slow
Hydraulic conductivity rate (Uhland core method)	More than 1 in./hr.[2/]	1-0.6 in./hr.	Less than 0.6 in./hr.
Percolation rate (Auger hole method)	Faster than 45 min./in.[2/]	45-60 min./in.	Slower than 60 min./in.
Depth to water table	More than 72 in.	48-72 in.	Less than 48 in.
Flooding	None	Rare	Occasional or frequent
Slope	0-8 pct	8-15 pct	More than 15 pct
Depth to hard rock,[4/] bedrock, or other impervious materials	More than 72 in.	48-72 in.	Less than 48 in.
Stoniness class	0 and 1	2	3, 4, and 5
Rockiness class	0	1	2, 3, 4, and 5

1/ Class limits are the same as those suggested by the Work-Planning Conference of the National Cooperative Soil Survey. The limitation ratings should be related to the permeability of soil layers at and below depth of the tile line.

2/ Indicate by footnote where pollution is a hazard to water supplies.

3/ In arid or semiarid areas, soils with moderately slow permeability may have a limitation rating of moderate.

4/ Based on the assumption that tile is at a depth of 2 feet.

COMPARISON OF SITE CHARACTERISTICS FOR LAND TREATMENT PROCESSES

	Principal Processes	
Characteristics	Slow Rate	Rapid infiltration
Slope	Less than 20% on cultivated land; less than 40% on non-cultivated land	Not critical; excessive slopes require much earthwork
Soil Permeability	Moderately slow to moderately rapid (.06-20 in./hr.)	Rapid (sands, loamy sands) (≥2.0 in./hr.)
Depth to Groundwater	2 to 3 ft. (minimum)	10 ft. (lesser depths are acceptable where underdrainage is provided)
Climatic Restrictions	Storage often needed for cold weather and precipitation	None (possibly modify operation in cold weather)

1 ft. = 0.305 m

APPENDIX B

ATMOSPHERE

Monthly Normals of Temperature and Precipitation of the Study Area.

STATION	ELEVATION		MONTHS J	F	M	A	M	J	J	A	S	O	N	D	AVERAGE
FERGUS* FALLS	1210 Feet	Temperature (degrees Farenheit)	8.5	13.4	26.3	43.5	56.1	65.7	71.2	69.9	59.0	48.2	29.8	15.1	42.2
		Precipitation (inches)	0.77	0.60	1.12	2.60	2.99	4.68	3.32	3.05	2.24	1.42	0.87	0.90	24.56
WADENA*	1350 Feet	Temperature (degrees Farenheit)	7.6	12.5	25.1	42.2	54.6	64.5	59.8	68.0	57.2	47.0	29.1	14.4	41.0
		Precipitation (inches)	0.80	0.58	1.28	2.74	3.39	4.65	3.91	3.86	2.52	1.68	1.07	0.84	27.32
OTTERTAIL** (Lake Study Area)	1300 Feet	Temperature (degrees Farenheit)	9.6	17.5	22.4	42.0	57.0	67.6	73.5	65.3	58.8	45.9	37.7	10.9	41.5
		Precipitation (inches)	0.78	0.59	2.20	2.67	3.19	4.67	3.66	3.45	2.38	1.55	0.97	0.87	25.94

Sources

* National Oceanic and Atmospheric Administration 1941-1970; Climatography of the U.S. No. 81 - Minnesota.

** Otter Tail Lake is located approximately half-way between Wadena and Fergus Falls, therefore the average readings from these two stations were used for the Study Area.

MINNESOTA AIR QUALITY STANDARDS

Pollutant/ Air Contaminant	Concentration	Remarks
(1) **Hydrogen Sulfide**[d] (primary standards)	0.05 ppm by volume (70.0 micograms per *cubic meter)*	½ hr. average not to be exceeded over 2 times per yr.
	0.03 ppm by volume (42.0 micrograms per cubic meter)	½ hr. average not to be exceeded over 2 times in any 5 consecutive days
(2) **Photochemical**[e] **Oxidants** (primary and secondary standards)	0.07 ppm by volume (130 micrograms per cubic meter)	maximum 1 hr. concentration not to be exceeded more than once per yr.
(3) **Carbon Monoxide**[f] (primary and secondary standards)	9 ppm by volume (10 milligrams per cubic meter)	maximum 8 hr. concentration not to be exceeded more than once per yr.
	30 ppm by volume (35 milligrams per cubic meter)	maximum 1 hr. concentration not to be exceeded more than once per yr.
(4) **Hydrocarbons**[g] (primary and secondary standards)	0.24 ppm by volume (160 micrograms per cubic meter)	maximum 3 hr. concentration (6 to 9 a.m.) not to be exceeded more than once per yr., corrected for methane
(5) **Sulfur Oxides**[h] (primary and secondary standards)	0.02 ppm by volume (60 micrograms per cubic meter)	maximum annual arithmetic mean
	0.1 ppm by volume (260 micrograms per cubic meter)	maximum 24 hr. concentration not to be exceeded more than once per yr.
	0.25 ppm by volume (655 micrograms per cubic meter)	maximum 3 hr. concentration not to be exceeded more than once per yr.
(6) **Particulate**[i] **Matter** (primary standard)	75 micrograms per cubic meter	maximum annual geometric mean
	260 micrograms per cubic meter	maximum 24 hr. concentration not to be exceeded more than once per yr.
Particulate Matter (secondary standard)	*60 micrograms* per cubic meter	*maximum* annual geometric mean
	150 micrograms per cubic meter	maximum 24 hr. concentration not to be exceeded more than once per yr.
(7) **Nitrogen Oxides**[j] (primary and secondary standards)	0.05 ppm (100 micrograms per cubic meter)	maximum annual arithmetic mean

Footnotes:

(a) All standards apply throughout the State of Minnesota.

(b) All measurements of ambient air quality are corrected to a reference temperature of 25° C. and a reference pressure of 760 mm of mercury.

(c) All measurements and tests shall be conducted by the methodology referenced herein, or other methodology as the Director shall hereafter approve.

(d) By methylene blue, or other method approved by the Director.

(e) *Neutral-buffered one percent potassium iodide colorimetric detection technique corrected for SO_2 and NO_2 interference*, gas phase chemiluminescence, or other method approved by the Director.

(f) *Nondispersive infrared spectrometry (N.D.I.R.), or other method approved by the Director.*

(g) Flame ionization, or other method approved by the Director.

(h) By pararosaniline, coulometric, or other method approved by the Director.

(i) High volume method, or other method approved by the Director.

(j) Jacobs-Hochheiser, or other method approved by the Director.

APPENDIX C

WATER QUALITY

CHAPTER FOURTEEN: WPC 14

CRITERIA FOR THE CLASSIFICATION OF THE INTRASTATE WATERS OF THE STATE AND THE ESTABLISHMENT OF STANDARDS OF QUALITY AND PURITY

WPC 14: The official policy and purpose of the State of Minnesota in regard to these matters is set forth in the Minnesota Water Pollution Control Statutes as amended by Minnesota Laws 1973, Chapter 374:

Sec. 115.42. It is the policy of the state to provide for the prevention, control and abatement of pollution of all waters of the state, so far as feasible and practical, in furtherance of conservation of such waters and protection of the public health and in furtherance of the development of the economic welfare of the state.

. . . It is the purpose of Laws 1963, Chapter 874, to safeguard the waters of the state from pollution by: (a) preventing any new pollution; and (b) abating pollution existing when Laws 1963, Chapter 874, become effective, under a program consistent with the declaration of policy above stated.

Sec. 115.44, Subd. 2. In order to attain the objectives of Laws 1963, Chapter 874, the Agency after proper study, and after conducting public hearing upon due notice, shall as soon as practicable, group the designated waters of the state into classes and adopt classifications and standards of purity and quality therefor. Such classification shall be made in accordance with considerations of best usage in the interest of the public and with regard to the considerations mentioned in subdivision 3 hereof.

Sec. 115.44, Subd. 8. If the Agency finds in order to comply with the federal water pollution control act or any other federal law or rule or regulation promulgated thereunder that it is impracticable to comply with the requirements of this section in classifying waters or adopting standards or in meeting any of the requirements thereof, compliance with the requirements of such action are waived to the extent necessary to enable the agency to comply with federal laws and rules and regulations promulgated thereunder. The agency may classify waters and adopt criteria and standards in such form and based upon such evidence as it may deem necessary and sufficient for the purposes of meeting requirements of such federal laws, notwithstanding any provisions in chapter 115 or any other state law to the contrary. In the event waters are classified and criteria and standards are adopted to meet the requirements of federal law, the agency shall thereafter proceed to otherwise comply with the provisions of this section which were waived as rapidly as is practicable. This authority shall extend to proceedings pending before the agency on May 20, 1973.

. . . Wherever advisable and practicable the agency may establish standards for effluent or disposal systems discharging into waters of the state regardless of whether such waters are or are not classified.

Sec. 115.03, Subd. 5. Notwithstanding any other provisions prescribed in or pursuant to chapter 115 and, with respect to the pollution of waters of the state, in chapter 116, or otherwise, the agency shall have the authority to perform any and all acts minimally necessary including, but not limited to, the establishment and application of standards, procedures, regulations, orders, variances, stipulation agreements, schedules of compliance, and permit conditions, consistent with and, therefore, not less stringent than the provisions of the Federal Water Pollution Control Act, as amended, applicable to the participation by the state of Minnesota in the National Pollutant Discharge Elimination System (NPDES) . . .

In accordance with this declaration of policy and legislative intent, and under the powers delegated to the Agency, the following intrastate water use classifications and corresponding standards of quality and purity are hereby adopted by the Pollution Control Agency as provided by law.

(a) Introduction

(1) Scope. The following classifications, criteria and standards of water and effluent quality and purity as hereby adopted and established shall apply to all intrastate waters of the state, notwithstanding any other intrastate water quality or effluent regulations of general or specific application, except that any more stringent water quality or effluent standards or prohibitions in the other applicable regulations are preserved.

(2) Severability. All provisions of this regulation shall be severable and the invalidity of any lettered paragraph or any subparagraph or subdivision thereof shall not void any other lettered paragraph or subparagraph, subdivision or any part thereof.

(3) Definitions. The terms "waters of the state" for the purposes of this regulation shall be construed to mean intrastate waters as herein below defined, and the terms "sewage," "industrial wastes," and "other wastes," as well as any other terms for which definitions are given in the Water Pollution Control Statutes, as used herein have the meanings ascribed to them in Minnesota Statutes, Sections 115.01 and 115.41, with the exception that disposal systems or treatment works operated under permit of the Agency shall not be construed to be "waters of the state" as the term is used herein. Interstate waters are defined as all rivers, lakes, and other waters that flow across or from part of state boundaries. All of the remaining designated waters of the state which

do not meet the definition of interstate waters given above are to be construed herein as constituting intrastate waters. Other terms and abbreviations used herein which are not specifically defined in applicable federal or state law shall be construed in conformance with the context, and in relation to the applicable section of the statutes, pertaining to the matter at hand, and current professional usage.

(4) Uses of the Intrastate Waters. The classifications are listed separately in accordance with the need for intrastate water quality protection, considerations of best use in the interest of the public and other considerations, as indicated in Minnesota Statutes, Section 115.44. The classification should not be construed to be an order of priority, nor considered to be exclusive or prohibitory of other beneficial uses.

(5) Determination of Compliance. In making tests or analyses of the intrastate waters of the state, sewage, industrial wastes or other wastes to determine compliance with the standards, samples shall be collected in such manner and place, and of such type, number and frequency as may be considered necessary by the Agency from the viewpoint of adequately reflecting the condiiton of the intrastate waters, the composition of the effluents, and the effects of the pollutants upon the specified uses. Reasonable allowance will be made for dilution of the effluents, which are in compliance with Section (c)(6), following discharge into waters of the State. The Agency by allowing dilution may consider the effect on all uses of the intrastate waters into which the effluents are discharged. The extent of dilution allowed regarding any specific discharge shall not violate the applicable water quality standards. The samples shall be preserved and analyzed in accordance with procedures given in the 1971 edition of Standard Methods for the Examination of Water and Waste-Water, by the American Public Health Association, American Water Works Association, and the Water Pollution Control Federation, and any revisions or amendments thereto. The Agency may accept or may develop other methods, procedures, guidelines or criteria for measuring, analyzing and collecting samples.

(6) Unclassified Intrastate Waters. Adoption of specific classifications and standards for unclassified intrastate waters, and/or changes in existing classifications and standards, will be done as soon as practicable by the Minnesota Pollution Control Agency for individually designated waters after the necessary studies and public hearings relating to the determination of present and future quality, characteristics and uses have been completed as required by law. In the absence of such official classifications and standards for any given intrastate waters, it shall be the policy of the Agency to consider all unclassified intrastate waters as waters of the highest quality consistent with their actual or potential use, and deserving of the equivalent

degree of protection from pollution, until the same may be affirmed or altered by adoption of standards or other official act of the Agency; except that where sewage, industrial wastes or other wastes are being discharged to unclassified intrastate waters during such interim period the concentrations of polluting substances in such separate industrial waste or other waste effluents shall be no higher than the permissible concentrations of polluting substances of a comparable nature in the effluents of municipal sewage treatment works which discharge into the same intrastate waters, unless specifically exempted from this requirement by other effluent standards or the terms of a valid waste disposal permit issued by the Agency.

(7) Natural Intrastate Water Quality. The intrastate waters may, in a state of nature, have some characteristics or properties approaching or exceeding the limits specified in the water quality standards. The standards shall be construed as limiting the addition of pollutants of human activity to those of natural origin, where such be present, so that in total the specified limiting concentrations will not be exceeded in the intrastate waters by reason of such controllable additions. Where the background level of the natural origin is reasonably definable and normally is higher than the specified standard the natural level may be used as the standard for controlling the addition of pollutants of human activity which are comparable in nature and significance with those of natural origin. The natural background level may be used instead of the specified water quality standard as a maximum limit of the addition of pollutants, in those instances where the natural level is lower than the specified standard and reasonable justification exists for preserving the quality to that found in a state of nature.

In the adoption of standards for individual intrastate waters, the Agency will be guided by the standards set forth herein but may make reasonable modifications of the same on the basis of evidence brought forth at a public hearing if it is shown to be desirable and in the public interest to do so in order to encourage the best use of the intrastate waters or the lands bordering such intrastate waters.

(8) Non-Degradation. Waters which are of quality better than the established standards shall be maintained at high quality unless a determination is made by the Agency that a change is justifiable as a result of necessary economic or social development and will not preclude appropriate beneficial present and future uses of the waters. Any project or development which would constitute a source of pollution to waters of the state shall be required to provide the best practicable control technology currently available not later than July 1, 1977 and the best available technology economically achievable not later than July 1, 1983, and any other applicable treatment standards as defined by and in accordance with the requirements of the Federal Water

Pollution Control Act, 33 U.S.C. 1251 et. seq., as amended, in order to maintain high water quality and keep water pollution at a minimum. In implementing this policy, the Administrator of the U.S. Environmental Protection Agency will be provided with such information as he requires to discharge his responsibilities under the Federal Water Pollution Control Act, as amended.

(9) Variance from Standards. In any case where, upon application of the responsible person or persons, the Agency finds that by reason of exceptional circumstances the strict enforcement of any provision of these standards would cause undue hardship, that disposal of the sewage, industrial waste or other waste is necessary for the public health, safety or welfare; and that strict conformity with the standards would be unreasonable, impractical or not feasible under the circumstances; the Agency in its discretion may grant a variance therefrom upon such conditions as it may prescribe for prevention, control or abatement of pollution in harmony with the general purposes of these classifications and standards and the intent of the applicable state and federal laws. The U.S. Environmental Protection Agency will be advised of any permits which may be issued under this clause together with information as to the need therefor.

(b) Water Use Classification - All Intrastate Waters of the State. Based on considerations of best usage in the interest of the public and in conformance with the requirements of the applicable statutes, the intrastate waters of the state shall be grouped into one or more of the following classes:

(1) Domestic Consumption. (To include all intrastate waters which are or may be used as a source of supply for drinking, culinary or food processing use or other domestic purposes, and for which quality control is or may be necessary to protect the public health, safety or welfare.)

(2) Fisheries and Recreation. (To include all intrastate waters which are or may be used for fishing, fish culture, bathing or any other recreational purposes, and for which quality control is or may be necessary to protect aquatic or terrestrial life, or the public health, safety or welfare.)

(3) Industrial Consumption. (To include all intrastate waters which are or may be used as a source of supply for industrial process or cooling water, or any other industrial or commercial purposes, and for which quality control is or may be necessary to protect the public health, safety or welfare.)

(4) Agriculture and Wildlife. (To include all intrastate waters which are or may be used for any agriculture purposes, including stock watering and irrigation, or by waterfowl or other wildlife, and for which quality control is or may be necessary to protect terrestrial life or the public health, safety or welfare.)

(5) Navigation and Waste Disposal. (To include all intrastate waters which are or may be used for any form of water transportation or navigation, disposal of sewage, industrial waste or other waste effluents, or fire prevention, and for which quality control is or may be necessary to protect the public health, safety or welfare.)

(6) Other Uses. (To include intrastate waters which are or may serve the above listed uses or any other beneficial uses not listed herein, including without limitation any such uses in this or any other state, province, or nation of any intrastate waters flowing through or originating in this state, and for which quality control is or may be necessary for the above declared purposes, or to conform with the requirements of the legally constituted state or national agencies having jurisdiction over such intrastate waters, or any other considerations the Agency may deem proper.)

(c) General Standards Applicable to All Intrastate Waters of the State.

(1) No untreated sewage shall be discharged into any intrastate waters of the state. No treated sewage, or industrial waste or other wastes containing viable pathogenic organisms, shall be discharged into intrastate waters of the state without effective disinfection. Effective disinfection of any discharges, including combined flows of sewage and storm water, will be required where necessary to protect the specified uses of the intrastate waters.

(2) No sewage, industrial waste or other wastes shall be discharged into any intrastate waters of the state so as to cause any nuisance conditions, such as the presence of significant amounts of floating solids, scum, oil slicks, excessive suspended solids, material discoloration, obnoxious odors, gas ebullition, deleterious sludge deposits, undesirable slimes or fungus growths, or other offensive or harmful effects.

(3) Existing discharges of inadequately treated sewage, industrial waste or other wastes shall be abated, treated or controlled so as to comply with the applicable standards. Separation of sanitary sewage from natural run-off may be required where necessary to ensure continuous effective treatment of sewage.

(4) The highest levels of water quality, including, but not limited to, dissolved oxygen, which are attainable in the intrastate waters by continuous operation at their maximum capability of all primary and secondary units of treatment works or their equivalent discharging effluents into the intrastate waters shall be maintained in order to enhance conditions for the specified uses.

(5) Means for expediting mixing and dispersion of sewage, industrial waste, or other waste effluents in the receiving intrastate waters are to be provided so far as practicable when deemed necessary by the Agency to maintain the quality of the receiving intrastate waters in accordance with applicable standards. Mixing zones be established by the Agency on an individual basis, with primary consideration being given to the following guidelines: (a) mixing zones in rivers shall permit an acceptable passageway for the movement of fish; (b) the total mixing zone or zones at any transect of the stream shall contain no more than 25% of the crosssectional area and/or volume of flow of the stream, and should not extend over more than 50% of the width; (c) mixing zone characteristics shall not be lethal to aquatic organisms; (d) for contaminants other than heat, the 96 hour median tolerance limit for indigenous fish and fish food organisms should not be exceeded at any point in the mixing zone; (e) mixing zones should be as small as possible, and not intersect spawning or nursery areas, migratory routes, water intakes, nor mouths of rivers; and (f) overlapping of mixing zones should be minimized and measures taken to prevent adverse synergistic effects.

(6) It is herein established that the Agency shall require secondary treatment as a minimum for all municipal sewage and biodegradable industrial or other wastes to meet the adopted water quality standards. A comparable high degree of treatment or its equivalent also shall be required of all non-biodegradable industrial or other wastes unless the discharger can demonstrate to the Agency that a lesser degree of treatment or control will provide for water quality enhancement commensurate with present and proposed future water uses and a variance is granted under the provisions of the variance clause. Secondary treatment facilities are defined as works which will provide effective sedimentation biochemical oxidation, and disinfection, or the equivalent, including effluents conforming to the following:

Substance or Characteristic	Limiting Concentration or Range*
5-Day biochemical oxygen demand	25 milligrams per liter
Fecal coliform group organisms	200 most probable number per 100 milliliters
Total suspended solids	30 milligrams per liter
Pathogenic organisms	None
Oil	Essentially free of visible oil
Phosphorus**	1 milligram per liter
Turbidity	25
pH range	6.5 - 8.5
Unspecified toxic or corrosive substances	None at levels acutely toxic to humans or other animals or plant life, or directly damaging to real property.

*The arithmetic mean for concentrations of 5-day biochemical oxygen demand and total suspended solids shall not exceed the stated values in a period of 30 consecutive days and 45 milligrams per liter in a period of 7 consecutive days. Disinfection of wastewater effluents to reduce the coliform organisms levels is required year around. The geometric mean for the fecal coliform organisms shall not exceed the stated value in a period of 30 consecutive days and 400 most probable number per 100 milliliters in a period of 7 consecutive days. The application of the coliform and pathogenic organism standards ordinarily shall be limited to sewage or other effluents containing admixtures of sewage and shall not apply to industrial wastes except where the presence of sewage, fecal coliform organisms or viable pathogenic organisms in such wastes is known or reasonably certain.

**Where the discharge of effluent is directly to or affects a lake or reservoir. Removal of nutrients from all wastes shall be provided to the fullest practicable extent wherever sources of nutrients are considered to be actually or potentially detrimental to preservation or enhancement of the designated water uses.

In addition to providing secondary treatment as defined above, all dischargers of sewage, industrial wastes or other wastes also shall provide the best practicable control technology not later than July 1, 1977, and best available technology economically achievable by July 1, 1983, and any other applicable treatment standards as defined by and in accordance with the requirements and schedules of the Federal Water Pollution Control Act, 33 U.S.C. 1251 eq. seq., as amended, and applicable regulations or rules promulgated pursuant thereto by the Administrator of the U. S. Environmental Protection Agency.

(7) Dischargers of sewage, industrial waste or other waste effluents shall be controlled so that the water quality standards will be maintained at all stream flows which are equal to or exceeded by 90 percent of the seven consecutive daily average flows of record (the lowest weekly flow with a once in ten year recurrence interval) for the critical month(s). The period of record for determining the specific flow for the stated recurrence interval, where records are available, shall include at least the most recent ten years of record, including flow records obtained after establishment of flow regulation devices, if any. Such calculations shall not be applied to lakes and their embayments which have no comparable flow recurrence interval. Where stream flow records are not available, the flow may be estimated on the basis of available information on the watershed characteristics, precipitation, run-off and other relevant data.

Allowance shall not be made in the design of treatment works for low stream flow augmentation unless such flow augmentation of minimum flow is dependable and controlled under applicable laws or regulations.

(8) In any instance where it is evident that the minimal treatment specified in Section (c)(6) and dispersion are not effective in preventing pollution, or if at the applicable flows it is evident that the specified stream flow is inadequate to protect the specified water quality standards, the specific standards may be interpreted as effluent standards for control purposes. In addition, the following effluent standards may be applied without any allowance for dilution where stream flow or other factors are such as to prevent adequate dilution, or where it is otherwise necessary to protect the intrastate waters for the stated uses:

Item*	Limits
5-day biochemical oxygen demand	5 milligrams per liter
Total suspended solids	5 milligrams per liter

*The concentrations specified in section (c)(6) of this regulation may be used in lieu thereof if the discharge of effluent is restricted to the spring flush or other high runoff periods when the stream flow rate above the discharge point is sufficiently greater than the effluent flow rate to ensure that the applicable water quality standards are met during such discharge period. If treatment works are designed and constructed to meet the specified limits given above for a continuous discharge, at the discretion of the Agency the operation of such works may allow for the effluent quality to vary between the limits specified above and in section (c)(6), provided the water quality standards and all other requirements of the Agency and the U. S. Environmental Protection Agency are being met. Such variability of operation must be based on adequate monitoring of the treatment works and the effluent and receiving waters as specified by the Agency.

(9) In any case where, after a public hearing, the Agency finds it necessary for conformance with Federal requirements, or conservation of the intrastate waters of the state, or protection of the public health, or in furtherance of the development of the economic welfare of the state, it may prohibit or further limit the discharge to any designated intrastate waters of any sewage, industrial waste, or other waste effluents, or any component thereof, whether such effluents are treated or untreated, or existing or new, notwithstanding any other provisions of classifications or specific standards stated herein which may be applicable to such designated intrastate waters.

(10) It shall be incumbent upon all persons responsible for existing or new sources of sewage, industrial wastes or other wastes which are or will be discharged to intrastate waters, to treat or control their wastes so as to produce effluents having a common level or concentration of pollutants of comparable nature or effect as may be necessary to meet the specified standards

or better, but this shall not be interpreted to prohibit the Agency after providing an opportunity for public hearing from accepting effective loss prevention and/or water conservation measures or process changes or other waste control measures or arrangements as being equivalent to the waste treatment measures required for compliance with applicable effluent and/or water quality standards or load allocations.

(11) All sources of sewage, industrial waste, or other waste which do not at present have a valid operation and discharge permit, or an application for the same pending before the Agency, shall apply for the same within 30 days of the adoption of this regulation, or the Agency may abate the source forthwith. The provisions of section (c)(6) relating to effluent quality standards, and the other provisions of this regulation, are applicable to existing sewage, industrial waste or other waste disposal facilities and the effluent discharged therefrom. Nothing herein shall be construed to prevent the Agency subsequently from modifying any existing permits so as to conform with federal requirements and the requirements of this regulation.

(12) Liquid substances which are not commonly considered to be sewage or industrial wastes but which could constitute a pollution hazard shall be stored in accordance with Regulation WPC 4, and any revision or amendments thereto. Other wastes as defined by law or other substances which could constitute a pollution hazard shall not be deposited in any manner such that the same may be likely to gain entry into any intrastate waters of the state in excess of or contrary to any of the standards herein adopted, or cause pollution as defined by law.

(13) No sewage, industrial waste or other wastes shall be discharged into the intrastate waters of the state in such quantity or in such manner alone or in combination with other substances as to cause pollution thereof as defined by law. In any case where the intrastate waters of the state into which sewage, industrial wastes or other waste effluents discharge are assigned different standards than the interstate or intrastate waters into which such receiving intrastate waters flow, the standards applicable to the intrastate waters into which such sewage, industrial waste or other wastes discharged shall be supplemented by the following:

The quality of any waters of the state receiving sewage, industrial waste or other waste effluents shall be such that no violation of the standards of any interstate or intrastate waters of the state in any other class shall occur by reason of the discharge of such sewage, industrial waste or other waste effluents.

(14) Questions concerning the permissible levels, or changes, in the same, of a substance, or combination of substances, of undefined toxicity to fish or other Biota shall be resolved in accordance with the latest methods recommended by the U. S. Environmental Protection Agency. The recommendations of the National Technical Advisory Committee appointed by the U. S. Environmental Protection Agency shall be used as official guidelines in all aspects where the recommendations may be applicable. Toxic substances shall not exceed 1/10 of the 96 hour median tolerance limit (TLM) as a water quality standard except that other more stringent application factors shall be used when justified on the basis of available evidence.

(15) All persons operating or responsible for sewage, industrial waste or other waste disposal systems which are adjacent to or which discharge effluents to these waters or to tributaries which affect the same, shall submit regularly every month a report to the Agency on the operation of the disposal system, the effluent flow, and the characteristics of the effluents and receiving waters. Sufficient data on measurements, observations, sampling and analyses, and other pertinent information shall be furnished as may be required by the Agency to adequately evaluate the condition of the disposal system, the effluent, and the waters receiving or affected by the effluent.

Fisheries and Recreation

Class B - The quality of this class of the intrastate waters of the state shall be such as to permit the propagation and maintenance of cool or warm water sport or commercial fishes and be suitable for aquatic recreation of all kinds, including bathing, for which the waters may be usable. Limiting concentrations or ranges of substances or characteristics which should not be exceeded in the intrastate waters are given below:

Substance or Characteristic	Limit or Range
Dissolved oxygen	Not less than 6 milligrams per liter from April 1 through May 31, and not less than 5 milligrams per liter at other times.
Temperature	5°F above natural in streams and 3°F above natural in lakes, based on monthly average of the maximum daily temperature, except in no case shall it exceed the daily average temperature of 86°F.
Ammonia (N)	1 milligram per liter
Chromium (Cr)	0.05 milligram per liter
Copper (Cu)	0.01 milligram per liter or not greater than 1/10 the 96 hour TLM value.

Substance or Characteristic	Limit or Range
Cyanides (CN)	0.02 milligram per liter
Oil	0.5 milligram per liter
pH value	6.5 - 9.0
Phenols	0.01 milligram per liter and none that could impart odor or taste to fish flesh or other freshwater edible products such as crayfish, clams, prawns and like creatures. Where it seems probable that a discharge may result in tainting of edible aquatic products, bioassays and taste panels will be required to determine whether tainting is likely or present.
Turbidity value	25
Fecal coliform organisms	200 most probable number per 100 milliliters as a monthly geometric mean based on not les than 5 samples per month, nor equal or exceed 2000 most probable number per 100 milliliters in more than 10% of all samples during any month.
Radioactive materials	Not to exceed the lowest concentration permitted to be discharged to an uncontrolled environment as prescribed by the appropriate authority having control over their use.

Industrial Consumption

Class B - The quality of this class of the intrastate waters of the state shall be such as to permit their use for general industrial purposes, except for food processing, with only a moderate degree of treatment. The quality shall be generally comparable to Class D intrastate waters used for domestic consumption, except the following:

Substance or Characteristic	Limit or Range
Chlorides (Cl)	100 milligrams per liter
Hardness	250 milligrams per liter
pH value	6.0 - 9.0
Fecal coliform organisms	200 most probable number per 100 milliliters

Class C - The quality of this class of the intrastate waters of the state shall be such as to permit their use for industrial cooling and materials transport without a high degree of treatment being necessary to avoid severe fouling, corrosion, scaling, or other unsatisfactory conditions. The following shall not be exceeded in the intrastate waters:

Substance or Characteristic	Limit or Range
Chlorides (Cl)	250 milligrams per liter
Hardness	500 milligrams per liter
pH value	6.0 - 9.0
Fecal coliform organisms	200 most probable number per 100 milliliters

Additional selective limits may be imposed for any specific intrastate waters as needed.

In addition to the above listed standards, no sewage, industrial waste or other wastes, treated or untreated, shall be discharged into or permitted by any person to gain access to any intrastate waters classified for industrial purposes so as to cause any material impairment of their use as a source of industrial water supply.

Agriculture and Wildlife

Class A - The quality of this class of the intrastate waters of the state shall be such as to permit their use for irrigation without significant damage or adverse effects upon any crops or vegetation usually grown in the waters or area, including truck garden crops. The following concentrations or limits shall be used as a guide in determining the suitability of the waters for such uses, together with the recommendations contained in Handbook 60 published by the Salinity Laboratory of the U. S. Department of Agriculture, and any revisions, amendments or supplements thereto:

Substance or Characteristic	Limit or Range
Bicarbonates (HCO_3)	5 milliequivalents per liter
Boron (B)	0.5 milligram per liter
pH value	6.0 - 8.5
Specific conductance	1,000 micromhos per centimeter
Total dissolved salts	700 milligrams per liter
Sodium (Na)	60% of total cations as milliequivalents per liter
Fecal coliform organisms	200 most probable number per 100 milliliters
Sulfates (SO_4)	10 milligrams per liter, applicable to waters used for production of wild rice during periods when the rice may be susceptible to damage by high sulfate levels.
Radioactive materials	Not to exceed the lowest concentrations permitted to be discharged to an uncontrolled environment as prescribed by the appropriate authority having control over their use.

Class B - The quality of this class of the intrastate waters of the state shall be such as to permit their use by livestock and wildlife without inhibition or injurious effects. The limits or concentrations of substances or characteristics given below shall not be exceeded in the intrastate waters:

Substance or Characteristic	Limit or Range
pH value	6.0 - 9.0
Total salinity	1,000 milligrams per liter
Fecal coliform organisms	200 most probable number per 100 milliliters
Radioactive materials	Not to exceed the lowest concentrations permitted to be discharged to an uncontrolled environment as prescribed by the appropria authority having control over their use.
Unspecified toxic substances	None at levels harmful either directly or indirectly

Additional selective limits may be imposed for any specific intrastate waters as needed.

Navigation and Waste Disposal

The quality of this class of the intrastate waters of the state shall be such as to be suitable for esthetic enjoyment of scenery and to avoid any interference with navigation or damaging effects on property. The following limits or concentrations shall not be exceeded in the intrastate waters:

Substance or Characteristic	Limit or Range
Fecal coliform organisms	200 most probable number per 100 milliliters
pH value	6.0 - 9.0
Hydrogen sulfide	0.02 milligrams per liter

Additional selective limits may be imposed for any specific intrastate waters as needed.

Other Uses

The uses to be protected in this class may be under other jurisdictions and in other areas to which the intrastate waters of the state are tributary, and may include any or all of the uses listed in the foregoing categories, plus any other possible beneficial uses. The Agency therefore reserves the right to impose any standards necessary for the protection of this class, consistent with legal limitations.

Appendix C-2

SKETCH MAP OF OTTER TAIL RIVER WATERSHED FROM FERGUS FALLS TO SOURCE

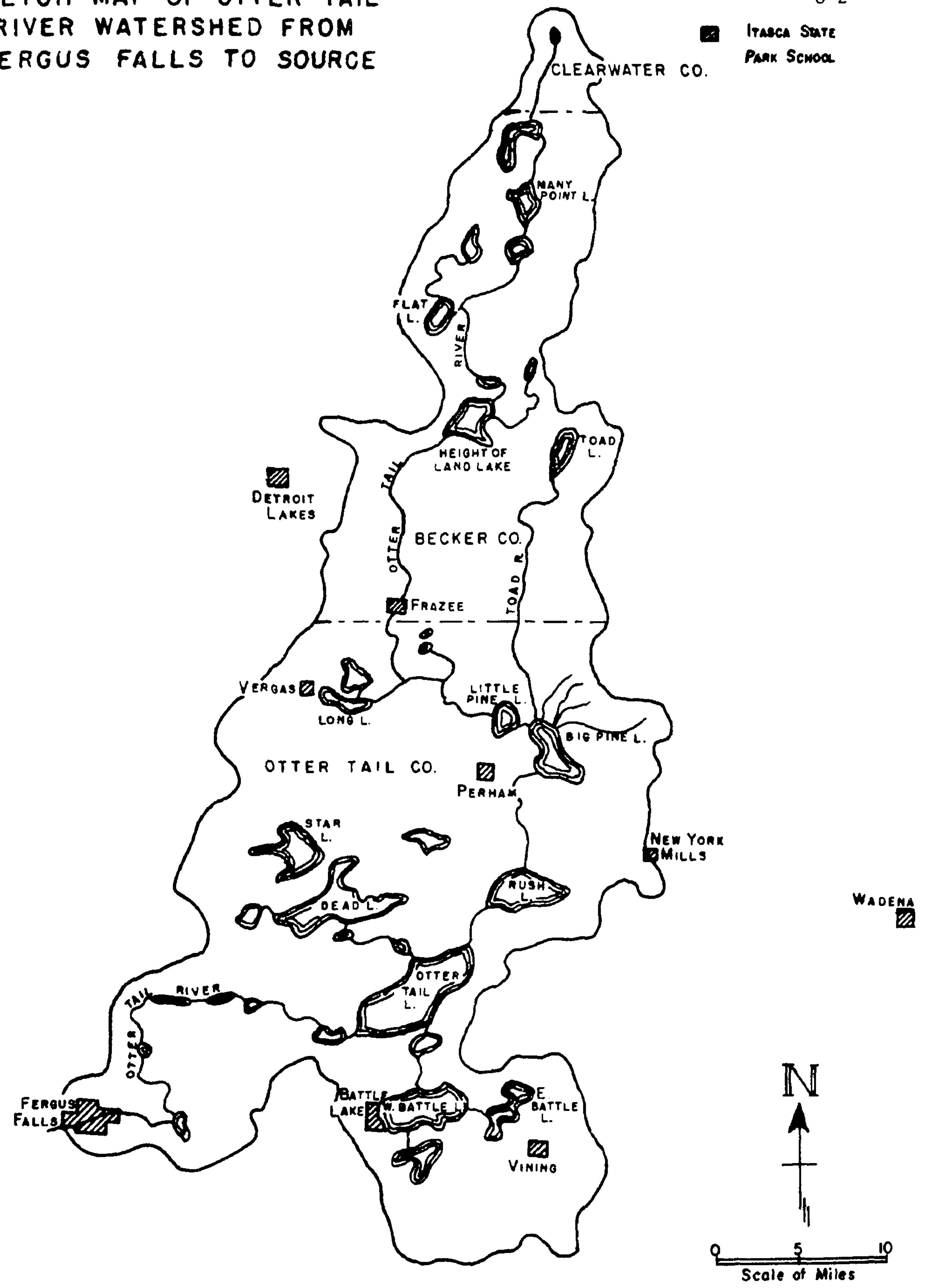
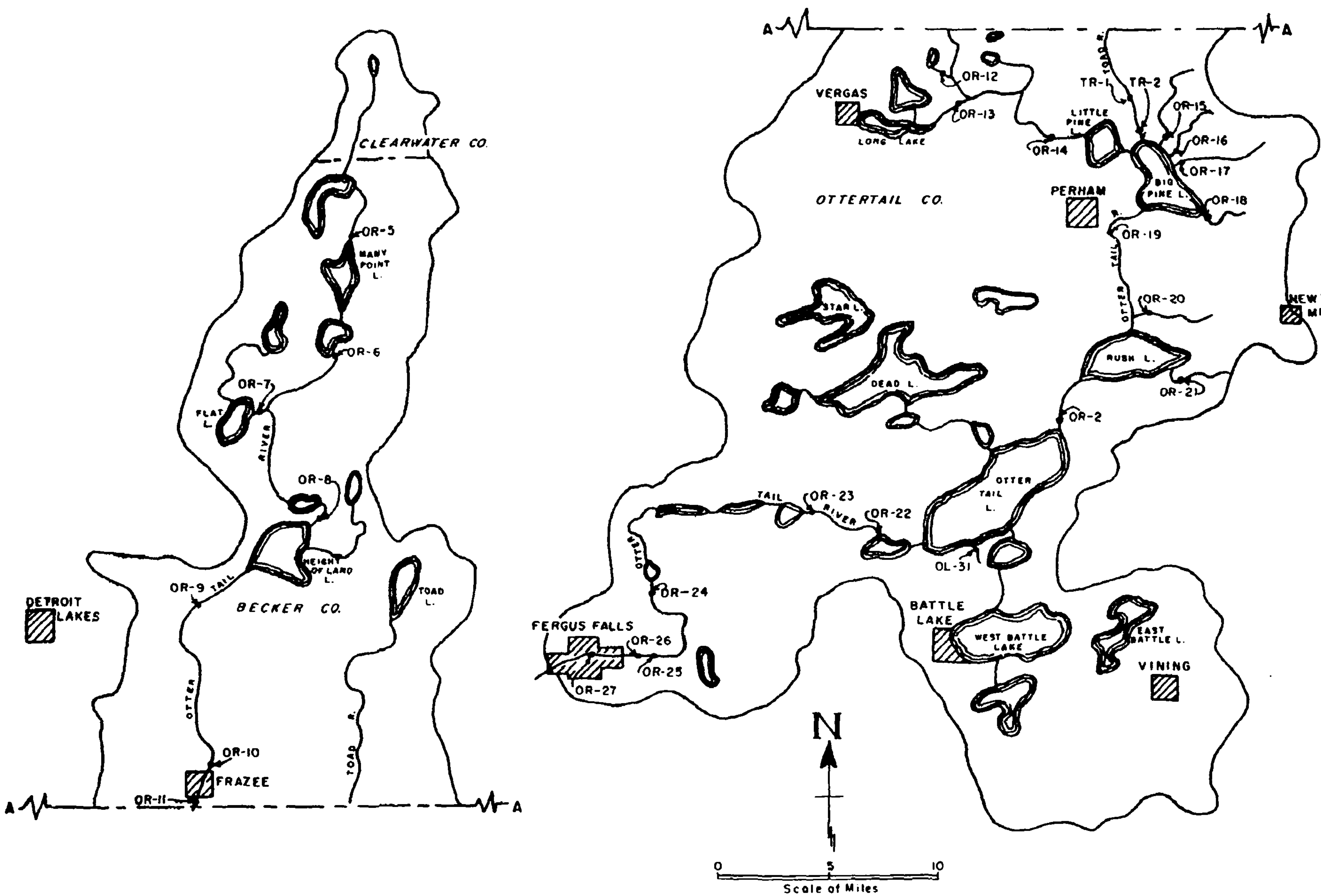


FIG. 1

MINN. POLLUTION CONTROL AGENCY
DIV. OF WATER QUALITY
JULY, 1969

SKETCH MAP OF SAMPLING LOCATIONS
OTTER TAIL RIVER SURVEY



LEGEND
OR-1, -Sampling stations
-Watershed boundary

FIG. 2

MINN. POLLUTION
CONTROL AGENCY
DIV. OF WATER QUALITY
JULY, 1969

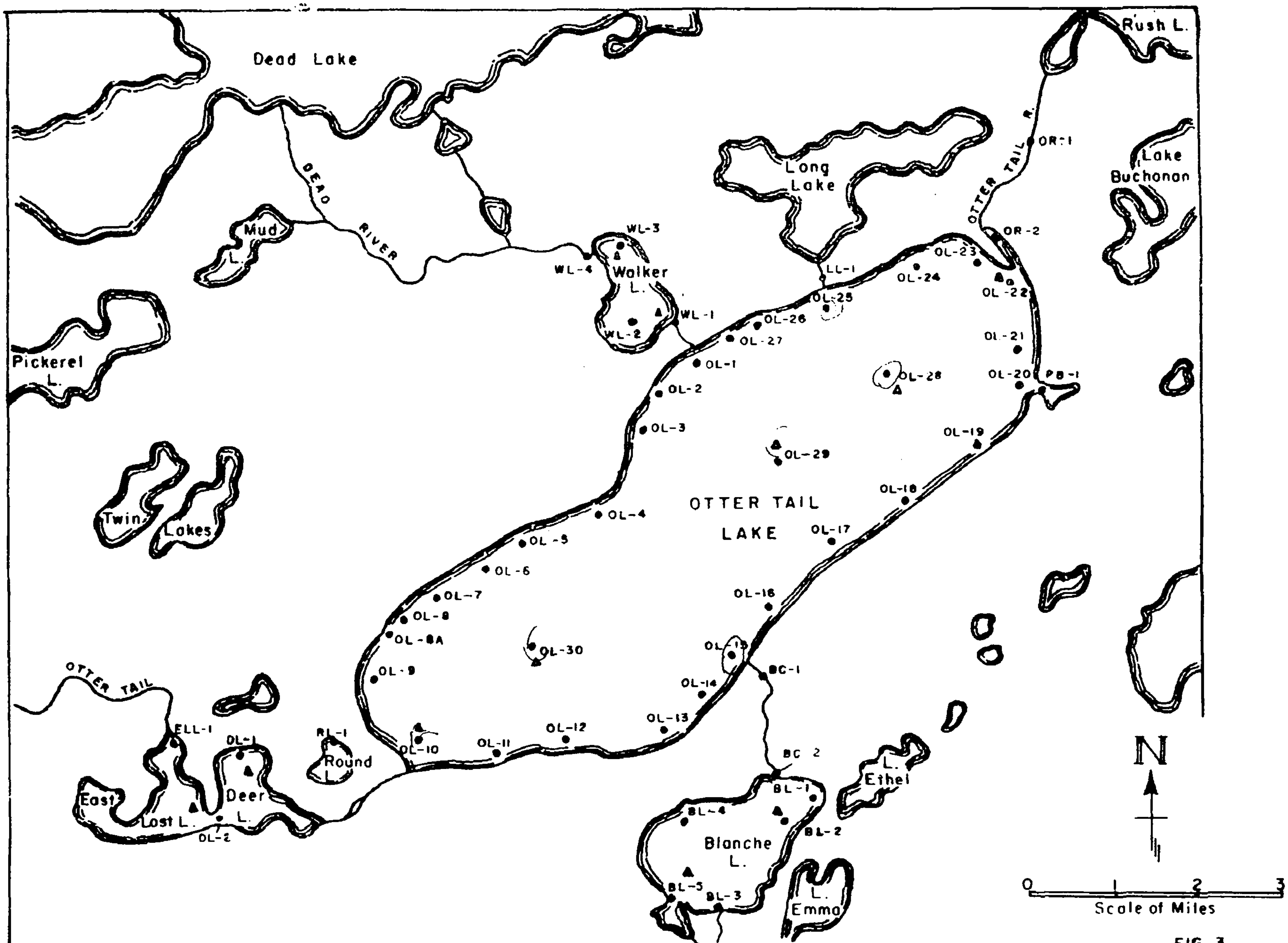


FIG. 3

LEGEND:

- OL-Otter Tail Lake
- OR-Otter Tail River
- BC-Balmoral Creek
- BL-Blanche Lake
- RL-Round Lake
- DL-Deer Lake
- ELL-East Lost Lake
- WL-Walker Lake
- PB-Pelican Bay
- LL-Long Lake
- Δ Plankton Samples

MINN. POLLUTION CONTROL AGENCY
DIV. OF WATER QUALITY
JUNE, 1969

MINNESOTA POLLUTION CONTROL AGENCY
DIVISION OF WATER QUALITY
Section of Standards and Surveys

TABLE I

Analytical Data of Otter Tail River*

Station	Description
OR-5	Otter Tail River, Becker Co., above entrance to Many Point Lake
OR-6	Otter Tail River, Becker Co., at outlet from Round Lake
OR-7	Unnamed creek, Becker Co., at outlet from Flat Lake (T141N, R39W, S33)
OR-8	Otter Tail River, Becker Co., between Rice Lake and Height of Land Lake
OR-9	Otter Tail River, Becker Co., bridge on County Highway 29 below Hubbel Pond Wildlife Area.

	OR-5	OR-6	OR-7	OR-8	OR-9
Date Collected	7/15/69	7/15/69	7/15/69	7/15/69	7/15/69
Time Collected	11:45	12:20	1330	1415	1515
Temperature °F	74°	73°	76°	77°	75°
Coliform group organisms) Con. M.P.N. per 100 ml.	840	50	700	<20	1300
Coliform group organisms) Fecal M.P.N. per 100 ml.	80	20	490	<20	50
Total Solids	180	180	220	200	180
Total Volatile Matter	140	130	150	140	130
Suspended Solids	3	3	10	5	5
Suspended Volatile Matter	3	3	7	5	5
Turbidity	2.7	2.4	8.5	3.2	3.5
Color	15	10	35	35	30
Total hardness as $CaCO_3$	150	150	140	140	160
Alkalinity as $CaCO_3$	160	150	160	150	140
pH Value	7.7	8.2	7.7	7.7	7.8
Chloride	2.6	1.8	<1	<1	<1
Dissolved Oxygen	4.5	5.7	2.3	3.7	6.5
Five-day Biochemical Oxygen Demand	2.3	1.8	2.5	2.5	2.0
Total Phosphorus	0.05	0.06	0.09	0.08	0.04
Soluble Phosphorus	0.04	0.03	0.06	0.06	0.03
Ammonia Nitrogen	.13 ~~0.05~~	0.08	0.33	0.14	0.14
Organic Nitrogen	.88 ~~0.19~~	0.59	1.4	1.1	0.93
Nitrite Nitrogen	.06 ~~0.08~~	0.04	0.05	0.04	0.03
Nitrate Nitrogen	<.02	<.02	0.08	0.04	<.02
Methylene Blue Active Sub. as ABS	0.12	0.10	<.1	0.10	0.10
Copper	<.01			<.01	
Cadmium	<.01			<.01	
Nickel	<.01			<.01	
Zinc	<.01			<.01	
Iron	0.05			0.25	
Manganese	.03			0.07	
Spec. Cond. umhos/cm @ 25° C.	280	270	280	270	260

* Results are in milligrams per liter as noted

TABLE I
Analytical Data of Otter Tail River (cont.)*

Station	Description
OR-10	Otter Tail River, Becker Co., on northern edge of Frazee
OR-11	Otter Tail River, Becker Co., culvert under U. S. Highway 10 south of Frazee
OR-12	Unnamed creek, Otter Tail Co., T137N, R 40W, S15
OR-13	Unnamed creek, Otter Tail Co., culvert on State Highway 228
OR-14	Otter Tail River, Otter Tail Co., bridge on County Road 60.

	OR-10	OR-11	OR-12	OR-13	OR-14
Date Collected	7/15/69	7/15/69	7/15/69	7/16/69	7/16/69
Time Collected	1600	1625	1700	0845	0905
Temperature °F		76°	72°	71°	70°
Coliform) group) Con. M.P.N. per 100 ml.	1100	110	2200	330	110
organisms) Fecal M.P.N. per 100 ml.	130	20	140	130	110
Total Solids	200	200	230	160	160
Total Volatile Matter	150	150	120	69	84
Suspended Solids	8	4	3	1	2
Suspended Volatile Matter	8	4	3	1	2
Turbidity	4.8	6.6	1.9	2.0	2.3
Color	25	35	70	15	25
Total hardness as CaCO3	160	200	180	170	170
Alkalinity as $CaCO_3$	170	180	180	180	170
pH value	7.6	7.6	7.3	7.7	7.7
Chloride	<1	5.6	1.8	6.0	1.2
Dissolved Oxygen	2.9	6.7	2.3	5.7	6.5
Five-day Biochemical Oxygen Demand	1.5	2.5	1.3	2.5	1.8
Total Phosphorus	0.10	0.18	0.09	0.03	0.07
Soluble Phosphorus	0.08	0.11	0.07	<.01	0.03
Ammonia Nitrogen	20	0.21	0.17	0.15	0.18
Organic Nitrogen	0.91	1.4	0.92	0.69	0.78
Nitrite Nitrogen	0.02	0.04	0.05	0.02	<.02
Nitrate Nitrogen	0.02	0.15	0.08	<.02	<.02
Methylene Blue Active Sub. as ABS	0.11	0.14	<.1	<.1	<.1
Copper					
Cadmium					
Nickel					
Zinc					
Iron					
Manganese					
Spec. Cond. umhos/cm @ 25° C.	290	316	305	330	310

* Results are in milligrams per liter as noted

TABLE I
Analytical Data of Otter Tail River (cont.)*

Station	Description
TR-1	Toad River, Otter Tail Co., at County Road 60
TR-2	Toad River, Otter Tail Co., above entrance to Big Pine Lake
OR-15	Unnamed creek, Otter Tail Co., above entrance to Big Pine Lake (T137N, R38W, S33)
OR-16	Unnamed creek, Otter Tail Co., above entrance to Big Pine Lake (T137N, R38W, S33)
OR-17	Unnamed creek, Otter Tail Co., above entrance to Big Pine Lake (T136N, R38W, S4)

	TR-1	TR-2	OR-15	OR-16	OR-17
Date Collected	7/16/69	7/16/69	7/16/69	7/16/69	7/16/69
Time Collected	0930	0950	1010	1030	1050
Temperature °F	71°	70°	67°	68°	67°
Coliform group organisms — Con. M.P.N. per 100 ml.	330	20	7900	2300	170
Coliform group organisms — Fecal M.P.N. per 100 ml.	80	20	640	1300	170
Total Solids		200	280	260	270
Total Volatile Matter		100	89	150	140
Suspended Solids		7	8	2	21
Suspended Volatile Matter		6	6	2	7
Turbidity		4.6	1.7	1.9	160
Color		30	100	100	75
Total hardness as $CaCO_3$		160	260	250	250
Alkalinity as $CaCO_3$		180	260	230	230
pH value		7.8	7.6	7.5	7.7
Chloride		6.3	3.7	5.2	4.8
Dissolved Oxygen	5.1	8.7	6.2	7.3	7.1
Five-day Biochemical Oxygen Demand		3.5	2.5	3.3	2.3
Total Phosphorus		0.12	0.25	0.21	0.25
Soluble Phosphorus		0.04	0.25	0.19	0.17
Ammonia Nitrogen		0.17	0.28	0.12	0.29
Organic Nitrogen		1.3	1.5	1.7	1.4
Nitrite Nitrogen		0.05	0.04	0.02	0.05
Nitrate Nitrogen		0.09	0.05	<.02	0.[illegible]
Methylene Blue Active Sub. as ABS		<.1	<.1	<.1	<.1
Copper					
Cadmium					
Nickel					
Zinc					
Iron					
Manganese					
Spec. Cond. umhos/cm @ 25° C.		340	4[illegible]0	430	420

* Results are in milligrams per liter as noted.

TABLE I

Analytical Data of Otter Tail River (cont.)*

Station	Description
OR-18	Unnamed creek, Otter Tail Co., above entrance to Big Pine Lake (T136N, R38W, S14)
OR-19	Otter Tail River, Otter Tail Co., bridge on U.S. Highway 10 southeast of Perham
OR-20	Unnamed creek, Otter Tail Co., culvert on County Highway 14 north of Rush Lake (T135N, R38W, S17)
OR-21	Unnamed creek, Otter Tail Co., (T135N, R39W, S28)
OR-2	Otter Tail River, Otter Tail Co., bridge above entrance to Otter Tail Lake.

	OR-18	OR-19	OR-20	OR-21	OR-2
Date Collected	7/16/69	7/16/69	7/16/69	7/16/69	7/16/69
Time Collected	1110	1135	1220	1250	1320
Temperature °F	64°	72°	69°	64°	73°
Coliform group organisms – Con. M.P.N. per 100 ml.	2300	130	3300	1100	220
Coliform group organisms – Fecal M.P.N. per 100 ml.	270	<20	3300	70	<20
Total Solids	310	150	300		130
Total Volatile Matter	100	84	130		34
Suspended Solids	2	4	2		3
Suspended Volatile Matter	2	4	2		3
Turbidity	0.3	3.4	3.3		0.3
Color	50	15	75		15
Total Hardness as $CaCO_3$	290	180	290		160
Alkalinity as $CaCO_3$	290	160	280		150
pH Value	7.5	8.0	7.4		7.7
Chloride	2.6	4.8	11		5.6
Dissolved Oxygen	4.7	8.0	5.6	4.1	4.9
Five-day Biochemical Oxygen Demand	2.3	2.5	2.3		2.0
Total Phosphorus	0.14	0.05	0.15		0.08
Soluble Phosphorus	0.13	0.05	0.14		0.06
Ammonia Nitrogen	0.18	0.20	0.07		0.13
Organic Nitrogen	0.86	0.90	1.2		1.0
Nitrite Nitrogen	<.02	<.02	0.02		0.02
Nitrate Nitrogen	<.02	<.02	<.02		<.02
Methylene Blue Active Sub. as ABS	<.1	<.1	<.1		<.1
Copper					<.01
Cadmium					<.01
Nickel					<.01
Zinc					<.01
Iron					
Manganese					
Spec. Cond. umhos/cm @ 25° C.	490	300	490		290

* Results are in milligrams per liter as noted.

TABLE I
Analytical Data of Otter Tail River (cont.)*

Station	Description
OL-31	Unnamed creek, Otter Tail Co., entering Otter Tail Lake (T133N, R40W, S1)
OR-22	Otter Tail River, Otter Tail Co., bridge below outflow of East Lost Lake
OR-23	Otter Tail River, Otter Tail Co., bridge on County Highway 35, 6 miles west of Otter Tail Lake
OR-24	Otter Tail River, Otter Tail Co., above Otter Tail Power Company's diversion to Hoot Lake.
OR-25	Otter Tail River, Otter Tail Co., above Otter Tail Power Hoot Lake Plant, Fergus Falls

	OL-31	OR-22	OR-23	OR-24**	OR-25**
Date Collected	7/16/69	7/16/69	7/16/69	7/17/69	7/17/69
Time Collected	1355	1415	1440	1000	1045
Temperature $^{\circ}F$	70°	73°	76°	74°	71°
Coliform group organisms) Con. M.P.N. per 100 ml.	7900	<20	40		
Coliform group organisms) Fecal M.P.N. per 100 ml.	4900	<20	20		
Total Solids		140	150		230
Total Volatile Matter		86	49	Sample	110
Suspended Solids		6	3	broken	8
Suspended Volatile Matter		4	3	in	4
Turbidity		2.3	2.2	transit	2.4
Color		10	10		15
Total hardness as $CaCO_3$		170	170		130
Alkalinity as $CaCO_3$		160	160		190
pH Value		8.1	8.3		7.9
Chloride		5.2	4.2		6.8
Dissolved Oxygen	1.8	9.3	11.1	4.5	7.2
Five-day Biochemical Oxygen Demand		2.3	1.8		
Total Phosphorus		0.07	0.07		0.07
Soluble Phosphorus		0.04	0.01		0.06
Ammonia Nitrogen		0.06	0.06		0.03
Organic Nitrogen		0.72	0.66		0.58
Nitrite Nitrogen		0.03	<.02		<.02
Nitrate Nitrgoen		<.02	<.02		0.09
Methylene Blue Active Sub. as ABS		<.1	<.1		<.1
Copper					
Cadmium					
Nickel					
Zinc					
Spec. Cond. umhos/cm @ 25° C.		320	.310		350

*Results are in milligrams per liter except as noted.
**Samples left over-weekend in bus station, coliforms and 5-day BOD's not run.

TABLE I
Analytical Data of Otter Tail River (cont.) *

Station	Description
OR-26	Otter Tail Power discharge canal in Fergus Falls
OR-27	Otter Tail River, Cascade St. bridge in Fergus Falls

	OR-26	OR-27
Date Collected	7/17/69	7/17/69
Time Collected	1115	1230
Temperature °F	86°	78°
Total Solids	200	210
Total Volatile Matter	110	88
Suspended Solids	2	8
Suspended Volatile Matter	2	3
Turbidity	1.1	3.4
Color	18	10
Total hardness as $CaCO_3$	170	180
Alkalinity as $CaCO_3$	160	170
pH Value	8.0	8.0
Chloride	3.4	3.4
Dissolved Oxygen	6.7	7.1
Total Phosphorus	0.07	0.06
Soluble Phosphorus	0.02	0.02
Ammonia Nitrogen	0.09	0.13
Organic Nitrogen	0.63	0.55
Nitrite Nitrogen	<.02	<.02
Nitrate Nitrogen	0.07	0.08
Methylene Blue Active Sub. as ABS	<.1	<.1
Copper		<.01
Cadmium		<.01
Nickel		<.01
Zinc		<.01
Spec. Cond. umhos/cm @ 25° C.	320	330

*Results are in milligrams per liter except as noted.

TABLE II
COMPARATIVE CHEMICAL CHARACTERISTICS
of OTTER TAIL LAKES
June 23-27, 1969

Parameter*	Otter Tail Lake	Deer Lake	East Lost Lake	Blanche Lake	Walker Lake	Round Lake
Alkalinity	170	160	170	192	210	210
Hardness	181	180	170	195	210	210
Specific Conductivity, umhos/cm	326	320	320	357	390	380
pH	8.0	8.0	8.0	8.2	7.9	8.1
DO	8.8	8.0	---	8.9	8.0	8.9
BOD	2.7	2.5	2.3	4.2	4.3	3.3
Total Phosphorus	.05	.035	.03	.05	.035	.04
Soluble Phosphorus	.04	.035	.03	.048	.035	.03
Ammonia	.16	.25	.25	.27	.24	.29
Nitrates	<.02	<.02	<.02	<.02	<.02	<.02
Nitrites	<.02	<.02	<.02	<.02	<.02	<.02
Organic Nitrogen	.54	.41	.46	.54	.78	.98
Total Nitrogen	.74	.70	.74	.83	1.03	1.31
Total Solids	176	205	210	223	260	230
Suspended Solids	7	3.5	3	2.7	2.5	6
Turbidity units	3.6	1.35	1.1	2.1	1.2	4.9

*Units in mg/l unless otherwise indicated.

MINNESOTA POLLUTION CONTROL AGENCY
DIVISION OF WATER QUALITY
Section of Standards and Surveys

TABLE III
Analytical Data of Otter Tail Lakes*

Field Number	Town, County Etc.	Sampling Point and Source of Sample
OL-1	Otter Tail Lake	50 yds. off of inflow from Walker Lake, 7 feet deep, 2 ft. sample
OL-2	Otter Tail Lake	50 yds off shore, 5 feet deep, 2 ft. sample
OL-3	Otter Tail Lake	30 yds. off shore from silo, 6 ft. deep, 2 ft. sample
OL-4	Otter Tail Lake	50 yds. off shore, 6 feet deep, 2 ft. sample
OL-5	Otter Tail Lake	100 yds. off shore, 6 feet deep, 2 ft. sample

	OL-1	OL-2	OL-3	OL-4	OL-5
Date Collected	6/26/69	6/26/69	6/26/69	6/26/69	6/26/69
Time Collected	0905	0915	0930	0945	0955
Temperature °F				62°	
Date Received by Lab.	6-27-69				
Coliform group organisms) Con. M.P.N. per 100 ml.	130	80	20	130	80
Coliform group organisms) Fecal M.P.N. per 100 ml.	20	20	20	20	20
Total Solids	230			240	
Total Volatile Matter	78			75	
Suspended Solids	12			18	
Suspended Volatile Matter	6			9	
Turbidity	8.6			13	
Color	15			10	
Total hardness as $CaCO_3$	200			180	
Alkalinity as $CaCO_3$	200			76	
pH value L36	7.7			7.9	
Chloride	9.3			9.1	
Dissolved Oxygen	8.5	8.7	8.8	8.6	9.0
Five-day Biochemical Oxygen Demand	2.8			2.8	
Total Phosphorus	0.10			0.06	
Soluble Phosphorus	0.07			0.04	
Ammonia Nitrogen	0.26			0.21	
Organic Nitrogen	0.65			0.64	
Nitrite Nitrogen	<.02			<.02	
Nitrate Nitrogen	<.02			0.04	
Methylene Blue Active Sub. as ABS	0.27			0.22	
Copper	<.01			<.01	
Cadmium	<.01			<.01	
Nickel	<.01			<.01	
Zinc	<.01			<.01	
Lead	<.01			<.01	
Iron	0.13			0.28	
Manganese	0.03			0.06	
Spec. Cond umhos/cm @ 25° C.	330			330	

*Results are in milligrams per liter except as noted.

TABLE III (cont.)
Analytical Data of Otter Tail Lakes*

Field Number	Town, County, Etc.	Sampling Point and Source of Sample
OL-6	Otter Tail Lake	100 yards offshore, 5 feet deep, 2 ft. sample
OL-7	Otter Tail Lake	75 yards offshore, 6 feet deep, 2 ft. sample
OL-8	Otter Tail Lake	50 yards offshore, 5 feet deep, 2 ft. sample
OL-8a	Otter Tail Lake	Directly off Barky's Resort - Waded out to 1' depth.
OL-9	Otter Tail Lake	50 yards offshore, 5 feet deep, 18" sample

	OL-6	OL-7	OL-8	OL-8a	OL-9
Date Collected					6/26/69
Time Collected	1005	1015	1030	1045	1055
Temperature °F	62°				
Date Received by Lab.					6-27-69
Coliform)					
group) Con M.P.N. per 100 ml.	<20	<20	20	270	50
organisms) Fecal M.P.N. per 100 ml.	<20	<20	<20	20	20
Total Solids			200		
Total Volatile Matter			70		
Suspended Solids			3		
Suspended Volatile Matter	Most		3		
Turbidity	of		2.7		
Color	Sample		10		
Total hardness as $CaCO_3$	Lost		190		
Alkalinity as $CaCO_3$			150		
pH value L36			8.1		
Chloride			10		
Dissolved Oxygen	8.8	9.0	8.7		9.0
Five-day Biochemical Oxygen Demand			1.8		
Total Phosphorus			0.10		
Soluble Phosphorus			0.05		
Ammonia Nitrogen			0.25		
Organic Nitrogen			0.46		
Nitrite Nitrogen			<.02		
Nitrate Nitrogen			0.04		
Methylene Blue Active Sub. as ABS			0.17		
Copper			<.01		
Cadmium			<.01		
Nickel			<.01		
Zinc			<.01		
Lead			<.01		
Iron			0.15		
Manganese			<.02		
Spec. Cond. umhos/cm @ 25° C.			320		

* Results are in milligrams per liter except as noted.

TABLE III (cont.)
Analytical Data of Otter Tail Lakes*

Field Number	Town, County Etc.	Sampling Point and Source of Sample
OL-10	Otter Tail Lake	400 yds. out from Bridge over Otter Tail R. 5 feet deep, 2 ft. sample
OL-11	Otter Tail Lake	75 yds. offshore, 6 feet of water, 18" sample
OL-12	Otter Tail Lake	100 yds. offshore, 4 feet of water, 2 ft. sample
OL-13	Otter Tail Lake	100 yds. offshore, 5 feet of water, 2 ft. sample
OL-14	Otter Tail Lake	75 yds. offshore, 4 feet of water, 2 ft. sample

	OL-10	OL-11	OL-12	OL-13	OL-14
Date Collected					
Time Collected	1105	1110	1125	1140	1150
Temperature °F				63°	
Coliform)					
group) Con. M.P.N. per 100 ml.	<20	20	20	20	20
organisms) Fecal M.P.N. per 100 ml.	<20	20	<20	<20	<20
Total Solids	200		210	200	
Total Volatile Matter	63		63	64	
Suspended Solids	4		3	3	
Suspended Volatile Matter	4		3	3	
Turbidity	2.8		2.1	2.3	
Color	10		15	10	
Total hardness as $CaCO_3$	180		180	180	
Alkalinity as $CaCO_3$	180		180	180	
pH value L36	7.9		7.4	8.1	
Chloride	9.3		10	8.8	
Dissolved Oxygen	9.0	8.9	8.9	8.7	8.8
Five-day Biochemical Oxygen Demand	1.5		1.8	2.0	
Total Phosphorus	0.04		0.05	0.04	
Soluble Phosphorus	0.03		0.05	0.03	
Ammonia Nitrogen	0.27		0.25	0.33	
Organic Nitrogen	0.46		0.60	0.46	
Nitrite Nitrogen	<.02		<.02	<.02	
Nitrate Nitrogen	<.02		<.02	<.02	
Methylene Blue Active Sub. as ABS	<.1		0.28	0.31	
Copper	<.01		<.01	<.01	
Cadmium	<.01		<.01	<.01	
Nickel	<.01		<.01	<.01	
Zinc	<.01		<.01	<.01	
Iron	0.03		0.06	0.03	
Lead	<.01		<.01	<.01	
Manganese	<.02		<.02	<.02	
Spec. Cond. umhos/cm @ 25° C.	330		320	320	

*Results are in milligrams per liter except as noted.

TABLE III (cont.)
Analytical Data of Otter Tail Lakes*

Field Number	Town, County, Etc.	Sampling Point and Source of Sample
OL-15	Otter Tail Lake	100 yds. offshore, 5 feet of water, 2 ft. sample
OL-16	Otter Tail Lake	150 yds. offshore, 4 ft. of water, 18" sample
OL-17	Otter Tail Lake	100 yds. offshore, 5 ft. of water, 18" sample
OL-18	Otter Tail Lake	100 yds. offshore, 4 ft. of water, 18" sample
OL-19	Otter Tail Lake	200 yds. offshore, 4 ft. of water, 18" sample

	OL-15	OL-16	OL-17	OL-18	OL-19
Date Collected	6/26/69				
Time Collected	1200	1135	1115	1105	1055
Temperature °F		61°	61°	61°	61°
Date Received by Lab.	6-26-69				
Coliform)					
group) Con. M.P.N. per 100 ml.	<20	<20	20	Bottle	20
organisms) Fecal M.P.N. per 100 ml.	<20	<20	20	Broken	<20
Total Solids	200		240		240
Total Volatile Matter	69		72		63
Suspended Solids	3		2		2
Suspended Volatile Matter	3		2		2
Turbidity	1.8		1.6		2.1
Color	15		5		10
Total hardness as $CaCO_3$	180		180		170
Alkalinity as $CaCO_3$	200		170		170
pH value L36	8.1		8.1		8.0
Chloride	11		9.1		8.8
Dissolved Oxygen	8.8	8.8	8.9	8.3	8.9
Five-day Biochemical Oxygen Demand	2.0		2.8		3.0
Total Phosphorus	0.05		0.06		0.05
Soluble Phosphorus	0.05				
Ammonia Nitrogen	0.25		0.27		0.22
Organic Nitrogen	0.52		0.38		0.43
Nitrite Nitrogen	<.02		<.02		<.02
Nitrate Nitrogen	<.02		<.02		<.02
Methylene Blue Active Sub. as ABS	0.23		<.1		<.1
Copper	<.01		<.01		<.01
Cadmium	<.01		<.01		<.01
Nickel	<.01		<.01		<.01
Zinc	<.01		<.01		<.01
Iron	0.04		0.05		0.03
Lead	<.01		<.01		<.01
Manganese	<.02		<.02		0.02
Spec. Cond. umhos/cm @ 25°C.	330		330		330

*Results are in milligrams per liter except as noted.

TABLE III (cont.)
Analytical Data of Otter Tail Lakes*

Field Number	Town, County, Etc.	Sampling Point and Source of Sample
OL-20	Otter Tail Lake	300 yds offshore, 5 ft. of water, 18• sample
OL-21	Otter Tail Lake	150 yds. offshore, 8 ft. of water, 18" sample
OL-22	Otter Tail Lake	75 yds. out from mouth of Otter Tail River, 6 feet of water, 2 ft. sample
OL-23	Otter Tail Lake	100 yds. offshore, 5 ft. of water, 2 ft. sample
OL-24	Otter Tail Lake	75 yds. offshore, 4 ft. of water, 2 ft. sample

	OL-20	OL-21	OL-22	OL-23	OL-24
Date Collected		6/25/69	6/26/69	6/26/69	6/26/69
Time Collected	1040	1030	1950	1940	1935
Temperature °F	61°	61°	67°		
Date Received by Lab.		6-25-69			
Coliform) Con. M.P.N. per 100 ml.	<20	<20	80	170	230
group Org) Fecal M.P.N. per 100 ml.	20	<20	<20	50	50
Total Solids	250		130		
Total Volatile Matter	86		5		
Suspended Solids	3		5		
Suspended Volatile Matter	3		2		
Turbidity	2.4		43		
Color	10		15		
Total hardness as $CaCO_3$	180		170		
Alkalinity as $CaCO_3$	170		160		
pH value L36	7.8		8.1		
Chloride	9.9		9.2		
Dissolved Oxygen	8.2	7.2	8.6	8.8	8.8
Five-day Biochemical Oxygen Demand	3.3		3.8		
Total Phosphorus	0.05		0.04		
Soluble Phosphorus			0.03		
Ammonia Nitrogen	0.31		<.05		
Organic Nitrogen	0.46		0.95		
Nitrite Nitrogen	<.02		<.02		
Nitrate Nitrogen	<.02		<.02		
Methylene Blue Active Sub. as ABS	<.1		0.34		
Copper	<.01		<.01		
Cadmium	<.01		.01		
Nickel	<.01		<.01		
Zinc	<.01		<.01		
Lead	<.01		<.01		
Iron	0.05		0.07		
Manganese	0.03		<.02		
Spec. Cond. umhos/cm @ 25° C.	320		310		

*Results are in milligrams per liter except as noted.

TABLE III (cont.)
Analytical Data of Otter Tail Lakes*

Field Number	Town, County, Etc.	Sampling Point and Source of Sample
OL-25	Otter Tail Lake	75 yds. offshore of channel to Echo Ranch Riviera, 5 ft. of water
OL-26	Otter Tail Lake	50 yds. offshore, 4 feet of water, 2 ft. sample
OL-27	Otter Tail Lake	25 yds. offshore, 5 feet of water, 2 ft. sample
OL-28	Otter Tail Lake	2 ft. sample in 70-80 feet of water
OL-28A	Otter Tail Lake	70 ft. sample in 70-80 feet of water

	OL-25	OL-26	OL-27	OL-28	OL-28A
Date Collected			6/26/69	6/26/69	6/26/69
Time Collected	1927	1920	1915	0815	0840
Temperature °F	66°			62°	62°
Date Received by Lab.				6/26/69	
Coliform) group)Con. MPN/100 ml.	110	20	230	<20	Not Rec'd.
organisms)Fecal MPN/100 ml.	<20	20	50	<20	
Total Solids	130			120	100
Total Volatile Matter	71			54	55
Suspended Solids	14			3	3
Suspended Volatile Matter	4			2	2
Turbidity	8.4			2.3	2.0
Color	15			15	15
Total hardness as $CaCO_3$	190			170	160
Alkalinity as $CaCO_3$	180			170	170
pH value L36	8.1			7.9	8.1
Chloride	8.2			13	9.2
Dissolved Oxygen	8.9	8.9	9.0	8.6	8.6
5-day Biochemical Oxygen Demand	4.0			3.3	2.3
Total Phosphorus	0.03			0.03	0.03
Soluble Phosphorus	0.03			0.03	0.03
Ammonia Nitrogen	<.05			<.05	<.05
Organic Nitrogen	0.72			0.58	0.33
Nitrite Nitrogen	<.02			<.02	<.02
Nitrate Nitrogen	<.02			0.05	<.02
Methylene Blue Active Sub. as ABS	0.31			0.24	<.1
Copper	<.01			<.01	
Cadmium	<.01			<.01	
Nickel	<.01			<.01	
Zinc	<.01			<.01	
Lead	<.01			<.01	
Iron	0.03			0.04	
Manganese	<.02			<.02	
Spec. Cond. umhos/cm @ 25°C	330			330	320

*Results are in milligrams per liter except as noted.

TABLE III (cont.)
Analytical Data of Otter Tail Lakes*

Field Number	Town, County, Etc.	Sampling Point and Source of Sample
OL-29	Otter Tail Lake	2 ft. sample in 100 feet of water
OL-29A	Otter Tail Lake	70 ft. sample in 100 feet of water
OL-30	Otter Tail Lake	2 ft. sample in 65 feet of water
OL-30A	Otter Tail Lake	60 ft. sample in 65 feet of water
PB-1	Otter Tail Lake	Pelican Bay Bridge - East side

	OL-29	OL-29A	OL-30	OL-30A**	PB-1
Date Collected					6/23/69
Time Collected	0845	0900	0910	0930	1960
Temperature °F	62°	62°	62°	62°	62°
Date Received in Lab.					6/24/69
Coliform)					
group)Con. MPN/100 ml.	<20	Not	<20	Not	110
organisms)Fecal MPN/100 ml.	<20	Rec'd.	<20	Rec'd.	<20
Total Solids	93	87	86	380	220
Total Volatile Matter	33	16	36	110	60
Suspended Solids	44	3	4	210	2
Suspended Volatile Matter	8	2	2	57	1
Turbidity	1.8	3.2	2.7	81	1.9
Color	10	15	15	15	5
Total hardness as $CaCO_3$	220	170	190	170	180
Alkalinity as $CaCO_3$	180	170	180	170	170
pH value L36	8.2	8.0	8.1	7.9	8.3
Chloride	11	9.3	9.8	8.1	<1
Dissolved Oxygen	8.7		8.9	8.4	12.0
5-day Biochemical Oxygen Demand	2.8	2.0	3.3	3.8	2.5
Total Phosphorus	0.06	0.03	0.03	0.14	0.02
Soluble Phosphorus	0.03	0.03	0.03	0.03	
Ammonia Nitrogen	<.05	<.05	<.05	<.05	0.08
Organic Nitrogen	0.55	0.52	0.55	0.59	0.51
Nitrite Nitrogen	<.02	<.02	<.02	<.02	0.02
Nitrate Nitrogen	<.02	<.02	<.02	<.02	<.02
Methylene Blue Active Sub. as ABS	0.16	0.26	0.16	<.1	0.34
Copper	<.01		<.01		<.01
Cadmium	<.01		<.01		<.01
Nickel	<.01		<.01		<.01
Zinc	<.01		<.01		<.01
Lead	<.01		<.01		<.01
Iron	0.05		0.10		0.02
Manganese	0.02		0.02		<.02
Spec. Cond. umhos/cm @ 25°C	330	320	320	320	330

*Results are in milligrams per liter except as noted.
**Sampler struck bottom.

TABLE III (cont.)
Analytical Data of Otter Tail Lakes*

Field Number	Town, County, Etc.	Sampling Point and Source of Sample
BL-1	Blanche Lake	25 yards offshore - 10 ft. depth, 2 ft. sample
BL-2	Blanche Lake	30 ft. depth - 2 ft. sample
BL-2A	Blanche Lake	30 ft. depth - 27 ft. sample
BL-3	Blanche Lake	Mouth of small creek flowing into Blanche Lake from Lake Emma
BL-4	Blanche Lake	Near diving board, 10 ft. depth - 2 ft. sample

	BL-1	BL-2	BL-2A	BL-3	BL-4
Date Collected	6/24/69	6/24/69	6/24/69	6/24/69	6/24/69
Time Collected	1420	1440	1435	1450	1535
Temperature °F	61°	61°	61°	64°	61°
Date Received by Lab					
Coliform)					
group)Con. MPN/100 ml.	20	<20		700	<20
organisms)Fecal MPN/100 ml.	<20	<20		<20	<20
Total Solids	230	220			230
Total Volatile Matter	89	86			98
Suspended Solids	3	3			3
Suspended Volatile Matter	3	3			3
Turbidity	2.2	1.9			2.3
Color	5	5			5
Total hardness as $CaCO_3$	190	190			200
Alkalinity as $CaCO_3$	200	190			190
pH value L36	8.4	8.2			8.2
Chloride	7.5	9.1			9.6
Dissolved Oxygen	8.7	9.0	8.5	8.7	9.2
5-day Biochemical Oxygen Demand	4.3	3.8			4.3
Total Phosphorus	0.03	0.04			0.04
Soluble Phosphorus	0.03	0.04			0.04
Ammonia Nitrogen	0.29	0.27			0.27
Organic Nitrogen	0.46	0.59			0.53
Nitrite Nitrogen	<.02	<.02			<.02
Nitrate Nitrogen	<.02	<.02			<.02
Methylene Blue Active Sub. as ABS	0.19	0.17			0.18
Copper	<.01	<.01			<.01
Cadmium	<.01	<.01			<.01
Nickel	<.01	<.01			<.01
Zinc	<.01	<.01			<.01
Iron	0.06	0.06			0.04
Lead	<.01	<.01			<.01
Manganese	0.02	<.02			<.02
Spec. Cond. umhos/cm @ 25°C	350	360			360

*Results are in milligrams per liter except as noted.

TABLE III (cont.)
Analytical Data of Otter Tail Lakes *

Field Number	Town, County Etc.	Sampling Point and Source of Sample
BL-5	Blanche Lake	Inlet from Annie Battle Lake - 2 ft. depth
DL-1	Deer Lake	100 yds. offshore Bambi Resort in 4 ft. water 18" sample
DL-2	Deer Lake	50 yds. into Deer L. from Channel between Deer and East Lost Lake - 8 foot depth, 18" sample
ELL-1	East Lost Lake	At outlet of Otter Tail River - 6 ft. depth 18"
WL-1	Walker Lake	Walker L. outflow to Otter Tail Lake - west side Bridge on HWY 7

	BL-5	DL-1	DL-2	ELL-1	WL-1
Date Collected	6/24/69	6/24/69	6/24/69	6/24/69	6/23/69
Time Collected	1520	1005	1035	1055	1600
Temperature °F		61°	61°	61°	62°
Date Received by Lab.	6/24/69				
Coliform)					
group)Con MPN/100 ml.	80	20	70	<20	80
organisms)Fecal MPN/100 ml.	<20	20	<20	<20	<20
Total Solids	230	200	210	210	220
Total Volatile Matter	95	89	99	92	65
Suspended Solids	2	3	4	3	3
Suspended Volatile Matter	2	3	3	3	3
Turbidity	1.8	1.5	1.2	1.1	3.6
Color	10	5	5	5	20
Total hardness as $CaCO_3$	200	190	170	170	220
Alkalinity as $CaCO_3$	190	150	170	170	220
pH value 136	8.1	8.0	8.0	8.0	8.1
Chloride	9.1	8.5	8.8	11	2.1
Dissolved Oxygen	9.8	8.8	8.9		9.5
5-day Biochemical Oxygen Demand	4.5	2.5	2.5	2.3	3.8
Total phosphorus	0.09	0.03	0.04	0.03	0.04
Soluble phosphorus	0.08	0.03	0.04	0.03	
Ammonia Nitrogen	0.26	0.26	0.25	0.25	<.05
Organic Nitrogen	0.58	0.36	0.46	0.46	0.85
Nitrite Nitrogen	<.02	<.02	<.02	<.02	<.02
Nitrate Nitrogen	<.02	<.02	<.02	<.02	<.02
Methylene Blue Active Sub. as ABS	0.18	<.1	<.1	<.1	0.38
Copper	<.01	<.01	<.01	<.01	<.01
Cadmium	<.01	<.01	<.01	<.01	<.01
Nickel	<.01	<.01	<.01	<.01	<.01
Zinc	<.01	<.01	<.01	<.01	<.01
Iron	0.05	0.14	0.04	0.08	<.02
Lead	<.01	<.01	<.01	<.01	<.01
Manganese	0.02	0.02	0.03	<.02	<.02
Spec. Cond. umhos/cm @ 25°C.	360	320	330	320	390

* Results are in milligrams per liter except as noted.

TABLE III (cont.)
Analytical Data of Otter Tail Lakes*

Field Number	Town, County Etc.	Sampling Point and Source of Sample
WL-2	Walker Lake	250 yards offshore - 6 ft. deep - 2 ft. sample
WL-3	Walker Lake	50 yards offshore of Don's Softwater - 7 ft. deep, 2 feet sample
WL-4	Dead River	Above entrance to Walker Lake
RL-1	Round Lake	End of Stafford Leitch's dock - 4 ft. depth, 2 ft. sample
LL-1	Long Lake	Ditch from Long Lake into Otter Tail River. E. Side Hwy 1

	WL-2	WL-3	WL-4	RL-1	LL-1
Date Collected	6/24/69	6/24/69	6/23/69	6/24/69	6/24/69
Time Collected	1720	1700	1720	1130	1635
Temperature °F		64°	61°	61°	
Date Received by Lab.					
Coliform) group)Con. MPN/100 ml.	<20	<20	260	<20	1100
organisms)Fecal MPN/100 ml.	<20	<20	20	<20	130
Total Solids	260	260	210	230	
Total Volatile Matter	110	120	68	110	
Suspended Solids	2	3	3	6	
Suspended Volatile Matter	2	3	2	6	
Turbidity	1.3	1.2	3.1	4.9	
Color	20	15	25	10	
Total hardness as $CaCO_3$	200	220	210	210	
Alkalinity as $CaCO_3$	210	210	210	210	
pH value L36	7.9	7.9	7.8	8.1	
Chloride	6.0	5.3	2.4	8.2	
Dissolved Oxygen	7.9	8.1	7.0	8.9	7.5
5-day biochemical oxygen demand	4.3	4.3	2.8	3.3	
Total Phosphorus	0.03	0.04	0.04	0.04	
Soluble Phosphorus	0.03	0.04		0.03	
Ammonia Nitrogen	0.29	0.20	0.13	0.29	
Organic Nitrogen	0.72	0.84	0.91	0.98	
Nitrite Nitrogen	<.02	<.02	<.02	<.02	
Nitrate Nitrogen	<.02	<.02	0.08	<.02	
Methylene Blue Active Sub. as ABS	0.22	0.19	0.40	0.28	
Copper	<.01	<.01	<.01	<.01	
Cadmium	<.01	<.01	<.01	<.01	
Nickel	<.01	<.01	<.01	<.01	
Zinc	<.01	<.01	<.01	<.01	
Iron	<.02	<.02	<.02	0.17	
Lead	<.01	<.01	<.01	<.01	
Manganese	0.04	0.03	<.02	0.03	
Spec. Cond. umhos/cm @ 25°C	390	390	380	380	

*Results are in milligrams per liter except as noted.

TABLE III (cont.)
Analytical Data of Otter Tail Lakes*

Field Number	Town, County, Etc.	Sampling Point and Source of Sample
OR-1	Ottertail River	Soo Line R.R. Bridge above Otter Tail Lake, S. Side
OR-2	Ottertail River	Ottertail R. Bridge - County Hwy. 1 - south side
OR-3	Ottertail River	South side bridge over Ottertail River at outlet to Otter Tail Lake
OR-4	Ottertail River	West side bridge over Ottertail River at inlet to Deer Lake
BC-1	Balmoral Creek	Culvert upstream side of Hwy 78 - 2 ft. deep, 18" sample

	OR-1	OR-2	OR-3	OR-4	BC-1
Date Collected	6/23/69	6/23/69	6/24/69	6/24/69	6/24/69
Time Collected	1620	1640	0900	0970	1615
Temperature °F	60°	61°	60°	61°	65°
Date Received by Lab.					6/24/69
Coliform group organisms Con. MPN/100 ml.	80	270	<20	230	230
Coliform group organisms Fecal MPN/100 ml.	<20	50	<20	<20	20
Total Solids	160	160	200	200	220
Total Volatile Matter	40	51	99	90	90
Suspended Solids	4	4	6	3	4
Suspended Volatile Matter	2	3	6	3	4
Turbidity	3.4	2.8	2.5	2.0	2.2
Color	15	15	5	5	5
Total hardness as $CaCO_3$	170	180	180	180	200
Alkalinity as $CaCO_3$	160	200	160	180	200
pH value L36	8.1	8.3	8.2	8.3	8.2
Chloride	2.2	1.8	16	6.2	9.7
Dissolved Oxygen	10.5	8.9	9.0	8.7	8.3
5-day Biochemical Oxygen Demand	3.0	3.0	3.0	4.3	4.3
Total Phosphorus	0.03	0.02	0.04	0.08	0.03
Soluble Phosphorus			0.03	0.07	0.03
Ammonia Nitrogen	0.13	0.07	0.26	0.27	0.26
Organic Nitrogen	0.71	0.73	0.51	0.52	0.46
Nitrite Nitrogen	0.02	0.02	<.02	<.02	<.02
Nitrate Nitrogen	0.04	<.02	<.02	<.02	<.02
Methylene Blue Active Sub. as ABS	0.40	0.29	0.21	0.25	0.29
Copper	<.01	<.01	<.01	<.01	<.01
Cadmium	<.01	<.01	<.01	<.01	<.01
Nickel	<.01	<.01	<.01	<.01	<.01
Zinc	<.01	<.01	<.01	<.01	<.01
Lead	<.01	<.01	<.01	<.01	<.01
Iron	<.02	0.03	0.06	0.05	0.06
Manganese	<.02	<.02	.02	<.02	0.02
Spec. Cond. umhos/cm @ 25°C	300	310	340	330	360

*Results are in milligrams per liter except as noted.

TABLE III (cont.)
Analytical Data of Otter Tail Lakes*

Field Number	Town, County Etc.	Sampling Point and Source of Sample
BC-2	Balmoral Creek	Dam at outlet from Blanche L. - upstream side

	BC-2
Date Collected	6/24/69
Time Collected	1400
Temperature °F	61°
Date Received by Lab.	
Coliform)	
group)Con. MPN/100 ml.	<20
organisms)Fecal MPN/100 ml.	<20
Total Solids	230
Total Volatile Matter	100
Suspended Solids	3
Suspended Volatile Matter	3
Turbidity	1.1
Color	5
Total hardness as $CaCO_3$	200
Alkalinity as $CaCO_3$	190
pH value L36	8.2
Chloride	7.3
Dissolved Oxygen	9.2
5-day Biochemical Oxygen Demand	4.0
Total Phosphorus	0.03
Soluble Phosphorus	0.03
Ammonia Nitrogen	0.21
Organic Nitrogen	0.48
Nitrite Nitrogen	<.02
Nitrate Nitrogen	<.02
Methylene Blue Active Sub. as ABS	0.24
Copper	<.01
Cadmium	<.01
Nickel	<.01
Zinc	<.01
Iron	0.06
Lead	<.01
Manganese	<.02
Spec. Cond. umhos/cm @ 25°C	350

*Results are in milligrams per liter except as noted.

TABLE IV Plankton of Otter Tail Lake
August 27, 1969

Group	Genera or Group	Total number of cells per liter	Volume of cells in c.c. per liter
Blue-Green			
	Gleotrichia	315,789	.039
	Microcystis flos aquae	273,684	.017
	Anabaena	196,631	.103
	Lyngbya	65,263	.045
	Coelosphaerium	14,210	.0009
	Microcystis aeruginosa	8,421	.002
Diatoms			
	Fragilaria	14,736	.215
	Melosira	13,736	.049
	Tabellaria	1,368	.010
	Asterionella	610	.002
	Stephanodiscus	10	.0004
Green			
	Dynobrion	1,731	.008
	Pediastrum	789	.004
	Ceratium	578	.043
	Volvox	132	.008
	Stauronastrum	30	.001
Protozoa			
	Vorticellids	3,947	.031
Crustacea			
	Copepods, adult	78	.468
	Copepods, nauplia	105	.061
Rotifer			
	Unidentified	100	.030

TABLE V Plankton of Blanche Lake
August 27, 1969

Group	Genera or Group	Total number of cells per liter	Volume of cells in c.c. per liter
Blue-Green			
	Microcystis flos aquae	132,596	.008
	Merismopedia	44,198	.005
	Gleotrichia	38,674	.072
	Ceolosphaerium	14,732	.0009
	Microcystis aeruginosa	7,366	.004
	Anabaena	589	.0906
Green			
	Pediastrum	4,419	.026
	Ceratium	257	.019
	Stauronastrum	147	.005
	Westella	92	.001
Diatom			
	Melosira	1,988	.007
	Gomphonema	747	2.1
	Fragilaria	368	.005
	Gyrosigma	36	.0001
	Tabellaria	23	.0001
	Asterionella	15	.0001
Crustacea			
	Copepod, adult	1,031	6.186
	Copepod, nauplia	589	.334
	Bosmina	147	.036
Rotifer			
	Keratella	147	.127
	Brachionus angularis	73	.058
	Filinia	73	.036
	Trichocerca	7	.009
	Asplancha	6	.005
Protozoa			
	Vorticellids	73	.0005

TABLE VI Plankton of Walker Lake
August 27, 1969

Group	Genera or Group	Total number of cells per liter	Volume of cells in c.c. per liter
Blue-Green			
	Microcystis flos aquae	3,887,468	.252
	Microcystis aeruginosa	296,675	.069
	Aphanizomenon	199,488	.024
	Ceolosphaerium	143,222	.009
	Anabaena	6,547	.003
	Lyngbya	4,887	.003
	Chrysocapsa planctonica	265	.001
Diatom			
	Melosira	450,120	1.60
	Nitschia	12,531	.0007
	Fragilaria	10,230	.149
	Synedra	1	<.0001
	Meridion	<1	<.0001
Green			
	Pediastrum	3,145	.018
	Ceratium	189	.014
	Stauronastrum	23	.0003
Rotifer			
	Unidentified groups	2,941	1.76
	Keratella	94	.081
	Trichocerca	23	.034
	Ascomorpha ecaudis	<1	<.0001
	Brachionus angularis	<1	<.0001
	Filinia	<1	<.0001
	Kellicottia	<1	<.0001
Protozoa			
	Vorticellids	1,439	.071
Crustacea			
	Copepod, adult	133	.79
	Copepod, nauplia	133	.077
	Daphnia longispina	58	.417
	Bosmina	<1	<.002

TABLE VII Plankton of Deer Lake
August 27, 1969

Group	Genera or Group	Total number of cells per liter	Volume of cells in c.c. per liter
Blue-Green			
	Anabaena	530,177	.277
	Microcystis flos aquae	54,675	.003
	Microcystis aeruginosa	2,071	.0005
	Lyngbya	1,875	.001
	Ceolosphaerium	1,479	<.0001
	Eucapsis	295	.001
	Oscillatoria	293	<.0001
	Merismopedia	236	<.0001
	Nodularia	236	<.0001
	Gleocystis	177	<.0001
Green			
	Synura	4,881	.02
	Chrysocapsa planctonica	409	.001
	Pediastrum	178	.001
	Ceratium	146	.01
	Chlorosarcina minor	31	.0004
	Dynobrion	27	.0001
	Ankistrodesmus	<1	<.0001
	Stauronastrum	<1	<.0001
Diatoms			
	Melosira	409	.001
	Navicula	165	.002
	Synedra ulna	147	.005
	Tabellaria	67	.0005
	Navicula	6	<.0001
	Meridion	4	<.0001
	Stephanodiscus dubiosis	<1	<.0001
Protozoa			
	Vorticellids	107	.0008
Crustacea			
	Copepod, adult	10	.060
	Copepod, nauplia	55	.032
	Bosmina	16	.032
	Chyodorus	6	.012
	Daphnia pulex	<1	<.0001
Rotifer			
	Unidentified groups	39	.02107
	Keratella	19	.016
	Filinia	5	.002
	Ascomorpha	3	.045
	Trichocerea cylindrica	<1	<.0001

MUNICIPAL	INDUSTRIAL	URBAN RUNOFF	SEPTIC TANKS	CROPLAND/PASTURE RUNOFF	FEEDLOT RUNOFF	NATURAL RUNOFF
			X			

WATER QUALITY: 51 NECESSITY: 20 PRIORITY: 7

LAKE ID: 562598 NAME: DEER MPCA DISTRICT #: 3 MPCA DATA REVIEW: 74/06

AREA (ACRES): 466.1 DEPTH (FT): 7 MED SOURCE: 01

R 40 TWP 133 SECT 26 WATERSHED NO: WATERSHED AREA (ACRES):

MEANDERED: COMMENTS: MILES OF SHORELINE: 3.80 % LITTORAL: 67

ECOL CLASS: CENTRARCHID-WALLEYE MGMT CLASS: CENTRARCHID-LARGEMOUTH BASS

INLETS: 1 # OUTLETS: 1 # PUBLIC ACCESS: 0 WATER COLOR:

USE:

PROBLEMS:

TROPHIC QUALITY

YR/MO	SOURCE	BIOL INDEX	SECCHI DEPTH	SECCHI INDEX	CHLOR	CHLOR INDEX	NUTRIENT INDEX	TOTAL P (MG/L)	% SUBM PLANTS	APPLICATION OF CUSO4
61/08	01	45.4	9.0	45.4	0.0	0.0	0.0	0.0	0.0	0.
72/07	04	47.5	10.0	43.9	8.70	51.8	41.5	0.010	0.0	0.
69/08	02	51.1	0.0	0.0	0.0	0.0	51.1	0.035	0.0	0.

LAKESHORE DEVELOPMENT

YR/MO	SOURCE	TOTAL # DWELLINGS	DWELLINGS/MILE OF SHORELINE	DWELLINGS/LAKE AREA (ACRES)
70/00	02	77	20.3	0.2
61/08	01		29.2	0.2

ADDITIONAL DATA

YR/MO	SOURCE	SURF O2 (MG/L)	PH	ALKAL (MG/L)	COND	TOTAL N (MG/L)	TOT INOR N (MG/L)	NO2 + NO3 N (MG/L)	TURB (JTU)	COLOR (PT)
61/08	01	8.1	0.0	187.5	0.0	0.0	0.0	0.0	0.0	0.0
72/07	04	8.6	7.8	119.0	200.0	0.0	0.09	0.04	0.0	0.0
72/07	04	0.0	0.0	114.0	0.0	0.0	0.0	0.0	0.0	0.0
69/08	02	8.0	8.0	160.0	320.0	0.7	0.29	0.04	1.35	0.0

POSSIBLE PROBLEM AREAS

MUNICIPAL	INDUSTRIAL	URBAN RUNOFF	SEPTIC TANKS	CROPLAND/PASTURE RUNOFF	FEEDLOT RUNOFF	NATURAL RUNOFF
			X			

WATER QUALITY: 51 NECESSITY: 20 PRIORITY: 7

LAKE ID: 560302 NAME: SILVER MPCA DISTRICT #: 3 MPCA DATA REVIEW: 74/06

AREA (ACRES): 894.0 DEPTH (FT): 16 MED SOURCE: 01

R 40 TWP 133 SECT 17 WATERSHED NO: WATERSHED AREA (ACRES):

MEANDERED: COMMENTS: MILES OF SHORELINE: 4.20 % LITTORAL: 42

ECOL CLASS: CENTRARCHID-WALLEYE MGMT CLASS: WALLEYE-CENTRARCHID

INLETS: 0 # OUTLETS: 0 # PUBLIC ACCESS: 1 WATER COLOR:

LAKE ID: 56[illegible] NAME: LONG MPCA DISTRICT #: 3 MPCA DATA REVIEW: 74/06

AREA (ACRES): [illegible]3.0 DEPTH (FT): 16 MAX SOURCE: 01

R 39 TWP 134 SECT [illegible] WATERSHED NO: WATERSHED AREA (ACRES):

MEANDERED: COMMENTS: MILES OF SHORELINE: 0.0 % LITTORAL:

ECOL CLASS: MARGINAL FISH-GAME MGMT CLASS:

INLETS: [illegible] # OUTLETS: 0 # PUBLIC ACCESS: WATER COLOR:

USE: (RICING

PROBLEMS:

TROPHIC QUALITY

YR/MO	SOURCE	BIOL INDEX	SECCHI DEPTH	SECCHI INDEX	CHLOR	CHLOR INDEX	NUTRIENT INDEX	TOTAL P (MG/L)	% SUBM PLANTS	APPLICATION OF CUSO4

LAKESHORE DEVELOPMENT

YR/MO	SOURCE	TOTAL # DWELLINGS	DWELLINGS/MILE OF SHORELINE	DWELLINGS/LAKE AREA (ACRES)
70/00	22	[illegible]	0.0	0.0

ADDITIONAL DATA

YR/MO	SOURCE	SURF O2 (MG/L)	PH	ALKAL (MG/L)	COND	TOTAL N (MG/L)	TOT INOR N (MG/L)	NO2 + NO3 N (MG/L)	TURB (JTV)	COLOR (PT)

WATER QUALITY: 0 NECESSITY: 5 PRIORITY: 0

LAKE ID: 5602[illegible] NAME: RICE MPCA DISTRICT #: 3 MPCA DATA REVIEW: 74/06

AREA (ACRES): [illegible] DEPTH (FT): 2.5 MED SOURCE: 01

R 39 TWP 135 SECT 28 WATERSHED NO: WATERSHED AREA (ACRES):

MEANDERED: COMMENTS: MILES OF SHORELINE: 3.80 % LITTORAL: 100

ECOL CLASS: GAME MGMT CLASS: WATERFOWL AND/OR FURBEARERS

INLETS: 2 # OUTLETS: 1 # PUBLIC ACCESS: 0 WATER COLOR:

USE: (FISHING ;

PROBLEMS (FISH KILL/FROM FISHING;

TROPHIC QUALITY

YR/MO	SOURCE	BIOL INDEX	SECCHI DEPTH	SECCHI INDEX	CHLOR	CHLOR INDEX	NUTRIENT INDEX	TOTAL P (MG/L)	% SUBM PLANTS	APPLICATION OF CUSO4
64/08	01	61.3	3.0	61.3	0.0	0.0	0.0	0.0	100.0	0.

LAKESHORE DEVELOPMENT

YR/MO	SOURCE	TOTAL # DWELLINGS	DWELLINGS/MILE OF SHORELINE	DWELLINGS/LAKE AREA (ACRES)

ADDITIONAL DATA

YR/MO	SOURCE	SURF O2 (MG/L)	PH	ALKAL (MG/L)	COND	TOTAL N (MG/L)	TOT INOR N (MG/L)	NO2 + NO3 N (MG/L)	TURB (JTV)	COLOR (PT)

WATER QUALITY: 61 NECESSITY: 20 PRIORITY: 10

WATER QUALITY: [illegible]   NECESSITY: [illegible]   PRIORITY: 0

LAKE ID: 56031C   NAME: WALKER   MPCA DISTRICT #: 3   MPCA DATA REVIEW: 74/06
AREA (ACRES): 694.0   DEPTH (FT): 29 MAX   SOURCE: 01
R 40 TWP 134 SECT [illegible]   WATERSHED NO: WATERSHED AREA (ACRES):
MEANDERED: COMMENTS: MILES OF SHORELINE: 4.30   % LITTORAL: 63

ECOL CLASS: CENTRARCHID-WALLEYE   MGMT CLASS: WALLEYE-CENTRARCHID
INLETS: [illegible]   # OUTLETS: 1   # PUBLIC ACCESS: 1   WATER COLOR:
USE: (FISHING) (BOATING/CANOEING) (WATERSKIING) (HUNTING/TRAPPING)
PROBLEMS:

TROPHIC QUALITY

YR/MO	SOURCE	BIOL INDEX	SECCHI DEPTH	SECCHI INDEX	CHLOR	CHLOR INDEX	NUTRIENT INDEX	TOTAL P (MG/L)	% SUBM PLANTS	APPLICATION OF CUSO4
69/08	02	51.1	0.0	0.0	0.0	0.0	51.1	0.035	0.0	0.
71/08	01	51.3	6.0	51.3	0.0	0.0	0.0	0.0	0.0	0.

LAKESHORE DEVELOPMENT

YR/MO	SOURCE	TOTAL # DWELLINGS	DWELLINGS/MILE OF SHORELINE	DWELLINGS/LAKE AREA (ACRES)
70/00	22	64.	14.9	0.1
71/08	01	40.	9.3	0.1

ADDITIONAL DATA

YR/MO	SOURCE	SURF O2 (MG/L)	PH	ALKAL (MG/L)	COND	TOTAL N (MG/L)	TOT INOR N (MG/L)	NO2 + NO3 N (MG/L)	TURB (TTV)	COLOR (PT)
69/08	02	8.0	7.9	210.0	390.0	1.0	0.28	0.04	1.20	0.0
71/08	01	9.6	0.0	290.0	0.0	0.0	0.0	0.0	0.0	0.0

WATER QUALITY: 51   NECESSITY: 20   PRIORITY: 0

LAKE ID: 56031S   NAME: BROWN   MPCA DISTRICT #: 3   MPCA DATA REVIEW: 74/06
AREA (ACRES): 183.0   DEPTH (FT): 4 MED   SOURCE: 01
R 40 TWP 134 SECT 31   WATERSHED NO: WATERSHED AREA (ACRES):
MEANDERED: COMMENTS: MILES OF SHORELINE: 2.80   % LITTORAL: 100
ECOL CLASS: GAME   MGMT CLASS: WATERFOWL AND/OR FURBEARERS
INLETS: 1   # OUTLETS: 1   # PUBLIC ACCESS: 1   WATER COLOR:
USE: (HUNTING/TRAPPING)
PROBLEMS: (FISH KILL/PROM FISHING)

TROPHIC QUALITY

YR/MO	SOURCE	BIOL INDEX	SECCHI DEPTH	SECCHI INDEX	CHLOR	CHLOR INDEX	NUTRIENT INDEX	TOTAL P (MG/L)	% SUBM PLANTS	APPLICATION OF CUSO4
58/07	01	53.9	5.0	53.9	0.0	0.0	0.0	0.0	0.0	0.

LAKESHORE DEVELOPMENT

YR/MO	SOURCE	TOTAL # DWELLINGS	DWELLINGS/MILE OF SHORELINE	DWELLINGS/LAKE AREA (ACRES)
70/00	22	26.	9.3	0.1

[illegible]	[illegible]		33.9	0.0
55/08	01	118.	19.9	0.0

ADDITIONAL DATA

YR/MO	SOURCE	SURF O2 (MG/L)	PH	ALKAL (MG/L)	COND	TOTAL N (MG/L)	TOT INOR N (MG/L)	NO2 + NO3 N (MG/L)	TURB (TTV)	COLOR (PT)
55/08	01	8.1	0.0	205.0	0.0	0.4	0.0	0.0	0.0	0.0

WATER QUALITY: 29 NECESSITY: 5 PRIORITY: 0

LAKE ID: 560240 NAME: BLANCHE MPCA DISTRICT #: 3 MPCA DATA REVIEW: 74/06

AREA (ACRES): 1352.0 DEPTH (FT): 12 MED SOURCE: 01

R 39 TWP 133 SECT 06 WATERSHED NO: WATERSHED AREA (ACRES):

MEANDERED: COMMENTS: MILES OF SHORELINE: 1.90 % LITTORAL: 74

ECOL CLASS: CENTRARCHID-WALLEYE MGMT CLASS: WALLEYE-CENTRARCHID

INLETS: 2 # OUTLETS: 1 # PUBLIC ACCESS: 1 WATER COLOR:

USE: (FISHING)(BOATING/CANOEING)(WATERSKIING)(SWIMMING)

PROBLEMS: (ALGAE)

TROPHIC QUALITY

YR/MO	SOURCE	BIOL INDEX	SECCHI DEPTH	SECCHI INDEX	CHLOR	CHLOR INDEX	NUTRIENT INDEX	TOTAL P (MG/L)	% SUBM PLANTS	APPLICATION OF CUSO4
51/07	01	45.4	9.0	45.4	0.0	0.0	0.0	0.0	0.0	0.
72/08	01	50.1	6.5	50.1	0.0	0.0	0.0	0.0	0.0	0.

LAKESHORE DEVELOPMENT

YR/MO	SOURCE	TOTAL # DWELLINGS	DWELLINGS/MILE OF SHORELINE	DWELLINGS/LAKE AREA (ACRES)
51/07	01	60.	31.6	0.0
70/00	22	106.	55.8	0.1
72/03	01	156.	82.1	0.1

ADDITIONAL DATA

YR/MO	SOURCE	SURF O2 (MG/L)	PH	ALKAL (MG/L)	COND	TOTAL N (MG/L)	TOT INOR N (MG/L)	NO2 + NO3 N (MG/L)	TURB (TTV)	COLOR (PT)
72/08	01	8.6	0.0	175.0	0.0	0.0	0.0	0.0	0.0	0.0

POSSIBLE PROBLEM AREAS

MUNICIPAL	INDUSTRIAL	URBAN RUNOFF	SEPTIC TANKS	CROPLAND/PASTURE RUNOFF	FEEDLOT RUNOFF	NATURAL RUNOFF
			X			

WATER QUALITY: 50 NECESSITY: 20 PRIORITY: 7

LAKE ID: 560241 NAME: ANNIE BATTLE MPCA DISTRICT #: 3 MPCA DATA REVIEW: 74/06

06

AREA (ACRES): 350.0 DEPTH (FT): SOURCE: 01

R 39 TWP 133 SECT 18 WATERSHED NO: WATERSHED AREA (ACRES):

MEANDERED: COMMENTS: MILES OF SHORELINE: 0.0 % LITTORAL:

ECOL CLASS: GAME MGMT CLASS: WATERFOWL AND/OR FURBEARERS

INLETS: # OUTLETS: # PUBLIC ACCESS: WATER COLOR:

LAKE ID: 340044 NAME: [illegible] MPCA DISTRICT #: 4 MPCA DATA REVIEW: 74/06

AREA (ACRES): 1697.0 DEPTH (FT): 20 AVE SOURCE: 01

R 33 TWP 120 SECT 16 WATERSHED NO: WATERSHED AREA (ACRES):

MEANDERED: COMMENTS: MILES OF SHORELINE: 9.39 % LITTORAL: 30

ECOL CLASS CENTRARCHID-WALLEYE MGMT CLASS: WALLEYE-CENTRARCHID

INLETS: 2 # OUTLETS: # PUBLIC ACCESS: 1 WATER COLOR:

USE:

PROBLEMS: (ROUGH FISH

TROPHIC QUALITY

YR/MO	SOURCE	BIOL INDEX	SECCHI DEPTH	SECCHI INDEX	CHLOR	CHLOR INDEX	NUTRIENT INDEX	TOTAL P (MG/L)	% SUBM PLANTS	APPLICATION OF CUSO4
54/07	01	52.7	3.0	61.3	0.0	0.0	52.7	0.039	0.0	0.
72/05	02	56.2	4.5	55.4	0.0	0.0	56.2	0.050	0.0	0.
72/06	02	53.0	0.0	0.0	0.0	0.0	53.0	0.040	0.0	0.
63/00	01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.
64/00	01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.
65/00	01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.
66/00	01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	43.
67/00	01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	235.
68/00	01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	64.
69/00	01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	65.

LAKESHORE DEVELOPMENT

YR/MO	SOURCE	TOTAL # DWELLINGS	DWELLINGS/MILE OF SHORELINE	DWELLINGS/LAKE AREA (ACRES)
54/07	01	91	9.7	0.1
72/00	22	230	24.5	0.1

ADDITIONAL DATA

YR/MO	SOURCE	SURF O2 (MG/L)	PH	ALKAL (MG/L)	COND	TOTAL N (MG/L)	TOT INOR N (MG/L)	NO2 + NO3 N (MG/L)	TURB (FTU)	COLOR (PT)
54/07	01	8.5	0.0	102.5	0.0	2.2	0.0	0.0	0.0	0.0
72/05	02	11.1	8.4	160.0	0.0	1.4	0.16	0.07	5.10	25.00
72/06	02	10.2	8.4	160.0	0.0	1.6	0.21	0.07	3.80	35.00

WATER QUALITY: 53 NECESSITY: 5 PRIORITY: 10

LAKE ID: 340045 NAME: MPCA DISTRICT #: 4 MPCA DATA REVIEW: 74/06

LC4 L05

AREA (ACRES): 29.0 DEPTH (FT): SOURCE: 01

R 33 TWP 120 SECT 17 WATERSHED NO: WATERSHED AREA (ACRES):

MEANDERED: COMMENTS: MILES OF SHORELINE: 0.0 % LITTORAL:

ECOL CLASS DRY BASIN MGMT CLASS:

INLETS: # OUTLETS: 1 # PUBLIC ACCESS: WATER COLOR:

USE:

PROBLEMS:

WATER QUALITY: 0 NECESSITY: 0 PRIORITY: 0

LAKE ID: 340079 NAME: GREEN NPCA DISTRICT #: 4 NPCA DATA REVIEW: 74/06

AREA (ACRES): 5821.0 DEPTH (FT): 30 MED SOURCE: 01

R 33 TWP 120 SECT 23 WATERSHED NO: WATERSHED AREA (ACRES):

05 H06

MEANDERED: COMMENTS: MILES OF SHORELINE: 11.60 % LITTORAL: 33

ECOL CLASS: FISH MGMT CLASS: WALLEYE-CENTRARCHID

INLETS: 1 # OUTLETS: 1 # PUBLIC ACCESS: WATER COLOR:

USE:

PROBLEMS:

TROPHIC QUALITY

YR/MO	SOURCE	BIOL INDEX	SECCHI DEPTH	SECCHI INDEX	CHLOR	CHLOR INDEX	NUTRIENT INDEX	TOTAL P (MG/L)	% SUBM PLANTS	APPLICATION OF CUSO4
56/08	01	37.9	5.4	52.8	0.0	0.0	37.9	0.014	0.0	0.
68/07	02	56.2	0.0	0.0	0.0	0.0	56.2	0.050	0.0	0.
68/07	02	58.9	0.0	0.0	0.0	0.0	58.9	0.060	0.0	0.
72/10	04	42.4	11.5	41.9	3.5	42.9	37.9	0.014	0.0	0.
72/10	04	43.4	11.0	42.5	4.0	44.2	39.8	0.016	0.0	0.
72/08	04	47.7	7.5	48.1	5.5	47.3	39.8	0.016	0.0	0.
72/08	04	38.3	0.0	0.0	4.1	44.4	38.9	0.015	0.0	0.
72/07	04	46.5	9.0	45.4	5.7	47.6	38.9	0.015	0.0	0.
72/07	04	47.4	8.7	45.9	6.4	48.8	37.9	0.014	0.0	0.
52/05	02	48.9	0.0	0.0	0.0	0.0	48.9	0.030	0.0	0.
68/07	02	53.0	0.0	0.0	0.0	0.0	53.0	0.040	0.0	0.
68/07	02	53.0	0.0	0.0	0.0	0.0	53.0	0.040	0.0	0.
70/05	02	68.9	0.0	0.0	0.0	0.0	68.9	0.120	0.0	0.
66/09	09	41.3	12.0	41.3	0.0	0.0	0.0	0.0	0.0	0.
67/09	09	51.3	6.0	51.3	0.0	0.0	0.0	0.0	0.0	0.

LAKESHORE DEVELOPMENT

YR/MO	SOURCE	TOTAL # DWELLINGS	DWELLINGS/MILE OF SHORELINE	DWELLINGS/LAKE AREA (ACRES)
70/00	22	407.	35.1	0.1
56/08	01	604.	52.1	0.1

ADDITIONAL DATA

YR/MO	SOURCE	SURF O2 (MG/L)	PH	ALKAL (MG/L)	COND	TOTAL N (MG/L)	TOT INOR N (MG/L)	NO2 + NO3 N (MG/L)	TURB (TTV)	COLOR (PT)
56/08	01	7.5	0.0	172.5	0.0	1.0	0.0	0.0	0.0	0.0
68/07	02	8.1	8.3	170.0	0.0	0.7	0.14	0.04	4.30	5.00
68/07	02	9.1	8.3	170.0	0.0	0.8	0.14	0.04	11.00	5.00
72/10	04	5.4	8.3	171.0	0.0	0.0	0.13	0.10	0.0	0.0
72/10	04	9.5	8.4	175.0	0.0	0.0	0.16	0.0	0.0	0.0
72/08	04	7.4	7.8	163.0	0.0	0.0	0.13	0.05	0.0	0.0
72/08	04	0.0	8.8	167.0	0.0	0.0	0.20	0.10	0.0	0.0
72/07	04	10.2	7.9	165.0	0.0	0.0	0.04	0.03	0.0	0.0
72/07	04	0.0	8.3	175.0	0.0	0.0	0.05	0.04	0.0	0.0
70/05	02	0.0	8.9	244.0	0.0	1.2	1.14	1.07	0.0	0.0
52/05	02	0.0	8.4	190.0	0.0	0.0	0.0	0.0	0.0	0.0
68/07	02	7.0	8.4	170.0	0.0	0.7	0.16	0.04	7.00	5.00
68/07	02	7.1	8.3	170.0	0.0	0.7	0.11	0.04	8.00	5.00
70/05	02	11.0	8.5	190.0	0.0	0.0	0.0	0.0	0.0	0.0
66/03	09	0.0	8.4	153.0	0.0	0.0	0.0	0.0	0.0	0.0
67/09	09	0.0	8.4	150.0	0.0	0.0	0.0	0.0	0.0	0.0

POSSIBLE PROBLEM AREAS

MUNICIPAL	INDUSTRIAL	URBAN RUNOFF	SEPTIC TANKS	CROPLAND/PASTURE RUNOFF	FEEDLOT RUNOFF	NATURAL RUNOFF
			X			

LAKE--RUSH COUNTY--OTTER TAIL 56 141 (2)

SECCHI DISK TRANSPARENCY,1975

			JUNE					JULY				AUGUST					SEPTEMBER	
WEEK	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
TRANS	11.0	11.0	11.0	11.0	8.0	7.0	6.5	6.0	6.0	5.0	5.0	5.0	5.0	5.0	5.0			

MEAN(JULY-AUG) 5.5 (NEAREST .5 FT) WATER COLOR--2

ALGICIDE USED--NONE

LAKE--CLITHERALL COUNTY--OTTER TAIL 56 238 (0)

SECCHI DISK TRANSPARENCY,1975

			JUNE					JULY				AUGUST					SEPTEMBER	
WEEK	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
TRANS													10.0	10.5				

MEAN(JULY-AUG) 10.5 (NEAREST .5 FT) WATER COLOR--

ALGICIDE USED--NONE

LAKE--CLITHERALL COUNTY--OTTER TAIL 56 238 (0)

SECCHI DISK TRANSPARENCY,1976

			JUNE					JULY				AUGUST					SEPTEMBER	
WEEK	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
TRANS	15.0	12.5	13.5	10.5	16.5	11.0			8.0	8.0	11.0	8.0	11.0	10.0	12.0			

MEAN(JULY-AUG) 9.5 (NEAREST .5 FT) WATER COLOR--1

ALGICIDE USED--NONE

LAKE--OTTERTAIL COUNTY--OTTER TAIL 56 242 (0)

SECCHI DISK TRANSPARENCY,1975

			JUNE					JULY				AUGUST					SEPTEMBER	
WEEK	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
TRANS	14.5	11.5	12.5	14.5	12.5	9.5	10.0	8.5	7.5	8.5	7.5	9.0						

MEAN(JULY-AUG) 8.5 (NEAREST .5 FT) WATER COLOR--

ALGICIDE USED--NONE

INVESTIGATION OF SEPTIC LEACHATE DISCHARGES
OTTERTAIL LAKE, MINNESOTA
APRIL, 1979

Prepared for

WAPORA, Inc.
Washington, D.C.

Prepared by

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

1.0 INTRODUCTION

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

Wastewater effluent contains a mixtuer of near UV fluorescent organics derived from whiteners, surfactants and natural degradation products which are persistent under the combined conditions of low oxygen and limited microbial activity.

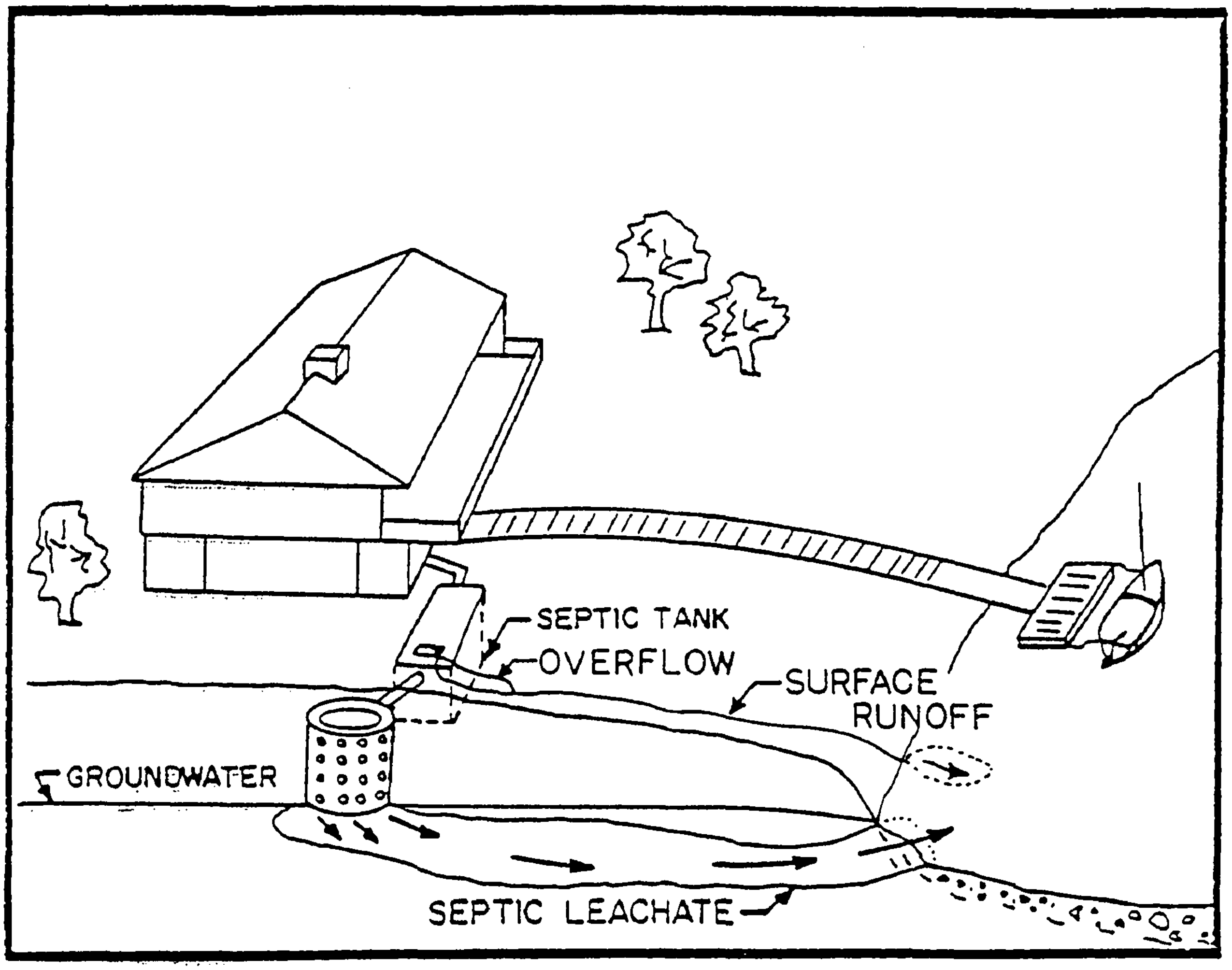


Figure 1. Excessive loading of septic systems causes the development of plumes of poorly-treated effluent which may 1) enter nearby waterways through surface runoff or which may 2) move laterally with groundwater flow and discharge near the shoreline of nearby lakes.

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

Surveys for shoreline wastewater discharges were conducted with a modified septic leachate detector and the K-V Associates, Inc. "Dowser" groundwater flow meter. The septic leachate detector (ENDECO Type 2100 "Septic Snooper") consists of the subsurface probe, the water intake system, the analyzer control unit, and a graphic recorder. Initially the unit is calibrated against stepwise increases of wastewater effluent, of the type to be detected, added to the background lake water. The probe of the unit is then placed in the lake water along the shoreline. Groundwater seeping through the shoreline bottom is drawn into the subsurface intake of the probe and travels upwards to the analyzer unit. As it passes through the analyzer, separate conductivity and specific fluorescence signals are generated and

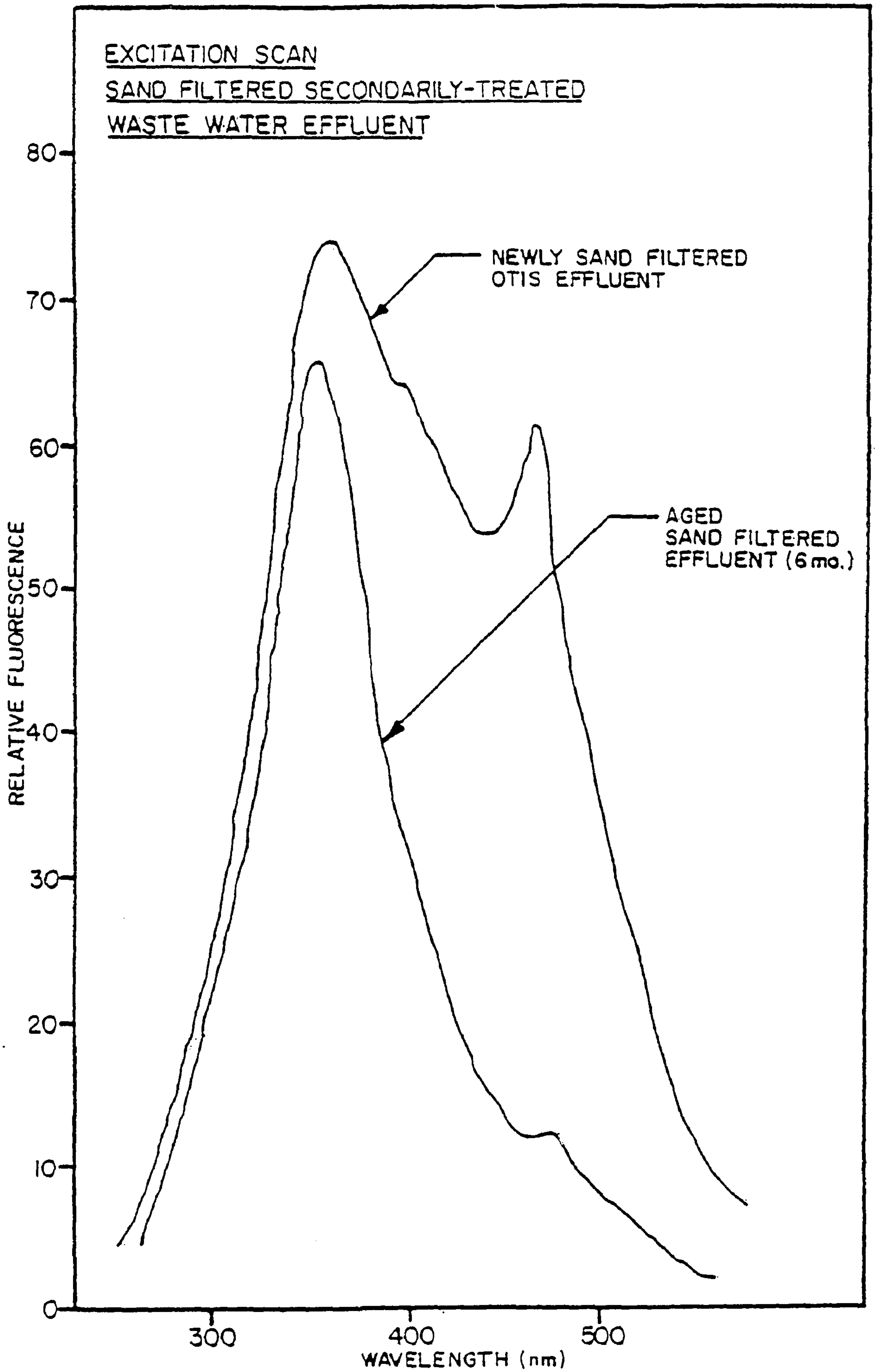


FIGURE 2. Sand-filtered Effluent Produces a Stable Fluorescent Signature, Here Shown Before and After Aging

sent to a signal processor which registers the separate signals on a strip chart recorder as the boat moves forward. The analyzed water is continuously discharged from the unit back into the receiving water. A portable unit obtained from ENDECO was used during the field studies, but was modified to operate under the conductance conditions encountered in the field.

1.1 Plume Types

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

1.1.1 Groundwater Plumes

Three different types of groundwater-related wastewater plumes are commonly encountered during a septic leachate survey: 1) erupting plumes, 2) passive plumes, and 3) stream source plumes. As the soil becomes saturated with dissolved solids and organics during the aging process of a leaching on-lot septic system, a breakthrough of organics occurs first, followed by inorganic penetration (principally chlorides, sodium, and other salts). The active emerging of the combined organic and inorganic residues into the shoreline lake water describes an erupting plume. In seasonal dwellings where wastewater loads vary in time, a plume may be apparent during late summer when shoreline cottages sustain heavy use, but retreat during winter during low flow conditions. Residual organics from the wastewater often still remain attached to soil particles in the vicinity of the previous erupting plume, slowly releasing into the shoreline waters. This dormant plume indicates a previous breakthrough, but sufficient treatment of the plume exists under current conditions so that no inorganic discharge is apparent. Stream source plumes refer to either groundwater leachings or nearstream septic leaching fields which enter into streams which then empty into the lake.

1.1.2 Runoff Plumes

Traditional failures of septic systems occur in tight soil conditions when the rate of inflow into the unit is greater than the soil percolation can accomodate. Often leakage occurs around the septic tank or leaching unit covers, creating standing pools of poorly-treated effluent. If sufficient drainage is present, the effluent may flow laterally across the surface into nearby waterways. In addition, rainfall or snow melt may also create an excess of surface water which can wash the standing effluent into water courses. In either case, the poorly-treated effluent frequently contains elevated fecal coliform bacteria, indicstive of the presence of pathogenic bacteria and, if sufficiently high, must be considered a threat to public health.

2.0 METHODOLOGY - SAMPLING AND ANALYSIS

The septic leachate survey covered two principal study areas in Otter Tail County, Minnesota. The first, and largest, water body area examined was Otter Tail Lake, an 8-mile long glacial depression coursed from northeast to southwest by the south-flowing Otter Tail River. This lake shoreline is almost entirely ringed by seasonal cottages interspersed with 10% year-round dwellings as well as a few cattle yards and cultivated croplands. The lake is very shallow along most all of the shoreline and the soils consist predominantly of medium sand of high porosity. The second study area was comprised of the adjacent satellite lakes: Blanche, Deer, Round, and Walker. These lakes were much smaller than Otter Tail Lake and were slightly less populated. Soils were, again, generally sandy and quite porous.

Objectives of this survey were:

1) To perform a complete shoreline scan for evidence of septic leachate (nutrient) intrusion using through-the-ice techniques for winter conditions. Forward progress, related to prevailing weather conditions, was expected to be at least one shoreline mile per day.

2) To take discrete water samples for subsequent nutrient analysis only at those locations of alleged effluent plumes revealed by the leachate detector instrument.

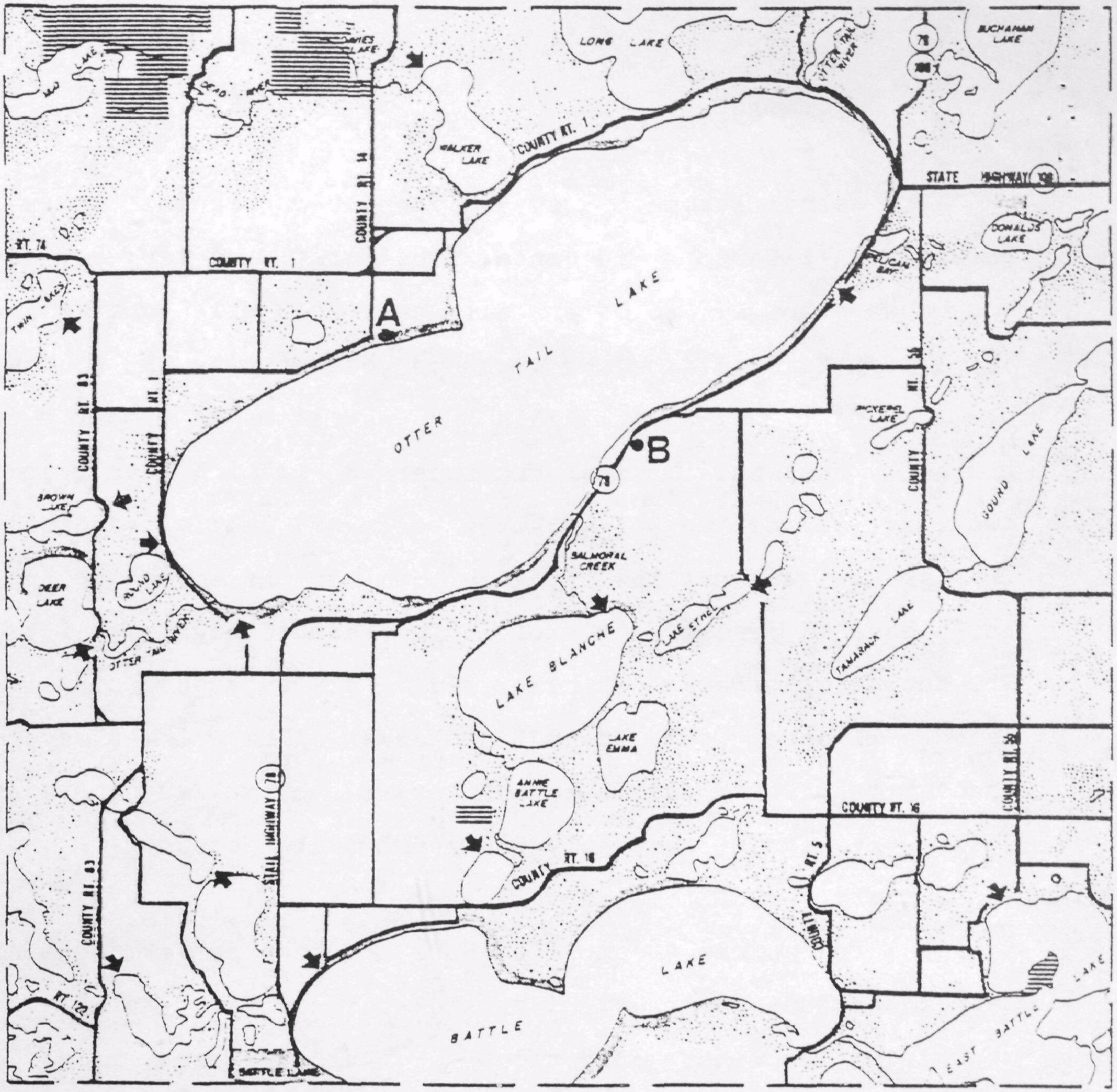
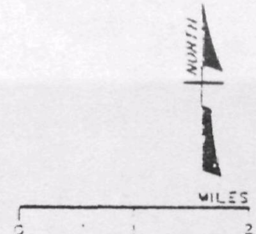


FIGURE 3. EXISTING LAND USE IN THE OTTER TAIL STUDY AREA

LEGEND

- RESIDENTIAL
- FOREST AND WETLANDS
- AGRICULTURAL AND OPEN PASTURELAND
- WILDLIFE MANAGEMENT AND GAME AREAS
- A PARK
- B GOLF COURSE
- ➔ PUBLIC ACCESS



[Source: USGS 1973; Otter Tail County Planning Advisory Commission 1968]
(WAPORA, 1978)

3) To take bacteria samples for fecal coliform analysis from all moving surface tributaries or exceptionally high shoreline effluent plumes.

4) To make visual observations relevant to sources of lake water degradation.

This survey was executed during the period from 22 March through end of April, 1979. Daytime temperatures ranged from 5^{o} to 45^{o}F. Ice measured 3 feet in depth and was very solid. Snow cover rarely exceeded 2 to 10 inches.

2.1 Procedure

Otter Tail Lake was surveyed in a continuous clockwise direction starting and ending at the outlet of the Otter Tail River. The survey team consisted of two men and lightweight mobile survey gear. The basic equipment platform was a 6' x 3' polyethylene sled (actually a collapsed portable ice house by "Snoboat"). The septic leachate detector instrument was securely lashed with shock cords to a large plastic ice chest, in turn lashed to the sled. A 12 vdc snowmobile battery powered the instrument and small water pump. This centrifugal water pump lifted sub-ice water from a drilled hole and discharged it through the instrument detector chamber and out a flexible plastic tube exhaust from which retained samples could be taken.

The large ice chest held chilled water samples as well as supplies and maintenance gear. Groundwater specimens were drawn through a rugged stainless steel well-point sampler developed by K-V Associates, Inc. This 7-foot long, 3/8 inch bore tube

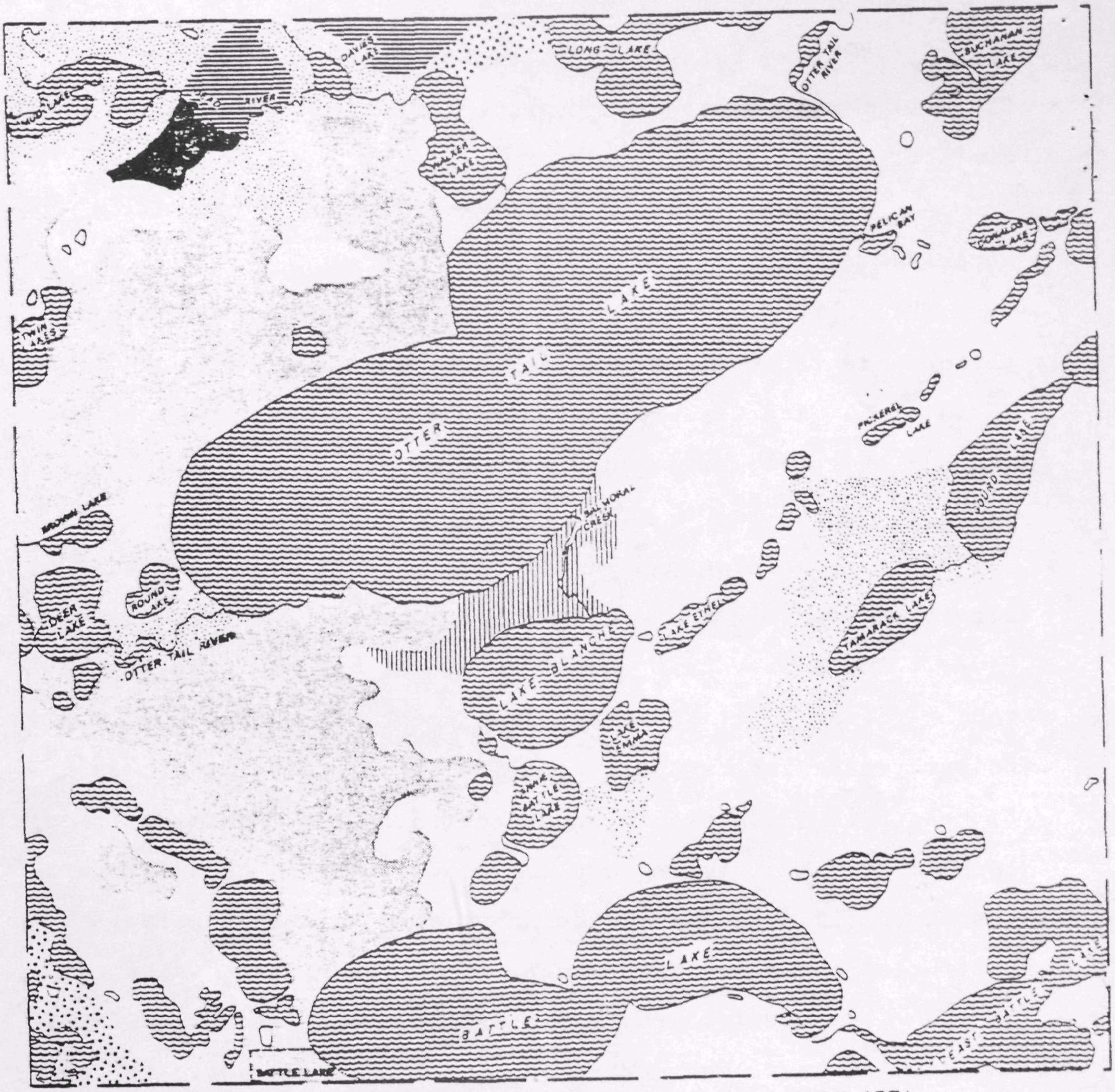


FIGURE 4. SOIL LANDSCAPES IN THE OTTER TAIL STUDY AREA

SALIDA-SIOUX-HUBBARD (Sandy over sandy, well drained soils)

UNNAMED (Sandy over sandy, poorly drained soils)

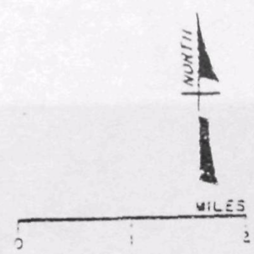
ESTERVILLE-ARVILLA (Loamy over sandy, well drained soils)

MARQUETTE-LENGBY (Deep silty or loamy, well drained soils)

PEAT (Organic soils)

NEBISH-MARQUETTE-TODD (Sandy over sandy, well drained soils)

UNNAMED (Loamy over mixed sandy, and loamy, well drained soils)



[Source: University of Minnesota 1969]

(WAPORA, 1978)

could easily be driven by hand up to 18 inches into the porous bottom sediment. Groundwater samples were drawn from sandy sediments of those holes displaying a high relative fluorescence signal. Interstitial water was extracted via simple hand vacuum pump and large plastic receiving chamber. All tubes were of large bore to minimize freezing obstructions. The captured groundwater could then be readily decanted apart from entrained sand and bottled for later analysis. Such bottom sample accompanied a surface sample for each significant plume discovery. In nearly every case, groundwater samples were withdrawn very easily through the loose sand bottom.

To gain access to the liquid water beneath the ice cover, a gasoline-powered "Jiffy" ice auger equipped with 5" diameter, 3' long drill bit on a 12" shaft extension was used.

In summary, the two-man team proceeded on foot in tandem around the lake perimeter with self-contained quipment in tow on lightweight plastic sleds. Skis or snowshoes were used as conditions required. The lead individual bored fresh holes on approximate 100-foot intervals, gauging the ice thickness as well as his free-water clearance to the sand bottom. He charted a path which would insure 6 to 10 inches of free water which, on Otter Tail Lake, frequently offset the team up to 100 yards from shore. The instrument operator, trailing closely behind, flushed his pump line in each new hole and processed a brief but steady stream of water through the detector. Relative fluorescence, conductivity and positional information were recorded in a bound log book. A USGS lakeshore map provided sufficient landmark detail for reasonable annotation of position versus hole humber.

2.2 Sample Handling

Both ground and surface water samples for nutrient analysis were retained in 250 ml clean plastic bottles, marked to correspond with hole numbers. The samples were preserved at 35°F or colder pending laboratory analysis at a later date.

Bacteria samples were captured in sterilized 250 ml plastic bottles and shipped the same day to Environmental Protection Laboratory in St. Cloud Minnesota for fecal coliform analysis.

2.3 Calibration

Each work day began with a calibration of the septic leachate instrument. Two solutions were required: the first, a background sample drawn from an assumed unpolluted central portion of the lake; the second, a 10% dilution in background water of local New York Mills treated effluent. An initial 20 liter volume of central lakewater lasted the entire survey as the background standard. A liter bottle of lagoon effluent was taken from the treatment facility in the nearby town of New York Mills. This sample was filtered to remove suspended solids prior to use. Injection of these two solutions into the leachate detector instrument, at ambient outdoor working temperature, allowed us to set a reasonable ZERO and SPAN adjustment.

2.4 Satellite Lakes

Surveys of four smaller lakes followed the completion of Otter Tail Lake. The same procedure was used, fair weather allowing for conclusion of each lake within a day's time for the septic scan with an additional day for bacterial sample retrieval. The north shore of Blanche Lake and Deer Lake, northern and eastern shores of Round Lake, and south shore of Walker Lake were surveyed. The shoreline areas represented the more populated shorefronts which are candidates for sewerage collection facilities.

2.5 Groundwater Flow Determination

The direction and rate of inflow of groundwater was measured at 8 locations around Otter Tail Lake and 4 locations at each of the satellite lakes surveyed. Snow cover and unsaturated sand cover was removed above beach regions and a K-V Associates, Inc. "Dowser"TM groundwater flow meter inserted into the saturated sand sediments. Conditions permitting, three separate determinations of flow rate were made, often with small-scale dye tracings of interstitial flow for confirmation. The observed compass direction and rate of flow was computed and compared with the rates anticipated by the Darcy equation from known groundwater heights.

2.6 Water Analysis

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

TM = Trademark

constituents:

conductivity (cond.)
orthophosphate phosphorus (PO_4-P)
total phosphorus (TP)

Over 200 small-volume (50 ml) water samples were obtained at locations of sample holes and 120 samples at selected plumes and background stations for analysis. The samples were placed in polyethylene containers, chilled, and frozen for transport and storage. Conductivity was determined by a Beckman (Model RC-19) conductivity bridge, orthophosphate-phosphorus and total phosphorus by the single reagent procedures following standard methods (EPA, 1975), and selected samples synchronous-scanned for fluorescence to confirm the organic source.

3.0 PLUME LOCATIONS

The Otter Tail Lakes study area included the shoreline of Otter Tail Lake and populated portions of the surrounding water bodies of Blanche, Deer, Round, and Walker Lakes. Based upon the soil atlas of Otter Tail County, 90% of the study area contains sandy, highly permeable soils of glacial outwash deposits. The dominant soil types are 1) sand over sandy, well-drained soils (Salida, Sioux, and Hubbard soils), 2) loamy over sandy, well-drained soils (Arvilla and Estherville soils), and sandy over sandy, poorly-drained soils (Figure). The outwash deposits extend downwards to depths of 50 to 100 feet, below which is about 200 feet thickness of undifferentiated glacial drift before bedrock (Precambrian crystalline rock) is intercepted, forming the "oasis", a large groundwater aquifer. Melting ice blocks caused the depressions, filled with groundwater, which form Otter Tail and its satellite lakes.

On the basis of groundwater drainage, lakes fall into categories of "confined lakes", "withdrawal" lakes, or a combination of both. In confined lakes, the groundwater inflow along one side is offset by an equivalent exfiltration along opposing shorelines, resulting in little change in net groundwater contribution to the lake. In other cases, the lake water body may behave as a withdrawal well, withdrawing groundwater from around most shorelines and discharging the net inflow of water as stream flow from the lake.

Otter Tail is a withdrawal lake, the substantial drop in hydraulic head from the inlet to the outlet serving to withdraw groundwater into the lake along the entire length of shoreline. As described in more detail in Section 7, "Groundwater Flow Characteristics and Nutrient Loading," the satellite lakes also induce even more rapid groundwater inflow along adjacent shorelines of Otter Tail Lake due to gravity leveling of water in the lakes which create abnormally high hydraulic heads nearby the shoreline. Septic system discharges within the areas adjacent to the lake upon entering the groundwater would be transported uncommonly fast towards the lake.

A total of 265 sample locations indicating plumes were observed along the shorelines surveyed (Figures 5-8). Of these, the vast majority (ca. 235) were found to be of groundwater origin; the others represented surface stream drainage inflows from lakes (ca. 30). Solid circles indicate locations of probable groundwater leachate sources, with plumes emerging from porous bottom sediments into the lake. Solid squares represent locations of observed surface discharges into lake waters. These may result from overflowing septic systems or from leaching systems along the stream shoreline as sources. A line is drawn from each symbol to the location of the ice hole sampled where the plume was encountered. Fluorescent spectral analysis was used where necessary to separate the discharges from bogs from wastewater inflows. Almost a one-to-one relationship existed between the number of locations of groundwater plumes and the number of year-reound (permanent) dwellings (Table 1).

Table 1. Number of groundwater plumes compared to occupancy.

Segment* Number	Residential Occupancy Permanent	Seasonal	Number of Groundwater Plume Locations	
1	7	23	5	
2	21	64	21	
3	14	45	21	(unnamed lake)
4	12	37	9	
5	2	6	2	
6	12	37	9	(Walker Lake)
7	14 (9)	40 (22)	14	(Walker Lake)
8	5	12	2	
9	4 (1)	9 (7)	14	(Long Lake)
11	21 (?)	45 (?)	16	(Long Lake)
12	13	29	inflow region	
13	7	15	2	
15	7	15	1	
16	7	14	3	
17	2	6	6	
18	1	3	1	
19	5	12	0	
20	6	13	6	
21	10 (8)	49 (31)	19	(Blanche Lake)
26	10 (8)	50 (29)	52	(Blanche Lake)
27	0	0	2	
28	2	8	5	
29	5	22	5	
30+32	8	42	1	(exfiltration?)

*see Figure 11

Frequencies of groundwater plume locations above that expected based on permanent occupancy occurred along shoreline areas where adjacent lake areas induced rapid subsurface flows. The higher than expected frequency of plumes emerging along the Otter Tail shoreline may be due to the strong inflow of Otter Tail "capturing" plumes from the adjacent shorelines of the satellite lakes. Rather than intruding into Blanche Lake, in all likelihood, septic system discharges from systems serving residences on the northern shore instead apparently flow towards Otter Tail Lake. Few erupting plumes were found on Blanche Lake, although segments 19, 26 along Otter Tail Lake downstream of their rapid groundwater flow show substantial areas affected by plumes. The same phenomenon appears to occur with an unnamed lake adjacent to segment 3 and Long Lake in segment 9.

An exceptionally low number of plume locations was observed in segment 30 + 32 which may indicate the most likely shoreline area where groundwater may come the closest to exfiltration rather than infiltration. The frequency of plume locations on Round Lake, in agreement with projected groundwater flow based on water height in the lakes, further supports the possibility of exfiltration.

The predominance of groundwater plumes corresponds to the observed soil conditions and conditions of septic tank soil absorption systems. The study area contains highly permeable sandy soil and seasonally high water tables where inadequately treated wastewater may be reaching the groundwater. In addition, a large number of septic leaching fields are submerged in groundwater, limiting aeration and treatment of the effluent. Coupled with the exceptionally rapid groundwater movement, the waste streams are entering the lake shoreline. The incidence of the high frequency of erupting plumes does not necessarily indicate a high transport of phosphorus to the lakewaters (section 7, "Groundwater Flow Characteristics and Nutrient Loading"). High frequency of plumes and noticeable phosphorus loading from groundwater sources is apparent in shoreline segments of Otter Tail Lake near the satellite lakes of segments 3,6,6,21, and 26. The same is likely true for segments 9 and 11, but insufficient water quality information was available for confirmation.

Key to Symbols Used on Sampling Location Maps

. ice hole location

D1 bacterial sample location

○ dormant groundwater plume

● erupting groundwater plume

□ organic surface water plume without dissolved solids load

■ organic surface water plume with dissolved solids load

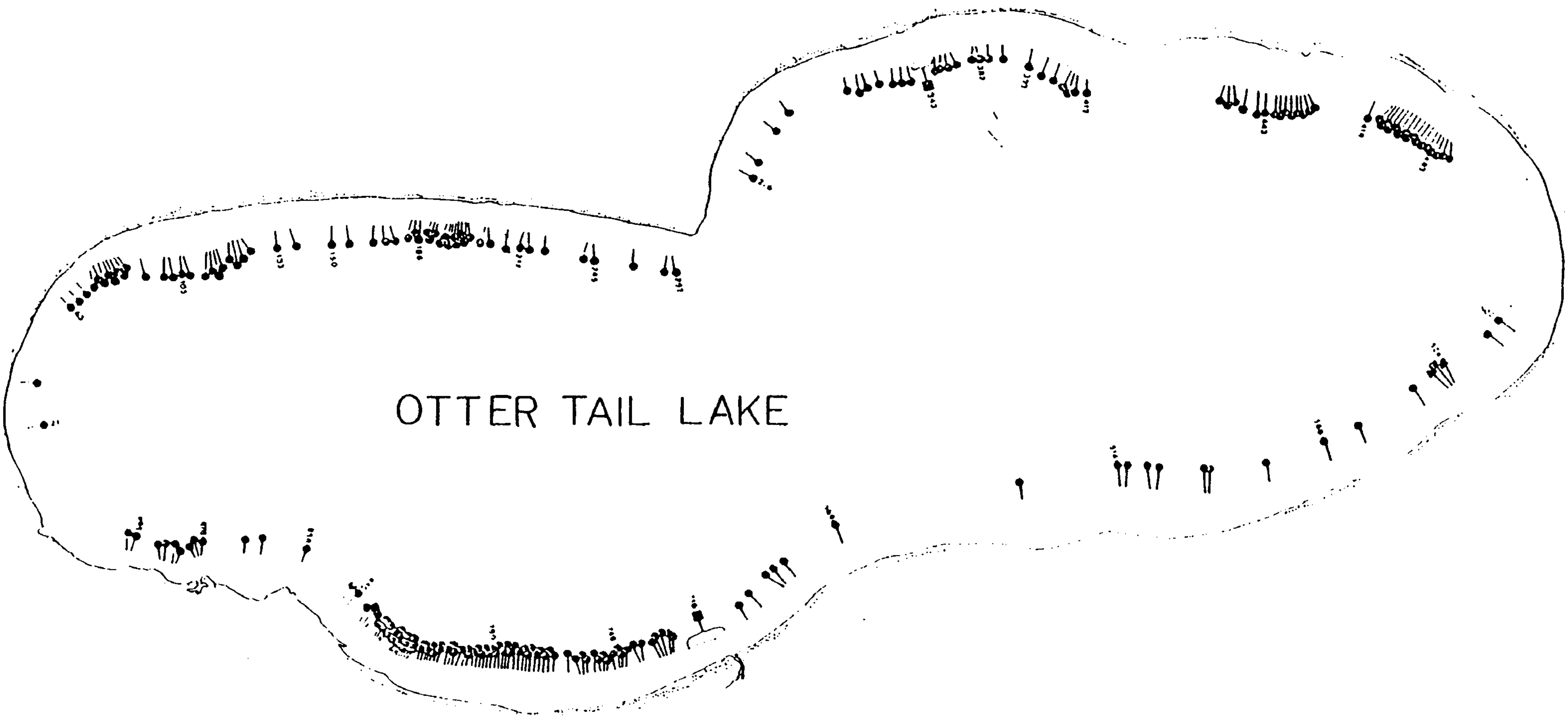


Figure 5. Plume and bacterial sample locations on Otter Tail Lake.

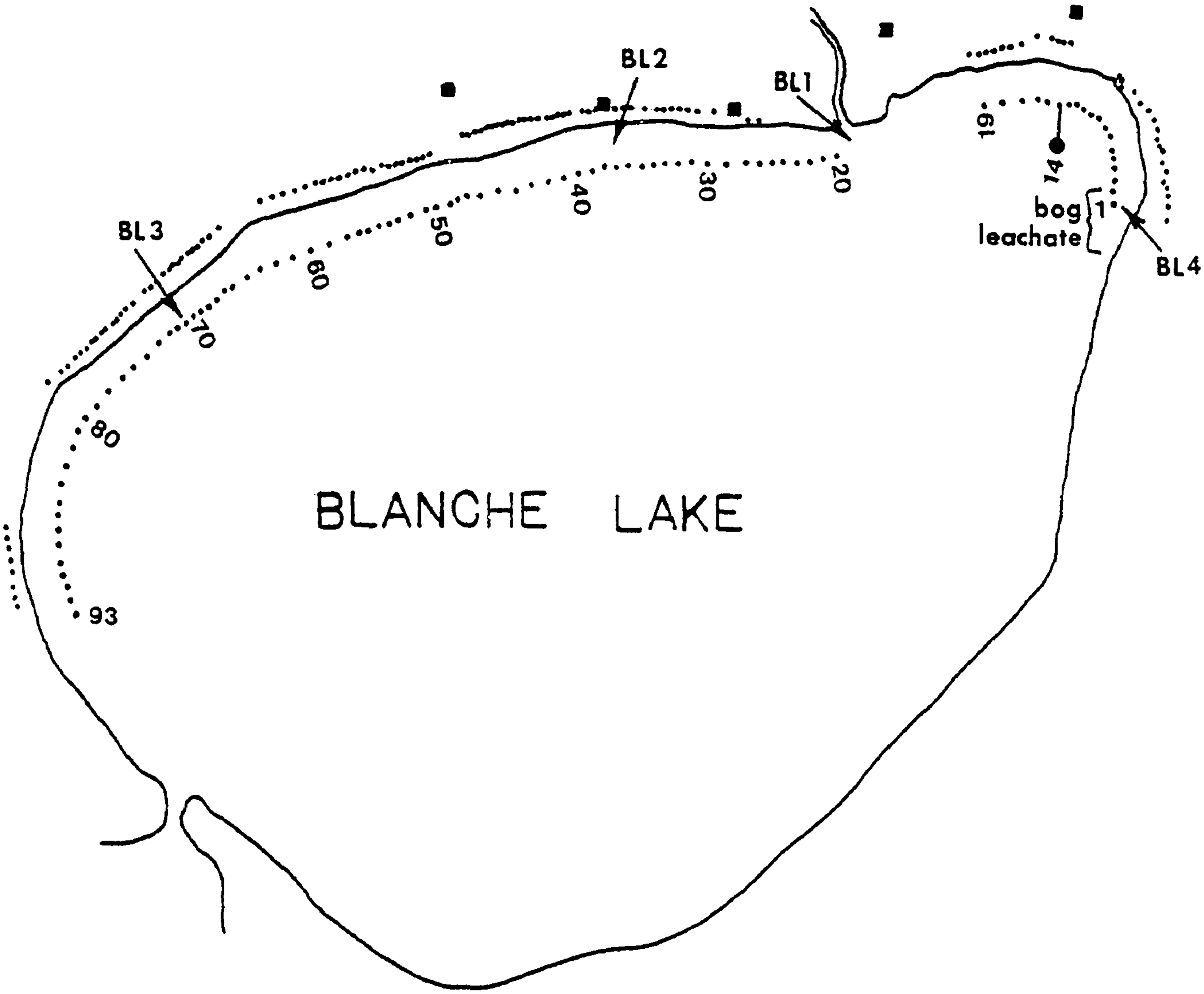
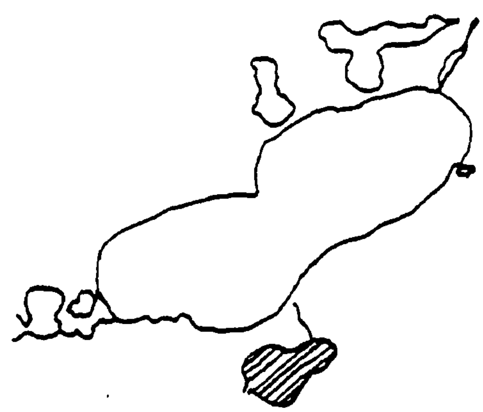


Figure 6. Sampling station, plume, and bacterial sample locations on Blanche Lake.



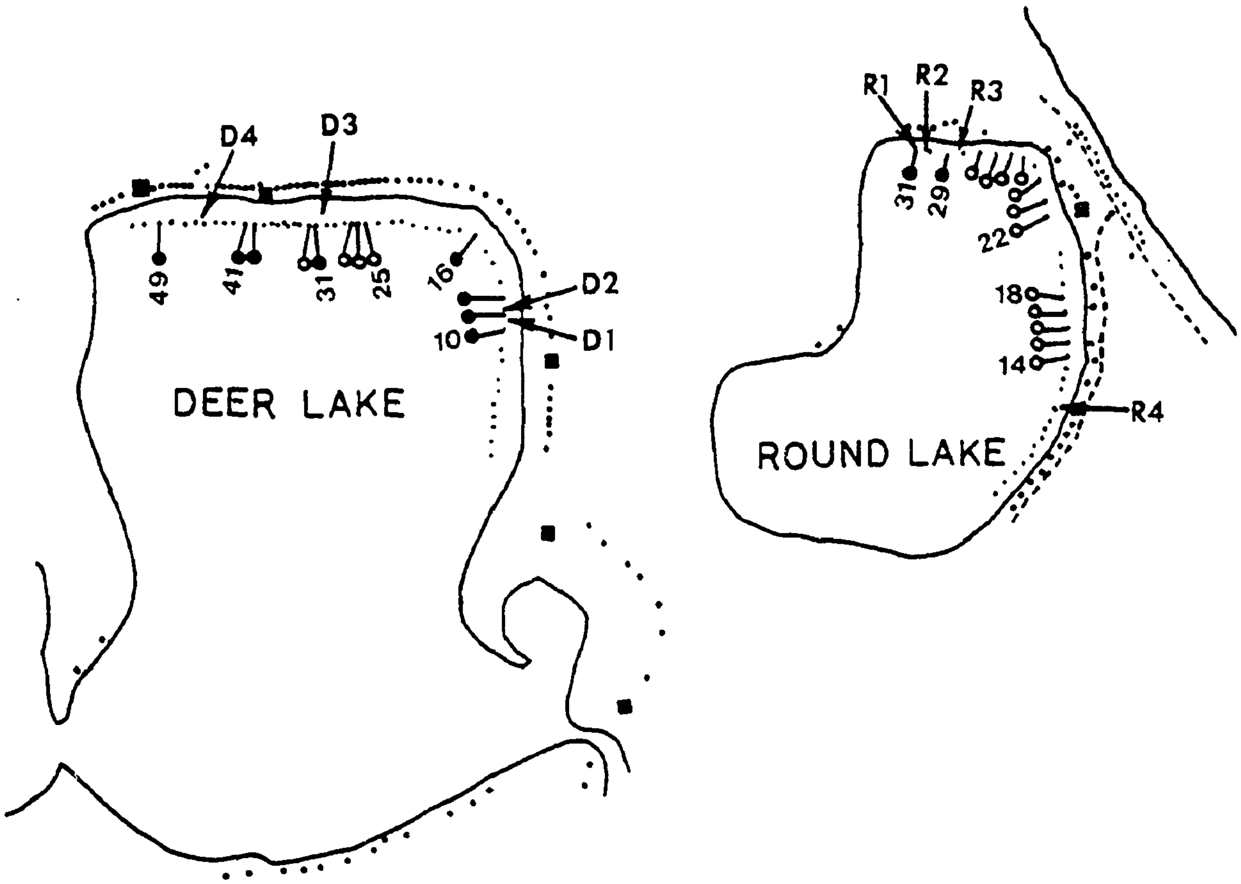


Figure 7. Sampling station, plume, and bacterial sample locations on Deer and Round Lakes.

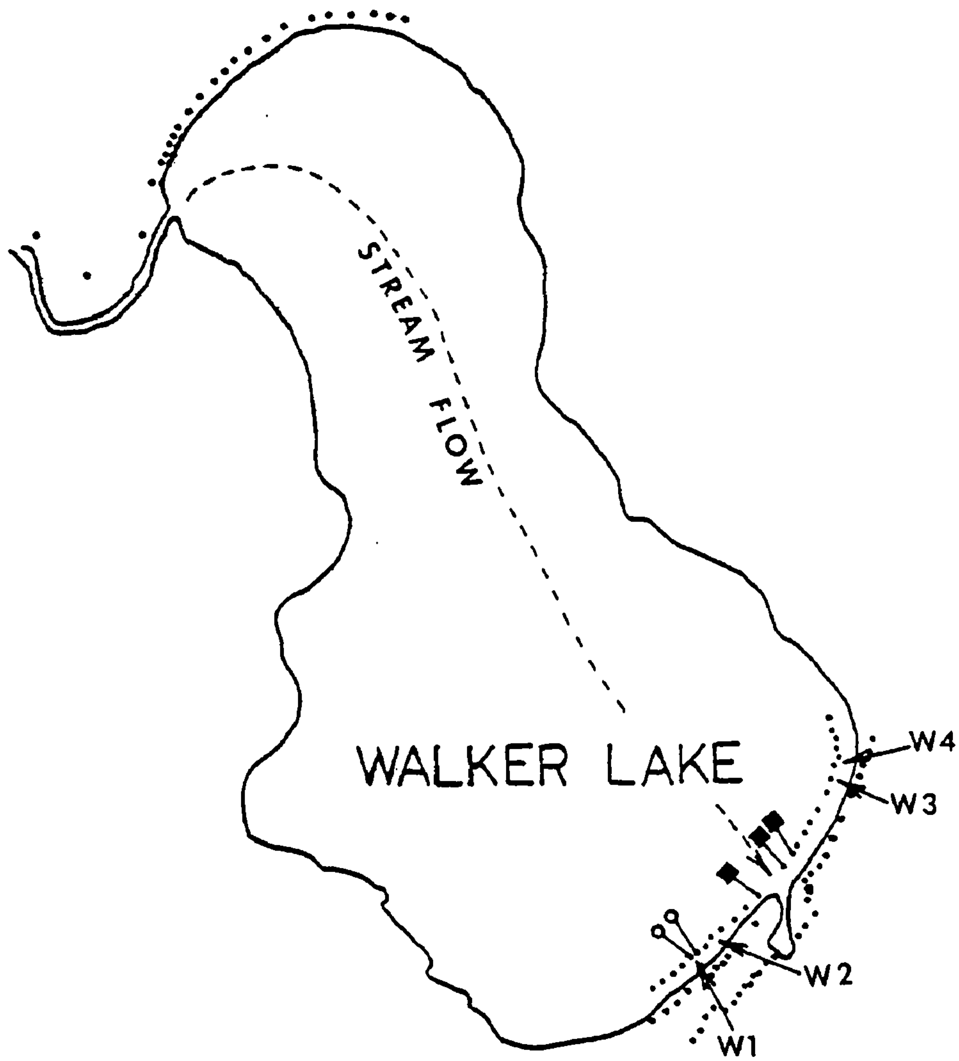
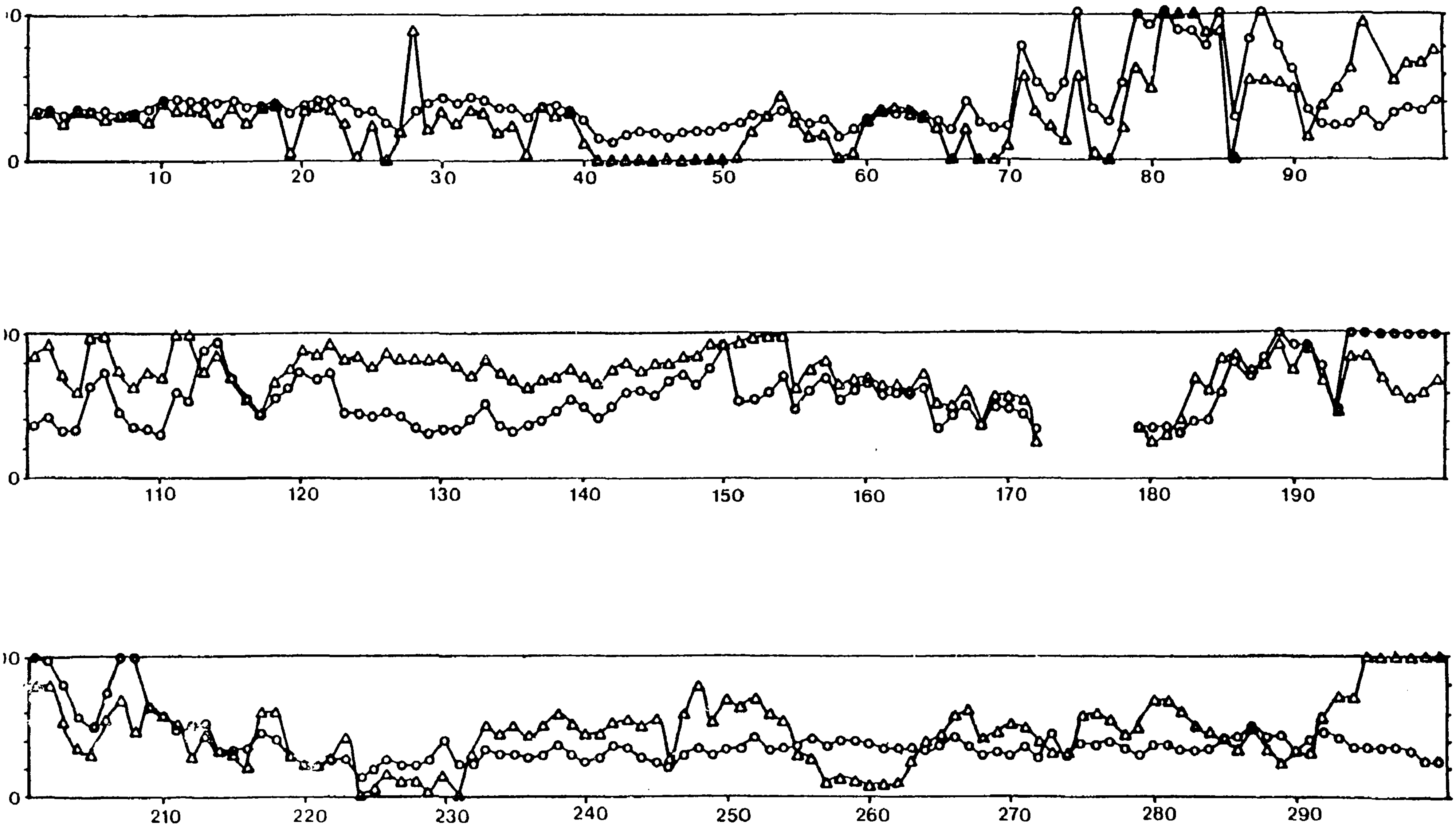


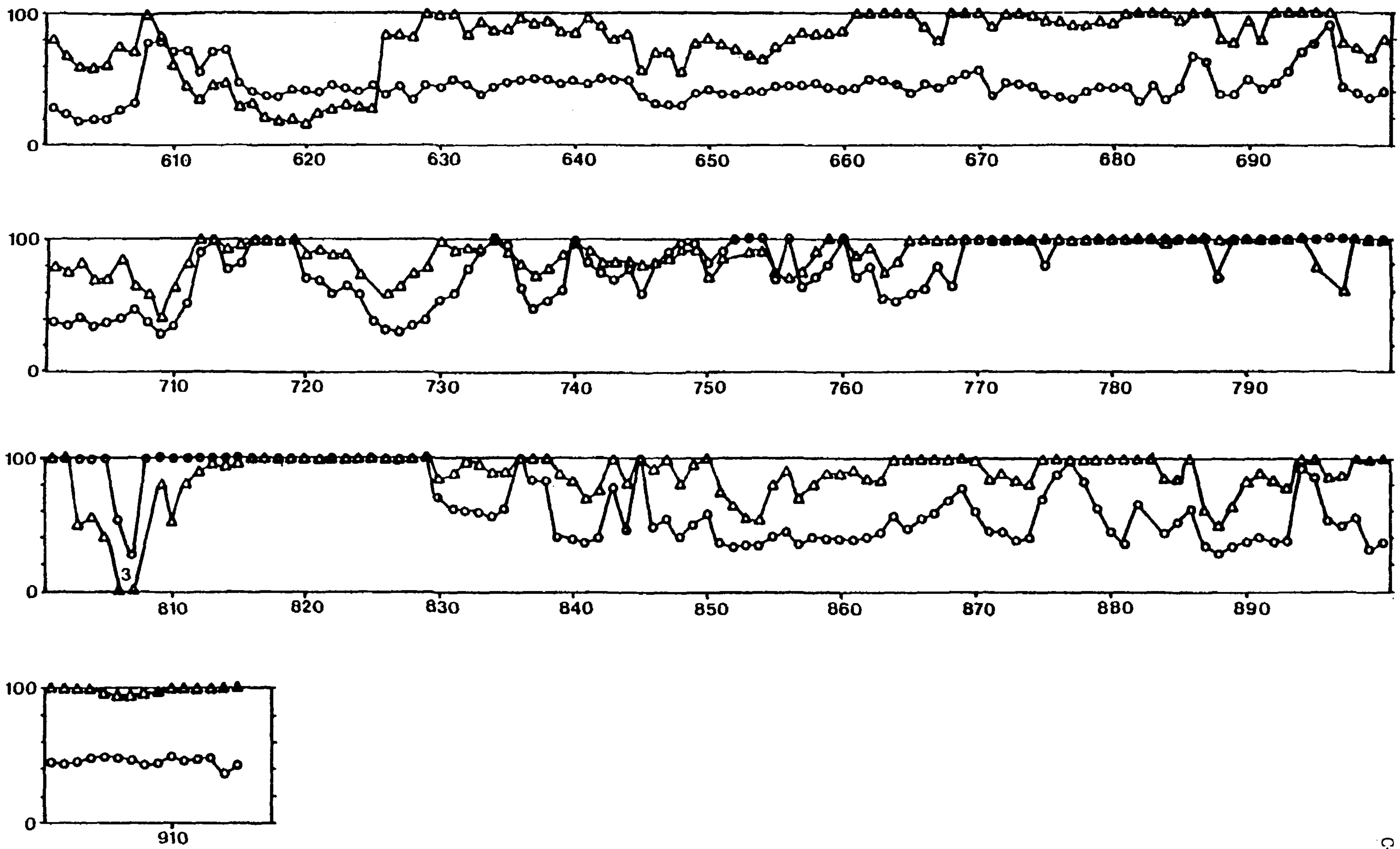
Figure 8. Sampling station, plume and bacterial sample locations on Walker Lake.

OTTER TAIL LAKE

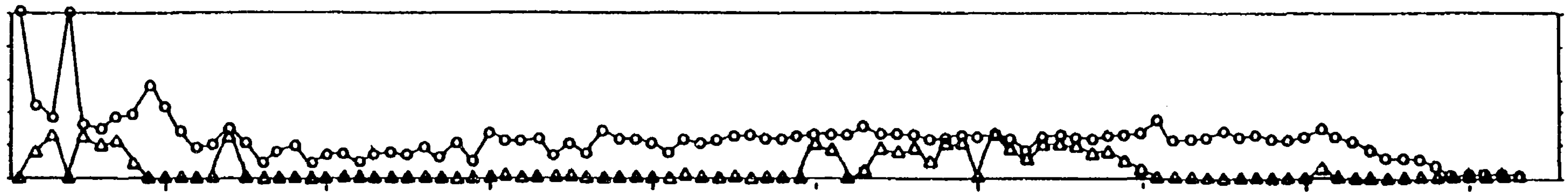


o fluorescense
Δ conductance

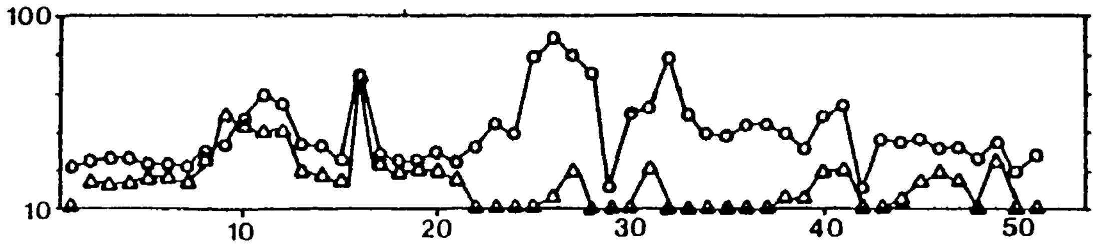
OTTER TAIL LAKE (cont.)



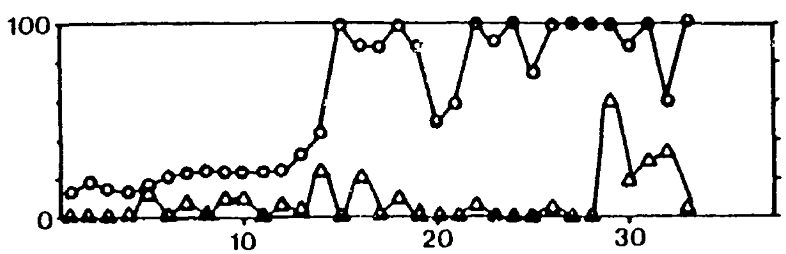
BLANCHE LAKE



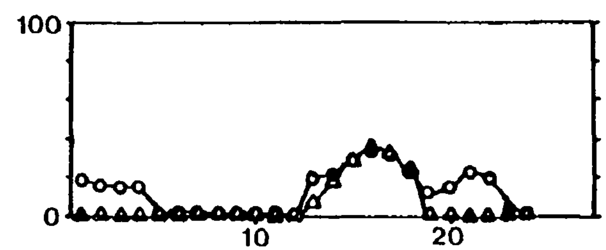
DEER LAKE



ROUND LAKE



WALKER LAKE



o fluorescense
Δ conductance

4.0 NUTRIENT ANALYSES

Completed analyses of the chemical content of 130 samples taken along the shorelines of Otter Tail Lake and its tributaries are presented in Table 2. The sample letters refer to the locations given in Figures 5 through 8 and the profiles of Figure 9. The symbol "S" refers to surface water sample and the symbol "G" to groundwater sample. Practically all groundwater samples represent easily flowing vacuum withdrawals from highly permeable sandy bottom sediments.

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

Table 2. Analysis of surface water (S) and groundwater (G) samples taken in the vicinity of wastewater plumes observed on the shorelines of Otter Tail Lake and its satellites: Blanche, Deer, Round, and Walker.

Otter Tail Lake

Sample Number		Conductivity	PO_4-P (ppm)	Total P (ppm)	Ratio ΔC	ΔTP	% Breakthrough P
Center 1	S	160	.003	.024			
Center 2	S	300	.001	.010			
1	S	250	.001	.049			
16	S	310	.003	.008			
54	S	250	.002	.008			
54	G	250	.002	.082			
71	S	310	.001	.006			
71	G	250	.011	.342			
79	S	365	.000	.006			
79	G	250	.003	.112			
81	S	380	.001	.007			
81	G	225	.006	.250			
83	S	235	.002	.011			
85	S	305	.004	.006			
85	G	300	.008	.221	50	.21	78%
87	S	260	.001	.007			
87	G	220	.004	.288			
105	S	300	.001	.005			
105	G	200	.002	.059			
106	S	340	.004	.007			
111	S	360	.001	.004			
111	G	245	.001	.038			
113	S	265	.001	.006			
113	G	140	.001	.004			
118	S	320	.001	.005			
118	G	245	.001	.015			
149	S	320	.000	.008			
149	G	240	.003	.034			
166	S	-	.003	.016			
186	S	275	.003	.007			
186	G	235	.005	.048			
190	S	265	.001	.010			
190	G	250	.003	.163			
194	S	320	.004	.004			
201	S	320	.002	.022			
207	S	350	.001	.008			
207	G	225	.004	.020			
309	S	325	.004	.009			
310	S	275	.002	.012			
310	G	200	.002	.082			
314	S	300	.002	.009			
314	G	175	.001	.053			

Table 2. (continued)

Otter Tail Lake

Sample Number		Conductivity	PO_4-P (ppm)	Total P (ppm)	Ratio ΔC	ΔTP	% Breakthrough P
326	S	240	.001	.007	150	.01	1%
326	G	400	.002	.020			
333	S	265	.004	.017			
333	G	250	.002	.016			
340	S	320	.001	.007			
352	S	-	.003	.015			
352	G	250	.006	.050			
360	S	250	.005	.016			
360	G	175	.003	.006			
397	S	290	.002	.009			
407	S	280	.003	.012			
407	G	250	.002	.013			
432	S	370	.003	.013			
432	G	275	.001	.048	25	.04	28%
443	S	345	.001	.006			
443	G	345	.001	.073	95	.06	11%
448	S	415	.010	.050			
448	G	325	.004	.109	75	.10	23%
481	S	325	.002	.012			
486	S	320	.004	.008			
486	G	225	.002	.078			
500	S	270	.001	.020			
550	S	325	.001	.010			
550	G	375	.009	.074	125	.06	8%
584	S	335	.001	.007			
584	G	225	.002	.163			
608	S	300	.002	.015			
608	G	352	.006	.078	102	.07	12%
670	S	445	.002	.015			
670	G	280	.007	.508			
686	S	330	.001	.013			
686	G	215	.007	.047			
694	S	360	.002	.018			
694	G	550	.002	.140	300	.13	8%
696	S	415	.001	.022			
696	G	285	.000	.020			
718	S	250	.004	.021			
734	S	190	.001	.007			
734	G	310	.001	.010	60	.00	<1%
752	S	345	.001	.010			
752	G	390	.001	.029	140	.02	5%
760	S	250	.006	.009			
760	G	-	.002	.012			
773	S	330	.002	.010			
773	G	310	.001	.009	60	.00	<1%

Table 2. (continued)

Otter Tail Lake

Sample Number		Conductivity	PO_4-P (ppm)	Total P (ppm)	Ratio ΔC	ΔTP	% Breakthrough P
777	S	400	.001	.007			
777	G	250	.001	.013			
786	S	310	.001	.016			
816A	S	485	.002	.078			
816A	G	275	.005	.151	25	.14	98%
822	S	415	.002	.019			
822	G	345	.002	.029	95	.02	4%
827	S	-	.003	.028			
827	G	275	.001	.028			
836	S	400	.005	.035			
836	G	275	.002	.063			
845	S	200	.002	.025			
845	G	345	.003	.206	95	.20	37%
854	S	200	.001	.010			
854	G	200	.004	.115			
869	S	300	.003	.031			
869	G	215	.001	.013			
877	S	390	.002	.011			
877	G	280	.007	.254			
888	S	215	.002	.012			
888	G	250	.001	.038			
Otter River Rt 1 bridge inlet	S	325	.002	.016			
Otter River 2nd inlet	S	325	.003	.018			
Otter River outlet	S	330	.001	.011			
Westig Canal	S	335	.008	.087			
Westig Canal	G	440	.002	.446	190	.44	41%
Balmoral Creek	S	380	.002	.018			
Walker L. Canal	S	410	.002	.016			
Pelican Bay	S	175	.001	.013			
Charney's well	G	185	.007	.071			
Aeres home & well	G	275	.025	.065			
Well F.N.1061	G	300	.005	.056			

Table 2. (continued)

Sample Number		Conductivity	PO_4-P (ppm)	Total P (ppm)
Round Lake				
1	S	215	.001	.017
1	G	260	.001	.096
14	S	250	.001	.018
14	G	415	.001	.106
15	S	325	.011	.115
15	G	200	.012	.260
30	S	200	.001	.011
30	G	400	.001	.042
34	S	250	.005	.026
34	G	310	.003	.102
Walker Lake				
1	S	400	.001	.012
1	G	450	.000	.031
6	S	275	.001	.017
6	G	150	.001	.038
22	S	300	.001	.031
22	G	540	.001	.043
24	S	300	.001	.024
24	G	350	.003	.130
Deer Lake				
1	S	300	.001	.012
1	G	350	.002	.446
10	S	250	.001	.009
10	G	430	.001	.037
16	S	300	.002	.014
16	G	250	.001	.068
29	S	100	.001	.016
29	G	250	.005	.267
46	S	350	.003	.024
46	G	380	.002	.192
Blanche Lake				
13	S	335	.004	.025
13	G	325	.002	.366
30	S	360	.002	.023
30	G	375	.001	.064
37	S	300	.001	.012
37	G	325	.001	.064
56	S	495	.002	.018
56	G	450	.001	.040
Background groundwater	G	250	.002	.010

5.0 NUTRIENT RELATIONSHIPS

Two types of wastewater discharges were observed along the shoreline of the Salem Lakes: groundwater seepage and surface runoff. The two sources are treated differently in evaluating their loading contributions.

5.1 Groundwater Plumes

By the use of a few calculations, the characteristics of the wastewater plumes can be described. Firstly, a general groundwater background concentration for conductance and nutrients is determined. The concentration of nutrients found in the plume is then compared to the background and to wastewater effluent from the lake region to determine the percent breakthrough of phosphorus and nitrogen to the lake water. Because the well-point sampler does not always intercept the center of the plume, the nutrient content of the plume is always partially diluted by surrounding ambient background groundwater or seeping lake-water concentrations. To correct for the uncertainty of location of withdrawal of the groundwater plume sample, the nutrient concentrations above background values found with the groundwater plume are corrected to the assumed undiluted concentration anticipated in local standard sand-filtered effluent (assuming 100% of conductance should pass through) and then divided by the net nutrient content of raw effluent over municipal water. Computational formulae can be expressed:

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

$C_i - C_o = \Delta C_i$ conductance

$TP_i - TP_o = \Delta TP_i$ total phosphorus

$TN_i - TN_o = \Delta TN_i$ total nitrogen (here, sum of NO_3-N and NH_4-N)

For attenuation during soil passage:

$$100 \times \left(\frac{\Delta C_{ef}}{\Delta C_i}\right) \frac{\Delta TP}{TP_{ef}} = \% \text{ breakthrough of phosphorus}$$

$$100 \times \left(\frac{\Delta C_{ef}}{\Delta C_i}\right) \frac{\Delta TN}{TN_{ef}} = \% \text{ breakthrough of nitrogen}$$

Where: C_o = conductance of background groundwater (µmhos/cm)

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

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

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

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

TP_{ef} = total phosphorus concentration of standard effluent

TN_o = total nitrogen content of background groundwater, here calculated as NO_3-N + NH_4-N

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

TN_{ef} = total nitrogen content of standard effluent

5.2 Surface Discharge Plumes

A number of locations were found where surface inflow under the ice entered the shoreline lake waters. The inflow was analyzed as stream inflow carrying wastewater loads. Each inflow carries a certain dissolved solids load possessing its own peculiar nutrient concentration of phosphorus (TP) and nitrogen (TN). The percent effluent was characterized in the surface water, based on a comparison with the New York Mills effluent standard. The fraction of phosphorus (TP)and nitrogen (TN) expected in a diluted sample of effluent with lake water was then compared to the background-corrected solids load and observed nutrient concentrations. The fraction of phosphorus and nitrogen accounted for by the observed dilution wastewater load is given as percent nutrient residual. If the amount of effluent-related nutrients is only a small percentage of the observed loading, other sources must be contributing, presumably due to road runoff, agricultural runoff, or other non-point sources.

The computational formulae can be expressed:

F_E = fluorescent units observed in water sample

F_B = fluorescent units corresponding to background lake surface water

F_S = fluorescent units corresponding to 100% standard effluent from nearby treatment plant

$$\Delta F = \frac{F_E - F_B}{F_S} = \text{fraction of effluent observed in shoreline water}$$

$100 \times \Delta F = \%E_o$ = percentage of effluent observed in shoreline water for fraction of nutrients accounted for by effluent fraction:

$$100 \times \frac{\left(\frac{\Delta C_{ef}}{\Delta C_i}\right)\Delta TP}{\Delta F \cdot TP_{ef}}$$ = observed phosphorus as % of expected effluent fraction in shoreline water

$$100 \times \frac{\left(\frac{\Delta C_{ef}}{\Delta C_i}\right)\Delta TN}{\Delta F \cdot TP_{ef}}$$ = observed nitrogen as % of expected effluent fraction in shoreline water

5.3 Assumed Wastewater Characteristics

Local samples of effluent were obtained at the New York Mills sewage treatment plant near the study area. A conductance : total phosphorus ratio of 950:4.0 was obtained. Subtracting the background lake water concentration of 300 µmhos/cm gives a C: TP ratio of 750:4.0 representing the change in concentration to source water by household use in the Otter Tail Lake study region.

6.0 COLIFORM LEVELS IN SURFACE WATERS

A series of water samples were analyzed at each lake for fecal coliform content to confirm the presence of surface runoff or soil short-circuiting from malfunctioning systems. Previous field surveys of Otter Tail Lake have shown no indication of pollution of the lake water by fecal matter (WAPORA, 1979). Most previous values were at or below limits of detection (20 mpn/100 ml). With the exception of the inlet of the Otter Tail River, virtually all samples from Otter Tail Lake and the satellite lakes contained negligible bacterial concentrations. A resampling of the Otter Tail bridge at the river inlet showed no detectable fecal coliform bacteria 7 days after the first sampling. Minnesota water quality standards specify that fecal colifrom numbers not exceed a geometric mean of 200 organisms per 100 ml of water based upon five samples per month or 400 organisms per 100 ml of water in more than 10% of all samples during any month for recreational use and aquatic life.

The results of the sampling confirmed that the sandy soils effectively filter out bacterial contamination even though certain chemical constituents penetrate readily with plume movement.

Table 3. Bacterial content of shoreline samples.

Station Number	Fecal Coliform No./100 ml	Location	Ice Hole Number
Otter Tail Lake			
1	0	Pelican Bay inlet	523
2	0	Balmoral Creek inlet	716
3	0	melt spot - F.N. 521	642
4	0	melt spot - F.N. 694	773
5	0	big white barn	783
6	8	spring near Rearing Pond	788
7	0	soft snow - F.N. 747	810
8	0	soft snow - F.N. 748	811
9	0	Otter Tail River outlet	915
10	0	nursing home	79
11	0	house - F.N. 1060	201
12	0	soft spot - F.N. 1063	203
13	0	gas station - resort	333
14	0	Walker Lake outlet	343
15	2	Long Lake canal	450
16	0	soft spot - F.N. 208	481
17	356	Otter Tail River - Rt. 1 bridge	-
17	0	Otter Tail River - 2nd sampling	-
18	0	Inflow: first inlet	-
19	2	Inflow: second inlet	-
Blanche Lake			
1	0	Balmoral Creek outflow	20
2	0	house - F.N. 066	37
3	0	house - F.N. 010	71
4	0	start of ice holes	1
Round Lake			
1	0	snow melt - F.N. 34	34
2	0	snow melt - F.N. 33	33
3	0	snow melt - F.N. 27	29
4	16	blue house - F.N. 7	10
Deer Lake			
1	0	house - F.N. 54	9
2	0	house - yellow ice	10
3	0	house - F.N. 28	29
4	0	house - clear ice	45
Walker Lake			
1	0	house F.N. 79	5
2	0	house - F.N. 75	6
3	0	house - F.N. 59	19
4	0	house F.N. 53	21

Table 3. (continued)

Station Number	Fecal Coliform No./100 ml	Location	Ice Hole Number
Well water			
F.N. 67	0	Walker Lake well (Lien)	
F.N. 68	0	Walker Lake well (Whisher)	
F.N. 888	0	Round Lake well	

7.0 GROUNDWATER FLOW CHARACTERISTICS AND NUTRIENT LOADING

Otter Tail Lake is surrounded by very permeable surficial deposits of glacial outwash. The aquifer deposits consist of stratified sand and gravel with occassional lenses of silt. The sandy deposits vary in thickness from 50 feet in the eastern areas to about 100 feet in the western sections. The principal water source is precipitation which directly falls onto its surface, which then flows laterally to the central drainage canal of the Otter Tail River basin.

While silt and clay layers restrict flow in the far south-eastern side near the town of Otter Tail, high rates of flow have been noticed for the sand and gravel sections of the northern shoreline and the southwestern segments. An estimated 5,000 acre-feet of water per year (approx. 4.5 mgd) leave the aquifer as underflow in the vicinity of the Otter Tail River at the southwest end of Otter Tail Lake (WAPORA, 1979). The transmissivity of the aquifer varies from 5,000 to about 200,000 gallons per day per foot with the highest values being found in the northeastern and southwestern sections of the study area.

7.1 Groundwater Flow Patterns

Since the mean elevation of nearby lakes represent the height of the groundwater levels, an approximation of inflow based upon Darcy's equation can be constructed for Otter Tail Lake. The velocity of flow through porous media (V_s) is proportional to the first power of the hydraulic gradient $\frac{dH}{dL}$

$$V_s = -P \frac{dH}{dL}$$

where P = intrinsic permeability of the aquifer. If an average aquifer thickness of 100 ft exists, the permeability for a 200,000 gpd per foot transmissivity is T/M or 2,000 gpd/ft^2 for a unit square area.

Using the observed hydraulic gradients for mean groundwater heights, the expected rates of flow were estimated for the Otter Tail shoreline (Figure 10). The direction of flow is indicated by the dirertion of the arrow and its rate of flow is proportional to length (units are in feet/day). The flow net analysis indicated that groundwater inflows would be expected around the entire periphery of Otter Tail Lake with the possible exception of the wastern shoreline near Round Lake. In general, the elevated hydraulic head differences caused by lakes or embayments would cause a probable doubling or tripling of groundwater inflow flow rates in segments adjacent to satellite lakes, particularly near the smaller sections of the segment 3 unnamed lake and Pelican Bay plus the broader shorelines adjacent to Blanche Lake, Walker Lake and Long Lake.

7.2 Field Investigations

Field observations of observed groundwater flow patterns added support to the assumed flow patterns. Groundwater flow was evaluated at eight discrete points around the Otter Tail Lake shoreline and at two locations on each satellite lake surveyed using the K-V Associates, Inc. "Dowser"TM groundwater flow meter and the more conventional dye test.

Study sites were chosen along sandy beaches within a yard or two of the water's edge. Under winter conditions, visual observations of the extent of shoreline ice cover provided a noticeable clue to the locations of more rapid intrusion of warmer groundwater into the colder lake waters. Heavy snow cover was correlated with limited groundwater flow while exposed sandy beaches betrayed rapid groundwater movement.

To implant the sensitive probe, a shallow hole was dug in the loose sand to the depth of saturated soil. The instrument sensor was driven 3" to 5" into the sand (groundwater table) and the compass direction was set to due north (magnetic). Measurement of direction and flow was accomplished within 10 minutes and was usually repeated three times at each site. The direction of flow and approximate time of travel was noted for each individual measurement and the mean used (Figure 10).

The observed directions of flow generally corresponded to that expected from the estimated groundwater gradients. The greatest difference was noted just north of a nursing home near the top of segment 1 (GW-5). A large discharge from the leaching field may have caused a local deflection of the flow rate which would account for the observed discrepancy. Along northern regions of Blanche Lake, Walker Lake, and the southern shoreline of Round Lake, no directional movement of the nearshore groundwater could be measured. These areas correspond to regions of anticipated exfiltration.

Table 4. Observed Rates of groundwater flow.

Station	Direction	Flow Rate (ft/day)	Comments
GW-1	300°	.5-.6	covered with 5' of snow
GW-2	315°	10-12	melted spot with vegetation
GW-3	330°	1-5	covered with 3' of snow
GW-4	340°	.6-.9	softer snow
GW-5	75°	11-13	snow melt in broad area (nursing home)
GW-6	165°	15	exposed beach sand off park
GW-7	150°	12-14	one foot of snow with exposed sand
GW-8	195°	17-19	yellow snow around exposed area

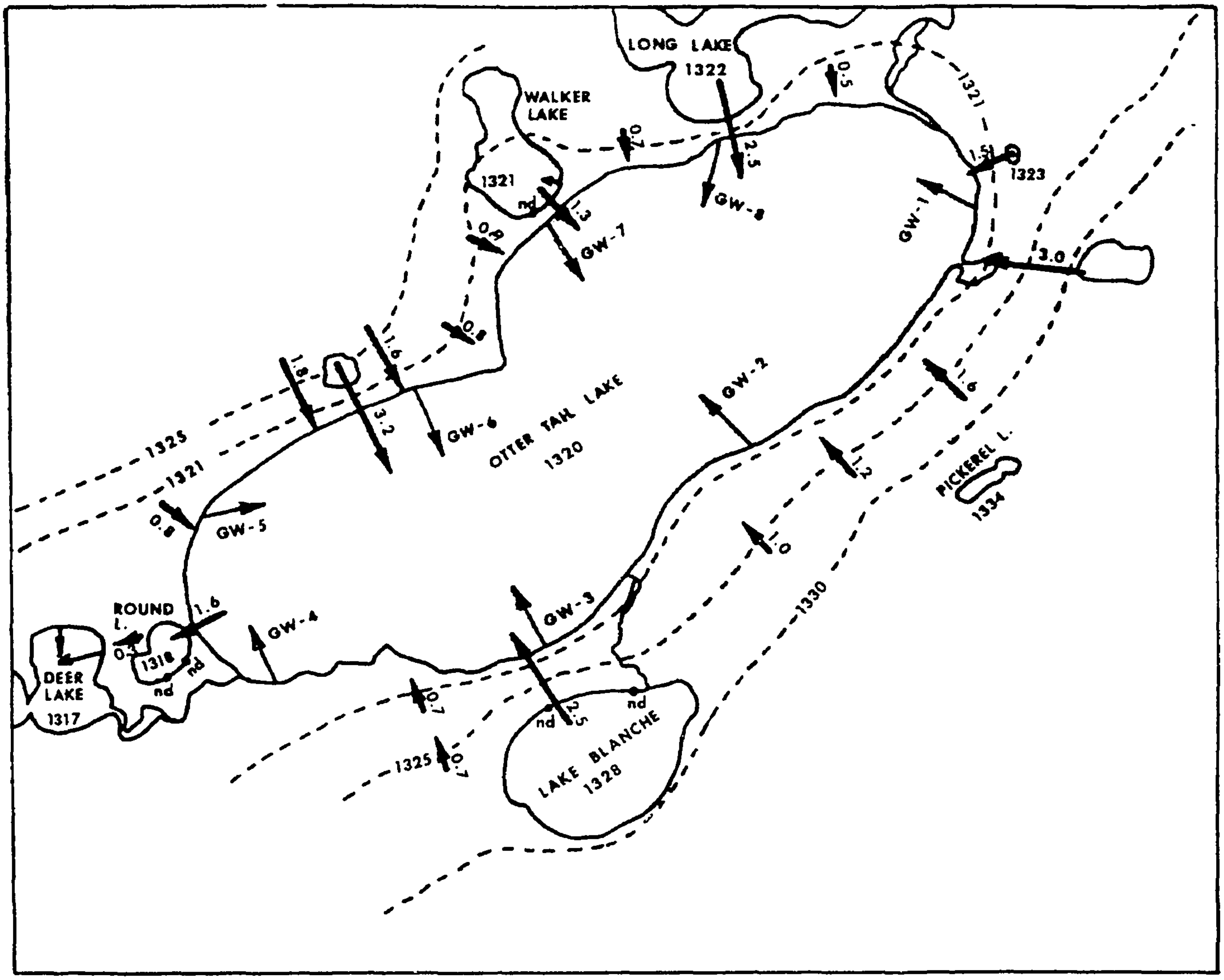


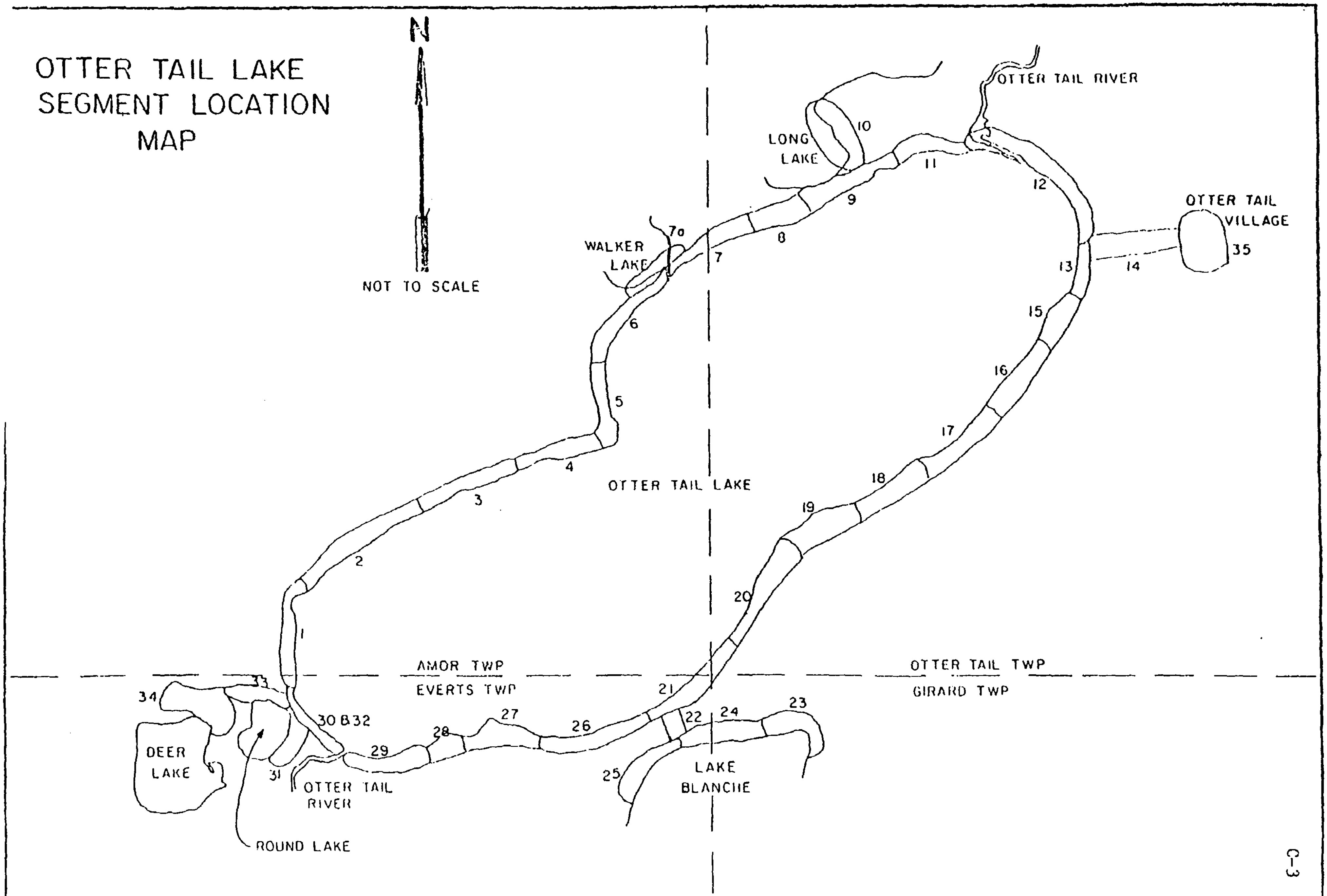
Figure 10. Groundwater flow patterns surrounding Otter Tail Lake.

——► (heavy)	groundwater flow rates based on Darcy's equation
——► (light)	groundwater flow direction and rates measured by the groundwater flow meter
----	approximate groundwater elevation
nd	no direction

Table 5. Calculated winter phosphorus loading per shoreline length based upon observed frequency of intercepted plumes and % breakthrough of nutrients. Expected relative groundwater flow and observed winter surface total phosphorus content are compared to the phosphorus loadings in the last two columns.

Segment	Existing Houses (H)	# of Major Plumes (P)	Estimated Frequency(%)	Nutrient Loading (kg/yr)	Approx. Shoreline Length (mi)	Loading per Shoreline Length KgP/mile	Mean Surface Phosphorus Content	Groundwater Flow Rate ft/day
1	7	5	71	5	.92	5.4	.007(3)	0.8
2	21	21	100	22	1.29	17	.006(10)	1.8
3	14	21	100+	22	1.15	19	.011(6)	2.2*
4	12	9	58	9	.99	9	-	.8
5	2	2	100	2	.79	2.5	-	.9
6	12	9	75	9	1.11	8	.009(4)	1.3
7	14	14	100	14	1.03	14	.014(4)	1.0
8	5	2	40	2	.64	3.1	.012(1)	0.7
9	4	14	100+	14	.83	17	.023(3)	2.5
11	21	16	76	16	1.19	13	.010(2)	.5
12	13	inflow			1.01	-	.016	-
13	7	2	29	2	.53	3.8	.020(1)	1.5
15	7	1	14	1	.48	2.1	.013(3)	3.0
16	7	3	43	3	.84	3.6	.010(1)	1.6
17	2	6	100+	6	1.04	5.8	.011(2)	1.2
18	1	1	100	1	.69	1.5	-	1.0
19	5	0	0	0	.55	0	-	1.0
20	6	6	100	6	.99	6.1	.016(4)	1.0
21	10	19	100+	19	1.10	17	.018(4)	2.0
26	10	52	100+	52	1.31	40	.022(5)	2.5
27	0	2	100+	2	.63	3.2	.016(2)	0.7
28	2	5	100+	5	.38	13	.011(1)	0.5
29	5	5	100	5	.79	6.3	.012(1)	0.5
30+32	8	1	13	1	.76	1.3	.008(1)	-1.6

*average across segment since small lake area
+based on mean house loading (2.5 persons x 3.5 lbs/capita/year) x % breakthrough (.26) x no. of plume locations



C-3

FIGURE 11. SEGMENT LOCATIONS WITHIN THE OTTER TAIL STUDY AREA

(WAPORA, 1978)

Shoreline areas had irregular rates of inflow, apparent through variations in snow thickness to even exposed snow melt areas of high flow. The naturally warmer groundwaters reduce snow cover by heat transfer which is dependent upon rate of movement. The shoreline north of Blanche Lake was laden with melt holes and depressions. Measurements of flow at exposed areas or melt holes revealed exceptional groundwater movement in excess of 10 feet/day. Although melting snow along shoreline areas probably contributed to the high rates of flow, the permeability of deposits of sand and gravel are sufficient to accomodate such a rapid subsurface discharge.

7.3 Nutrient Relationships

Although previous investigations of groundwater-based lakes have verified a relationship between nutrient-leaching from nearshore septic systems and attached algae growth, especially *Cladophora sp.* (K-V Associates, Inc., 1978), the interstitial phosphorus concentrations were rarely above .017 mg/l or 2% breakthrough. Generally, phosphorus is not normally transported from septic tank disposal fields to surface waters by groundwater. However, under the high groundwater inflow rates and high water table levels surrounding Otter Tail Lake, promoting phosphorus mobility, substantial transport appears to occur. Frequencies of breakthrough of phosphorus from intercepter plumes average 26% with regions of substantial transport related to locations of exceptionally high groundwater flow.

The relationship of phosphorus loading to groundwater flow is emphasized by:

1) The occurrence of erupting groundwater plumes from near-shore septic systems around almost the entire periphery of Otter Tail Lake, consistent with a "withdrawal" lake.

2) A statistically significant correlation between a) density of permanent residences and number of erupting plumes, b) groundwater phosphorus concentrations and surface water concentrations, and c) frequency of plumes and estimated groundwater flow rates.

3) An exceptionally high groundwater flow rate sufficient to "flush out" seasonal septic systems located within 100 feet of the shoreline in at least a 5-month period.

Groundwater nutrient loadings from septic systems become significant for certain segments of Otter Tail Lake. An estimate of their impact can be seen from Table 5. The method used to estimate phosphorus loadings from the National Eutrophication Survey (USEPA, 1972) assumes seven percent (0.25 lbs/capita/year) of a 3.5 lbs/capita/year of total phosphorus found in raw wastewater will reach the lake. Sampling of groundwaters where plumes were present indicated a mean of 26% penetration of phosphorus, with high groundwater flow areas showing substantially higher leaching. Since ice holes were drilled at 100 foot intervals, similar to the average distance between houselots, each plume intersected should be indicative of leaching from that lot. Because of the high groundwater flow, the number of plumes was compared with only the permanent residences. A high correlation existed between the two columns with a mean frequency of 78% incidence of plumes from the number of projected permanent residences per segment. The per capita loading for Otter Tail Lake is 2.8 times the presumed national mean phosphorus loading of .25 lbs/capita/year or .7 lbs/capita/year.

The highest shoreline phosphorus loadings from groundwater sources are expected for segments 26, 3, and 0. Attached algal growth may be anticipated for these areas. The extent of any algal growth could not be determined during this study because of ice cover. However, total phosphorus contents of water samples from the different segments showed the highest mean levels in segments 26 and 9. Of note, the lowest was observed for segment 30+32, the only segment where exfiltration is likely.

8.0 CONCLUSIONS

A through-the-ice septic leachate survey was conducted along the shoreline of Otter Tail Lake, Minnesota during April, 1979. The following observations were obtained from the shoreline profiles, analyses of groundwater and surface water samples, and evaluation of groundwater flow rates and patterns:

1) Over 200 of the 975 ice holes drilled at houselot intervals along the shoreline showed evidence of erupting groundwater plumes of septic leachate origin.

2) Erupting plumes occurred around the entire periphery of the lakeshore front, significantly correlated with the number of permanent residence.

3) The highest frequency of plumes was found in lakeshorelines exhibiting induced high groundwater inflow due to adjacent satellite lakes.

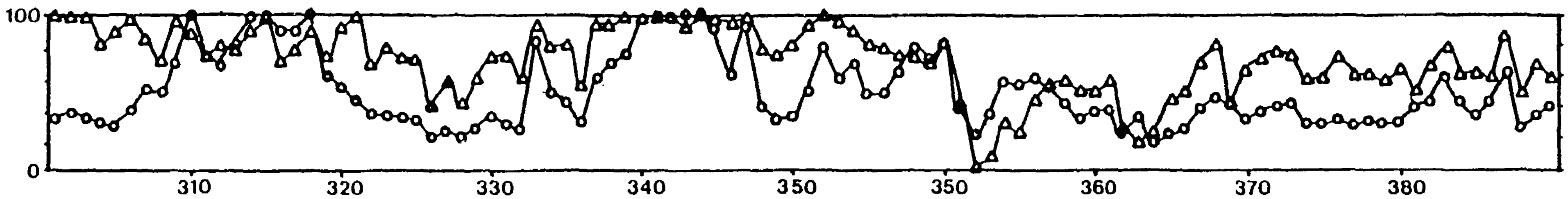
4) In general, the attenuation of phosphorus from nearshore septic systems is not high, with a mean breakthrough of 26% found for intercepted erupting plumes. The per capita loading for Otter Tail Lake is estimated as 2.8 times the presumed national mean phosphorus loading of .25 lbs/capita/year or .7 lbs/capita/year.

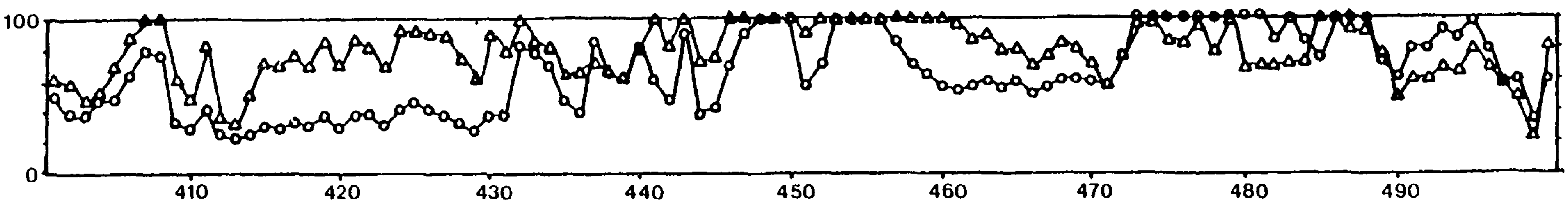
5) During winter, the mean concentration of total phosphorus in the surface waters of nearshore lake segments was generally lower ($\bar{x}$ = .013) than that of the inflow of the Otter Tail River

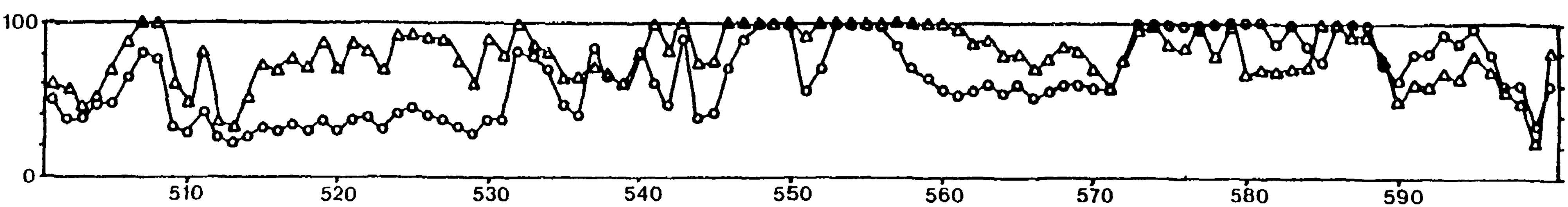
(.016 mg/l). However, the segments admacent to Blanche Lake (.022 mg/l) and Long Lake (.023 mg/l) show elevated levels in regions of high anticipated groundwater phosphorus loadings.

6) No evidence of fecal bacterial contamination of surface waters was found despite the high incidence of erupting plumes.

OTTER TAIL LAKE (cont.)







Camp Nidaros
Richville, MN 56576
July 8, 1978

Ms Jackie Russell
Wapora, Inc.
6900 Wisconsin Avenue N. W.
Washington, D. C. 20015

Dear Jackie,

Enclosed are the data which you asked me to obtain for you. These are shown as coliform group colonies per 100 ml sample as determined by Millipore Filtration Test on samplings of surface water from the Otter Tail Lake outlet for the periods February 25, 1969 through August 13, 1973, and January 7, 1974 through March 8, 1976.

If there are any data on the skipped periods, or if there are any on samplings at the inlet to the lake, I have been unable to locate them.

I dug up the data on the large sheets in the files of our Otter Tail County Shoreland Management office. The data on the short sheet was obtained from a copy on hand in the files of Ulteig Engineers.

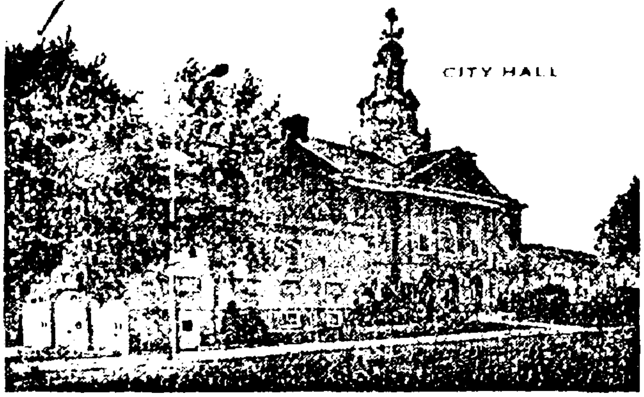
I don't know why these data were not available from the City of Fergus Falls Health Department, but Arnold Ellingson told me he knew nothing about them. However, you will find enclosed a copy of his letter to Ulteig Engineers dated March 15, 1976. He probably misinterpreted my request.

As you know, we are extremely anxious to get this show on the road, so if there is anything further we can do to expedite the completion of your report, kindly let us know.

I know that Mark Oakman is anxious to get tromping around the area. I shall continue to gather the data he has requested in the hope that the air survey can get under way soon.

Sincerely,

W. A. (Bill) Rundquist
President
Otter Tail Lake Property Owners Association



City of Fergus Falls

FERGUS FALLS, MINNESOTA 56537

OFFICE OF:
HEALTH DEPARTMENT
ARNOLD O. ELLINGSON
CITY SANITARIAN

March 15, 1976

RECEIVED
MAR 17 1976
ULTEIG ENGINEERS, INC.
BISMARCK, N. DAK.

Ulteig Engineers
Attention:
R. D. Anderson
Box 1569
Fargo, North Dakota 58102

Dear Sirs:

The following information was requested during our conversation on March 12, 1976. This information includes dates of surface water samplings from the Otter Tail Lake Outlet during the period January 1, 1974 through March 8, 1976. Results of analysis are shown as coliform group colonies per 100 ml sample as determined by Millipore Filtration Test.

Sincerely,

Arnold O. Ellingson
City Sanitarian

AOE/eh

E	COLIFORM GROUP ORGANISMS - Per 100 ml	DATE	COLIFORM GROUP	DATE	COLIFO GROUP
/-74	16	1-0-75	-0-	2-23-76	-0-
-15-74	36	1-13-75	-0-	3-1-76	-0-
1-22-74	24	1-20-75	-0-	3-8-76	-0-
1-28-74	12	1-27-75	-0-		
2-4-74	-0-	2-3-75	-0-		
2-11-74	12	2-10-75	4		
2-19-74	4	3-3-75	-0-		
2-25-74	4	3-10-75	-0-		
3-5-74	-0-	3-17-75	-0-		
3-11-74	-0-	3-31-75	4		
3-18-74	4	4-7-75	-0-		
3-26-74	24	4-14-75	4		
4-1-74	4	4-21-75	-0-		
4-8-74	-0-	4-49-75	---		
4-15-74	28	5-5-75	4		
4-22-74	-0-	5-12-75	---		
4-30-74	44	5-19-75	-0-		
5-6-74	187	5-27-75	8		
5-13-74	212	6-1-75	16		
5-20-74	52	6-9-75	---		
5-28-74	348	6-17-75	-0-		
6-3-74	468	6-26-75	-0-		
6-10-74	140	6-30-75	8		
6-17-74	76	7-7-75	4		
6-24-74	108	7-14-75	12		
7-1-74	228	7-21-75	4		
7-8-74	56	7-28-75	12		
7-15-74	232	8-4-75	272		
7-22-74	296	8-11-75	16		
7-29-74	404	8-17-75	4		
8-6-74	100	8-25-75	520		
8-12-74	80	9-2-75	52		
8-19-74	72	9-8-75	52		
8-26-74	32	9-15-75	96		
9-3-74	48	9-22-75	4		
9-9-74	120	10-6-75	8		
9-16-74	52	10-14-75	48		
9-23-74	16	10-20-75	44		
9-30-74	16	10-27-75	240		
10-7-74	8	11-3-75	-0-		
10-15-74	16	11-10-75	12		
10-21-74	4	11-17-75	4		
10-28-74	8	11-24-75	-0-		
11-4-74	16	12-1-75	32		
11-12-74	-0-	12-8-75	-0-		
11-18-74	-0-	1-5-76	-0-		
11-24-74	-0-	1-12-76	-0-		
12-2-74	-0-	1-19-76	-0-		
12-9-74	-0-	1-26-76	-0-		
12-16-74	-0-	2-3-76	-0-		
12-23-74	-0-	2-10-76	-0-		
12-30-74	-0-	2-17-76	-0-		

Bacteria Data
Otter Tail Lake Outlet

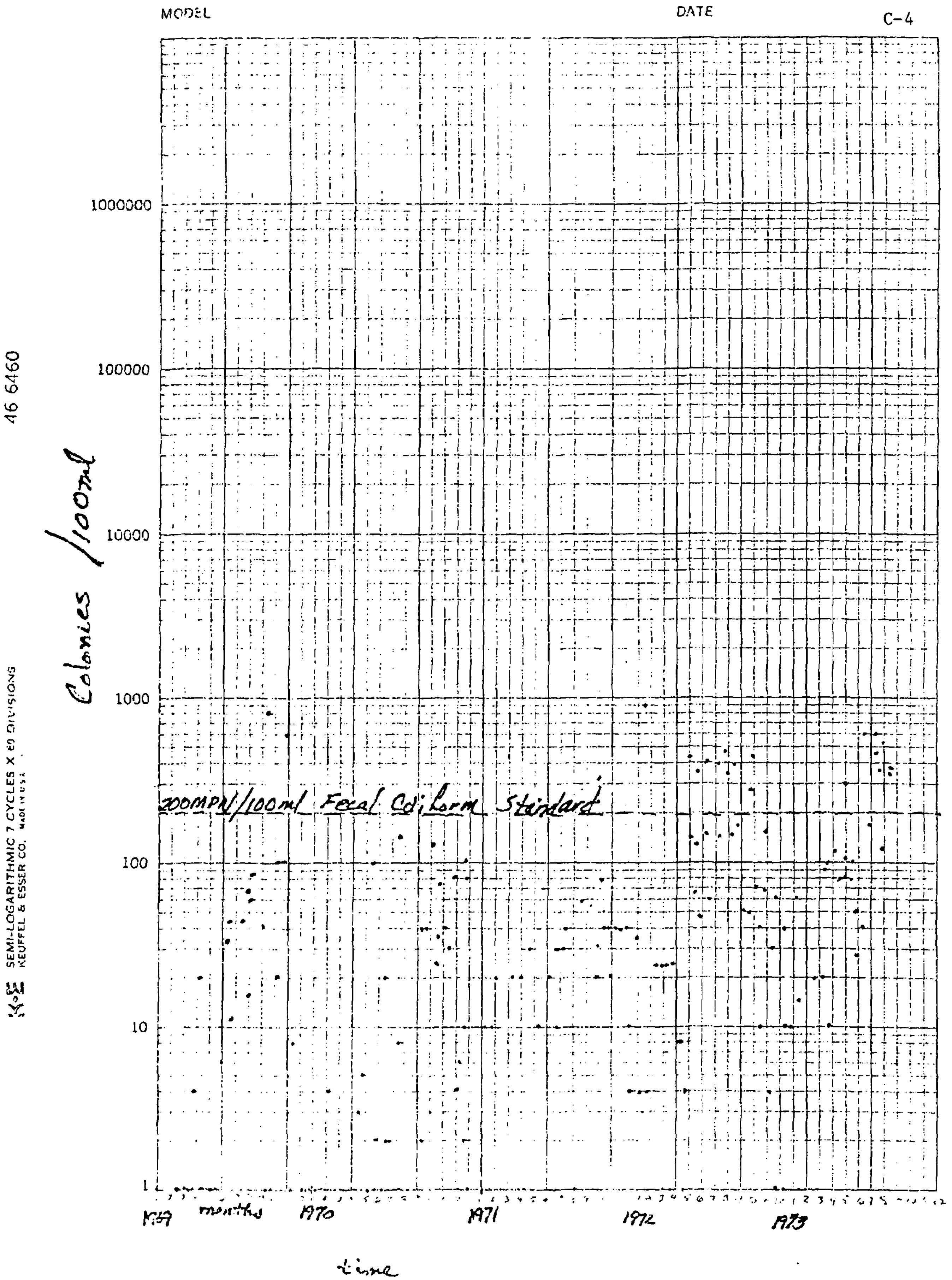
Date/Coliform Density/100 ml (MFT)

2/25/69	0	10/28/69	6.00	6/29/70	0
3/7/69	0	11/4/69	-	7/7/70	0
3/11/69	0	11/11/69	0	7/13/70	0
3/20/69	0	11/19/69	8	7/20/70	8
3/26/69	4	11/25/69	-	7/27/70	140
4/2/69	20	12/3/69	0	8/5/70	-
4/8/69	0	12/8/69	0	8/11/70	260
4/15/69	1	12/16/69	-	8/17/70	2
4/22/69	0	12/30/69	0	8/24/70	40
4/29/69	1	1/6/70	0	8/31/70	-
5/6/69	-	1/13/70	0	9/8/70	130
5/13/69	-	1/20/70	0	9/14/70	24
5/20/69	0	1/27/70	0	9/21/70	36
5/27/69	4	2/2/70	0	9/28/70	70
6/3/69	9	2/9/70	4	10/5/70	40
6/10/69	34	2/17/70	0	10/12/70	30
6/17/69	46	2/2/3/70	0	10/19/70	80
6/24/69	12	3/2/70	0	10/26/70	40
7/1/69	-	3/9/70	0	11/2/70	0
7/9/69	46	3/16/70	0	11/9/70	6
7/14/69	15	3/24/70	0	11/17/70	28
7/22/69	68	3/30/70	0	11/23/70	10
7/27/69	59	4/6/70	0	11/30/70	0
8/4/69	72	4/13/70	3	12/7/70	0
8/11/69	87	4/20/70	5	12/15/70	0
8/18/69	-	4/27/70	0	12/21/70	100
8/26/69	-	5/4/70	0	12/28/70	80
9/7/69	41	5/11/70	100	1/4/71	10
9/17/69	800	5/18/70	0	1/11/71	0
9/22/69	0	5/25/70	2	1/18/71	10
9/29/69	0	6/1/70	1	1/25/71	0
10/7/69	20	6/8/70	20	2/1/71	0
10/9/69	100	6/15/70	2	2/7/71	0
10/21/69	100	6/22/70	2	2/16/71	0

Date/Coliform Density/100 ml (MFT)

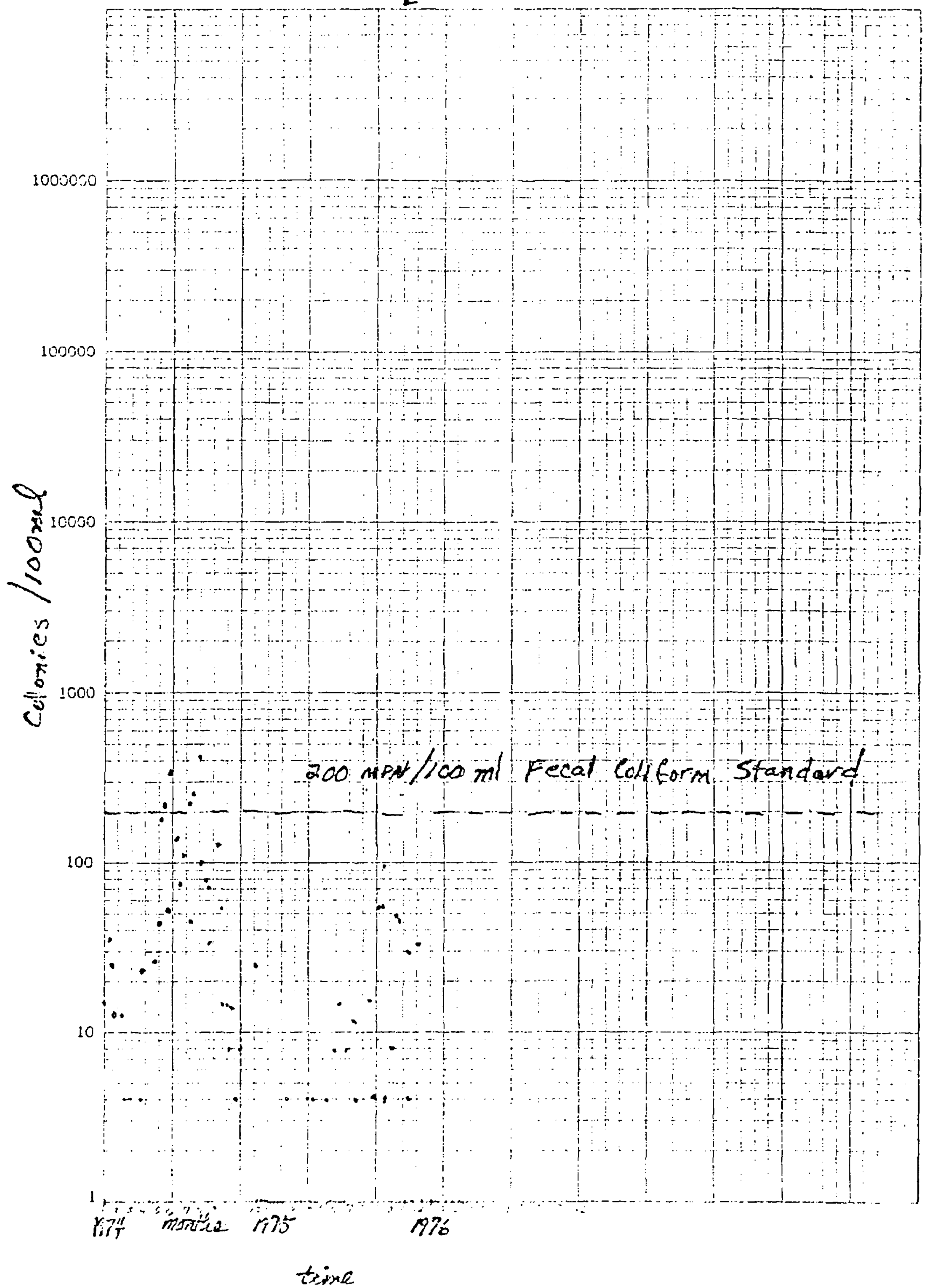
2/22/70	0	12/27/71	36	10/24/72	10
3/2/71	20	1/3/72	4	10/30/72	160
3/8/71	0	1/10/72	-	11/6/72	4
3/15/71	0	1/18/72	900	11/13/72	30
3/22/71	0	1/24/72	-	11/20/72	60
3/29/71	20	1/31/72	4	11/27/72	0
4/5/71	0	2/7/72	-	12/4/72	0
4/12/71	-	2/14/72	24	12/11/72	40
4/19/71	30	2/22/72	24	12/18/72	10
4/26/71	0	2/28/72	0	12/26/72	10
5/3/71	240	3/6/72	24	1/3/73	60
5/10/71	0	3/13/72	0	1/8/73	16
5/17/71	10	3/20/72	24	1/16/73	0
5/25/71	70	3/27/72	0	1/22/73	0
6/1/71	20	4/4/72	8	1/29/73	4
6/7/71	0	4/10/72	0	2/6/73	0
6/14/71	0	4/17/72	4	2/13/73	0
6/21/71	10	4/24/72	4	2/20/73	20
6/28/71	30	5/1/72	132	2/26/73	0
7/6/71	30	5/8/72	64	3/5/73	20
7/12/71	40	5/15/72	128	3/12/73	90
7/19/71	0	5/22/72	48	3/19/73	100
7/26/71	60	5/30/72	-	3/26/73	10
8/2/71	55	6/5/72	130	4/2/73	120
8/9/71	20	6/12/72	60	4/9/73	80
8/16/71	30	6/19/72	88	4/17/73	80
8/23/71	170	6/22/72	-	4/24/73	120
8/31/71	230	7/5/72	TNTC	4/30/73	108
9/7/71	80	7/10/72	310	5/8/73	80
9/13/71	50	7/17/72	136	5/15/73	100
9/20/71	40	7/24/72	360	5/22/73	50
9/27/71	40	7/31/72	250	5/29/73	28
		8/7/72	150	6/5/73	40
10/16/71	20	8/14/72	TNTC	6/11/73	600
10/26/71	40	8/21/22	390	6/19/73	60
11/1/71	30	8/28/72	136	6/26/73	160
11/8/71	0	9/5/72	50	7/3/73	600
11/15/71	220	9/11/72	29	7/10/73	460
11/22/71	10	9/18/72	50	7/17/73	370
11/29/71	60	9/25/72	412	7/23/73	120
12/6/71	40	10/2/72	70	7/30/73	512
12/13/71	10	10/10/72	40	8/6/73	320
12/20/71	4	10/16/72	68	8/13/73	360

BACTERIAL LEVELS AT OTTER TAIL LAKE OUTLET
MPT : COLONIES/100ml (Fergus Falls Health Department, 1969-76)



BACTERIAL LEVELS AT OTTER TAIL LAKE OUTLET
AFT: COLONIES/100ml (Fergus Falls Health Department, 1969-76)
[CONTINUED]

MODEL DATE



SEASONAL AND LONG-TERM CHANGES IN LAKE WATER QUALITY

Seasonal changes of temperature and density in lakes are best described using as an example a lake in the temperate zone which freezes over in winter. When ice coats the surface of a lake, cold water at $0^{o}C$ lies in contact with ice above warmer and denser water between 0^{o} and $4^{o}C$.

With the coming of spring, ice melts and the waters are mixed by wind. Shortly, the lake is in full circulation, and temperatures are approximately uniform throughout (close to $4^{o}C$). With further heating from the sun and mixing by the wind, the typical pattern of summer stratification develops. That is, three characteristic layers are present: (1) a surface layer of warm water in which temperature is more or less uniform throughout; (2) an intermediate layer in which temperature declines rapidly with depth; and (3) a bottom layer of cold water throughout which temperature is again more or less uniform. These three layers are termed epilimnion, metalimnion (or thermocline), and hypolimnion, respectively. The thermocline usually serves as a barrier that eliminates or reduces mixing between the surface water and the bottom water.

In late summer and early fall, as the lake cools in sympathy with its surroundings, convection currents of cold water formed at night sink to find their appropriate temperature level, mixing with warmer water on their way down. With further cooling, and turbulence created by wind, the thermocline moves deeper and deeper. The temperature of the epilimnion gradually approaches that of the hypolimnion. Finally, the density gradient associated with the thermocline becomes so weak that it ceases to be an effective barrier to downward-moving currents. The lake then becomes uniform in temperature indicating it is again well mixed. With still further cooling, ice forms at the surface to complete the annual cycle.

The physical phenomenon described above has significant bearing on biological and chemical activities in lakes on a seasonal basis. In general, growth of algae, which are plants, in the epilimnion produces dissolved oxygen and takes up nutrients such as nitrogen and phosphorus during the summer months. Algal growth in the hypolimnion is limited mainly because sunlight is insufficient. As dead algae settle gradually from the epilimnion into the hypolimnion, decomposition of dead algae depletes a significant amount of dissolved oxygen in the bottom water. At the same time, stratification limits oxygen supply from the surface water to the bottom water. As a result, the hypolimnion shows a lower level of dissolved oxygen while accumulating a large amount of nutrients by the end of summer. Then comes the fall overturn to provide a new supply of dissolved oxygen and to redistribute the nutrients via complete mixing.

Over each annual cycle, sedimentation builds up progressively at the bottom of the lake. As a result, this slow process of deposition of sediments reduces lake depth. Because major nutrients enter the lake along with the sediments, nutrient concentrations in the lake increase over a long period of time. This aging process is a natural phenomenon and is measured in hundreds or thousands of years, depending on specific lake and watershed characteristics.

Human activities, however, have accelerated this schedule considerably. By populating the shoreline, disturbing soils in the watershed, and altering hydrologic flow patterns, man has increased the rate of nutrient and sediment loading to lakes. As a result, many of our lakes are now characterized by a state of eutrophication that would not have occurred under natural conditions for many generations. This cultural eutrophication can in some instances be beneficial, for example by increasing both the rate of growth of individual fish and overall fishery production. In most cases, however, the effects of this accelerated process are detrimental to the desired uses of the lake.

The eutrophication process of lakes is classified according to a relative scale based on parameters such as productivity, nutrient levels, dissolved oxygen, and turbidity in the lake water. Lakes with low nutrient inputs and low productivity are termed oligotrophic. Dissolved oxygen levels in the hypolimmion of these lakes remain relatively high throughout the year. Lakes with greater productivity are termed mesotrophic and generally have larger nutrient inputs than oligotrophic lakes. Lakes with very high productivity are termed eutrophic and usually have high nutrient inputs. Aquatic plants and algae grow excessively in the latter lakes, and algal blooms are common. Dissolved oxygen may be depleted in the hypolimnion of eutrophic lakes during the summer months.

EFFLUENT STANDARDS

The general effluent standards for intrastate waters are included in the provisions of paragraph (C)(6) of WPC 14 and outlined as follows:

Substance or Characteristics	Limiting Concentration or Range*
5-Day Biochemical Oxygen Demand	25 milligrams per liter
Fecal coliform group organisms	200 most probable number per 100 milliliters
Total suspended solids	30 milligrams per liter
Pathogenic organisms	None
Oil	Essentially free of visible oil
Phosphorus**	1 milligram per liter
Turbidity	25
pH range	6.5-8.5
Unspecified toxic or corrosive substances	None at levels acutely toxic to humans or other animals or plant life, or directly damaging to real property.

In addition to providing secondary treatment as defined above, all discharges of sewage, industrial wastes or other wastes also shall provide the best practicable control technology not later than July 1, 1977, and best available technology economically achievable by July 1, 1983, and any other applicable treatment standards as defined by, and in accordance with the requirements and schedules of, the Federal Water Pollution Control Act, 33 U.S.C. 1251 et. seq., as amended, and applicable regulations or rules promulgated pursuant thereto by the Administrator of the U.S. Environmental Protection Agency.

NON-POINT SOURCE MODELING - OMERNIK'S MODEL

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

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

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

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

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

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

where:

P = Total phosphorus concentration - mg/l as P

N = Total nitrogen concentration - mg/l as N

A = Percent of watershed with agricultural plus urban land use

B = Percent of watershed with forest land use

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

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

1.85 = f, multiplicative standard error for Equation 1.

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

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

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

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

where:

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

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

SIMPLIFIED ANALYSIS OF LAKE EUTROPHICATION

Introduction

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

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

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

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

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

Historical Development

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

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

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

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

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

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

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

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

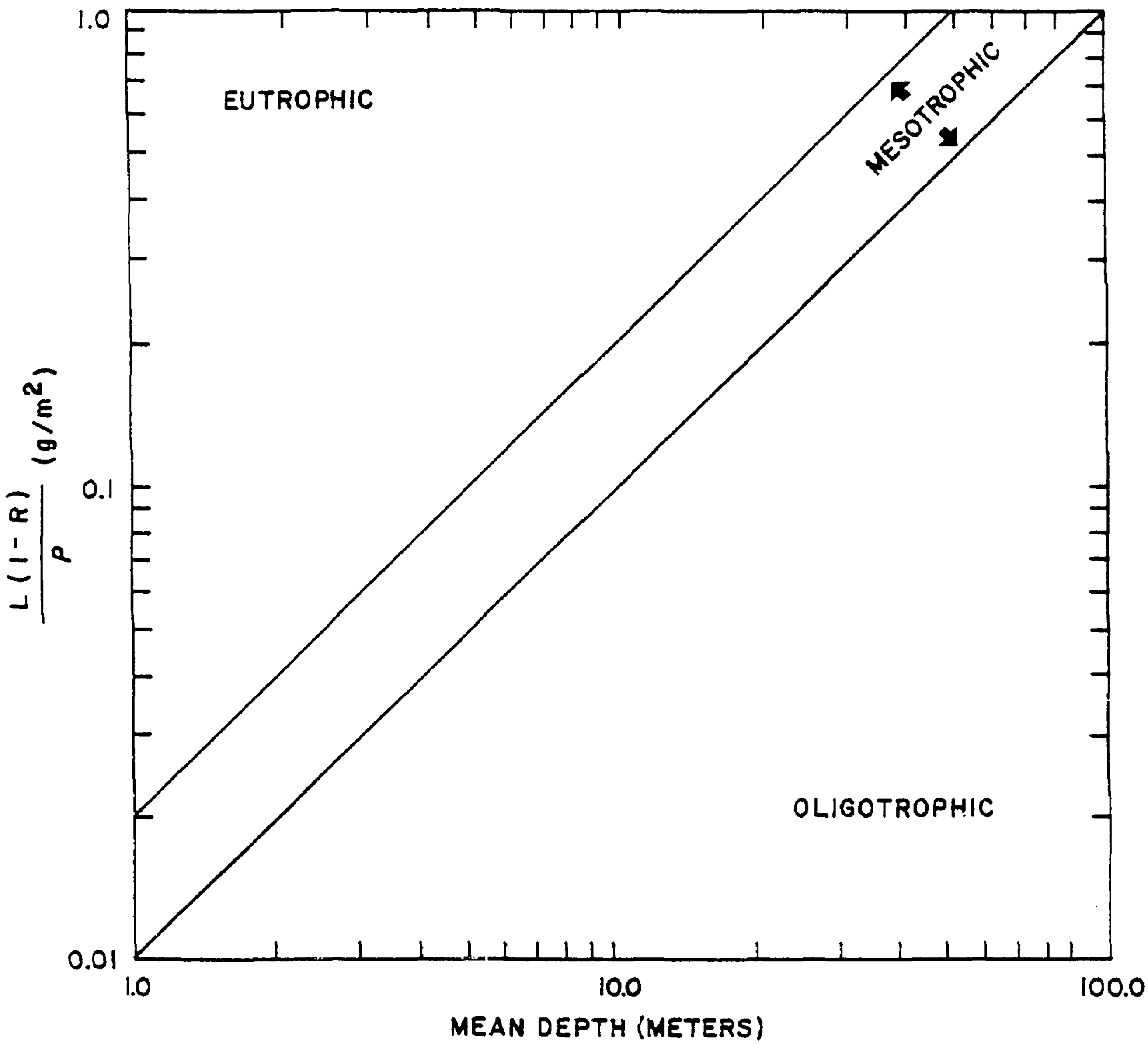
Assumptions and Limitations

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

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

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

FIGURE 1



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

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

APPENDIX D

SEPTIC TANK DESIGN STANDARDS

OFFICE OF SHORELAND MANAGEMENT
COUNTY OF OTTER TAIL
Fergus Falls, Minnesota 56537
Phone 218--739-2271

--MINIMUM SHORELAND ORDINANCE STANDARDS--

--LAKE OR STREAM CLASSIFICATION--

	N E Natural Environment	R D Recreational Development	G D General Development	R S River and Stream
Lot Area	80,000 Sq. Ft.	40,000 Sq. Ft.	20,000 Sq. Ft.	40,000 Sq. Ft.
Water Frontage	200 Ft.	150 Ft.	100 Ft.	200 Ft.
Building Set Back from Shoreline	200 Ft.	100 Ft.	75 Ft.	75 Ft.
Land Height Above High Water Mark at Building Site	3 Ft.	3 Ft.	3 Ft.	3 Ft.
Building Set Back From State Highway	50 Ft.	50 Ft.	50 Ft.	50 Ft.
Building Set Back from Roads and Streets	40 Ft.	40 Ft.	40 Ft.	40 Ft.

Side Yard Minimums for all Classes of Lakes and Rivers:

1 Ft.-59 Ft. -- 10% of Building Line	80 Ft.-89 Ft. -- 16% of Building Line
60 Ft.-69 Ft. -- 12% of Building Line	90 Ft.-99 Ft. -- 18% of Building Line
70 Ft.-79 Ft. -- 14% of Building Line	100 Ft. or more - 20 Feet

SEWAGE DISPOSAL SYSTEMS: (Also see Note A on reverse side)

SEPTIC TANK (A Sealed Tank)

	N E	R D	G D	R S
Mimimum Distance from Nearest Well	50 Ft.	50 Ft.	50 Ft.	50 Ft.
Minimum Distance from Occupied Building	10 Ft.	10 Ft.	10 Ft.	10 Ft.
Minimum Distance from Lake or Stream	150 Ft.	75 Ft.	50 Ft.	50 Ft.
Minimum Distance from Property Line	10 Ft.	10 Ft.	10 Ft.	10 Ft.

ABSORPTION SYSTEM (Drain Field, Cesspool, etc.)

	N E	R D	G D	R S
Minimum Distance from Seepage Pit to Well	75 Ft.	75 Ft.	75 Ft.	75 Ft.
Minimum Distance from Drain Field to Well	50 Ft.	50 Ft.	50 Ft.	50 Ft.
Minimum Distance from Lake or Stream	150 Ft.	75 Ft.	50 Ft.	50 Ft.
Minimum Distance from Occupied Building	20 Ft.	20 Ft.	20 Ft.	20 Ft.
Minimum Distance from Property Line	10 Ft.	10 Ft.	10 Ft.	10 Ft.
Minimum Distance from Bottom of Absorption System to Ground Water Table (Vertical)	4 Ft.	4 Ft.	4 Ft.	4 Ft.

Building and Sewage System Permits are required.
Special Use Permits are required for grading, filling, and commercial ventures in shoreland use areas.

(See Shoreland Management Ordinance for Details).

APPENDIX D

NOTE A

Septic tank and soil absorption or similar systems shall not be acceptable for disposal of domestic sewage for developments on lots adjacent to public waters under the following circumstances:

1. Low swampy areas or areas subject to recurrent flooding.
2. Areas where ground water table is within four feet of the bottom of soil absorption system.
3. Area of bedrock where conditions restrict percolation of effluent.
4. Area of critical slope conditions as follows:

Percolation Rate (minutes)	Critical Slope
Less than 3	20% or more
3 to 45	15% or more
45 to 60	10% or more

ABSORPTION AREA REQUIREMENTS FOR PRIVATE RESIDENCES AND OTHER ESTABLISHMENTS

Percolation Rate (time required for water to fall 1 inch in minutes)	Required absorption area in square feet standard trench and seepage pit.[2] *Per Bedroom	Per gallon of waste per day
1 or less	70	.70
2	85	.85
3	100	1.00
4	115	1.15
5	125	1.25
10	165	1.65
15	190	1.90
30 -4	250	2.50
45 -4-5	300	3.00
60	330	3.30

*Per Bedroom column provides for Residential Garbage Grinders and Automatic Sequence Washing Machines.

1. Absorption area for standard trenches is figures as trench-bottom area.
2. Absorption area for seepage is figures as effective side-wall area beneath the inlet.
3. In every case sufficient area should be provided for at least two bedrooms.
4. Unsuitable for seepage pits if over 30.
5. Unsuitable for absorption systems if over 60.

*For more detailed information see Shoreland Management Ordinance, Otter Tail County, Minnesota.

D

MALCOLM K. LES, Administrator

APPENDIX E

BIOTA

INVENTORY OF FISHES FOUND IN THE OTTER TAIL LAKE STUDY AREA

	Otter Tail Lake (1953)	Lake Blanche (1973)	Deer Lake (1962)	Round Lake (1975)	Walker Lake (1971)
Game Fish					
Whitefish (Coregonus clupeaformis)	X				
Cisco (Leucichthys artedii tullibee)	X		X		
Muskelunge (Esox masquinongy)	X				X
Northern Pike (Esox lucius)	X	X	X	X	
Walleye (Stizostedion vitreum)	X	X	X	X	X
Pumpkinseed (Lepomis gibbosus)	X	X	X	X	
Bluegill (Lepomis macrochirus)	X	X	X	X	X
Rock Bass (Ambloplites rupestris)	X	X	X		
Yellow Perch (Perca flavescens)	X	X	X	X	X
Largemouth Bass (Micropterus salmoides)	X	X	X	X	
Smallmouth Bass (Micropterus dolemieui)	X	X			
Trout-Perch (Percopis omiscamaycus)	X				
Brown Bullhead (Ictalurus nebulosus)	X	X	X	X	X
Black Bullhead (Ictalurus melas)		X	X	X	X
Yellow Bullhead (Ictalurus natalis)		X	X	X	X
Whitefish (Coregonus clupeaformis)	X				
Green Sunfish (Lepomis cyanellus)				X	
Hybrid Sunfish (Lepomis sp.)	X		X		
Black Crappie (Pomosix nigromaculatus)	X	X	X		X
Forage Fish					
Northern Mimic Shiner (Notropis volucellus)	X				
Horneyhead Chub (Hybopsis biguttata)			X		
Western Golden Shiner (Notemigonus crysoleucas)			X		
Common Shiner (Notropis cornutus)			X		
Bigmouth Shiner (Notropis dorsalis)			X		
Blackchin Shiner (Notropis heterodon)			X		
Bluntnose Minnow (Pimephales notatus)	X		X		
Northern Logperch (Percina caprodes)			X		
Western Banded Killifish (Fundulus diaphanus)			X		
Blackside Darter (Percina maculata)			X		
Johnny Darter (Etheostoma nigrum)	X		X		
Iowa Darter (Etheostoma exile)	X		X		
Rough Fish					
White Sucker (Catostomus commersoni)	X	X		X	X
Common Sucker (Catostomus commersoni)	X		X		
Shorthead Redhorse (Moxostoma macrolepidotum)	X		X		
Dogfish (Amia calva)			X		
Carp (Cyprinus carpio)		X			
Bowfin (Amia calva)					X

NOTE: If a given species is not listed as being present in a lake during these particular surveys, that does not necessarily mean the species does not exist in that lake.

Source: Minnesota Department of Natural Resources, Fish and Wildlife Survey Unit, 1957-1975.

DOMINANT SPECIES OF AQUATIC VEGETATION IN THE LAKES OF THE STUDY AREA

	Otter Tail Lake, 1951	Lake Blanche	Round Lake	Walker Lake
Sago pondweed (*Potomogeton pectinatus*)	X	X		X
Floating real pondweed (*Potamogeton natans*)	X			X
Flatstem pondweed (*Potamogeton zosteriformis*)	X	X	X	
Clasping real pondweed (*Potamogeton Richardsonii*)		X	X	X
Bushy pondweed (*Najas cf. flexilis*)			A	
Hardstern bulrush (*Scirpis acutus*)			X	A
Cattail (*Typha latifolia*)			X	X
Sedge (*Cyperus* sp.)				X
Wild rice (*Zizania* sp.)				X
Muskgrass (*Chara* sp.)	X		X	A
White water lily (*Nymphaea* sp.)				X
Yellow water lily (*Nuphar* sp.)				X
Blatterwort (*Utricularia vulgaris*)				X
Water milfoil (*Myriophyllum* sp.)				X
Arrowhead (*Sagittaria* sp.)			A	X
Bulrush (*Scirpus validus*)		A		
Coontail (*Ceratophyllum* sp.)		X		
Bluegreen Algae (*Spirogyra*)	X	X	X	X

A = Abundant
X = Present

Source: Minnesota Department of Natural Resources, Fish and Wildlife Survey Unit, 1957-1975.

Waterfowl Species List For Ottertail, Long, Walker, Blanch, Deer, and Round Lakes and Immediate Vicinity.

SPECIES	SPRING MIGRATION	SUMMER BREEDING	FALL MIGRATION
Common Loon	C	C	C
Western Grebe	O	O	O
Red-Necked Grebe	R	—	R
Horned Grebe	R	—	R
Fared Grebe	R	—	R
Pied-Billed Grebe	C	C	C
Whistling Swan	C	—	C
Canada Goose	C	C	C
White-Fronted Goose	R	—	R
Snow-Blue Goose	O	—	O
Mallard	C	C	C
Black Duck	O	R	O
Pintail	O	O	O
American Widgeon	C	R	C
Northern Shoveler	O	R	O
Blue-Winged Teal	C	C	C
Green-Winged Teal	C	O	C
Wood Duck	C	C	C
Redhead	C	O	C
Canvasback	C	R	C
Ring-Necked Duck	C	O	C
Greater Scaup	O	—	O
Lesser Scaup	C	—	C
Common Goldeneye	C	R	C
Bufflehead	C	—	C
Ruddy Duck	C	O	C
Common Merganser	C	—	C
Red-Breasted Merganser	R	—	R
Hooded Merganser	C	—	C

C= Common
O= Occasional
R= Rare
-= Never Found

TREES OF THE OTTER TAIL LAKE STUDY AREA

Red Oak	(*Quercus rubra*)
White Oak	(*Quercus alba*)
Bur Oak	(*Quercus macrocarpa*)
Hickory	(*Carya* sp.)
Sugar Maple	(*Acer saccharum*)
Red Maple	(*Acer rubrum*)
Basswood	(*Tilia americana*)
Aspen	(*Populus grandidentata*)
Cottonwood	(*Populus deltoides*)
Paper Birch	(*Betula papyrifera*)
Black Ash	(*Fraxinus nigra*)
Green Ash	(*Fraxinus pennsylvanica*)
Box Elder	(*Acer negundo*)
Hackberry	(*Celtis occidentalis*)
Black Cherry	(*Prunus serotina*)
Ironwood	(*Carpinus caroliniana*)
Butternut	(*Juglans cinerea*)
American Elm	(*Ulmus americana*)
White Pine	(*Pinus strobus*)
Red Pine	(*Pinus resinosa*)
Jack Pine	(*Pinus banksiana*)
White Spruce	(*Picea glauca*)
Black Spruce	(*Picea mariana*)

Balsam Fir (*Abies balsamea*)

Tamarack (*Larix laricina*)

Willow (*Salix* spp.)

Alder (*Alnus* spp.)

Source: (By telephone, Mr. William Brandt, Minnesota Forestry Division)

MAMMALS AND BIRDS--OTTER TAIL LAKE REGION, OTTER TAIL COUNTY

Note: This appendix was prepared by Mr. Gary Otnes, of Fergus Falls, Minnesota, from his personal files and observations from information provided by the West Central Bird Club, and from the references noted below.

UPLAND GAME BIRD SPECIES LIST FOR AMOR, OTTER TAIL, EVERTS AND GIRARD TOWNSHIPS

Ring-Necked Pheasant--Occasional

Hungarian Partridge--Occasional

Ruffed Grouse--Common

Greater Prairie Chicken--Rare

American Woodcock--Common

Common Snipe--Common

Source: Minnesota Department of Natural Resources, 1978.

MAMMALS - OTTER TAIL LAKE REGION, OTTER TAIL COUNTY

Star Nosed Mole -	Condylura cristata
Masked Shrew -	Sorex cinereus
Arctic Shrew -	Sorex arcticus
Northern Water Shrew -	Sorex palustris
Short-tailed Shrew -	Blarina brevicauda
Little Brown Bat -	Myotis lucifugus
Silver Haired Bat -	Lasionycteris noctivagans
Big Brown Bat -	Eptesicus fuscus
Red Bat -	Lasiurus borealis
Hoary Bat -	Lasiurus cinereus
Raccoon -	Procyon lotor
Ermine -	Mustela erminea
Long-tailed Weasel -	Mustela frenata
Least Weasel -	Mustela nivalis
Mink -	Mustela vison
Badger -	Taxidea taxus
Striped Skunk -	Mephitis mephitis
Red Fox -	Vulpes vulpes
Gray Fox -	Urocyon cinereoargenteus (rare)
Woodchuck -	Marmota monax
Thirteen-lined Ground Squirrel -	Spermophilus tridecemlineatus
Eastern Chipmunk -	Tamias striatus
Red Squirrel -	Tamiasciurus hudsonicus
Gray Squirrel -	Sciurus carolinensis
Fox Squirrel -	Sciurus niger
Southern Flying Squirrel -	Glaucomys volans
Plains Pocker Gopher -	Geomys bursarius
Deer Mouse -	Peromyscus maniculatus
Woodland Deer Mouse -	Subspecies of above
White Footed Mouse -	Peromyscus leucopus
Southern Bog Lemming -	Synaptomys cooperi
Southern Red-backed Vole -	Clethrionomys gapperi
Meadow Vole -	Microtus pennsylvanicus (very abundant)
Muskrat -	Ondatra zibethicus
Meadow Jumping Mouse -	Zapus hudsonius
White-tailed Jack-Rabbit -	Lepus townsendii
Eastern Cottontail -	Sylvilagus floridanus
White-tailed Deer -	Odocoileus virginianus

Others which could show up in the area but have not been observed include: Bobcat, Franklin's and Richardson's Ground Squirrels, Snowshoe Hare, Spotted Skunk, Keen's Myotis, Coyote, and Moose.

Source: Burt, William H. MAMMALS OF THE GREAT LAKES REGION, 1967. Michigan; University of Michigan.

Orr, Robert T. VERTEBRATE BIOLOGY, 1967. Pennsylvania; W.B. Saunders Company.

Jones, J.K., Jr., D.C. Carter, and H.H. Genoways. 1975. Revised checklist of North American Mammals North of Mexico. Occasional Paper No. 28, The Museum, Texas Tech. University, 14pp.

REPTILES AND AMPHIBIANS - OTTER TAIL LAKE REGION

TOADS

American Toad - *Bufo americanus*

FROGS

Pickerel Frog - *Rana palustris*
Northern Leopard Frog - *Rana pipiens*
Green Frog - *Rana clamitaus*
Gray Treefrog - *Hyla versicolor*
Ornate Chorus Frog - *Pseudacris ornata*
Wood Frog - *Rana sylvatica*
Spring Peeper - *Hyla crucifer*

SNAKES

Garter Snake - *Thamnophis sirtalis*
Bullsnake - *Pituophis melanoleucus*
Redbelly Snake - *Storeria occipitomaculata*
Eastern Hognose Snake - *Heterodon platyrhinos*
Western Hognose Snake - *Heterodon nasicus*
Smooth Green Snake - *Opheodrys vernalis* (rare)
Kingsnake - *Lampropeltis doliata* (rare)

SALAMANDERS

Tiger Salamander - *Ambystoma tigrinum*
Necturus (Mud Puppy) - *Necturus maculosus*

TURTLES

Western Painted Turtle - *Chrysemys picta*
Snapping Turtle - *Chelydra serpentina*

LIZARDS

Other reptiles and amphibians which may occur include: Shortshell Turtle, Blanding's Turtle, Box Turtle, Spotted Turtle, Wood Turtle, Jefferson Salamander, and various Newts.

Source: Orr, Robert T. VERTEBRATE BIOLOGY, 1967. Pennsylvania; W.B. Saunders Company.

Vertebrate Taxonomy Class Research Project. FAUNA OF THE ST. CLOUD REGION, 1967. Minnesota; St. Cloud St. University.

RESIDENT BIRDS FOUND YEAR ROUND - some species are migratory, with a certain percent remaining year round i.e., Blue Jay, Common Crow

Great Blue Heron -	rare in winter
Mallard	
Sharp-Shinned Hawk -	rare in winter
Cooper's Hawk -	rare in winter
American Kestrel -	lesser numbers in winter
Ruffed Grouse	
Ring-Necked Pheasant	
Gray Partridge	
Rock Dove (common pigeon)	
Screech Owl	
Great Horned Owl	
Barred Owl	
Long-Eared Owl -	rare in winter
Belted Kingfisher -	rare in winter near open winter
Common Flicker -	rare in winter
Pileated Woodpecker	
Red-Bellied Woodpecker -	rare in winter
Hairy Woodpecker	
Downy Woodpecker	
Horned Lark	
Blue Jay	
Common Crow	
Black-Capped Chickadee -	less common in summer
White-Breasted Nuthatch	
Brown Creeper -	rare in summer
Starling	
House Sparrow	
Pine Siskin -	erratic from season to season
American Goldfinch	
Dark Eyed Junco -	rare in summer
Song Sparrow	

RESIDENT MIGRATORY BIRDS DURING SPRING, SUMMER, FALL - KNOWN BREEDERS

Pied-Billed Grebe
Northern Green Heron
American Bittern
Canada Goose
Gadwall
Pintail
Blue-Winged Teal
Northern Shoveler
Wood Duck
Redhead
Ruddy Duck

Red-Tailed Hawk
Sora
American Coot
Killdeer
Common Snipe
Forster's Tern
Black Tern
Mourning Dove - also rarely found in winter in sheltered areas
Black-Billed Cuckoo
Common Nighthawk
Chimney Swift
Ruby-Throated Hummingbird
Red-Headed Woodpecker
Yellow Bellied Sapsucker
Eastern Kingbird
Western Kingbird
Great-Crested Flycatcher
Eastern Phoebe
Least Flycatcher
Eastern Wood Peewee
Tree Swallow
Bank Swallow
Rough-Winged Swallow
Barn Swallow
Cliff Swallow
Purple Martin
House Wren
Long-Billed Marsh Wren
Short-Billed Marsh Wren
Gray Catbird
Brown Thrasher
American Robin
Eastern Bluebird
Red-Eyed Vireo
Warbling Vireo
Yellow Warbler
Common Yellowthroat
Bobolink
Western Meadowlark
Yellow-headed Blackbird
Red-winged Blackbird
Northern Oriole
Common Grackle
Brown-Headed Cowbird
Rose-Breasted Grosbeak
Indigo Bunting
Savannah Sparrow
Swamp Sparrow
Vesper Sparrow
Chipping Sparrow
Clay-Colored Sparrow
Grasshopper Sparrow

RESIDENT MIGRATORY BIRDS - SPRING, SUMMER, FALL - BREEDING PERSONALLY UNKNOWN IN AREA, BUT LIKELY

Red-Necked Grebe
Least Bittern
Ring-Necked Duck
Canvasback
Broad-Winged Hawk
Marsh Hawk
Virginia Rail
Spotted Sandpiper
Alder Flycatcher
Veery
Cedar Waxwing - occasionally occurs in winter also
Yellow-Throated Vireo
American Redstart
Scarlet Tanager
Field Sparrow

RESIDENT MIGRATORY BIRDS - SPRING, SUMMER, FALL - BREEDING PERSONALLY UNKNOWN IN AREA, BUT POSSIBLE

Common Loon
Western Grebe
Green-Winged Teal
Upland Sandpiper
Franklin's Gull - breeds in colonies that shift location annually
Yellow-Billed Cuckoo
Short-Eared Owl
Ovenbird
Orchard Oriole
Loggerhead Shrike
Brewer's Blackbird
Eared Grebe

RESIDENT MIGRATORY BIRDS - SPRING, SUMMER, FALL - BREEDING PERSONALLY UNKNOWN IN AREA, AND UNLIKELY

American Pigeon
Lesser Scaup
Common Goldeneye - much more common in winter
Hooded Merganser
Common Tern - somewhat rare in area

RESIDENT MIGRATORY BIRDS - SPRING, SUMMER, FALL - BREED FAR FROM ASIA OR ARE NONBREEDERS i.e. IMMATURES, BIRDS NESTING IN COLONIES ELSEWHERE, ETC.

White Pelican
Double-Crested Cormorant
Great Egret
Black-Crowned Night Heron
Osprey
Herring Gull
Ring-Billed Gull

MIGRATORY BIRDS - SPRING, FALL - NOT RESIDENT TO AREA

Horned Grebe
Whistling Swan
White-Fronted Goose
Snow Goose
Bufflehead
Common Merganser
Red-Breasted Merganser
Golden Eagle
Bald Eagle
American Golden Plover
Black-Bellied Plover
Greater Yellowlegs
Lesser Yellowlegs
Pectoral Sandpiper
Bonaparte's Gull
Yellow-Bellied Flycatcher
Winter Wren
Hermit Thrush
Swainson's Thrush
Gray-Cheeked Thrush
Golden-Crowned Kinglet
Ruby-Crowned Kinglet
Water Pipit
Solitary Vireo
Philadelphia Vireo
Black-and-White Warbler
Tennessee Warbler
Orange-Crowned Warbler
Nashville Warbler
Magnolia Warbler
Yellow-Rumped Warbler
Black-Throated Green Warbler
Blackburnian Warbler
Chestnut-Sided Warbler
Bay-Breasted Warbler
Blackpoll Warbler

Palm Warbler
Northern Waterthrush
Mourning Warbler
Wilson's Warbler
Canada Warbler
Rusty Blackbird
Rufous-Sided Towhee
Harris' Sparrow
White-Crowned Sparrow
White-Throated Sparrow
Fox Sparrow
Lincoln's Sparrow
Lapland Longspur

MIBRATORY BIRDS - SPRING, FALL - NOT YET IDENTIFIED IN AREA, BUT FOUND WITHIN TWENTY MILE RADIUS IN SIMILIAR HABITAT - CAN BE EXPECTED IN AREA

Black Duck
White Winged Scoter
Surf Scoter
Ruddy Turnstone
Semipalmated Plover
Piping Plover
American Woodcock
Solitary Sandpiper
White-Rumped Sandpiper
Baird's Sandpiper
Least Sandpiper
Dunlin
Semipalmated Sandpiper
Western Sandpiper
Sanderling
Short-Billed Dowitcher
Long-Billed Dowitcher
Stilt Sandpiper
Marbled Godwit
Hudsonian Godwit
American Avocet
Wilson's Phalarope
Northern Phalarope
Whip-Poor-Will

WINTER VISITANT BIRDS NOT RESIDENT TO AREA - SOME ARRIVE IN LATE FALL AND REMAIN UNTIL LATE WINTER

Snowy Owl
Great Gray Owl - extremely rare
Bohemian Waxwing

Northern Shrike
Evening Grosbeak
Purple Finch
Pine Grosbeak
Hoary Redpoll
Common Redpoll
Red Crossbill - rare
White-Winged Crossbill
Tree Sparrow
Snow Bunting

Source: Bull, John and John Farrand, Jr. THE AUDUBON SOCIETY FIELD GUIDE TO NORTH AMERICAN BIRDS, EASTERN REGION, 1977. New York; Alfred A. Knopf, Inc.

Green, Janet C. and Robert B. Janssen. MINNESOTA BIRDS, WHERE WHEN, AND HOW MANY, 1975. Minnesota; University of Minnesota Press

Peterson, Roger Tory. A FIELD GUIDE TO EASTERN LAND AND WATER BIRDS, 1947; A FIELD GUIDE TO WESERN LAND AND WATER BIRDS, 1961. Both, Boston; Houghton Mifflin.

Roberst, Thomas S. A MANUAL FOR THE IDENTIFICATION OF THE BIRDS OF MINNESOTA AND NEIGHBORING STATES, 1955. Minnesota; University of Minnesota Press

Robbins, Chandler S. Bertel Brunn, and Herbert S. Zim. BIRDS OF NORTH AMERICA, 1966. New York; Western Publishing Company, Inc.

APPENDIX F

POPULATION PROJECTION METHODOLOGY

METHODOLOGY UTILIZED BY WAPORA TO DETERMINE EXISTING AND FUTURE POPULATION AND DWELLING UNITS FOR THE OTTER TAIL SERVICE AREA

Table 1 gives population and dwelling unit equivalents for the proposed Service Area for 1976 and the year 2000. They are presented for the service area as a whole, and for the segments into which it was divided. The service area consists of 35 segments in four townships (Amor, Everts, Girard, Otter Tail) plus Otter Tail Village. The segments were delineated to structure the Proposed Service Area in a way that enables on-site/cluster systems to be designed and analyzed.

1976 POPULATION ESTIMATES

The 1976 population estimate for the Otter Tail Lake Proposed Service Area was based on an analysis of aerial photography and information from locally knowledgeable sources. The following information was obtained from these sources:

- Dwelling unit equivalent count by subarea and segments (see Table F-1).
- Permanent and seasonal resident percentage breakdowns.
- Permanent and seasonal dwelling unit occupancy rates (persons/household).

Table F-1 presents the results of the dwelling unit equivalent count and distinguishes between permanent and seasonal residences. Dwelling unit equivalents in the Proposed Service Area consisted of residences, resorts, nursing homes, trailer parks, stores, inns and restaurants. The 1976 Lakeshore Directory[1] was used to classify each of these units identified by the aerial photo.

Mr. Rundquist[2] compiled the permanent/seasonal split for residences.

Based on these dwelling unit equivalents, a permanent and seasonal population total for 1976 was derived by multiplying the permanent and seasonal dwelling unit totals for each segment by their respective occupancy rates. The occupancy rates were obtained through a telephone and correspondence survey with local sources knowledgeable about the area. The results of this survey indicated that a 3.0 permanent and 5.0 seasonal occupancy rate were appropriate for the population estimates in all subareas except Otter Tail Village. For Otter Tail Village, occupancy rates of 2.0 for permanent units and 5.0 for seasonal units were utilized. The population estimates derived are indicated in Table F-1.

2000 POPULATION PROJECTIONS

The year 2000 permanent and seasonal baseline population projections considered the three growth factors influencing future population levels in the Otter Tail Lake Facilities Planning Area: 1) the rate of growth or decline of the permanent population; 2) the rate of growth or decline of the

---

[1] 1976 Lakeshore Directory - Otter Tail, Walker, Deer, Blanche, Round, and Long Lakes, Lakeshore Directory Service, 1976.

[2] President, Otter Tail Lake Property Owners Association.

seasonal population; and 3) the potential conversion of seasonal to permanent dwelling units. The best available information regarding each of these factors was utilized and resulted in the following methodology and assumptions:

- All lots in the proposed service area that were found to be developable in accordance with environmental constraints and the provisions of the Otter Tail County Shoreland Management Ordinance were projected to be "built out" by 2000. The use of this "built out" assumption was based on the rapid population growth rates in the four townships and the high levels of residential construction activity for the area reported in the C-40 Construction Reports. The additional consideration that nearly the entire Service Area consists of desirable lakeshore or near-lake properties further supported this assumption.

- The only exception to the assumption that the area would be built out is Otter Tail Village, where, based on past population trends, it was assumed that no population growth would occur during the planning period.

- The number of nursing homes, commercial establishments and restaurants was assumed to remain constant.

- The population increase attributed to the growth of resort areas was determined by a telephone survey of resort owners. These anticipated increases in resort population were translated into dwelling unit equivalents and subtracted from the control total.

- The remaining increase in dwelling units was distributed across the segments according to the number of developable lots in each segment.

- A conversion rate of approximately .5% per year was applied to existing seasonal residences to reflect the conversion of seasonal to permanent units resulting from retirement age households. This resulted in 100 seasonal units converted to permanent units during the planning period.

- Smaller occupancy rates of 2.8 for permanent and 4.0 for seasonal residences were used to transform the dwelling unit equivalents into population totals. The smaller occupancy rates were used to reflect the decline in family sizes projected to occur both nationally and in rural areas of Minnesota.

Based on these assumptions and the methodology described above, populations and dwelling unit equivalent projections for the year 2000 were developed for each segment and subarea (Table F-2).

COMPARISON OF WAPORA, INC., AND FACILITIES PLAN POPULATION PROJECTIONS

The Proposed Service Area population estimates and projections prepared in the Otter Tail Facilities Plan were not utilized in this EIS for the following reasons:

- Permanent and seasonal dwelling units were not differentiated.

- Permanent and seasonal occupancy rates were not differentiated nor where they reduced for the 2000 projections to reflect the trend toward smaller family sizes.

- The growth rate in dwelling units projected in the Facilities Plan is based on an unsupported linear extrapolation of current development rates and does not consider anticipated development pressures.

- The Facilities Plan projection of new dwelling units does not consider the restrictions on development imposed by natural constraints and the Otter Tail County Shoreland Management Ordinance.

- The Facilities Plan estimates and projections did not provide a subarea or segment breakdown of where population growth would occur.

Based on these differences, the WAPORA, Inc. population estimate and projection for the Proposed Service Area differs from the Facilities Plan totals. The WAPORA 1976 estimate (6,349 people) is .9% higher than the Facilities Plan estimate of 6,288 people. The Facilities Plan population projections (8,668 people by 1996) is higher than the WAPORA projection of 7,555 by nearly 15%.

Table F-1

POPULATION AND DWELLING UNIT EQUIVALENTS FOR THE TOTAL, PERMANENT, AND SEASONAL POPULATION OF THE PROPOSED OTTER TAIL LAKE SERVICE AREA (1976)

TOWNSHIP &	DWELLING UNIT EQUIVALENTS												POPULATION		
	TOTAL			RESIDENCES			RESORTS			OTHER(1)					
SEGMENT #	t	p	s	t	p	s	t	p	s	t	p	s	t	p	s
Amor	453	123	330	356	88	268	63	9	54	34	26	8	2,019	369	1,650
1	74	33	41	30	7	23	21	3	18	23	23	0	304	99	205
2	93	23	70	85	21	64	7	1	6	1	1	0	419	69	350
3	66	15	51	59	14	45	7	1	6				300	45	255
4	49	12	37	49	12	37							221	36	185
5	8	2	6	8	2	6							36	6	30
6	64	15	49	49	12	37	14	2	12	1	1	0	290	45	245
7 (part)	50	10	40	34	8	26	7	1	6	9	1	8	230	30	200
7a	38	10	28	31	9	22	7	1	6				170	30	140
21 (part)	8	0	8	8	0	8							40	0	40
33	3	3	0	3	3	0							9	9	0
Everts	467	74	393	351	65	286	63	9	54	53	0	53	2,187	222	1,965
21 (part)	59	10	49	59	10	49							275	30	245
22	2	2	0	2	2	0							6	6	0
24 (part)	53	10	43	39	8	31	14	2	12				245	30	215
25	37	8	29	37	8	29							169	24	145
26	74	12	62	60	10	50	14	2	12				346	36	310
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	40	2	38	10	2	8				30	0	30	196	6	190
29	34	6	28	27	5	22	7	1	6				158	18	140
30 & 32	70	9	61	50	8	42	7	1	6	13	0	13	332	27	305
31	35	6	29	25	6	19				10	0	10	163	18	145
34	63	9	54	42	6	36	21	3	18				297	27	270
Girard	60	16	44	39	13	26	21	3	18				268	48	270
23	37	13	24	30	12	18	7	1	6				159	39	120
24 (part)	23	3	20	9	1	8	14	2	12				109	9	100
Otter Tail	378	101	277	306	93	213	42	6	36	30	2	28	1,688	303	1,385
7 (part)	20	6	14	20	6	14							88	18	70
8	17	5	12	17	5	12							75	15	60
9	13	4	9	13	4	9							57	12	45
10	8	1	7	8	1	7							38	3	35
11	74	23	51	66	21	45	7	1	6	1	1	0	324	69	255
12	52	13	39	42	13	29				10	0	10	234	39	195
13	29	8	21	22	7	15	7	1	6				129	24	105
14	8	3	5	7	2	5				1	1	0	34	9	25
15	22	7	15	22	7	15							96	21	75
16	21	7	14	21	7	14							91	21	70
17	26	2	24	8	2	6				18	0	18	126	6	120
18	11	2	9	4	1	3	7	1	6				51	6	45
19	17	5	12	17	5	12							75	15	60
20	26		7	19	6	13	7	1	6				116	21	95
21 (part)	34	8	26	20	6	14	14	2	12				154	24	130
Otter Tail Village	82	76	6	82	76	6	—	—	—	—	—	—	182	152	30
TOTAL	1,440	390	1,050	1,134	335	799	189	27	162	117	28	89	6,344	1,094	5,250

(1) Nursing homes; trailer parks; stores; inns and restaurants.

Source: WAPORA, Inc., 1978.

Code: t = total
p = permanent
s = seasonal

Table F-2

POPULATION AND DWELLING UNIT EQUIVALENTS FOR THE TOTAL, PERMANENT, AND SEASONAL POPULATION OF THE PROPOSED OTTER TAIL LAKE SERVICE AREA (2000)

TOWNSHIP & SEGMENT #	DWELLING UNIT EQUIVALENTS: TOTAL t	TOTAL p	TOTAL s	RESIDENCES t	RESIDENCES p	RESIDENCES s	RESORTS t	RESORTS p	RESORTS s	OTHER(1) t	OTHER(1) p	OTHER(1) s	POPULATION t	POPULATION p	POPULATION s
Amor	674	213	461	544	178	376	96	9	87	34	26	8	244	597	1,844
1	100	42	58	46	15	31	31	4	27	23	23	0	350	118	232
2	142	46	96	130	44	86	11	1	0	1	1	0	513	129	384
3	101	30	71	90	29	61	11	1	0				368	84	284
4	75	24	51	75	24	51							271	67	204
5	12	4	8	12	4	8							43	11	32
6	97	27	70	75	25	50	21	1	20	1	1	0	356	76	280
7 (part)	72	18	54	52	16	36	11	1	10	9	1	8	266	50	216
7a	58	16	42	47	15	32	11	1	10				213	45	168
21 (part)	12	1	11	12	1	11							47	3	44
33	5	5	0	5	5	0							14	14	0
Everts	694	158	536	543	147	396	98	11	87	53	0	53	2,586	442	2,144
21 (part)	91	723	68	91	23	68							336	64	272
22	3	3	0	3	3	0							9	9	0
24 (part)	82	20	62	60	18	42	22	2	20				304	56	248
25	57	18	39	57	18	39							206	50	156
26	115	25	90	93	23	70	22	2	20				430	70	360
27	0	0	0	0	0	0	11	1	10	0	0	0	0	0	0
28	45	4	41	15	4	11				30	0	30	175	11	164
29	53	13	40	42	12	30	11	1	10				196	36	160
30 & 32	102	20	82	78	19	59	11	1	10	13	0	13	384	5,628	328
31	49	12	37	39	12	27				10	0	10	182	34	148
34	97	20	77	65	15	50	32	5	27				364	56	308
Girard	90	27	63	59	25	34	31	2	29				328	75	252
23	55	23	32	45	22	23	10	1	9				192	64	128
24 (part)	35	4	31	14	3	11	21	1	20				135	11	124
Otter Tail	562	192	370	468	183	285	64	7	57	30	2	28	2,019	539	1,480
7 (part)	31	12	19	31	12	19							110	34	76
8	26	10	16	26	10	16							92	28	64
9	20	8	12	20	8	12							70	22	48
10	12	3	9	12	3	9							45	9	36
11	112	42	70	100	40	60	11	1	10	1	1	0	398	118	280
12	74	26	48	64	26	38				10	0	10	265	73	192
13	45	15	30	34	14	20	11	1	10				162	42	120
14	12	4	8	11	3	8				1	1	0	43	11	32
15	34	14	20	34	14	20							119	39	80
16	32	14	18	32	14	18							111	39	72
17	30	3	27	12	3	9				18	0	18	117	9	108
18	17	3	14	6	2	4	11	1	10				65	9	56
19	26	10	16	26	10	16							92	28	64
20	40	13	27	29	12	17	11	1	10				144	36	108
21 (part)	51	15	36	31	12	19	20	3	17				186	42	144
Otter Tail Village	82	76	6	82	76	6	—	—	—	—	—	—	182	152	30
TOTAL	2,102	666	1,436	1,706	609	1,087	289	29	260	117	28	89	7,555	1,805	5,750

(1) Nursing homes; trailer parks; stores; inns and restaurants.

Source: WAPORA, Inc., 1978.

Code: t = total
p = permanent
s = seasonal

APPENDIX G

LETTER FROM MICHLOVIC

moorhead state university
moorhead, minnesota 56560

Department of Sociology and Anthropology

June 16, 1978

Mark Oakman
Wapora
6900 Wisconsin Ave. NW
Washington, D.C. 20015

Dear Mr. Oakman:

Earlier this week you phoned me about the possible impact certain construction activity would have on archaeological materials in the Lake Ottertail region of Minnesota. Based on my own experience in the archaeology of western Minnesota, and the Ottertail Lake area specifically, I would like to offer the following comments. I hope they are of some use in your evaluation of the environmental impact proposed construction activity might have.

During the summer of 1977 a crew from Moorhead State University, directed by myself, conducted salvage operations at the Dead River site, situated at the mouth of the Dead River on the north shore of Ottertail Lake. Although the site was heavily disturbed by modern occupations, an abundance of prehistoric artifacts and ecofacts were recovered, most of which related to a Blackduck component dated to A.D. 885. Middle Woodland and Initial Middle Missouri influences were also identified at the site. These finds were somewhat surprising since our initial expectations at Dead River were that we would find evidence of a Kathio (Mille Lacs) occupation. The components at Dead River represent an unusual southward extension of Blackduck, and a northeastward penetration of a variant of the Initial Middle Missouri tradition. Previous work around Ottertail at the Morrison Mounds produced a Malmo component, extruded from the east-central Minnesota region and a site at Maplewood Park, northwest of the Lake, yielded evidence of a Kathio occupation (a successor to Malmo in the Mille Lacs area). Since a great deal of archaeological work has not been done in the Ottertail area, and since the few excavations conducted indicate a surprising range of cultural materials, it is difficult to predict exactly what archaeological resources are present. In my own opinion, large scale land disturbance activities would certainly endanger more than a few culturally unique sites, and many others that belong to cultures already known from the region but which are only partially understood. I might also mention that this particular region of Minnesota has a certain theoretical interest to prehistorians insofar as it abuts two major environmental zones--the prairie to the west and forests to the east. The kinds of cultural adaptations effected by aboriginal populations in this sort of situation can be of tremendous scientific value.

In sum, the Ottertail Lake region is quite rich archaeologically, and excavations in that area so far have provided a complex picture of prehistoric cultural events and processes. Until more sites are excavated and analysed it is likely that additional site discoveries will continue to alter our understanding of the prehistory of the Ottertail area.

Sincerely,

Michael G. Michlovic

Michael G. Michlovic
Assistant Professor,
Anthropology

APPENDIX H

FLOW REDUCTION DEVICES

Incremental Capital Costs of Flow Reduction in the Otter Tail Study Area

Dual-cycle toilets:

$20/toilet x 2 toilets/permanent dwelling x 666 permanent dwellings in year 2000	=	$26,640
$20/toilet x 1 toilet/seasonal dwelling x 1705 seasonal dwellings in year 2000	=	34,120
Shower flow control insert device:		
$2/shower x 2 shower/permanent dwelling x 666 permanent dwellings in year 2000	=	2,664
$2/shower x 1 shower/seasonal dwelling x 1706 seasonal dwellings in 2000	=	3,412
Faucet flow control insert device:		
$3/faucet x 3 faucets/permanent dwelling x 666 permanent dwellings in year 2000	=	5,994
$2/faucet x 2 faucets/seasonal dwelling x 1706 seasonal dwellings in 2000	=	6,824
Total		$79,654

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

Flow Reduction and Cost Data for Water Saving Devices

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

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

APPENDIX I

ON-SITE SYSTEMS

SUGGESTED PROCEDURES AND CRITERIA FOR DESIGNING COLLECTOR SEWAGE SYSTEMS
(For Discussion at the 1978 Home Sewage Treatment Workshops)

Roger E. Machmeier
Extension Agricultural Engineer
University of Minnesota

1. For collector systems serving more than 15 dwellings or 5,000 gallons per day, whichever is less, an application for a permit must be submitted to the Minnesota Pollution Control Agency. If the Agency does not act within 10 days upon receipt of the application, no permit shall be required.

2. A permit likely will be required by the local unit of government and they should be involved in preliminary discussions and design considerations.

3. Estimating sewage flows:

   A. Classify each home as type I, II, III, or IV. (See table 4, Extension Bulletin 304, "Town and Country Sewage Treatment.)

   B. Determine the number of bedrooms in each home and estimate the individual sewage flows.

   C. Total the flows to determine the estimated daily sewage flow for the collector system. Add a 3-bedroom type I home for each platted but undeveloped lot.

   D. For establishments other than residences, determine the average daily sewage flow based on water meter readings or estimate the flow based on data furnished by the Minnesota Department of Health or Pollution Control Agency. See Workbook pages I-2, I-3 and I-4.

   Note: Always install a water meter on any establishment other than a private residence and maintain a continuous record of the flow of sewage.

4. Whenever possible, transport or pump septic tank effluent over long distances rather than raw sewage.

5. Each residence should have a septic tank so that solids are separated and effluent only flows in the collector line.

6. Size individual septic tanks according to the recommendations of WPC-40 or local ordinances.

7. If a common septic tank is used, the minimum capacity should be at least 3,000 gallons and compartmented if a single tank.

8. The diameter and grade of the collector sewer line should be based on a flow equal to 35 percent of the flow quantities in Point 3 occurring in a one-hour period.

9. When raw sewage flows in the collector line, the diameter and grade of the sewer pipe must be selected to provide a mean velocity of not less than 2 feet per second when flowing full (0.7% for 4-inch and 0.4% for 6-inch). The maximum grade on 4-inch should be no more than 1/4-inch per foot (2%) to prevent the liquids from flowing away from the solids.

10. A gravity collector line, whether for raw sewage or sewage tank effluent, shall not be less than 4 inches in diameter.

11. Cleanouts, brought flush with or above finished grade, shall be provided wherever an individual sewer line joins a collector sewer line, or every 100 feet, whichever is less, unless manhole access is provided.

12. The pumping tank which collects sewage tank effluent should have a pumpout capacity of 10 percent of the estimated daily sewage flow plus a reserve storage capacity equal to at least 25 percent of the average daily sewage flow.

13. The pumping tank should have a vent at least 2 inches in diameter to allow air to enter and leave the tank during filling and pumping operations.

14. The pumping tank should have manhole access for convenient service to the pumps and control mechanisms.

15. The pumping tank must be watertight to the highest known or estimated elevation of the groundwater table. Where the highest elevation of the groundwater table is above the top of the pumping tank, buoyant forces shall be determined and adequate anchorage provided to prevent tank flotation.

16. Pumps for sewage tank effluent:

    A. There should be dual pumps operating on an alternating basis. The elevation of the liquid level controls should be adjustable after installation of the pumps in the pumping tank.

    B. Each pump should be capable of pumping at least 25 percent of the total estimated daily sewage flow in a one-hour period at a head adequate to overcome elevation differences and friction losses.

    C. The pumps should either be cast iron or bronze fitted and have stainless steel screws or be of other durable and corrosion-proof construction.

    D. A warning device should be installed to warn of the failure of either pump. The warning device should actuate both an audible and visible alarm. The alarm should continue to operate until manually turned off. The alarm should be activated each time either pump does not operate as programmed.

    E. A pump cycle counter (cost approximately $10) should be installed to monitor the flow of sewage. The number of pump cycles multiplied by the gallons discharged per dose will provide an accurate measurement of sewage flow.

17. Some site conditions may dictate that all or part of the sewage be pumped as raw sewage. The following recommendations should be followed:

    A. When the raw sewage is pumped from 2 or more residences or from an establishment other than a private residence, dual sewage grinder pumps should be used. The pumps should operate on an alternate basis and have a visible and audible warning device which should be automatically activated in the event of the failure of either pump to operate as programmed.

B. The pumps should either be cast iron or bronze fitted and have stainless steel screws or be of other durable and corrosion-proof construction.

C. To minimize physical agitation of the septic tank into which the raw sewage is pumped, a pumping quantity not in excess of 5 percent of the initial liquid volume of the septic tank shall be delivered for each pump cycle and a pumping rate not to exceed 25 percent of the total estimated daily sewage flow occurring in one hour.

D. The diameter of the pressure pipe in which the raw sewage flows shall be selected on the basis of a minimum flow velocity of 2.0 feet per second.

E. The discharge head of the pump shall be adequate to overcome the elevation difference and all friction losses.

F. The diameter of the pressure pipe for the sewage shall be at least as large as the size of sewage solids the pump can deliver.

18. In some cases a pressure main may be the most feasible method to collect septic tank effluent.

A. Each residence or other establishment has a septic tank and a pumping station.

B. The required discharge head of the pump depends upon the pressure in the collector main. The hydraulics of flow and friction loss must be carefully calculated.

C. The pressure main does not need to be installed on any grade but can follow the natural topography at a depth sufficient to provide protection against freezing.

D. A double checkvalve system should be used at each pumping station.

E. A corporation stop should be installed on the individual pressure line near the connection to the main pressure line.

F. Cleanouts along the pressure main are not required.

G. Discharge the pumped septic tank effluent into a settling tank prior to flow into the soil treatment system. The settling tank will serve as a stilling chamber and also separate any settleable solids.

19. Sizing the soil treatment unit:

A. Make soil borings in the area proposed for the soil treatment unit at least 3 feet deeper than the bottom of the proposed trenches. Look for mottled soil or other evidences of seasonal high water table in the soil.

B. Make 3 percolation tests in each representative soil present on the site.

C. Using the percolation rate of the soil and the sewage flow estimate from point 3, refer to table III of WPC-40 or table 4 of Extension Bulletin 304, "Town and Country Sewage Treatment" to determine the total required trench bottom area.

20. Lay out the soil treatment unit using trenches with drop box distribution of effluent, so only that portion of the trench system which is needed will be used. Drop boxes also provide for automatic resting of trenches as sewage flow fluctuates or as soil absorption capacity varies with amount of soil moisture. Trenches can extend 100 feet each way from a drop box so that a single box can distribute effluent to 200 feet of trench.

Department of
LAND & RESOURCE MANAGEMENT
COUNTY OF OTTER TAIL
Phone 218–739–2271
Court House
Fergus Falls, Minnesota 56537
MALCOLM K. LEE, Administrator

October 18, 1978

Ms. Rhoda Granat, Librarian
Wapora, Inc.
6900 Wisconsin Ave. N.W.
Washington, D.C. 20015

Dear Ms. Granat:

Enclosed is some of the material we have available on cluster or collector systems. Otter Tail County now has upwards of twenty similar systems in operation at this time and we are pleased with the results for several reasons. Our two main concerns are that of treatment and reasonability of cost. We feel that a properly designed, installed and maintained septic system meets both of these criteria. Based on test results provided by Roger Machmeier, Extension Agricultural Engineer, University of Minnesota we feel that adequate treatment is obtained. Costs of installing a septic system are not a huge burden on the landowner. Currently a system consisting of a septic tank and drainfield can be installed, by a competent contractor, for $800 - $1200. If a pump is required the cost may be in the $1500 range which we feel is not unreasonable. It has been our experience that the individual cost in a collector system usually is equal to or less than that of having an independent septic system. In speaking with Mike Hansel, MPCA we have also learned that funding would be available for collector systems which would further ease the landowner's cost burden.

Our office along with a sizeable portion of those people that would be affected directly have some serious concerns regarding a "municipal type" sewage system being installed and operated in the proposed area. The first that comes to mind, is cost - it will certainly be high and were not sure that the amount projected includes the dewatering that would be necessary to install the gravity mains. The elevation of a fair percentage of the district does not even have the elevation required for a drainfield and the installation of sewer mains in this area would certainly necessitate their being placed directly in the ground water table, which brings up further concerns of seepage, leekage, etc.

Another concern is that of volume. Not being a professional engineer, it doesn't seem either feasible or reasonable that a municipal type system designed for over 1,000 dwellings would have adequate flowage in the winter months for the 150 or so residents, without pumping additional water through the system. The desirability and source of a water supply for such a purpose might in itself be questionable since lake lavels are a volatile issue in themselves.

It is our opinion that a number of cluster or collection systems combined with some independent septic systems meet the needs of adequate treatment at a reasonable cost. This opinion is also shared by the University of Minnesota Extension Engineer and the Minnesota Pollution Control Agency. While there is evidence of a pollution problem in the project area now we are also concerned with long range problems and feel that the "Collector systems" are feasible for many reasons and bear detailed investigation and study.

Sincerely,

Larry Krohn
Administrative Assistant
Land & Resource Management

lmb

cc: Arnold Hemquist
John Rist, P.E.

APPENDIX J

MANAGEMENT OF SMALL WASTE FLOWS DISTRICTS

MANAGEMENT CONCEPTS FOR SMALL WASTE FLOW DISTRICTS

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

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

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

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

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

LEGISLATION BY STATES AUTHORIZING MANAGEMENT OF SMALL WASTE FLOW DISTRICTS

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

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

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

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

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

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

SOME MANAGEMENT AGENCIES FOR DECENTRALIZED FACILITIES

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

Westboro (Wisconsin Town Sanitary District)

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

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

Washington State

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

Georgetown Divide (California) Public Utility District (GDPUD)

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

Santa Cruz County (California) Septic Tank Maintenance District

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

Bolinas Community (California) Public Utility District (BCPUD)

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

Kern County (California) Public Works

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

Marin County (California)

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

APPENDIX K

COST AND FINANCING

DESIGN AND COSTING ASSUMPTIONS

(1) Spray Irrigation, Rapid Infiltration

- Pretreatment for spray irrigation and rapid infiltration includes preliminary treatment units (bar screens, grit removal) and stabilization lagoons. Storage of this pretreated wastewater is provided by conventional (deep) lagoons.

- Chlorination of wastewater is required prior to land treatment.

- Application system capacities are based on an effective use period of 150 days, based on the 210 day storage required by MPCA.

- Application rates are 2 in/day for spray irrigation and 12 in/week for rapid infiltration.

- Spray irrigation application is based on using alfalfa cover crop.

- Two land application sites were examined: one about 1/3 mile west of Otter Tail in Amor Township; the second about 2000 feet south of Otter Tail Lake in Section 32 of Otter Tail Township.

(2) Prefabricated Contact Stabilization Plant

- Costs were based on areawide costs for similar facilities.

- Selected site for treatment plant was 1 mile west of Otter Tail Lake, about 300 feet north of Otter Tail River.

- Alum and polymer were assumed to be added to aid in settling and to obtain the phosphorus limitation of 1.0 mg/1.

- Dechlorination provided because of the potential requirement for effluent limitations on residual chlorine.

- The capital cost of installing a modular design, as opposed to a single unit plant, has been incorporated into the treatment costs using costs for 2 prefabricated plants of 0.25 mgd each.

(3) Cluster Systems

- The design and costs for wastewater treatment utilizing cluster systems were developed based on a "typical" system with 25 homes per cluster.

- Design assumptions:

  - flow - 60 gpcd - peak flow 45 gpm

  - 3.7 persons/home - 3-bedroom home

- 25% of existing septic tanks need to be replaced with new 1000-gallon tanks.

- Collection of wastewaters is by gravity to a pump station.

- 750-foot transmission (2 1/2 inch force main) to absorption field assumed.

- Pump Station (30 gpm)required for transmission, 30-foot static head assumed from pump station to distribution box.

Collection

- All sewer lines are to be placed at or below 8 feet of depth to allow for frost penetration in the Otter Tail Lake area. Gravity lines are assumed to be placed at an average depth of 15 feet.

- Shoring of gravity collection lines was determined on a segment basis. Ten percent less shoring is required for force mains and low pressure sewers due to their shallow average depth.

- A minimum velocity of 2 fps will be maintained in all pressure sewer lines and force mains to provide for scouring.

- An even distribution of population was assumed along collection lines for all alternatives indicated.

- A peaking factor for design flows of the various systems investigated was based on the Ten State Standards in concurrence with the Otter Tail Lake Facility Plan.

- All pressure sewer lines and force mains 8 inches in diameter or less will be PVC SDR26, with a pressure rating of 160 psi. Those force mains larger than 8 inches in diameter will be constructed or ductile iron with mechanical joints.

- Cleanouts in the pressure sewer system will be placed at the beginning of each line, and one every 500 feet of pipe in line. Cleanout value boxes will contain shut-off valves to provide for isolation of various sections of line for maintenance and/or repairs.

- Individual pumping units for the pressure sewer system include a 2- by 8-foot basin with discharge at 6 feet, control panel, visual alarm, mercury float level controls, valves, rail system for removal of pump, antifloatation device, and the pump itself. Effluent pumps are 1-1/2 and 2 HP pumps which reach a total dynamic head of 80 and 120 feet respectively.

- All flows are based on a 60 gallon per capita day (gpcd) design flow for residential areas. Infiltration for new sewers is based on a rate of 200 gallons per inch - mile of gravity sewer lines.

- The costs presented for each alternate are comparable costs to each other. However, the costs generated may not reflect actual construction costs due to the degree of accuracy utilized in preparation of these estimates.

Analysis of Cost Effectiveness

- Quoted costs are in 1978 dollars
- EPA Sewage Treatment Plant (STP) Index of 135 (rth Quarter 1977) and Engineering News Record Index of 2693 (1 March 1978) used for updating costs.
- i, interest rate = 6-5/8%
- Planning period = 20 years
- Life of facilities, structures - 50 years
  Mechanical components - 20 years
- Straight line depreciation
- Land for land application site valued at $1000/acre.

PROJECT COSTS
FACILITY PLAN PROPOSED ACTION

OTTER TAIL LAKE
COST ESTIMATE

Alternative Proposed Action
Q = 0.50 mgd

Costs in $1978
x 1,000

	Spray Irrigation On West Shore		
	Capital Costs	O&M Costs	Salvage Value
Influent pumping	77.00	2.00	25.41
Influent pipe	159.81	0.20	95.89
Preliminary treatment	29.70	3.60	13.40
Distribution pumping	79.65	1.64	37.44
Stabilization pond	412.50	22.40	247.50
Field clearing	60.75	---	---
Field leveling	31.05	---	18.63
Distribution (center pivot)	66.15	13.20	31.09
Admin & Lab	56.70	3.77	27.22
Monitoring wells	11.88	1.53	5.70
Roads & fences	63.45	1.14	18.63
Land (200 acres)	200.00	---	361.23
Crop revenue	---	(-9.90)	---
Chlorination	28.60	3.00	11.13
Subtotal	$1,277.24	$42.58	$ 893.27
Engr., Contg., etc.	319.31	---	178.65
TOTAL	$1,596.55	$42.58	$1,071.92

PROJECT COSTS
FACILITY PLAN PROPOSED ACTION

OTTER TAIL LAKE - COLLECTION
COST ESTIMATE

Proposed Alternative

Costs in 1978 Dollars x $1,000

SERVICE AREA	CAPITAL COSTS	O&M COSTS	SALVAGE VALUE
1980			
Entire Service Area	6,839.93	50.66	2,808.60
25% Engineering Contingencies	1,709.98		561.72
TOTAL	$8,549.91	$50.66	$3,370.32
1980 - 2000			
Entire Service Area	31.17/yr.		
25% Engineering Contingencies	7.79		
TOTAL	$ 38.96/yr.		

PROJECT COSTS
FACILITY PLAN PROPOSED ACTION

ECONOMIC ANALYSIS OF ALTERNATIVE
($1,000)

Proposed Alternate

					PRESENT WORTH				
ALTERNATE ITEM	YEAR	CAPITAL DOLLARS	O&M DOLLARS	SALVAGE VALUE	(1) CAPITAL DOLLARS	(2) O&M DOLLARS	(3) SALVAGE VALUE	TOTAL PRESENT WORTH (1+2+3)	EQUIVALENT COST
Treatment	1980	$1,596.60	$42.60	$1,071.90	$1,596.60	$464.80	$297.10	$ 1,764.30	
Collection	1980	$8,549.90	$50.70	$3,370.30	$8,549.90	$533.10	$934.20	$ 8,168.80	
Collection	2000	$ 39.00/yr.	-	-	$ 425.50	-	-	$ 425.50	
								$10,358.60	$948.80

LIMITED ACTION ALTERNATIVE

Costs in 1978 Dollars
x $1,000

ITEM	CAPITAL COSTS	O&M COSTS		SALVAGE VALUE
1980				
Replace Septic System	473.3	15.0		59.6
Install Mound System	166.4	1.5		6.0
Holding Tanks	25.7	14.9		15.4
H_2O_2 Treatment	74.9	---		---
Grey Water (ST/SAS)	218.9	6.9		109.9
Black Water	1,643.5	112.4		621.9
Subtotal	$2,602.7	$150.7		$ 812.8
25% Engr. & Contg.	650.7	---		203.2
TOTAL	$3,253.4	$150.7		$1,016.0
1980 - 2000				
Septic System	39.4/yr.	11.5/yr.	÷ 20 = 0.58	314.8
Mounds	6.8/yr.	0.62/yr.	= 0.03	54.3
Holding Tanks	1.1/yr.	6.1/yr.	= 0.31	8.5
Grey Water	48.1/yr.	3.5/yr.	= 0.18	74.6
Black Water	87.2/yr.	64.2/yr.	= 3.21	422.4
Subtotal	$182.6/yr.	85.9/yr.	4.3*	$ 874.6
25% Engr. & Contg.	45.7	---		218.7
TOTAL	$228.3/yr.	$85.9/yr.	4.3*	$1,093.3

*Gradient per year/20 years.

LIMITED ACTION ALTERNATIVE

ECONOMIC ANALYSIS OF ALTERNATIVE
($1,000)

ALTERNATE ITEM	YEAR	CAPITAL DOLLARS	O&M DOLLARS	SALVAGE VALUE	(1) CAPITAL DOLLARS	(2) O&M DOLLARS	(3) SALVAGE VALUE	TOTAL PRESENT WORTH (1+2+3)	AVERAGE ANNUAL EQUIVALENT COST
Collection	1980	$3,253.4	$150.7	$1,016.0	$3,253.4	$1,644.0	$281.6	$4,615.8	
Collection	2000	$ 228.3/yr.	$ 4.3*	$1,093.3	$2,490.5	$ 349.0	$343.6	$2,536.4	
								$7,152.2	$655.9

*Gradient per year/20 years.

EIS ALTERNATIVE 2
RAPID INFILTRATION

OTTER TAIL LAKE
COST ESTIMATE

Alternative 2A
Q = 0.18 mgd

Costs in $1978
x 1,000

	North and West Shore Rapid Infiltration		
	Capital Costs	O&M Costs	Salvage Value
Influent pumping	26.95	1.50	8.89
Influent pipe	98.00	0.20	58.80
Preliminary treatment	13.00	2.00	5.87
Distribution pumping	64.80	0.80	30.46
Stabilization pond	110.00	10.20	66.00
Field clearing	4.73	---	---
Field leveling	---	---	---
Distribution (rapid-infilt.)	19.58	2.35	9.20
Recovery wells	8.78	0.80	4.21
Admin & Lab	52.65	2.47	25.27
Monitoring wells	2.43	0.03	1.17
Roads & fences	15.00	0.40	5.27
Land (47 acres)	47.00	---	---
Crop revenue	---	---	---
Chlorination	---	---	---
Effluent pipe	146.00	0.60	87.60
Subtotal	$608.92	$21.35	$387.62
Engr., Contg., etc.	157.48	---	77.52
TOTAL	$761.15	$21.35	$465.14

EIS ALTERNATIVE 2
RAPID INFILTRATION

OTTER TAIL LAKE
COST ESTIMATE

Alternative 2A
Q = 0.12 mgd

Costs in $1978
x 1,000

	South Shore Rapid Infiltration		
	Capital Costs	O&M Costs	Salvage Value
Influent pumping	17.60	1.40	5.81
Influent pipe	61.30	0.10	36.80
Preliminary treatment	13.00	2.00	5.87
Distribution pumping	55.35	0.41	26.02
Stabilization pond	66.00	7.20	39.60
Field clearing	4.30	---	---
Field leveling	---	---	---
Distribution (rapid infilt.)	14.85	1.85	6.78
Recovery wells	8.51	0.55	4.08
Admin & Lab	51.30	1.99	24.63
Monitoring wells	2.43	0.03	1.17
Roads & fences	12.83	0.41	2.40
Land (37 acres)	37.00	---	66.82
Chlorination	---	---	---
Effluent pipe & outfall	77.30	0.30	46.40
Subtotal	$421.77	$16.24	$266.58
Engr., Contg., etc.	105.44	---	53.31
TOTAL	$527.21	$16.24	$319.90

EIS ALTERNATIVE 2
RAPID INFILTRATION

OTTER TAIL LAKE - COLLECTION
COST ESTIMATE

2.2

Costs in 1978 Dollars
x $1,000

SERVICE AREA	CAPITAL COSTS	O&M COSTS	SALVAGE VALUE
1980			
Small Flow System, S.E.	1,474.52	18.44	421.57
Small Flow System, W.	1,974.90	26.23	523.94
Cluster Systems	2,118.72	43.14	757.00
On-Site, ST-SAS	158.40	8.87	17.23
Subtotal	5,726.54	96.68	1,719.74
25% Engineering Contingencies	1,431.64		343.95
TOTAL	$7,158.18	$96.68	$2,063.69
2000			
Small Flow System, S.E.	20.00	0.32	130.30
Small Flow System, W.	24.55	0.37	150.69
Cluster Systems	37.07	0.80	388.86
On-Site, ST-SAS	4.67	0.19	16.06
Subtotal	86.29/yr.	1.68*	685.91
25% Engineering Contingencies	21.57		137.18
TOTAL	$ 107.86/yr.	$ 1.68*	$ 823.09

* Gradient per year over 20 years.

EIS ALTERNATIVE 2
RAPID INFILTRATION

ECONOMIC ANALYSIS OF ALTERNATIVE
($1,000)

2.3

					PRESENT WORTH				
ALTERNATE ITEM	YEAR	CAPITAL DOLLARS	O&M DOLLARS	SALVAGE VALUE	(1) CAPITAL DOLLARS	(2) O&M DOLLARS	(3) SALVAGE VALUE	TOTAL PRESENT WORTH (1+2+3)	AVERAGE ANNUAL EQUIVALENT COST
Treatment	1980	$ 761.20	$21.40	$ 465.10	$ 761.20	$ 233.50	$128.90	$ 825.80	
Treatment	1980	$ 527.20	$16.20	$ 319.90	$ 527.20	$ 176.70	$ 88.70	$ 615.20	
Collection	1980	$7,158.20	$96.70	$2,063.70	$7,158.20	$1,054.80	$572.10	$ 7,640.90	
Collection	2000	$ 107.90/yr.	$ 1.70*	$ 823.10	$1,177.20	$ 138.00	$228.20	$ 1,087.00	
								$10,168.90	$931.50

* Gradient per year over 20 years.

EIS ALTERNATIVE 2
SPRAY IRRIGATION

OTTER TAIL LAKE
COST ESTIMATE

Alternative 2
Q = 0.18 mgd

Costs in $1978
x 1,000

	North and West Shore Spray Irrigation		
	Capital Costs	O&M Costs	Salvage Value
Influent pumping	26.95	1.50	8.89
Influent pipe	98.00	0.20	58.80
Preliminary treatment	13.00	2.00	5.87
Distribution pumping	64.80	0.80	30.46
Stabilization pond	110.00	10.20	66.00
Field clearing	24.30	---	---
Field leveling	13.77	---	8.26
Distribution (center pivot)	35.10	7.42	16.50
Admin & Lab	52.65	2.47	25.27
Monitoring wells	6.08	0.08	2.92
Roads & fences	35.10	0.76	11.34
Land (88 acres)	88.00	---	158.94
Crop revenue	---	(-3.64)	---
Chlorination	10.56	1.90	4.11
Subtotal	$578.31	$23.69	$379.36
Engr., Contg., etc.	114.58	---	79.47
TOTAL	$722.89	$23.69	$476.83

EIS ALTERNATIVE 2
SPRAY IRRIGATION

OTTER TAIL LAKE
COST ESTIMATE

Alternative 2
Q = 0.12 mgd

Costs in $1978
x 1,000

	South Shore Spray Irrigation		
	Capital Costs	O&M Costs	Salvage Value
Influent pumping	17.60	1.40	5.81
Influent pipe	61.30	0.10	36.80
Preliminary treatment	13.00	2.00	5.87
Distribution pumping	55.35	0.41	26.02
Stabilization pond	66.00	7.20	39.60
Field clearing	16.20	---	---
Field leveling	19.13	---	6.20
Distribution (center pivot)	27.68	4.25	13.01
Admin & Lab	51.30	1.99	24.63
Monitoring wells	6.08	0.08	2.92
Roads & fences	28.35	0.61	8.10
Land (64 acres)	64.00	---	115.59
Crop revenue	---	(-2.34)	---
Chlorination	7.15	1.80	2.78
Subtotal	$424.14	$17.50	$287.15
Engr., Contg., etc.	106.04	---	57.43
TOTAL	$530.18	$17.50	$344.58

EIS ALTERNATIVE 2
SPRAY IRRIGATION

OTTER TAIL LAKE - COLLECTION
COST ESTIMATE

2.2

Costs in 1978 Dollars
x $1,000

SERVICE AREA	CAPITAL COSTS	O&M COSTS	SALVAGE VALUE
1980			
Small Flow System, S.E.	1,474.52	18.44	421.57
Small Flow System, W.	1,974.90	26.23	523.94
Cluster Systems	2,118.72	43.14	757.00
On-Site, ST-SAS	158.40	8.82	17.23
Subtotal	5,726.54	96.68	1,719.74
25% Engineering Contingencies	1,431.64		343.95
TOTAL	$7,158.18	$96.68	$2,063.69
2000			
Small Flow System, S.E.	20.00	0.32	130.30
Small Flow System, W.	24.55	0.37	150.69
Cluster Systems	37.07	0.80	388.86
On-Site, ST-SAS	4.67	0.19	16.06
Subtotal	86.29/yr.	1.68*	685.91
25% Engineering Contingencies	21.57		137.18
TOTAL	$ 107.86/yr.	$ 1.68*	$ 823.09

* Gradient per year over 20 years.

EIS ALTERNATIVE 2
SPRAY IRRIGATION

ECONOMIC ANALYSIS OF ALTERNATIVE
($1,000)

2.3

					PRESENT WORTH				
ALTERNATE ITEM	YEAR	CAPITAL DOLLARS	O&M DOLLARS	SALVAGE VALUE	(1) CAPITAL DOLLARS	(2) O&M DOLLARS	(3) SALVAGE VALUE	TOTAL PRESENT WORTH (1+2+3)	AVERAGE ANNUAL EQUIVALENT COST
Treatment	1980	$ 722.90	$23.70	$ 476.80	$ 722.90	$ 258.60	$132.20	$ 849.30	
Treatment	1980	$ 530.20	$17.50	$ 344.60	$ 530.20	$ 190.90	$ 95.52	$ 625.60	
Collection	1980	$7,158.20	$96.20	$2,063.70	$7,158.20	$1,054.80	$572.10	$ 7,640.90	
Collection	2000	$ 107.90/yr.	$ 1.70*	$ 823.10	$1,177.20	$ 138.00	$228.20	$ 1,087.00	
								$10,202.80	$934.60

* Gradient per year over 20 years.

EIS ALTERNATIVE 1
RAPID INFILTRATION

OTTER TAIL LAKE
COST ESTIMATE

Alternative 1A
Q = 0.12 mgd

Costs in $1978
x 1,000

	South Shore Rapid Infiltration		
	Capital Costs	O&M Costs	Salvage Value
Influent pumping	17.60	1.40	5.81
Influent pipe	61.30	0.10	36.80
Preliminary treatment	13.00	2.00	5.87
Distribution pumping	55.35	0.41	26.02
Stabilization pond	66.00	7.20	39.60
Field clearing	4.30	---	---
Field leveling	---	---	---
Distribution (rapid infilt.)	14.85	1.85	6.78
Recovery wells	8.51	0.55	4.08
Admin & Lab	51.30	1.99	24.63
Monitoring wells	2.43	0.03	1.17
Roads & fences	12.83	0.41	2.40
Land (37 acres)	37.00	---	66.82
Chlorination	---	---	---
Effluent pipe & outfall	77.30	0.30	46.40
Subtotal	$421.77	$16.24	$266.58
Engr., Contg., etc.	105.44	---	53.31
TOTAL	$527.21	$16.24	$319.90

EIS ALTERNATIVE 1
RAPID INFILTRATION

OTTER TAIL LAKE - COLLECTION
COST ESTIMATE

1.2

Costs in 1978 Dollars
x $1,000

SERVICE AREA	CAPITAL COSTS	O&M COSTS	SALVAGE VALUE
1980			
Small Flow System, S.E.	1,474.52	18.44	421.57
Cluster Systems	3,346.81	71.23	1,148.51
On-Site, ST-SAS	470.22	27.20	67.04
Subtotal	5,291.55	116.87	1,637.12
25% Engineering Contingencies	1,322.89		327.42
TOTAL	$6,614.44	$116.87	$1,964.54
2000			
Small Flow System, S.E.	20.00	0.32	130.30
Cluster Systems	69.51	1.46	649.95
On-Site, ST-SAS	14.39	0.57	49.48
Subtotal	103.90/yr.	2.35*	829.73
25% Engineering Contingencies	25.98		165.95
TOTAL	$ 129.88/yr.	$ 2.35*	$ 995.68

* Gradient per year over 20 years.

EIS ALTERNATIVE 1
RAPID INFILTRATION

ECONOMIC ANALYSIS OF ALTERNATIVE
($1,000)

1.3

ALTERNATE ITEM	YEAR	CAPITAL DOLLARS	O&M DOLLARS	SALVAGE VALUE	PRESENT WORTH (1) CAPITAL DOLLARS	(2) O&M DOLLARS	(3) SALVAGE VALUE	TOTAL PRESENT WORTH (1+2+3)	AVERAGE ANNUAL EQUIVALENT COST
Treatment	1980	$ 527.20	$ 16.20	$ 319.90	$ 527.20	$ 176.70	$ 88.70	$ 615.20	
Collection	1980	$6,614.40	$116.90	$1,964.50	$6,614.40	$1,275.40	$544.60	$7,345.20	
Collection	2000	$ 129.90/yr.	$ 2.40*	$ 995.70	$1,417.20	$ 194.80	$276.00	$1,336.00	
								$9,296.40	$851.60

* Gradient per year over 20 years.

EIS ALTERNATIVE 1
SPRAY IRRIGATION

OTTER TAIL LAKE
COST ESTIMATE

Alternative 1
Q = 0.12 mgd

Costs in $1978
x 1,000

	South Shore Spray Irrigation		
	Capital Costs	O&M Costs	Salvage Value
Influent pumping	17.60	1.40	5.81
Influent pipe	61.30	0.10	36.80
Preliminary treatment	13.00	2.00	5.87
Distribution pumping	55.35	0.41	26.02
Stabilization pond	66.00	7.20	39.60
Field clearing	16.20	---	---
Field leveling	19.13	---	6.20
Distribution (center pivot)	27.68	4.25	13.01
Admin & Lab	51.30	1.99	24.63
Monitoring wells	6.08	0.08	2.92
Roads & fences	28.35	0.61	8.10
Land (64 acres)	64.00	---	115.59
Crop revenue	---	(-2.34)	---
Chlorination	7.15	1.80	2.78
Subtotal	$424.14	$17.50	$287.15
Engr., Contg., etc.	106.04	---	57.43
TOTAL	$530.18	$17.50	$344.58

EIS ALTERNATIVE 1
SPRAY IRRIGATION

OTTER TAIL LAKE - COLLECTION
COST ESTIMATE

1.2

Costs in 1978 Dollars x $1,000

SERVICE AREA	CAPITAL COSTS	O&M COSTS	SALVAGE VALUE
1980			
Small Flow System, S.E.	1,474.52	18.44	421.57
Cluster Systems	3,346.81	71.23	1,148.51
On-Site, ST-SAS	470.22	27.20	67.04
Subtotal	5,291.55	116.87	1,637.12
25% Engineering Contingencies	1,322.89		327.42
TOTAL	$6,614.44	$116.87	$1,964.54
2000			
Small Flow System, S.E.	20.00	0.32	130.30
Cluster Systems	69.51	1.46	649.95
On-Site, ST-SAS	14.39	0.57	49.48
Subtotal	103.90/yr.	2.35*	829.73
25% Engineering Contingencies	25.98		165.95
TOTAL	$ 129.88/yr.	$ 2.35*	$ 995.68

* Gradient per year over 20 years.

EIS ALTERNATIVE 1
SPRAY IRRIGATION

ECONOMIC ANALYSIS OF ALTERNATIVE
($1,000)

1.3

ALTERNATE ITEM	YEAR	CAPITAL DOLLARS	O&M DOLLARS	SALVAGE VALUE	PRESENT WORTH (1) CAPITAL DOLLARS	(2) O&M DOLLARS	(3) SALVAGE VALUE	TOTAL PRESENT WORTH (1+2+3)	AVERAGE ANNUAL EQUIVALENT COST
Treatment	1980	$ 530.20	$ 17.50	$ 344.60	$ 530.20	$ 190.90	$ 95.50	$ 625.60	
Collection	1980	$6,614.40	$116.90	$1,964.50	$6,614.40	$1,275.40	$544.60	$7,345.20	
Collection	2000	$ 129.90/yr.	$ 2.40*	$ 995.70	$1,417.20	$ 194.80	$276.00	$1,336.00	
								$9,306.80	$852.50

* Gradient per year over 20 years.

EIS ALTERNATIVE 3
SPRAY IRRIGATION

OTTER TAIL LAKE
COST ESTIMATE

Alternative 3
Q = 0.30 mgd

Costs in $1978
x 1,000

	North and West Shore Spray Irrigation		
	Capital Costs	O&M Costs	Salvage Value
Influent pumping	46.20	1.70	15.25
Influent pipe	130.00	0.20	78.00
Preliminary treatment	15.95	2.70	7.20
Distribution pumping	68.85	1.11	32.36
Stabilization pond	214.50	16.80	128.70
Field clearing	36.45	---	---
Field leveling	20.25	---	12.15
Distribution (center pivot)	45.90	9.32	21.57
Admin & Lab	54.68	3.00	26.25
Monitoring wells	9.50	1.22	4.56
Roads & fences	45.90	1.01	13.77
Land (130 acres)	130.00	---	234.80
Crop revenue	---	(-5.99)	---
Chlorination	17.60	2.30	6.85
Subtotal	$ 835.78	$33.37	$581.46
Engr., Contg., etc.	208.95	---	116.29
TOTAL	$1,044.73	$33.37	$697.75

EIS ALTERNATIVE 3
SPRAY IRRIGATION

OTTER TAIL LAKE
COST ESTIMATE

Alternative 3
Q = 0.12 mgd

Costs in $1978
x 1,000

	South Shore Spray Irrigation		
	Capital Costs	O&M Costs	Salvage Value
Influent pumping	17.60	1.40	5.81
Influent pipe	61.30	0.10	36.80
Preliminary treatment	13.00	2.00	5.87
Distribution pumping	55.35	0.41	26.02
Stabilization pond	66.00	7.20	39.60
Field clearing	16.20	---	---
Field leveling	19.13	---	6.02
Distribution (center pivot)	27.68	4.25	13.01
Admin & Lab	51.30	1.99	24.63
Monitoring wells	6.08	0.08	2.92
Roads & fences	28.35	0.61	8.10
Land (64 acres)	64.00	---	115.59
Crop revenue	---	(-2.34)	---
Chlorination	7.15	1.80	2.78
Subtotal	$424.14	$17.50	$287.15
Engr., Contg., etc.	106.04	---	57.43
TOTAL	$530.18	$17.50	$344.58

EIS ALTERNATIVE 3
SPRAY IRRIGATION

OTTER TAIL LAKE - COLLECTION
COST ESTIMATE

3.2

Costs in 1978 Dollars
x $1,000

SERVICE AREA	CAPITAL COSTS	O&M COSTS	SALVAGE VALUE
1980			
Small Flow System, S.E.	1,474.52	18.44	421.57
Small Flow System, Largest	3,740.41	46.67	1,094.35
Cluster Systems	626.56	14.10	207.70
On-Site, ST-SAS	120.35	6.48	12.87
Subtotal	5,961.84	85.69	1,736.49
25% Engineering Contingencies	1,490.46		347.30
TOTAL	$7,452.30	$85.69	$2,083.79
2000			
Small Flow System, S.E.	20.00	0.32	130.30
Small Flow System, Largest	38.61	0.57	234.53
Cluster Systems	6.60	0.15	59.00
On-Site, ST-SAS	3.41	0.14	11.72
Subtotal	68.62/yr.	1.18*	435.55
25% Engineering Contingencies	17.16		87.11
TOTAL	$ 85.78/yr.	$ 1.18*	$ 522.66

* Gradient per year over 20 years.

EIS ALTERNATIVE 3
SPRAY IRRIGATION

ECONOMIC ANALYSIS OF ALTERNATIVE
($1,000)

3.3

					PRESENT WORTH				
ALTERNATE ITEM	YEAR	CAPITAL DOLLARS	O&M DOLLARS	SALVAGE VALUE	(1) CAPITAL DOLLARS	(2) O&M DOLLARS	(3) SALVAGE VALUE	TOTAL PRESENT WORTH (1+2+3)	AVERAGE ANNUAL EQUIVALENT COST
Treatment	1980	$ 530.20	$17.50	$ 344.60	$ 530.20	$190.90	$ 95.50	$ 625.60	
Treatment	1980	$1,044.70	$33.40	$ 697.80	$1,044.70	$364.40	$193.40	$ 1,215.70	
Collection	1980	$7,452.30	$85.70	$2,083.80	$7,452.30	$935.00	$577.60	$ 7,809.70	
Collection	2000	$ 85.80/yr.	$ 1.20*	$ 522.70	$ 936.10	$ 97.40	$144.90	$ 888.60	
								$10,539.60	$965.40

* Gradient per year over 20 years.

EIS ALTERNATIVE 4

OTTER TAIL LAKE
COST ESTIMATE

Alternative 4
Q = 0.34 mgd

Costs in $1978
x 1,000

	North and West Shore Spray Irrigation		
	Capital Costs	O&M Costs	Salvage Value
Influent pumping	51.70	1.80	17.06
Influent pipe	130.00	0.20	78.00
Preliminary treatment	18.70	2.80	8.44
Distribution pumping	71.55	1.24	33.63
Stabilization pond	225.50	18.30	135.30
Field clearing	43.20	---	---
Field leveling	24.30	---	14.58
Distribution (center pivot)	51.30	10.26	24.11
Admin & Lab	55.35	3.18	26.57
Monitoring wells	9.50	1.22	4.56
Roads & fences	51.30	1.09	15.39
Land (145 acres)	145.00	---	261.89
Crop revenue	---	(-6.83)	---
Chlorination	18.70	2.40	7.27
Subtotal	$ 896.10	$35.66	$626.80
Engr., Contg., etc.	224.03	---	125.36
TOTAL	$1,120.13	$35.66	$752.16

EIS ALTERNATIVE 4

OTTER TAIL LAKE
COST ESTIMATE

Alternative 4
Q = 0.16 mgd

Costs in $1978
x 1,000

	South Shore Spray Irrigation		
	Capital Costs	O&M Costs	Salvage Value
Influent pumping	24.20	1.40	7.99
Influent pipe	61.30	0.10	36.80
Preliminary treatment	13.00	2.00	5.87
Distribution pumping	60.75	0.69	28.56
Stabilization pond	95.70	10.20	57.42
Field clearing	21.60	---	---
Field leveling	10.01	---	6.01
Distribution (center pivot)	32.40	6.36	15.23
Admin & Lab	52.00	2.21	24.96
Monitoring wells	6.08	0.08	2.92
Roads & fences	30.38	0.53	10.53
Land (79 acres)	79.00	---	142.68
Crop revenue	---	(-3.13)	---
Chlorination	9.46	1.80	3.68
Subtotal	$495.88	$22.24	$342.65
Engr., Contg., etc.	123.97	---	68.53
TOTAL	$619.85	$22.24	$411.18

EIS ALTERNATIVE 4

OTTER TAIL LAKE - COLLECTION COST ESTIMATE

4.2

Costs in 1978 Dollars x $1,000

SERVICE AREA	CAPITAL COSTS	O&M COSTS	SALVAGE VALUE
1980			
Alt. #4 - East	1,988.14	25.83	593.26
Alt. #4 - West	4,564.74	56.69	1,367.90
Subtotal	6,552.88	82.52	1,961.16
25% Engineering Contingencies	1,638.22		392.23
TOTAL	$8,191.10	$82.52	$2,353.39
2000			
Alt. #4 - East	25.41	0.40	166.55
Alt. #4 - West	40.74	0.58	240.20
Subtotal	66.15/yr.	0.98*	406.75
25% Engineering Contingencies	16.54		81.35
TOTAL	$ 82.69/yr.	$ 0.98*	$ 488.10

* Gradient per year over 20 years.

EIS ALTERNATIVE 4

ECONOMIC ANALYSIS OF ALTERNATIVE
($1,000)

4.3

					PRESENT WORTH				
ALTERNATE ITEM	YEAR	CAPITAL DOLLARS	O&M DOLLARS	SALVAGE VALUE	(1) CAPITAL DOLLARS	(2) O&M DOLLARS	(3) SALVAGE VALUE	TOTAL PRESENT WORTH (1+2+3)	AVERAGE ANNUAL EQUIVALENT COST
Treatment	1980	$ 619.90	$22.20	$ 411.20	$ 619.90	$242.20	$114.00	$ 748.10	
Treatment	1980	$1,120.10	$35.70	$ 752.20	$1,120.10	$389.50	$208.50	$ 1,301.10	
Collection	1980	$8,191.10	$82.50	$2,353.40	$8,191.10	$900.00	$652.40	$ 8,438.70	
Collection	2000	$ 82.70/yr.	$ 1.00*	$ 488.10	$ 902.20	$ 81.20	$135.30	$ 848.10	
								$11,336.00	$1,038.40

* Gradient per year.

EIS ALTERNATIVE 5

OTTER TAIL LAKE
COST ESTIMATE

Alternative 5
Q = 0.50 mgd

Costs in $1978
x 1,000

	Prefab Contact Stabilization Plant		
	Capital Costs	O&M Costs	Salvage Value
Influent pumping	77.00	2.00	30.20
Influent pipe	187.10	0.50	112.30
Preliminary treatment	76.80	3.60	34.60
Prefab Plant*	480.00	27.10	144.00
Chlorination	21.60	2.40	---
Chemical addition	43.20	4.80	---
Contract sludge hauling	---	7.50	---
Land (2 acres)	2.00	---	3.61
Administration	---	3.90	---
Lab Analysis	---	3.70	---
Yard work	---	1.10	---
Effluent pipe	8.60	---	5.20
Dechlorination	15.30	0.60	6.00
Subtotal	911.60	$57.20	$335.91
Engr., Contg., etc.	227.90	---	67.18
TOTAL	$1,139.50	$57.20	$403.09

* Note: Capital Cost of Prefab Plant includes two Modular Units rated at 0.25 mgd each.

EIS ALTERNATIVE 5

OTTER TAIL LAKE - COLLECTION
COST ESTIMATE

5.2

Costs in 1978 Dollars
x $1,000

SERVICE AREA	CAPITAL COSTS	O&M COSTS	SALVAGE VALUE
1980			
Entire Service Area	6,839.93	50.66	2,808.60
25% Engineering Contingencies	1,709.98		561.72
TOTAL	$8,549.91	$50.66	$3,370.32
1980 - 2000			
Entire Service Area	31.17/yr.		
25% Engineering Contingencies	7.79		
TOTAL	$ 38.96/yr.		

EIS ALTERNATIVE 5

ECONOMIC ANALYSIS OF ALTERNATIVE
($1,000)

5.3

					PRESENT WORTH				
ALTERNATE ITEM	YEAR	CAPITAL DOLLARS	O&M DOLLARS	SALVAGE VALUE	(1) CAPITAL DOLLARS	(2) O&M DOLLARS	(3) SALVAGE VALUE	TOTAL PRESENT WORTH (1+2+3)	AVERAGE ANNUAL EQUIVALENT COST
Treatment	1980	$1,139.50	$57.20	$ 403.09	$1,139.50	$624.00	$111.70	$ 1,651.80	
Collection	1980	$8,549.90	$50.66	$3,370.30	$8,549.90	$552.70	$934.20	$ 8,168.40	
Collection	2000	$ 39.00/yr.	-	-	$ 425.50	-	-	$ 425.50	
								$10,245.70	$938.50

FACILITY PLAN PROPOSED ACTION WITH FLOW REDUCTION

OTTER TAIL LAKE
COST ESTIMATE

Alternative Flow Reduction
Q = 0.38 mgd

Costs in $1978
x 1,000

	Spray Irrigation on West Shore		
	Capital Costs	O&M Costs	Salvage Value
Influent pumping	58.30	2.00	19.24
Influent pipe	159.81	0.20	95.89
Preliminary treatment	20.90	3.60	9.41
Distribution pumping	72.90	1.04	34.26
Stabilization pond	297.00	19.30	178.20
Field clearing	47.25	---	---
Field leveling	27.00	---	16.20
Distribution (center pivot)	56.70	11.14	26.65
Admin & Lab	55.35	3.40	26.57
Monitoring wells	10.69	1.38	5.13
Roads & fences	54.54	1.10	16.36
Land (160 acres)	160.00	---	288.98
Crop revenue	---	(-7.80)	---
Chlorination	23.10	2.40	9.01
Subtotal	$1,043.54	$37.76	$725.90
Engr., Contg., etc.	260.89	---	145.18
TOTAL	$1,304.43	$37.76	$871.08

FACILITY PLAN PROPOSED ACTION WITH FLOW REDUCTION

OTTER TAIL LAKE - COLLECTION
COST ESTIMATE

Flow Reduction

Costs in 1978 Dollars
x $1,000

SERVICE AREA	CAPITAL COSTS	O&M COSTS	SALVAGE VALUE
1980			
Entire Service Area	6,467.59	48.33	2,706.15
25% Engineering Contingencies	1,616.90		541.23
TOTAL	$8,084.49	$48.33	$3,247.38
1980 - 2000			
Entire Service Area	31.17/yr.		
25% Engineering Contingencies	7.79		
TOTAL	$ 38.96/yr.		

FACILITY PLAN PROPOSED ACTION WITH FLOW REDUCTION

ECONOMIC ANALYSIS OF ALTERNATIVE
($1,000)

Flow Reduction

ALTERNATE ITEM	YEAR	CAPITAL DOLLARS	O&M DOLLARS	SALVAGE VALUE	PRESENT WORTH (1) CAPITAL DOLLARS	PRESENT WORTH (2) O&M DOLLARS	PRESENT WORTH (3) SALVAGE VALUE	TOTAL PRESENT WORTH (1+2+3)	AVERAGE ANNUAL EQUIVALENT COST
Treatment	1980	$1,304.40	$37.80	$ 871.10	$1,304.40	$412.40	$241.50	$1,475.30	
Collection	1980	$8,084.50	$48.30	$3,247.40	$8,084.50	$526.90	$900.20	$7,711.20	
Collection	2000	$ 39.00/yr.	-	-	$ 425.50	-	-	$ 425.50	
								$9,612.00	$880.50

COST SHARING

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

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

Federal Contribution

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

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

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

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

Individual Systems (Privately or Publicly Owned)

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

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

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

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

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

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

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

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

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

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

Collection Systems

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

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

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

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

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

Elements of the substantial human habitation and cost-effectiveness eligibility requirements for new collector sewers are portrayed in Figure J-3 in a decision flow diagram. These requirements would apply for any pressure, vacuum or gravity collector sewers except those serving on-site or small waste flow systems.

Household Service Lines

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

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

☆ U.S. GOVERNMENT PRINTING OFFICE: 1979—652-614