A LAKE CLASSIFICATION SYSTEM: A TOOL FOR LAKE PLANNING IN THE THOMPSON--NICOLA REGIONAL DISTRICT, BRITISH COLUMBIA

by

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ABSTRACT

The goals of the thesis are:

1) to develop a lake classification system for use in planning for regional patterns of lake development; it is presented as one element within a framework for the analysis and allocation of the lake resource to various demands, focusing upon recreational use;

2) to illustrate the application of the lake classification system, to a selection of lakes in the Thompson-Nicola Regional District, British Columbia (TNRD, B.C.).

For the purposes of the thesis, lake system planning is defined as that process of systematic analyses and allocation of the lake resource to various competing demands, on a regional scale. One potentially useful step in lake system planning is the application of a lake classification system.

The resource method was organized around three parts:

1) a review and critique of existing lake planning methods, focusing upon those taking a regional approach and using a classification scheme;

2) the descriptive elements of the lake resource important to planning; and

3) the demands for the lake resource in the study region.

B.C.'s south-central area has hundreds of lakes, some of which are being used for irrigation, salmon rearing habitat, transportation, sewage disposal, domestic supply, tourism, and/or recreation. Some of these uses are increasing annually, creating greater pressures upon the lake resource. Further, the resource itself is a complex system consisting of many interacting, interdependent elements. Thus two factors indicate the need for lake planning and management;

1) the limited supply of the resource and its complex nature; and

2) the demands to use lakes for a variety of purposes, some of which compete and conflict with each other. A lake planning framework can help to achieve a balance between the supply of and the demand for lakes, by manipulating either the supply or the demand, or both.

The development of a complete lake system planning process is beyond the scope of this thesis. Therefore it focuses on a classification system as a potentially useful tool within the lake planning process. The proposed classification scheme consists of the following classes:

I. Wilderness Lakes,

II. Natural Environment Lakes,

III. General Use Lakes and Subclass-Developed Lakes,

IV. Development Lakes and Subclass-Intensive Use Lakes, and

V. Special Case Lakes.

The objective, definition, criteria, standards, and recommended management guidelines are presented for each class. Finally, some lakes in the TNRD are used to illustrate the application of the lake classification system.

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont'd) Page

LIST OF TABLES & FIGURES

MAP 92H, Edition 2, Hope
" 92I " ", Ashcroft } in Sp Collections

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CHAPTER ONE:

LAKE SYSTEM PLANNING

THESIS OBJECTIVE

The goals of this thesis are:

1) to develop a lake classification system for use in planning for regional patterns of lake development; it is presented as one element within a framework for the analysis and allocation of the lake resource to various demands, focusing upon recreational use;

2) to illustrate the application of the lake classification system, to a selection of lakes in the Thompson-Nicola Regional District, British Columbia (TNRD, B.C.).

These broad goals lead to the following objectives:

1) to investigate the use of biophysical carrying capacity in lake classification;

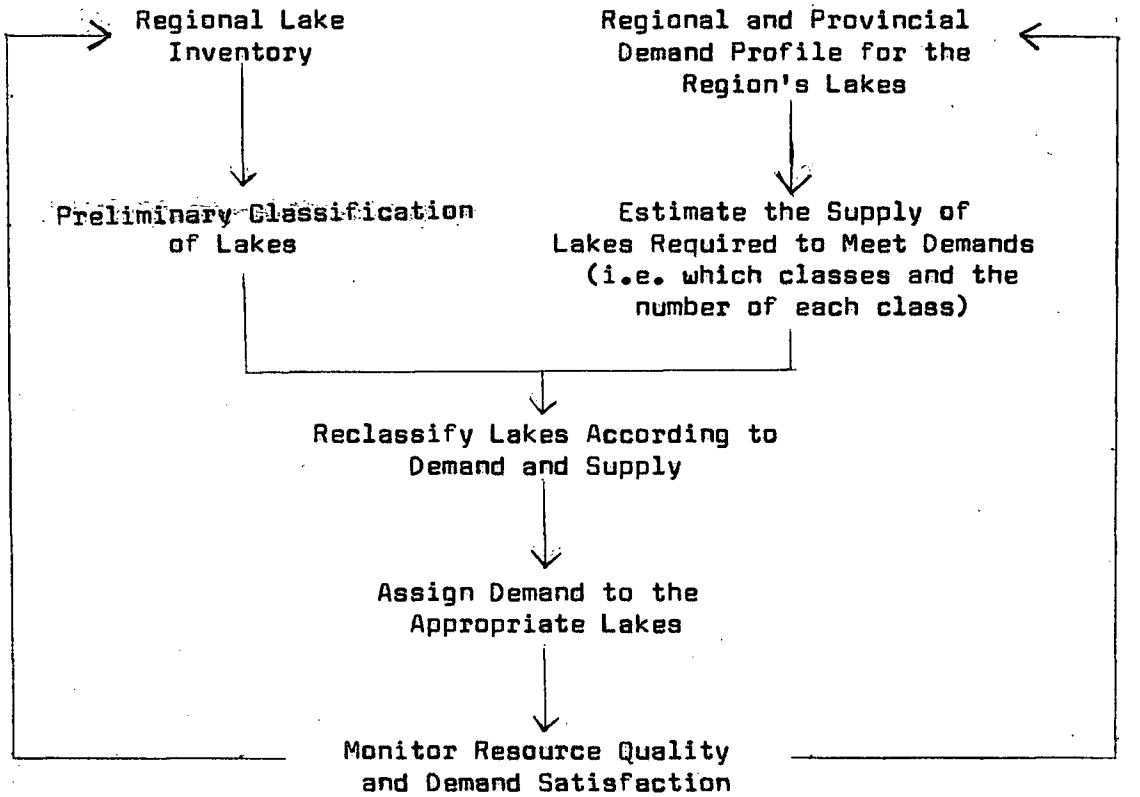
2) to investigate the use of perceptual carrying capacity in lake classification; and

3) attempt to separate potentially conflicting lake and shoreline uses by delineating appropriate uses for each lake class.

For the purpose of this thesis lake system planning is defined as that process of systematic analyses and allocation of the lake resource to various competing demands on a regional scale. One step in lake system planning might be the application of a lake classification system.

The relationship of lake classification to lake system planning is illustrated in Figure 1. An agency might adopt the policy to plan and manage lakes in a systematic manner, on a regional basis. A lake classification system is one planning tool to help implement that policy. Classification of lakes is only one step in the lake planning process.

Figure 1: The Lake System Planning Process



THE RESOURCE

Physically, a lake is a complex aquatic system, consisting of many interacting, interdependent factors such as: water, nutrients, dissolved minerals, oxygen, sunlight, plant and animal life, temperature, thermal stratification, depth, and turbidity. The concept "lake" becomes more complex when the shoreline and backshore elements are included. The shoreline is the land-water interface and contributes additional factors such as soils, slope, drainage, and other forms of plant and animal life which live in the land-water interface. This interface may be a beach, marsh, swamp, bank or cliff. The third contributing element is the surrounding land, known as the backshore. It adds all the interdependent factors of terrestrial ecosystems. All three elements - the water, the shoreline, and the backshore - together create the lake ecosystem. For

the purposes of this thesis, a lake planning unit is defined as the lake ecosystem consisting of the lake water, the shoreline, and the backshore of 500 meters (m) measured from the shoreline, unless a greater distance is otherwise stipulated. Whenever the word "lake" is used in this thesis, it refers to this lake planning unit unless otherwise indicated.

One characteristic of lakes important to planning is the trophic status. Trophic status refers to a lake's productivity; i.e. the rate at which the lake ecosystem produces biomass. Lakes are referred to as being oligotrophic, mesotrophic, or eutrophic:

1) "Oligotrophic Lakes - Those poorly provided with the basic nutrients required for plant and animal production."
(Ontario Land Use Coordination Branch - 1977, p. 56).

2) "Mesotrophic Lake - One that is intermediate in fertility; neither notably high nor notably low in its total productivity. Intermediate between oligotrophic and eutrophic."
(Ibid).

3) "Eutrophic - Waters containing advanced nutrient enrichment and characterized by a high rate of organic production."
(Ibid).

Eutrophication is,

> The process of becoming increasingly enriched in nutrients. It refers to the entire complex of changes which accompanies increasing nutrient enrichment." (Ibid).

It eventually occurs in all lakes as they naturally grow old. Lakes gradually fill in during geological time, becoming smaller, until they are replaced by terrestrial plant communities. Human activity can and does increase the rate of this process when domestic and industrial wastes are dumped into the water.

As well as increased productivity, eutrophication is characterized by,

> ...structural simplification of biotic components, and a reduction in the ability of the metabolism of the organisms to adapt growth responses to imposed changes (reduced stability) (Wetzel 1975, p. 4).

A change in stability, due to cultural nutrient loading, may cause such events as the collapse of sport and commercial fisheries; deteriorating water quality unfit for domestic consumption and recreational use. By the very act of using a lake, society can unintentionally render a lake unuseable in the long-run. Therefore lake use needs to be planned and managed so that people can continue to enjoy the benefits and amenities of lakes.

Two other characteristics of lakes important to planning, are their tangible and intangible values. Tangible values are those values which can be measured by the economic market. Some examples of lake's tangible values are:

- the market price of crops irrigated with lake water;
- the market price of commercial fish catches; and
- the money paid by municipal residents for their domestic water supply.

Intangible values are those values which cannot be measured by the economic market. Some examples of a lake's intangible values are:

- the cool relief of swimming on a hot summer day;
- the view provided from a canoe in the middle of the lake;
- as wildlife habitat.

These latter values can generally be referred to as aesthetics and include such qualities as scenery, quiet, and solitude. The natural surroundings provide the greatly needed alternative to the urban environment. It is these aesthetic qualities which many people seek and value so highly. Thus lake planning and management can help to retain both the tangible and intangible values of lakes.

Finally, the concept of carrying capacity applies to the lake resource. Carrying capacity is a useful planning and management tool. The reader is directed to Chapter Two, in which this concept is discussed in detail.

The characteristics of the lake resource discussed above, i.e. their trophic status, the process of eutrophication, the tangible and intangible values and carrying capacity, indicate the need for lake planning and management. Some means or framework is required to analyze this valuable resource and then to allocate it to a variety of uses. Creating such a framework is the goal of this thesis.

THE RATIONALE

Having identified the need for a lake planning framework, a crucial question remains to be answered. Why bother? Why should such a framework be developed for making decisions about lakes?

The first factor is the limited supply of lakes. The supply is limited not only in the actual number, but also by their individual suitability for use, access, ownership, and in some cases by over-use which renders them unuseable. The second factor is the demands to use lakes for a variety of purposes: irrigation, salmon rearing habitat, transportation, sewage disposal, domestic supply, tourism, and recreation. Demands are increasing annually for some lakes, for example cottage development. Further, some uses conflict with each other as they compete for the water surface and/or shore. Not all lake uses can be satisfied, nor should they be accommodated, at one lake. Demands should be allocated among the lakes most suitable for the various uses or activities.

A balance must be found between the supply of lakes and the demands placed upon them, if the resource base is to continue to be

available and if people are to continue to receive the benefits resulting from lake use. Further the uses themselves must be balanced relative to each other, so that no single use or uses come to exclude other legitimate uses. Achieving a balance is important in maintaining biophysical and aesthetic attributes of lakes, which are the very reasons why people are attracted to and use lakes. A lake planning framework can help to work toward achieving the balance between the supply of and the demand for lakes, by manipulating either the supply or the demand, or both.

A third factor to be considered in the demand for lakes is their common property nature. Lakes are a public resource. (Even in the case where all the surrounding land is privately owned, the water is owned by the Crown). Because of this non-individualistic lake ownership, some users often feel no personal obligation to help maintain resource quality, nor do they perceive their actions as contributing to the total, potentially negative, impact. As a result, these negative, incremental actions can lead to an unattractive lake for everyone, in spite of regulations and management to maintain resource quality. Thus a framework which takes into account the variety of uses and users, can attempt to deal with the common property nature of lakes.

Finally, there is the matter of the regional approach in the planning framework. The advantages of taking a regional approach - i.e. considering the lakes within a region as a system - are that:

1) a more comprehensive view can better allocate the total supply of the lake resource;

2) there is greater flexibility in balancing demand and supply;

3) it is more efficient with regard to staff effort, time, and money, in that similar lake-by-lake, individual studies are not repeated.

THE STUDY AREA

The Thompson-Nicola Regional District (TNRD) is located in south central British Columbia (BC) (see MAP 1). It features great biophysical diversity, exemplified by the fact that it includes five of the eight biogeoclimatic zones of BC. (Krajina 1965). The diversity of landscapes ranges from the low-lying semi-arid parkland with Ponderosa Pine, bunchgrass, and sagebrush; to montane forests of Douglas Fir and Englemann Spruce; to the cool continental climate of the Cariboo Parkland; to the humid, interior wet-belt with Western Hemlock and Red Cedar. As part of these diverse landscapes, one finds a myriad of lakes, streams, and rivers. The major river systems are the North Thompson, the Thompson, and the Fraser. Other resources include forests, minerals, wildlife, and agricultural land. This rich supply of resources, of which lakes are just one, must indeed be well-managed in order to sustain the present and potential benefits for the people of this region and the province.

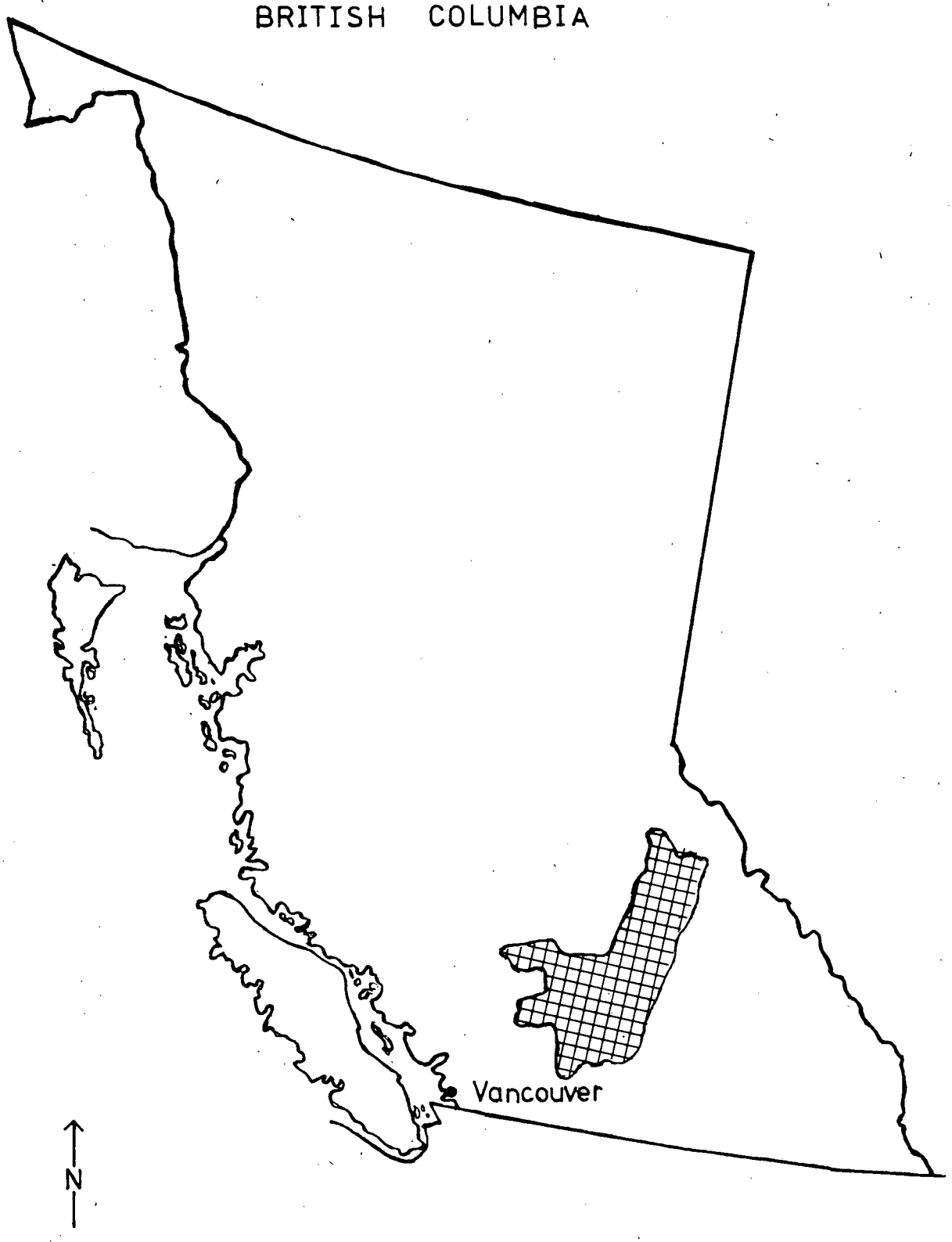
The population of the TNRD is over 100,000, of which 58,311 (1976) reside in Kamloops, the major urban centre (BC Regional Index 1978). The region's population is relatively young compared to other regions; 68% are less than 35 years old. The forest industry is the largest component of the regional economic base and the main employer. Other components are mining, agriculture, government, tourism-recreation, transportation, and secondary manufacturing. The region is provided with excellent access, being traversed by the Trans-Canada, Yellowhead, and #5 Highways; the Canadian Pacific and Canadian National Railways; and serviced by a major airline (Pacific Western). The region as a whole has grown rapidly over the past decade.

As the urban focal point of the region, Kamloops has important service, economic, administrative, and educational functions. It too

MAP 1

THE THOMPSON - NICOLA REGIONAL DISTRICT,

BRITISH COLUMBIA



is undergoing tremendous growth in its population, actual area, and economy.

> When proposed major resource projects within Kamloops' sphere of influence become a reality, further rapid advancement can be expected, although the Kamloops economy has matured to the point where continued, steady, internally-generated growth is virtually assured. (BC Regional Index 1978, p. 231).

The combination of rapid economic growth, an increasing, young and active population with an average family income of $9,000 to 10,000 annually, and excellent access for visitors to the region, have placed many pressures upon the scenic landscapes and abundant natural resources. "There is every indication that the pressure on the resource base from industry, transportation, and population demands will continue to grow." (B.C. 1976, p. 90). In short, the region's rapid development has been and continues to be accompanied by "...a significant volume of environmental and land use issues and conflicts. (B.C. 1976, p. 13). The region's lakes are an excellent illustration of such issues and conflicts, as they are the target of an increasing number of users and uses. The following chapters attempt to establish a means of dealing with the issue of the lake resource, its environmental quality and use.

CHAPTER TWO:

THE USE OF THE CARRYING CAPACITY CONCEPT IN LAKE SYSTEM PLANNING

INTRODUCTION

The objective of this chapter is to specify the rationale for selecting the carrying capacity standards used in the proposed lake classification system. The concept of carrying capacity continues to be useful in outdoor recreation planning. Carrying capacity is defined as,

> ...the number of user-unit use...that the recreation site can provide in an average year without permanent biological or physical deterioration of the site's ability to support recreation or appreciable impairment of the recreational experience (Chubb and Ashton 1969, p. 59).

It is a measure of the number of units per area; for example hikers per mile, campsites per acre, or boats per acre of surface water.

The concept of carrying capacity was initially applied to terrestrial recreation resources and was later applied to aquatic recreation resources, i.e. lakes. A review of the recreation resource and lake planning literature indicates a consensus as to why this concept is used as a planning and management tool (Wager 1964, Chubb & Ashton 1969, Lime & Stankey 1971, Jaakson 1970, Jaakson et al 1976, Red Deer Regional Planning Commission 1976). Lakes, like most recreation resources, are finite and essentially non-renewable. Further they are common property (i.e. public) resource and should continue to provide a variety of outdoor recreation opportunities. Lake planning and management can help to preserve those lake characteristics which attract people initially, using carrying capacity as a means of estimating appropriate levels of use and development.

Many types of carrying capacities have been defined, along with proposed methods of measurement. A selection of types from one list includes aesthetic, biotic, spatial, environmental, facility, ecological, and psychological (Verburg 1974). Despite the variety of terms and definitions, three over-riding factors are involved in determining carrying capacity:

1) the biophysical characteristics of the resource,

2) the demands and impacts of the resource user, and

3) management intervention to balance 1) and 2) respectively (Verburg 1974).

In short, there is continuous interaction among the resource, its users, and management.

Natural resources have certain biophysical characteristics which make them suitable for and able to sustain various types and amounts of recreational use. For example, a deep, cold lake of several hundred acres in a forested setting is more capable of supporting sport fishing, camping, and cottaging than a shallow, warm lake of 50 acres set in a semi-arid grassland. At the same time, the users or recreationists hold different expectations about their impending experience. As well, they have different perceptions about the recreation resource at the time that they are using it. These differences are due to a variety of factors such as past experiences, education, personality, and socio-economic background. For example, suppose two canoeists go to the large, cold lake seeking wilderness travel, quiet, and solitude. While they are canoeing, a large power boat zips by at high speed. The power-boaters, with their noise and speed, infringe upon the canoeists' solitude and wilderness experience. On the other hand, those in the power boat set out fully expecting and wanting to meet other people and

do not mind encountering the canoeists. Both groups have different expectations and perceptions of appropriate lake use.

Resource management agencies may intervene between the resource and its users. Management objectives establish the type of recreational opportunities to be provided. The objectives may be determined through a combination of: an evaluation of the resources, expressed public opinion, rates of use, or perhaps political pressure. The management agency is caught between the limited supply of the recreation resource and the demands of recreationists, and must somehow achieve a balance between the two. To further the previous example, the two unsatisfied canoeists with the support of their 'Wilderness Protection Society', may successfully petition the resource agency to prohibit the use of boat motors on that lake.

Biophysical and Perceptual Carrying Capacity

The definition of carrying capacity given on page 9 can be divided into its components:

1) the biophysical and
2) the psychological or perceptual capacities.

Although the two components are inter-related, they deal with different aspects of capacity making it easier to deal with them separately. This writer agrees with Verburg (1974) that perhaps it is the wrong approach to expect a single, definitive answer or figure as has been the tendency in the past:

> Perhaps it would be much more productive if we established at least two capacity guidelines for each area; one related to the biophysical capacity of the site; one related to the psychological or social capacity of the site. Then, if in light of management objectives, neither capacity guideline is completely satisfactory, a compromise can be attempted. Otherwise, one or the other guideline is chosen and the difficult task of melding two different units or concepts is avoided. (p. 57).

The following definitions are used in this paper:

1) Biophysical carrying capacity is the number of user units that a lake can accommodate in one year without permanent biological or physical deterioration of the lake.

2) Perceptual carrying capacity is the number of user units that a lake can accommodate without appreciable impairment of the recreational experience judged by the recreationist at the time of participation.

Although any one lake has both types of capacity, the two will not usually be the same number of units per area, for a particular lake. Further, an agency cannot manage one lake simultaneously for both capacity levels. Therefore the management agency must make trade-offs between the two capacity standards, or give priority to one over the other standard, for each lake. If one considers the great biophysical variety among lakes, it is obvious that lakes or types of lakes will have not only different biophysical capacities but also different perceptual capacities. Thus the carrying capacities proposed in this paper vary with the classes in the classification scheme, with the understanding that management must either make the necessary trade-offs or give priority to one standard, as discussed above.

BIOPHYSICAL CARRYING CAPACITY

Biophysical parameters are used to indicate the biophysical carrying capacity because they can be measured fairly objectively. However the actual choice of one particular figure to be a standard is subjective. There are no 'proven' standards; for example the discrepancy between European and North American preferences for recreational water quality. The parameters used here are not converted to an acres-per-unit figure because any conversion standards are quite arbitrarily chosen, and further complicate the matter of measuring, choosing, and managing

capacity. The capacity standards proposed below are a combination of established capacity ratings (Canada Land Inventory, CLI), actual physical characteristics, and water quality standards.

The biophysical carrying capacity standards are stated in a qualitative manner for Classes I and II, and are specified for Classes III and IV. No standards are presented for Class V, Special Case Lakes because of the unique conditions which it is expected to accommodate. These lakes require individual analysis and therefore, no capacity standards can be established beforehand.

With regards to Class I, Wilderness Lakes, there are a few agencies through which use might be regulated, for example the Lands Branch, the Parks Branch, and the TNRD through its parks function. However these types of lakes are scattered throughout the region, usually without special designation as a park or reserve. Until Wilderness lake areas are given some special status, it appears that it would be administratively difficult to control the number of users. It is hoped that the limited access to and facilities at Wilderness Lakes will discourage heavy use, thereby maintaining natural conditions. However the agencies with lake related responsibilities should monitor these lakes in order to determine if present use is causing negative impacts. The resulting information can then be used to establish appropriate capacity standards and means of implementation. A similar explanation of the carrying capacity standards is offered for Class II, Natural Environment Lakes: i.e. the administrative difficulties, lack of special designation, and the need to monitor use in order to establish appropriate standards. Although these lakes do have motorized access, the facilities are limited, again to discourage heavy use and to maintain natural conditions.

In regards to Class III and IV, there are several existing administrative structures through which development can be controlled. The TNRD is responsible, among other things, for processing rezoning applications within unincorporated areas. A land owner must apply for a rezoning in order to change the land use or to subdivide private property, in this case to create cottage lots. The TNRD can give or withhold their approval in accordance with the proposed classification scheme. The B.C. Lands Branch also controls lakeshore development by issuing Special Use Permits, which allows the lesee to build a cottage on the lake-side lot leased from the Crown. For those lakes which might have unacceptable faecal coliform counts, the B.C. Ministry of Health has the authority to prohibit continued public use until the water quality improves. Finally, the B.C. Parks Branch and the Forest Service Recreation Division, are the major agencies which provide public recreation facilities. The location, size, type, and maintenance of facilities are the critical factors in controlling public use.

CLASSIFICATION CRITERIA

CLI Recreation Capability Ratings

The CLI Recreation Capability ratings are an existing system which maps the carrying capacity of land and water for recreation. It is based upon a scale of 1 to 7, with 1 indicating the highest carrying capacity for intensive activities. Although the CLI system is limited because it lacks detail, it can indicate those areas best able to sustain intensive use and for which further, site specific investigations would be worthwhile. The CLI ratings then, act as a first level screening to determine recreation capability. Because the ratings refer to intensive use, it is not used within Class I and II but only for Class III and IV.

Class III, General Use Lakes, are characterized by a rating of 3 and 4 because there is no intention to provide intensive development of public facilities nor cottaging. The objective is to provide mostly public recreation and limited cottaging, in a natural and rural landscape. The objective of Development Lakes, Class IV, is to provide opportunities for public recreation and cottaging at greater densities, allowing the development of more urban-like facilities. Therefore high capability ratings are required, 1, 2, and 3.

Surface Area and Mean Depth

The specific surface area and mean depth criteria are taken from Ableson (1978). The author does not discuss why he includes them, however the principle for using them is simple enough. Larger, deeper lakes not only have greater surface area and shoreline length to accommodate more users, the volume of water is greater thus decreasing the concentration of the nutrients from waste disposal entering the lake. (Dilution will occur only to a point beyond which the excess nutrients cause a change in the lake's trophic status). The actual figures, 60 and 100 hectares (ha.) and 5 meters (m.), appear to be arbitrarily chosen as no justification is offered by the author.[1] This shortcoming is recognized yet some indicator of size and depth is needed for the reasons given above.

Chlorophyll a

The chlorophyll a measures are adapted from Ableson (1978), who in turn has used the work of Dillon (1975). (See Table 1). The amount

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[1] In a letter to the TNRD, dated Sept. 20, 1978, Abelson states that, "The minimum size criteria of 150 and 250 acres were based in part on size criteria adopted by other government agencies in Canada and the U.S. Ultimately however, the Lakeshore Committee was forced to rely on value judgements which were referenced to the critical nature of many of the small land locked lakes in our region."

of chlorophyll a indicates a lake's productivity or trophic status. Phosphorus, usually the limiting nutrient for productivity, is added to a lake mostly from the sewage effluent from cottages and public facilities. This situation can lead to an eutrophic state.

> ...the term eutrophication is synonymous with increased growth rates of the biota of lakes, and that the rate increasing productivity is accelerated over that rate that would have occurred in the absence of pertubations of the system. (Wetzel 1975, p. 243).

The greater the chlorophyll a measure, the more eutrophic the lake. The more the lake is eutrophic, the less suitable it is for cold water sport fisheries and body contact activities. Also abundant algae blooms and rooted aquatic plants are less aesthetically pleasing visually and they tend to become tangled with swimmers and in boat motor propellers. Because General Use Lakes are less developed, less phosphorus and other nutrients will be artificially added. Therefore a higher chlorophyll a measure is initially acceptable. More development and hence added nutrients are expected for Development Lakes. Thus a lower chlorophyll a measure is required initially.

Secchi Disk and Total Dissolved Solids

Secchi disk is a measure of water transparency. The greater the depth of transparency, the less the algae concentrations and/or suspended solids. It is another means of indicating lake productivity because there is a negative correlation between the depth of light penetration and chlorophyll a. Total dissolved solids (TDS) is an additional measure of productivity. "Productivity is higher in areas where the dissolved solids concentration in the water is higher" (Ontario Land Use Coordination Branch 1977, p. 54). These parameters and the range of standards provided are used for the same reasons just discussed for the chlorophyll a measure.

TABLE 1

MAXIMUM PERMISSABLE AVERAGE SUMMER CHLOROPHYLL *a* CONCENTRATIONS *

LEVEL 1 — 2 mg m^{-3}; for lakes to be used primarily for body contact water recreation; where it is desirable to maintain hypolimnetic concentrations of oxygen in excess of 5 mg L^{-1} in order to preserve cold water fisheries; the lake will be extremely clear with a mean Secchi disc visibility greater than 5M; the lake will be generally unproductive.

LEVEL 2 — 5 mg m^{-3}; for lakes to be used primarily for body contact water recreation; where preservation of cold water fisheries is not imperative; lake will be moderately productive; mean Secchi disc visibility of 2-5m.

LEVEL 3 — 10 mg m^{-3}; for lakes where body contact water recreation is of lesser importance; cold water fisheries difficult to maintain; hypolimnetic oxygen depletion common (less than 5 mg L^{-1}); Secchi disc visibility less than 2m; possibility of winter kill of fish in shallow lakes; developing algae and rooted aquatic problems.

LEVEL 4 — 25 mg m^{-3}; for lakes where body contact water recreation is of minor importance; unsuitable for cold water fisheries; hypolimnetic oxygen depletion likely to commence in summer; considerable danger of winter kill of fish, except in deep lakes; extensive algae blooms and rooted aquatics.

* Modified from Dillon

Source: Ableson 1978

Ontario Water Quality Index

The water quality index is a rating system devised by the Lake Planning Unit, Land Use Coordination Branch, Ontario Ministry of Natural Resources. It is based upon the aggregate of six water quality parameters:

1) mean depth,
2) chlorophyll *a*,
3) secchi disk depth,
4) oxygen (O_2) distribution (midsummer),
5) morpho-edaphic index (the ratio of TDS to the mean depth), and
6) iron/phosphorus ratio in the hypolimnion under anaerobic conditions.

There are score tables for each parameter. (See Table 2). The water quality index rating of 1 - oligotrophic to 7 - eutrophic, is based upon the total aggregate score. The higher the score, the higher the rating: i.e. tending toward an eutrophic state. Thus Development Lakes require a score of 3 or less because more nutrients will potentially be added. General Use Lakes require a score of 6 or less because fewer nutrients will potentially be added than for Development Lakes.

Faecal Coliform Count

In Classes III and IV, the B.C. Ministry of Health standards for faecal coliform counts are included to ensure public health. For Classes I and II the density of use is intended to be much lower. Thus problems of public health are not expected. However, should the volume of use ever reach such levels so as to cause concern, the public health conditions should be investigated and standards applied.

Slope and Soils

Septic fields are the traditional means of domestic sewage disposal for cottages, resorts, and campgrounds. (The following discussion also applies to outhouses which have the same requirements for soils

TABLE 2

WATER QUALITY INDEX - SCORE TABLES

MEAN DEPTH		OXYGEN DISTRIBUTION		CHLOROPHYLL A	
Distribution	Score	Distribution	Score	Distribution	Score
0 - .9 metres	10	Clinograde & anaerobic conditions	10	14.1 + ug/l	10
1 - 1.9 metres	8	Metalimnetic maximum & hypolimnion depletion	8	9.1 - 14	7
2 - 3.9 metres	6	Metalimnetic maximum	6	4.1 - 9	4
4 - 7.9 metres	4	Clinograde	4	2.1 - 4	2
8 - 14.9 metres	2	Orthograde	0	0 - 2	0
15+ metres	0				

SECCHI DISC READING		MORPHO-EDAPHIC INDEX		IRON-PHOSPHOROUS RATIO (mg/l iron/ mg/l phosphorous)	
Distribution	Score	Distribution	Score	Distribution	Score
0 - .9 metres	10	10+	10	30+	0
1 - 1.9 metres	8	6 - 9.9	8	25 - 39.9	2
2 - 2.9 metres	6	4 - 5.9	7	20 - 24.9	4
3 - 3.9 metres	4	2 - 3.9	6	15 - 19.9	6
4 - 4.9 metres	3	1 - 1.9	5	10 - 14.9	8
5 - 6.9 metres	2	.5 - .9	2	0 - 9.9	10
7+ metres	0	Less than .5	0		

Total Score	Water Quality Index		User days/ acre/year *	User days/ hectare/year	User days/ km^2/year
0 - 3	1	Oligotrophic	1	2	200
4 - 8	2		3	8	800
9 - 13	3		5	11	1,200
14 - 19	4	Mesotrophic	10	25	2,500
20 - 27	5		15	38	3,800
28 - 39	6		20	50	5,000
40 - 60	7	Eutrophic	30	75	7,500

* These figures are not intended to convey precise scientifically supported intervals, but are assigned as "safe" figures. Their origins represent the collective opinions of many people engaged in water management and research. These values will be subject to constant review as the "state of the art" advances.

Source: Ontario Land Use Coordination Branch 1977.

suitable for nutrient removal). Septic fields are usually located in soils which have high water transport abilities; i.e. more porous and coarser relative to other soils. However, "...the better a septic tank drain field system operates as a wastewater disposal system, the poorer it operates as a means of protecting lakes or groundwater systems from nutrient enrichment." (Ableson 1978, p. 13). Nutrient removal is a function of the particle size distribution in soils, the fixation of phosphorous and ammonia, and nitrate uptake by plants in soil with a high capillary potential, which "...implies that the medium and fine-textured soils should be more satisfactory than coarse sandy soil..." for nutrient removal (Ableson 1978, p. 12). (See Table 3).

Steep slopes allow the subsurface waste water to be transported to a lake faster than shallower slopes. The waste water drainage will be faster yet if the steep slope is a layer of impervious soil or bedrock. In addition to water pollution considerations, steep slopes are less suitable as development sites. The degree of erosion increases as cutbanks are made to create level cottage sites, driveways, and roads. The subsequent erosion can then ruin fish feeding and spawning grounds through siltation. As well, aesthetic values can be reduced as the siltation decreases water clarity.

TABLE 3

SOIL SUITABILITY FOR SUBSURFACE DISPOSAL OF SEPTIC TANK EFFLUENT

	SUITABILITY CLASS		
Site Factor	1	2	3
Depth (ft.) to Bedrock	>6	4-6	<4
Depth (ft.) to an Impermeable Layer	>6	4-6	<4
Depth (ft.) to Water Table	>6	4-6	<4
Slope (%)	0-5 Single; 0-2 Multiple	5-15 Single; 2-9 Multiple	15 Single; 9 Multiple
Distance (ft.) to Water Well or Surface Water	>200	50-200	<50
Flooding Hazard	None	Very Slight	Moderate or High
Seepage	None	Very Slight	Moderate or High
Soil Drainage	Moderately well	Imperfectly; Well	Poorly; Rapidly
Percolation Rate (min/in)	10-25	25-30 3-10	>30 <3
Soil Structure	Granular; Sub-angular blocky	Blocky; Columnar; Prismatic; Platy	Single-grained; Massive
Soil Texture	Silt loam; Clay loam; Sandy loam; Fine sand; Clay	Loamy sand; Coarse sand; Silt; Clay	Gravel; Any texture with high water table
Stoniness (% by volume)	<20	20-50	>50

Source: Ableson 1978

Biophysical Carrying Capacity Standards

I. Wilderness Lakes

The amount of use per year which does not negatively alter the natural conditions.

II. Natural Environment Lakes

The amount of use per year which does not negatively alter the natural conditions.

III. General Use Lakes

-The lake has an area greater than 60 ha. and a mean depth greater than 5m.

-The shoreline has the CLI Recreation Capability ratings 3 and 4.

-One of the following water quality standards:
- mean summer chlorophyll a - less than 10 milligrams per cubic meter (mgm^{-3}),
- secchi disk - greater than 2m.,
- TDS - less than 200 parts per million (ppm.),
- Ontario water quality index rating - 6 or less.

-The faecal coliform counts conform to the health safety standards of the B.C. Ministry of Health.

-The lakeshore does not have predominantly steep slopes nor soils which are unsuitable for nutrient removal.

IV. Development Lakes

-The lake has an area greater than 100 ha. and a mean depth greater than 5m.

-The shoreline has CLI Recreation Capability ratings 1, 2, and 3.

-One of the following water quality standards:
- mean summer chlorophyll a - less than 5 mgm^{-3},
- secchi disk - greater than 2m.,
- TDS - less than 150 ppm.,
- Ontario water quality index - 3 or less.

-The faecal coliform counts conform to the health safety standards of the B.C. Ministry of Health.

-The lakeshore does not have predominantly steep slopes nor soils unsuitable for nutrient removal.

PERCEPTUAL CARRYING CAPACITY

Virtually no lake planning study to date includes a separate perceptual carrying capacity standard. This factor is usually discussed but then no attempt is made to distinguish it from the biophysical capacity standards (for example, Red Deer Regional Planning Commission 1976, Jaakson et al 1976, Ontario Ministry of Natural Resources, Land Use Coordination Branch 1977). One study does include a "crowding potential" but no explanation is given for the figures (Ableson 1978). This lack of separate perceptual standards may be explained by:

1) management's failure to recognize its role of balancing the biophysical and perceptual factors; and/or

2) the difficult and subjective nature of measuring perception and then selecting a standard.

The most common method of measuring perception, a questionnaire survey by interview or by mail, is subject to a number of limitations as a research method (Babbie 1973). However some measure of user preference should be included to reflect the users' perceptions of the lake resource and its acceptable level and/or types of use.

Perceptual Carrying Capacity Standards

Recognizing the difficulties referred to earlier, an attempt is made to establish some perceptual carrying capacity standards. These standards are as follows:

I. Wilderness Lakes

There is more than 8 ha. of water surface per unit.[2]

II. Natural Environment Lakes

There is more than 8 ha. of water surface per unit.

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[2] A unit is defined as an individual, group, or family; however the mean unit size is 4 persons (TNRD Lake User Survey 1978).

III. General Use Lakes

There is more than 4 ha. of water surface per unit.

IV. Development Lakes

There is more than 2 ha. of water surface per unit.

The standards are based upon:

1) intended lake use and objective within the classification scheme,

2) available information for the study region regarding lake activities and user preferences,

3) a range of lake surface areas,

4) standards used elsewhere in Canada and the U.S., and

5) the writer's personal judgement.

In regards to the perceptual standards for Classes I and II, the difficulties encountered in determination and administration, are similar to those for these classes' biophysical capacity standards. Monitoring the perception of use can help to alleviate these difficulties. With the resulting data, more appropriate standards and means of implementation can be better determined.

There are several administrative structures through which the number of user-units may be established and controlled, for General Use and Development Lakes. The number of units potentially using a lake can be calculated by adding together the number of cottage lots, public campsites and picnic sites, Special Use Permit lots, and private fishing camps' cabins and campsites. This information can be obtained from the TNRD, the B.C. Assessment Authority lists, B.C. Parks Branch, B.C. Forest Service Recreation Division, Lands Branch files, and tourist accommodation guide books.

The Factors Involved

Intended Lake Use Within the Classification Scheme

The perceptual capacity standards proposed vary with the intended use or theme of each lake class. Providing a range of standards, with one standard provided for each lake class, allows more flexibility in balancing the supply of and demand for lakes. People will choose a lake according to their activities, desired facilities, and preferred density of use. Ideally those preferring a less occupied lake would choose, for example, a Natural Environment or General Use Lake rather than a Development Lake, where people can expect to find a greater density of use.

Lake Activities and User Preferences

The overall results of the TNRD Lake User Survey, 1978, show that most people are attracted to the lakes for fishing (80%) and for the peace and quiet (72%). Very few indicated power boating and water skiing as attractive (9% and 7% respectively). Further these latter two activities have the greatest negative impact upon the most popular activities, are the noisiest, and require the most space on a lake (Lake User Survey, TNRD 1978 and Jaakson 1970). It appears that fishermen will accept and tolerate other people fishing but not those power boating nor water skiing. The average number of boats per unit is one, usually a small fishing boat with limited horsepower motors. Thus less lake surface per unit is required in consideration of both safety and perceptions of crowding.

The TNRD survey results did not indicate any correlation between the size of a particular lake and perception of volume of use at that lake. It is assumed that the larger the lake the less the perception of crowding or of a high use level. This lack of correlation may be due

to many factors:

1) the design and actual wording of the questionnaire,

2) the subconscious influence of the interviewer,

3) the size and shape of the lake,

4) the uses and activities occurring at the time of the interview or answering the mailed questionnaire, and

5) the different tolerance levels between public lake users and cottage owners.

The Range of Lake Surface Areas

For Classes III and IV, it is intuitively reasonable that smaller, intentionally less developed lakes should have more surface area per unit than larger, intentionally more developed lakes. General Use Lakes, being smaller than Development Lakes, have less surface area with which to absorb users. Thus there is a larger ratio of surface area per unit, 4 ha. Development Lakes, being larger, can absorb more use and thus has a smaller ratio of lake surface per unit, 2 ha. Although there is no surface area size specified for Classes I and II, the largest ratio of area per unit, 8 ha., is provided for the Wilderness and Natural Environment Lakes, so that those seeking to experience the outdoors are not subjected to an environment dominated by human activity, mechanized equipment, or other trappings of modern, Canadian society.

Standards Used Elsewhere in Canada and the United States

There is great variation among standards used in other studies. Also these standards establish both biophysical and perceptual capacities in one number. Despite the lack of justification, the standards listed below reflect the appropriate amounts of use, in the professional judgement of others.

- Threinen & Schneberger 1964 (Wisconsin) - 10 acres/boat
- Regional District of Okanagan-Smilkameen 1972 (B.C.) - 2.5 acres/use unit.
- North Atlantic Regional Water Resources Study Group, U.S. Army Corps of Engineers 1972 - 1/3 to 9 acres/boat.
- Red Deer Regional Planning Commission 1976 (Alberta) - 10 acres/boat.
- Jaakson et al 1976 (Saskatchewan) - 20 acres/boat for motorboat cruising and water skiing, 10 acres/boat for fishing, and 8 acres/boat for canoeing, kayaking, and sailing.
- Ontario Ministry of Natural Resources 1977 - 10 acres/boat.
- Ableson 1978 (B.C.) - 5 acres/dwelling.

Not only are the above standards fairly arbitrary, most of them apply only one standard to all the lakes under consideration. There is not a range of suitable standards: i.e. there is not an appropriate standard applied to each type of lake according to the biophysical differences among lakes, or types of lakes, and the variety of activities taking place.

CONCLUSION

An important assumption is made by this writer that perceptual carrying capacity is usually exceeded before the biophysical carrying capacity. It is possible then, that the perceptual standards can determine the limit to development rather than the biophysical standards, assuming that management intervention ensures that limit. Although the perceptual standards are based upon some statistical results, they use previous studies and personal judgement. These standards are subjective, which is the major criticism of the previously cited studies. Therefore it is recognized that the use of the perceptual standards, to limit development, may not be the most sound criterion upon which to base such a decision. However it is better to implement some type of criterion and then test it, rather than having no criterion at all. Only through further research can such capacity standards be improved and justified.

One final point must be made. Any and all carrying capacity standards are cultural value judgements. It is society's belief that a certain environmental quality or capacity standard is acceptable or not, which ultimately determines a lake's suitability and capability for recreation or other uses.

CHAPTER THREE:

THE LAKE CLASSIFICATION SYSTEM AND RECOMMENDED MANAGEMENT GUIDELINES

INTRODUCTION

Webster's New Collegiate Dictionary (1977) defines a 'system' as,

1a. a regularly interacting or interdependent group of items forming a unified whole;

1d. a group of devices or artificial objects or an organization forming a network especially for distributing something or serving a common purpose;

3b. a manner of classifying, symbolizing or schematizing.

'Classification' is defined as,

...2a. a systematic arrangement in groups or categories according to established criteria.

These terms are fundamental to the concept of lake system planning. The group of lakes is a system managed as a network to serve a common purpose; i.e. to provide the opportunity for a variety of lake uses, especially recreation, and to maintain the lake ecosystems. The individual lakes can be systematically assigned through a classification scheme, to use categories or classes according to established criteria and according to the demand profile. In order for the lake classes to work as a system, the type and extent of the user demand must be known so that the managing agency can best allocate the resource to these demands.

By establishing a role or theme for each class, incompatible uses are separated and the most suitable lakes are allocated to sustain particular uses. A wider range of classes and levels of development provide greater flexibility and greater probability, than at present,

that demands will be satisfied. As well, the lakes' ecosystem integrity is assured because in theory the lakes will be subject to only those uses which they are inherently capable of sustaining. Ideally such a system will foster optimal lake use.

One influence upon the regional lake system concept is Rees (1978), who points out:

> ...the overall goal of lake system planning is to optimize the social value inherent in a system of lakes, by distributing the demand for various lake-oriented recreational activities among the lakes according to their inherent capabilities. ...planning the development of a number of lakes as a system, to take advantage of their individual potentials will result in greater net benefits to society. Environmental damage is minimized while a fuller range of recreational demands is satisfied (pp. 2 & 3).

Rees (1978) suggests classification criteria based upon aesthetic attributes, biophysical characteristics, and socio-economic factors. His recommended classes are Special Use, Wilderness Recreation, General Outdoor Recreation, and Intensive Use Lakes.

Other earlier studies have adopted a similar perspective. Work carried out by the Red Deer Regional Planning Commission (RDRPC), Alberta (1976), is helpful in illustrating the regional point of view in lake management. Their philosophy states that,

> Lakes are a public resource and consequently should be planned and managed for the total public good as part of a regional (or provincial) open space and recreation area system... (p. 7).

As well, the RDRPC recognizes the inter-relationship among lakes in forming the regional system: "...policies and management plans need to be developed for all lakes so that the uses of one lake or type of lake will complement the uses of other lakes" (Ibid. p. 7). This complementary relationship leads to the recognition that each lake has a function or role within the system. Although no two lakes are identical, they can

be grouped together according to homogeneous characteristics, upon which their roles are based. The RDRPC uses three classes - Development, Scenic, and Wilderness; the Scenic and Development classes are further refined by distinguishing a Provincial, Regional, or Local status of importance. The classes are defined according to Canada Land Inventory (CLI) rating for waterfowl, ungulates, sport fish, recreation; and existing development.

Although the RDRPC establishes a regional perspective and classification system it does not make use of water quality criteria in classification. Water quality is crucial in determining a lake's suitability and capability for different uses. Indeed Albeson (1978) proposes lakeshore development guidelines based on water quality variables related to relative lake productivity. His purpose is,

> ...to preserve and enhance water quality in recreational lakes while at the same time providing management policies consistent with existing and future use ... they represent a development policy based primarily upon lake trophic status. (p. 1).

The lake classes established by Ableson are Natural Environment, Critical, Restricted Recreational Development, and General Development. These classes are based upon the following criteria: crowding potential (the ratio of lake surface to length of shoreline); existing development; natural physical characteristics; water quality and ecological classification; and fish and wildlife values. Ableson's contribution is his use of such water quality criteria as average summer chlorophyll a values and soils suitable for nutrient removal. In the present study, the water quality standards established by the Ontario Land Use Coordination Branch (1977) are also used. However, it should be noted that both Ableson and Ontario have used the work of Dillon (1975) and there-

fore their water quality standards are similar.[1]

The classification schemes cited above use similar classes, for similar reasons. As well, they have several classification factors in common, which may be grouped under present development, biophysical characteristics (fish and wildlife values), and water quality. In the case of the Thompson-Nicola region, more detailed criteria for classification are required because of conditions particular to the study area and the Thompson-Nicola region in general. These conditions include the great biogeoclimatic diversity within the relatively small region; the large number of lakes; the dominance of resource based industries (ranching, logging, mining) and their abundant access roads; the continual urban pressures upon some lakes (for example Paul, Knouff-Sullivan, Nicola); and the occurrence of 35% to 46% of the total provincial angling effort.[2] Such factors strongly influence such planning considerations as access, volume of use, user perception of the activities and uses, lake and shore use other than recreation, the range of present recreation activities, and the visual resources. With more diverse criteria, a wider range and more refined classes of lakes than suggested in previous studies, have been devised in the following classification scheme. The classification criteria will be discussed individually before presenting the classification system and recommended management guidelines.

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[1] Mr. N. Gordon, Head, Lake Planning Unit, Ontario, stated in conversation with the writer that their water quality standards are more strict that Dillon's in that Ontario's allowed less shoreline development for a particular water quality (Dec. 21, 1978, Toronto).

[2] B.C. Fish and Wildlife, Kamloops office staff believe that the figures may be as high as 46%, although statistics support the figure of 35%.

CLASSIFICATION CRITERIA

The relative importance of criteria vary among the classes depending upon a particular class' objective and role. The standards are based upon the following criteria: access, present land and water uses, ownership and perimeter development, water quality, natural features (i.e. biophysical characteristics), and perceptual carrying capacity. The biophysical and perceptual carrying capacity standards are discussed in detail in Chapter Two, and therefore they are not included in this discussion.

In any set of guidelines, criteria are intended to describe the ideal state, not reality. Therefore it is recognized that not all the lakes will meet all the criteria for any single class. For example, a lake's present perimeter development may exceed the 30% standard for General Use Lakes by only a few percentiles, yet the lake meets all the other criteria. In these circumstances exceptions to individual class criteria are allowed so that the overall lake system planning objectives can be more closely achieved. In short, trade-offs must be made between excepting certain class criteria and attempting to fulfill the user demands within the region.

Access

Access is probably one of the most important factors in controlling the demand for a particular lake. Most people choose destinations to which it is convenient to drive. Access to Wilderness Lakes is limited to non-motorized means in order to maintain the wilderness character: i.e. "...uncultivated, uninhabited, and essentially undisturbed by human activity" (Webster's Dictionary 1977). Difficult access tends to discourage use, thereby helping to preserve the lakes' natural features.

Limited motorized access is allowed to Natural Environment Lakes so that more people, for example the aged, the handicapped, and families with small children, have the opportunity to enjoy the features more easily. For the remaining classes motorized access is assumed. Within the Recommended Management Guidelines for General Use and Development Lakes, the location and type of road (improved gravel or hardsurface) are included as a further means of influencing realized use.

Present Land and Water Use

Present land and water use shape the role of the lakes. Obviously there can be no present land nor water use, for industrial, commercial, or agricultural purposes, of Wilderness Lakes because it is contrary to that class' objectives. A lake may be classified as Wilderness if there is a pattern of wilderness recreation use, despite the lack of important, unique, or representative natural features. The requirements of little or no industrial and agricultural use are similar for Natural Environment Lakes, although some existing uses are compatible with its objective, such as a few cottages or a fishing camp (a commercial-recreation use). Also, a lake may be classified a Natural Environment if there is a pattern of low-key recreation use in still natural surroundings, despite the lack of important, or representative features.

Reference to the Agricultural Land Reserve (ALR), water licenses, and agricultural sources of nutrient input, for Natural Environment, General Use, and Development Lakes, are made in recognition that the use of lakes for agricultural purposes is legitimate. Often a lake is the only adequate water source for a ranch and upon which the rancher's livelihood depends. However there are other legitimate uses as well,

which must be managed and balanced to maintain the lake resource upon which they all depend. Finally, the rural landscape has great appeal to people who live in urban areas.

Perimeter Development and Ownership

The actual percentage and density of perimeter development is the major influence upon a lake's environmental quality and use. The type of ownership is not as crucial as the actual presence of the development. The ownership of development may take several forms, for example:

1) a Provincial Park campground - Crown land;
2) a commercial fishing camp on Crown leased land;
3) cottages on privately owned (fee simple) land;
4) cottages on Federal Indian Reserve land and leased from an Indian Band.

The point is that the development is present or may be in the future, under a variety of forms of tenure. The amount of perimeter development should be limited according to a lake's biophysical characteristics, user preferences, and the overall planning objectives.

Of course ownership is an important factor influencing demand and lake use. A variety of land tenure forms among the Crown and individuals allows a mix of private and public access to a lake and therefore a variety of opportunities for use. For planning purposes however, the development of Crown land is easier to control than the development of private land. Additionally, Crown ownership is a means of maintaining management jurisdiction over the natural resources by provincial agencies, gaining the benefits of their expertise and furthering the public good.

The perimeter development criterion and the perceptual carrying capacity criterion reinforce each other by limiting the amount of

development to that criterion which is reached first, i.e. the maximum % perimeter development allowed or the number of acres of lake surface per unit. The water quality standards are also reinforced by limiting the amount of development which would potentially add nutrients to the lake and by retaining a portion of the perimeter in a natural state.

Natural Features

Natural features are obvious criteria because they are the elements which attract people, which determine the lakes' suitability for use, and which determine their capability to sustain uses. The CLI, BC Fish and Wildlife, and Ducks Unlimited ratings are used to determine areas of high ungulate and waterfowl value, in order to preserve important wildlife habitat. Also by designating these wildlife areas in which development is prohibited, the wildlife are protected from potential harassment by domestic pets owned by cottagers, campers, and other lake users. These areas also indicate opportunities for viewing wildlife, an educational and aesthetic consideration. The BC Fish and Wildlife fishery ratings indicate lakes which have high value for public sport fishing, spawning, and rearing. The outstanding or typical vegetation, scenery, or geological features are included in the present classification, in consideration of education, aesthetics, and preservation for research purposes. All the foregoing are the primary criteria for the Wilderness and Natural Environment classes because these lakes are defined by their important, unique, or representative natural features, the preservation of which is the classes' objective.

In the remaining classes, natural features receive less emphasis as definitive factors but they are considered within the management guidelines. In the General Use and Development classes, soils, slope,

and drainage are used to indicate areas most suitable for development. The overall objective is still to maintain natural, non-urban surroundings because people visit lakes to experience and enjoy the natural surroundings.

Visual Resources

People generally are most sensitive in environmental matters, to that which they see (with the possible exception of that which they might hear or smell). Further it is assumed that people generally consider clearcut logging and open-pit or strip mining as unpleasant sights, especially when they are participating in outdoor recreation and want natural surroundings.

The ten year old clearcut is stipulated in the Natural Environment, General Use, and Development Lakes classes, because within that time the early successional, vegetative species will be well established. If natural re-vegetation has not begun in three to five years, the BC Forest Service (BCFS) or the forest company concerned, will plant seedlings in the cut area.[3] (Of course there are variations in regeneration time depending upon the species, the biogeoclimatic zone, and the logging methods used). Although only deciduous species, not climax coniferous species, will have had time to grow in ten years, the area will appear green to the casual observer and therefore acceptable. Allowing one-fourth of the lake perimeter to be a ten to twenty-five year old clearcut is based upon the same reasoning, but the vegetation will have had even more time to grow toward maturity and thus will look even more natural.

The 100 m. buffer zone is stipulated in the same three classes mentioned above, because it is BCFS policy to leave up to five chains

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[3]Registered Professional Forester (Personal Communication 1979).

(330 ft. or approximately 100 m.) of forest undisturbed around a FS Recreation Site; a Use, Relaxation, and Enjoyment of the Public (UREP) site; or a Special Use Permit site. If there are no recreational sites, 25% of the lake perimeter may be logged every 25 years right to the shoreline.[4] This policy furthers the stipulation, in the three classes named, that a ten to twenty-five year old clearcut may be present within 25% of the buffer zone.

RECOMMENDED MANAGEMENT GUIDELINES

Only a brief word is necessary regarding the management guidelines as they are self-explanatory. These guidelines are suggested in order to ensure that:

1) the lakes retain their designated roles and continue to serve the classes' particular objectives, and

2) to help maintain the integrity of the lakes' ecosystems.

Finally, the guidelines are intended to promote resource agency coordination in achieving 1) and 2) above.

LAKE CLASSIFICATION SYSTEM AND RECOMMENDED MANAGEMENT GUIDELINES

I. Wilderness Lakes

Objective: To conserve lake environments in their natural state and secondly to provide the opportunity for wilderness recreation, i.e. non-mechanized camping and travel, nature appreciation, peace and solitude.

Definition: Those lakes and the surrounding four km. with important, unique, aesthetic and/or spiritual features worthy of conservation in their uncultivated, uninhabited, and undeveloped state; and those lakes which are not capable of sustaining intensive development because of their particular biophysical characteristics; to which access is non-motorized.

Criteria and Standards

Access
- By hiking, horseback, or other non-motorized means only, within the four km buffer zone, measured from the lakeshore.

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[4] BCFS Recreation Section, Kamloops (Personal Communication 1979).

Ownership and Perimeter Development
- 100% Crown ownership.
- No development of any kind (i.e. cottages, farms, resorts, etc.).

Present Land and Water Use
- No commercial, industrial, nor agricultural use, public or private.
- An existing pattern of wilderness recreation (optional).

Natural Features - One of:
- important, unique, aesthetic and/or spiritual features;
- CLI or Ducks Unlimited Waterfowl Capability ratings 1, 2, or 3;
- CLI Ungulate Capability ratings 1, 2, or 3;
- BC Fish and Wildlife Ungulate Capability ratings good or high.

Visual Resource
- An untouched natural condition; no extractive or developmental use has altered the natural viewscape.

Carrying Capacity
- Biophysical: The amount of use per year which does not negatively alter the natural conditions.
- Perceptual: There is more than 8 ha. of water surface per unit.

I. Recommended Management

Access
- Allow non-motorized access only through the 4 km. buffer zone, to the lake.

Ownership and Perimeter Development
- No alienations nor leases granted; remains 100% Crown land.
- No development of any kind, except for the primitive campsites.

Present Land and Water Use
- Prohibit any future commercial, industrial, or agricultural use, public or private, except for the establishment of primitive campsite facilities.
- Prohibit the use of boat motors or any other mechanized equipment.
- Provide primitive campsite facilities (i.e. outhouses and fireboxes) in suitable locations. Outhouses must be 90 m. to 150 m. from the shoreline, according to the soil's ability to remove nutrients.

Natural Features
- Maintain indigenous fish stocks where possible, in cooperation with the BC Fish and Wildlife Fisheries Management Plan.
- Conserve the natural features in their undeveloped state.

Visual Resource
- Maintain the natural viewscape.

Carrying Capacity
- Biophysical: Manage the lakes so as to maintain the natural water quality and other features as much as possible.

- Perceptual: If users express concern about the density of use, attempt some means to regulate the number of users.

II. Natural Environment Lakes

Objective: To provide opportunities for the public, to participate in dispersed outdoor recreation activities within natural surroundings.

Definition: Those lakes with important, or representative features worthy of conservation in their natural state; and those lakes which are not capable of sustaining intensive development because of their particular biophysical characteristics.

Criteria and Standards

Access
- By motorized means.

Ownership and Perimeter Development
- Cottage and fishing camp lots, whether owned or leased, together occupy up to 15% of the lake perimeter; the remaining 85% is undeveloped and preferably Crown land.

Present Land and Water Use
- No commercial, industrial, or agricultural use, except for limited cottaging, fishing camps, and/or basic public facilities.
- An existing pattern of low-key recreational use within natural surroundings (optional).
- The allowable portion of land for development (i.e. up to the 15%) shall not be part of the ALR.

Natural Features - One of:
- Important, or representative natural features;
- CLI or Ducks Unlimited Waterfowl Capability ratings 1, 2, or 3.
- BC Fish and Wildlife Ungulate Capability ratings good or high.
- Fisheries values for spawning and rearing habitat, and for sport fishing.
- Future or further development not compatible with BC Fish and Wildlife Fisheries Management Plan.

Visual Resource
- If present, logging clearcuts less than ten years old are not within 100 m. of the lake or the visual horizon, whichever is less; those clearcuts ten to 25 years old do not constitute more than 25% of the area within the 100 m. zone.
- If present, open pit or strip mining operations are not within 100 m. of the lake or the visual horizon, whichever is less.

Carrying Capacity
- Biophysical: The amount of use per year which does not negatively alter the natural conditions.
- Perceptual: There is more than 8 ha. of water surface per unit.

II. Recommended Management

Access
- Roads parallel to the shore shall be constructed a distance away from the lakeshore.
- Access to the lake-shore shall be restricted to specified development sites.

Ownership and Perimeter Development
- Allow no development or subdivision beyond the 15% perimeter development limit.

Present Land and Water Use
- Rustic commercial fishing camps are compatible with this class objective.
- Provide basic public facilities (i.e. parking, outhouses, and fireboxes) and locate them so that they will not threaten the viability of existing commercial fishing camps. Outhouses must be 90 m. to 150 m. back from the shoreline, according to the soils' ability to remove nutrients.
- In cooperation with the pertinent agencies, ban the use of boat motors or establish boat motor size or type (electric) restrictions, appropriate for the lake's size and use.

Natural Features
- Water Licenses shall not change existing water levels so as to negatively effect the aquatic or shoreline habitat, or access to the water.
- Exclude boat use from the waterfowl nesting and molting areas.

Visual Resource
- Request logging and mining operations to leave a buffer zone around the lake of at least 100 m. or the visual horizon, whichever is less.

Carrying Capacity
- Biophysical: Manage the lakes so as to maintain the natural water quality and other features, as much as possible.
- Perceptual: If users express concern about the density of use, attempt to regulate the number of users.

III. General Use Lakes

Objective: To provide opportunities for moderately intensive public outdoor recreation such as fishing camps, and private cottaging and to retain to the extent possible the natural lake environment.

Definition: Those lakes in a predominantly natural and rural landscape, used for recreational and agricultural purposes.

Developed Subclass - Definition: Those lakes which have equalled or exceeded the carrying capacity standards for General Use Lakes and meet the other criteria.

Criteria and Standards

Access
- By motorized means.

Ownership and Perimeter Development
- Private cottage and fishing camp lots, whether owned or leased, occupy up to 30% of the lake perimeter, so long as the carrying capacity standards are not exceeded. The remaining 70% is undeveloped and preferably Crown land.

Present Land and Water Use
- The maximum portion of land for development (i.e. up to the 30%) shall not be part of the ALR.

Natural Features
- Not crucial to the identification of lakes for this class.

Visual Resources
- If present, logging clearcuts less than ten years old are not within 100 m. of the lakeshore or the visual horizon, whichever is less; those clearcuts ten to 25 years old do not constitute more than 25% of the area within the 100 m. zone.
- If present, open pit or strip mining operations are not within 100 m. of the lakeshore or the visual horizon, whichever is less.

Carrying Capacity
Biophysical:
- The lake has an area greater than 60 ha. and a mean depth greater than 5 m.
- The shoreline has CLI Recreation Capability ratings 3 and/or 4.
- One of the following water quality standards:
  - mean summer chlorophyll a - less than 10 mgm^{-3};
  - secchi disk - greater than 2m.;
  - TDS - less than 200 ppm.;
  - Ontario water quality index rating - 6 or less.
- The faecal coliform counts conform to the health safety standards of the BC Ministry of Health.
- The lakeshore does not have predominantly steep slopes nor soils which are unsuitable for nutrient removal.

Perceptual
- There is more than 4 ha. of water surface per unit.

III. Recommended Management

Access
- Roads parallel to the shore shall be constructed a distance away from the lakeshore.
- Improved gravel roads are appropriate.
- Access to the shore shall be restricted to specified development sites.

Ownership and Perimeter Development
- Permit subdivision and perimeter development up to the maximum 30% or to the density of use of 4 ha. of water surface per unit, whichever is reached first.

Present Land and Water Use
- Provide public day-use and overnight facilities (i.e. parking, outhouses, tables, fireboxes, campsites) and locate them so that they will not threaten the viability of existing commercial fishing camps.
- Encourage cluster designs for new cottage developments, leaving the shoreline for the owners' common use.
- Development shall not be permitted on:
  - steep slopes,
  - poorly drained soils,
  - shoreline with extensive rooted, emergent aquatic vegetation,
  - soils not suitable for nutrient removal.
- All septic tank disposal fields and outhouses must be 90 m. to 150 m. back from the shoreline, according to the soils' ability to remove nutrients.

Natural Features
- Vegetation removal for development purposes should be minimized.
- Locate subdivisions and development away from ungulate and waterfowl habitat.
- Avoid filling in any portion of the shoreline and marshy areas.

Visual Resources
- Request logging and mining operations to leave a 100 m. buffer zone or the visual horizon intact, whichever is less.
- Locate cottages and other structures so that they are inconspicuous when viewed from the lake.

Carrying Capacity
- Do not permit the density of use to exceed the 4 ha. of water surface per unit standard, even if there is less than 30% perimeter development.
- Nutrient input from agricultural sources shall be minimized.
- Maintain the water quality so that the standards are not exceeded.

Developed Subclass
- Allow no further development or subdivision.
- Apply all the above management guidelines.

IV. Development Lakes

Objective: To provide opportunities for intensive use and development, while maintaining environmental quality standards in consideration of aesthetic, safety, and health aspects.

Definition: Those lakes intensively used for cottaging, recreational, residential, commercial and agricultural purposes.

Criteria and Standards

Access
- By motorized means.

Ownership and Perimeter Development
- Development may occupy up to 35% of the perimeter for lakes less than 800 ha., and 50% of the perimeter for lakes greater than 800 ha., so long as the carrying capacity standard, 2 ha. of surface water per unit, is not exceeded. The remaining 65% and 50% respectively, is undeveloped and preferably Crown land.

Present Land and Water Use
- The maximum portion of land for development (i.e. up to 35% and 50%) shall not be part of the ALR.

Natural Features
- Not crucial to the identification of lakes for this class.

Visual Resources
- If present, logging clearcuts less than ten years old are not within 100 m. of the lake or the visual horizon, whichever is less; those clearcuts ten to 25 years old do not constitute more than 25% of the area within the 100 m. zone.
- If present, open pit or strip mining operations are not within 100 m. of the lake or the visual horizon, whichever is less.

Carrying Capacity
Biophysical
- The lake has an area greater than 100 ha. and a mean depth greater than 5 m.
- The shoreline has CLI Recreation Capability ratings 1, 2, and/or 3.
- One of the following water quality standards:
  - mean summer chlorophyll a - less than 5 mgm^{-3};
  - secchi disk - greater than 2 m.;
  - TDS - less than 150 ppm.;
  - Ontario water quality index - 3 or less.
- The faecal coliform counts conform to the health safety standards of the BC Ministry of Health.
- The lakeshore does not have predominantly steep slopes nor soils unsuitable for nutrient removal.

Perceptual
- There is more than 2 ha. of water surface per unit.

IV. Recommended Management

Access
- Roads parallel to the shore shall be constructed a distance away from the lakeshore.
- Improved gravel road and hardsurface roads are appropriate.
- Access to the shore shall be restricted to specified development sites.

Ownership and Perimeter Development
- Permit subdivision and perimeter development up to the maximum 35% and 50% for lakes less than and greater than 800 ha. respectively, or to the density of use of 2 ha. of water surface per unit user, whichever is reached first.

Present Land and Water Use
- Provide public day-use and overnight facilities (i.e. parking, outhouses, tables, fireboxes, camp-sites, sani-stations, and boat launches), and locate them so that they will not threaten the viability of existing fishing camps.
- Septic tank disposal fields and outhouses must be 90 m. to 150 m. back from the shoreline, according to the soils' ability to remove nutrients.

- Development shall not be permitted on:
  - steep slopes,
  - poorly drained soils,
  - shoreline with extensive emergent aquatic vegetation,
  - soils not suitable for nutrient removal.
- Encourage cluster designs for new cottage developments, leaving the shoreline for the owners' common use.
- Attempt to separate competing uses by time or spatial regulations, to decrease the potential conflict among power boaters, waterskiers, fishermen, swimmers, manual boaters, or agricultural users.

Natural Features
- Vegetation removal for development purposes should be minimized.
- Locate all development away from ungulate and waterfowl habitat.
- Avoid filling in any portion of the shoreline and marshy areas.

Visual Resources
- Request logging and mining operations to leave a 100 m. buffer zone or the visual horizon intact, whichever is less.
- Locate cottages and other structures so that they are inconspicuous when viewed from the lake.

Carrying Capacity
- Do not permit the density of use to exceed 2 ha. of water surface per unit, even if there is less than 35% and 50% perimeter development for lakes less than and greater than 800 ha. respectively.
- Nutrient input from agricultural sources shall be minimized.
- Maintain the water quality so that the standards are not exceeded.

In some cases development pressures may continue to increase within a region despite existing development. In order to deal with these continual pressures, it may be preferable to allow an excessive amount of development at some Development Lakes whose environmental quality has already been compromised. As a result, the development demands are not satisfied at less developed or undeveloped lakes, thus protecting their higher environmental values. A cognizant trade-off is made between exceeding the Development Lakes class carrying capacity standards and retaining the environmental values elsewhere. The Subclass Intensive Use Lakes is provided to deal with these cases.

Subclass: Intensive Use Lakes

Objective: To accommodate further demands for development including non-recreational, at already developed lakes in order to protect higher environmental values at other less developed lakes.

Definition: Those lakes which have exceeded the normal Development Lakes carrying capacity standards, yet for which further development may be appropriate in the context of the lake system planning objectives.

Criteria and Standards
- All the Criteria and Standards for the Development Lakes apply, except for the carrying capacity standards.

Recommended Management
- All the management guidelines for the Development Lakes apply, except those concerning carrying capacity.
- Implement corrective measures to improve deteriorating water quality and to alleviate problems associated with unacceptable types and densities of use and conflicting uses.

V. Special Case Lakes

Objective: To allow for individual management plans to be established for those lakes in a 'one-of-a-kind' situation.

Definition: Those lakes which do not meet any of the other classes' criteria; or are essentially single-purpose; or are characterized by unique biophysical, land or water use, or ownership conditions; which warrant special consideration, for example, a lake within an Ecological Reserve, or a lake bordering a municipality (Kamloops Lake).

Criteria and Standards
- As required for each case.

Recommended Management
- As required for each case.

CHAPTER FOUR:

THE CASE STUDY LAKES-- AN APPLICATION OF THE LAKE CLASSIFICATION SYSTEM

INTRODUCTION

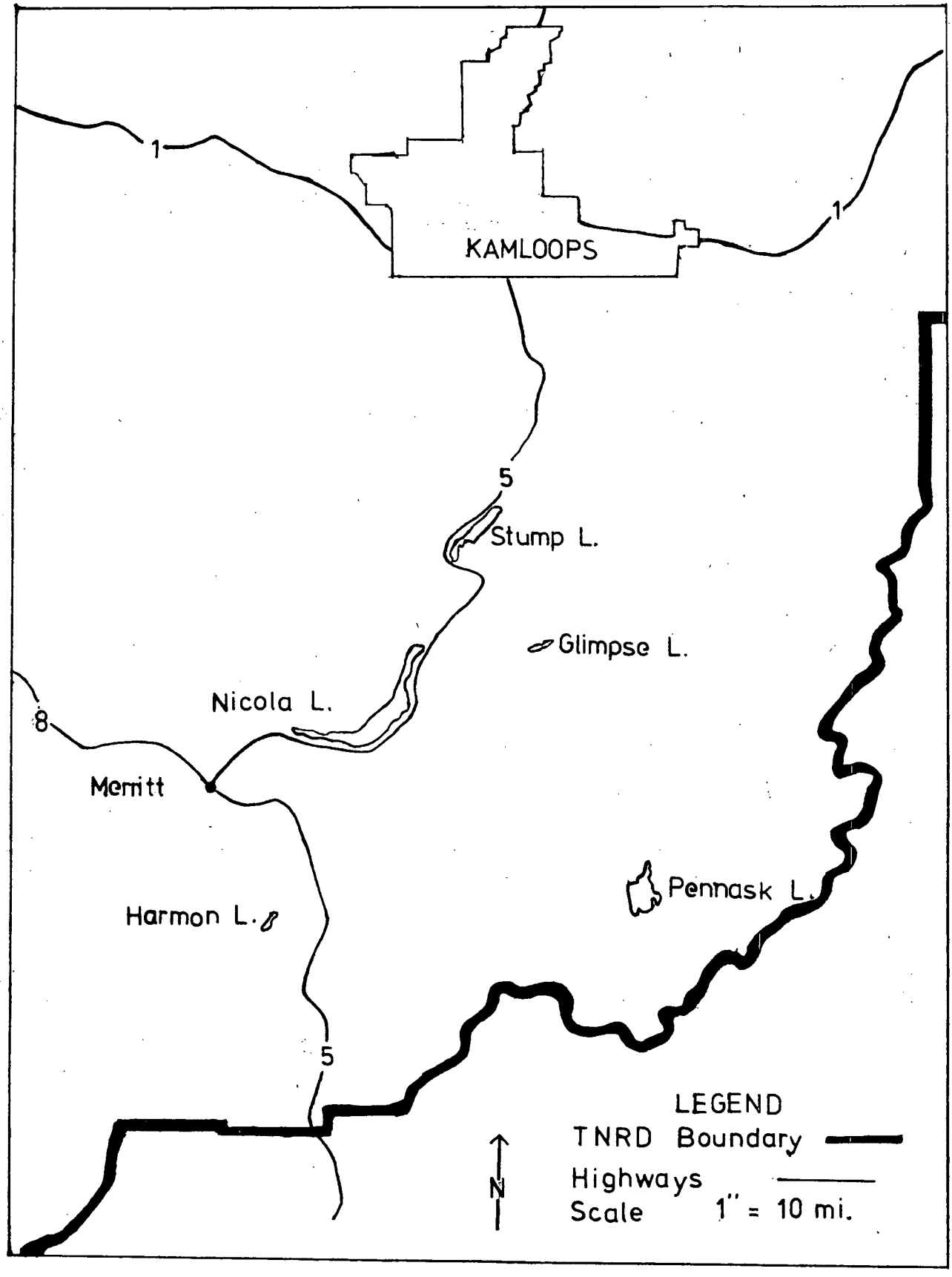
This chapter illustrates the application of the lake classification system, not the complete lake system planning process. Some lakes have been chosen to illustrate the application of the Lake Classification System. These lakes are within the Nicola sub-region of the TNRD (see Map 2). The largest town in the area is Merritt, with a population of 9,290 (B.C. Regional Index 1978). The area's economy is based upon forestry, mining, and agriculture. Some large ranches are found in this sub-region, as it contains prime grazing land. There are several large Indian Reserves as well. The area is well known for its excellent fishing and large selection of lakes. The town of Merritt advertises, "A lake a day as long as you stay," as part of their tourist promotion efforts.

The lakes were chosen on the basis of the following factors:

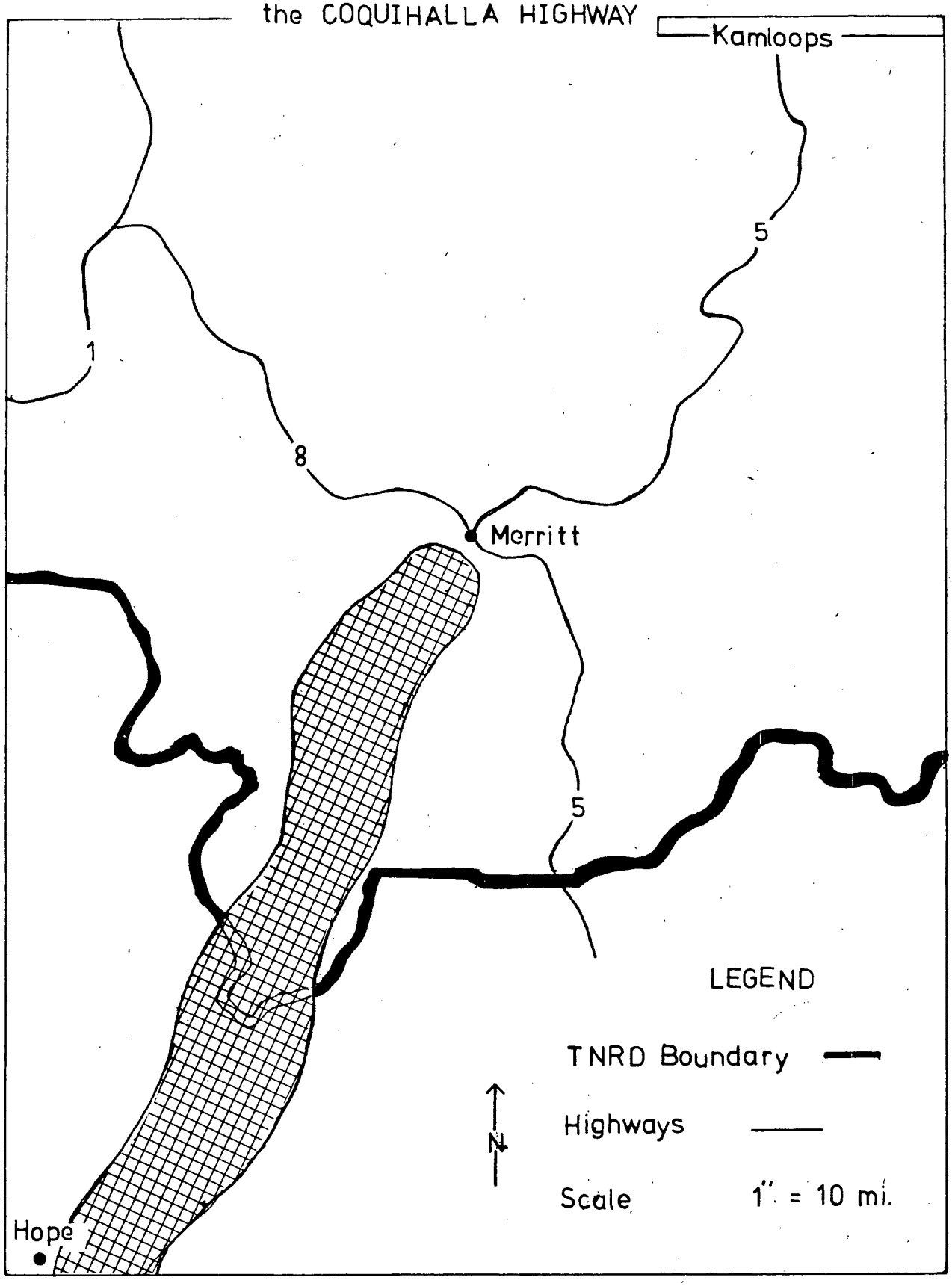
1) the future impact upon the area of the Coquihalla Highway (see Map 3);
2) previous studies of the area and available data;
3) interesting land and water use and ownership aspects;
4) suggestions of the TNRD Planning Department staff;
5) located within one of the province's "...most significant areas for fresh water sport fishing" (Youds 1977, p. 55). See also Appendix A).

The lakes are described in the following pages in order from north to south: they are Stump, Glimpse, Nicola, Pennask, and Harmon Lakes. Any blanks on the following data charts indicate that the particular data is not available. Therefore these lakes are tentatively classified and should be reassessed as the data becomes available.

MAP 2
CASE STUDY LAKES



MAP 3: GENERAL ROUTE of the COQUIHALLA HIGHWAY



STUMP LAKE

AREA: 772 ha. MEAN DEPTH: 11.7 m.

CAPABILITY RATINGS FOR:

	CLI	BC Fish & Wildlife	Ducks Unlimited
Recreation	3, 4, 5		
Waterfowl	5 (3)		
Ungulates		low	

WATER QUALITY PARAMETERS:

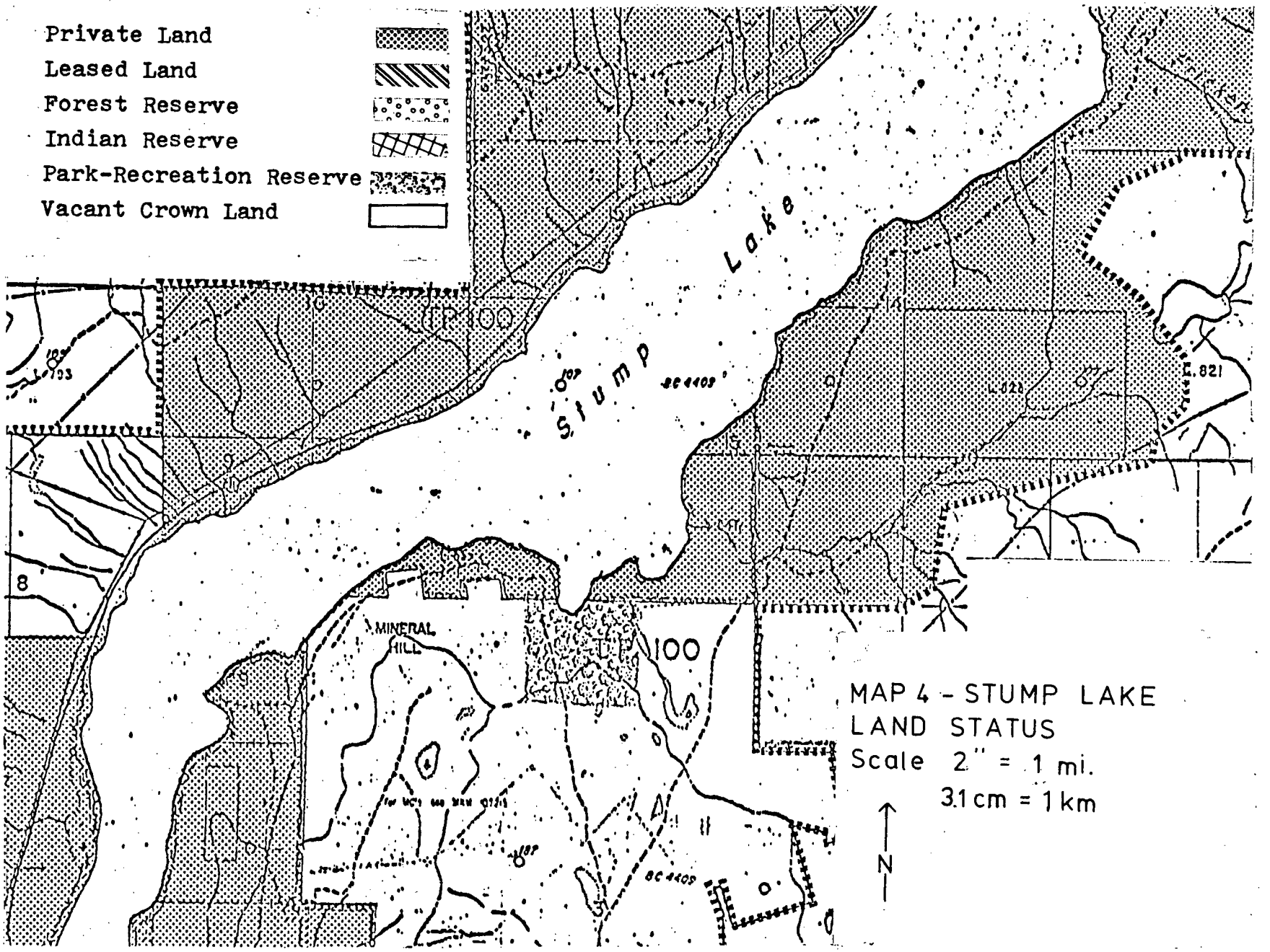
Chlorophyll a	
Secchi Disk	
TDS	1200 ppm.
Faecal Coliform	
Ont. Water Quality Index Rating	

COMMENTS:

- The land is all privately owned among two ranches and some lots.
- Most of the land is within the ALR.
- There is an excellent beach on the south east side which is heavily used. However it is not a designated Parks or Forest Service site and is unmanaged. It has been rated a Problem Area (Neilson 1976).
- According to Youds' study (1977) it has potential for organized camping and picnicking, and pleasure boating opportunities are excellent.
- There is high potential for cabin development according to the Thompson-Okanagan Region Fisheries Management Plan (BC Fish and Wildlife). The lake is stocked.

CLASSIFICATION: GENERAL USE

This class was chosen because of the CLI Recreation Capability ratings, the present agricultural land use, and the judgements presented by the Youds' study (1977) and the Fisheries Management Plan. However the TDS count indicates declining water quality. The water level has been dropping for the past ten years and the lake has internal drainage. Any development, therefore, requires careful management and monitoring of the water quality, and must also respect the ALR.



SOURCE: TNRD 1978

GLIMPSE LAKE

AREA: 94 ha. MEAN DEPTH:

CAPABILITY RATINGS FOR:

	CLI	BC Fish & Wildlife	Ducks Unlimited
Recreation	5		
Waterfowl	6		6
Ungulates		low	

WATER QUALITY PARAMETERS:

Chlorophyll a	2.5 µg/l
Secchi Disk	5 m.
TDS	217 ppm.
Faecal Coliform	
Ont. Water Quality Index Rating	

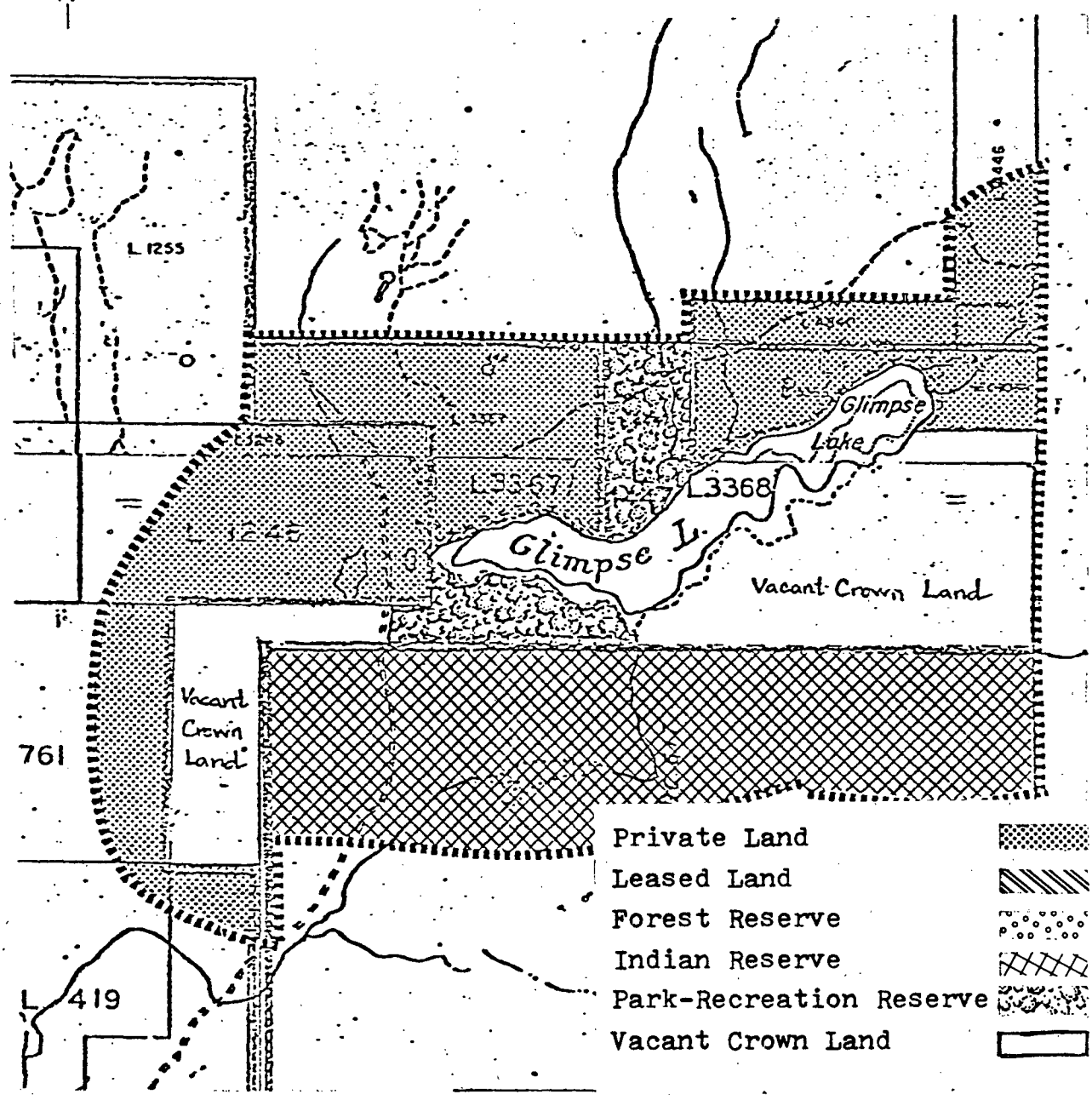
COMMENTS:

- There are 60 private cottage lots, one fishing camp, a BCFS Recreation site, two Park Reserves, and vacant Crown land.
- The land is all within the ALR except for a portion on the north west side.
- About 20% of the perimeter is developed.
- There is a small dam at the lake's outlet, controlled by a local rancher.
- It has potential for organized camping and picnicking but there is no significant potential beyond present use; it is at capacity for angling (Youds 1977).
- There is no potential for further cabin development (Thompson-Okanagan Region Fisheries Management Plan). The lake is a number 1 stocking priority with Fish and Wildlife.

CLASSIFICATION: GENERAL USE - DEVELOPED SUBCLASS

Although the lake does not meet all the biophysical capacity criteria, it does meet the other criteria. The class' definition and objective suits the lake and its present uses. The Developed Subclassification is supported by the Fisheries Management Plan and the Youds' study (1977).

MAP 5 — GLIMPSE LAKE
LAND STATUS
Scale 2" = 1 mi
3.1cm = 1km



SOURCE: TNRD 1978

NICOLA LAKE

AREA: 6144 ha. MEAN DEPTH: 23 m.

CAPABILITY RATINGS FOR:

	CLI	BC Fish & Wildlife	Ducks Unlimited
Recreation	3, 4		
Waterfowl	6, (4)		4 -impt.limited to specific sites.
Ungulates		high, good	

WATER QUALITY PARAMETERS:

Chlorophyll a	
Secchi Disk	
TDS	
Faecal Coliform	3.4 mpn per 100 ml.
Ont. Water Quality Index Rating	

COMMENTS:

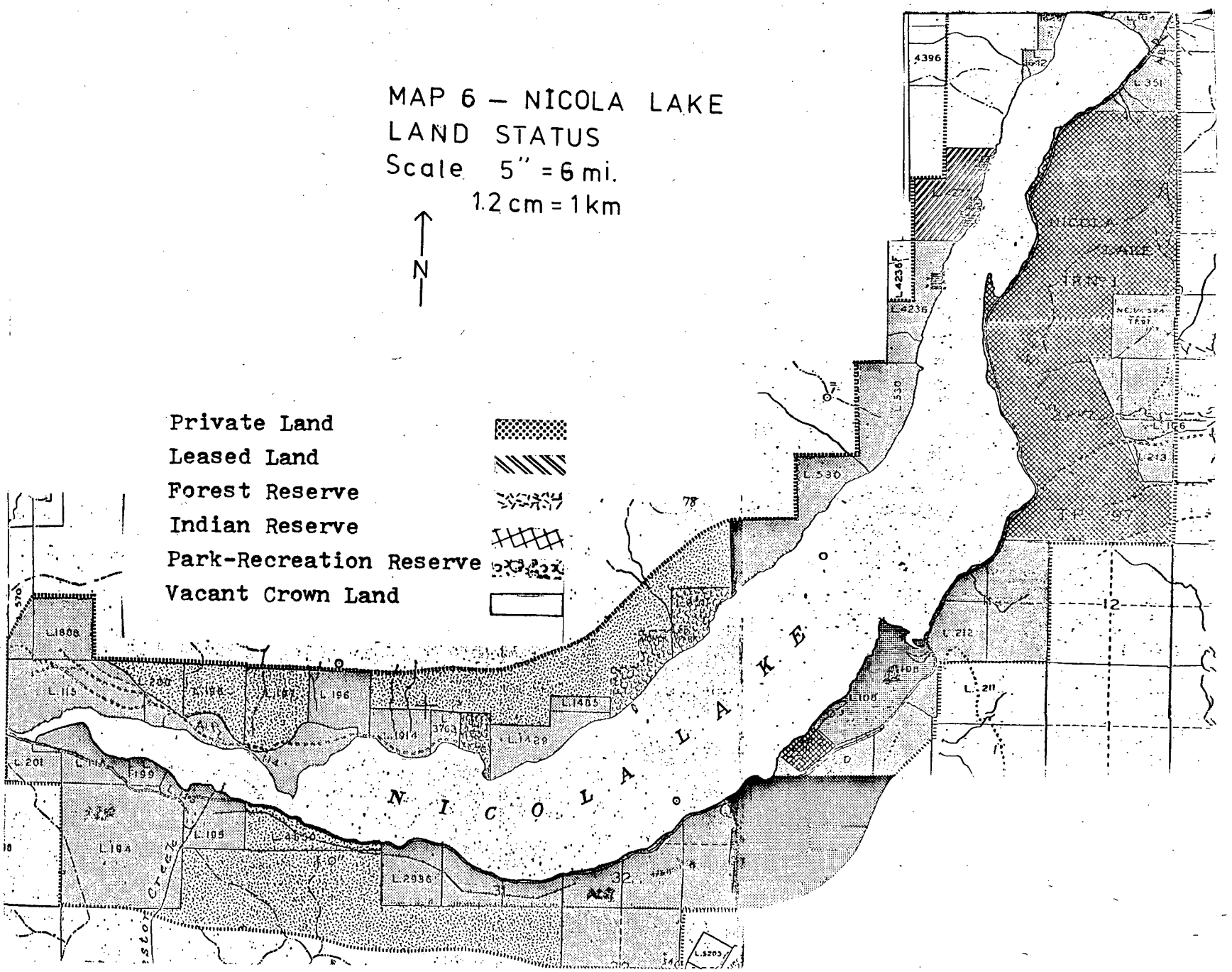
- There is a mixture of private lots (72), Indian Reserve, and Crown land, Monck Provincial Park.
- The land along the southeast and west end shore are in the ALR.
- Highway #5 parallels the eastern shore for its total length.
- Salmon spawn in the Nicola River and rear in the lake. The lake is not stocked.
- There is potential for organized camping and picnicking, and opportunities for pleasure boating are excellent (Youds 1977).
- The north west side has an unofficial recreation site which is heavily used.
- Youds (1977) notes that there is limited site potential and the lake is developed to near capacity.
- There is much subdivision potential and further development is compatible with the Fisheries Management Plan.

CLASSIFICATION: DEVELOPMENT LAKE

This class was chosen because of the existing land and water uses, and because development is compatible with the Fisheries' Management Plan. However Youds' (1977) opinion to the contrary should be considered as future development is contemplated. Although there is no water quality data, such a huge deep lake should be suitable for and capable of sustaining intensive use. The salmon rearing habitat and the ungulate range along the west shore need to be protected.

MAP 6 — NICOLA LAKE
LAND STATUS

Scale 5" = 6 mi.
1.2 cm = 1 km



SOURCE: TNRD 1978

PENNASK LAKE

AREA: 950 ha. MEAN DEPTH: 6.8 m.

CAPABILITY RATINGS FOR:

	CLI	BC Fish & Wildlife	Ducks Unlimited
Recreation	3, 4		
Waterfowl	6		
Ungulates		high, good	

WATER QUALITY PARAMETERS:

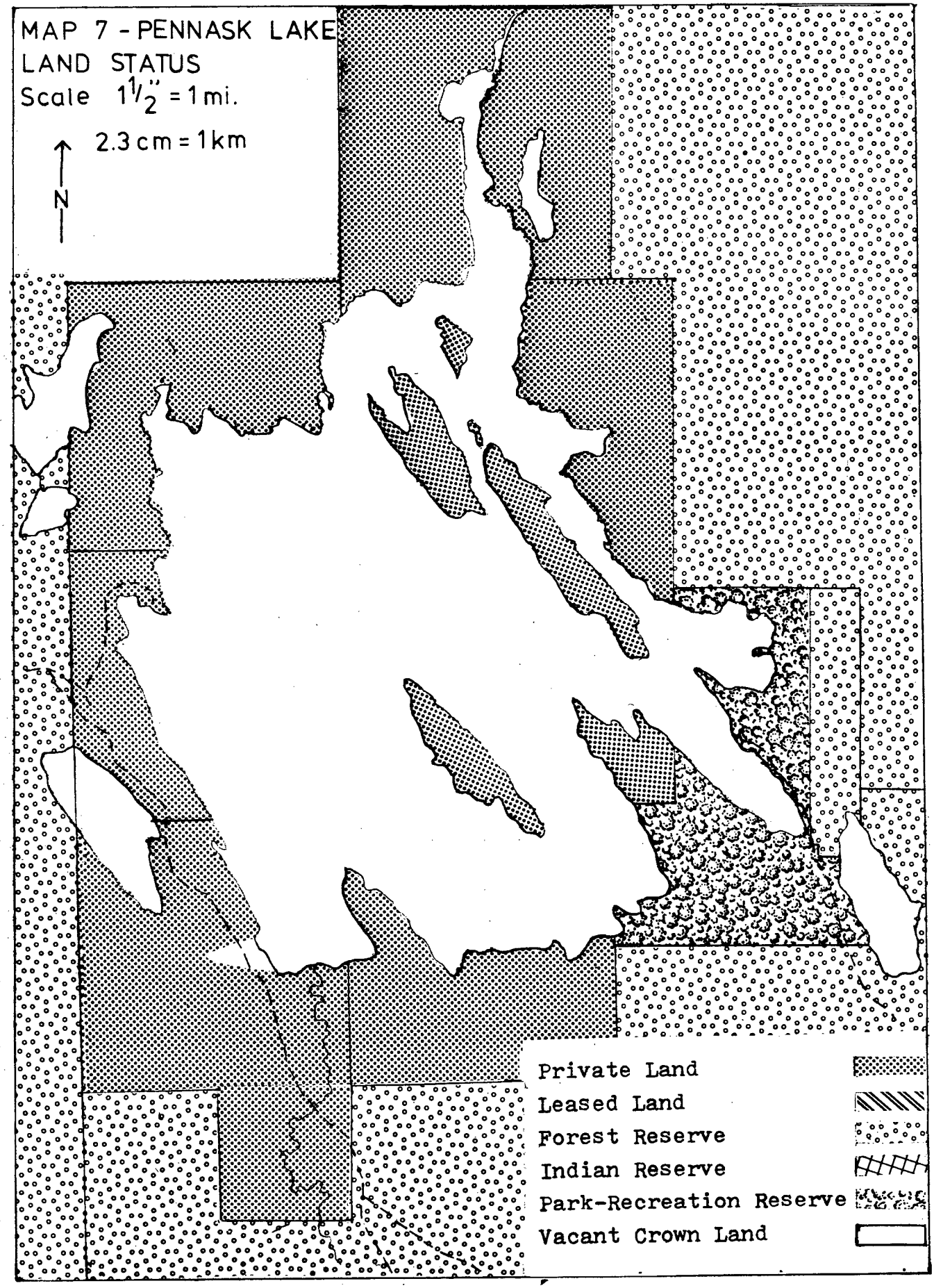
Chlorophyll a	3 µg/l
Secchi Disk	3.7 m.
TDS	27 ppm.
Faecal Coliform	
Ont. Water Quality Index Rating	4

COMMENTS:

- Most of the surrounding land is privately owned, by the Pennask Lake Company, a private fishing club which has a lodge by the lake. The remaining land is the Pennask Lake Recreation Area (604 acres), Crown land.
- The lake is a vital source of trout eggs for the Fish and Wildlife stocking program, providing 40% of the province's needs. The lake is not stocked and only fly fishing is allowed.
- Opportunities for pleasure boating are rated as fair, however it would be incompatible with the fisheries conservation program (Youds 1977).
- Further development is not compatible with the Fisheries Management Plan, which also notes the lake's outstanding aesthetic values.

CLASSIFICATION: SPECIAL CASE

This class was chosen primarily because of the provincially important trout egg supply and secondly because of the high aesthetic values and ungulate capability rating. This classification is supported by the Youds' study (1977) and by the Fisheries Management Plan.


MAP 7 - PENNASK LAKE
LAND STATUS
Scale 1 1/2" = 1 mi.
2.3 cm = 1 km
N
Private Land
Leased Land
Forest Reserve
Indian Reserve
Park-Recreation Reserve
Vacant Crown Land

HARMON LAKE

AREA: 32 ha. MEAN DEPTH: 8.6 m.

CAPABILITY RATINGS FOR:

	CLI	BC Fish & Wildlife	Ducks Unlimited
Recreation	4		
Waterfowl	4, 5		4
Ungulates		low	

WATER QUALITY PARAMETERS:

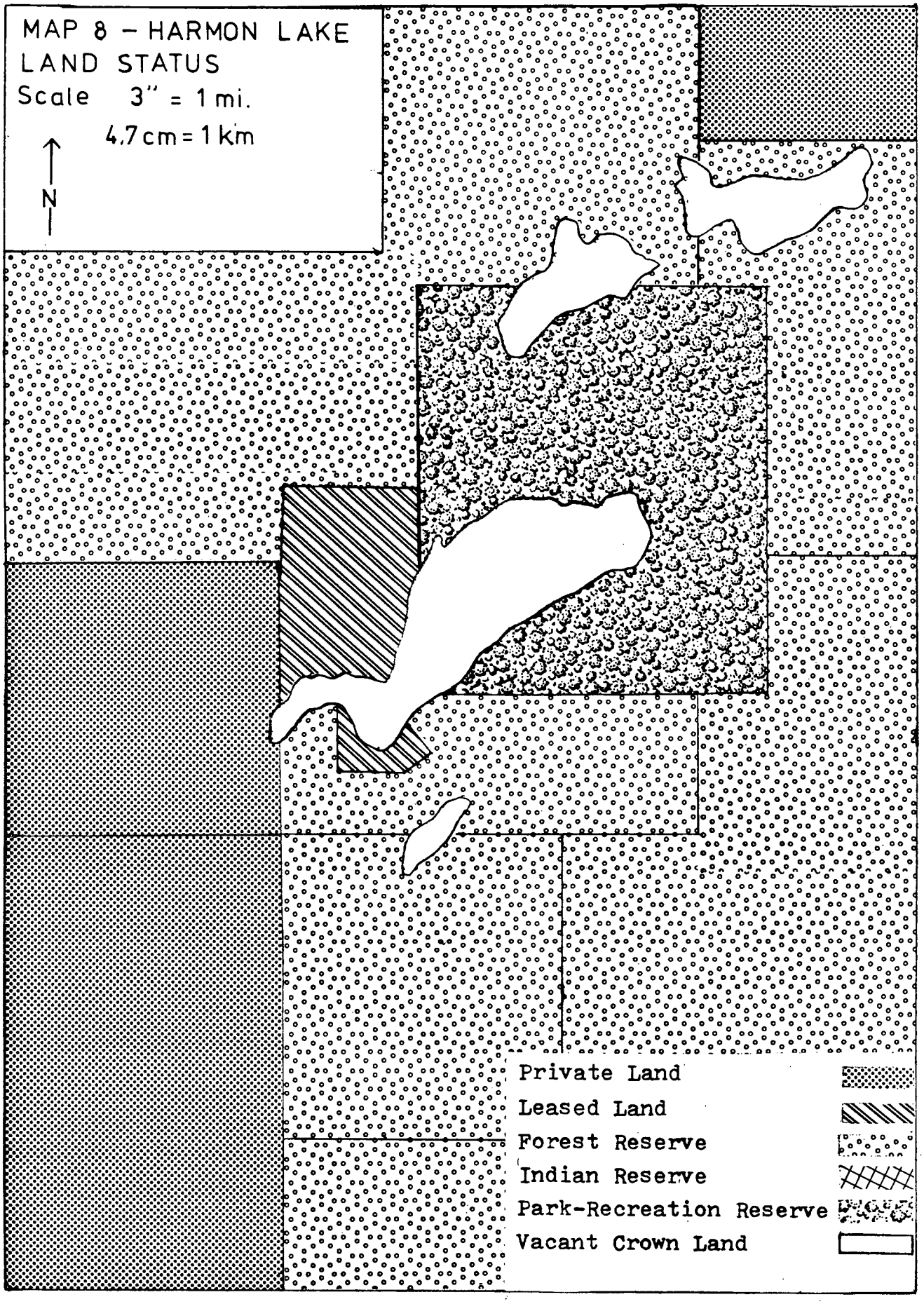
Chlorophyll a	2.5 µg/l
Secchi Disk	4.3 m.
TDS	218 ppm.
Faecal Coliform	
Ont. Water Quality Index Rating	5

COMMENTS:

- Most of the surrounding land is a Park Reserve and additional portions are Crown leases.
- There is a BCFS Recreation site.
- There is potential for organized camping and picnicking in the vicinity, and major potentials beyond present use for angling, A.T.V. zoning, and cross-country skiing (Youds 1977).
- Another study has rated the lake as a Potential Area (Neilson 1976).
- Further private or commercial development is not compatible with the Fisheries Management Plan, which rates public use of the lake as a high value. A fishery rehabilitation program was carried out last fall (1978) and will be stocked in the future.

CLASSIFICATION: NATURAL ENVIRONMENT

This class was chosen because of the present pattern of low-key, public recreational use, and because of the judgement of the Fisheries Management Plan. Further this lake's small size is a major constraint to even moderately intensive use and development, contrary to the suggestions of Youds (1977) and Neilson (1976).


MAP 8 – HARMON LAKE
LAND STATUS
Scale 3" = 1 mi.
4.7 cm = 1 km
N
Private Land
Leased Land
Forest Reserve
Indian Reserve
Park-Recreation Reserve
Vacant Crown Land

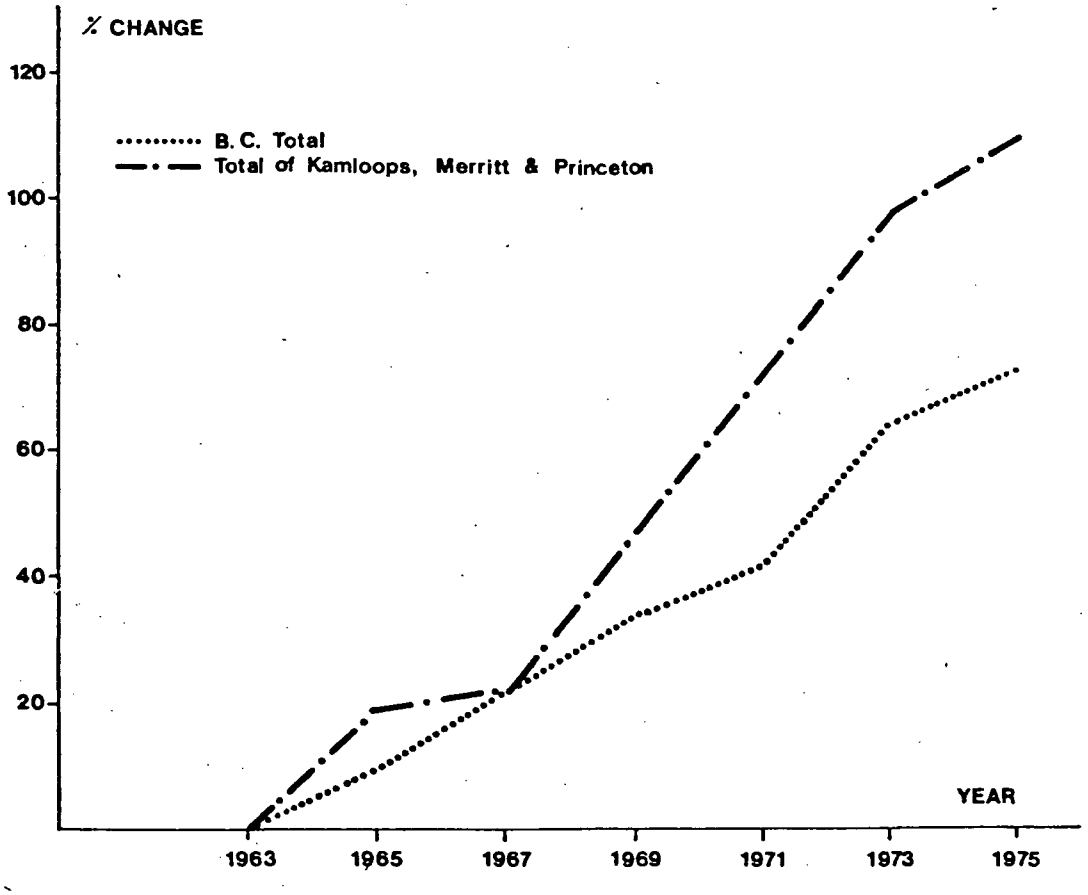
CONCLUSIONS

The usefulness and practicality of the lake classification system will be shown as it is implemented. The next question, and perhaps the most difficult to answer is, implementation by whom? The complexity of the lake resource and the variety of demands require a comprehensive, regional approach. Thus an administrative structure is needed which represents all the provincial resource agencies and the Regional District.

One means of implementing lake system planning, and the associated lake classification system, is through the TNRD Planning Department with advice from their Technical Planning Committee (TPC). The TPC consists of the regional staff representatives of most provincial agencies, including natural resource management units. This local committee could also act with the advice and coordination on policy matters of the Thompson-Okanagan Region Resource Management Committee, which has essentially the same membership at a higher level. In this way, the relevant resource agencies could contribute to the lake system planning process at two levels of regional hierarchy. Furthermore, not only would the resource agencies contribute to the Regional District's planning process, but the resource agencies would receive and exchange information about each other's management plans involving lakes. Thus the TPC would have an important role in coordinating management plans for the region's lakes. Implementation however, leads to the tangled issue of overlapping resource management jurisdictions and often conflicting agency objectives. This issue is a thesis topic in itself and is best left to future research.

APPENDIX A

ANNUAL RESIDENT ANGLER LICENCE PURCHASES
(PERCENT CHANGE FROM 1963 BASE)



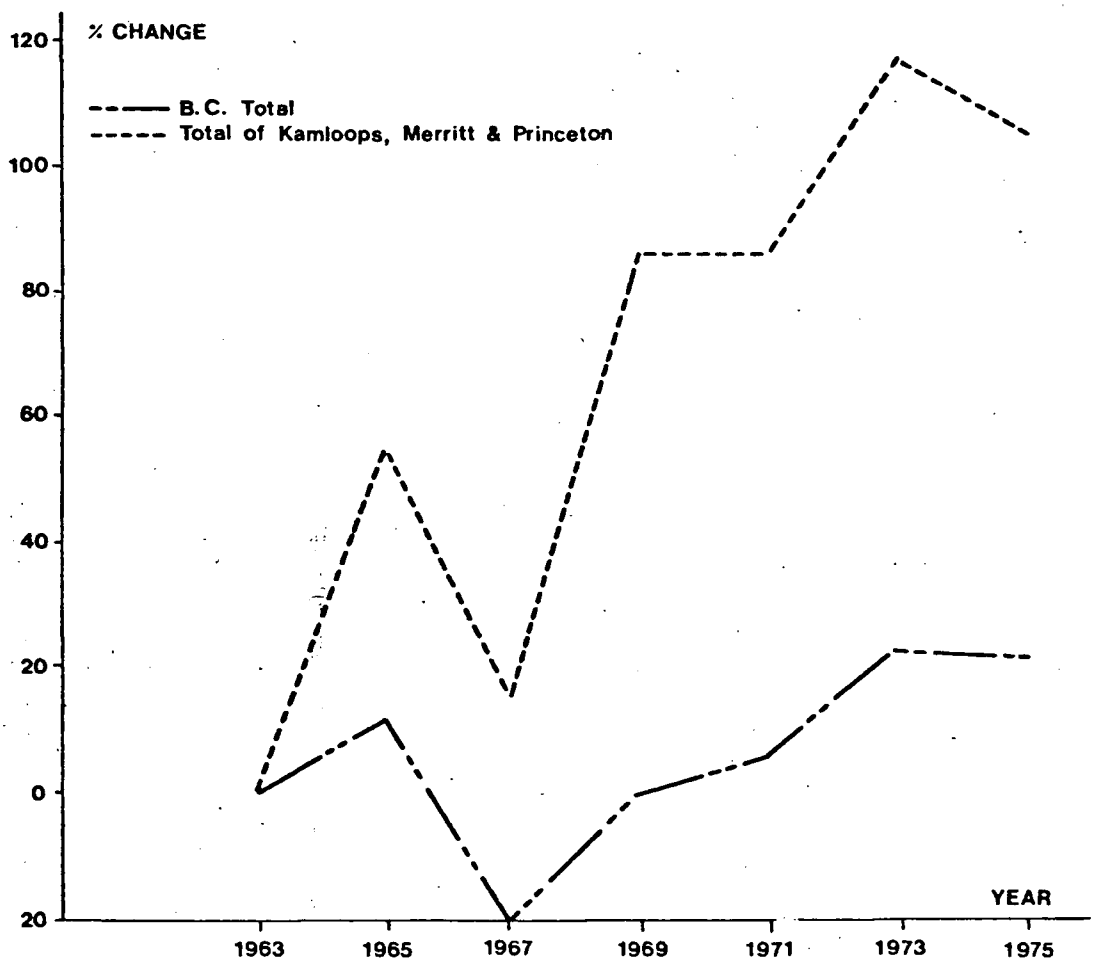
Note: Figure for 1963 represents purchases during calendar year. All subsequent figures represent purchases between April 1st of the year indicated and March 31st of the year following.

Source: B. C. Fish & Wildlife Branch

SOURCE: Neilson 1976

APPENDIX A

ANNUAL NON RESIDENT ANGLER LICENCE PURCHASES (PERCENT CHANGE FROM 1963 BASE)



Note: Figure for 1963 represents purchases during the calendar year. All subsequent figures represent purchases between April 1st of the year indicated and March 31st of the year following.

Source: B.C. Fish & Wildlife Branch

SOURCE: Neilson 1976

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