MATTAGAMI REGION CONSERVATION AUTHORITY
Timmins, Ontario

Porcupine Lake and River Study

JANUARY 1978

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Acres Consulting Services Limited

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1 - SUMMARY, CONCLUSIONS, RECOMMENDATIONS AND PHASE II STUDY

1.1 - Summary

This report contains the results of the following studies:

- hydrology and hydraulics of Porcupine Lake and Porcupine River downstream from the lake

- annual flooding of areas around the lake and low-level conditions during the summer months

- water quality and weed growth in the lake and the extent to which these factors relate to water level fluctuations.

Hydrotechnical analyses of the present situation were carried out utilizing available lake level recordings and streamflow data from hydrometric stations in the vicinity of Porcupine Lake. The Timmins storm flood and the 1-in-50- and the 1-in-100-year flood hydrographs were determined and the lake level response to these events evaluated. Environmental conditions controlling weed growth in the lake were examined. To assess lake usage and present-day mean annual flood damage, a socioeconomic survey was undertaken. Total annual costs to the community were evaluated for the existing situation and for a range of proposed remedial measures.

1.2 - Conclusions

1.2.1 - Existing Conditions

(a) Flooding

Approximately every second year the communities around the lake experience economic losses due to flood damage (see Figure 17). The present-day tangible mean annual flood damage is estimated to be approximately $22,000.

The peak lake levels associated with the Timmins storm and the 1-in-50- and 1-in-100-year floods for present-day conditions in the lower river are

Flood Event	Peak Lake Level (m)	(ft)
Timmins storm	280.6	(920.5)
50-year	281.1	(922.1)
100-year	281.2	(922.5)

The associated floodplains are plotted on the map in Appendix B.

Flood levels are affected by the flow conditions in the first 9 km of the Lower Porcupine River. Hence, any substantial flow blockage (log or ice jams and beaver dams) allowed to develop along this channel, such as at Broulan Reef Mine Road bridge (Bridge 14 - Figure 1), will increase the lake flood levels. The present extent of aquatic vegetation does not contribute significantly to flow resistance in this channel particularly during the spring flood period.

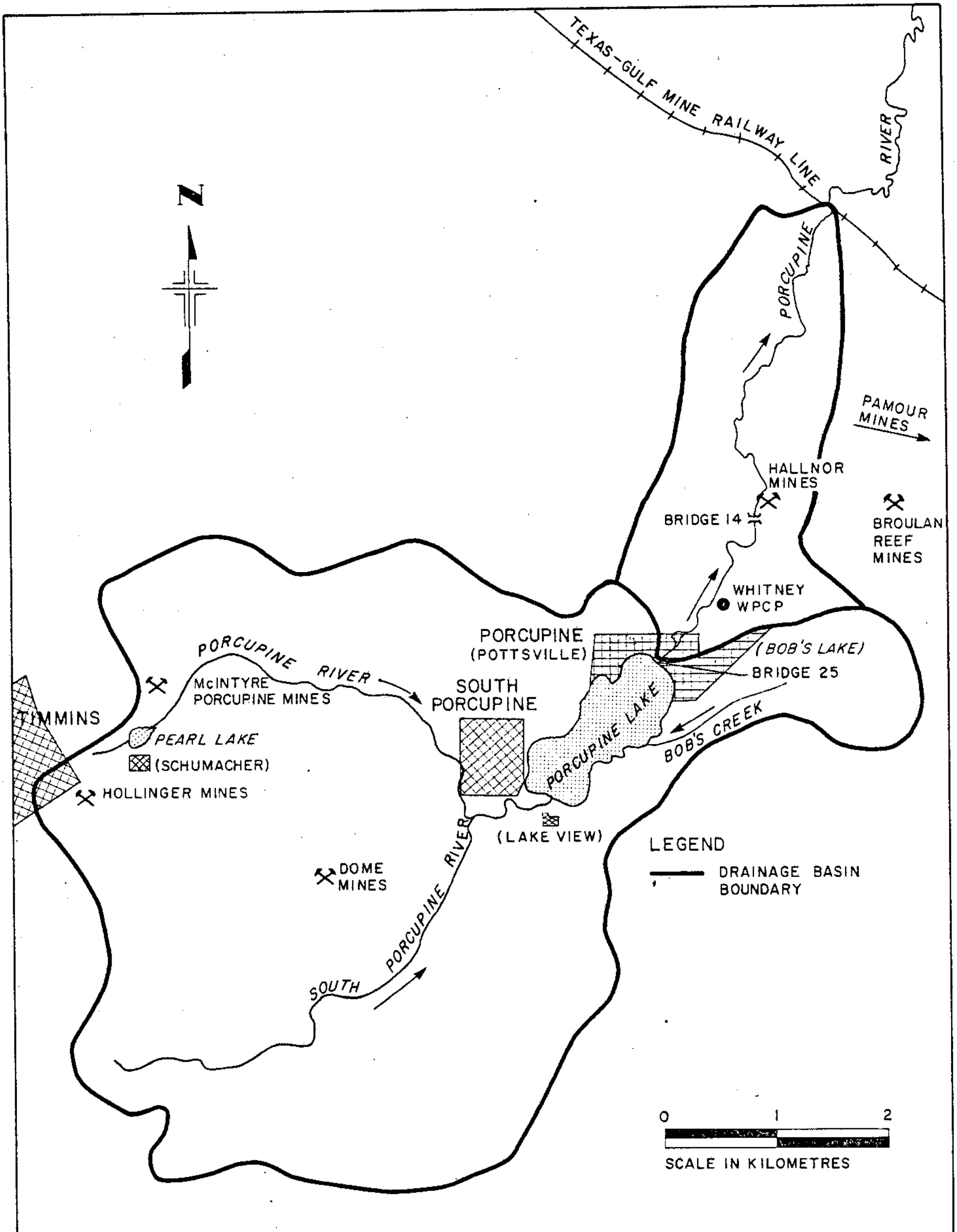

FIG. 1

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PORCUPINE LAKE AND RIVER STUDY

PORCUPINE LAKE AND VICINITY

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(b) Low Levels

The MNR air base is the lake user most affected by low lake levels. Even with average river inflow during summer months, aircraft movements at the air base are hampered. During a 1-in-5-year return period, July low-flow period operations at the base are severely affected (see Figure 12).

(c) Water Quality

Although the lake is nutrient enriched, the water quality is adequate for recreational activites such as boating, swimming and fishing, and for the support of a waterfowl population. A problem does, however, arise along the South Porcupine shore in the Commercial Avenue area where bacteria counts are occasionally high. This is probably due to spillage and/or leakage from septic tanks along this shore.

Due to the commissioning of the Whitney water pollution control plant (WPCP), water quality in the lake can be expected to gradually improve over the years. The planned expansion to this plant should increase the rate of improvement.

(d) Weed Growth

Aquatic weeds currently cover extensive areas along the shores of the lake (see Figure 13). This growth does cause some difficulty to boats and float planes requiring access to the center of the lake. These problems are generally not water-level dependent. Therefore, schemes aimed at improving low lake levels would not reduce the weed problems.

(e) General

Porcupine Lake has considerable potential for the development of recreational activities such as boating, fishing and, to a limited extent, swimming, and as waterfowl habitat. This potential is not being fully utilized.

1.2.2 - Remedial Measures

(a) Flooding

Flood levels and consequently flood damage can be reduced by channel clearance and/or excavation in the upper 9 km of the Lower Porcupine River. For the present state of development, only the minimum channel clearance scheme is justifiable in terms of tangible benefits and costs. It has a benefit/cost ratio just under unity.

(b) Low Levels

The low-level regime of the lake can be considerably improved by constructing an inexpensive low-level overflow weir at the outlet to the lake.

(c) Water Quality

The proposed expansions to the Whitney WPCP, and the diversion of sewage from Schumacher to the Timmins WPCP, should increase the rate at which the water quality of the lake is improving. Additional improvement could be achieved by tracing and eliminating the sources of bacteria in the Commercial Avenue area in South Porcupine and possibly also by connecting the Bob's Lake community to the Whitney WPCP.

(d) Weed Growth

As the water quality improves, weed growth should gradually diminish. However, due to the nutrients trapped in the sediments on the lake bottom, no noticeable reduction in rooted aquatics will take place for at least another 5 years.

Large-scale mechanical or chemical removal of weed growth is impractical. However, small-scale removal is feasible and can be undertaken in localized areas to improve boating and float plane access, swimming, etc.

1.3 - Recommendations

(a) Flooding

- Long Term

Before any flood-level alleviation measure is adopted, the following course of action is recommended.

- A detailed and extensive topographic survey of the first 10 km of the Lower Porcupine River (from the lake outlet point to the rail bridge) should be undertaken. This survey should include a long section, cross-sections at roughly 300-m (1,000 ft) intervals, sampling of bed and bank material, and a detailed inventory of the volume of material in the various beaver dams and other blockages. This information should then be used to firm up the channel clearance and excavation cost estimates appearing in this report.

- Any channel excavation or clearance scheme should only be designed in conjunction with a general development plan for the area. Such a plan should be based on a review of residential, industrial and recreational requirements, and outline a proposed development strategy to satisfy these requirements. If such a comprehensive plan is not available, studies should be undertaken to develop it.

Utilizing the results of the development plan and the more detailed channel clearance/excavation cost estimates, and considering both tangible and intangible costs and benefits, the appropriate degree of channel improvement to the Lower Porcupine River can be evaluated. No channel clearance or excavation should be undertaken without prior construction of a low-level control structure such as the weir depicted in Figure 20.

- Short Term

  - No structural remedial measures are recommended.

  - A "Flood Proofing Study"[29] is presently being carried out for Environment Management Service, Inland Waters Directorate, Water Planning and Management Branch, DOFE. The above study is to produce a set of flood proofing standards to assist lakeshore residents with their present flood proofing activities. Consideration should be given to disseminating some of the ideas developed in this study.

  - The construction of any permanent buildings on land below level 281.2 m (922.5 feet) should be discouraged.

  - A careful watch should be maintained on the lower river to ensure that no additional blockages develop (particularly in the Broulan Mines Road Bridge), or that existing blockages do not become more severe. This can be done by undertaking regular (yearly or twice yearly) inspection trips on the upper 9 km of the river. During these trips, all obstructions should be photographed and documented. Comparison of the results of successive field trips will highlight potentially troublesome blockages. In addition, during every flood season, the outflow from the lake should be measured and plotted against the lake level. In time, this information will serve as a warning of any blockages that may be developing. This information can also be used to check on the calculated lake level outflow curves appearing in this report.

- Consideration should be given to implementing the peak flood-level warning system outlined in Section 7.1.3(b).

(b) Low Levels

The proposed low-level overflow weir illustrated in Figure 20 should be built. Any proposals for alterations to the MNR air base should be reconsidered in light of the alterations to the lake level regime caused by this weir.

(c) Water Quality

- Measurements should be undertaken along Bob's Creek to establish more precisely how much of the pollutants from the Bob's Lake community are entering Porcupine Lake. If this quantity is found to be substantial, efforts should be made to divert this sewage flow to the Whitney WPCP. (It may be desirable to undertake this diversion in any case to improve the water quality in Bob's Lake and Creek.)

- The source of the bacteria occasionally found along the South Porcupine shore of the lake (probably leakage from septic tanks) should be identified and the matter rectified (possibly by connecting the sewers still draining to septic tanks to the Whitney WPCP).

- Sediment samples should be taken at least once a year and analyzed for Kjeldhal nitrogen, nitrate nitrogen and total phosphorus. These results plus the monthly water quality results from the MOE water quality station at the Highway 101 bridge should be plotted up and used to establish the trend in water and sediment quality.

(d) Weed Growth

- No general large-scale chemical or mechanical eradication of weed growth should be undertaken.

- Depending on local requirements, small-scale mechanical weed removal programs can be undertaken to improve boat, float plane or swimmer access. Selection of the type of weed control measure will depend on local conditions. Some experimentation may be necessary.

- To monitor changes in weed growth and to obtain early warning of any occurrence of the extremely troublesome Eurasian milfoil, an aquatic weed program such as outlined in Section 7.2(d) should be implemented.

1.4 - Phase II Study

From the above recommendations, Phase II study would involve the following.

(a) A detailed survey of the Lower Porcupine River as discussed in Section 1.3(a) above.

(b) Outlining a development plan for the shores of the lake (see Section 1.3(a) above). An additional study may be required to provide sufficient data for the establishment of such a plan.

(c) The capital costs associated with the various channel clearance and dredging schemes should be firmed up using the data obtained under (a) above.

(d) Utilizing the information contained from the outline development plan, the capital cost estimates associated with the various lower river channel improvement schemes (point (c) above) and the data contained in this report, the appropriate degree of river channel improvement should be assessed by considering both tangible and intangible benefits and costs.

2 - INTRODUCTION

2.1 - Terms of Reference and Authorization

On April 25, 1977, Acres Consulting Services Limited was commissioned by the Mattagami Region Conservation Authority to undertake Phase I of the Porcupine Lake Study. This phase involved hydrotechnical and environmental studies, and an investigation of ameliorative measures aimed at maintaining Porcupine Lake level fluctuations within an acceptable range. Under the Terms of Reference[1], the study includes

- presentation of feasible alternatives which produce acceptable lake level fluctuations, sketches of the measures, and cursory benefit-cost analyses based on tangible benefits

- high water levels: determination of the floodplains resulting from the following hydrologic events
  - 1-in-100-year flood
  - 1-in-15-year flood
  - Timmins regional storm

- low water levels: determination of the minimum acceptable lake levels for various activities in the lake.

The study area defined in the Terms of Reference includes Porcupine Lake and Porcupine River downstream from the lake. (For clarity, this section of the river is usually referred to as the Lower Porcupine River in this report.)

2.2 - Scope

Details of the tasks carried out are as follows (see also Acres proposal[2] of April 1, 1977).

Task 1 - Hydrotechnical Studies - The required lake inflow flood hydrographs and typical low lake level sequences were evaluated. The flood flows were transformed to lake levels by means of a lake level-outflow relationship and level pool storage routing. The lake level-outflow relationship was determined from a series of backwater calculations performed along a 10.3-km (6.4 mi) stretch of the Lower Porcupine River downstream from the lake.

Task 2 - Field Survey - A field reconnaissance and survey of the Lower Porcupine River was undertaken to visually assess flow resistance factors and for locating obstructions, as well as supplementing and checking available cross-sectional data from former studies. The field survey yielded the data used for evaluating the cost of the channel clearance and excavation remedial measures considered.

Task 3 - Socioeconomic Survey - Interviews and discussions were held with local people to assemble data for determining the mean annual flood damage and to establish desirable minimum lake levels for recreational facilities and the air bases.

Task 4 - Environmental Survey - A water quality and aquatic weed distribution survey was undertaken to provide a qualitative description of the biological problems caused by low lake levels and the high nutrient concentrations, and to provide environmental input to the assessment of proposed remedial schemes. A preliminary assessment and costing of remedial measures for weed control was also carried out. Although not specifically called for in the original terms of reference, this study was included to provide a more comprehensive evaluation of lake level problems.[2]

Task 5 - Evaluation of Remedial Schemes - Feasible remedial measures were studied and costed. The performance of each scheme was evaluated in terms of lake level response during flood as well as low-flow periods. The approximate environmental impact on each scheme was assessed.

3 - GENERAL DESCRIPTION

3.1 - Physical

Porcupine Lake is located in the City of Timmins, 10.5 km (6.5 mi) east of Timmins proper (see Figure 1). It has a surface area of 280 ha (680 acres), at a water elevation of 279.5 m (917.0 ft) and a corresponding maximum depth of 5 m (16.4 ft). At the southwest end of the lake lies the community of South Porcupine, and at the northwest end the communities of Porcupine and Pottsville. The western shore of the lake consists of open land between the built-up areas of South Porcupine and Porcupine. Development has not taken place along the eastern shore of the lake, and this area is covered extensively by forests.

Inflow to the lake is from the Porcupine River and Bob's Creek, which have a combined drainage area of 87 km^2 (33.6 sq mi), excluding the surface area of the lake. The topography is generally flat and the prevailing soil types range from sandy clay to clay and silt. Approximately 89 percent of the drainage basin is covered by forests. The remaining area contains several small lakes, mine tailings dams and urban development.

3.2 - Climate and Rainfall

Because of its northerly location, Porcupine Lake is subject to severe winter conditions. Mean daily temperatures vary from -8 to -17 degrees C (December to March). The mean annual precipitation is 855 mm (33.7 in.), of which 295 mm (11.7 in.) (water equivalent) falls as snow.[4] Snowmelt usually occurs in April. The summers are generally warm and moist (mean daily temperatures vary between +10 and +17 degrees C (June to September).

3.3 - History

Between 1905 and 1909, gold was found in the immediate vicinity of Porcupine Lake. This precipitated an influx of people to the area and, by 1910, towns were booming at the northeastern corner of the lake (Golden City and Porcupine), the southwestern corner (South Porcupine), the north shore (Pottsville), and at Schumacher and Timmins. In 1911 a forest fire devastated the area, causing extensive damage to South Porcupine and Pottsville. The fire did not slow development, however, and during the next 40 years the area produced more than a billion dollars worth of gold.

During the period 1940 to 1970, as the yield from the gold mines began to diminish, Porcupine gradually stepped into a new role as a producer of base metals and nonmetallic minerals. This has ensured the future of the area.

3.4 - Problems Associated with Lake Flood Levels

During snowmelt in early spring, the lake level rises and flooding of lakeshore properties and facilities generally occurs. Most of the affected areas are located in the communities of Porcupine and South Porcupine (see Figure 1). The total estimated flood damage to the communities surrounding the lake during the 1976 spring flood amounted to approximately $115,000. In addition to tangible damage, a large degree of inconvenience is experienced during high lake levels; air bases in the area are not able to operate; sewerage systems are flooded; roads are overtopped and become impassable; and the local residents suffer personal inconveniences, such as having to move furniture and pump water from basements.

3.5 - Problems Associated with Low Lake Levels

During summer months the lake levels are low (see Figure 2). This factor, associated with the shallow nature of the lake (especially close to the shore), causes the following problems:

- restriction of continuous operation of the air bases
- exposure of unsightly weed beds which may decompose and cause odor problems
- restriction of recreational activities (swimming, boating) by the shallow depths and exposed weed beds.

These problems are aggravated during severe and continuous periods of drought.

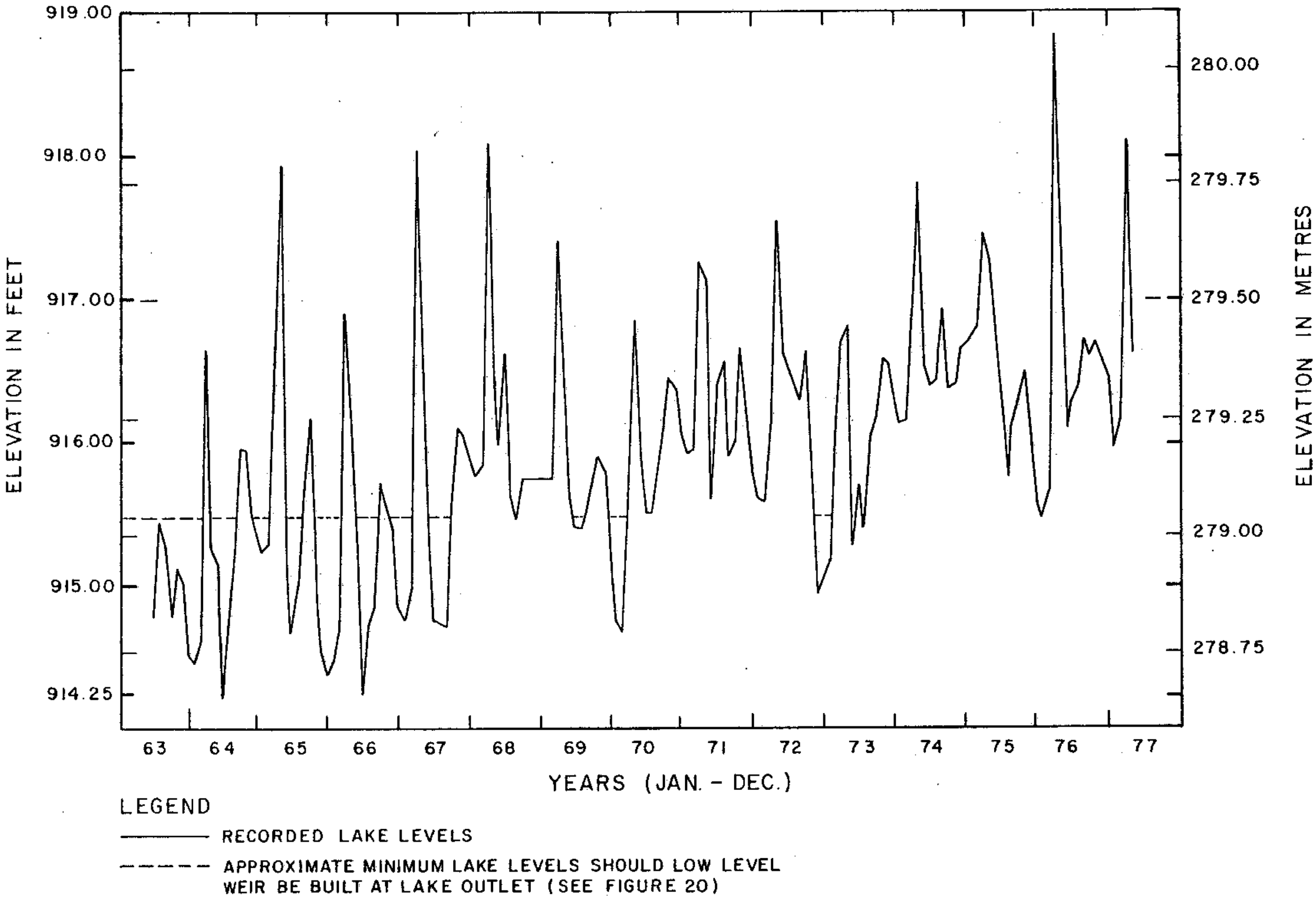

FIG. 2

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PORCUPINE LAKE AND RIVER STUDY

PORCUPINE LAKE - MEAN MONTHLY LAKE LEVELS (AUGUST 1963 TO MAY 1977)

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4 - HYDROTECHNICAL ASPECTS

4.1 - Hydrology

4.1.1 - General

The Timmins storm which occurred on August 31, 1961 has been designated as the "Regional Design Storm" for the Porcupine area by the Conservation Authorities Branch.[5] This storm is a summer rainfall event. The more common floods in the area are snowmelt or combined rainfall/snowmelt events which generally occur in the April-May period. These events constitute the majority of the annual maximum flood events in this area. These two flood types are dealt with separately below.

4.1.2 - The Flood Generated by the Timmins Storm

At the center of the Timmins storm, 20 mm (8 in.) of rain was recorded within a 12-hour period. A synthetic hydrograph generation procedure is necessary to calculate the flood hydrograph resulting from the Timmins storm centered over the drainage basin.

For purposes of this study, the flood hydrograph synthesization techniques developed by the Soil Conservation Services (SCS)[6] were used. The required coefficient techniques were evaluated according to SCS prescribed practice using known basin physiographic characteristics and information contained in references 6, 7 and 8. They are outlined below.

- Hydrologic soil group curve number CN = 65

- Basin lag time = 5.75 hours, calculated using the following equation[9]

$$\text{Basin lag time} = 0.5\left(\frac{L.Lc}{\sqrt{S}}\right)^{0.38}$$

where L = length of main stream from lake inlet to basin divide in miles

Lc = distance from lake inlet to point on stream nearest basin centroid in miles

S = weighted slope of main stream (dimensionless)

- Peak rate factor = 400, calculated using the following expression[9]

Peak rate factor = Cp 650

where Cp = coefficient (a value of 0.62 was selected for the Porcupine River).

The resulting synthetic hydrograph has a peak of 133 m^3/s (4,700 cfs) and is shown in Figures 3 and 4.

There is no gauging station within the drainage basin. Lake levels, therefore, are the sole means of calculating Porcupine River discharges. These levels are recorded every 24 hours by Dome Mines at their water intake/pumphouse at the east side of Porcupine Lake.[10] With this temporal resolution, it is not possible to record the response to rainfall floods which have times to peak which are typically less than 24 hours.

It is therefore not feasible to reconstruct any summer flood hydrographs and to use them to confirm the above synthetic hydrographs parameters.

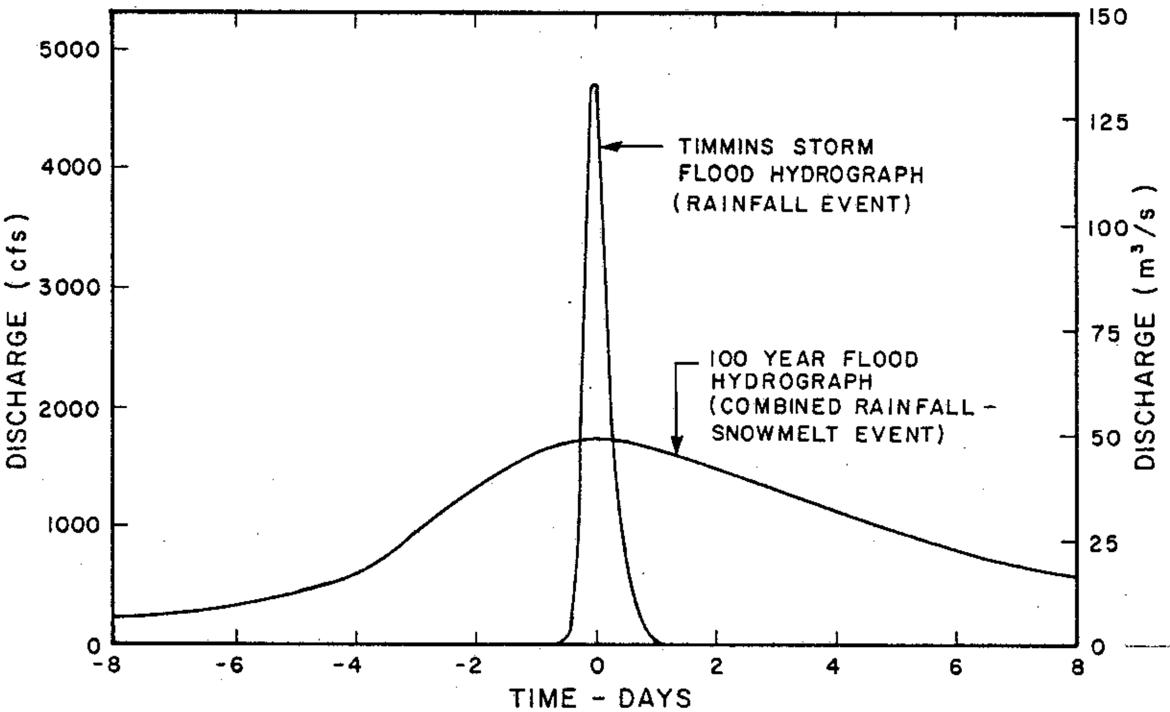

FIG. 3 - TYPICAL INFLOW FLOOD HYDROGRAPHS FOR PORCUPINE LAKE

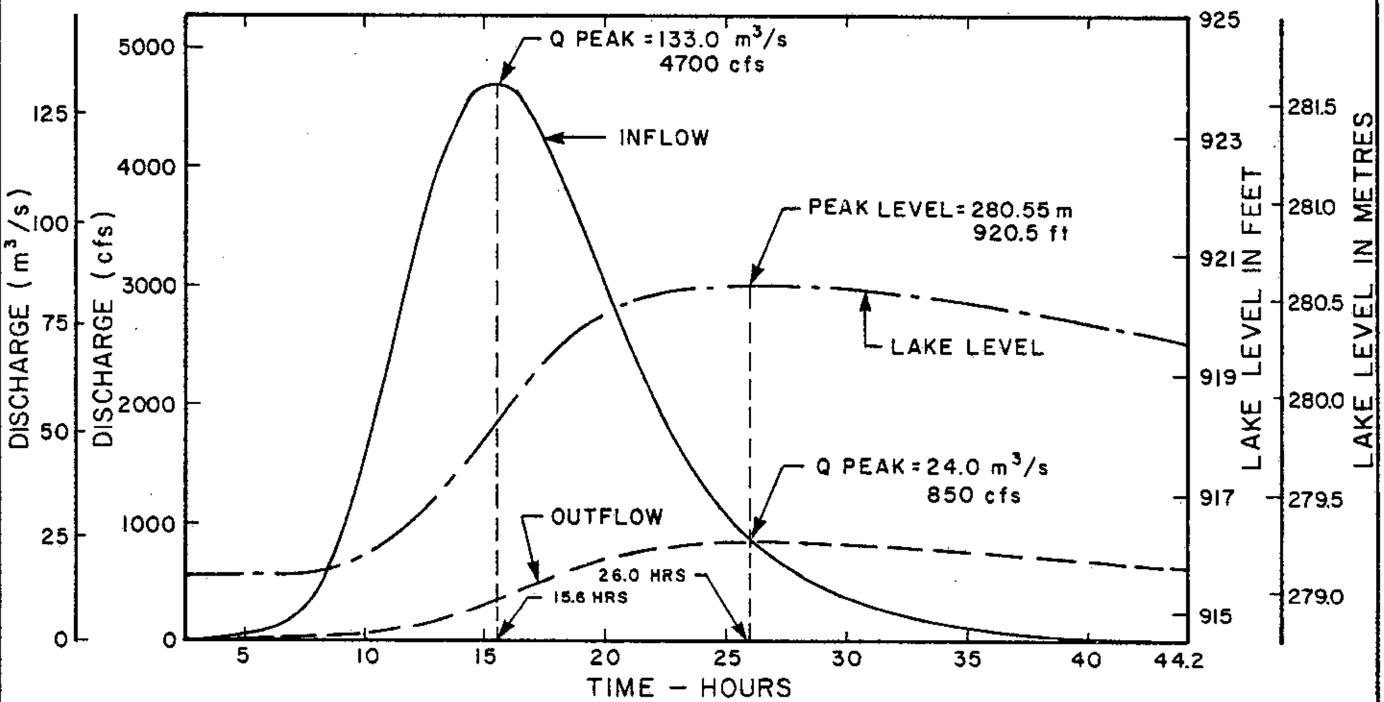

FIG. 4 - RESULT OF ROUTING TIMMINS FLOOD THROUGH PORCUPINE LAKE

FIG. 3 & 4

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PORCUPINE LAKE AND RIVER STUDY

PORCUPINE LAKE-FLOW FLOOD HYDROGRAPHS AND FLOOD ROUTING

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4.1.3 - 1-in-50-and 1-in-100-Year Flood Hydrographs

In order to estimate the magnitude and shape of the 1-in-50 and 1-in-100-year flood hydrographs, use was made of lake level data. A continuous record of 14 years of daily observations is available from June 1963 to present.

The maximum inflow flood hydrograph for each year was determined by carrying out reverse level pool lake routing calculations, utilizing lake level-outflow and lake level-volume relationships (see Figure 5), and 61 days of measured lake levels (30 days before and 30 days after the occurrence of the peak lake level). The evaluation of the stage-discharge relationship at the outlet of the Porcupine Lake (at MOT bridge No. 25) is described in Section 4.2.3. For the purpose of this exercise it was assumed that the lake level-outflow relationship during flood periods has remained constant over the past 14 years. As this assumption may not be valid the results achieved are checked by comparison with data from other hydrometric stations in the area as described below.

A flood frequency analysis was performed on the resulting 14 peak inflow rates (see Figure 6). A 3-parameter log normal distribution (3PLN), fitted by the method of maximum likelihood, was found to be the most appropriate curve. The 1-in-50-and 1-in-100-year flood peaks abstracted from this curve are

$$\left.\begin{array}{l} \text{- 1-in-50-year} = 44\ m^3/s\ (1{,}550\ \text{cfs}) \\ \\ \text{- 1-in-100-year} = 49\ m^3/s\ (1{,}720\ \text{cfs}) \end{array}\right\}\ \begin{array}{l}\text{daily} \\ \text{mean} \\ \text{discharge}\end{array}$$

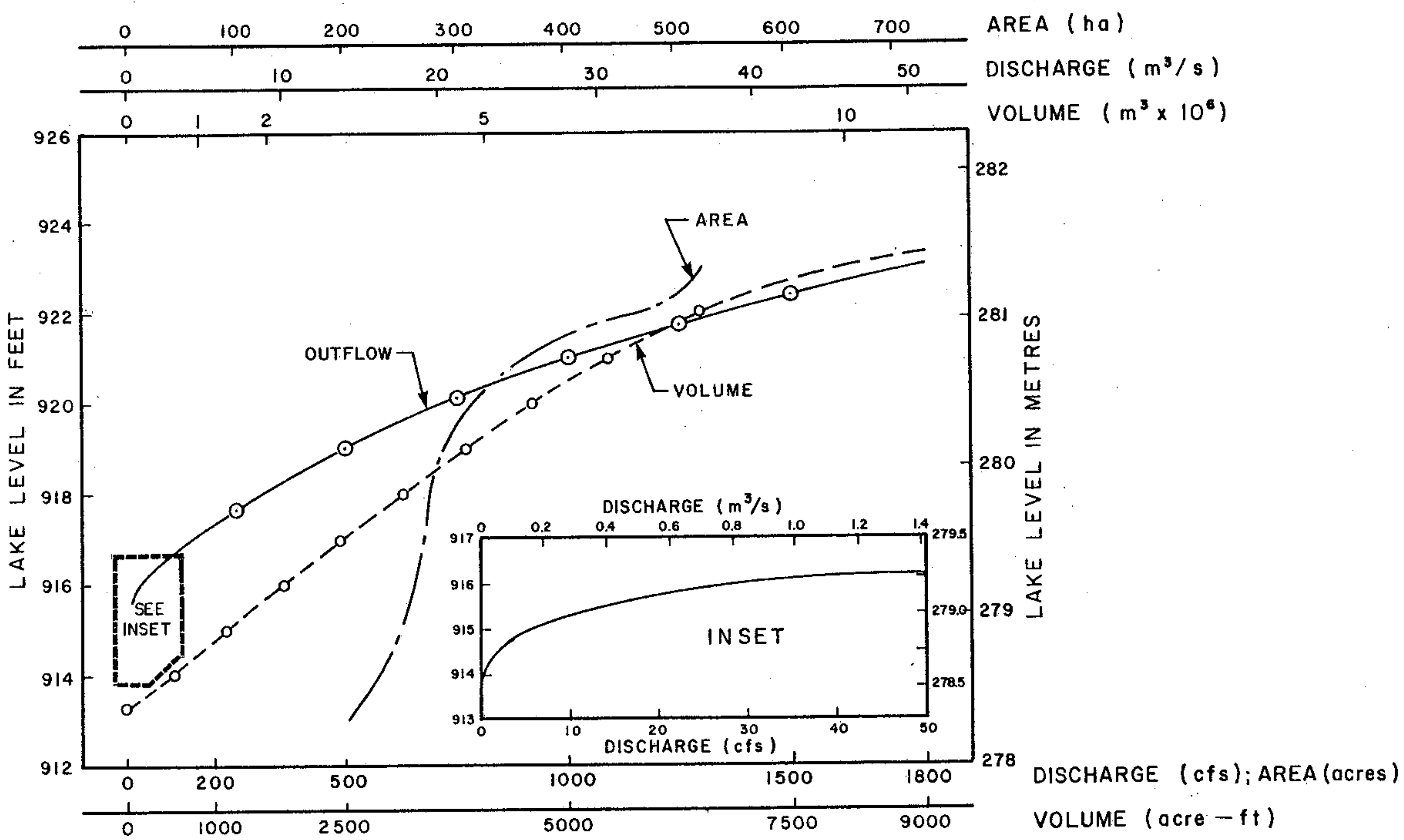

FIG. 5

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PORCUPINE LAKE AND RIVER STUDY

PORCUPINE LAKE - GEOMETRY AND LAKE LEVEL- OUTFLOW CURVE

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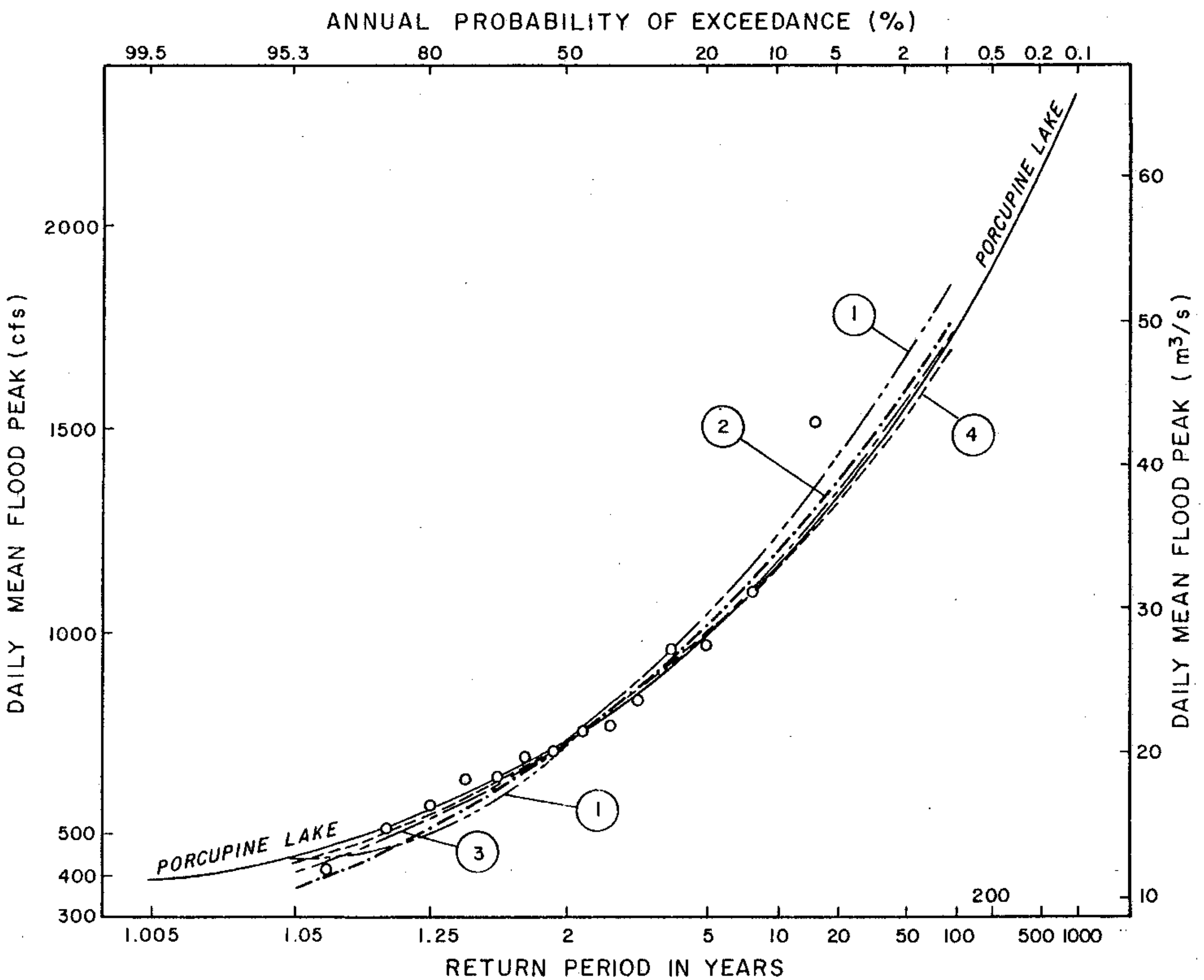

LEGEND

- PORCUPINE LAKE INFLOW BASED ON ANNUAL MAXIMUM FLOOD PEAKS CALCULATED FROM OBSERVED LAKE LEVELS
- 1 WEST MONTREAL RIVER AT MISTINIKON LAKE DAM
- 2 AUX SABLES RIVER AT MASSEY
- 3 DUCHESNAY RIVER AT NORTH BAY
- 4 FREDERICK HOUSE RIVER AT FREDERICK HOUSE LAKE DAM

NOTE

ALL FLOOD FREQUENCY CURVES ARE 3 PARAMETER LOG NORMAL.

CURVES 1 TO 4 HAVE BEEN ADJUSTED TO COINCIDE WITH PORCUPINE LAKE CURVE AT MEAN ANNUAL FLOOD

FIG. 6

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PORCUPINE LAKE AND RIVER STUDY

PORCUPINE LAKE INFLOW FLOOD FREQUENCY

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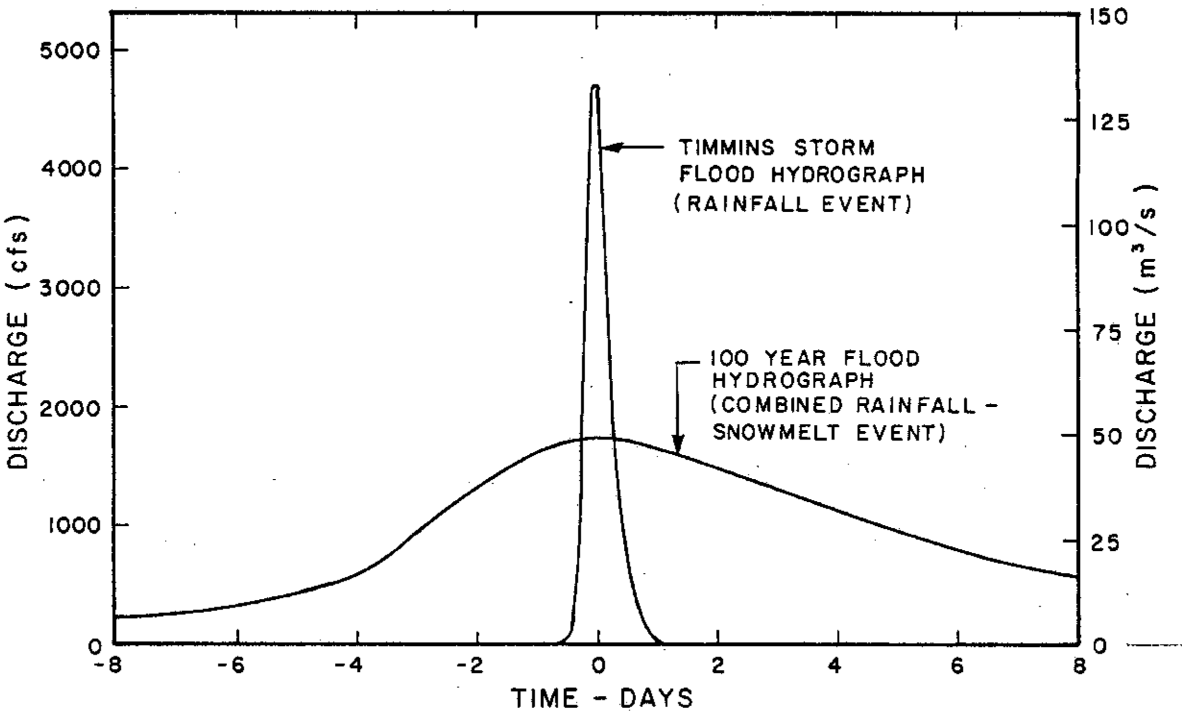

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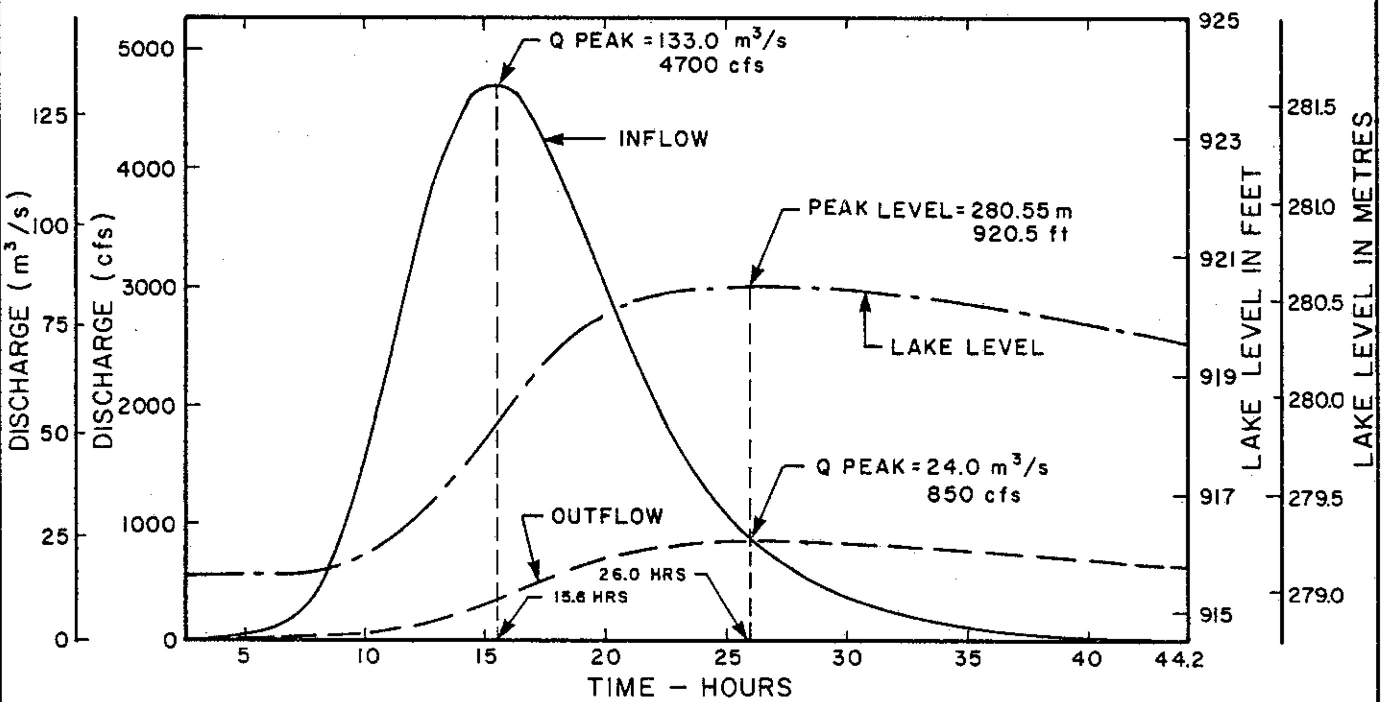

FIG. 4 - RESULT OF ROUTING TIMMINS FLOOD THROUGH PORCUPINE LAKE

FIG. 3 & 4

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PORCUPINE LAKE AND RIVER STUDY

PORCUPINE LAKE-FLOW FLOOD HYDROGRAPHS AND FLOOD ROUTING

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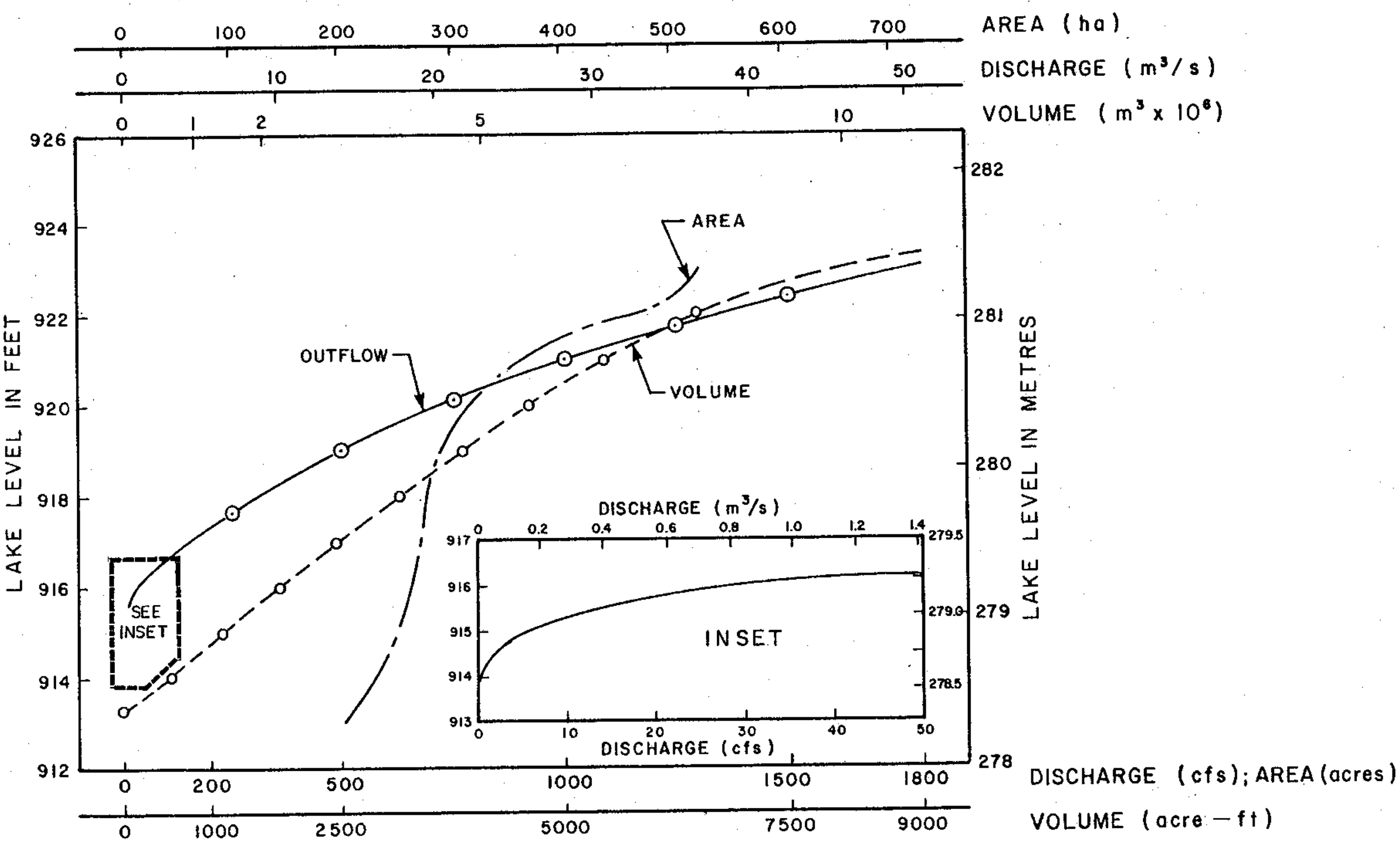

FIG. 5

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PORCUPINE LAKE AND RIVER STUDY

PORCUPINE LAKE - GEOMETRY AND LAKE LEVEL- OUTFLOW CURVE

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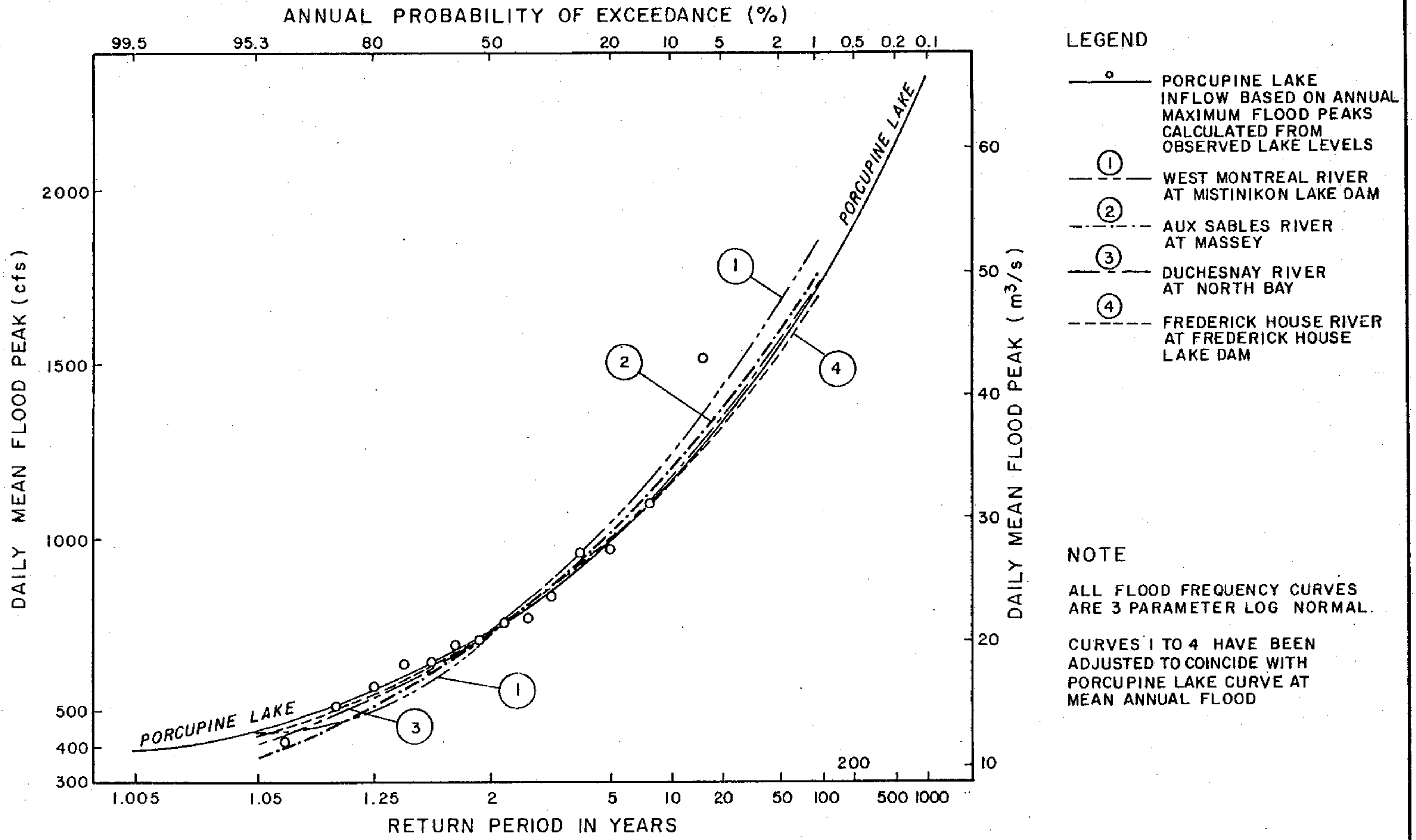

FIG. 6

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PORCUPINE LAKE AND RIVER STUDY

PORCUPINE LAKE INFLOW FLOOD FREQUENCY

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A typical dimensionless* inflow hydrograph shape was evaluated by selecting the median shape from the seven largest inflow hydrographs derived from the reverse routing procedure. The hydrographs were centered about their peaks and rendered dimensionless by dividing the ordinates by the peak discharge. Combining this dimensionless shape with the flood peaks calculated above, yields typical 1-in-50- and 1-in-100-year flood hydrographs which are shown in Figures 7 and 8.

To verify the above calculations, a local regional flood frequency analysis was carried out using daily mean annual maximum flood peak data derived from neighboring hydrometric stations.[11,12,13] A total of five stations was considered (see Tables 1 and 2).

Three-parameter log normal curves were fitted to these data to facilitate direct comparison with the Porcupine Lake inflow flood frequency curve.** These curves were adjusted for the Porcupine Lake drainage area by first rendering them dimensionless by dividing their ordinates by the mean annual flood (2-year return period) and then dimensionalizing them by multiplying by the mean annual flood at Porcupine, viz, 21.0 m^3/s (740 cfs) abstracted from the Porcupine Lake inflow curve in Figure 6. The result of this analysis is shown in Figure 6, from which it can be noted that there is close agreement thus verifying the shape of the inflow flood peak frequency curve.

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* The hydrographs developed are in fact semidimensionless. It was not necessary to render the horizontal or time scale dimensionless as all the hydrographs had very similar base widths.

** The 3 - parameter log normal curve was found to yield the best fit in the majority of cases and was therefore consistently applied to all data.

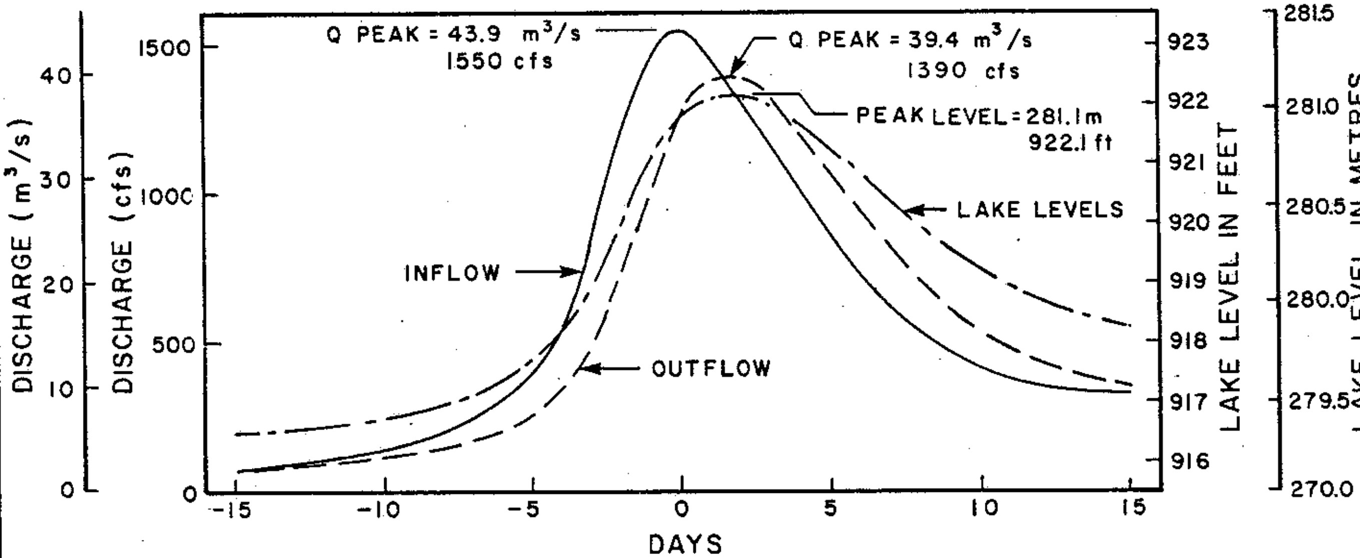

FIG. 7 – 50 YEAR FLOOD

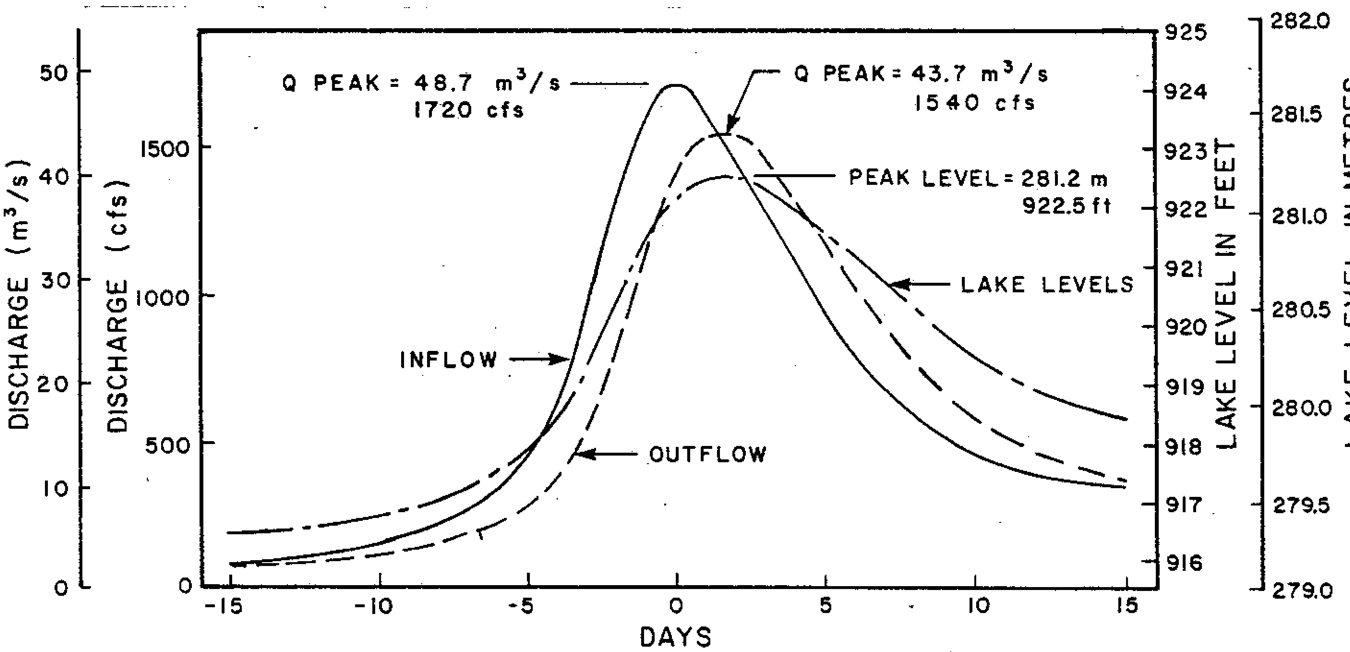

FIG. 8 – 100 YEAR FLOOD

FIG. 7 & 8

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PORCUPINE LAKE AND RIVER STUDY

RESULTS OF ROUTING 50 AND 100 YEAR FLOODS THROUGH PORCUPINE LAKE

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TABLE 1

HYDROMETRIC STATIONS

Ref No. Used in This Study	Station Identification Number	River	Station Location	Gauge Location Latitude	Gauge Location Longitude	Straight Line Distance From Porcupine Lake (km)	Type of Control	Period of Record (years)
1	04LB001	Mattagami River	Smooth Rock Falls	49°16'04"	81°38'30"	94	Regulated	41
2	04LC001	Groundhog River	Horwood Lake	48°07'00"	82°16'30"	90	Regulated	15
3	04MB003	Watabeag River	Watabeag Lake Dam	48°17'34"	80°32'43"	55	Regulated	23
4	04MD002	Frederick House River	Frederick House Lake Dam	48°47'33"	81°00'53"	33	Regulated	26
5	02JD012	West Montreal River	Mistinikon Lake Dam	48°02'30"	80°42'20"	62	Regulated	26
6	04LA002	Mattagami River	Timmins	48°28'45"	81°21'15"	11	Regulated	5
7	04LF001	Kapukasang River	Kapukasang	49°25'04"	82°26'15"	135	Regulated	51
8	02JE018	Farr Creek	North Cobalt	47°25'28"	79°37'59"	167	Natural	4
9	02JC009	Blanche River	Swastika	48°06'31"	80°06'21"	91	Natural	5
10	02DD008	Duchesnay River	North Bay	46°19'53"	79°30'20"	274	Natural	19
11	02CE002	Aux Sables	Massey	46°12'54"	82°04'14"	262	Regulated	55

TABLE 2

LOCALIZED REGIONAL FLOOD FREQUENCY ANALYSIS

Ref No. Used in This Study (See Table 1)	Drainage Basin Area sq mi	km^2	Flood Peaks Q_{100} (m^3/s)	Q_2 m^3/s)	Q_{100}/Q_2	Q_2/km^2 (m^2/s/km^2)
4	1,120	2,900	396.4	170	2.33	.059
5	686	1,776	317.2	126.6	2.51	.071
10	37	96	41.1	17.7	2.32	.184
11	524	1,357	249.5	105.1	2.37	.077
Porcupine Lake Inflow	33.6	87	48.7	21.0	2.32	.241

Note

Q_2 = 1-in-2-year flood peak (mean annual flood peak)

Q_{100} = 1-in-100-year flood peak

The mean annual flood peaks evaluated at the neighboring basins range from .06 to .18 $m^3/s/km^2$ for drainage basins varying in size from 2,900 km^2 (1,120 sq mi) to 96 km^2 (37 sq mi -- see Table 2). For Porcupine Lake the value is 0.24 $m^3/s/km^2$. This is in agreement with the general trend found in the area. The difference of 33 percent between the Porcupine Lake and the Duchesnay River (see Table 2) flood peaks (both have similar drainage basin areas) should not be regarded as significant and could be due to errors in estimating the flood peaks and differences in the flood response characteristics of the two drainage basins.

4.1.4 - Low-Flow Sequences

As is the case with the flood analysis, lack of data required the use and analysis of data from neighboring hydrometric stations.

Mean Annual Runoff Estimate - Tables 1 and 3 give the station identification data and the mean annual runoff per unit area respectively. The mean annual runoff (MAR) for Porcupine Lake was evaluated by averaging the MAR per unit area for the first nine stations listed in Table 1. (These MAR values were obtained by using the available record at each station) This resulted in a value of 0.0114 $m^3/s/km^2$ (1.04 cfs/sq mi) which yields a MAR of 1.0 m^3/s (35 cfs) for Porcupine Lake drainage basin. The direct contribution of precipitation on the lake surface contributes only .0035 m^3/s to the mean annual runoff and has been ignored for purposes of this study.

TABLE 3

DETERMINATION OF MEAN ANNUAL RUNOFF OF PORCUPINE LAKE DRAINAGE BASIN

Ref No. Used in This Study	Catchment Area		Mean Annual Runoff	
			Total	Per Unit Area
(see Table 1)	sq mi	(km^2)	(m^3/s)	($m^3/s/km^2$)
1	3,860	9,993	116.38	0.0116
2	1,300	3,366	34.83	0.0103
3	92	238	2.59	0.0109
4	1,120	2,900	32.28	0.0111
5	686	1,776	21.01	0.0118
6	2,140	5,540	71.22	0.0114
7	2,610	6,757	79.00	0.0117
8	24.3	62.9	0.699	0.0111
9	97	251	3.11	0.0124
			Mean =	0.01136

Mean of all stations = 0.01136 $m^3/s/km^2$. Assume it applies to Porcupine Lake

Catchment area of Porcupine Lake = 87 km^2 (33.6 sq mi)

$\therefore$ Mean annual runoff into Porcupine Lake = 87 x 0.01136 = 1.0 m^3/s (35 cfs)

Low-Flow Sequences - It should be noted that the majority of the gauged basins in Table 1 contain regulation of some sort. Although regulation does not normally affect the MAR, it can severely distort low-flow sequences. The only unregulated basin with a relatively long period of record, in the vicinity of Porcupine Lake, is the Duchesnay River at North Bay (Station 02DD008). Data from this basin was therefore used to develop low-flow statistics for the Porcupine Lake drainage basin.

From each of the 19 years of available record, the minimum monthly mean summer season (July, August, September) discharges were abstracted, ranked in descending order and plotted on probability paper. A smooth curve was drawn through the plotted points. This frequency curve was converted to Porcupine Lake inflows by multiplying the Duchesnay discharge values by the following ratio

$$\frac{\text{MAR of Porcupine Lake drainage basin}}{\text{MAR of Duchesnay River, Station 02DD008}} = \frac{1.04\,m^3/s}{1.54\,m^3/s} = 0.675$$

The 1-in-2-, 1-in-5- and 1-in-20-year monthly mean low flows for Porcupine Lake were read off this curve and are given below:

Recurrence Interval (years)	Monthly Mean Discharge during summer months m^3/s (cfs)
2	0.23 (8.1)
5	0.085 (3.0)
20	0.028 (1.0)

To put the above discharge into perspective the long term average summer (July to September inclusive) flow for the Duchesnay was evaluated and converted to Porcupine Lake using the above ratio. This yielded an average summer flow into Porcupine Lake of 0.8 m^3/s (29 cfs).

4.2 - Hydraulic Aspects of the Lower Porcupine River

4.2.1 - Description

A reconnaissance and field survey of the Lower Porcupine River was carried out to assess the magnitude of flow roughness factors, locate and document obstructions, and to supplement and check cross-sectional data available in the Conservation Authorities Branch study.[14] A reach of 10.3 km downstream from bridge No. 25 on Highway 101 was covered. The description of the river is given in Table 4 and Figure 9. Table 5 gives additional information on bridge 25 and 14 (on the Broulan Reef Mine Road).

4.2.2 - River Channel Geometry

The survey carried out in 1976 by the engineering section of the Conservation Authorities Branch of the MNR covered the reach of the Lower Porcupine River from the Highway 101 crossing (bridge No. 25) to a point 8.6 km downstream.[14] Fifteen cross sections were surveyed at seven different locations (see Figure 9).

TABLE 4

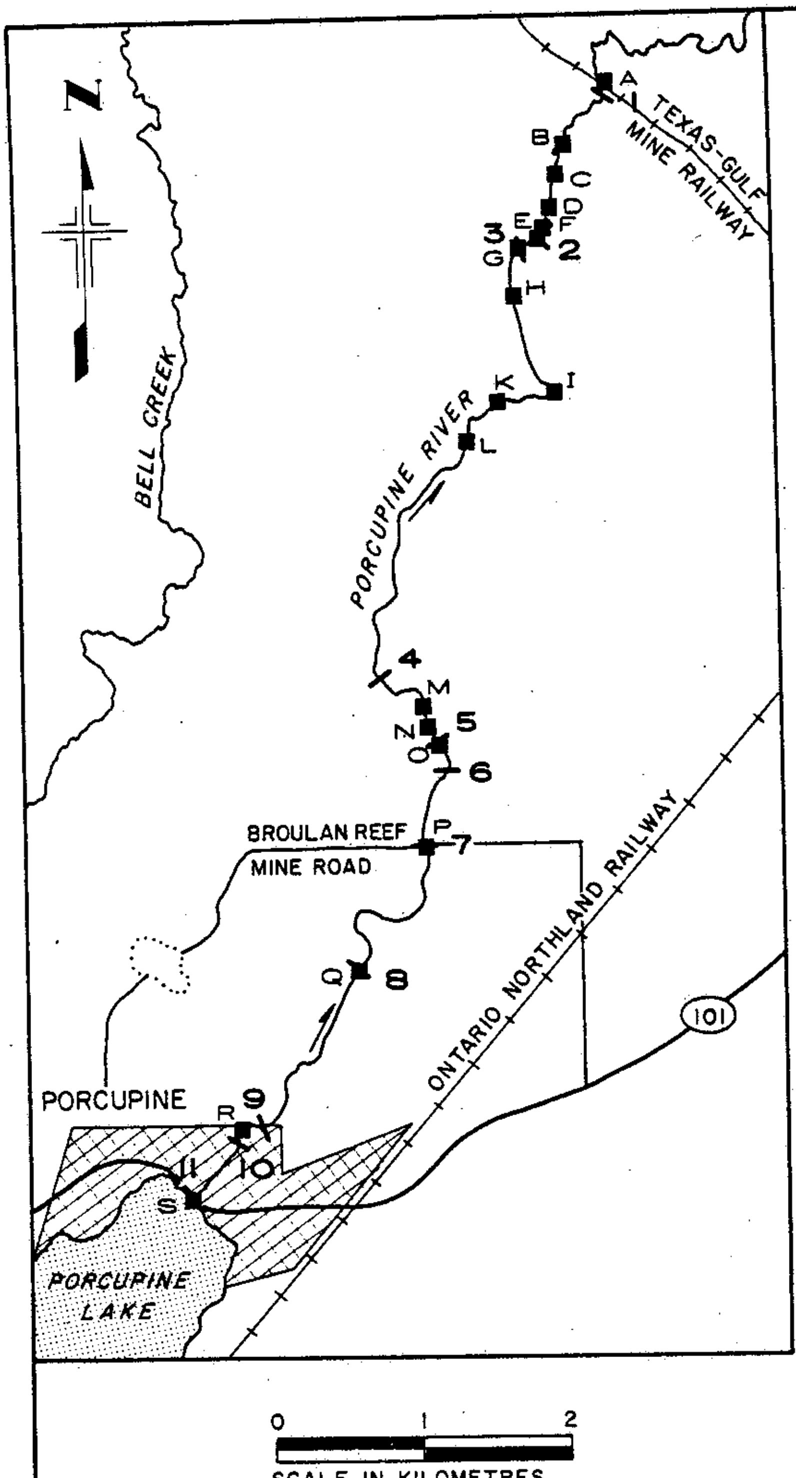
DESCRIPTION OF LOWER PORCUPINE RIVER

Field Survey Carried Out on June 24 - 25, 1977

Point (see Figure 9)	Description
A	Three Armco pipes, 6.1-m diameter, underlying the Texas Gulf Mine railway. Weeds in riverbed. Wide and open section locally with scrub extending into the main channel. Some 250 m upstream the main river channel narrows and the vegetation growth is higher and denser. Strong meandering. Channel width 20 m.
B	Channel width 18 m; depth 1.5 m; bushes and forest extend to bank of main channel.
C	Beaver dam, 0.15-m drop in water level. Channel width 18 m. Overhanging scrub.
D	Water depth 1.35 m. Same physical characteristics as Point C.
E	Beaver dam, 0.02-m drop in water level. Same physical characteristics as Point C.
F	Log jam. Estimated drop in water level equal to 0.45 m. Irregular cross section over jam. Local wide and open stretch of water.
G	Rapids. Water depth varies from 0.60 to 0.75 m. Narrow section. Rapids are 175 m long. Beaver dam firmly established at beginning of rapids. Total drop in water level of 0.45 m.
H	Two log jams forming partial blockage. Physical characteristics of section same as C.
I	Beaver dam 100 m long. River width 12 m locally, but generally 15 m. Overhanging scrub. Logs floating in main channel, probably cut by beavers. Water depth 1.35 m.

TABLE 4 (cont'd)

Point (see Figure 9)	Description
J	Not used.
K	Beaver dam, 0.02-m drop in water level. Width of section 15 m. General river channel characteristics as for I.
L	Small log jam. From L - M, river channel characteristics as at I. Uniform section.
M	Beaver dam, 0.02-m drop in water elevation.
N	River widens. Overbank is partially clear. Beaver dam in construction.
O	Deposits from mine tailings. Local obstruction to river flow.
P	Broulan Reef Mine Road bridge (bridge No. 14). When opening is clear, this bridge forms no obstruction. However, has potential for blockage and resultant severe flow obstruction.
Q	Section is open and wide. Water depth 1.35 m. Two log jams and weeds. Scrub.
R	Shallow lake. Outlet of lake is wide and open. Overbanks covered with scrub and trees.
S	Bridge 25 on Highway 101.



LEGEND

SURVEYED RIVER CROSS-SECTIONS
CHAINAGE AND SOURCE

1 TEXAS-GULF MINE RAILWAY LINE 10290 m, ACS*

2 LOG JAM, 8860m, CAB**

3 RAPIDS, 8530m, CAB

4 HYDRO WIRES, 5010 m, ACS

5 MINE TAILINGS, 4280 m, CAB

6 PUMP HOUSE, 4160 m, CAB

7 BRIDGE No. 14, 3640 m, CAB

8 WEEDS, 2040 m, CAB

9 OUTLET SHALLOW LAKE, 660 m, ACS

10 SHALLOW LAKE, 480 m, ACS

11 BRIDGE No. 25 HWY 101, 0m CAB

POINTS AT WHICH RIVER DESCRIPTION IS GIVEN IN TABLE 4

■

NOTE

*ACS - ACRES CONSULTING SERVICES LIMITED

**CAB - CONSERVATION AUTHORITIES BRANCH REF. 14

FIG. 9

MATTAGAMI REGION CONSERVATION AUTHORITY
PORCUPINE LAKE AND RIVER STUDY
LOWER PORCUPINE RIVER

ACRES

TABLE 5

TECHNICAL DATA PERTAINING TO BRIDGES 25 (HIGHWAY 101) AND 14 (BROULAN REEF MINE ROAD)

Bridge 14

Roadway and original bridge owned and maintained by City of Timmins. Steel deck subsequently built by Miller Paving Ltd.

Length of deck	- 32.3 m (106 ft)	
Width of deck	- 4.9 m (16 ft)	
Load limit	- 7.25 tonnes (8 tons)	
Structural ratings	- superstructure	- poor
	- substructure	- poor

Bridge 25

Owned and maintained by MTC

Length of deck	- 50 m (164 ft)
Width of deck	- 13.7 m (45 ft)
Spans	- 6 x 7.9 m (6 x 26 ft)
Load limit	- 18.15 tonnes (20 tons)
Structural ratings	- superstructure and deck - major cracking has occurred
	- substructure - treated timber piles show signs of weathering

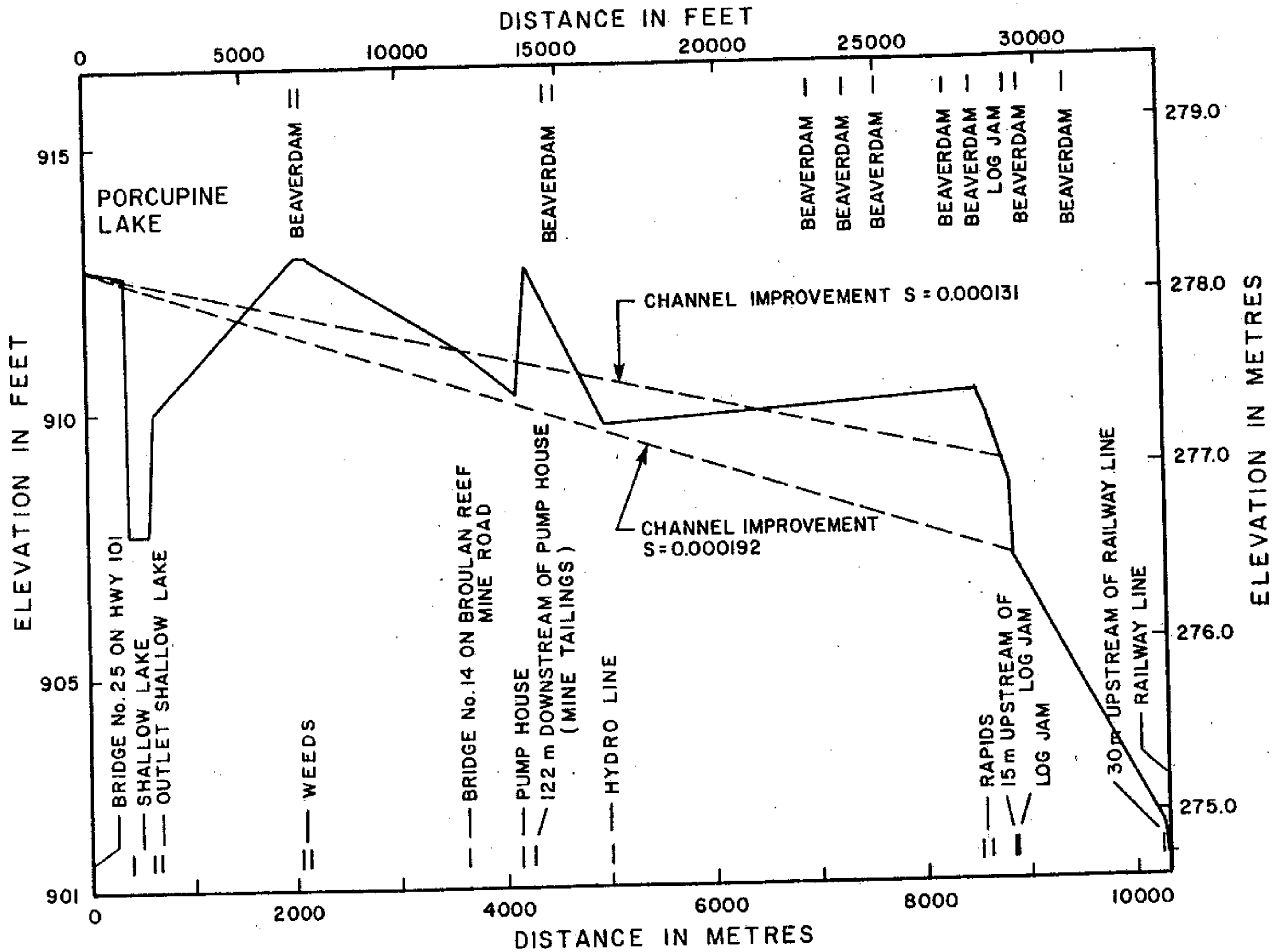


FIG. 10

MATTAGAMI REGION CONSERVATION AUTHORITY
PORCUPINE LAKE AND RIVER STUDY

ACRES

LONGITUDINAL PROFILE OF PORCUPINE RIVER DOWNSTREAM OF PORCUPINE LAKE

In 1977, Acres surveyed an additional four cross sections (No. 1, 4, 9 and 10; Figure 9). In addition to the surveyed sections, 1:2,500 mapping, where available, was used to fill in river geometry between surveyed sections to provide input to the backwater calculations discussed below.

The riverbed profile is shown in Figure 10. The profile exhibits three major "high spots";

- the aquatic weeds at distance 2,040 m (6,700 ft)
- the mine tailings at distance 4,275 m (14,025 ft)
- the rapids at distance 8,535 m (28,000 ft).

The weeds consist of mats of floating leaves which have grown across the entire width of the river and extend along the river for some 50 m (160 ft). The leaves float on top of the water, but the roots extend into accumulations of silt deposits and decaying organic matter on the bed of the river.

Mine tailing ponds extend close to the river and spills from these ponds are deposited in the river. The problem was reviewed in 1972 by the Ministry of the Environment,[15] but it is not known what steps will be taken to prevent further spilling. It is, however, imperative to prevent any future spillage as this may seriously impair the discharge capacity of the channel and increase flood levels in the lake.

The rapids are a firmly established natural control.

4.2.3 - Calculations

A series of backwater calculations were carried out to establish a lake level-outflow relationship at the outlet of Porcupine Lake (i.e. at bridge No. 25 on Highway 101). A Manning roughness coefficient of 0.045 was used for the river channel downstream from Shallow Lake, incorporating the influence of beaverdams. For the river in the Shallow Lake area, a coefficient of 0.030 was used. For the overbank flow area, a coefficient of 0.100 was used to simulate the effect of dense growth.

This value was locally adjusted to account for change in the density of the overbank growth (for instance at Shallow Lake). The selection of these values was based on the nature of the terrain and not on discharge and water slope measurements, as these were not available for flood flows.

The lake level-outflow relationship was evaluated by performing backwater calculations (using the HEC-2 program[30]) for discharges varying from 42.5 m^3/s (1,500 cfs) to 2.8 m^3/s (100 cfs). The results are shown in Figure 5.

4.3 - Lake Level Characteristics

Use was made of the 14 years of lake level observations (see Section 4.1.3) to determine the lake level regime. Figure 2 shows the graphical representation of mean monthly levels. All annual peak lake levels occur in spring (April-May). Low lake levels occur both in winter and in summer.

Scrutiny of Figure 2 reveals an upward trend in the low lake levels (assuming the water level data are reliable). This could be caused by either

- an increase over the years in the number of beaver dams or other physical obstructions (log jams, mine tailings) or

- gradual deterioration of the channel linking Porcupine to Shallow Lake (constructed in 1938) due to siltation and vegetation growth.

No upward trend is displayed by the maximum flood levels.

Based on the above data, the mean annual lake level is 279.2 m (915.9 ft).

4.3.1 - Peak Levels

The response of the lake to flood inflows was determined by a level pool routing procedure[16] for the Timmins storm and the 1-in-50- and 1-in-100-year flood hydrographs. The starting lake level for the Timmins storm hydrograph routing was assumed to be the mean summer level, 279.08 m (915.62 ft). For the 50- and 100-year flood hydrographs, the starting lake level was taken as the mean lake level 15 days before the occurrence of the highest annual spring lake levels during the period of record; i.e. the approximate time to peak of spring flood lake level (see Figures 7 and 8). Figure 11 illustrates that the starting lake level can affect the return period of the peak level. For example, because of the low lake levels prior to the flood event the 1964 flood peak, which is the fourth highest on record, only produced the twelfth highest peak flood level. Utilizing the average starting level in the routing calculations ensures that the return period of the simulated peak lake level coincides with the return period of the input hydrograph.

The results of these routing exercises are shown in Figures 4, 7 and 8. The resultant peak lake levels are

Timmins storm	- 280.55 m (920.51 ft)
1-in-50-year flood	- 281.07 m (922.14 ft)
1-in-100-year flood	- 281.18 m (922.52 ft)

The higher flood levels associated with the 1-in-50- and the 1-in-100-year floods, compared to the Timmins storm, are due to the much larger volume of water involved. Figure 3 illustrates the difference in the hydrograph shapes.

Appendix B depicts the corresponding floodplain outline.

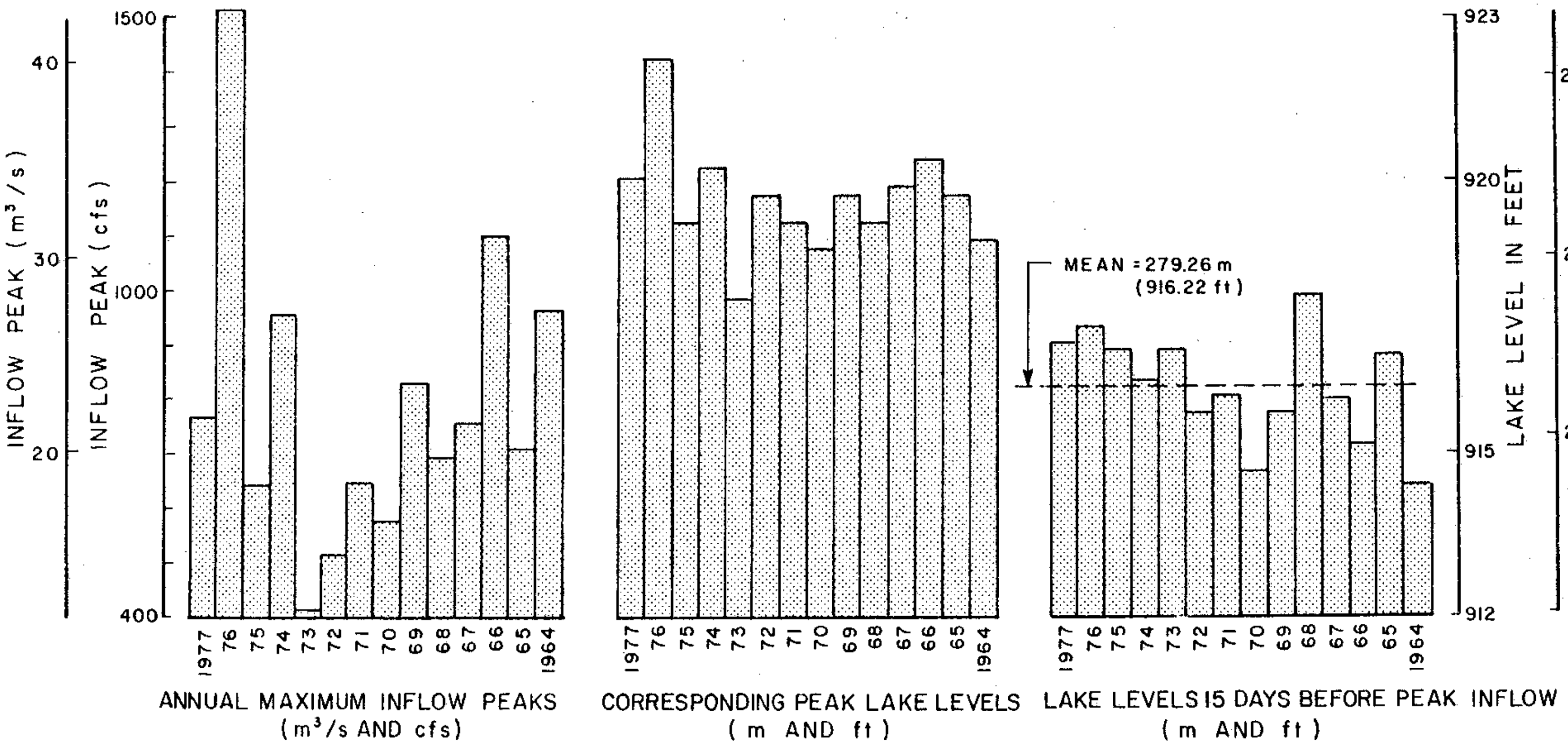


FIG. 11

MATTAGAMI REGION CONSERVATION AUTHORITY

PORCUPINE LAKE AND RIVER STUDY

PORCUPINE LAKE PEAK INFLOWS, PEAK LAKE LEVELS AND LAKE LEVELS 15 DAYS BEFORE PEAK

ACRES

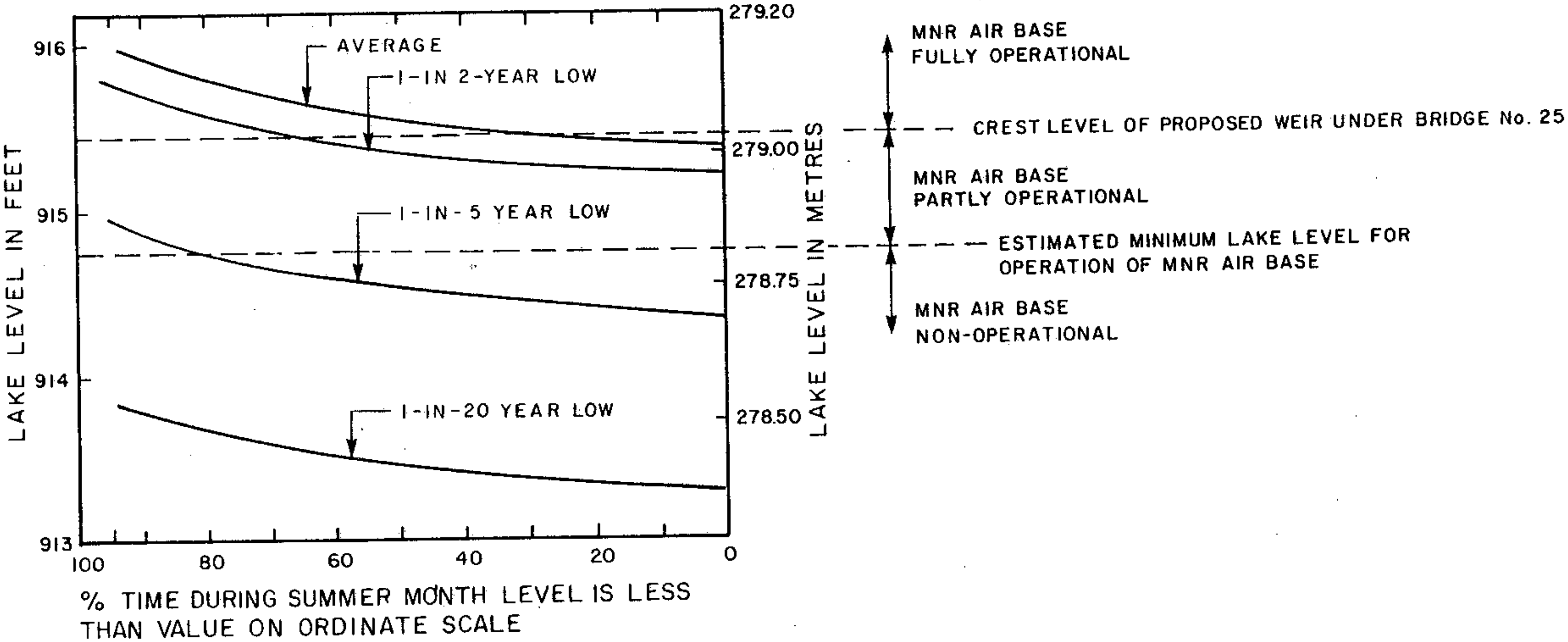
4.3.2. - Low Lake Level Sequences

Using the minimum mean monthly summer lake levels (July - September) from the 14 years of lake level data, the 1-in-2-, 1-in-5- and 1-in-20-year minimum summer monthly mean low lake level sequences were determined. The analytic procedure used is identical to that undertaken to evaluate the 1-in-2-, 1-in-5-, and 1-in-20-year summer monthly low flows outlined in Section 4.1.4. In addition, the average summer level was evaluated. The results achieved are as follows:

Summer (July - September, inclusive) monthly lake levels

Average	279.1 m (915.6 ft)
1-in-2-year low	279.0 m (915.4 ft)
1-in-5-year low	278.8 m (914.6 ft)
1-in-20-year low	278.4 m (913.5 ft)

In order to assess in more detail the level fluctuations during a summer month, daily duration curves were developed. The month of July was selected as being representative of summer conditions. Daily level data for the five lowest average July levels on record were selected and used to develop a dimensionless summer month duration curve. (The individual duration curves were rendered dimensionless by dividing by the mean monthly level and were averaged to yield the desired curve). The mean monthly levels, given above for the average and the 1-in-2-, 1-in-5- and 1-in-20-year lows, were used to dimensionalize these curves and to produce the duration curves plotted in Figure 12. The required range of lake levels for problem-free operation of the MNR air base has also been added to Figure 12. This allows the percentage time of problem-free operation to be assessed for typical summer months.



NOTE

SUMMER CONSISTS OF MONTHS OF JULY, AUGUST AND SEPTEMBER

FIG. 12

MATTAGAMI REGION CONSERVATION AUTHORITY
PORCUPINE LAKE AND RIVER STUDY

SUMMER MONTH LAKE LEVEL-DURATION CURVE AND MNR AIR BASE OPERATIONAL REQUIREMENTS

ACRES

The low level and flow values and statistics developed above and in Section 4.1.4 were utilized to refine definition of the lower end of the lake level-outflow curve depicted in Figure 5. The assumption was made that during low-flow periods the lake level is in steady state and that the mass balance equation can be written as

inflow = outflow via Lower Porcupine River
+ net evaporative loss.

This assumption plus the average monthly evaporation data[18] listed in Table 6 allowed lake levels and corresponding lake outflow values to be calculated. These values were then plotted and used to define the lower portion of the curve given in Figure 5.

In addition, the results obtained in a study on Porcupine Lake recently conducted by Acres were also used.[17] This study yielded 1-in-2-, 1-in-5- and 1-in-20-year seasonal low flows. The values for the summer, autumn and winter seasons (July - September, October - December, and January - March) were used in conjunction with the corresponding seasonal lake levels evaluated from the 14 years of lake level data.

TABLE 6

MONTHLY GROSS AND NET PRECIPITATION AT PORCUPINE LAKE

Month	Gross Precipitation* (mm) (1)	Open Water Surface Evaporation** (mm) (2)	Net Precipitation (mm) (3) = (1) - (2)
January	55	-	55
February	50	-	50
March	50	-	50
April	46	-	46
May	70	64	6
June	87	112	-25
July	88	117	-29
August	100	80	20
September	89	52	37
October	68	28	40
November	90	10	80
December	63	-	63
Total	856	463	393

*Reference 4
Gross precipitation at Timmins Airport for 15 - 19 years of record

**Reference 18
Data based on 10 years of record.

5 - ENVIRONMENTAL ASPECTS

5.1 - Sources of Pollution

In the early 1900's, sewage from Golden City, Pottsville and South Porcupine entered Porcupine Lake and River virtually untreated, as did sewage from Schumacher which flowed into Pearl Lake and the Porcupine River. Water pollution and associated weed growth must have been noticeable in Porcupine Lake and River within a few years after the first gold finds.

5.1.1 - 1966 Summary of Pollution Sources[19,20]

For the location of the places referred to below, see Figures 1 and 13.

(a) Domestic Waste Disposal

Porcupine (excluding Pottsville and Bob's Lake) - Domestic waste from 93 of the 123 residences was conveyed to a municipal septic tank which discharged to the Lower Porcupine River. The remaining homes had their own septic tanks and tile bed systems. Surface drainage flowed in to Porcupine Lake and the Lower Porcupine River.

Pottsville - Domestic waste from 92 of the 117 residences was conveyed to a municipal septic tank which discharged into Porcupine Lake. The remaining homes had septic tanks and tile bed systems. Surface drainage flowed into Porcupine Lake.

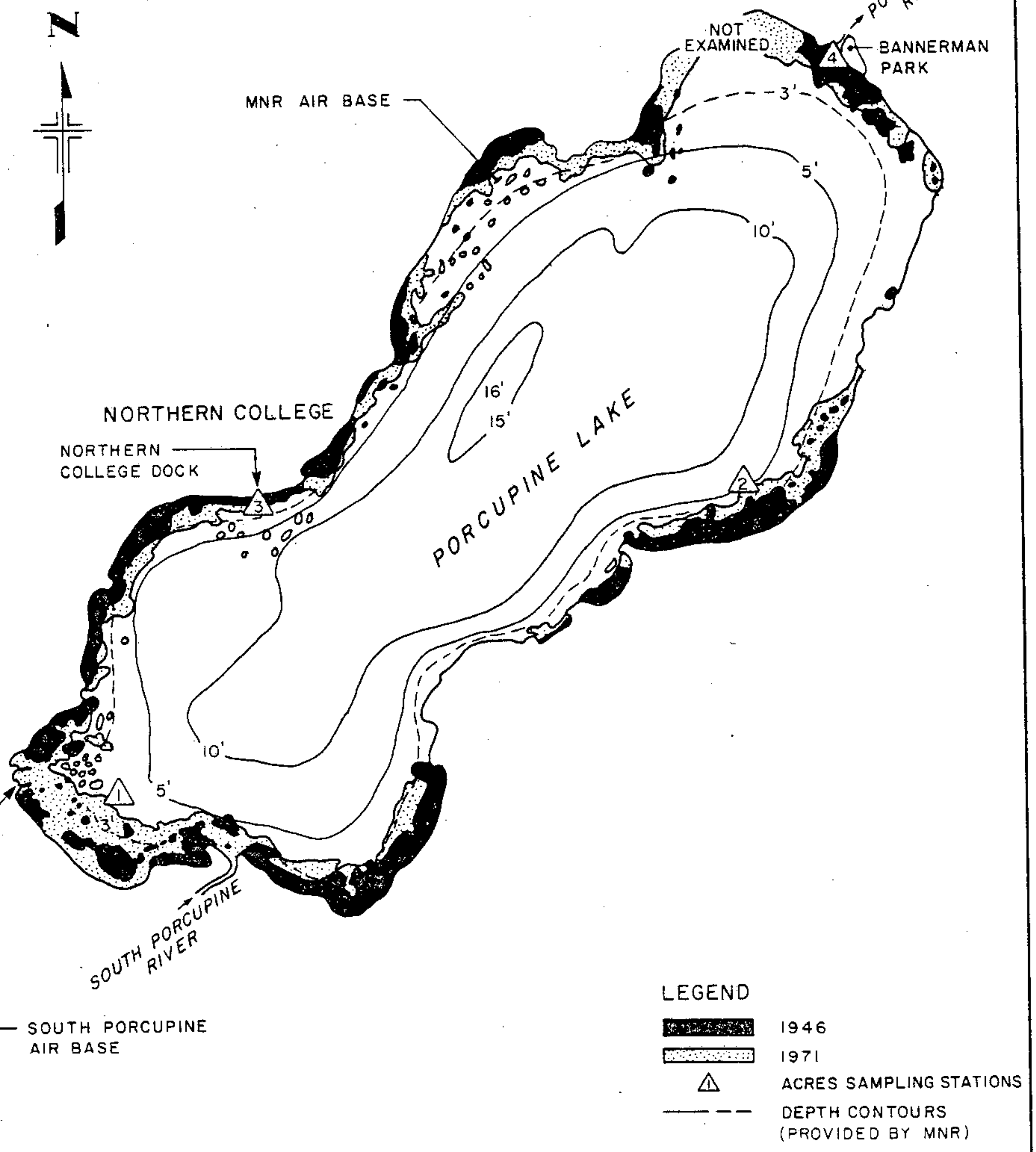


FIG. 13

MATTAGAMI REGION CONSERVATION AUTHORITY

PORCUPINE LAKE AND RIVER STUDY

EXTENT OF AQUATIC MACROPHYTE BEDS, PORCUPINE LAKE

ACRES

Bob's Lake - Domestic waste from the 38 homes was diverted into a lagoon which was flushed seasonally into Bob's Creek. (The total population of Porcupine, including Pottsville and Bob's Lake was 1,000.)

South Porcupine - Approximate population 4,507. Domestic sewage was transferred to two municipal septic tanks, one of which discharged to Porcupine River, the other to Porcupine Lake. Surface run-off flowed into the Porcupine River and Lake. Some houses were served by individual septic tanks.

Lakeview Subdivision - Approximate population 250. The majority of residences were served by septic tank systems, some of which discharged directly to roadside ditches. The remainder were served by pit privies and the South Porcupine sanitary sewer system.

Schumacher (including Gold Center) - Approximate population 3,224. Domestic waste was conveyed to four municipal septic tanks, two of which discharged to Pearl Lake, the other two into tributaries of Porcupine River.

(b) Industrial Waste Disposal

Dome Mines Limited - Sanitary waste was conveyed to septic tanks which discharged along with industrial waste into a tributary of South Porcupine River.

McIntyre Porcupine Mines Limited - Sanitary waste was conveyed to various septic tanks, all of which drained to Pearl Lake.

Hollinger Consolidated Gold Mines Limited (mine closed since 1969) - Sanitary waste was discharged to several septic tanks which eventually drained either to Pearl Lake, Gillies Lake, or the Schumacher sewer system.

Pamour Porcupine Mines Limited - Domestic sewage was treated in individual septic tanks. The combined domestic and industrial effluent drained to a tributary of the Lower Porcupine River, which joins the river below Hoyle (i.e., just before the river flows into Nighthawk Lake).

Hallnor Mines Limited (mine closed since 1966) - Domestic sewage was conveyed to two septic tanks which discharged to a tributary of the Lower Porcupine River.

Broulan Reef Mines Limited (mine closed since 1966) - Sanitary waste was directed to a septic tank which discharged to an open ditch which eventually drained to the Lower Porcupine River.

5.1.2 - 1974 Summary of Pollution Sources

By 1974, several changes had occurred and the situation was as follows.

(a) Domestic Waste Disposal

Whitney Water Pollution Control Plant (commissioned February 28, 1974) - Served Porcupine, Pottsville, an area north of Northern College, Northern College itself, South Porcupine and Lakeview. It provided secondary treatment and discharged to the Lower Porcupine River.

Bob's Lake - As in 1966.

Porcupine - A few homes had individual septic tanks which discharged to Porcupine Lake.

South Porcupine - A few homes had individual septic tanks which discharged to Porcupine Lake.

North Eastern Psychiatric Hospital (300 patients, near Shallow Lake) - This hospital was served by a lagoon which discharged into Shallow Lake on the Lower Porcupine River.

Schumacher - As in 1966.

(b) Industrial Waste Disposal

As in 1966, except for those mines that had been closed down and Hollinger Consolidated Gold Mines Ltd. which still discharged some sanitary waste to the Schumacher sewer system.

5.1.3 - Future Sources of Pollution

(a) Domestic Waste Disposal

As in 1974, except for the following.

Enlarged Whitney WPCP - Plans to enlarge the plant in 1979 will eliminate the current need to bypass sewage directly into Porcupine Lake during periods of high flows. It may also service the Bob's Lake area and eliminate the present lagoon facility there.

(b) Schumacher - In 1978 the sewage presently discharged to Pearl Lake will be diverted to the Timmins WPCP.

(b) Industrial Waste Disposal

As in 1974.

5.1.4 - Nonpoint Sources

Apart from the salt used for treating the roads in winter (see Section 5.2), nonpoint sources of pollutants (i.e., those derived from storm-water runoff from the drainage basin surface area) are probably minimal.

5.2 - Water Quality

A detailed discussion of the chemical and physical parameters is included in Appendix A. A brief summary follows.

Porcupine Lake is shallow and does not exhibit thermal stratification in summer. It has an orthograde dissolved oxygen profile indicating that mixing by wind action occurs over the full depth.

While the lake remains aerobic throughout summer, its condition in winter is not well understood. Dissolved oxygen readings taken at the outlet throughout winter indicate that, although the level drops significantly (down to 2 to 3 mg/ℓ), the lake may not actually become anaerobic. The lack of reported fish kills supports this conclusion.

Alkalinity (96 to 99 mg/ℓ), conductivity (660 to 710 μmhos) and pH (8.3 to 8.7) indicate that the lake is alkaline. Chloride concentrations are high (30 to 33 mg/ℓ) and appear to be rising as development around the lake increases. This is probably due to chlorides derived from runoff from road surfaces.

The critical plant nutrient, phosphorus, is present in excessive quantities in both the water (0.07 to 0.09 mg/ℓ) and the lake bottom sediments (0.11 to 0.18 mg/g dry basis). Prior to construction of the Whitney WPCP, concentrations in the water frequently exceeded the critical value for nuisance growth of algae (0.02 mg/ℓ) by a factor of 15, and even today still exceed this value by a factor of 5. This indicates that Porcupine Lake water quality is still affected by domestic sewage inflow and by recycling of phosphorus in the sediments.

High chlorophyll a concentrations (5.6 to 14.0 μg/ℓ) indicate that the lake is either mesotrophic or eutrophic. Low Secchi disc readings support this.

No serious water quality problems are caused by other chemicals, heavy metals, and bacteria (Conroy, personal communication).

Water quality and sediment samples from the Lower Porcupine River indicate that extremely enriched conditions occur below the Whitney WPCP. Total phosphorous concentration in the water was 0.32 mg/ℓ, and alkalinity had reached 122 mg/ℓ. However, downstream from this point, improvement was noticeable due to absorption of nutrients by river plants and sediments.

5.3 - Aquatic Weeds

Porcupine Lake is characterized by intensive growths of submergent and emergent macrophytes, and filamentous algae.

In Figure 13, the extent of macrophytes in 1946 and 1971 (as delineated on Forest Resources air photography) is compared. In 1946, weed beds were restricted almost exclusively to depths of less than 1 m (3 ft), and did not cover all suitable substrate at this depth. They tended to be patchy and open rather than intensive. By 1971, the weed beds had extended considerably, virtually filling all suitable substrate with a depth of 1 m (3 ft) or less, and extending out to a 1.5-m (5 ft) depth in several places. In addition, the weed beds appear to have intensified to form denser beds.

The major cause of the increase in weed growth is the high phosphorous concentration in the water and the sediments of the lake. The high flushing rate of Porcupine Lake (approximately 6 to 8 times annually) has dampened the effects of the high phosphorous loadings and prevented the lake from becoming even more eutrophic.

Comparison of the 1971 Forest Resources air photograph with photographs taken by Acres in July 1977 show that many weed beds have remained identical in extent and shape, and that no notable increases in any weed beds have occurred during the last 6 years. This may indicate that either

- all suitable substrate with sufficient light penetration is now filled, or
- decreased phosphorous levels in the water since 1974 are inhibiting weed spread.

Of these possibilities, the first is the most likely.

In July 1977, the dominant weed species in Porcupine Lake were

Yellow water lily	- *Nuphar* sp
Sago pondweed	- *Potamogeton pectinatus*
Richardson's pondweed	- P. *richardsonii*
Floating-leaf pondweed	- P. *natans*
Flat-stemmed pondweed	- P. *zosteriformis*
Milfoil	- *Myriophyllum exobescens*
Bulrush	- *Scirpus* sp
Cattail	- *Typha* sp
Arrowhead	- *Sagittaria* sp
Filamentous algae	- *Cladophora*, *Oedogonium*

Since 1946, it is very likely that the species and their relative proportions have changed. *Cladophora* is known to become abundant in lakes and rivers where nutrient levels are high, and has probably increased considerably since 1946.

The Porcupine River, both upstream and downstream from Porcupine Lake, is characterized by intensive growths of duckweed and filamentous algae. It is notable that, in the Timmins area, duckweed is only found to any extent in Bob's Lake, Bob's Creek, and in the Porcupine River (Papineau, personal communication). These water bodies all receive domestic wastes. At points of flow restriction in the river, such as beaver dams, the *Lemna* mats become several centimetres thick.

Since 1974, conditions in the Lower Porcupine River downstream from Whitney WPCP may have deteriorated, as nutrients formerly discharged into Porcupine Lake are released into the Lower Porcupine River. The plant provides secondary treatment and, although it reduces the concentration of phosphorus in the sewage which passes through it by half, large quantities are still discharged into the river (Appendix A, Phosphorus). In addition, the lagoon effluent from the North Eastern Psychiatric Hospital which is also high in nutrients flows into the Lower Porcupine River. These two nutrient sources can be expected to generate extensive weed growth along the river.

Proceeding down the Lower Porcupine River from Whitney WPCP, conditions improve. Downstream from the bridge at Hoyle the river is relatively free of aquatic vegetation and the more obvious signs of excessive enrichment.

5.4 - Future Water Quality and Weed Growth

5.4.1 - Water Quality

Since the Whitney WPCP began operation, phosphorous levels in Porcupine Lake have decreased by a factor of 3. In 1978 and 1979, the planned enlargement of the Whitney WPCP and the diversion of Schumacher sewage should result in a further decrease in phosphorous concentrations in the lake.

The phosphorous concentrations after the WPCP is enlarged will depend on two major factors

- the level of continued nutrient loadings from the other sources listed in Section 5.1, and

- the degree of phosphorous recycling from the bottom sediments.

Under anaerobic conditions, which might exist during winter, significant quantities of phosphorus could re-enter the water column. In addition, rooted macrophytes can reintroduce sedimented phosphorus to the water as they decay. The net effect of these processes is that with time the phosphorous levels in the sediments will decline, and phosphorous recycling will then decrease in importance as a factor controlling the concentration in the water column.

Eventually, a steady state will be reached which will depend on the continuing input of phosphorus and it is possible that this level will be below that necessary to cause algal blooms.

Downstream from Porcupine Lake, no improvement will be seen in water quality or weed growth until tertiary treatment is implemented at the Whitney WPCP and the hospital lagoon. In fact, conditions may further deteriorate in 1979 when the Whitney WPCP is enlarged and the return effluent load to the river is increased.

5.4.2 - Weed Growth

The initial effect of reduced phosphorous levels in Porcupine Lake is a decrease in phytoplankton populations and algal blooms. This decrease has already been observed during the last two summers. The serious algal blooms that had occurred in previous years were not observed (Raiche, personal communication).

Unlike phytoplankton, rooted aquatics can obtain phosphorus from the sediments and their growth is therefore not immediately limited by improvements in water quality. No decrease in the extent of weed beds can be expected until the phosphorus in the sediments is depleted. With the enriched sediments available in Porcupine Lake, it is anticipated that it will be at least another 5 years before any improvement is noticed in the extent of these beds.

6 - SOCIOECONOMIC ASPECTS

6.1 - Recreational and Wildlife Uses

6.1.1 - Boating

In 1974, the Ontario Sailing Association held a seminar which stimulated interest in sailing. As a result of this seminar, there are presently 10 to 15 sailboats which use Porcupine Lake. As interest grows, this number may eventually reach 40 to 50 boats (Williams, personal communication). A sailing school is held each summer.

Although present use of the lake by sailboats and power-boats is limited, it would increase if launching and docking facilities were improved.

At present, there are no proper launching facilities on Porcupine Lake and boats are launched at Bannerman Park (see Figure 13) with some difficulty. The Department of Parks and Recreation is considering the installation of a boat ramp at Bannerman Park this year (Salvadore, personal communication).

Present docking facilities are limited to the Northern College Dock which was built in 1977 (see Figure 13). The dock is available for private use, and may, in future, be used for extension programs in sailing and powerboating. A boat ramp, parking lot and trailer facilities are proposed for the site (Newell, personal communication).

Aquatic weeds are generally a minor problem to boaters. At Bannerman Park, even the relatively light motorboat traffic maintains a channel clear of weeds. This channel is used by sailboats to gain access to the center of the lake.

Launching is, however, very difficult at the south end of the lake where aquatic weed beds are extensive. These difficulties arise as much from the shallow nature of the lake as from the weeds. In any case, prevailing winds dictate against sailing in this area (Williams, personal communication).

Once access to the lake is gained, aquatic weeds do not significantly interfere with either motor or sailboats.

Some problems with weeds are encountered at the Northern College Dock. Increased usage should help to reduce troublesome weed growth; however, active weed control may be necessary to gain full access and usefulness from this facility.

Little canoeing is done on Porcupine Lake or River. The aquatic weeds do not greatly interfere with canoeing on the lake, but certainly do with canoeing on the river. In addition, the septic odors and generally poor state of the Lower Porcupine River substantially detract from the enjoyment of canoeing.

6.1.2 - Swimming

In 1955 - 1956, Bannerman Park was used for swimming. Between 1958 and 1965, sporadic swimming programs were held, but since 1965 there has been very little swimming in Porcupine Lake. The reasons for this are as follows.

(a) The lake is shallow, and swimmers must get well offshore before the water is deep enough for enjoyable swimming.

(b) The bottom sediments are soft organic muds and silts.

(c) The water quality deteriorated during the late 1950's and early 1960's. Swimming areas at South Porcupine have been, and still are, periodically closed due to high coliform counts. The beach at Bannerman Park has only once been officially closed, although on many occasions prior to operation of the Whitney WPCP bacterial counts had become high enough that swimming was "discouraged". Associated with periods of high bacterial counts are septic odors which further discourage swimming.

(d) Aquatic weeds and algae interfere with swimming. At the beach area at South Porcupine, an experimental area was covered with polyethylene and sand in the 1960's (Newell, personal communication). This treatment effectively stopped the growth of the rooted aquatics, but the plastic soon became covered with cladophora. As water quality improves, algal growths and cladophora will disappear. However, rooted aquatics will remain a problem at any beach area.

(e) Associated with aquatic weeds and swimming is the problem of swimmer's itch which is caused by incomplete penetration of the skin by cercarial blood flukes (Schistosomatidae). Swimmer's itch has never been reported from

Porcupine Lake but, due to the presence of waterfowl and snails which act as host to the blood flukes, it could become a problem if there were regular swimming in the lake.

(f) There are many other more suitable swimming areas within 40 km (25 mi) of Timmins, i.e.,

McDonald Lake	- private
Timmins Pool	- public
Gillies Lake	- public
Bob's Lake	- public
Mattagami River	- public
Bigwater Lake	- private
Kamiskotia Lake	- public
Joesy Lake	-
Keefer Lake	-
Kenogomissi Lake	- public
Papakomeka Lake	-
Reid Lake	- private
Barber's Bay	- public
Frederick House Lake	- public
Kettle Lakes Provincial Park	- public

6.1.3 - Fish and Fishing

Porcupine Lake is a good lake for fish. Perch, pickerel, pike and suckers are the most common species (Perry, personal communication). Pickerel numbers have dropped recently (Perry, personal communication), although pickerel are still taken from Porcupine Lake (McCubbin, personal communication). Pike and perch numbers have probably risen since aquatic weed growth increased (Perry, personal communication).

No surveys are available to indicate the amount of fishing done on Porcupine Lake, but it appears that the lake is used quite heavily, particularly by children. Unfortunately, the fish caught are frequently not eaten as there is a common belief that fish from Porcupine Lake are "polluted". In fact, this is not the case, and fish from the lake are perfectly edible (Perry, personal communication).

6.1.4 - Waterfowl (Perry, personal communication)

Porcupine Lake acts as a waterfowl sanctuary because the lake lies within the city limits and there is no hunting. Up until 1970, the lake was heavily used by waterfowl, both during the migration season and for breeding purposes. American widgeon nested on the lake itself, while mallards, blacks, blue-winged teal and occasional green-winged teal nested in the river. A black duck banding station at the north end of the lake banded a couple of hundred ducks each fall. Since 1970, both breeding and migrating numbers have dropped dramatically. Porcupine Lake is presently not used by local ducks as a staging area at all, although some use is still made of the hospital's sewage lagoon. This drop in numbers is attributed to a widespread and major shift in migration routes throughout the area.

The lake is presently very underutilized, but it is impossible to predict how long this situation will last. As there is plenty of good habitat available, duck numbers may well increase again in the near future. Experiments in introducing wild rice to Porcupine Lake are being carried out at Northern

College in the hopes of attracting migrating Canada and snow geese (Newell, personal communication).

6.2 - Air Bases

There are two air bases operating on the lake. Both bases are situated along the western lakeshore. The northerly base is located just south of Porcupine (see Figure 13) and is owned by the MNR. It incorporates a split-level, fixed dock and a floatplane ramp. The southerly air base is located in South Porcupine. This base is used by a commercial airline (Austin White River Airlines) as well as by private aircraft. It consists of two separate docks, aprons and hangars. The number of takeoffs and landings at the two bases is roughly equal (Papineau, personal communication). However, the annual number of takeoffs and landings is not known.

Continuous operation of the air bases is impeded by low and high lake levels. The range of lake levels within which the air bases can operate satisfactorily is shown in Table 7.

The maximum lake level of 280.4 m (920.0 ft) above which operation of the MNR air base is impossible will only be exceeded during floods which generally occur in spring. Even though the air base is not very busy during the spring period (Swant, personal communication), the flooding is still considered to be an inconvenience.

Low lake levels are a problem as well. From Figure 12, it can be seen that, during an average summer month, a lake level lower than 279.03 m (915.45 ft) will be experienced about 30 percent of the time. This means that for

TABLE 7

LAKE LEVEL REQUIREMENTS
AT AIR BASES

		Maximum Level	Minimum Level
MNR Air Base	Low Level Dock	279.44 m (916.80 ft)	278.81 m (estimated) (914.75 ft)
	High Level Dock	280.41 m (920.00 ft)	279.03 m (915.45 ft)
South Porcupine Base		279.45 m (916.85 ft)	279.12 m (estimated) (915.75 ft)

approximately 9 days during the month the air base will experience operational problems due to low lake levels. Conditions are worse during a 1-in-5-year low-flow sequence when the lake level is below 278.81 m (914.75 ft), minimum operating level, for 80 percent of the time (24 days) during a summer month. During a 1-in-20-year low-flow sequence no operation is possible.

Some weed growth occurs around the dock of the MNR air base. Although considered to be an inconvenience, this growth does not prevent aircraft operations from taking place. Some extension of the docks in the near future is envisaged to allow for an additional two aircraft to be stationed at the base.

The situation at the South Porcupine air base is more critical. A lake level variation of only 0.33 m (1.1 ft), 279.10 to 279.45 m, can be tolerated if the base is to operate efficiently.

Aprons and hangars are flooded regularly and, during the spring floods, a water depth of 0.75 m (2.5 ft) above the hangar floor is not uncommon. Extensive weed growth along the aprons hinders aircraft movements. Operations from this air base are so restricted that commercial flights have been transferred to Timmins Airport (Deluce, personal communication).

6.3 - Flood Damage

In order to evaluate the existing mean annual flood damage, a survey of the damage caused by the 1976 flood was carried out. Interviews were conducted with staff members of the City Council of Timmins, the MOE, the MNR, the Mattagami Region Conservation Authority, as well as local business representatives and house owners. Information gleaned from these interviews was used to estimate the 1976 flood damage. The results are as follows.

City of Timmins (construction of walkways, etc)	9,000
MOE (placing berms around pump stations)	23,000
Mattagami Region Conservation Authority	1,000
Business (10 premises--pump rental, berm construction, repairs, etc)	18,000
Private houses (36 premises--pump rental, berm construction, repairs, etc)	34,000
(The damage estimates for businesses and private houses were based on a sample of 8 premises)	
Subtotal	$85,000
Unaccounted for (general disruption of services, etc--assumed lump sum)	30,000
TOTAL	$115,000

Utilizing available 1:2,500 mapping (dated May 1974), the number of properties which would be flooded for a range of flood levels were evaluated. By relating these values to the number of properties which were flooded during the 1976 event, a lake level-flood damage curve was developed (see Figure 14). The combination of this curve with the lake level-frequency curve (Figure 16) yielded the flood damage probability curve shown in Figure 15. The mean annual flood damage equals the area under this curve[21] and amounts to $21,600. The contribution of specific flood magnitudes to the mean annual damage is shown in Figure 17. This figure indicates, for example, that provision of flood protection against a 20-year flood will eliminate a major part of the mean annual flood damage.

6.4 - Potential Uses of the Lake

There is a need for a major community park in the east end of the Timmins municipal area. Porcupine Lake is an obvious choice. Northern College has the beginnings of an excellent waterfront development, and it might be possible to combine a park with their shoreline plans (Salvador, personal communication).

The greatest attraction in such a park would be boating and fishing. If suitable facilities were provided, boating would become very popular; and as water quality improves, pickerel could be stocked, providing excellent sport fishing. Neither of these uses would be in conflict with the current extent of macrophytes, except in the immediate area of the docking and launching facilities. Localized weed control could solve that problem.

Porcupine Lake will never be a prime area for swimming, even after the algal and bacterial problems are solved. The lake's shallow nature and soft bottom require careful design and the expenditure of large sums to build and maintain suitable beaches. [At Gillies Lake, 8 km (5 mi) from Porcupine Lake, sand was dumped each winter from 1956 to 1973 in order to establish a suitable beach

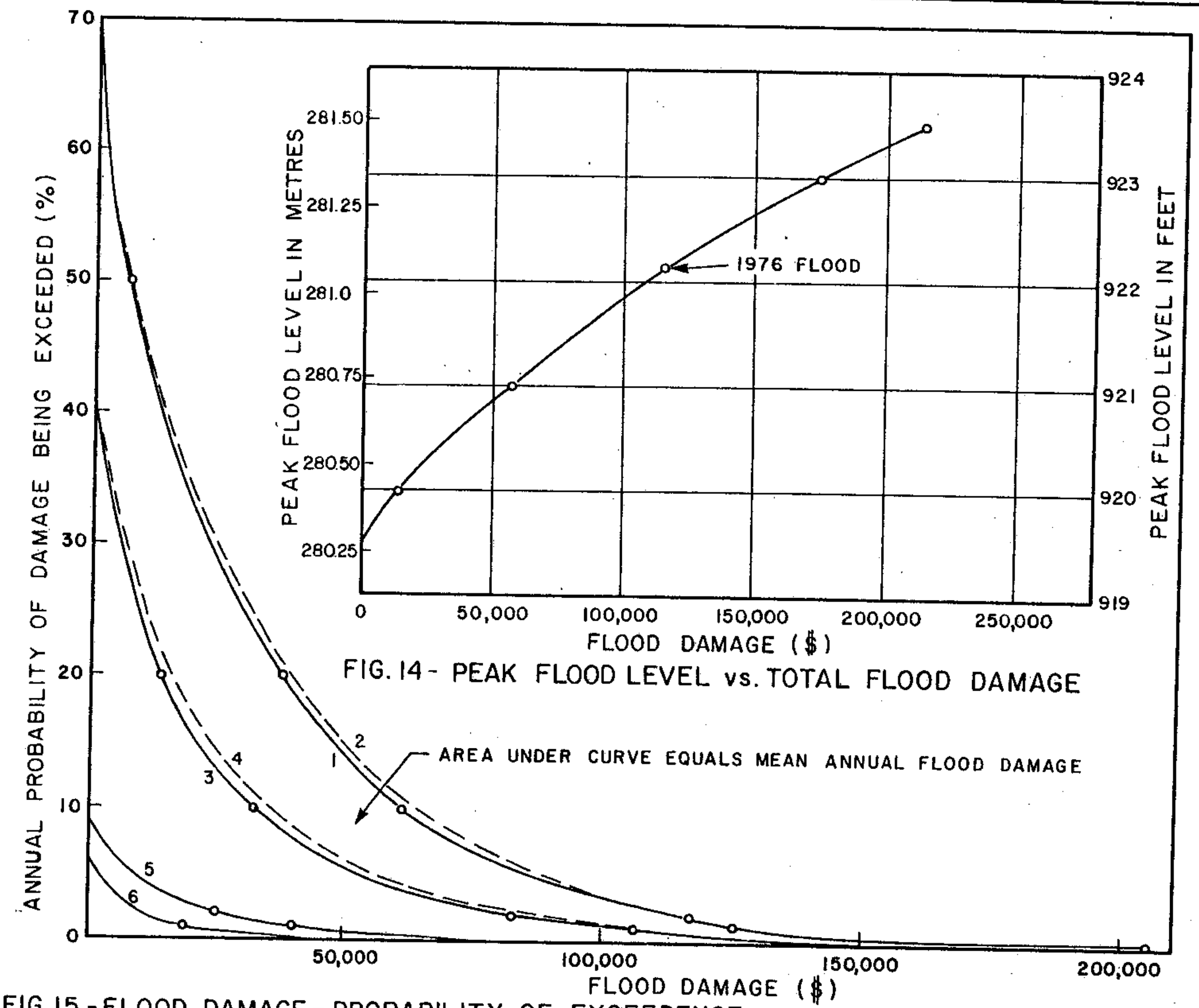


FIG. 14 - PEAK FLOOD LEVEL vs. TOTAL FLOOD DAMAGE

FIG. 15 - FLOOD DAMAGE - PROBABILITY OF EXCEEDENCE CURVE

LEGEND (FIG. 15)

1 EXISTING SITUATION
2 EXISTING SITUATION WITH WEIR
3 MINIMUM CHANNEL CLEARANCE
4 MINIMUM CLEARANCE WITH WEIR
5 CHANNEL TYPE A
6 CHANNEL TYPE B

NOTE (FIG'S 14 & 15)

DAMAGE VALUES IN 1977 DOLLARS

FIG'S 14 & 15

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EVALUATION OF MEAN ANNUAL FLOOD DAMAGE

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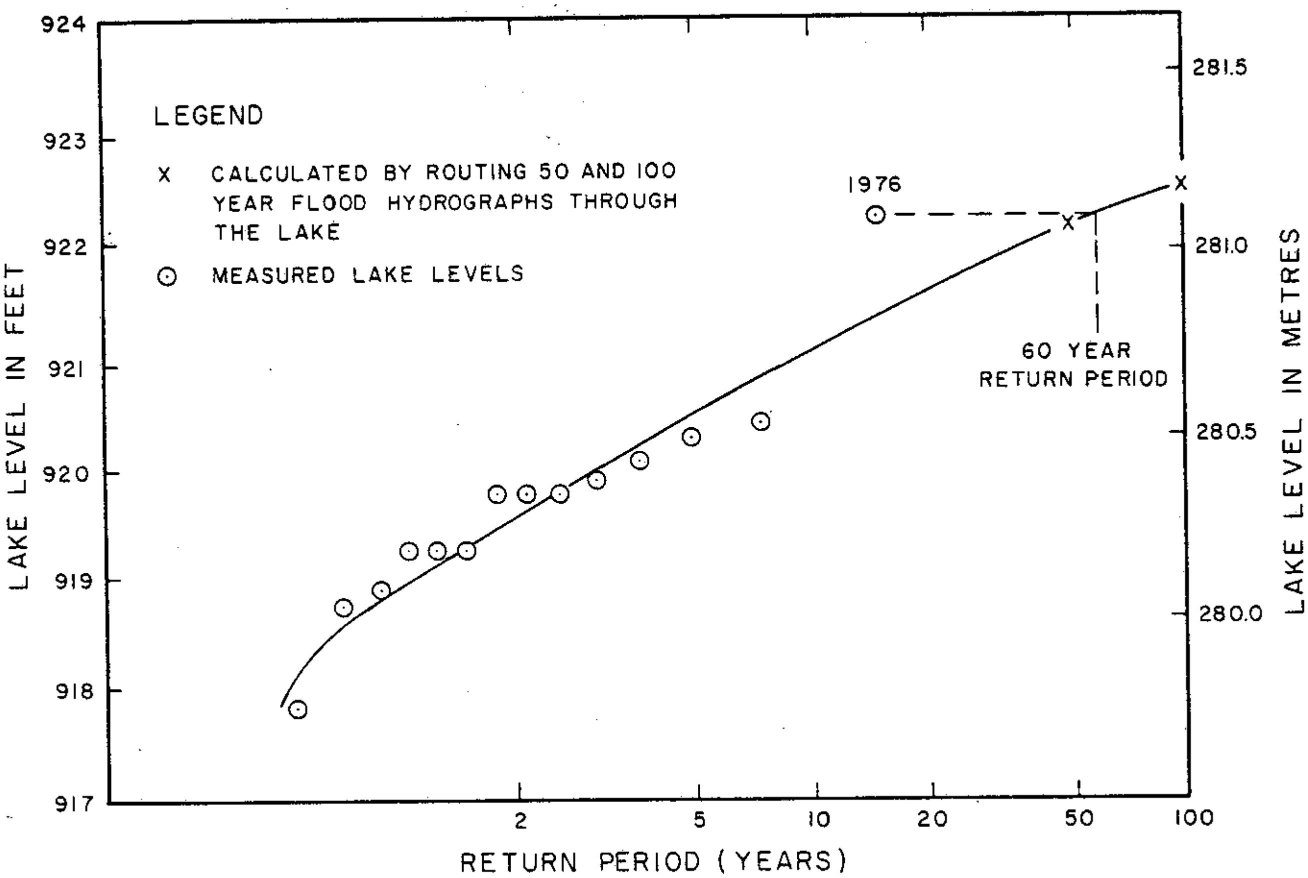

FIG.16-LAKE LEVEL FREQUENCY CURVE

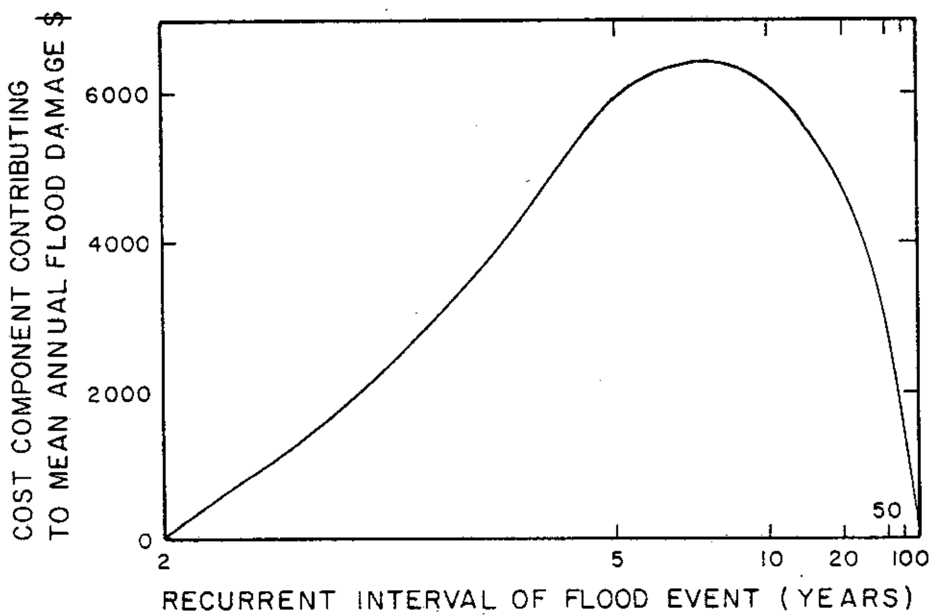

FIG.17- CONTRIBUTION OF SPECIFIC FLOOD EVENTS TO MEAN ANNUAL FLOOD DAMAGE

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LAKE LEVEL FREQUENCY CURVE
AND MEAN ANNUAL FLOOD DAMAGE COMPONENTS

FIG.16 & 17

ACRES

extending 60 m (200 ft) offshore.] In addition, weed problems will persist and would require weed control measures to clear beach areas.

As wilderness becomes increasingly expensive and inaccessible (even in the Timmins area), the demand for park areas and recreational lakes within the urban centers will increase. Therefore, it can be expected that Porcupine Lake will become increasingly important as a waterfront leisure area.

7 - AMELIORATIVE MEASURES

7.1 - Available Measures for Remedying Problems Associated with Water Level Fluctuations

The following alternatives aimed at alleviating the problems caused by lake level fluctuations were studied.

Category	Alternative No.	Description
	1	Do nothing
Structural	2	Lower Porcupine River, Minimum Channel Clearance
	3	Lower Porcupine River, Channel Excavation, Type A
	4	Lower Porcupine River, Channel Excavation, Type B
	5	Reconstruction of Air Base Docks
	6	Construction of Small Overflow Weir at Lake Outlet
	7	Construction of an Entirely New Lake Outlet Channel
Non-structural	8	Expropriation
	9	Flood Warning/Proofing System

The costs of these alternatives as well as a summary of the effects on conditions in the lake are summarized in Tables 8 and 9.

TABLE 8

SUMMARY OF AMELIORATIVE MEASURES FOR WATER LEVEL CONTROL

Remedial Measure		Effect of Measure on Reduction in Flood Levels					Benefit/Cost Ratio of Measure
		1-in-50-Year Flood		1-in-100-Year Flood		Low Lake Levels	
No.	Description	(m)	(ft)	(m)	(ft)		
1	Do nothing	0	(0)	0	(0)	None	N/A
2	Minimum channel clearance	0.17	(0.57)	0.18	(0.60)	-	0.94
3	Channel improvement Type A	0.56	(1.83)	0.55	(1.81)	-	0.59
4	Channel improvement Type B	0.72	(2.35)	0.69	(2.28)	-	0.39
5	Build new MNR dock	None		None		None	N/A
6	Build small weir	Negligible		Negligible		+	
	Build small weir plus measure No. 2	Negligible		Negligible		+	0.83
	Build small weir plus measure No. 3	Negligible		Negligible		+	0.58
	Build small weir plus measure No. 4	Negligible		Negligible		+	0.38
7	Construct new lake outlet	+		to be controlled		+	0.03
8	Expropriation - 1-in-50-year	None		None		None	0.14
	Expropriation - 1-in-100-year	None		None		None	0.10
9	Flood warning/proofing system	None		None		None	N/A

Note

+ = beneficial effect

\- = detrimental effect

N/A = not applicable

TABLE 9

BENEFITS AND COSTS OF AMELIORATIVE MEASURES
(ALL COSTS IN $1,000)

Remedial Measure		Flood Damage		Cost			Benefit*	Capital And O & M Cost	Benefit/ Cost Ratio	Total Cost Present Value
No.	Description	Mean Annual	Present Value	Capital	Operation & Maintenance Annual	Operation & Maintenance Present Value	Present Value 196.1-(4)	Present Value		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)=(5)+(7)	(10)=(8)/(9)	(11)=(4)+(9)
1	Do nothing	21.6	196.1	0	0	0	0	0	na	196.1
2	Minimum channel clearance	9.8	89.0	45.0	7.5	68.1	107.1	113.1	0.94	202.1
3	Channel improvement Type A	1.5	13.6	240	7.5	68.1	182.5	308.1	0.59	321.7
4	Channel improvement Type B	0.7	6.4	420	7.5	68.1	189.7	488.1	0.39	494.5
5	Build new MNR dock	21.6	196.1	35	0	0	0	35.0	na	231.1
6	Build small weir	22.1	200.6	5.5	0.25	2.3	-4.5	7.8	na	208.4
	Build small weir plus measure No. 2	10.7	97.1	50.5	7.75	70.3	99.0	120.8	0.83	217.9
	Build small weir plus measure No. 3	1.5	13.6	245.5	7.75	70.3	182.5	315.8	0.58	329.4
	Build small weir plus measure No. 4	0.7	6.4	425.5	7.75	70.3	189.7	495.8	0.38	502.2
7	Construct new lake outlet	0	0	7,000	10.0	90.8	196.1	7,091	0.03	7,091
8	Expropriation (50 Yr)	2.8	25.4	1,200	0	0	170.7	1,200	0.14	1,225
	" (100Yr)	1.6	14.5	1,900	0	0	181.6	1,900	0.10	1,915

Assumptions

Economic life = 25 years
Annual interest rate = 10 percent

Notes

*The benefit is equal to the reduction in flood damage costs.

7.1.1 - Do-Nothing Alternative (Alternative No. 1)

Should no remedial work be undertaken, it can be expected that the average annual flood damage will amount to approximately $22,000. However, should development in the area increase and more buildings be erected in the flood-prone areas, this figure will gradually increase. The air base will continue to have operating problems. The water and sediment quality of the lake will gradually improve over the years and weed growth and algal blooms should decrease. It should be borne in mind that the above comments apply to the present physical system. Should changes occur such as the development of flow blockages on the Lower Porcupine River, the flood damage could increase dramatically.

7.1.2 - Structural Alternatives

(a) Improvements to the Lower Porcupine River Channel

A reduction of lake flood levels can be achieved by improving flow conditions in the Lower Porcupine River. At present, flow in the river is controlled by the log jam (Figure 9, Section 2) and by the beaver dam at the beginning of the rapids (Figure 9, Section 3). By removing these obstructions, the control moves downstream to the relatively steep reach (0.123 percent) between the log jam and the Texas Gulf Mine Railway (Figure 9, Section 1). The three 6.1-m diameter Armco culverts through the railway line do not affect outflow from the lake, provided the culvert entrances are not blocked by beaver dams or debris. Apart from all the beaver dams located between the lake and the railway line, other obstructions include the deposits from the Pamour Mine tailings (Figure 9, Section 5) and to a limited extent, the floating weed (Figure 9, Section 8, and Figure 10). The maximum afflux caused by bridge 14 (Broulan Reef - Figure 9, Section 7) without debris, varies from 0.0 m to 0.06 m (0 ft to 0.2 ft) for discharges up to the 100-year flood event.

For each of the channel improvement measures considered, three backwater computer runs were carried out to establish new lake level outflow relationships (see Figure 18). For these computations Manning's roughness coefficient of 0.035 was used for the main flow channel and, as before, a coefficient of 0.10 for the overbank flow. By routing the 2-, 5-, 10-, 50- and 100-year inflow flood hydrographs through the lake, the altered flood damage probability curves in Figure 15 were developed.

In view of the ability of beavers to rebuild dams in short periods, as well as the possibility of accumulation of debris, all channel improvement schemes require continuous maintenance programs.

Three degrees of channel clearance were considered and are discussed below.

<u>Minimum Channel Clearance (Alternative No. 2)</u>

Initial Capital Cost = $45,000
Annual Maintenance = $7,500
This scheme involves the removal of the log jam at chainage 8.86 km (5.50 miles)-- Figure 9, Section 2.

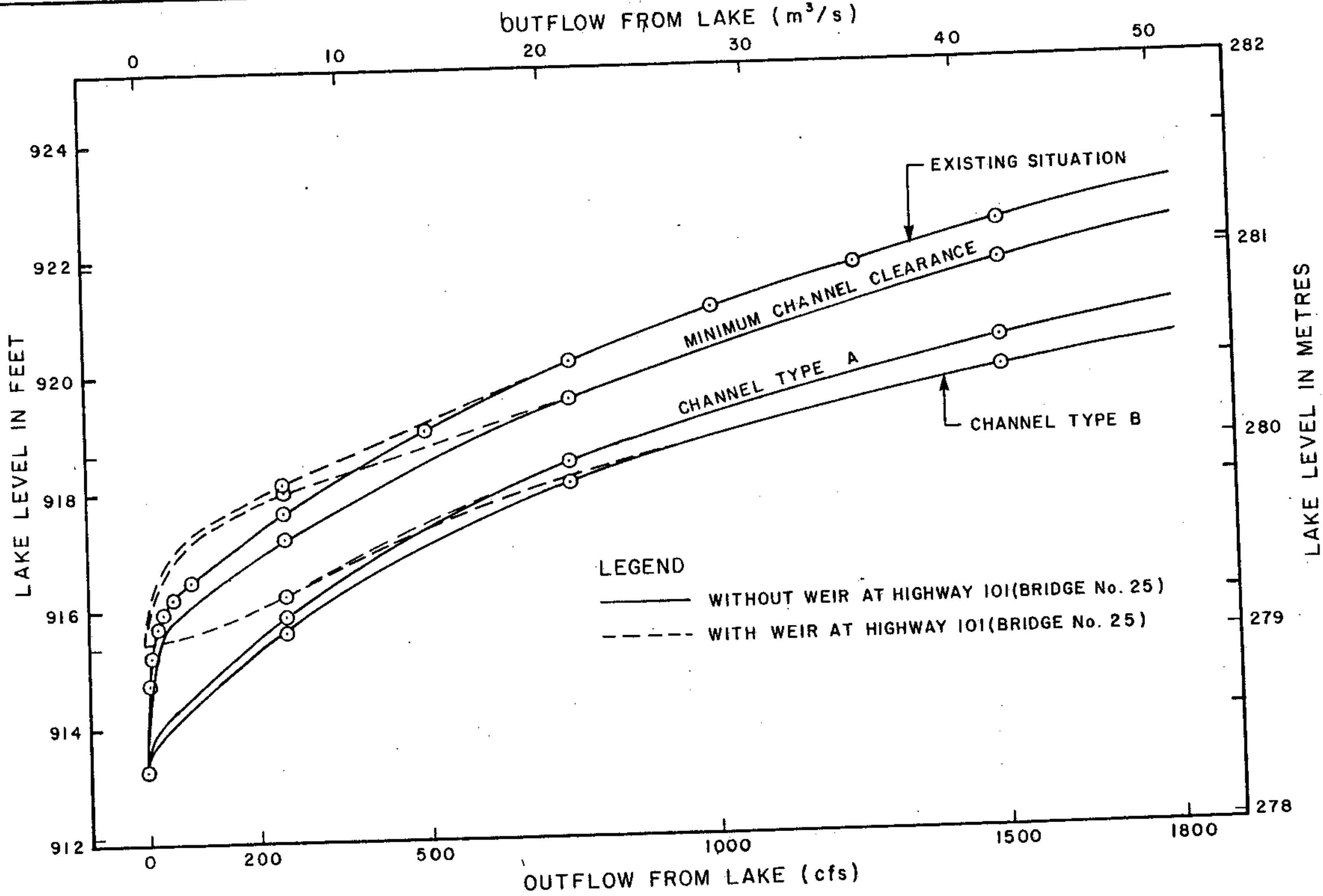

FIG. 18

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LAKE LEVEL-OUTFLOW RELATIONSHIPS FOR CHANNEL CLEARANCE/EXCAVATION MEASURES and the eleven beaver dams (see Figure 10), as well as clearing the channel bed of branches and logs for a reach of 10.3 km (6.4 mi) to the Texas-Gulf Railway line.

This alternative reduces lake levels during 50- and 100-year flood events by 0.2 m (0.6 ft). This results in a reduction in the annual flood damage of $11,800. The increased discharge capacity of the river will cause low lake levels to drop more during the dry period and adversely affect the operation of the air base.

Channel Excavation Type A (Alternative No. 3)

Initial Capital Cost = $240,000
Annual Maintenance = $7,500

This measure is aimed at evening out the channel bed of the Porcupine River between the lake outlet and the log jam (Figure 9, Sections 2 to 11), by excavating a new channel.

The average slope of such a channel is 0.000131 and the cross section is trapezoidal with side slopes of 1-in-3 and a bottom width of 20 m (66 ft).

No excavation is required at bridge 14 (Figure 9, Section 7). Figure 10 shows the longitudinal section of the river bottom. The excavation is assumed to be carried out by a light suction dredger starting at Shallow Lake (Figure 9, Section 10) and working in a downstream direction. In the cost calculation, it was assumed that excavated material will be disposed of in the proximity of the river channel.

A decrease of peak lake flood levels of 0.55 m (1.8 ft) is achieved. The annual flood damage is reduced by $20,100, and is practically eliminated. However, the same adverse effects discussed for Alternative No. 2 above, occur.

Channel Excavation Type B (Alternative No. 4)

Initial Capital Cost = $420,000
Annual Maintenance = $7,500
This is a similar measure to Channel Type A above except that the channel slope is steepened to 0.000192. This increases the discharge capacity but also the amount of excavation.

A minimal additional reduction (compared with Alternative 3) in peak flood levels of 0.15 m (0.5 ft) is achieved. The mean annual flood damage is $850. Adverse effects on air base operations and weed control will be more pronounced than for Alternative 3.

(b) Construction of Air Base Docks (Alternative No. 5)

Initial Capital Cost = $35,000 (Swant and Shewen, personal communication)
Annual Maintenance = no more than at present
The MNR air base dock is fixed, which is a contributing factor to many of the problems caused by both high and low water levels. The provision of floating docks attached to the raised portion of the present dock would eliminate the major inconveniences. A layout sketch is shown in Figure 19. This dock could operate satisfactorily for levels ranging from 278.8 m (914.80 ft) to 280.4 m (920.00 ft).

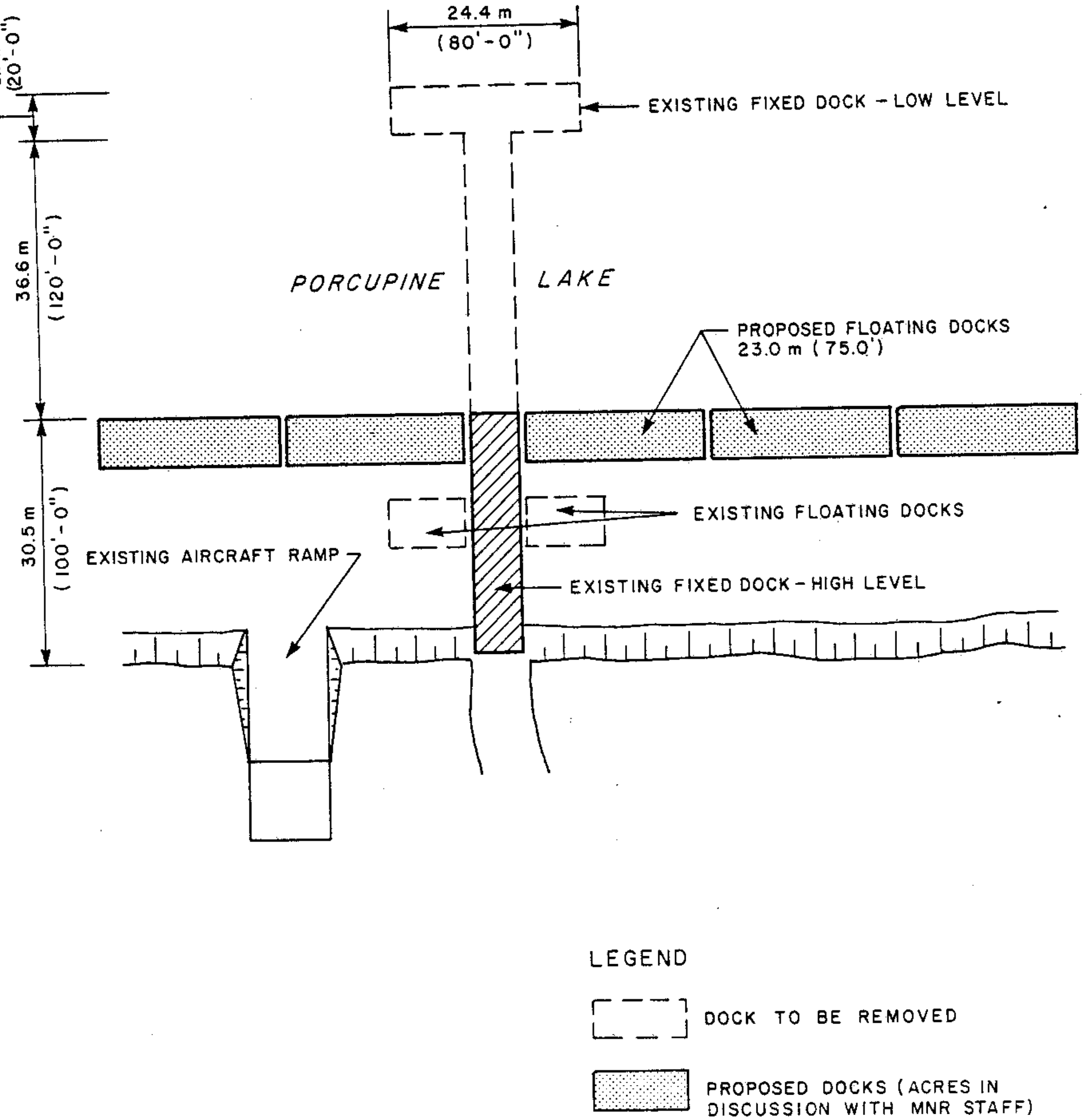

FIG. 19

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PORCUPINE LAKE AND RIVER STUDY

PROPOSED RECONSTRUCTION OF MNR AIR BASE DOCKS

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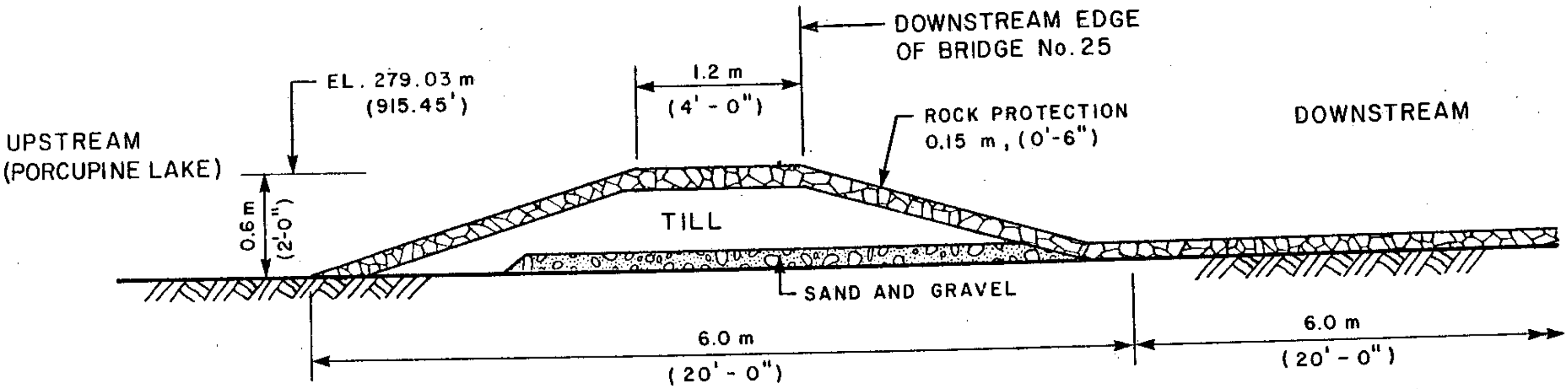
(c) Construction of a Small Overflow Weir at Lake Outlet (Alternative No. 6)

Initial Capital Cost = \$5,500

Annual Maintenance = \$250

A definite improvement in the low-level regime of the lake could be achieved by the construction of a small weir at the downstream edge of bridge 25 on Highway 101. A typical cross section through this weir is shown in Figure 20. The design is based on the results of the soils investigation carried out in 1966 by E. M. Peto Associates Ltd.[22] The average height of the weir is 0.6 m (2.0 ft). The weir crest is fixed at level 279.03 m (915.45 ft), the minimum required level to ensure full and continuous operation of the MNR air base.

The advantage of constructing a small weir at the outlet of the lake is that the operating conditions at the air bases during dry periods increase considerably (Figures 2 and 12). In fact, with a minimum lake level of 279.0 m (915.5 ft), a continuous operation of both air bases is still ensured during the occurence of a 1-in-20-year low-level sequence. However, a slight increase in mean annual flood damage must be accepted. Should no channel clearance be undertaken (Alternative No. 1) the mean annual flood damage increases from \$21,600 to \$22,100, i.e. by \$500 (Table 9). For the minimum channel clearance exercise (Alternative No. 2) the corresponding increase is from \$9,800 to \$10,700, i.e. \$900. No measurable increase is anticipated should channel excavation be undertaken (Alternatives 3 and 4).



NOTES

TILL SHOULD HAVE AT LEAST 20% PASSING
THE 200 SIZE SIEVE

APPROXIMATE LENGTH OF WEIR EQUALS 40m (130.0')

FIG. 20

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PORCUPINE LAKE AND RIVER STUDY

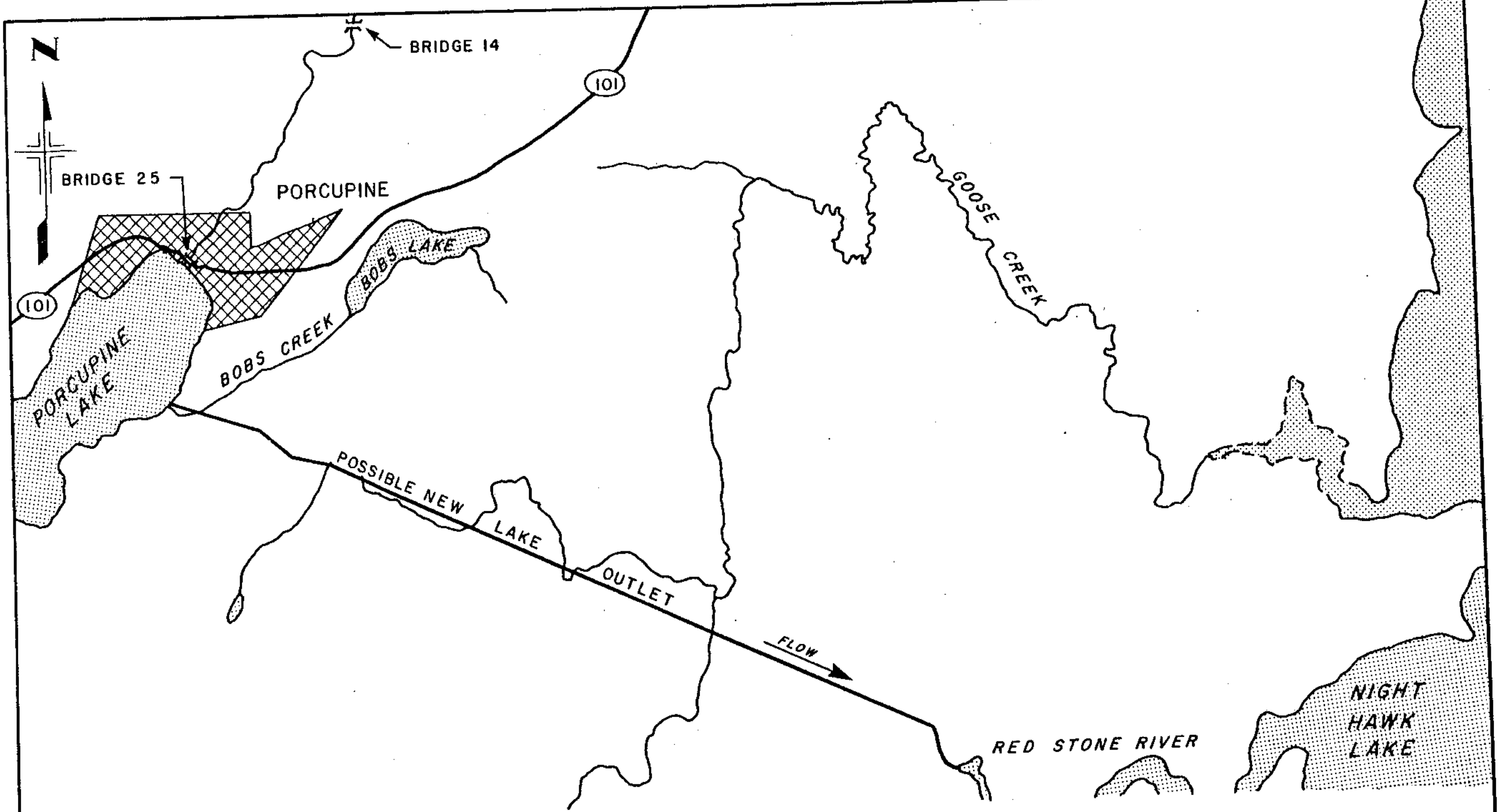
PROPOSED WEIR UNDER BRIDGE 25, HWY 101

ACRES

(d) <u>Construction of an Entirely New Lake Outlet Channel (Alternative No. 7)</u>

Initial Capital Cost = $7,000,000
Annual Operation and Maintenance = $10,000
The construction of a completely new outlet for Porcupine Lake was investigated. The proposed alignment of such a channel follows a straight line between Porcupine Lake and Night Hawk Lake (see Figure 21). It starts at Bob's Creek outlet into Porcupine Lake and follows Goose Creek in an easterly direction. Where Goose Creek flows north, the canalization is continued on to the Redstone River. The length of canalization is approximately 8.0 km (5.0 miles) and the maximum excavation depth is 16 m (52.5 ft). The average bottom slope is 0.085 percent, and the channel has a bottom width of 10.0 m (32.8 ft). The side slopes are approximately 1:2.

This study revealed that this scheme is, at this stage, completely uneconomic. No time was therefore devoted to studying the implications of this measure on the Lower Porcupine River. (Although a minimum discharge could be maintained in the Lower Porcupine, the present degree of pollution would be aggravated).



0 1 2
SCALE IN KILOMETRES

FIG. 21

MATTAGAMI REGION CONSERVATION AUTHORITY
PORCUPINE LAKE AND RIVER STUDY

LOCATION OF POSSIBLE NEW LAKE OUTLET

ACRES

7.1.3 - Nonstructural Alternatives

(a) Expropriation (Alternative No. 8)

Total Cost for 1-in-50-year protection = $1,200,000
Total Cost for 1-in-100-year protection = $1,900,000

To reduce future flood damage, the properties prone to flooding could be expropriated. The buildings should be demolished and could be replaced by open space and parks. Figure 17 shows that removal of all buildings up to the 1-in-50-year flood level eliminates the major portion of the annual flood damage. For purposes of this study expropriation up to the 1-in-50- and the 1-in-100-year flood level was considered.

Based on the number of properties involved and assigning an estimated mean value to each property, (based on a sample of 8), expropriation up to the 50- and 100-year flood levels amounts to $1.2 million and $1.9 million respectively. This cost does not include demolition of the buildings and restoration of the open space.

(b) Flood Warning/Proofing System Alternative No. 9

Flood Proofing - At present the local residents undertake a certain amount of flood proofing. Earth berms are built to protect properties, pumps are hired to keep basements dry, etc. A Flood Proofing Study[29] is currently in progress. It is aimed at investigating the various methods and techniques available for the design and construction of flood proofing residential, commercial and industrial buildings and structures and the preparation of a set of standards that can be used in conjunction with existing building codes. There may well be a significant amount of useful information forthcoming from this study which could assist the local residents to improve current flood proofing practices. As soon as this study becomes available it should be reviewed, and consideration should be given to implementing some of the proposed guidelines and standards.

Flood Warning - This measure only applies to spring flood events. Snow depth gaugings at two or three locations in the drainage basin would have to be carried out twice a week in the early spring season. Utilizing forecast weather data and prepared flood routing charts, or simple calculation procedures, the peak lake level response could be predicted several days in advance. This would enable the community to have sufficient time to prepare and considerably reduce the nuisance value of flooding.

The benefits and costs associated with the first eight alternatives discussed above are listed in Table 9. The benefits of any scheme are defined as the reduction in flood damage. Table 9 illustrates that all the alternatives have tangible benefit/cost ratios of less than unity. The minimum channel clearance exercise, Alternative No. 2, is the only measure with a benefit/cost ratio approaching unity.

7.2 - Aquatic Weed Control Options

The following weed control options were considered (Table 10)

Alternative No.	Description
10	Cutting and Harvesting
11	Polyethylene Blankets
12	Chemical Control
13	Do Nothing and Instigation of a Monitoring Program

(a) Cutting and Harvesting (Alternative No. 10)

Aquatic vegetation harvesting is a relatively new method of weed control. It is superior to cutting which produces floating plant fragments that may develop roots and grow elsewhere, or sink or wash onshore and decompose. Rotting vegetation exerts an oxygen demand which may deplete oxygen in the water, and releases nutrients which can cause algal blooms. In addition, rotting weeds onshore are unsightly and cause odor problems.

Harvesting weeds has the benefit of actively removing the plant nutrients nitrogen and phosphorus from the lake system. It does not appear to affect fish or invertebrate populations even in major harvesting programs.[23] However, harvesting machinery is very expensive and is still in the experimental stage. In addition, disposal of the weeds can present a problem. Harvesting must be done at least once each season and sometimes more frequently.

TABLE 10

SUMMARY OF WEED CONTROL OPTIONS

Weed Control Alternative		Costs				Weed Control				
No.	Description	Installation Cost $/ha	($/acre)	Annual Cost $/ha	($/acre)	Effectiveness	Period of Control	Effect on Recreation	Nutrient Removal	Warning of Eurasian Milfoil
10	Limited harvesting of weeds			370	150	Immediate	Repeat annually	Good	Yes	N/A
11	Limited use of polyethylene sheets	2,500	1,000	400	163	Immediate	10 years (estimate)	Very good	N/A	N/A
12	Limited chemical control			250-370	100-150	Immediate	Repeat annually	Good	N/A	N/A
13	Do nothing and monitor			400 in total		Long term	Permanent*	No effect immediately, eventual improvement	N/A	Yes

*Provided Eurasian milfoil is not introduced.

The Timmins MNR has a small weed cutter which was used in Porcupine Lake in the early 1960's. Reports on its effectiveness vary, and it has not been used now for 10 or 11 years, partly because of manpower shortages and partly because the water depth was too shallow for its effective use. In addition, it has no facilities for harvesting weeds. This would have to be done manually, thus increasing costs considerably.

Costs (Wile, personal communication)

- Annual costs for a large machine, such as is currently being used in the Kawarthas, is approximately \$370 per hectare, (\$150 per acre). This includes the capital cost (\$40,000 to \$45,000) amortized over 10 years.

- A moderate sized harvester has recently become available for \$8,000 to \$10,000. No operating costs are yet available.

- Small cutters usually do not have automatic harvesters and require manual labor to collect the weeds from the water and transfer the material to shore. Figures on the cost per acre are not available from the Ontario MOE, nor are they available for the small cutter owned by the MNR in Timmins.

(b) Polyethylene Blankets (Alternative 11)

Dark heavy-duty polyethylene placed on the bottom of a lake prevents weed growth by eliminating sunlight. Polyethylene can be very effective, but is difficult to place. The polyethylene sheets are usually placed by spreading the plastic on the ice in late winter and weighing it down with sand. Once the ice has melted and the sheet has settled on the bottom, additional sand cover should be provided. If the sheets are not properly weighted, wave action and traffic will cause shifting and tearing.

The greatest advantage of using plastic is that it is a relatively permanent solution. However, sometimes plants may reestablish after several years in the overlying sand, especially if it contains organic matter. They may also grow through air holes provided to allow the escape of gases which form in the underlying muds.

Plastic has been used successfully in the Kettle Lakes Park and in Porcupine Lake at a swimming area near South Porcupine (Newell, personal communication).

As mentioned previously, in the case of Porcupine Lake, Cladophora grew on the sand. As phosphorus levels decrease in the lake water, this problem should be eliminated. Another problem which may be encountered is that plastic might be difficult to use near the south shore air bases, as shallow water depths could restrict the dumping of sufficient sand.

Costs (Wile, personal communication)

The use of black heavy-duty construction plastic is recommended. The cost is approximately $2,500 per hectare ($1,000 per acre) including installation.

(c) Chemical Control (Alternative 12)

In general, mechanical methods of weed control are preferable to chemical methods, as the latter require a considerable amount of study before they can be used effectively or safely. Prior to implementation of a chemical control program the following points must be considered:

- The oxygen demand and nutrient release generated by the rotting vegetation must be calculated, and an evaluation made of the area which can be treated at any one time.

- In order to select the correct pesticide, the species to be controlled must be correctly identified.

- Water chemistry and temperature must also be considered in selecting the correct pesticide and the application technique.

- Water currents must be taken into account as contact between chemical and plant must be maintained for approximately 24 hours.

Several different chemicals may be required as there is no single chemical which adequately controls all species of aquatic plant and algae. In addition, application methods and times will vary, and, at best control will last a single season. For these reasons, the MOE recommends that only small areas of water of high recreational value should be treated by chemical methods[24] and requires that a licence and a permit be obtained each year.

The following is a brief list of some of the chemicals registered for use by the MOE. These change frequently as new products come on the market. Selection of a chemical should be made in conjunction with the Ministry at the time of treatment.

Filamentous algae, pond scums	Copper sulfate: dosage - 0.5 - 1.0 gm/m^3 (1.4 - 2.7 lb/acre-ft)
Mixed submerged aquatics	Diquot (Reglone A): dosage - 22.5 ℓ/ha (2 gal[active]/acre)
Emergents: arrowhead, water plantain, pickerel weed, wild rice, cat-tails, bulrushes	Paraquat: dosage - 1.1 - 2.2 kg/ha (1 - 2 lb/acre)
Water lilies	2, 4-D Ester (Aqua Kleen): dosage - 34 - 45 kg/ha (30 - 40 lb[active]/acre) repeat treatment may be necessary
Duckweed	Diquot: dosage - 11 ℓ/ha (1 gal/acre)

Costs

The following are approximate annual costs (one application per year) for Reglone A and Aqua Kleen, two of the more commonly used chemicals:

Aqua Kleen (2, 4-D Ester)

Chemical	$210/ha ($85/acre)
Man-hour and equipment	$ 25/ha ($10/acre)
Total	$235/ha ($95/acre)

(Repeat treatment may be required)

Reglone A (Diquot)

Chemical	$295/ha ($120/acre)
Man-hour and equipment	$ 25/ha ($10/acre)
Total	$334/ha ($135/acre)

Other estimates for control of mixed emergents vary from $247 to $370/ha ($100 to $150/acre) (MacKenzie, personal communication).

(d) Do Nothing Alternative and Instigation of a Monitoring Program (Alternative 13)

As discussed in Section 5.4, Porcupine Lake is in the process of being "cleaned up". However, this is a slow process and the results may not be noticeable for many years. Eventually, rooted aquatics should recede to approximately their prepollution levels.

In the Lower Porcupine River, no improvement will occur, and duckweed might even increase after 1979. Should tertiary treatment be installed in the Whitney WPCP, conditions would improve.

There is, however, a potential problem in Porcupine Lake which argues against a "do nothing" option. At present, conditions in Porcupine Lake are ideal for a species of milfoil called Myriophyllum spicatum (Eurasian milfoil), which is so far not present in Porcupine Lake, but is rapidly extending northward through Ontario. The introduction of Eurasian milfoil to Porcupine Lake could cause massive increases in the extent of the weed cover, and require rapid and drastic action to save the lake for recreational purposes. Therefore, a monitoring program aimed at obtaining early warning of any impending problems is essential. This program could be very simple and consist of identifying weed species and their relative abundance along a few transects extending into the lake on an annual basis.

Any presence of Eurasian milfoil should be reported to the MOE, and any substantial increase in its abundance viewed with alarm. Treatment would require lake-wide chemical control. Early treatment would alleviate many of the problems associated with this species.

In addition to providing an early warning system, the monitoring program would provide reliable data on changes occurring in the lake weed beds as "cleanup" proceeds.

Costs

The cost would involve one biologist for approximately 3 days per year, and the cost of a boat for 1 day.

7.3 - Discussion of Ameliorative Measures

(a) Water Level Control Measures (Alternatives 1 - 8)

A review of the first nine alternative measures leads to the general conclusion that, due to the low annual flood damage of $21,600, no tangible economical benefit is achieved by carrying out any of the proposed measures (see Table 9). Justification for implementation of any of these measures must therefore be based on an assessment of the value of the intangible benefits such as reduction in the level of inconvenience, reduction in flood levels, etc.

A complete relief of the present situation can be achieved by constructing a new lake outlet (Alternative 7). However, the cost of such a scheme is exhorbitant and certainly not warranted at this stage. Expropriation which will eliminate the major inconvenience caused by flooding does not solve the low lake level and weed growth problems and has high economic and social cost. Installation of a flood warning system and/or the introduction of additional flood proofing measures, will reduce the level of inconvenience and may also reduce current economic losses.

Significant improvements in low-level conditions can be achieved by the construction of a small weir under bridge 25 on Highway 101. It will maintain a minimum lake level, thus improving operation of both air bases. It has an extremely low annual cost (interest, depreciation and maintenance of approximately $850).

Comparing the two channel improvement measures (Alternatives 3 and 4), it is found that benefit/cost ratios decrease considerably from 0.59 to 0.39. Figures 15 and 18 indicate that the increased benefits due to channel improvement Type B are limited. In effect, the number of properties which will benefit from going from Type A to B channel only amount to five out of twenty-five. The increase in construction cost, however, is substantial.

(b) Weed Growth Control Measures

The advantages and disadvantages of aquatic vegetation in the lake and river are:

Advantages[24]

Weed growth

- helps to maintain the oxygen balance essential to fish and invertebrate life
- provides suitable habitat for the production of aquatic invertebrates which serve as food for fish
- helps to maintain low water temperatures essential for many fish species
- provides shade and protection for young game fish and forage fish species
- provides food and/or protection for many species of waterfowl
- stabilizes bottom sediments and decreases turbidity
- certain species are aesthetically pleasing.

Disadvantages

Weed growth

- is occasionally unsightly
- interferes with canoeing on the river
- interferes to a minor extent with boating on Porcupine Lake
- interferes with swimming
- interferes to a minor extent with float plane operation.

Fishing and boating are the major recreational uses of Porcupine Lake. Since weeds are essential to maintaining the fishing and are only a minor problem to boating, a major weed control program would seem unjustifiable. In addition, with time, the weed beds will recede and become less of a problem. At most, local control in the immediate area of docks or a beach area (should one be developed) are all that should be contemplated. Although the MOE would probably approve the use of chemicals for limited use (Raiche, personal communication), plastic would be a better method of control in beach areas, as it would also improve lake bottom conditions. In the immediate area of docks, while mechanical methods of control are recommended, convenience and cost will play a large part in choosing the weed control method.

CONVERSION FACTORS (METRIC TO IMPERIAL)

Metric units have been used throughout this report with imperial units in parentheses. The conversion factors used are listed below.

	To Convert From	To	Multiply By
Length	mm	inches	0.03937
	m	feet	3.2809
	km	miles	0.6214
Area	km^2	sq miles	0.3861
Volume	m^3	cubic feet	35.315
	$m^3 \times 10^6$	acre-feet	810.7
Discharge	m^3/s	cubic feet per second	35.315

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List of Personal Communications - 2

Tkachuk, T., Porcupine Health Unit, 217 Algonquin, East, Timmins, Ontario

Wile, I., Lake Management Scientist, Water Resources Branch, Water Quality Section, P. O. Box 213, Rexdale, Ontario

Williams, T., 220 Earl Street, Porcupine, Ontario

APPENDIX A - WATER QUALITY

Water quality data for the past 6 years (1972 - 1977) were available from the MOE Highway 101 bridge station at the north end of Porcupine Lake.[25] In addition, unpublished data collected during two sampling programs in June and August of 1974 were obtained from the MOE (Conroy, personal communication). To supplement the 1977 data, Acres conducted a brief sampling program of Porcupine Lake and the lower river on July 18 and 19, 1977. Sampling Stations 1 to 4 are shown in Figure 13. Station 5 is on the Porcupine River at the Broulan Reef Road crossing (bridge 14, Figure 9) and Station 6 is at the Highway 101 bridge near Hoyle.

A1 - PHYSICAL PARAMETERS

A1.1 - Temperature

The temperature profile measured in the deepest area of the lake on July 19, 1977 (see Table 11) indicated hydrothermal (constant with depth) conditions. The June 20, 1974 profile measured by the MOE (Conroy, personal communication) exhibited the same characteristics. The August 14, 1974 profile shows a slight decrease of 2 degrees C with depth. This indicates that the lake does not stratify in summer, probably due to its shallow nature and mixing effect of the wind.

A1.2 - Dissolved Oxygen

The July 19, 1977 dissolved oxygen profile (Table 11) is orthograde (constant with depth), with values remaining at 8.3 ppm until immediately above the surface of the sediments where a lower value of 7.8 ppm was recorded. This corresponds to the 1974 dissolved oxygen profiles which were also found to be orthograde (Conroy, personal communication).

Normally, orthograde dissolved oxygen profiles are associated with oligotrophic, unproductive lakes, low in nutrients. In the case of Porcupine Lake, however, the profiles are orthograde probably because of the shallow nature of the lake and the constant mixing by wind.

Under ice cover, when no mixing or oxygen exchange can take place, lower dissolved oxygen readings prevail. Surface dissolved oxygen readings from the Highway 101 bridge indicate this to occur on occasions (Table 12), but also indicate that the lake does not become anaerobic as might be expected. This information is supported by the fact that winter fish kills on Porcupine Lake are very rare. Only one small kill was recorded a few years ago (Salvador, personal communication). On the other hand, Lower Porcupine River downstream from Porcupine Lake frequently goes anaerobic in summer during periods of low flows. At such times, odor problems and fish kills occur (Conroy, personal communication).

TABLE 11

TEMPERATURE AND DISSOLVED OXYGEN DISTRIBUTION PROFILE, JULY 19, 1977 (IN DEEPEST AREA OF THE LAKE)

Depth	Temperature (degrees C)	Dissolved Oxygen (mg/litre)
Surface	22	8.3
1 m	22	8.3
2 m	22	8.3
3 m	22	8.3
4 m	22	8.3
5 m	22	7.8

TABLE 12

SURFACE DISSOLVED OXYGEN UNDER ICE CONDITIONS (mg/ℓ) PORCUPINE LAKE, HIGHWAY 101 BRIDGE, WHITNEY TOWNSHIP[25]

	Jan	Feb	Mar	Apr	Dec
1972	11.0	8.0	3.0	3.0	12.0
1973	8.0	8.0	7.0	open?	9.0
1974	3.0	3.0	4.0	2.0	-
1975	3.0	5.0	7.0	open?	14.0
1976	12.0	7.0	7.0	9.0	5.0

A2 - WATER CHEMISTRY

A2.1 - pH

On July 19, 1977, pH values varied from 8.3 to 8.7 in Porcupine Lake (Table 13). This corresponds with the pH values ranging from 8.05 to 8.60 measured in August 1974, and indicates alkaline water conditions. In the river downstream from Porcupine Lake, the pH ranged from 7.15 to 7.6.

A2.2 - Alkalinity and Conductivity

In June and August 1974, alkalinity as $CaCO_3$ in Porcupine Lake ranged from 76 to 96 mg/ℓ. In July 1977, alkalinity ranged from 96 to 99 mg/ℓ (Table 3). This indicates high alkalinity and hard water conditions.

Alkalinity in the Porcupine River at the Broulan Road crossing, below the Whitney WPCP and Hospital Lagoon outfalls, reached 122 mg/ℓ. Below Hoyle, alkalinity dropped to 72 mg/ℓ.

Conductivity ranged from 660 to 710 µmhos in 1977 (Table 13), and 470 to 650 µmhos in 1974.

A2.3 - Chloride

High chloride concentrations are often indicators of pollution from domestic or industrial sources and urban runoff.

TABLE 13

WATER QUALITY RESULTS, JULY 18 - 19, 1977

Station	pH	Conductivity (μmhos)	Total Phosphorus (mg/ℓ)	Kjeldahl N (mg/ℓ)	Nitrate/ Nitrite $(NO_3-NO_2)-N$ (mg/ℓ)	Alkalinity (mg/ℓ)	Chloride (mg/ℓ)	Chlorophyll a (μg/ℓ)
1	8.4	700	0.07	0.7	0.03	99	30	14.0
2	8.7	660	0.07	0.6	0.03	96	32	10.7
3	8.3	710	0.09	0.4	0.04	97	32	5.6
4	8.45	690	0.08	0.6	0.04	98	33	16.7
5	7.15	690	0.32	0.8	0.07	122	32	5.7
6	7.6	-	0.03	0.5	0.04	72	15	2.1

Values from June and August 1974 ranged from 16 to 19 mg/ℓ. In July 1977, they ranged from 30 to 33 mg/ℓ (Table 3). While these values are low compared to MOE permissible drinking water standards, they are high compared to other lakes in the area (Conroy, personal communication). The only other lake in the area with comparable chloride concentrations is Pearl Lake (Conroy, personal communication). As indicated in Section 5.1 - Nutrient Sources, both lakes have been recipients of municipal sewage and urban runoff for many years.

Average chloride concentrations for each year from 1972 through 1976 (Table 14) indicate that chloride concentrations may be increasing. It is likely that chloride will continue to increase as usage around the lake continues to rise.

Chloride concentration at Station 6 at Hoyle (Table 13) in July 1977 was 15 mg/ℓ. This indicates that considerable improvement in water quality takes place in the Lower Porcupine River as one progresses downstream.

A2.4 - Nutrients

A2.4.1 - Nitrite, Nitrate, Free Ammonia, Total Kjeldahl Nitrogen

Total Kjeldahl nitrogen is a measure of the total nitrogenous matter present including ammonia and organic nitrogen and excluding nitrate and nitrite. Both ammonia and organic nitrogen are important in assessing the availability of nitrogen for biological uptake, and are present in high concentrations in domestic sewage. Nitrate is another form of nitrogen which is readily used by aquatic plants and algae.

TABLE 14

WATER QUALITY RESULTS, YEARLY AVERAGES
PORCUPINE LAKE, HIGHWAY 101, WHITNEY TOWNSHIP
(Reference 25 and Conroy, personal communication)

		Chloride (mg/ℓ)	Total Phosphorus (mg/ℓ)	Kjeldahl N (mg/ℓ)	Nitrite (mg/ℓ)	Nitrate (mg/ℓ)
1972		19	0.22	1.38	0.010	0.07
1973		18	0.34	1.21	0.018	0.14
1974	Jan and Feb	20.4	0.42	1.6	0.013	0.19
1974	Mar to Dec	20.4	0.33	0.84	0.041	0.33
1974	June and Aug		0.11			
1975		21.5	0.09	0.71	0.020	0.18
1976		23.2	0.10	0.67	0.018	0.08

It is seldom abundant as it is quickly converted to organic nitrogen by plants. Nitrite is rapidly and easily converted to nitrate, and its concentrations are also usually low.

After the Whitney WPCP began operating, Kjeldahl nitrogen in the lake fell to approximately half its previous value (Table 14), and the yearly average has steadily decreased. The level still remains just above the normal range for unpolluted waters (0.1 to 0.5 mg/ℓ).[25] Samples taken in July 1977 yielded similar results, with values ranging from 0.4 to 0.7 mg/ℓ in the lake, and 0.5 to 0.8 mg/ℓ in the river (Table 3). Highest values were found at Station 5 below the Whitney WPCP and Hospital Lagoon outfalls, and lowest values at Station 6 near Hoyle.

Nitrate values have not changed significantly since the commissioning of the Whitney WPCP. However, average values for each year (Table 14) do not exceed the concentration commonly found in unpolluted waters (0.5 mg/ℓ).[25]

Nitrite concentrations do not usually exceed a few mg/ℓ. Average values given in Table 14 indicate that this is also the case in Porcupine Lake.

Combined values for nitrate/nitrite nitrogen for July 1977 are listed in Table 13. Results are comparable to the average values in Table 14 with highest concentrations found at Station 5.

A2.4.2 - Phosphorus

In temperate fresh waters, phosphorus is considered to be the limiting nutrient, and its addition to a lake will accelerate the eutrophication process. Experience has indicated that phosphorous concentrations above 0.02 mg/ℓ will encourage algal blooms and excessive weed growth.

In Figure A.1 the total phosphorous concentrations for the period 1972 - 1977 are plotted. In Table 14, average concentrations are recorded. These concentrations are very high. Prior to building the Whitney WPCP, the values frequently exceeded the 0.02 mg/ℓ limit by a factor of 15. Since commissioning of the plant, however, the values usually exceeded the limit by only a factor of 5. While this speaks well for the effectiveness of the Whitney WPCP, it indicates that Porcupine Lake is still being affected by domestic sewage, or the release of residual phosphorus trapped in the sediments.

It should be kept in mind that the Whitney WPCP merely shifts the point of entry of the nutrients from Porcupine Lake to the Lower Porcupine River. The 1975 plant operation summary for the Whitney WPCP indicated that, on the average, the concentration of phosphorus in sewage passing through the plant is reduced by 50 percent.[26] However, during low-flow periods in the Lower Porcupine River, the impact of an average 3.55 million ℓ/day (.78 Mgd) of effluent, with an average phosphorous concentration of 2.1 mg/ℓ is substantial.

Results from the July 1977 sampling program are recorded in Table 13. Lake values for total phosphorus varied

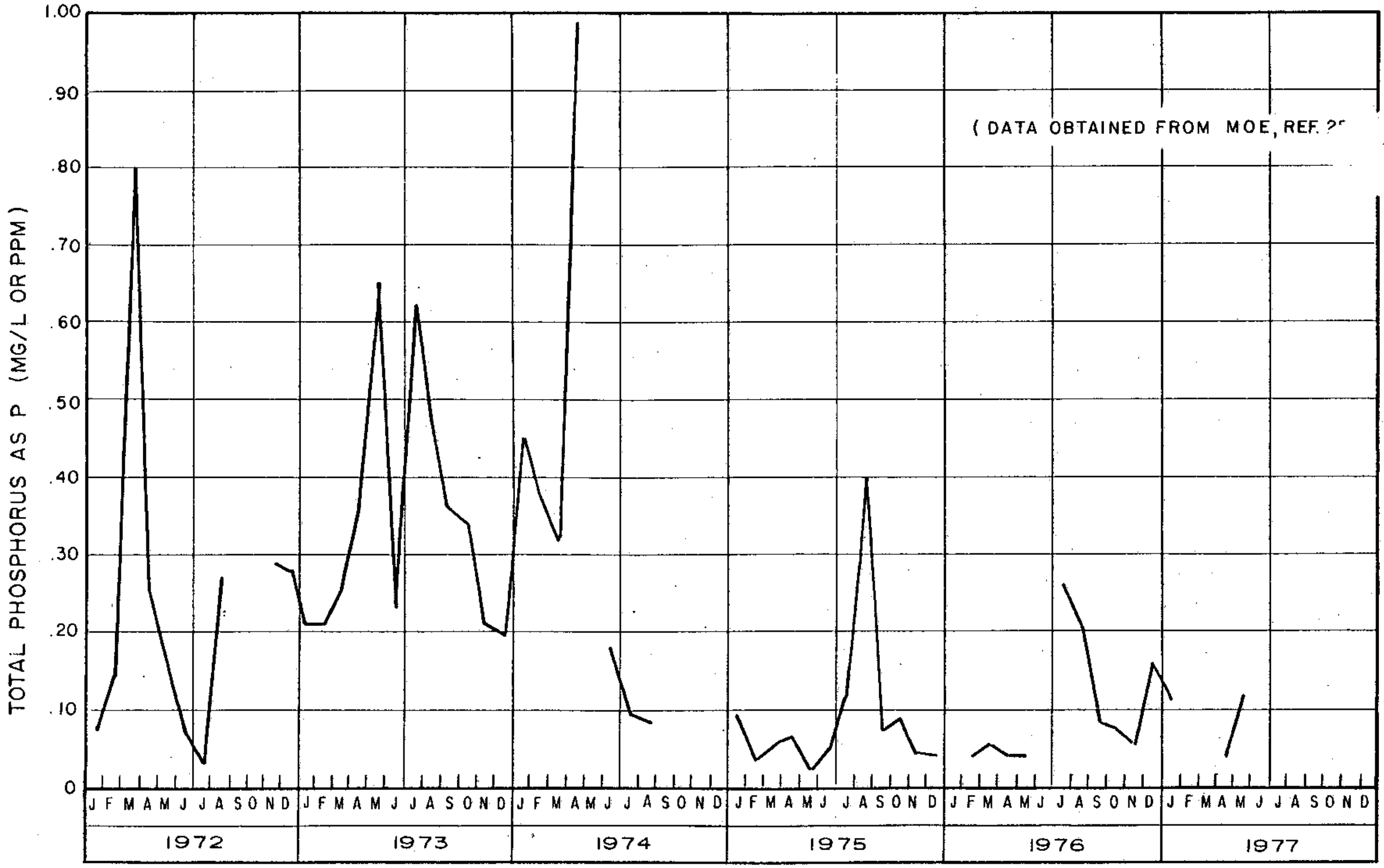

FIG. A.1

MATTAGAMI REGION CONSERVATION AUTHORITY

PORCUPINE LAKE AND RIVER STUDY

TOTAL PHOSPHORUS LEVELS PORCUPINE LAKE AT HWY 101, WHITNEY TWP

ACRES

from 0.07 to 0.09 mg/ℓ, which compares well with average values given in Table 14. At Station 5, however, phosphorous concentration was as high as 0.32 mg/ℓ. This was directly due to the effect of the Whitney WPCP and Hospital Lagoon outfalls. At Station 6 downstream from Hoyle, phosphorous levels were down to 0.03 mg/ℓ, indicating that considerable improvement in water quality takes place with distance along the Lower Porcupine River downstream from the Whitney WPCP.

A3 - CHLOROPHYLL A AND SECCHI DISK READINGS

Chlorophyll *a* is a measure of the amount of plant material or phytoplankton in the water, and is commonly used as an indicator of the trophic status of lakes. As the concentration of phytoplankton (rather than silt) controls the transparency of water in lakes such as Porcupine Lake, the secchi disc reading is directly related to chlorophyll *a* concentration, and is thus a good indicator of the level of biological activity.

In June 1974, secchi disc readings of 3.5 m and chlorophyll *a* concentrations of 0.5 - 1.0 μg/ℓ indicated low to moderate algal densities. However, August 1974 secchi disc readings decreased to 1.0 m, and chlorophyll *a* concentrations rose to 4.3 - 8.2 μg/ℓ, indicating that the lake was mesotrophic to eutrophic. Such variation in readings is not unusual as algal blooms frequently peak in spring and fall.

The July 1977 chlorophyll *a* readings for Porcupine Lake ranged from 5.6 - 16.7 μg/ℓ, and secchi disc readings were 3.1 m.

As in 1974, this indicates mesotrophic to eutrophic conditions. Chlorophyll *a* concentration was 5.7 μg/ℓ at Station 5 below the Whitney WPCP, and 2.2 μg/ℓ at Station 6 at Hoyle.

A4 - OTHER PARAMETERS

A4.1 - Bacteriological Quality

Bacteriological samples were taken both in June and August 1974, and revealed counts for total faecal coliform organisms within Ministry standards for recreational waters.

The Timmins Public Health Unit has indicated that bacteriological counts at the north end of the lake near Bannerman Park have always been acceptable, except for one episode in 1975 when a septic system broke and spilled raw sewage along the "beach" area. "Beaches" in South Porcupine in the Commercial Avenue area have been and still are closed periodically due to high bacterial counts (Tkachuk, personal communication).

A4.2 - Heavy Metals

Concentrations of copper, arsenic, silver, mercury and lead are within Ministry drinking water standards. Although the levels of manganese do not comply with these standards, they do not pose a health hazard (Conroy, personal communication).

A4.3 - Phenol

Phenol concentrations in 1974 were within Ministry standards (Conroy, personal communication).

A5 - SEDIMENTS

Phosphorus supplied to a lake is lost not only by outflow, but also by internal processes, particularly sedimentation. It is not possible to predict the sedimentation rate of phosphorus in a lake, but Lerman calculated that the fraction of phosphorous input to the lake sediments generally ranges from 25 to 50 percent.[27] In other words, substantial amounts of phosphorus are trapped by the sediments of a lake.

Although total phosphorous concentration in the water dropped dramatically after commissioning of the Whitney WPCP (see Figure A-1 and Table 14), recycling of phosphorus from the bottom sediments is probably occurring. (This recycling process has been reported in Bob's Lake [Conroy, personal communication] and may significantly slow the "cleaning" process in the lake.)

Total phosphorus, nitrate, nitrite and total nitrogen (Kjeldahl) figures for Porcupine Lake sediments are given in Table 15. The concentrations present in the sediments indicate that the lake bottom is extremely enriched. Sediment surveys in the Porcupine River downstream from the Whitney WPCP taken in 1974 showed the bottom sediments to be extremely organic also (Conroy, personal communication).

TABLE 15

SEDIMENT ANALYSIS,
JULY 18 - 19, 1977

Station	Sediment Depth	Moisture (% by wt)	Kjeldahl N (mg/gram dry basis)	Nitrate (NO -N) (mg/gram dry basis)	Total Phosphorus (mg/gram dry basis)
1	1 - 2 cm	69	1.6	0.003	0.11
1	3 - 4 cm	69	1.5	0.003	0.18
2	1 - 2 cm	34	0.8	0.001	0.13