REPORT ON WATER QUALITY

IN

STOCO LAKE

1972

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PREFACE

The Province of Ontario contains many thousands of beautiful small inland lakes which are most attractive for recreational use. Lakes close to urban areas and accessible by road often receive heavy use in terms of cottage development, camp sites, trailer parks and picnic areas.

A heavy influx of people may subject a lake and its surrounding environment to great stress. In many cases, developments are carried out on attractive lakes only to find that when this is complete the lake qualities which were initially so appealing have been damaged. The appearance of the shoreline can be marred by construction, fishing ruined by over harvesting or the growth and decay of excessive amounts of algae and weeds. Motor boats introduce noise and petroleum pollution. Inadequate disposal of human wastes can place a great stress on the lake environment.

The accepted custom of having a "place at the lake" continues to apply pressure for more development, giving rise to an ever greater expansion of problems.

The Ontario Ministry of the Environment is attempting to bring some of these stress factors under control with a variety of programs. The cottage pollution control program was initiated in 1967 and was expanded in 1970 in order to solve the cottage waste disposal problem in recreational lakes. There are three ongoing studies carried by the Ministry:

1) evaluation of existing waste disposal systems and enforcement of repairs to those found to be unsatisfactory.

2) research to improve the knowledge of septic tank operation and effects in shallow soil areas and evaluation of alternative methods of private waste disposal.

3) evaluation of present water quality in a number of recreational lakes. A totally undeveloped lake near Huntsville was studied in 1972, in order to obtain more information about natural water quality conditions within a Precambrian Lake, which would assist in defining any unnatural conditions encountered in the developed lakes surveyed.

This report on Stoco Lake is one of a series dealing with the water quality aspects of the recreational lakes studies in 1972. As well as defining the present status of water quality in the lakes, the data are meant to provide an historical reference for comparison of conditions at any future time.

SUMMARY

Surveys were carried out on Stoco Lake in 1972 to evaluate the present status of the water quality with respect to bacteria, algae and aquatic plant growth. Plant nutrient and dissolved oxygen concentrations in the surface and bottom waters were also determined.

Stoco Lake is located in the County of Hastings, Township of Hungerford. The lake lies within the Precambrian Shield and surrounding area is characterized by rocky outcrops and shallow overburden covering the bedrock.

Large areas of Stoco Lake were found to be badly contaminated with bacteria and exceeded the Ministry of the Environment recreational use criteria. The rest of Stoco Lake was generally within the MOE Recreational Use Criteria.

The major pollution source appeared to be the Tweed municipal sewage discharge. This sewage was dispersed over a large area of Stoco Lake by the Moira River inflow. A sewage works consisting of collection works, pumping stations and waste stabilization pond is being developed by the municipality in co-operation with the Ministry of the Environment. The project is presently in the state of final design, with construction expected to commence in 1974. Another pollution source was detected at the mouth of the Clare River.

Stoco Lake, being downstream from Moira Lake, also suffers from problems of arsenic contamination and phosphorus enrichment.

While the arsenic content is higher than desirable, it is within the permissible limit for public water supplies.

Not only does Stoco Lake provide a suitable habitat for plants owing to its shallowness and fertile bottom deposits, but the nutrient levels in the lake are sufficient to support both algal and aquatic plant communities, each of which thrive to an objectionable degree. Following the completion of the new municipal sewage lagoon a gradual improvement in Stoco Lake water quality can be expected.

PURPOSE OF THE SURVEYS

Moira Lake's history of problems relating to nutrient enrichment and arsenic contamination has been documented in several reports. The most complete documentation of these problems is contained in Owen (1969), Biological Survey of the Moira River and (1973) Abatement of Arsenic Contamination in the Moira River at Deloro, both are MOE reports and available upon request.

The surveys were designed, and tests selected, in order to evaluate the present conditions in the lakes with respect to:

- concentration of bacteria
- plant nutrients and algae
- water quality with depth
- density and species of aquatic plants
- inventory of shoreline development

As a result of human activity in the recreational lake environment, some wastes may reach the lake itself and this can lead to either or both of two major types of water quality impairment; microbial contamination and excessive growths of algae and aquatic plants. The two problems can result from a common or different source of pollution, but the consequences of each are quite different.

Microbial contamination by raw or inadequately treated sewage does not significantly change the appearance of the water but poses an immediate public health hazard if the water is used for drinking or swimming. This type of pollution can be remedied by preventing wastes from reaching the lake and water quality will return to satisfactory conditions since most disease causing bacteria do not persist in the lake.

Nutrient enrichment, or eutrophication, results from the addition of plant fertilizers which occur naturally and are also present in virtually all forms of raw or treated human wastes. High concentrations of these fertilizers (plant nutrients), mainly nitrogen and phosphorus, support extensive growths of rooted aquatic plants and of microscopic free-floating plants called algae. Eutrophication greatly affects the lake appearance but generally does not pose a health hazard. Problems due to nutrient enrichment are generally long lasting and may become irreversible.

Changes in water temperature, dissolved oxygen and quality with depth are very important characteristics of a lake and were examined in the surveys.

The growth of weeds along the shore was noted during the surveys. Aquatic weed beds provide shelter and food for many kinds of fish. Too much growth is undesirable since it can upset the oxygen balance in the lake and can interfere with recreational uses of the lake.

DESIGN OF THE SURVEYS

Timing

Five-day bacteriological, chemical and biological surveys were carried out from June 14-18, August 16-20 and September 14-18, 1972 on Stoco Lake.

A proper estimation of the bacterial population requires several measurements over a period of time which can then be averaged as a

geometric mean. Measurements over five consecutive days at each station are regarded as the minimum number which will give reliable bacterial data.

Chemical samples were collected on the first and last days of the surveys at inlet and outlet stations and on the first, third and fifth days at the mid-lake stations. Chlorophyll samples were collected each day at the inlet and mid-lake stations.

Selection of Sample Locations

Twenty-eight bacteriological sample sites were established over the whole lake. Chemical samples were collected at 3 inlet stations, 2 outlet stations and at 2 mid-lake stations. In addition to these surface samples, chemical and bacteriological samples were taken from the bottom water at the mid-lake stations. Aquatic plant samples were collected in areas representative of sparse, medium and dense growth.

Field Tests

The temperature and dissolved oxygen values were measured at the deep water stations with an electronic probe lowered into the lake and water clarity was measured with a secchi disc (Figure 1). The pH and conductivity of the samples were measured in the field.

Bacteriological Tests

Three groups of bacteria were determined on each sample: total coliforms, fecal coliforms, fecal streptococci. These organisms are used as "indicators" of fecal contamination. Many diseases common to man can be transmitted by feces, consequently, the probability of occurrence of these diseases is usually highest in areas where the water is contaminated. The total coliforms, fecal coliforms and fecal streptococci organisms are all indigenous to man and other warm blooded animals and are found in the colon and feces in tremendous numbers. Hence, these indicator organisms in the water denotes the presence of fecal contamination and hence the risk of disease causing organisms.

Standard plate count (SPC) determinations were made on some mid-lake stations in order to determine densities of some natural water bacteria. The SPC media will only support the growth of those organisms that do not require special nutrients, oxygen requirements and/or incubation temperatures. The SPC is used as a measure of general bacterial activity.

Chemical Tests

Hardness, alkalinity, chloride, iron and conductivity were measured in order to define the mineral composition of the water. The types of plants and animals which thrive, effects of toxic materials and suitability of the lake for various management techniques depend on the mineral content.

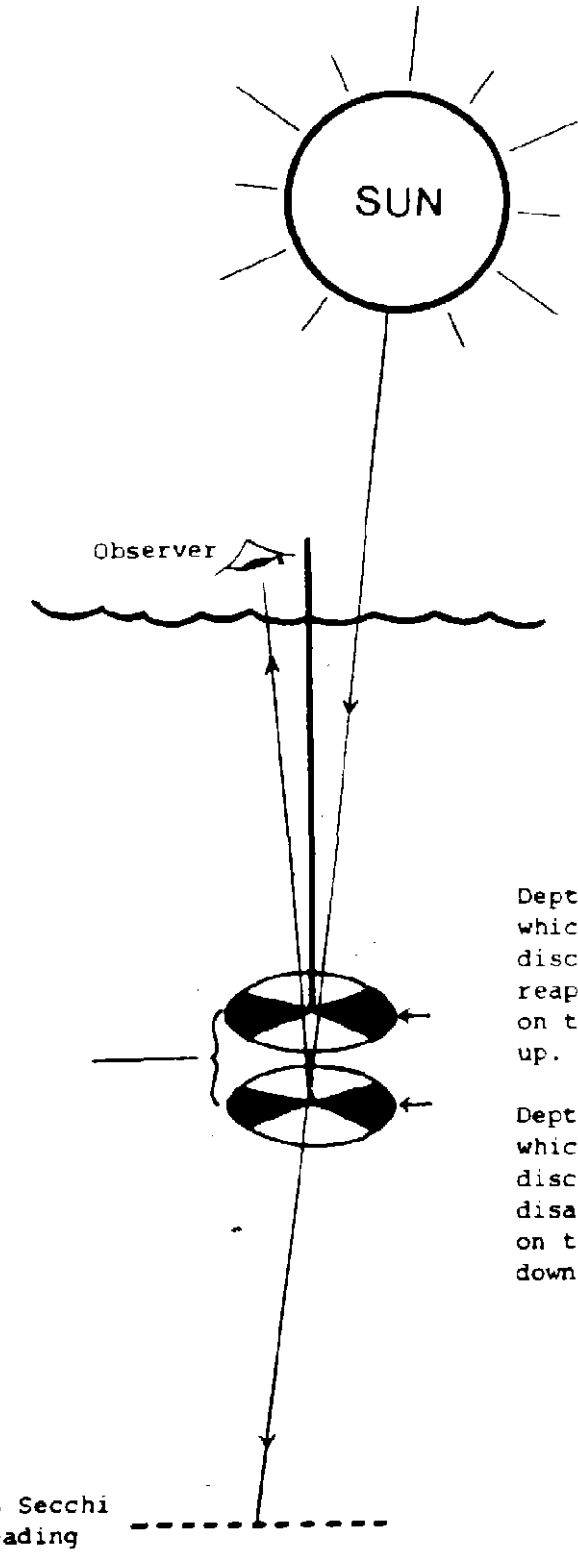
Total and soluble phosphorus were measured in the inlet and bottom water samples while total phosphorus only was measured in the mid-lake and outlet surface samples. Soluble phosphorus concentrations are used mainly to substantiate various interpretations of the total phosphorus concentrations.

The total kjeldahl nitrogen is essentially the amount of nitrogen contained in organic material. It was measured in all of the chemical samples. The soluble forms of nitrogen, ammonia, nitrite and nitrate were measured in the inlet and bottom water samples. They are particularly important in bottom waters since nitrogen is regenerated from decaying organic matter in these forms.

Chlorophyll a concentrations are an indication of the amount of algae in the water. The live algae are confined mainly to the lighted surface waters which extend down to a depth of about twice the secchi disc reading. The chlorophyll samples were collected by raising the sample bottle through the depth of the illuminated zone as it filled. The sample was then representative of the average number of algae through the depth of the surface waters.

The "Secchi Disc Reading" is obtained by averaging the depth at which a 23cm (9") dia. black and white plate, lowered into the lake just disappears from view and the depth where it reappears as it is pulled up.

Most of the free-floating algae are suspended in the illuminated region between the lake surface and 2 times the Secchi disc reading.



Clear, algae-free lake: Secchi disc readings tend to be greater than 3m (9 feet).

Turbid or algae-rich lake: Secchi disc readings tend to be less than 3m (9 feet).

Figure 1: USE OF SECCHI DISC TO DETERMINE WATER CLARITY

DESCRIPTION OF THE STOCO LAKE AREA

Soil and Lake Characteristics

Stoco Lake is situated in the Township of Hungerford, Hastings County adjacent to the Village of Tweed and is the town's major recreational lake (Figure 2).

Stoco Lake lies in the Precambrian Shield and the surrounding area is characterized by a rolling terrain which is mainly covered with a sandy loam overburden. The southeast end of the lake near the Community of Stoco is composed of farmland and is lightly treed. Soil cover consists of the Tioga and Dummer loam series with the Tioga series being predominant. It is slightly acidic in nature with good drainage potential and has an average depth of 1.5 meters (5 feet). Further up the east shore and directly across on the west shore, the area is designated as the Rock Outcrop Complex, which is 90 percent bare or thinly covered rock. Monteagle soil which is a sandy loam glacial till, forms part of the complex and muck or peat occurs in the depressions. The area is covered with a heavy, mixed forest. An area of marsh is present in a slight depression surrounding the Clare River. As the terrain changes north of the Clare River to light slopes, a dark grey sand of the Granby series appears. This soil provides drainage and is on the average 60 centimeters (24 inches) thick. This area has varying forestation from sparse hardwoods (elm, silver birch and maple) at the southerly part, to a dense forest of mixed proportions in the north bay. The area surrounding Sulphide

Creek belongs to the Rockland series which is composed of 50 to 90 percent rock and contains some small deposits of muck and sandy loam in the crevices.

The northwest shore of the lake is of the Wendigo series which is composed of a shallow calcareous sand loam and provides good drainage. The forest cover is medium to dense and is composed of mixed vegetation with cedar, poplar, and white pine being predominant. The Bondhead Sandy Loam series is present around the Moira River and the north shore of Sugar Island. This coarse soil provides good drainage and has an average depth of three feet. The area surrounding the Moira River West Channel is the muck series. This soil consists of 38 centimeters (15 inches) or more of organic material overlying mineral soils. The organic material is partially decomposed and black in colour.

Stoco Lake lies in the Lower Moira River Watershed which is part of the greater Moira River Drainage Basin. The immediate watershed of the lake covers an area of 317 square kilometers (123 square miles). The drainage areas for the Skootamatta and Moira rivers which are not included in the immediate watershed, also have an effect on the lake as they join and become the major inflow into Stoco Lake. The lake has a surface area of 5 square kilometers (2 square miles) and an irregular shoreline of 16 kilometers (10 miles). It has a mean depth of 4 meters (14 feet) and a maximum depth of 9 meters (32 feet).

Stoco Lake is fed by Sulphide Creek, the Clare River and Moira River. Sulphide Creek flows into the north end of the lake, draining a large swampy area and some small lakes. The Clare River having a much greater flow also drains a large swampy area and several small lakes and creeks. The Clare River flows into the lake at its northeast shore. The largest of the three inlets is the Moira River which enters the lake at its west shore, by the Village of Tweed. This river drains Moira Lake and the Black and Skootamatta rivers. The two outlets of the lake are located at the south end of the lake. These are called the East Channel and the West Channel which join about 2 miles south of Stoco Lake to form the Moira River.

Water Usage

Many of the cottagers as well as the Village of Tweed use wells as their source of domestic water supply. The Village of Tweed is served by a municipal water works system which obtains its supply of water from two drilled wells which are connected to a standpipe with a capacity of 160,000 gallons (727,000 liters).

Recreational usage of the lake includes boating, fishing and swimming, although these activities may be restricted due to the heavy aquatic plant growths. From 1968 to 1971 the local Health Authorities posted the park beach as unfit for swimming as a result of their routine bacteriological sampling program. These signs were not posted in 1972.

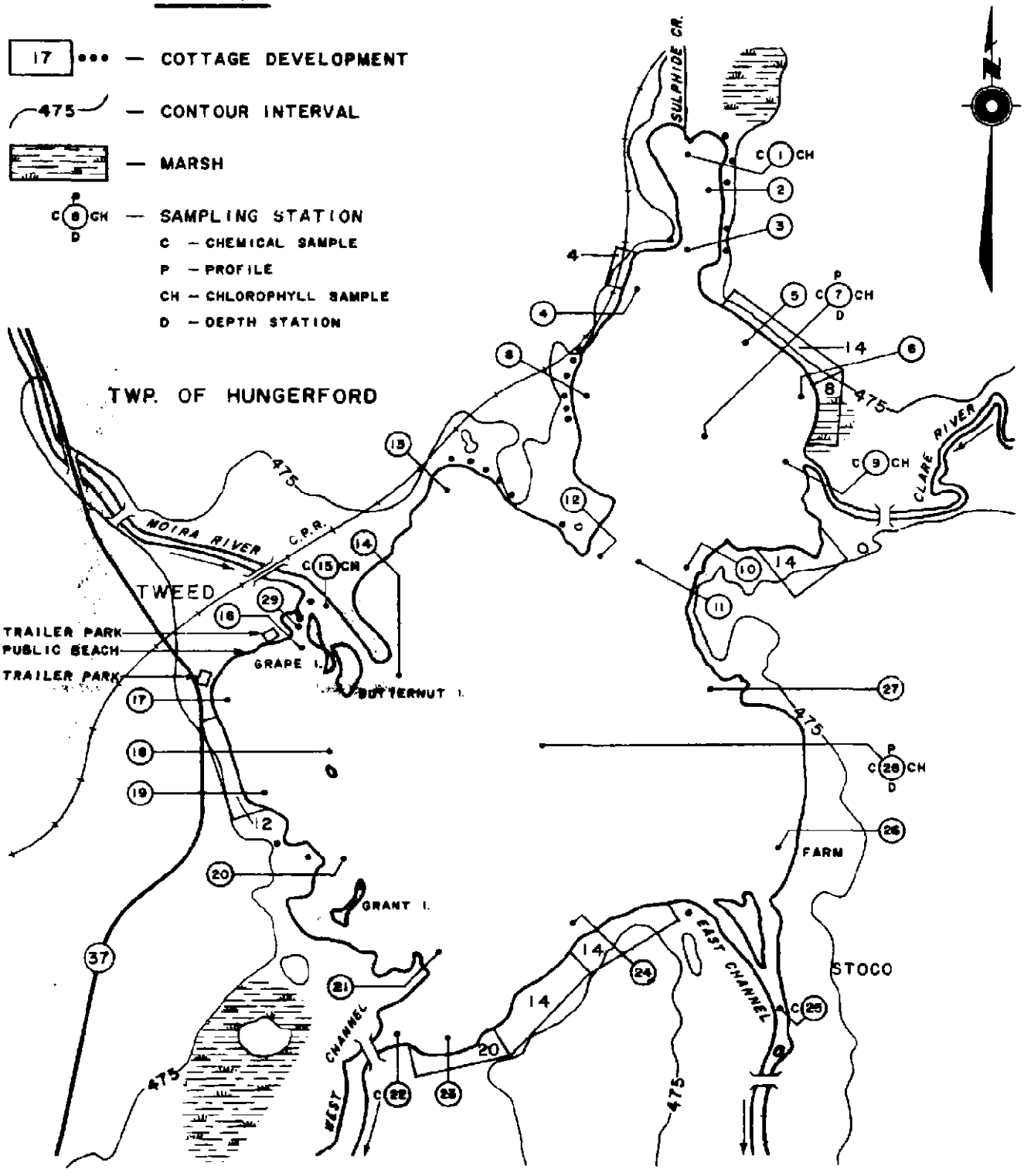
According to information available from the Ministry of Natural Resources, the lake offers a sport fishery of northern pike, maskinonge, smallmouth and largemouth bass and walleye. Some of the coarse fish in the lake are black bullhead, channel catfish, rock bass and white sucker. Stocking of maskinonge fingerlings and fry has been carried on with some regularity since 1937.

The Village of Tweed is served by a municipal waste disposal system which consists of three septic tanks and a combined storm and sanitary sewer collection system. Two of the septic tanks discharge to the Moira River through submerged outfall pipes and the third tank is located in the village park and discharges through a submerged outfall to the lake. The installation of a sewage lagoon with phosphorus removal to replace the septic tanks is at the final design stage and construction should commence in 1974.

Shoreline Development

Stoco Lake is generally well developed with the exception of the southeast shore. There are approximately 120 cottages, two resorts and two small trailer camps on the lake. The Village of Tweed with a population of 1,800 is located at the mouth of the Moira River and the community of Stoco is located just south of the East Channel outlet (Figure 2).

FIGURE 2 - COTTAGE DEVELOPMENT AND SAMPLING STATIONS OF STOCO LAKE



0 1/4 1/2 MILES

ENVIRONMENT ONTARIO	
RECREATIONAL LAKES PROGRAM STOCO LAKE 1972 WATER QUALITY SURVEY	
SCALE: AS SHOWN	
DRAWN BY: A.R.S.	DATE: DEC., 1972
CHECKED BY:	DRAWING No: 72-98-DE

RESULTS AND DISCUSSION

Bacteriology

The quantities of bacteriological data necessitated statistical methods to summarize the results into a concise presentation without the inconsistency associated with mannual interpretation. The methods used are based on the analysis of variance and Barlett's test of homogeneity by which stations on a lake can be grouped into areas with the same bacterial level. Areas or stations with only slight differences in bacterial concentration can be isolated. It was found on previous work that areas, or stations, with significantly higher bacterial numbers generally indicated a pollution input. Details of statistical methods and data are available on request.

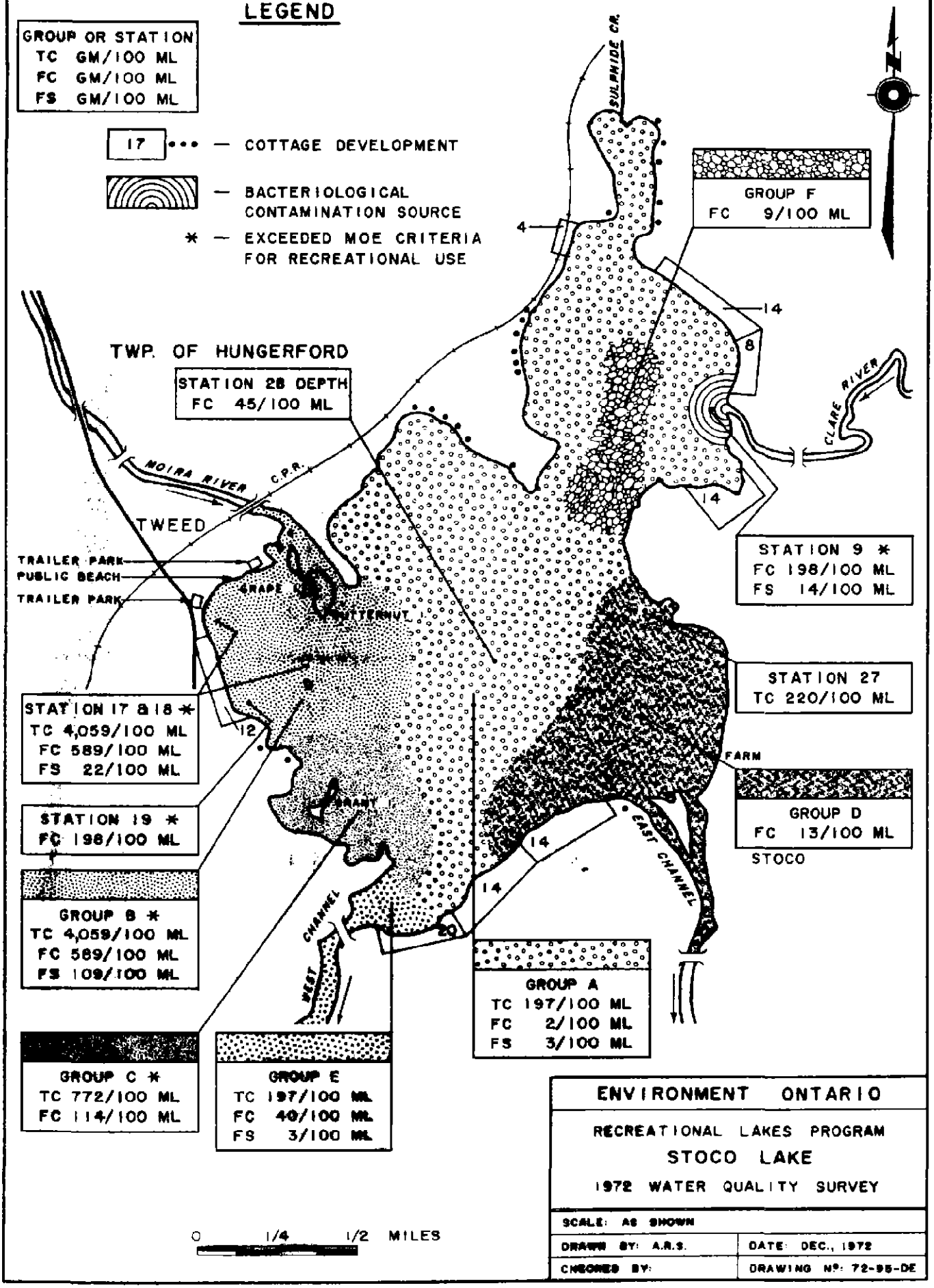
Most of Stoco Lake had exceptionally poor bacteriological water quality, especially the outflow of the Moira River, and the area around the municipality of Tweed, which exceeded the Ministry of the Environment's criteria for all three parameters during the spring, summer and fall surveys. A serious health hazard existed in Stoco Lake according to the Ministry's criteria which states : "Where ingestion is probable, recreational waters can be considered impaired when the coliform (TC), fecal coliform (FC), and/or enterococcus (FS) geometric mean density exceed 1,000, 100 and/or 20 per 100 ml, respectively". (1).

(1) Guidelines and Criteria for Water Quality Management in Ontario. Ministry of the Environment, 1972.

In June, the lowest mean bacterial levels in Stoco Lake (Group A), were 197 TC, 2 FC, and 3 FS/100 ml (Figure 3). However, most of the sampling stations exceeded these means for one or more parameters. The area surrounding the mouth of the Moira River and the municipality of Tweed (Group B) had excessively high bacterial means of 4,059 TC, 589 FC, and 109 FS/100 ml. This contamination was probably a result of sewage outfalls from the Village of Tweed and indicated a definite health hazard to bathers. Other Ministry reports have established the need for adequate sewage treatment facilities in the Village of Tweed. The impact of the contamination from Tweed was so great that it even affected the mid-lake depth station 28D which had 45 FC/100 ml. The bacterial levels decreased with distance from Tweed and the movement of the contamination appeared to be toward the West Channel outflow. Stations 17 and 18 showed a decrease in FS to 22/100 ml while Station 19 decreased to 198 FC/100 ml and Group C on the southwest shore showed a further reduction to 772 TC/100 ml and 114 FC/100 ml. Group E, at the outflow, was lowest but still showed a high level of contamination with 40 FC/100 ml. All this area can be considered unsafe for swimming.

The Clare River also exceeded the MOE recreational use FC criteria with 198 FC/100 ml. Other minor contaminated areas included Group F in the north central area (9 FC and 3 FS/100 ml), Station 27 (220 TC, 13 FC/100 ml) and Group D, around the East Channel outflow (13 FC/100 ml).

FIGURE 3 - DISTRIBUTION OF BACTERIA IN JUNE



In August, most of Stoco Lake and geometric mean bacterial levels of 248 TC, 3 FC and 5 FS/100 ml (Figure 4). However, the lake area around Tweed (Group D) was again impaired with bacterial means of 1,100 TC, 148 FC and 108 FS/100 ml, all in excess of the MOE Recreational Use Criteria. Again, the bacterial levels decreased the farther the water was sampled from Tweed. The Group C area, just south of the Moira River inflow had lower FS levels of 47/100 ml, while the bacterial levels in the Group D area, off the southwest shore, decreased to 248 TC, 10 FC and 5 FS/100 ml. Bacteriological results at Station 9, again indicated the mouth of the Clare River to be a major contamination input with 51 FC/100 ml and 85 FS/100 ml. Station 1 in the far northern tip of the lake had slightly elevated FC and FS levels of 7 and 32/100 ml, respectively, possibly from the Sulphide Creek outflow.

During the September survey, the same trend in bacterial populations was evident (Figure 5), with exceptionally high levels of total coliforms, fecal coliforms and fecal streptococci (3,348 TC, 305 FC and 213 FS/100 ml) in the portion of the lake adjacent to Tweed (Group B and E). Much lower counts and acceptable densities were present in the rest of the lake (Figure 5). The overall TC and FS levels for the remainder of the lake were 298 TC and 9 FS/100 ml. The FC levels increased from 2/100 ml in the northern Group A area to 8/100 ml in the central Group D area and finally 21 FC/100 ml in the southern Group C area. Only Station 22 in the West Channel outflow had elevated TC levels of 628/100 ml.

FIGURE 4 - DISTRIBUTION OF BACTERIA IN AUGUST

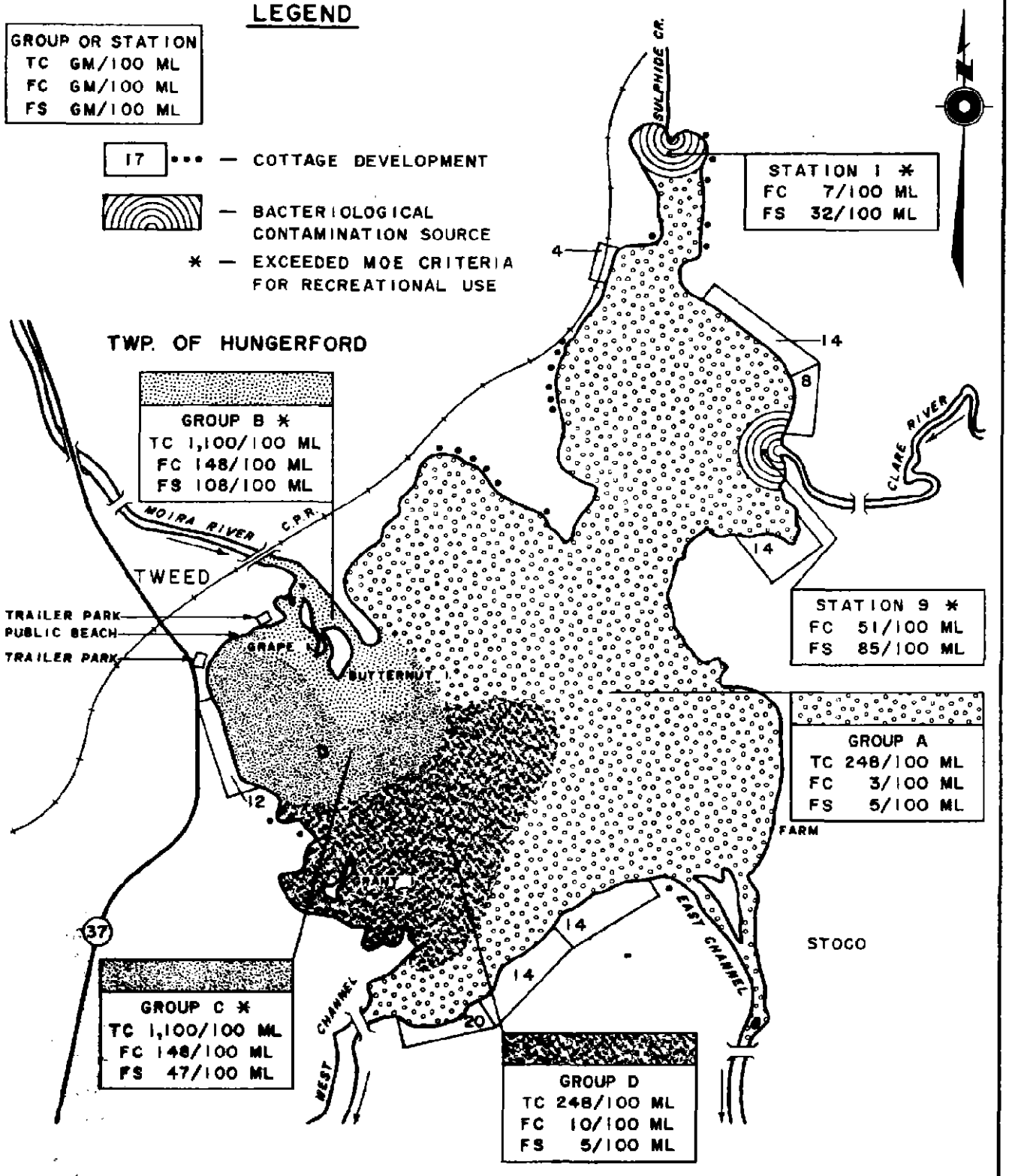


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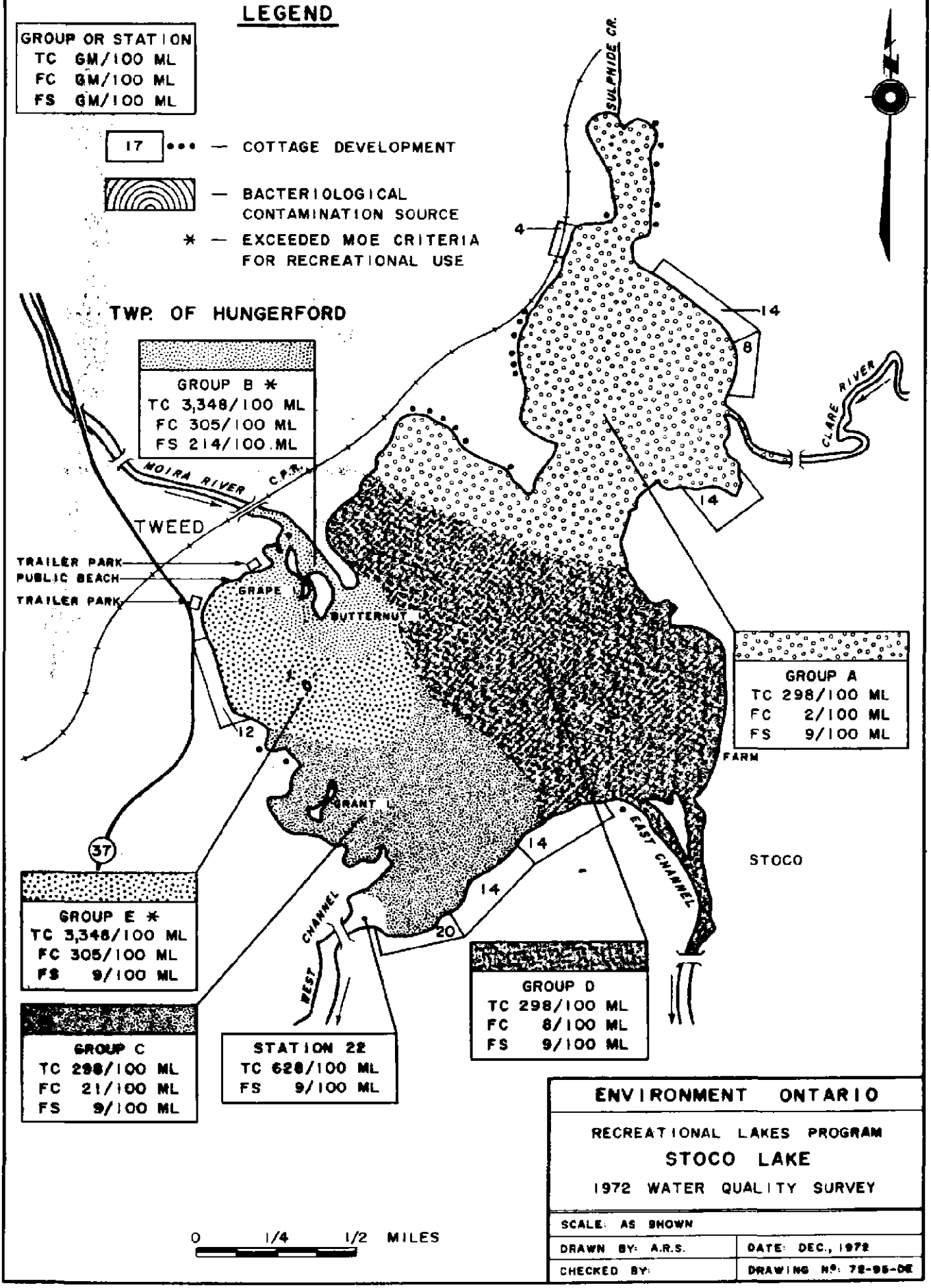
FIGURE 5 – DISTRIBUTION OF BACTERIA IN SEPTEMBER



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Standard plate count densities in the mid-lake areas (Stations 7 and 28) were 35,098/100 ml and 5,546/100 ml during the spring survey, 6,583/100 ml and 6,923/100 ml during the summer survey with higher levels in the fall of 13,063/100 ml and 17,411/100 ml.

The bacterial levels encountered during the three 1972 Stoco Lake surveys were indicative of a serious health hazard to bathers within the Moira River outflow and around the municipality of Tweed. At times, these unacceptable bacterial levels extended over large areas of the lake, generally along the southwest shore and within the Clare River inflow.

No rainfall was recorded at the Cambellford Meteorological Station during the surveys and it may be assumed that these surveys represent dry weather conditions, which favour better bacteriological water quality.

Chemistry

The main supply of water to Stoco Lake is the Moira River as sampled at Station 100 and Station 15. Hardness of 72 mg/l, measured at these stations in June was lower than for the lake as a whole, reflecting the higher hardness inputs from the minor inlets. By September, the hardness of the Moira River had increased to 90 mg/l which closely approached that of the rest of Stoco Lake. Inlet Station 9 had a hardness which varied from 94 to 134 mg/l with no pronounced trend from June to September.

Alkalinity varied in proportion to the hardness and ranged from 59 mg/l to 129 mg/l. Chloride in the 4 to 6 mg/l ranged was constant throughout the survey. Conductivity changed in direct proportion to changes in hardness and went from 147 to 277 umhos as hardness varied from 72 to 140 mg/l for the various stations.

Iron concentrations in Stoco Lake were generally in the 0.2 to 0.3 mg/l ranged except for the Moira River stations which were in the 0.4 to 0.45 mg/l range. Somewhat lower values were found during the September survey with Station 15 at 0.25 mg/l and most of the other lake stations below that value.

Mention should be made of a sample from Station 1 on August 16 which had an alkalinity of 49 mg/l, a hardness of 62 mg/l and a conductivity of 126 micromhos. The iron concentration of this sample was 0.6 mg/l. These results are not consistent with the overall survey results and may be due to the dilution effects of a rainfall prior to sampling.

Arsenic was determined during the August and September surveys. In August, Station 15 showed a concentration of 0.04 mg/l. This was higher than the rest of the lake anc identifies the probable source as the Moira River. Stations 1, 7 and 9 did not have a measurable amount. In September all stations had a concentration of 0.02 to 0.03 mg/l except for the bottom water of Station 7 which had 0.05 mg/l. These levels of arsenic are above the desirable concentration of less than 0.01 mg/l for drinking water, but are within the maximum permissible level of 0.05 mg/l for the continuous use as a drinking water supply.

Ample amounts of nutrients were present in the Moira River inflow and throughout the body of Stoco Lake. Total phosphorus levels ranged from 30 to 50 ug/l, while total kjeldahl nitrogen values occurred in September and were associated with free ammonia values up to 130 ug/l. This is probably a result of decaying vegetation.

Samples collected from Station 9 at the inlet of the Clare River had low total phosphorus values, indicating that this inlet was not a contributing source to the elevated phosphorus content in Stoco Lake.

Decomposition of organic matter was tending to use up the dissolved oxygen (DO) but the resulting depletions were temporary, as is characteristic of shallow lakes. Low concentrations of DO were observed on the first day of each survey, accompanied by slight temperature gradients. However, mixing eliminated the temperature differences and either completely restored the DO, as at the shallower of the two mid-lake stations (Station 7), or materially increased it as at Station 28 (two meters deeper) before the end of each five day survey period.

Chlorophyll a and Water Clarity

The mean chlorophyll a concentration at the mid-lake stations over the three year surveys was 6 ug/l and indicates that the lake was characterized by moderate amounts of suspended algae which are well above the levels observed in nuisance-free lakes. Similarly, the mean secchi disc transparency of 1.3 m indicates water of poor clarity.

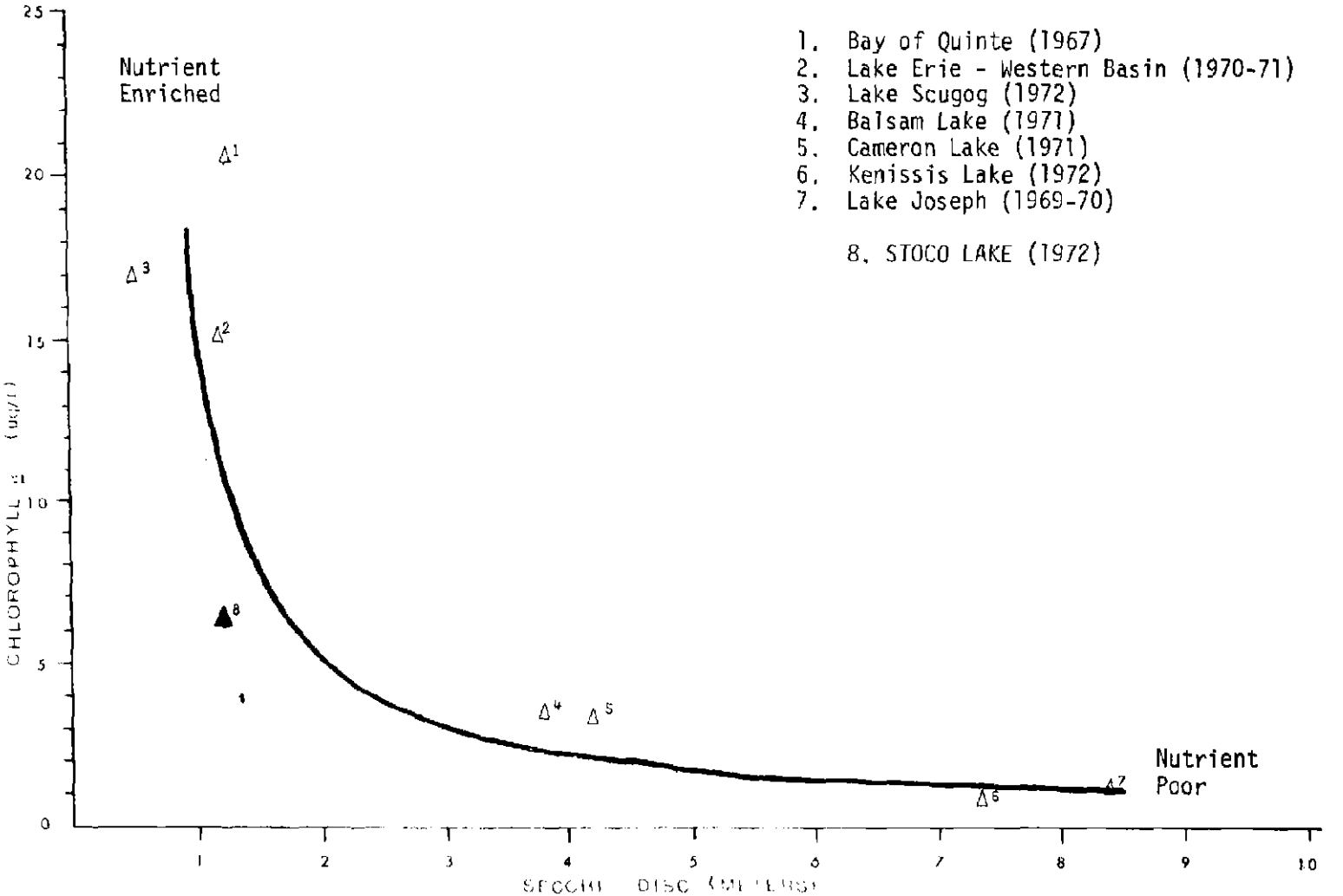

Figure : The mean of chlorophyll a and Secchi disc measurements in Stoco Lake relative to a curve describing the chlorophyll a - Secchi disc relationship in many Ontario lakes. Seven other well known lakes are included for comparison with Stoco Lake.

On a scale of lake enrichment as indicated by chlorophyll a concentrations and water transparency, Stoco Lake is considerably more enriched than Balsam and Cameron lakes - two relatively clear water lakes (Figure 6). In water clarity, it is not far removed from such highly enriched waters as the Bay of Quinte, the western basin of Lake Erie and Lake Scucog (Figure 6) which are less transparent as a result of greater amounts of suspended algae. Preliminary studies on other lakes similarly affected by nutrient inputs from municipal waste treatment facilities have indicated an improvement in water quality following either diversion of the waste effluent or phosphorus removal during the treatment process. A gradual improvement in Stoco Lake water quality in terms of increased clarity and smaller amounts of suspended algae will be looked for following improved waste treatment and phosphorus removal from sewage wastes within the watershed.

Aquatic Plants in Shoreline Area

Aquatic plants representing 14 genera from which 17 different species were identified were found in shoreline areas of Stoco Lake (Table 1). Some of the plants could only be identified to genus because they lacked the fruiting or flowering structures necessary for complete identification. Figure 7 outlines the location and extent of the plant growth and lists the plants found in each area. While this figure shows the distribution and total density of the plants, the density or dominance of any particular plant type was not determined.

TABLE 1: Aquatic plants found in shoreline areas of Stoco Lake. For convenience, the plants are divided into two categories: (a) submergent-aquatic plants which live for the most part underwater and (b) emergent-plants which produce floating or aerial leaves.

Scientific Name (Genus, species)	Common Name	Distribution*
(a) Submergent		
Elodea canadensis	Canada waterweed	A
Ceratophyllum demersum	Coontail	V.A.
Myriophyllum sp.	Milfoil	V.A.
Utricularia vulgaris	Bladderwort	C
Vallisneria americana	Tapegrass	A
Najas flexilis	Bushy pondweed	A
Potamogeton gramineus	Variable pondweed	A
Potamogeton amplifolius	Bass weed	C
Potamogeton Richardsonii	Richardsons pondweed	C
Potamogeton zosteriformis	Flat-stemmed pondweed	A
Potamogeton sp.	Unidentified pondweed	A
Heteranthera dubia	Water star grass	C
(b) Emergent		
Pontederia cordata	Pickerelweed	V.A.
Nuphar variegatum	Yellow waterlily	V.A.
Sagittaria sp.	Arrowhead	A
Scirpus sp.	Bulrush	A
Bidens Beckii	Bur marigold	C
Equisetum sp.	Horsetail	C

* V.A. - very abundant
A. - abundant
C. - common