#55

MAIN REPORT

of the
CONSULTATIVE BOARD

"to everything there is a season
and a time for every purpose"

including
THE COMPREHENSIVE FRAMEWORK PLAN
prepared under the

CANADA–BRITISH COLUMBIA OKANAGAN BASIN AGREEMENT

MARCH 1974

BC – 15

FINAL PUBLICATIONS IN THIS SERIES

1. SUMMARY REPORT OF THE CONSULTATIVE BOARD
2. THE MAIN REPORT OF THE CONSULTATIVE BOARD
3. TECHNICAL SUPPLEMENTS TO THE MAIN REPORT

   I Water Quantity in the Okanagan Basin
   II Water Quantity Computer Models
   III Water Quantity Alternatives and Supporting Water Quantity Data
   IV Water Quality and Waste Loadings in the Okanagan Basin
   V The Limnology of the Major Okanagan Basin Lakes
   VI Review and Evaluation of Wastewater Treatment in the Okanagan Basin
   VII Value and Demand for Water in the Okanagan Basin
   VIII Water-Based Recreation in the Okanagan Basin
   IX Fisheries and Wildlife in the Okanagan Basin
   X Economic Growth Projections
   XI Public Involvement
   XII Planning, Administration and Institutional Considerations

Cover Photo by Tom W. Hall -

'Summer Scene on Okanagan Lake'

Enquiries for copies of these publications should be directed to --

B.C. Water Resources Service,
Parliament Buildings,
VICTORIA, B.C.

CANADA - BRITISH COLUMBIA OKANAGAN BASIN AGREEMENT

THE MAIN REPORT OF THE CONSULTATIVE BOARD

MARCH, 1974

PUBLISHED BY

OFFICE OF THE STUDY DIRECTOR
BOX 458, PENTICTON, B.C.

CANADA-BRITISH COLUMBIA CONSULTATIVE BOARD

(OKANAGAN BASIN AGREEMENT)

BRITISH COLUMBIA

B.E. MARR
H.D. DEBECK
W.N. VENABLES

CANADA

A.T. PRINCE
E.R. TINNEY
R.L. McLAREN

LETTER OF TRANSMITTAL

March 31, 1974

Honorable Robert Williams
Minister
Department of Lands, Forests
and Water Resources
Victoria, British Columbia

Honorable Jack Davis,
Minister
Department of the Environment
Ottawa, Canada

SIRS:

The Consultative Board is pleased to present the main report containing the 'Comprehensive Framework Plan' resulting from the study undertaken in accordance with the Canada-British Columbia Okanagan Basin Agreement signed in October, 1969.

The comprehensive plan outlined has taken into account the consensus of public opinion as required in the terms of reference of the Agreement, including the views obtained following the release of a draft of this report in November, 1973. The Board is very appreciative of this public involvement in developing the framework plan, and in particular, the dedicated efforts of public involvement Task Force members.

In presenting these Findings and Recommendations the Board recognizes that they are based on the present state of the art using best judgement, and that the science involved in such areas as waste treatment is still imperfect. However, the framework plan developed is sufficiently flexible to encompass changes with time.

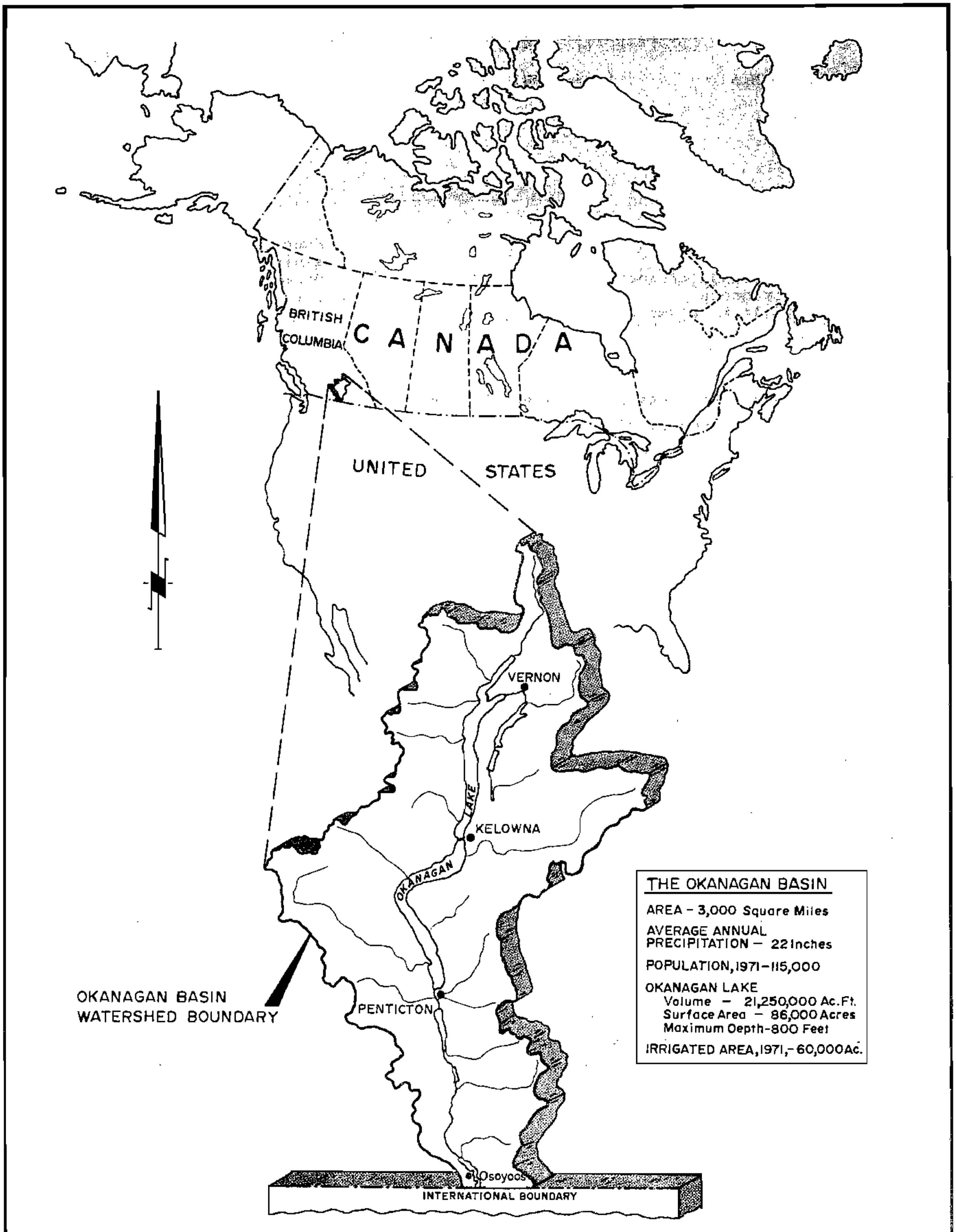
We would particularly draw your attention to Recommendations I and II, which concern the implementation of the plan. The deteriorating quality of water in the main valley lakes, and the water quantity problems that may arise should a prolonged drought period occur are continuing problems that require immediate consideration. Even assuming that a start is made on implementation of the plan in 1974, it will take two to three years to design, finance and construct appropriate works during which some further decline in water quality may be anticipated. This is the heart of the Board's conclusions; namely, that the future of the Valley rests primarily in the hands of local residents, with the support and assistance of senior governments.

The Board appreciates the continuing support given to it by the Ministers and their respective Departments along with the assistance rendered by other departments and organizations. The Board is particularly appreciative of the major contribution made by the Study Committee and the Study Director.

Respectively submitted,

B.E. MARR
Provincial Co-Chairman
Consultative Board

A.T. PRINCE
Federal Co-Chairman
Consultative Board



THE OKANAGAN BASIN
IN
BRITISH COLUMBIA — CANADA

Figure A

FOREWORD

Background

The Okanagan Valley is one of the most important river basins in the Southern Interior of British Columbia. Situated in the warm and dry interior of the Province, the region is both scenically attractive and climatically desirable, and has consequently experienced a rapidly expanding resident and tourist population growth. This influx of people has been accompanied by intensified, and sometimes conflicting, uses of the limited water and land resources of the basin.

Although Okanagan Lake provides the region with a large natural reservoir, replenishment of water is irregular owing to extreme variations in runoff from snow-melt and rainfall from year to year. As demands for the consumption of water for agricultural and municipal uses increase, particularly in tributary basins, the available supplies for non-consumptive uses in recreation, aesthetics and fisheries decrease. Added to the uncertainty concerning water supplies is the gradual deterioration of the quality of the valley's major lakes, indicated by an abundant growth of weeds around the shorelines and occasional algae blooms during the hot summer months.

These water resource problems have become a matter of increasing concern to the local residents. The complexities of the problems and the anticipation that pressure on the valley's water resources will continue to increase in the future, suggested the need for studies to develop suitable water management practices for the conservation of this resource. As a result the Canada British Columbia Okanagan Basin Agreement was enacted to carry out such studies, with recognition it would be of a pilot nature to develop and test new techniques for furthering comprehensive river basin planning in Canada.

The Agreement

The Canada-British Columbia Okanagan Basin Agreement*,signed in October 1969, set out the purpose and terms of reference of the four-year preliminary study. The purpose of the Agreement was to develop a comprehensive framework plan for the development and management of water resources for the social betterment and economic growth of the Okanagan community. As the Agreement also made several references to maintaining a high level of environmental quality, the goals of the framework plan are as follows:

*See Appendix A, page

1. Economic Development: To develop water and related resources as required to ensure a viable economic base in the Okanagan Basin,
2. Environmental Quality: To maintain and enhance the quality of the natural environment through management and protection of water and related resource systems such as fisheries, wildlife and recreational areas.
3. Social Betterment: To enhance social betterment in the Okanagan by creating a more equitable distribution of income, employment and opportunity between regions within the basin.

It should be recognized that these goals may conflict, for example a high rate of economic growth may not be compatible with maintenance of high levels of environmental quality. Therefore, the framework plan should attempt to achieve a desirable balance between these goals. Such a balance will only be struck after detailed consultation with a broad representation of public opinion based on discussions of water management alternatives.

Water resource management by itself, will not ensure the achievement of these multiple goals. Many other resources should also be integrated into a framework plan for the Okanagan, but because of the immediacy of some water resource problems in the Okanagan, the Agreement placed first priority on water management. Water related resources such as water-based recreation and sport fishery management which are also important components of the Okanagan life-style, are also brought into development of the framework plan.

The Agreement specifies that the planning horizon for the Okanagan Study will be to the year 2020. It is simply not possible - nor is it desirable - to base the framework plan on one projection of economic growth for the next fifty years. First, knowledge of the future - especially past 1980 - is extremely uncertain, and second, public values may change. Thus, it appears preferable to make the framework plan as flexible as possible so that it can suit a wide range of future growth options. This does not mean that nothing should be done, on the contrary,measures may have to be undertaken now to preserve future options for the next generation. Three future growth patterns for the basin were considered,each involving differing rates of economic growth and levels of environmental quality, so that the framework plan could be made as flexible as possible to cover a wide range of developments.

Scope of the Study

The Agreement sets out in some detail the scope of studies required to prepare the framework plan. First, social and economic studies are required to examine the existing relationships between water resources, economic growth and aesthetic values. For each of the three different forecasts of economic activity in the Okanagan, projections of water requirements, waste loadings from industry and municipalities and recreational demands for fishing and shoreline activities were estimated. In addition, socio-economic studies were needed to evaluate water resource development and management alternatives. Because economic, environmental and social goals are explicitly stated, this evaluation must include both economic (dollars) and non-economic values.

Second, detailed hydrologic studies were to be undertaken to assess the water supply potential of both surface and groundwater resources, to evaluate means of regulating flows through storage and diversion to meet consumptive and non-consumptive water requirements and to analyze ways for augmenting existing water supplies within the Okanagan Basin itself.

Third, a similar broad range of studies was undertaken in the field of water quality analysis. The present quality of the lakes and streams was assessed and an inventory of all direct and indirect sources of wastes discharged into these waters was prepared. Analytical studies were undertaken to determine the capacity of surface waters to assimilate present and future waste materials without adversely affecting potential uses of these waters for drinking or recreational purposes.

In view of the immediacy of water quality problems in the Okanagan, the Agreement called for the development of pilot projects for advanced treatment of waste water including spray irrigation using treated municipal waste water and chemical means to remove nutrients and other pollutants. These projects were established in the three major municipalities in the Okanagan - Vernon, Kelowna and Penticton.

In keeping with this new approach to resource planning, the Agreement specified that a broad array of both structural and non-structural alternatives should be evaluated while developing the framework plan. Consequently, the adequacy of the existing institutional and legal framework to manage water and related resources was studied and recommendations made on changes in this framework that will be required to ensure more efficient water and waste management in the Okanagan over the next fifty years.

It was also recognized from the beginning of this study, that planning cannot be undertaken in a vacuum, insulated from the residents of the Okanagan Basin. Because the study involves such critical questions as the type of the life-style sought by the Okanagan community, the balance between environmental quality and economic growth and efficient ways of utilizing the water resource, the Okanagan public had to be involved directly in the planning process.

Consequently, public participation was an essential ingredient in developing the framework plan, and new techniques were devised and applied to obtain a broad representation of public opinion from informed citizens.

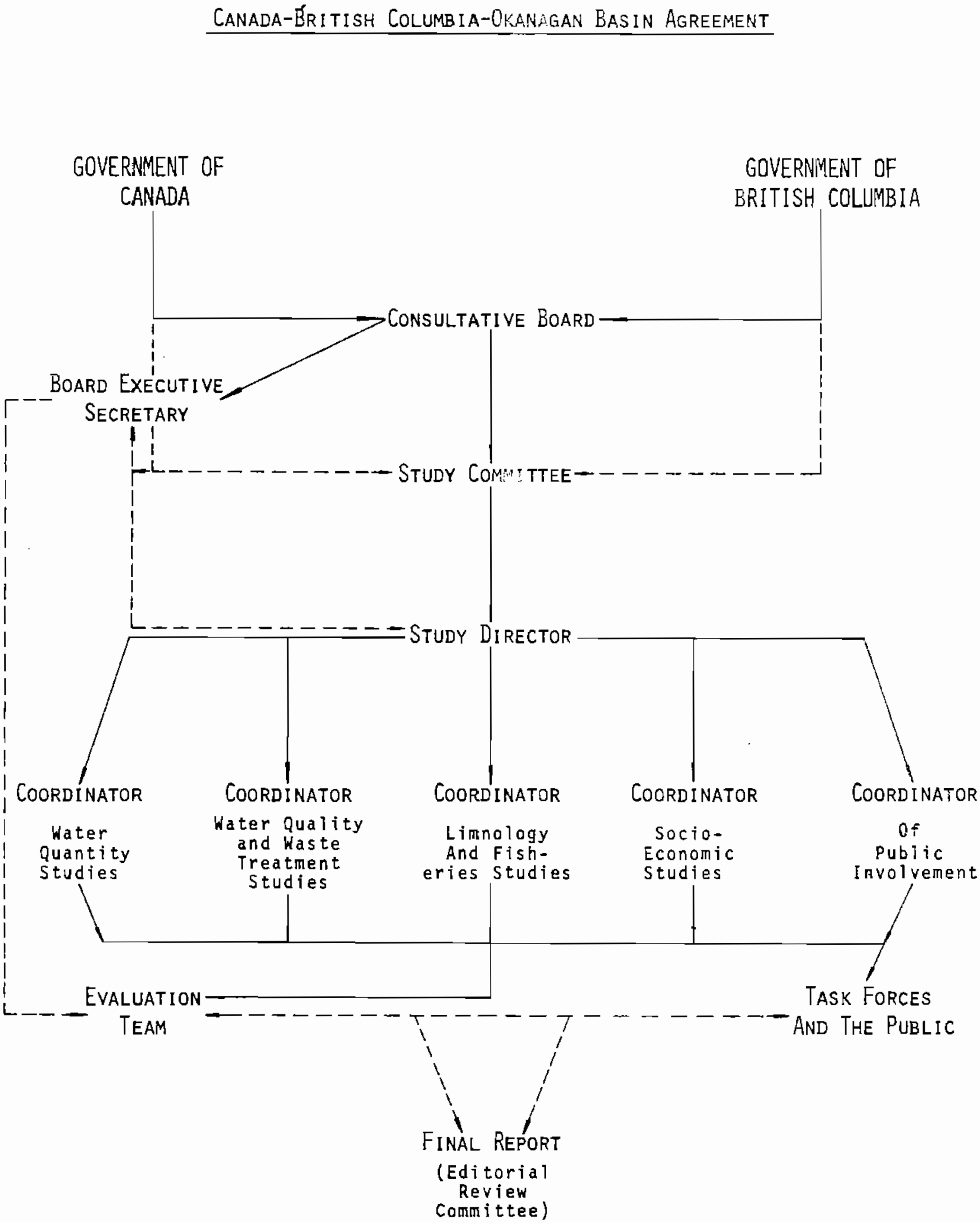
Administrative Arrangements

To facilitate joint federal-provincial participation in the planning process, a six-member Canada-British Columbia Consultative Board was established with three members each appointed by Canada and British Columbia. This Board was made responsible for the undertaking and overall supervision of the study program. The Board in turn appointed the Okanagan Study Committee with equal representation from both governments, to carry out the joint planning studies and pilot projects in accordance with the Terms of Reference of the Agreement. The functions of the Study Committee were coordinated by a Study Director appointed for this purpose by the Committee, and carried out by various government organizations who were assigned specific portions of the study program. These administrative arrangements and the personnel involved are shown in Figure 1 and Table 1 respectively.

The Agreement placed financial control of the study in the hands of the Consultative Board, with the provision that total study costs must not exceed $2 million and that these costs would be shared equally by both governments. The Agreement called for a final report by October 29, 1973. Through mutual agreement by the two governments, the study was extended to March 31, 1974

A draft of the Findings and Recommendations and the Main Report were released to the public on November 28, 1973 followed by a public media discussion held at Kelowna, B.C. on December 3, 1973.

Final publications covering the work carried out under the Canada-British Columbia Okanagan Basin Agreement are listed on the inside front cover of this report.



ORGANIZATION STRUCTURE

Figure 1

TABLE 1

MEMBERS OF THE OKANAGAN BASIN STUDY
Shown in Figure 1, Organizational Structure

NAME	POSITION	AFFILIATION AT TIME OF APPOINTMENT TO STUDY*
1. CONSULTATIVE BOARD		
(a) FEDERAL		
1. Dr. A.T. Prince	Co-Chairman	Director, Inland Waters Branch, Energy, Mines and Resources Canada
2. Dr. E.R. Tinney	Member	Director, Policy and Planning Branch, Energy, Mines and Resources Canada
3. Mr. K. Lucas	Member 1970-72	Director, Resource Development Service, Fisheries and Forestry Canada
(i) Replaced by Mr. R.L. McLaren	Member 1972-74	Regional Director, Environmental Protection Service, Environment Canada
(b) PROVINCIAL		
4. Mr. B.E. Marr	Co-Chairmen	Chief Engineer, B.C.W.I.B. W.R.S. Dept. of Lands, Forests, and Water Resources
5. Mr. W.H. Venables	Member	Director B.C.P.C.B. W.R.S. Dept of Lands, Forests and Water Resources
6. Mr. H.D. Debeck	Member	Comptroller Water Rights Branch W.R.S. Dept. of Lands, Forests and Water Resources
Mr. J.C. Bunge	Board Secretary 1970-71	B.C.W.I.B. W.R.S. Dept. of Lands, Forests and Water Resources
(i) Replaced by Mr. J.G.A. Kidd	Board Secretary and Consultant 1971-73	Underwood, McLellan and Associates, Vancouver British Columbia
2. STUDY COMMITTEE		
(a) FEDERAL		
1. Mr. R.C. Hodges	Co-Chairman 1970-71	Chief, Planning Divison, Energy, Mines and Resources
(i) Replaced by Dr. J. O'Riordan	Co-Chairman 1971-73	Policy and Planning Branch, Energy, Mines and Resources
2. Mr. L. Edgeworth	Member 1970-71	Chief, Resource Development Branch, Fisheries Service, Pacific Region
(i) Replaced by Mr. F.C. Boyd	Member 1971-74	Chief Environmental Quality Unit, Fisheries Service, Pacific Region
3. Dr. C.C. Strachan	Member 1970-71	Director, Summerland Research Station, Department of Agriculture, Canada
(i) Replaced by Dr. J.L. Mason	Member 1971-74	Head, Soil Service Section, Summerland Research Station Department of Agriculture, Can
(b) PROVINCIAL		
1. Mr. T.A.J. Leach	Co-Chairman	Asst. Chief Engineer B.C.W.I.B. W.R.S. Dept of Lands, Forests and Water Resources, Victoria, B.C.
2. Mr. E.H. Vernon	Member	Chief, Fisheries Management, Fish and Wildlife Branch Dept. of Recreation and Conservation, Victoria, B.C.
3. Mr. M.W. Slezak	Member	Chief, Projects and Research Division, B.C. P.C.B. W.R.S. Dept of Lands, Forests and Water Resources, Victoria, B.C.
Dr. R.J. Buchanan	Interim Coordinator 1969-70	Water Resources Service Dept. of Lands, Forests and Water Resources, Victoria, B.C.
Mr. A.M. Thomson	Study Director 1970-74	Canada-British Columbia Okanagan Basin Agreement
3. COORDINATORS	FIELD OF STUDY	
1. Mr. T.A.J. Leach	Water Quantity	Asst. Chief Engineer B.C.W.I.B. W.R.S. Dept of Lands, Forests and Water Resources, Victoria, B.C.
2. Mr. M.W. Slezak	Water Quantity and Waste Treatment 1970-72	Chief, Projects and Research Division, B.C. P.C.B. W.R.S. Dept of Lands, Forests and Water Resources, Victoria, B.C.
(i) Replaced by Mr. D. Corrigan	Water Quantity and Waste Treatment 1972	B.C.P.C.B. W.R.S. Dept of Lands, Forests and Water Resources, Victoria, B.C.
(ii) Replaced by Mr. E. Haughton	Water Quantity and Waste Treatment 1973-74	B.C.P.C.B. W.R.S. Dept of Lands, Forests and Water Resources, Victoria, B.C.
3. Dr J.G. Stockner	Limnology-Fisheries 1970-73	Freshwater Institute, Fisheries Research Board Environment Canada
(i) Replaced by Mr. G.D. Koshinsky	Limnology- Fisheries 1973	Freshwater Institute, Fisheries Research Board Environment Canada
(ii) Replaced by M. Pinsent	Limnology-Fisheries 1973-74	Fish and Wildlife Service, Dept of Recreation and Conservation, Victoria, B.C.
4. Dr. J. O'Riordan	Socio-Economics (Federal)	Policy and Planning Branch., Energy, Mines and Resources
5. Mr. C.H. Thomas	Socio-Economics (Provincial)	Water Resources Service, Department of Lands Forests and Water Resources, Victoria, B.C.
6. Mr. G.W. Sinclair	Public Involvement 1972-74	G.W. Sinclair and Associates, Penticton, B.C.
4. EDITORIAL REVIEW COMMITTEE		
1. A.M. Thomson	Study Director	As Shown Above
2. Mr. T.A.J. Leach	Co-Chairmen Study Committee	As Shown Above
3. Dr. J. O'Riordon	Co-Chairman Study Committee	As Shown Above
5. SPECIAL AFFILIATIONS		
1. Mr. H.B. Rosenberg	Federal Coordinator, Ottawa	Policy and Planning Branch, Energy, Mines and Resources, Canada
2. Dr. S.O. Russell	Water Quantity Consultant	University of British Columbia
3. Dr. W. Oldham	Waste Treatment Consultant	University of British Columbia

* Federal members associated with the Department of Energy, Mines and Resources at the initiation of the Study, were transferred to the Department of the Environment, Canada, following its formation in June, 1971.

Summary of Findings and Recommendations

1. GENERAL FINDINGS OF THE OKANAGAN STUDY

The Okanagan Valley at present has a strong economic base and a generally high quality natural environment. Continuation of the recent rapid pace of economic growth could threaten this desirable balance and lead to a decline in the quality of natural and urban environments. Only through careful planning and integrated management of the basin's water, land and human resources can the present economic and environmental harmony of the basin continue.

Due to the recent program of industrial incentive,tne Okanagan economy is well diversified and can be expected to grow steadily over the next fifty years. However, as there is some uncertainty about the rate of growth, the Study developed three alternative projections of economic growth to the year 2020. One projection involved the continuation of existing economic policies, a second assumed that the rate of economic growth would be quickened through new industrial incentive programs after 1980 and a third projected a slowing down in the rate of economic growth, compared to that expected under current economic policies, through controls on industrial expansion. The main features of these three projections (to 2020) are compared to present (1970) conditions in the following table, which indicate that all economic indices such as population, employment, tourism and valley income should increase between 2.5 and 3.5 times during this planning period.

EXAMPLES OF THE RANGE OF ECONOMIC GROWTH
THAT MAY OCCUR IN THE OKANAGAN BASIN TO 2020

PROJECTION	DESCRIPTION	POPULATION	EMPLOYMENT	IRRIGATED ACRES	NUMBER OF TOURISTS
Present Situation		115,000	29,800	60,000	700,000
Projection I	Continuation of Present Economic Policies	391,000	105,000	59,600	2,300,000
Projection II	High Economic Growth	430,000	118,000	56,600	2,300,000
Projection III	Low Economic Growth	290,000	76,000	73,700	1,800,000

Under good water management there is enough water in the basin to supply all projected withdrawals and meet proposed fishery and recreation requirements in the main valley and in the tributary sub-basins. This assumes the withdrawal of larger volumes of water from Okanagan Lake during prolonged drought periods, than has occurred in the past. Additional headwater storages will be required, and in selected streams reservoir operations will be modified to serve the multiple uses of sport fisheries and irrigation. There is no need for the large scale importation of water under any of the economic growth projections made in this study, provided that a greater range of operating levels is recognized for Okanagan Lake. This range should normally not exceed four feet in any one year, but a total variation of nine feet may occur between an extreme flood level in one year and an extreme low lake level following a succession of drought years.

Phosphorus has been identified as one of the major nutrients promoting undesirable algal blooms and rooted aquatic plant growth in the main valley lakes, and also as the nutrient which can be most successfully controlled to reduce this growth and improve or maintain the quality of water in these lakes. Major waste management programs are therefore proposed over the next ten years to ensure the maintenance of lake water quality by reducing these phosphorus loadings. The capacity of tributary streams to assimilate pollutants is considered even more limited, due to extreme variations in flows, and complete removal of all direct polluting discharges to stream waters will be necessary if stream water quality is to be improved. With appropriate waste management, the quality of all major surface waters in the basin can be maintained to support both withdrawal and recreational requirements.

Water-based recreation - swimming, boating, fishing - is dependent upon good water quality in the lakes and shoreline planning. It will continue to play an important role in the economic and social life-style of tourist and residents of the Valley. The preservation of crown and public lands around the shorelines of the main lakes will allow the development of public beaches to meet projected recreation demands with little need to obtain private properties.

Water resources management, though an important component in planning the valley's future, will not by itself ensure that the present desirable balance between economic growth and high environmental quality will continue over the next fifty years. Other resources should also be carefully managed, on a valley-wide basis, as forecast population growth will undoubtedly place pressure on such important factors as land, transportation and urban environments. In particular, land use will have a significant impact on future water quality, water-based recreation and fisheries. Planning these resources must be integrated with water management to ensure a continuation of the current prosperous economic and environmental balance in the basin.

A number of citizen 'task forces' representing a wide range of public interests were established during the Okanagan Study to develop a consensus regarding the preferred future 'life-style' for the valley community. In their final report to the Okanagan Study Committee (entitled "To Our Children's Children"), these task forces unanimously supported Projection III involving a lower pace of economic growth, protection of agricultural lands and maintenance of a high quality environment. The primary recommendation of this valley consensus is that:

> *"Future planning in the Okanagan should place primary emphasis on environmental protection, giving due emphasis to maintaining the economic viability of the valley."*

Consequently, it is upon this premise, in concert with Projection III, (Low Economic Growth Rate) that the framework plan outlined in this report is recommended.

Economic benefits (or costs) in this report refer to those that can be expressed directly in monetary terms such as increased or more efficient agricultural and industrial production, land value enhancement, expenditures of recreationists, etc. Social and environmental benefits refer to those benefits that do not have a market value, such as employment opportunities, availability and enjoyment of beaches, water quality, etc. Some of these can be expressed in quantitative units however, and have been assigned dollar values based on opinion surveys.

It should be emphasised that the framework plan is designed to improve the social and economic well-being of the Okanagan community. Consequently, not all the recommendations can be justified on the basis of economic benefits only, though the plan does become viable when quantifiable social and environmental benefits are included. This reflects the high value placed by the valley community on such benefits. Because the inclusion of social and economic values is a relatively new concept in comprehensive basin planning, it has not been possible to quantify all such values associated with various components of the plan. Attempts at expressing values placed on a day at the beach or a day fishing were made through the use of questionnaire surveys. However, values associated with benefits that may accrue from such factors as aesthetic enhancement, landscape diversity and decreased health hazards have not been assessed.

It is not possible to total all benefits and costs of the framework plan as the implementation of some components is somewhat uncertain being dependent upon economic projections over 20 years into the future. However, a number of recommendations require immediate action (prior to 1980) to maintain good water resource management in the Okanagan. The major costs and benefits of these recommendations are summarized below and have been discounted to present (1970) values for comparison purposes. Phosphorus removal is only effective where sanitary sewers and conventional waste treatment facilities have been established. The costs of these have not been included in the following table as such facilities are required to protect the health of the valley communities. The additional capital cost of this program to 1985 has been estimated at $17 to $22 million dollars.

SUMMARY TABLE OF COSTS & BENEFITS FOR IMMEDIATE ACTIONS

All values Discounted to 1970 Dollars

ACTION	CAPITALIZED COST	ECONOMIC BENEFITS	SOCIAL AND ENVIRONMENTAL BENEFITS
1. Water Quantiy-Structural Improvements in Mainstem System	$1,000,000	$ 500,000	significant values not quantifiable
2. Waste Treatment-Phosphorus Removal Facilities to 1985	$3,800,000	$4,100,000	$9,200,000
3. Sport Fishery Management - Tributary Storage and Reproduction Requirements	$1,140,000	$ 500,000	$ 800,000

2. BASIC RECOMMENDATIONS

The following basic recommendations are made to establish a framework for developing the comprehensive plan for water resource management in the Okanagan Basin.

One Regional District For Basin

1. *"That the boundaries of the present Regional Districts of North Okanagan, Central Okanagan and Okanagan-Similkameen be redrawn to create a single Okanagan Basin Regional District having boundaries coincident with those of the watershed, to be responsible for those water resource management functions that pertain to the Valley as a whole and in particular the implementation of those recommendations in this report that are Valley-wide in scope, especially waste treatment, the orderly development of shoreline recreation facilities, and flood-plain zoning."*

Good water management is essential to the maintenance of desirable life-styles of the Okanagan community. Because all parts of the basins are linked by the flowing nature of water, it is important to avoid actions in one part that will adversely affect the environment in another or reduce the future potential of valley-wide economic activities, for example the attraction of tourists. As this feature of common interest throughout the valley affects many aspects of planning, a number of recommendations in this report cut across existing jurisdictions and apply to the basin as a whole.

This valley-wide approach applies in particular to recommended upgrading of existing waste treatment facilities, and the provision of new ones where the benefits of improved lake quality are valley-wide and treatment on a regional basis is feasible in meeting objectives. It is considered unfair that under a particular scheduling program, certain communities could be asked to bear the major portion of the costs of a waste management program which benefits the basin as a whole.

It appears to be the consensus of the Okanagan Community that a single authority be established to coordinate the implementation of the framework plan. As much use as possible should be made of existing institutions, for neither the public nor the senior governments desire the creation of a new intervening level of government. The success of the task forces during the study in bringing together people from all parts of the basin verifies that valley-wide consensus on water management problems is possible.

Provincial legislation is available to establish a regional district for the watershed. While the process of setting up such an authority normally provides for the assignment of a number of functions, it is felt that certain characteristics and functions essential to the success of this new body should be identified in the documents establishing it, for example, in the letters patent. These are:

(i) that all residents within the watershed be required to share in the burden of costs, or to undertake necessary common actions, that clearly affect the valley as a whole, for example, upgrading the quality of the main lakes.

(ii) that standards set by governments for such things as water quality be considered as minimum standards for the Basin and may need upgrading to provide a superior quality of the environment, in specific locations.

(iii) that the Regional District should be supported by a technical resource advisory committee representing the resource agencies concerned. The establishment of such a group is now provided for in provincial legislation.

(iv) that continuing public participation, which has been a principal feature of this study, be imbedded in the future planning process and be built into the institutional arrangements proposed herein.

Finally, this study has not examined all the implications outside the Valley that would be incurred in creating a single valley authority for the Okanagan watershed. A wider examination may reveal other alternatives for the boundaries of a Regional District more suitable for this broader multiple watershed region. In working out these boundaries, however, it is important to keep in mind the four characteristics listed above. To repeat, it is the opinion of the Board and the results of opinion surveys in the valley that a single valley authority is clearly the best option for the Okanagan Basin itself.

The above recommendation was the subject of considerable discussion after release of the DRAFT report with local political leaders, in particular, taking the position that such a major re-organization of local government was at least premature and would raise very difficult administrative problems.

Alternatives to Recommendation 1.

The Board has reconsidered this matter and now puts forward two alternatives to recommendation #1, either of which could achieve the same objectives.

Alternative 1(a) takes care of certain local administrative problems arising from separation of certain communities, by selecting an appropriate boundary for the new Regional District.

Alternative 1 (a):

"That the boundaries of the present Regional Districts of North Okanagan, Central Okanagan and Okanagan-Similkameen be redrawn to create a single Regional District, including within it's boundaries the total area of Okanagan Basin watershed in Canada; to be responsible for those water resource management functions that pertain to the Valley as a whole and in particular, the implementation of the recommendations in this report that are Valley-wide in scope, especially Waste Treatment, the orderly development of shoreline recreational facilities and flood plain zoning."

The second alternative based on a proposal developed by the three Regional Districts is as follows:

Alternative 1 (b):

"That the Okanagan Basin Water Board be reconstructed and Letters Patent amended to give the Board authority to carry out water resource management functions described above, in Alternative 1 (a)."

The success of this alternative would depend upon the willingness of the Regional Districts to delegate powers to the Water Board and to work together in achieving Valley-wide aims clearly defined in this report.

Implementation Task Force

2. *"That to ensure continuity from planning to implementation of the framework plan, Canada and British Columbia establish - on or before 31 March, 1974 - an Implementation Task Force which has local representation."*

The Task Force is to advise and recommend to the federal and provincial governments and to local governments, actions required to implement the comprehensive plan and to submit on or before 30 June 1974 a draft implementation agreement. This agreement shall take into consideration the actions on recommendation of this report that may be taken by local government, and by either senior government. Where joint action is required the agreement shall include provisions for equitable cost-sharing as developed by the senior governments.

Nothing in this recommendation should inhibit on-going programs presently in progress and the implementation of recommendations where responsibilities are clear.

Water Quantity Management Mainstem System

3. *"That the water available be managed such that, without large scale importation of water, all present and projected future water uses around Okanagan Lake and along Okanagan River are satisfied; recognizing that during a prolonged drought cycle, increased drawdown of Okanagan Lake and some cut-back in releases to Okanagan River for non-consumptive uses may be necessary."*

Through implementation of water conservation measures within the Okanagan, all water requirements can be met. Large scale importation of water into the Okanagan is not necessary based on present studies. In extreme drought conditions Okanagan Lake would have to be drawn down from time to time below the present minimum elevation of 1118.8 feet and fishery flows for sockeye salmon reduced. Such drawdowns should not create severe problems provided that a program of adjustments to water intakes around Okanagan Lake and along Okanagan River is undertaken immediately and the public is made fully aware of the consequences of such lake drawdowns.

Water Quantity Management Tributary Streams

4. *"That major conflicts in water use between irrigation and fishery requirements in tributary streams be avoided by managing Mission, Equesis and Trepanier Creeks for fisheries and irrigation purposes, and developing other major creeks primarily for domestic and agricultural water use."*

Some 4,300 acre-feet of headwater storage should be licenced and developed to meet fishery requirements on Mission and Equesis Creeks. An additional 25,000 acre-feet of headwater storage are available on these and other major tributaries to meet a possible expansion of 9,000 acres of agricultural land. Such agricultural expansion was given high priority by the valley community to enhance the economic and social environment of the basin. On certain creeks additional water will have to be obtained from other sources to supply potential agricultural demands, (e.g. Kelowna Creek).

Capital costs of this storage development for agriculture, exclusive of water distribution costs are estimated at 6.9 million dollars, with capitalized economic benefits of 3.25 million dollars. The social benefits related to agricultural development have not been estimated. The costs and benefits of a sport fishery program are included in Recommendation 10.

Water Quantity Floods

5. *"That potential flood damage around Okanagan and Osoyoos Lakes and along Okanagan River be minimized through the institution of flood plain zoning and emergency protection measures."*

Flooding in the Okanagan, other than on Osoyoos Lake occurs about once every 15 years. On Osoyoos Lake major floods occur about once every 10 years. Large-scale structural measures for flood control cannot be economically justified in Canada alone and thus occasional flooding will continue to occur around these two lakes. Flood plain zoning will avoid potential increases in shoreline property damage while implementation of protective measures on an emergency basis will reduce flood damage to existing properties.

On Okanagan Lake the 200 year flood elevation has been estimated at 1125.5 feet and on Osoyoos Lake at 919.25 feet. Two feet of freeboard over and above this maximum flood elevation is also required for protection against wave action.

It is therefore recommended that the flood plain zone for all undeveloped areas shall include all lands up to an elevation of 1127.5 feet for Okanagan Lake and up to elevation 921 feet for Osoyoos Lake. Land use within these flood plain zones would be limited to agricultural cropland, parkland for recreation and wildlife sanctuaries.

An information brochure on emergency protective measures and flood proofing should be issued to all occupants on the flood plain as a measure of reducing the damage to properties already existing in the flood plain zone.

I.J.C. Reference Osoyoos Lake

6. *"That the Governments of Canada and British Columbia immediately take the necessary steps to refer a study of Osoyoos Lake level regulations to the International Joint Commission."*

Adjustments to intakes along Okanagan River will allow reductions in flows in the river to conserve water but these flow reductions may create problems of maintaining desirable lake levels on Osoyoos Lake during drought periods unless control at the outlet of Osoyoos Lake is improved. Thus, this study should determine what measures need to be taken either in Canada or the United States to:

(a) maintain Osoyoos Lake levels during drought periods.

(b) reduce flood damage around the lake.

Water Quality Tributary Streams

7. *"That a program of pollution control for tributary streams be established by instituting strict regulations on feedlot and septic tank developments, removing all direct discharges to streams of industrial and municipal wastes causing pollution and protecting streams with appropriate green strips in areas where logging or cultivation is practiced or where there are concentrations of cattle, horses, or other livestock."*

High coliform counts, oxygen deficiencies, turbidity and concentrations of iron, manganese and phosphorus in certain tributary creeks affect the quality of water supplies for drinking, fish propagation and other uses. The origin of these pollutants is primarily from industrial and municipal waste effluents, septic tank sources, concentrations of livestock and erosion. The prevention of pollution from these sources through appropriate pollution control programs, is required to improve the quality of water in tributary streams to meet the standards outlined in this report.

Water Quality Main Valley Lakes

8. *"That a waste management program aimed at reducing phosphorus loadings to control rooted aquatic plant and algae growth in the main valley lakes be undertaken immediately by the regional authority."*

Phosphorus was identified as one of the key nutrients promoting undesirable aquatic plant and algal growth in the main valley lakes, and the nutrient which may be most successfully controlled to reduce this growth and the resulting deterioration in water quality. The valley consensus stated that it is of prime importance to arrest this decline and reverse the process wherever possible. Consequently, the framework plan has established a waste management program for reducing the amount of phosphorus discharged from municipal, industrial and domestic sources, to control the growth of algae and rooted plants in the main valley lakes. The capital costs of this program over and above that required to protect the health of the valley community is estimated at 2.0 to 2.3 million dollars by 1985, with annual costs estimated at $490,000. In comparison, economic benefits associated with the maintenance of a high level of qualitv in the main valley lakes total $265,000 annually with social benefits estimated at $1,100,000 annually.

Phosphorus removal is possible only where conventional waste treatment facilities are available. The additional capital cost of conventional treatment to 1985, including sanitary sewers and secondary treatment plants, has been estimated at 17 to 22 million dollars. The year 1985 was considered the limit to which meaningful projections could be made for waste treatment costs based on existing technology and water quality data.

Programs for financial assistance to local governments for implementing waste management projects are available under the following acts:

Federal National Housing Act
Provincial Municipal Treatment Plant Assistance Act
British Columbia Taxation Act

Water Based Recreation

9. *"That shoreline recreation be enhanced through the protection and development of shorelines for beach recreation and maintenance of high levels of water quality."*

Due to trends towards increased leisure time and the unique recreation potential of the Okanagan, the valley community placed second priority (after human and agricultural consumptive use) in water and related resource management, to recreation planning. To meet the expected four-fold increase in demands for beach recreation, all public and Crown lands with good recreational potential should be preserved for that use. Some 40,000 linear feet of additional shoreline must be developed for public recreation by 2020 together with 4,000 linear feet of additional public access to the lakeshore and 10 to 12 new boat launching facilities. The economic value of these additional facilities totalled over the fifty year planning horizon is estimated at $13 million with social values totalling $47 million.

Fisheries

10. *"That sport fishery resources (kokanee and rainbow trout) be enhanced by protecting existing habitat and improving both natural and artificial reproductive facilities."*

The valley community supports a sport fishery enhancement program for the headwater and main valley lakes. In addition to supplying water in selected tributaries, spawning beds should be rehabilitated and artificial stocking of headwater lakes increased. The total costs of this program are estimated at $3 million by 2020 (including the storage shown in Recommendation 4) with minimum economic and social benefits of $2.9 million and $4.6 million respectively for sport fisheries.

Monitoring the Framework Plan

11. *"That the response of water resources to management measures implemented under the framework plan be monitored continuously, with a full review of the plan to be undertaken by 1980 to ensure that the plan continues to meet the social and economic goals of the valley community."*

Despite the large investment involved in preparing the comprehensive plan, there are many uncertainties in the development of water management alternatives, especially in waste treatment requirements to reduce phosphorus loadings to the main lakes (for example, technological advances in waste treatment may improve opportunities for waste management in the future). Consequently, it is important to monitor how the water resource responds to management measures implemented under the plan on a continuing basis, with a full review by 1980 to make necessary corrections to the plan.

SUMMARY
Table of Contents

Table of Contents

List of Tables

TABLES

TABLES

TABLES

TABLES

TABLES

CHAPTER 13 Page

CHAPTER 14

TABLES

TABLES

List of Figures

FIGURES

FIGURES

FIGURES

FIGURES

FIGURES

CHAPTER 19

MAP SECTION

PART I
INTRODUCTION

CHAPTER 1

The Okanagan Basin

The Okanagan Basin lies in the south central plateau area of the Province of British Columbia (Figure 1.1). The central drainage system consists of a chain of lakes stretching from Wood Lake near the City of Vernon to the International Border. These lakes are connected by the Okanagan River which flows south to join the Columbia River near Brewster in the State of Washington, U.S.A. The Canadian portion of the basin has a length of 110 miles, a maximum width of 60 miles, and covers an area of 3165 square miles, which represents slightly less than one percent of the total land area of British Columbia.

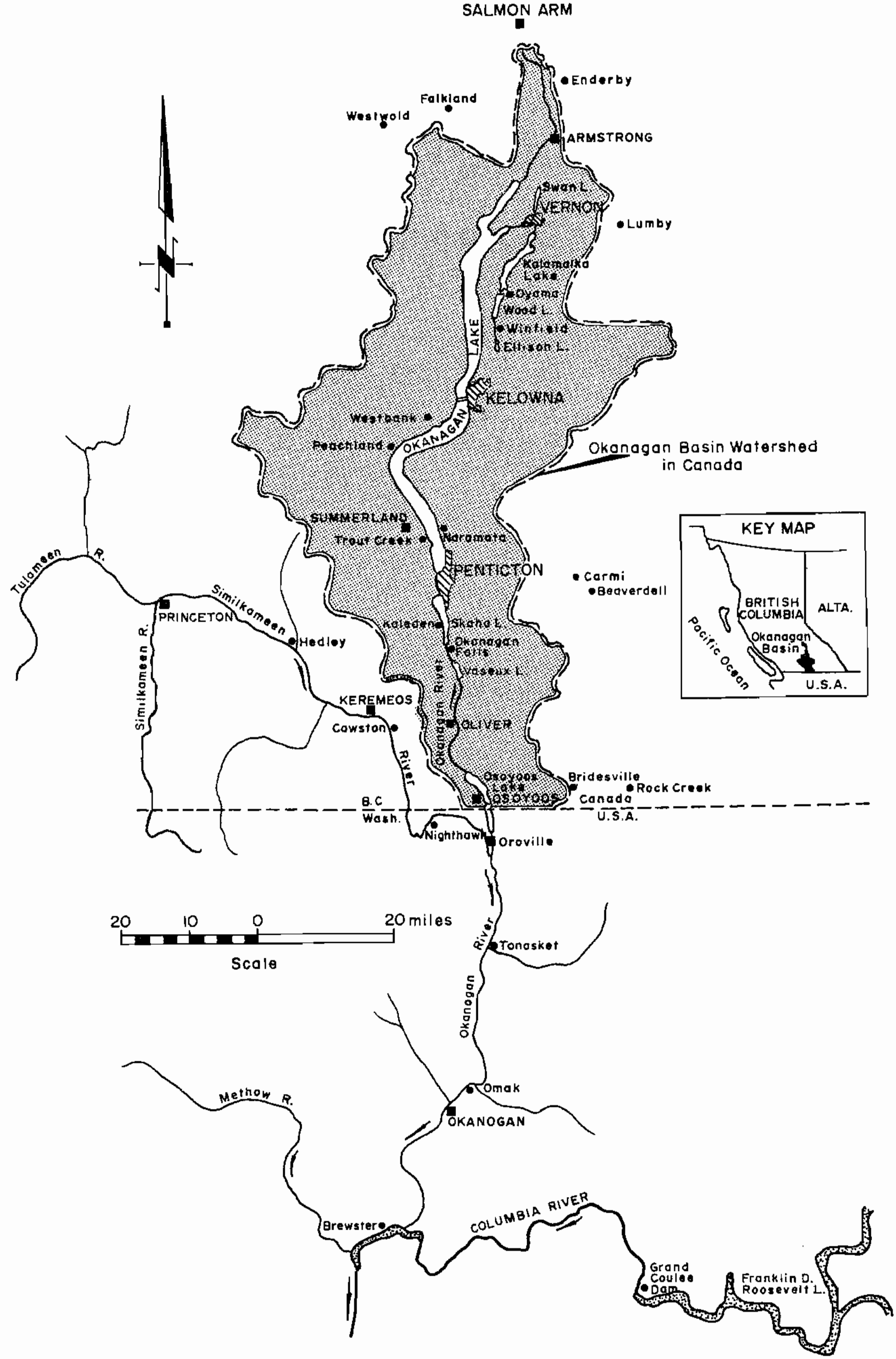
DESCRIPTION OF BASIN

1.1 Physiography

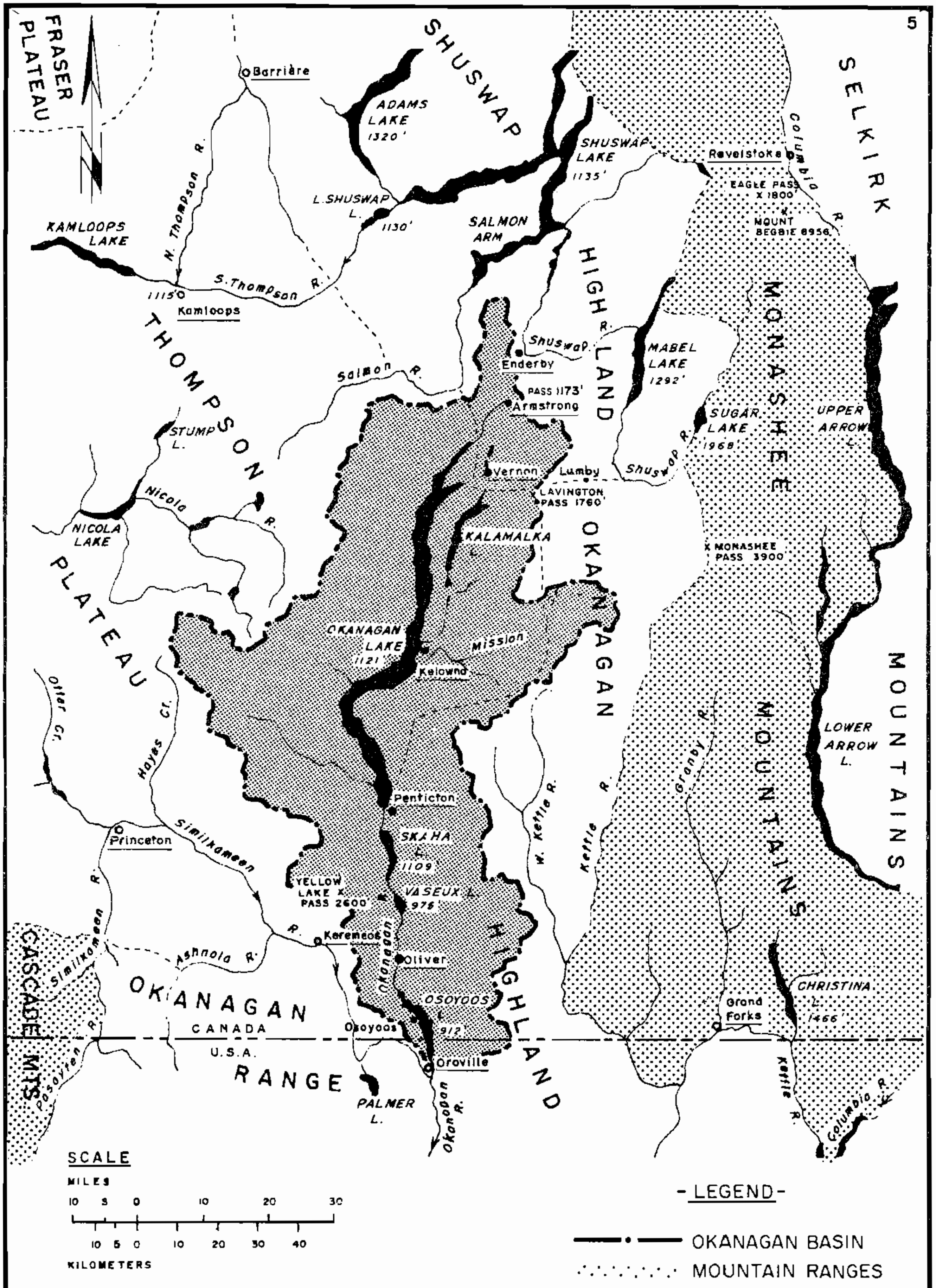
The Okanagan Basin in Canada is bounded on the south by the International Boundary, on the east by the Kettle River Basin, on the west by the Similkameen River Basin and to the north by the Shuswap River Basin. Most of the area within these four watersheds consists of high plateau land with an average elevation of 5000 feet in the south decreasing to 4000 feet in the north (Figure 1.2). This plateau is sharply split by the Okanagan Trench, a wide deep valley which has been eroded by stream and glacial action. The Monashee Mountains, some 20 to 40 miles east of the trench, have an average elevation of about 7,000 feet, but several peaks in the vicinity of Mabel and Sugar Lakes support glaciers at altitudes approaching 10,000 feet.

The results of Pleistocene glaciation which ended about 10,000 years ago can be seen throughout the Okanagan Valley. A layer of ice, probably about 7,000 feet thick, chiselled mountain peaks and ridges and scoured north-south valleys into smooth troughs. As the ice receded, the terrain was left draped with a layer of mixed stones, silt and clay, called "glacial till". The depth of this mantle varies from two to forty feet and has served as the parent material for most of the soils in the area.

When the huge ice sheet began to melt, there was a superabundance of water. Rivers and streams were much larger than at present, and quickly began the process of clearing valleys of much of their deep glacial debris. However, the ice did not melt uniformly and in the Okanagan Valley large remnant ice-lakes remained. In order to by-pass these ice-lakes, melting water flowed roughly parallel to the ice but at considerably higher elevations than the present valley floor. As the water from the valley sides with its load of glacial till met the glacial ice, its velocity was reduced and a considerable



OKANAGAN DRAINAGE BASIN IN CANADA ——— Figure 1.1



OKANAGAN BASIN
PHYSIOGRAPHIC MAP

Figure I.2

amount of this glacial material was sorted and deposited in places along the edge of the ice-lake. Gradually as the ice melted the glacial streams followed successively lower channels until the drainage pattern became approximately the same as it is today. Along most of the Okanagan Valley between Osoyoos Lake and Armstrong, discontinuous ribbons of material deposited from melt water form gently sloping terraces along the valley sides. The well known silt terraces near the south end of Okanagan Lake are an outstanding feature of glacial-stream deposition. Smaller glacial-fluvial terraces, often called "benches" may be found throughout most of the Valley.

On the plateau surface, the retreating ice exposed shallow depressions, many of which are now occupied by small lakes. The chain of lakes along the Okanagan trench, as mentioned previously, is also a result of glacial action. In these cases, the glaciers scoured immense depressions in the valley bottoms. These "overdeepened" sections later became filled with water as the ice melted. Further evidence of glacial action is the separation of lake bodies by narrow alluvial fans such as is evident at Penticton, and between Wood and Kalamalka Lakes near Vernon.

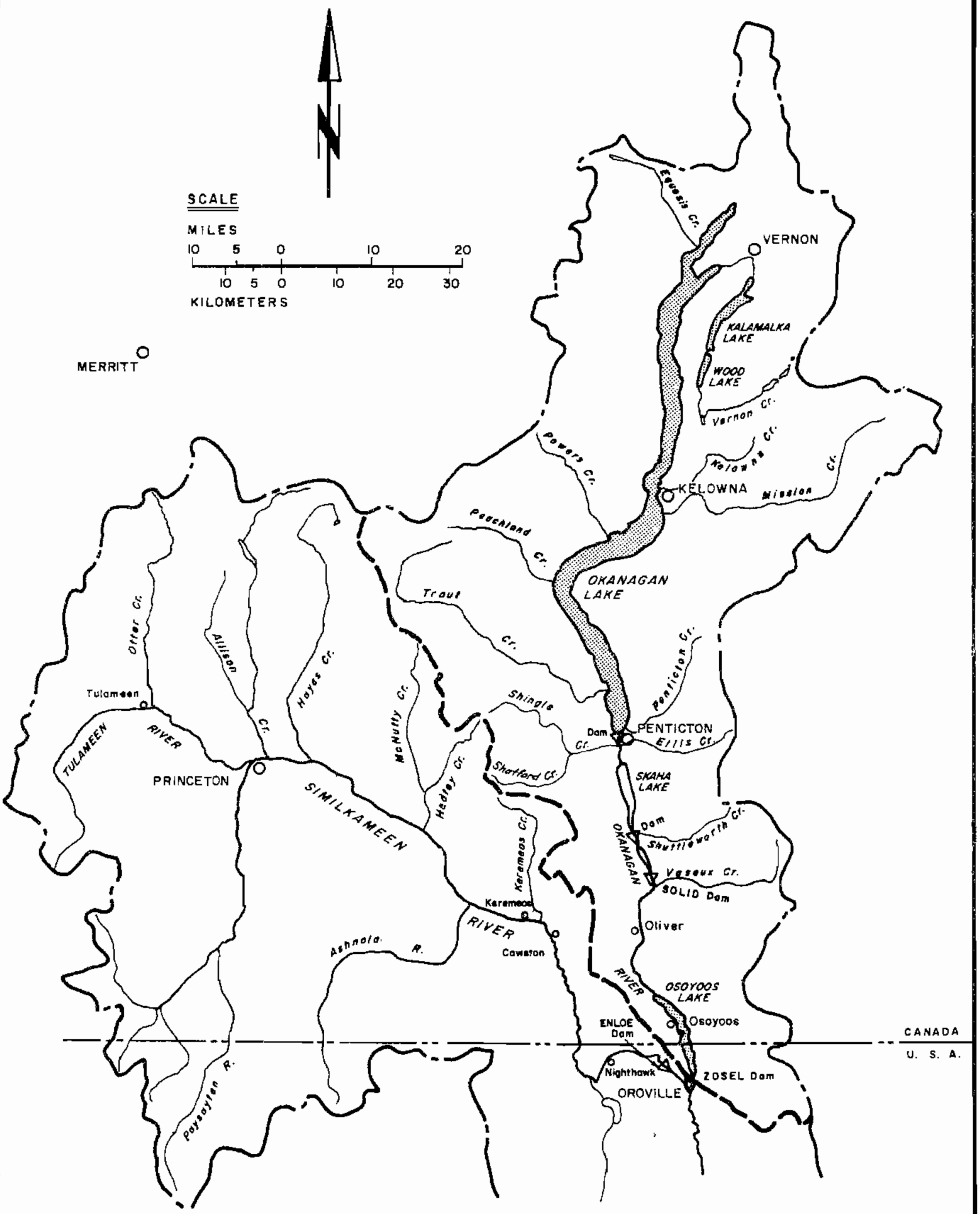
There are several relatively low passes between the Okanagan Basin and adjoining drainage systems including Spallumcheen Valley north of Armstrong (elevation 1,173), the Lavington Pass (elevation 1,760) west of Lumby and the divide between the Southern Okanagan and the Similkameen near Yellow Lake (elevation 2,600). All three are the location for transportation routes and the first two have been studied with respect to possible water diversions into Okanagan Lake.

1.2 Drainage

From the Okanagan Basin divide near Armstrong, drainage is southward through the mainstem lakes including Okanagan, Skaha, Vaseux and Osoyoos Lakes (Figure 1.3).

Major tributaries of Okanagan Lake, listed in order of decreasing annual discharge are Mission, Vernon, Trout, Penticton, Equesis, Kelowna, Peachland and Powers Creeks.

The Okanagan Lake Dam at Penticton and the improved four miles of Okanagan River Channel running south and discharging into Skaha Lake are part of the Okanagan Flood Control Project, which was constructed jointly by the Federal and Provincial Governments during 1950 to 1958 under the terms of the Okanagan Flood Control Act. While one of the main objectives of the project was to relieve flooding such as occurred in 1942, and 1948 it also provides storage regulation for irrigation, fisheries, water based recreation and aesthetics within the Okanagan mainstem system.



OKANAGAN – SIMILKAMEEN BASIN

Figure I.3

The Project also includes a concrete dam at Okanagan Falls which regulates the level of Skaha Lake. The discharge from this dam flows southward through an improved Okanagan River Channel for 3.3 miles to discharge into Vaseux Lake. Its fall of approximately 30 feet in this portion of the river is controlled by four drop structures.

Below the Vaseux Lake Dam, the Okanagan River remains in its natural state for four miles, and a portion of this reach, about a mile downstream from the dam, together with Wenatchee Lake in the State of Washington, form the two remaining major spawning areas for the Sockeye (blueback) salmon in the Columbia River system. Some 30 years ago (prior to the construction of Grand Coulee Dam upstream of the confluence of the Okanogan River with the Columbia River in the United States) the much larger Upper Columbia watershed was also available as a spawning area for the salmon. There is normally no salmon migration in the Okanagan River above Vaseux Lake Dam.

In its lower reaches, the Okanagan River channel has been improved from just north of Oliver downstream for some 10 miles to Osoyoos Lake. In this section of the river, there are 13 drop structures each designed for a fall of three feet. These concrete structures have multiple weir openings specially designed for fish passage.

The normal low water elevation of Osoyoos Lake is maintained by the Zosel Dam at Oroville, Washington.

At Oroville and immediately downstream the Okanogan and incoming Similkameen Rivers follow meandering courses for about one and a half miles before becoming a single channel.

The Similkameen River Basin is situated about 125 miles east of the Pacific Coast astride the International Boundary as shown in Figure 1.3. The Similkameen Basin consists of approximately 2,880 square miles in Canada, the balance of the total catchment of 3,580 square miles being in the United States.

The Similkameen River headwaters are in the Cascade Mountains in the vicinity of the International Boundary. It is joined by the Pasayten River from the south, flows northerly for 35 miles to Princeton, and is there joined by its largest tributary, the Tulameen River. From Princeton, its course is generally south-easterly for 88 miles to its confluence with the Okanogan near Oroville, after crossing the boundary near Nighthawk. The largest tributaries downstream from Princeton are Allison, Hayes, Hedley and Keremeos Creeks from the north and the Ashnola River from the South. The relative insignificance of these tributaries, as far as run-off is concerned, is realized when it is noted that the watershed area above Princeton, consisting of only 40 percent of the whole basin, yields approximately 70 percent of its run-off.

While the study is limited to the Canadian portion of the Okanagan River the fact that Osoyoos Lake is divided by the International Border has required the extension of the hydrological analysis downstream to the lake outlet at Oroville, Washington. Further, the backwater effect from the Similkameen River at its confluence with the Okanogan River below Oroville, which can reduce and even reverse the direction of flow at the outlet of Osoyoos Lake, has required an examination of the peak flows on this major tributary.

Only minor storage development has taken place on tributaries of the Similkameen in Canada.

The only important development in the United States portion of the basin is the hydro-electric plant of the Okanogan County Public Utility District on the mainstem some five miles above Oroville at the Enloe Dam. This run of the river plant has an installed capacity of 3,200 kilowatts, and operates under a maximum head of 78 feet. While the Similkameen River is considered to be a tributary of the Okanagan it carries about four times the annual flow of the latter as measured near Oroville.

1.3 Climate

The climate of the Okanagan Basin is somewhat less continental than the rest of the interior. The warm summer with fairly low humidity as well as the relatively mild winters provide an attractive environment for agriculture and recreation. Typical climatic conditions at major urban centers in the Okanagan Valley are shown in Table 1.1.

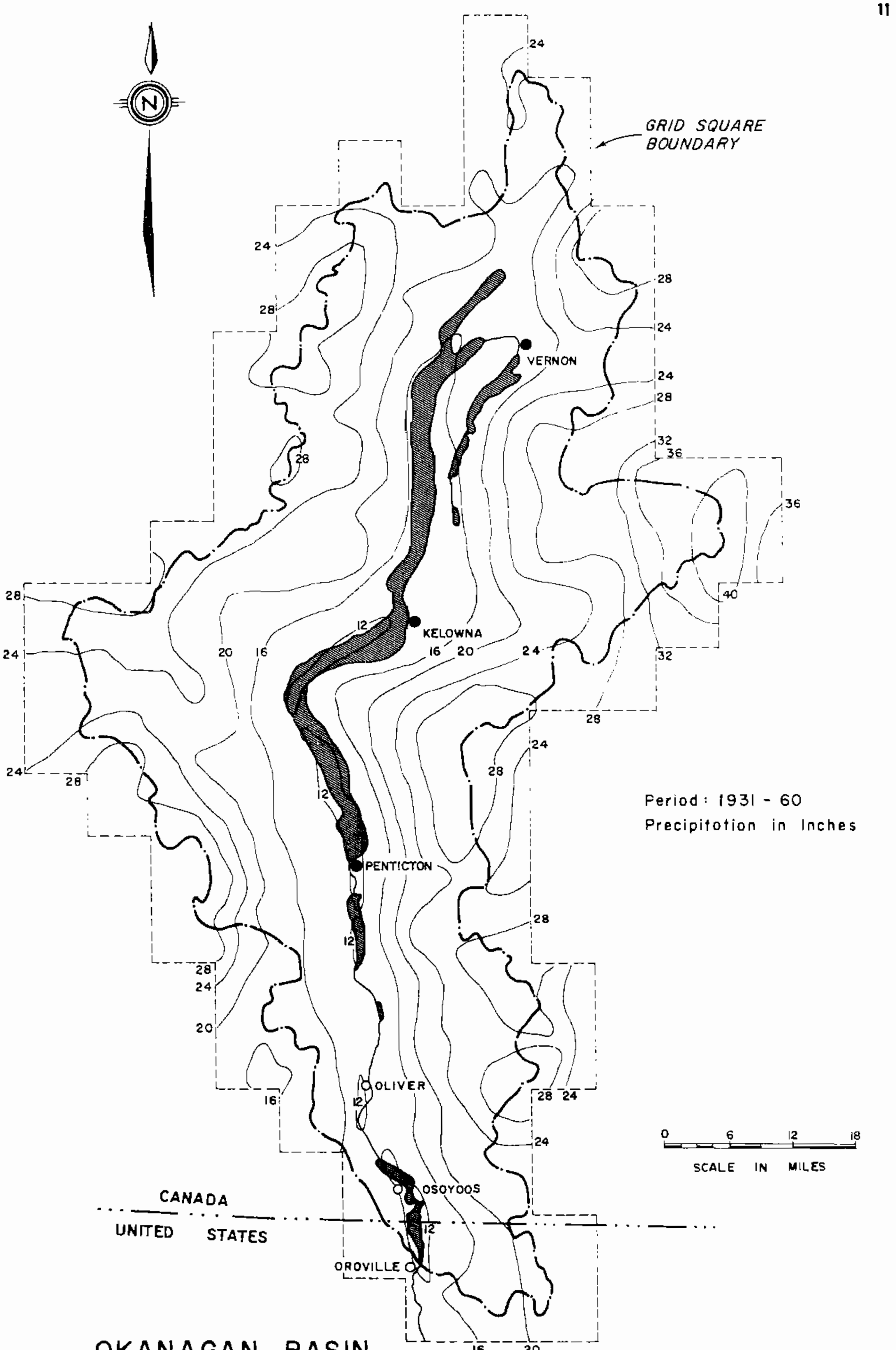
Most of the region is in the dry shadow of the Cascade Mountains which forms a barrier to westerly storms. In the valley bottom precipitation increases from south to north with Oliver having an annual average of only 10.7 inches compared to 17 inches for Armstrong. In the high plateau region near Kelowna, the average annual precipitation as measured at McCulloch, is 27 inches. Conversely, mean air temperature, length of growing season, frost-free period, and the total degree-days during the growing season decreases from south to north.

A more general picture of the average conditions throughout the basin are shown in Figures 1.4 and 1.5 where lines of mean annual precipitation and temperature are shown respectively. The mean annual precipitation (Figure 1.4) increases not only with latitude but also with elevation. Further, there is considerable contrast in the heavier precipitation in the northeast area of some 40 inches, compared to 28 inches for the western portion of the Basin, which

TABLE 1.1

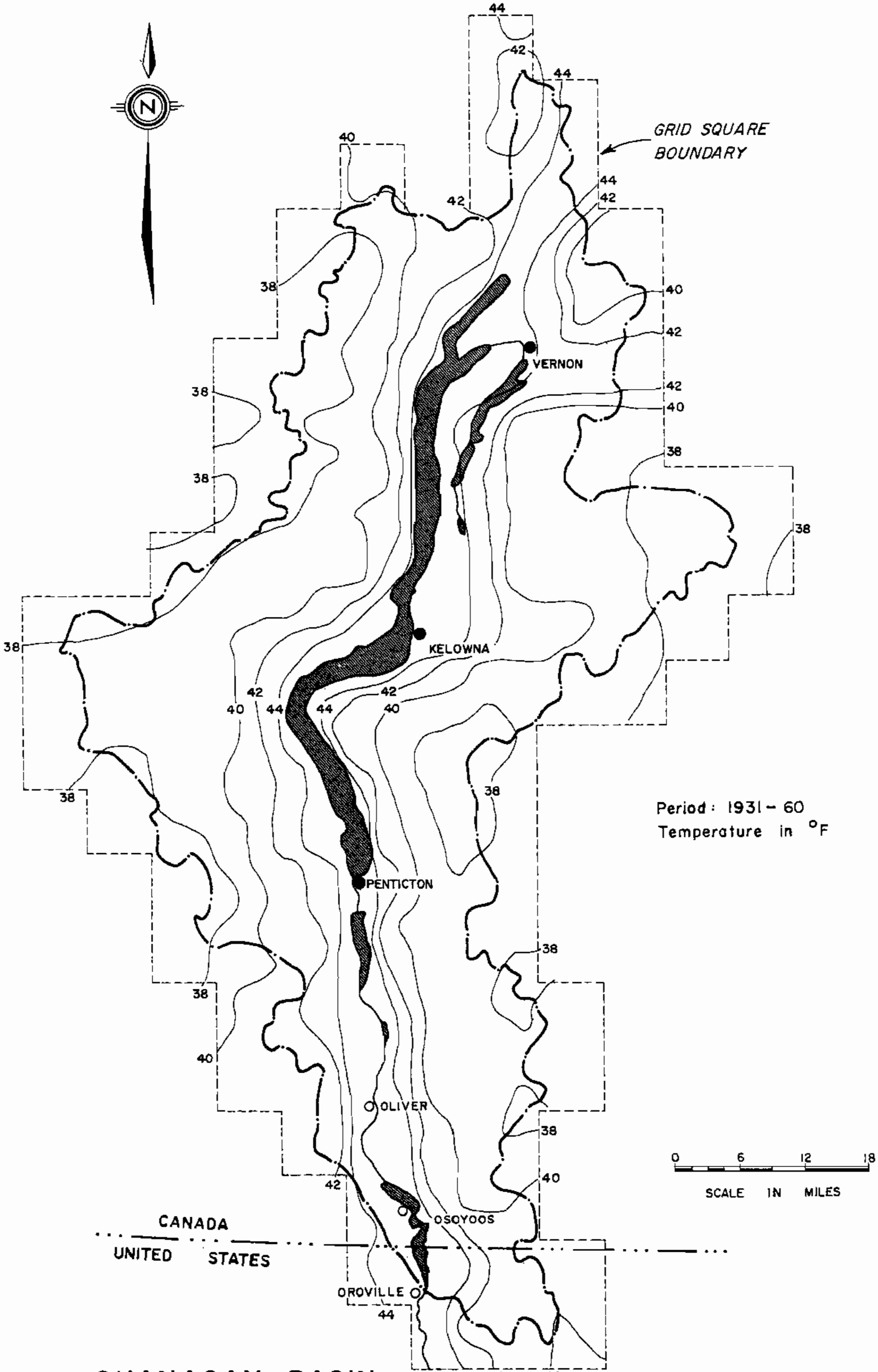
Representative Climatic Data, Okanagan Valley - Taken in part from B.C. Department of Agriculture publication entitled Agricultural Outlook Conferences 1966.

Station	Elevation	Mean Annual Precip-itation	Mean January Precip-itation	Mean July Precip-itation	Mean Annual Temper-ature	Mean January Temper-ature	Mean July Temper-ature	Mean Data Last Spring Frost	Mean Data First Fall Frost	Mean Frost-free Period	Degree Days 42° F.	Mean Growing Season (Mean daily temp. 42° F)
	ft.	in.	in.	in.	°F.	°F.	°F.	-	-	day	-	day
Salmon Arm	1660	21.0	-	-	45	-	-	May 6	Oct. 5	153	3391	199
Armstrong	1200	17.06	1.84	1.13	44	21	66	May 23	Sept. 14	114	3063	194
Vernon (Coldstream)	1582	15.22	1.55	1.06	45	22	67	May 6	Oct. 5	147	3248	200
Okanagan Centre	1140	13.38	1.39	0.95	48	27	68	-	-	134	-	-
Kelowna	1590	12.09	1.06	0.78	47	26	68	May 12	Oct. 3	143	3442	200
McCulloch	4100	26.82	2.87	1.78	37	16	56	-	-	20	-	-
Summerland (Research Sta.)	1491	11.00	1.06	0.86	48	25	70	Apr. 24	Nov. 9	198	3756	212
Penticton (Airport)	1140	11.32	1.08	0.89	48	27	68	May 7	Oct. 3	149	3530	217
Oliver	1008	10.71	1.07	0.76	49	26	71	May 3	Oct. 1	152	4021	226



OKANAGAN BASIN
MEAN ANNUAL PRECIPITATION

Figure 1.4



OKANAGAN BASIN
MEAN ANNUAL TEMPERATURE

Figure 1.5

falls within the "precipitation shadow" for moist Pacific air moving in from the west. The annual mean precipitation for the Okanagan Basin north of Oroville is some 22 inches.

Similarly the mean annual temperature decreases with latitude and elevation as shown in Figure 1.5. Table 1.1 shows a variation in mean annual temperature from 49°F for Oliver (elevation 1008 feet) to 37° F for McCulloch (elevation 4100 feet). The annual mean temperature for the Okanagan Basin north of Oroville is 41° F.

The hot, very dry air of summer, is characteristic of the Okanagan Valley. Even the continental polar air, which invades the valley from the north during the winter is usually warmed during its movement into more southerly latitudes, and as a result, the Okanagan Valley does not undergo long periods of continuous cold such as occur in the more northerly parts of the province.

The movement of Pacific air generally brings comparatively mild weather to the Interior of British Columbia. At times however, cold polar air may produce rapid temperature changes and a Frost Warning Service operated by the Atmospheric Environment Service of Environment Canada, located at Penticton Airport, is active during May and June.

It will be noted that the difference in average temperature in the South Okanagan between the warmest month (July) and the coldest month (January) is about 35° to 45° F. while the northern area, (from Westbank to Grindrod) and the mountainous plateau surface as represented by McCulloch are about five degrees cooler. January mean temperatures are typically from 25° to 28° F. for the South Okanagan and from 21° to 26° F for the rest of the Valley.

Annual evaporation from Okanagan Lake is estimated to vary between 29 and 43 inches while further south at Osoyoos Lake the losses are even higher and in the range of 36 to 50 inches. The average basin evapotranspiration is estimated to be 17 inches.

From an agricultural viewpoint the Okanagan Valley is considered to have one of the most favourable climates in the Province. A long frost-free period (150 to 200 days), and high temperatures 3,000 to 4,000 degree-days) during the growing season, permits the raising of many heat-sensitive crops. South of Vernon, soil moisture deficiencies during the growing season may exceed 12 inches and irrigation is a necessity. North of this point, moisture deficiencies range between nine and 12 inches and dry farming may be practiced successfully on the heavier textured soils, and to some extent on the lighter textured soils.

1.4 Soils

As outlined in an earlier section most soils in the Okanagan basin originated from glacial deposits. As a result of the influence of organic matter, topography, climate and time, this glacial till has in many places formed cultivable soils. It is estimated there are 77,000 acres of arable land in the Okanagan Basin as shown in Table 3.5.(Chapter 3)

Five major soil groups exist within the Okanagan Basin - namely, Brown Dark Brown, Black, Brown-Podzolic-Grey Wooded and Ground Water Soils (Figure 1.6).

Brown soils are confined to the Okanagan Valley south of Summerland and are typically found in the driest, hottest sites where annual precipitation is about nine to eleven inches.

The Dark Brown soils have more organic matter in the surface horizons than Brown soils,and texture varies from finely granular in sandy soil to fine crumb structure in clay loam and clay. They are more fertile and with irrigation produce large varieties of fruits and vegetables. These soils are found between Summerland and Oyama.

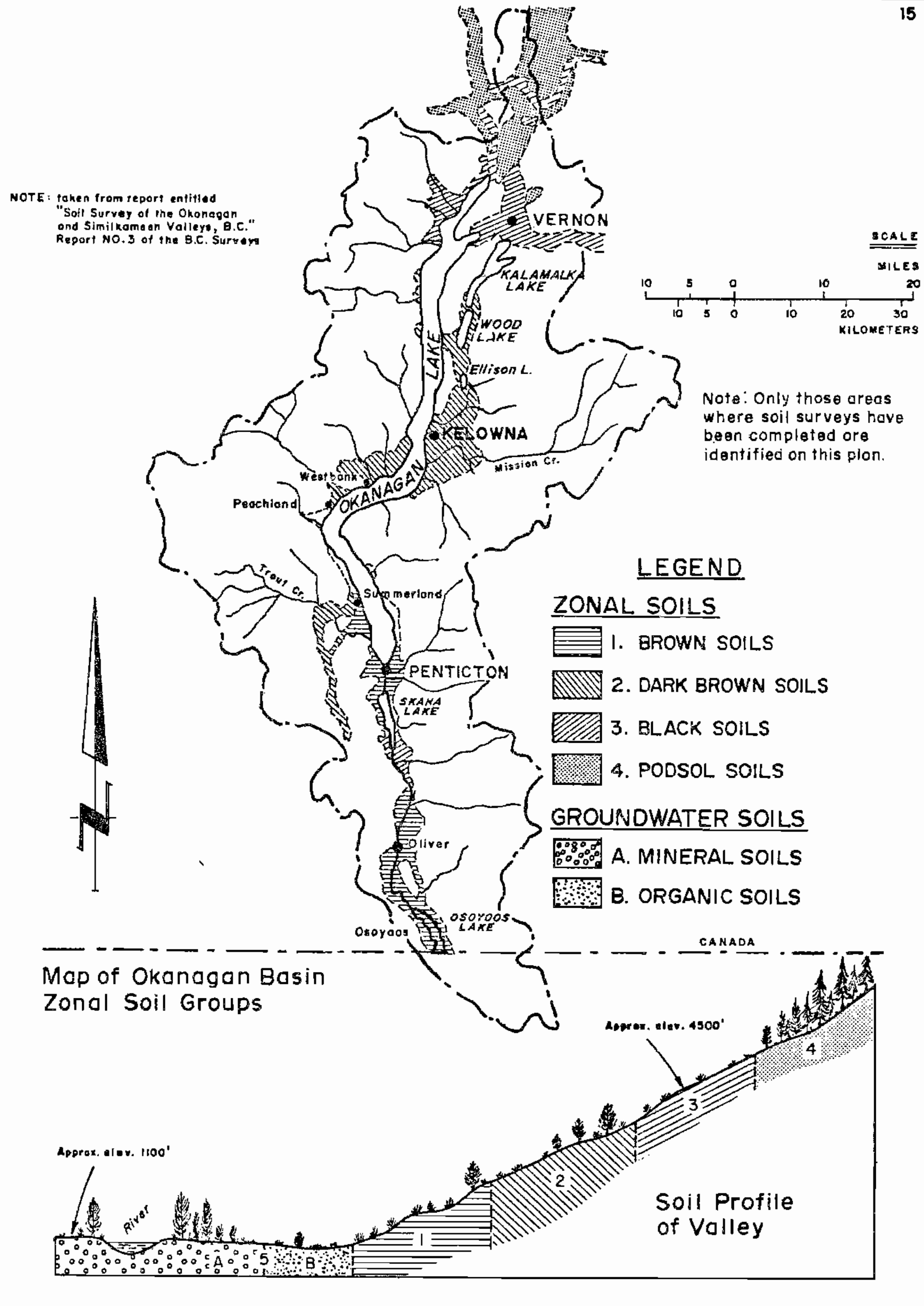
The Dark Brown soils give way to the Black soils at higher elevations where grass and areas of timber are found. These soils are fertile, rich in organic matter and with a soil structure varying from fine granular in sandy loams and loams, to granular and crumbly in clay loam and clay. For maximum production these soils should be irrigated. They are currently used for grazing, dry-farmed for cereals or irrigated for forage crops and vegetables.

The Brown-Podzolic-Grey Wooded soils are located at higher elevations and support a tree cover. These soils are quite fertile and those with medium to heavy texture could be used for dry-farming.

Groundwater soils may be defined as those having a fluctuating water table, and bog or muck soils which have a water table at or near the surface. Typically found on level or gently sloping land, these soils are medium textured and generally support a moderate to dense tree cover. Groundwater soils with good natural drainage are used for orchard crops. The balance or wetter soils are used for forage crops, gardens and berries.

1.5 Vegetation

There are three main vegetation zones in the Okanagan composed of the Osoyoos-Arid, Dry Forest and Sub-Alpine. The Osoyoos-Arid is, in general, associated with low elevations, (normally less than 2,000 feet) and low precipitation, which is typical of the southern Okanagan. Higher annual precipitation, (10-20 inches) broadly separates the Dry Forest from the Osoyoos-Arid zone. Sub-Alpine vegetation is mostly observed at elevations



PLAN AND PROFILE OF OKANAGAN BASIN SOIL TYPES

Figure 1.6

from 4,000 to 6,000 feet. It is typically associated with the plateau surface and mountain slopes on both sides of the valley. Cooler temperatures and 20 to 30 inches of precipitation are characteristic.

The Osoyoos-Arid zone does not support trees except for yell, pine or deciduous groves along river-courses. Short grasses, mainly bunch grass, are the common cover with associated desert shrubs such as rabbit-brush, sage brush and cactus.

In the Dry Forest zone good quality grazing grasses characterize the vegetation cover, except where over-grazing has introduced less palatable grasses and herbs. Yellow pine is the climax forest species and grows over much of the Dry Forest zone as individual specimens or in thin stands. Douglas fir and western larch are widely distributed on the moister fringes of the Dry Forest. Deciduous species, such as mountain birch, aspen and alder are often found on moist sites in valley bottoms or near lake shores. Spring blooming plants are abundant when the winter snows have melted.

Generally, above 4,000-4,500 feet elevation the upper limit of the Dry Forest is reached and the Sub-Alpine zone begins. It is typically forested with open grassland found in scattered patches on drier south-facing slopes. Englemann spruce and alpine fir are the most common variety of trees between 4,000 and 6,000 feet elevation. Burned or logged-over areas are frequently characterized by extensive stands of sub-dominant lodgepole pine. The forest undergrowth consists mostly of grasses and shrubs.

Although not extensive in the basin, an Alpine vegetation zone occurs in some areas above 6,000 feet where sub-alpine species such as heather, dwarf juniper, willow, etc. grow.

CHAPTER 2

Historical Development

The settlement and development of south central British Columbia has been influenced by a wide range of activities. Fur trading, mining, extensive ranching, forestry and intensive horticulture have all left an imprint upon the face of this part of the Province.

The lucrative fur trade that had developed on the west coast of North America in the latter part of the eighteenth century resulted in extensive exploration of the coastal fringe, but the inland territory remained unexplored until Alexander Mackenzie's pioneer traverse of North America in 1793. The reports of Mackenzie's exploration started a spirited rivalry for control of the western fur trade by companies from eastern Canada, particularly the Hudson Bay Company and the North West Company. This resulted in extensive exploration of the interior of British Columbia by the intrepid explorers who are remembered in the names of some of our rivers and other geographical landmarks. Following the Okanagan River on a fur trading mission up the Columbia River, David Stuart is believed to be the first white man to make its discovery.

In the early 1820's the Okanagan became a major trading route into the interior forts of what was then known as New Caledonia. Trading goods were brought by ship from England to Astoria, and later to Fort Vancouver on the Columbia River. These goods were loaded into long canoes and paddled up the Columbia River to Fort Okanagan at its junction with the Okanagan. The load was then shifted to mule trains and transported over the fur-brigade trail along the west of Okanagan Lake to a point near its northern end and thence to Fort Kamloops for distribution beyond that point. Furs were returned over the same route. However, permanent settlement along the Okanagan Valley was discouraged by the fur companies.

The beginning of the 1850's saw a significant influx of population. Gold was discovered in the Lower Fraser River in 1857 and as news of this spread, thousands of men crossed from the United States and journeyed through the Okanagan to gold fields near Yale, Boston Bar, Lilloet and later to the Caribou or the Similkameen Valley.

For the first time, the population of homesteaders and settlers became large enough to support agricultural development. Between 1861 and 1864, an estimated 14,000 head of cattle, horses and sheep were imported to the Okanagan from Oregon. Wheat and other grains were grown on moister soils in the valley bottoms and stock were grazed on the hillsides. Beef cattle were regularly driven from the Okanagan over the Dewdney Trail to Hope, and horses were supplied for transportation to the gold fields.

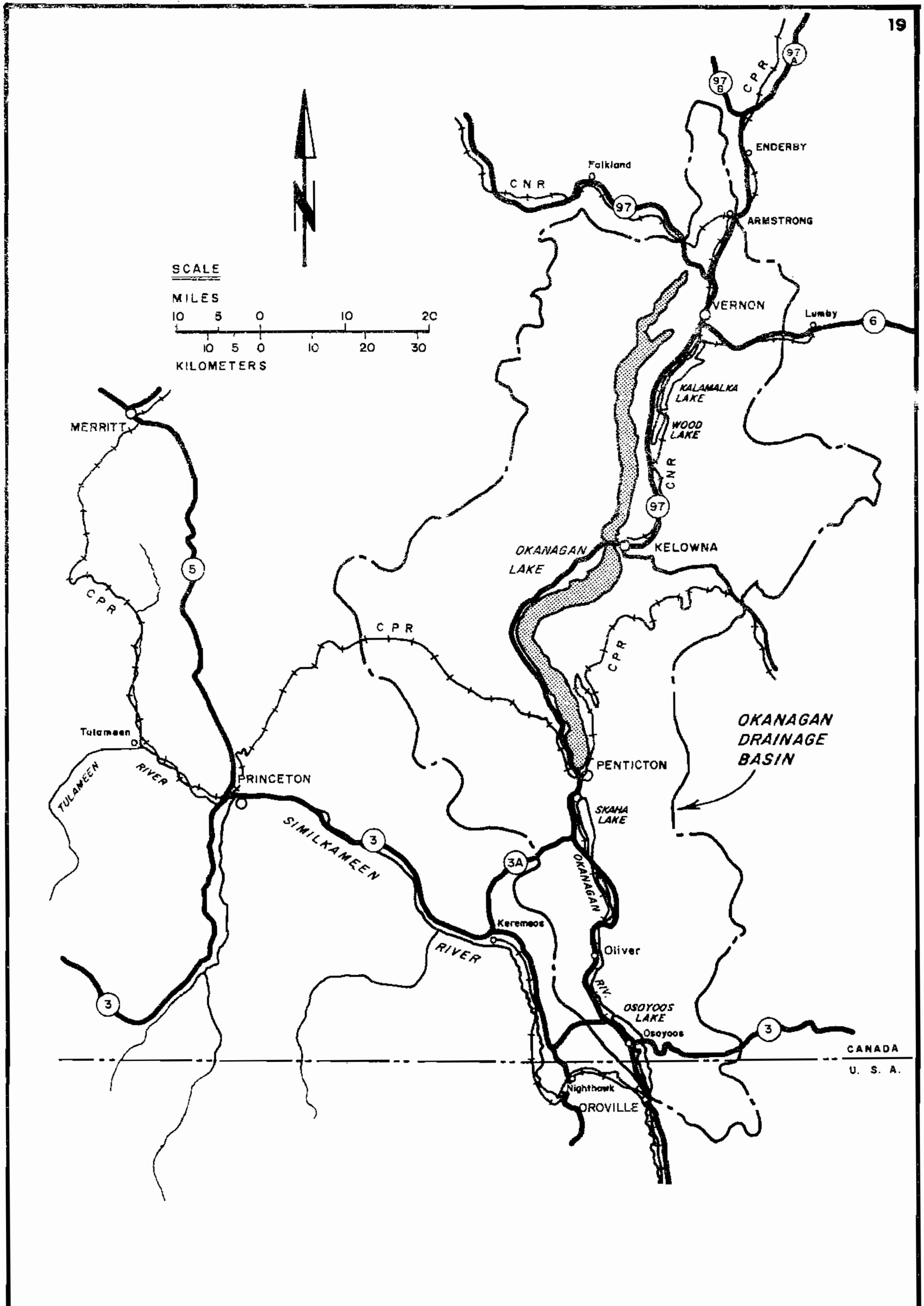
The gold-rush was waning by the 1880's but a small permanent population had been established. In 1876, a road was completed between Kamloops and the Oblate Father's mission near the present city of Kelowna. During the 1880's the building of the Canadian Pacific Railway marked the beginning of the final stabilization of the Okanagan. Regular steamer service was inaugurated on Okanagan Lake in 1886 and the Shuswap and Okanagan Railway was completed from Sicamous to Okanagan Landing in 1892. These lake steamers continued to ply the lakes until 1935 when improved highways in the valley made the service no longer practical.

The period from 1860 to 1920 marked a period of great mining activity in areas immediately surrounding the Okanagan Valley in the Similkameen, Kettle and Granby basins. Flourishing copper and gold mines sprung up at such places as Phoenix, Deadwood and Boundary Camp. Osoyoos became an important supply center for this industry.

An expanding transportation network in the Okanagan Valley was coupled with an important agricultural advance. The large Coldstream Ranch near Vernon and the Guisachan Ranch at Kelowna began to grow apples as a commercial crop in 1892. A land boom resulted with subdivision of large holdings for orchard development. Irrigation companies were formed; storage and packing plants were constructed. Centers such as Penticton, Kelowna and Vernon became firmly established. In addition to apples, it was found the hot, dry soils of the southern part of the valley were suitable for soft fruits such as apricots and peaches. Land that sold for $1.00 per acre in 1898 commanded a price of $1,000 per acre in 1910.

Rapid overproduction and in many cases, poor land management brought about a collapse of the boom in the early years of World War I. However, after the war -in the 1920's, final stabilization began. A highly integrated cooperative system was established for fruit marketing. The valley bottom between Vernon and Shuswap Lake developed into an important dairy area. Livestock ranching for cattle and sheep remained an important part of the economy. After World Was II, the forest industries became the most important element in the economy. Mills were developed in nearly every settlement and a wide variety of wood products were produced. In 1957, a plywood factory was established in Kelowna.

The economic development paralleled expansion of transportation facilities. In 1949 a highway link was completed through difficult mountain terrain from Princeton to Hope. Complete modernization of the highway through the Okanagan Valley and from Osoyoos through the Kettle Valley to Grand Forks has made the Okanagan one of the most readily and easily accessible parts of the Province (Figure 2.1). With the development of this transportation system, the Okanagan Basin entered a new era of economic growth.



TRANSPORTATION ROUTES Figure 2·1

PART II

EXISTING RESOURCE BASE

CHAPTER 3

Economic Base

Rarely do economic regional boundaries correspond to those of natural watersheds, but the Okanagan Valley does contain a mix of economic activities which distinguish it from neighbouring regions. The basin does not represent a self-contained economy however, but rather a portion of the growing economic base in Southern British Columbia. Thus, it is necessary to recognize that economic forces beyond the basin have been, and will continue to be, instrumental in shaping economic development within its boundaries.

Between 1961 and 1971, the economy of the Okanagan Valley has been in a process of transition. The economic structure of the region has moved rapidly from being dominated by primary or resource-based activities in agriculture, forestry and mining, to one dependent upon secondary and tertiary economic activities associated with non-resource based manufacturing, tourist and service industries. This change is essentially the result of the Federal Government's Regional Incentives Program which provided government grants and subsidies to both new and expanding industries in the Okanagan between 1965 and 1971. Almost $100 million of industrial development occurred in the basin as a direct consequence of this program.

This industrial expansion has significantly quickened the pace of growth in the Okanagan over the past 10 years due to the availability of employment opportunities which have in turn, stimulated population growth. The increased rate of economic growth has placed greater demands upon the Okanagan water resource for water supply and the assimilation of industrial and municipal wastes. Consequently, it is important to understand how the Okanagan basin economy has grown over the past decade so that projections of future growth to 2020 can be undertaken and the consequences of such growth on water resource management be assessed.

This chapter discusses some of the reasons for economic growth in the valley and describes the present structure of the Okanagan economy. It begins with an overview of the growth of population and employment since 1961 and then examines growth in the major economic sectors including manufacturing industry, agriculture, forestry, mining, recreation and tourism. Most of the information base used in the following discussion was obtained from Statistics Canada census data and from an economic survey of sampled business activities in the basin. These data were used to prepare an economic model of the basin for projecting economic growth over the next 50 years. This model is discussed in Chapter 13.

3.1 POPULATION

The population in the Okanagan Basin in 1971 was approximately 114,500 or about 5.2% of the Provincial total. Between 1961 and 1971, the valley's population increased by 39,500 or 52.8% compared to a population growth of 34.1% for British Columbia as a whole. Most of this growth in the Okanagan occurred between 1966 and 1971, when the population increased by 30.2% compared to 16,6% for the Province - a direct result of the industrial development program initiated in 1965.

As population statistics for the Okanagan Valley itself are only available from 1961, analysis of longer time-trends of population growth in the region must rely on data pertaining to census subdivisions 3A and 3B, the boundaries of which are illustrated in Figure 3.1, and approximately conform to the area covered by the three Regional Districts of North Okanagan, Central Okanagan and Okanagan-Similkameen. Population growth trends for the period 1940-71 for these three census subdivisions are shown in Figure 3.2, and are compared with population growth for the Okanagan Basin for the last decade of this period. This figure clearly indicates the relative increase in the rate of population growth over the past ten years.

Inward migration has played a significant role in population growth, accounting for over 50% of the total increase in the two census subdivisions

TABLE 3.1
POPULATION CHANGE BY TYPE IN
CENSUS SUB-DIVISIONS 3A, 3B, 6B, 1951-1971

PERIOD		CENSUS SUB-DIVISION 3A	3B	TOTAL	%
1951-56	Total Increase	4,871	1,960	6,831	
	Natural Increase	3,094	2,191	5,285	78
	Net In-migration	1,777	- 231	1,546	22
1956-61	Total Increase	7,376	1,720	9,096	
	Natural Increase	3,671	1,850	5,521	61
	Net In-migration	3,705	- 130	3,575	39
1961-66	Total Increase	9,494	1,851	11,345	
	Natural Increase	2,937	1,377	4,314	37
	Net In-migration	6,557	474	7,021	63

Census statistics for 1966-71 are not yet available.

(-) denotes net outward migration
Source: Population Statistics, Statistics Canada

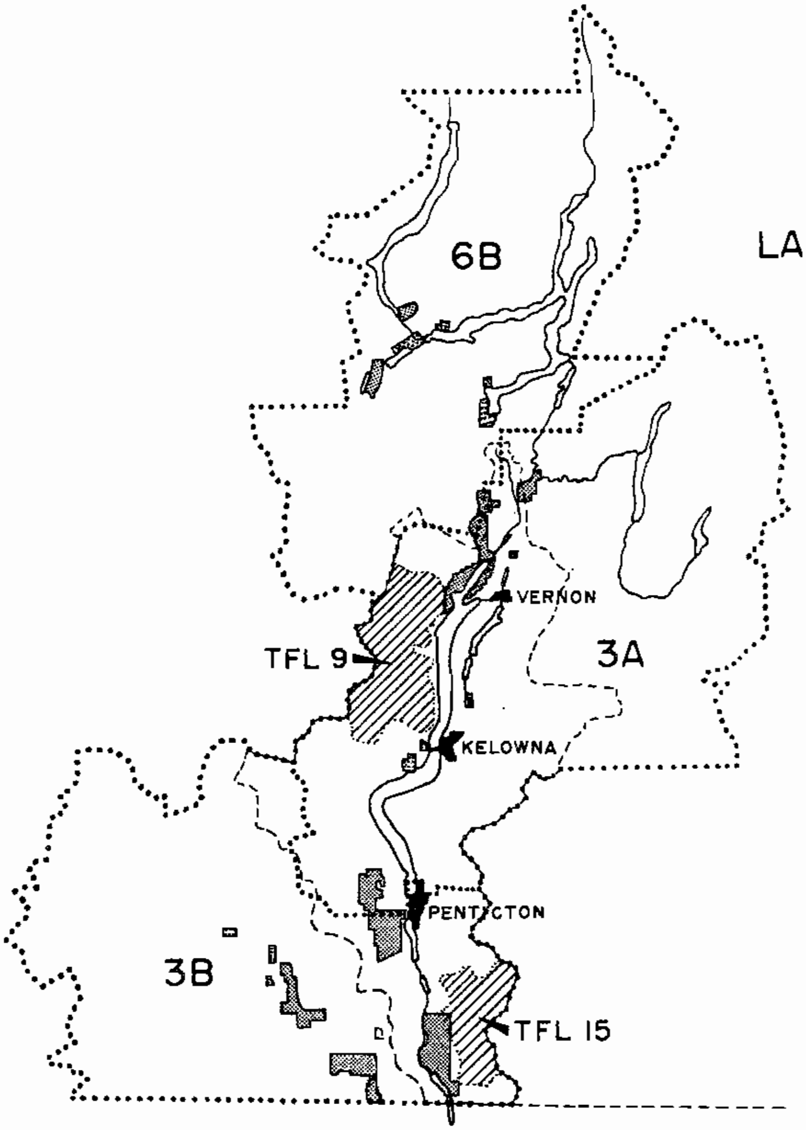
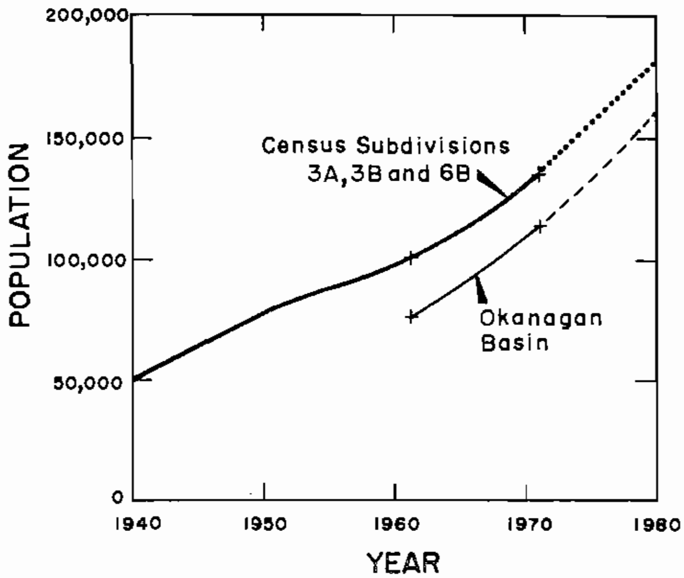


Figure 3·1



POPULATION GROWTH in the CENSUS SUBDIVISIONS 3A, 3B, and 6B and in the OKANAGAN BASIN.

Figure 3·2

between 1951 and 1966 (Table 3.1). Natural births accounted for the balance. Indeed, net in-migration into census sub-division 3A (North and Central Okanagan) which has incurred the largest population growth has accounted for over 60% of the total increase in that subdivision. The reasons for the high proportion of net in-migration in population growth include the increased availability of jobs during the 1960's and the relatively low regional birth rate, due to the high proportion of older people in the population structure.

This high proportion of older people in the Okanagan compared to the Province as a whole is illustrated in Table 3.2 and is probably a reflection of the region's popularity as a retirement centre. Table 3.2 also indicates that there are relatively less persons in the 15-34 age groups, a common feature of smaller economic regions where job opportunities have been limited in the past and the young people migrate to the large urban centres. It appears likely that this later imbalance could be reduced in the future as opportunities for employment and education increase and diversify along with the expansion of population.

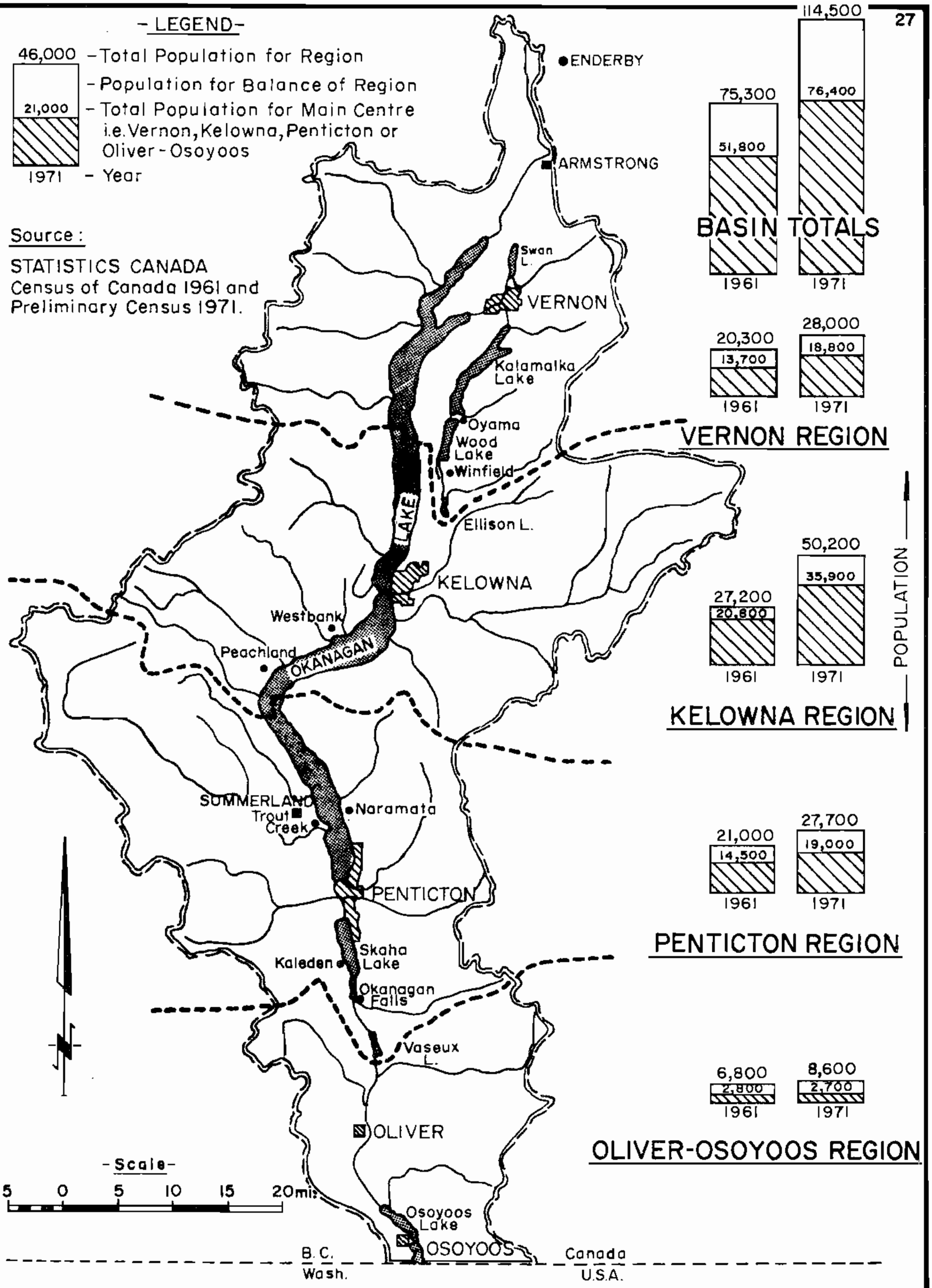
TABLE 3.2

AGE GROUP DISTRIBUTION, 1971

AGE (Years)	OKANAGAN-SIMILKAMEEN CENSUS OIVISIONS	BRITISH COLUMBIA
0-14	28%	28%
15-34	26%	31%
35-54	23%	23%
55-over	23%	18%

Population growth has not occurred at equal rates in all regions of the Okanagan Basin (Figure 3.3). The Central Okanagan region, extending from Peachland to Winfield and including Kelowna has experienced the fastest rate of growth over the past decade, its population increasing by over 83% to reach 50,100 in 1971. As will be noted in the next section, much of this rapid growth has been due to the concomitant increase in job opportunities in manufacturing and service industries.

Population in other regions of the basin has grown at less than half the pace of that experienced in the Kelowna region over the past decade. The Oliver-Osoyoos regional population increased by 28% to 8700 in 1971 due primarily to tourist industry development and an influx of retired persons. The Penticton and Vernon regional populations grew by 32% and 40% respectively due to expansion of tourism, manufacturing and associated retail and service trades.



POPULATION BY ECONOMIC REGION IN THE OKANAGAN BASIN FOR 1961 AND 1971. Figure 3·3

3.2 EMPLOYMENT

The growth of population can be directly related to the growth of employment in the Okanagan. Generally speaking, regions such as the Okanagan Basin experience economic growth because they are able to produce goods which can be exported to other regions in British Columbia or elsewhere. Until the mid-1960;s, the Okanagan economy relied upon the production and export of primary resource products in agriculture, forestry and mining, most of which were sold to the rest of the Province and Canada. These primary economic activities stimulated employment which in turn created a demand for a wide range of goods and services, such as education, health care, retail shopping, finance. These service trades themselves employed people who, with their families and dependents, created more demands for services.

The money earned through the export of primary resources is re-invested in these primary economic activities creating more jobs both in the industries themselves, and in the service or support industries that supply materials for production. For example, increased exports of tree fruits requires a greater demand for packing cartons which in turn requires greater production in the logging industry resulting in a spiraling growth.

As a result of the introduction of the Federal Government's Industrial Incentive Program, the primary resource based activities have been superceded by non-resource based manufacturing as the major growth-creating industry. These non-resource based industries which include the manufacture of mobile homes, boats, trailers, glass, chemicals, etc. are not dependent upon the primary resource base in the Okanagan, nor are they directly dependent upon the proximity of markets. Rather they are sometimes referred to as 'footloose' industries because they can locate in any region where there are good transportation links with the supply of raw materials and the markets. The offer of financial incentives to locate in the Okanagan was a deciding factor for many firms which were affected by the high economic and environmental costs of locating in major urban centres in British Columbia or elsewhere.

To indicate the importance of how basic industries influence population growth, it has been estimated that one job created in the basic sector creates an additional 3 jobs in the non-basic or service indistries, including health care, education, retail and other personal services. As each employed person generally has about 2.5 dependents (spouses, children), total population would grow by about 10 persons. In other words, creation of 100 new jobs in the basic industries could increase the valley population by over 1000 people.

Table 3.3 indicates that over the past decade, employment increased by almost 10,000 jobs, mostly in non-resource based manufacturing (1,440 jobs), retail and service trades (3,510 jobs) and health and education (1,450 jobs).

Agricultural and logging sectors experienced a decline in employment over the same period, while employment in mining increased due to the opening of the Brenda Mine near Peachland. Although agricultural production increased over the past decade, there has been a reduction in agricultural employment. This decline can be attributed to a number of factors including increasing competition from American and European suppliers of tree fruits, sub-division of agricultural land for housing and industrial expansion and increases of productivity per worker. Similarly, declines in logging employment are not reflective of a decrease in output, but rather are a result of increased productivity. As a result of these changes, there has been a proportional shift in employment by sector, retail and service trades employing over 69% of the Okanagan labour force in 1970 compared with 65% in 1961, while employment in the primary activities has dropped from almost 19% to 11% over the same period.

TABLE 3.3

EMPLOYMENT BY SECTOR - 1961 TO 1970

SECTOR	EMPLOYMENT[1]		SHARE OF TOTAL EMPLOYMENT	
	1961	1970	1961	1970
Agriculture	2,930	2,650	15.7%	9.3%
Mining	40	360	0.2	1.3
Logging	500	300	2.7	1.0
Manufacturing - Resource Based	1,650	2,010	8.9	7.1
Non-resource Based	720	2,160	3.9	7.6
Services - Tourism	640	1,230	3.4	4.3
Services - Retail	12,130	19,760	65.2	69.4
TOTAL	18,610	28,470	100.0	100.0

Source : 1. Estimates developed from Statistics Canada, Census of Manufacturing, Agriculture, Merchandising and Labour Force, 1961.

The rapidly increasing importance of non-resource based manufacturing is further illustrated in Table 3.4, which presents the value of total production and actual income that remains in the Okanagan generated by the major basic industries - agriculture, manufacturing and tourism. The value of production in non-resource based manufacturing has increased about seven times and the value of income about three times during the past decade, making it the leading industry in the growth-inducing sector of the economy. Despite the reduction in actual employment in the agricultural sector, the value of its production increased by over 30% between 1961 and 1970, while the value of services and expenditures by tourists more than doubled over the same period.

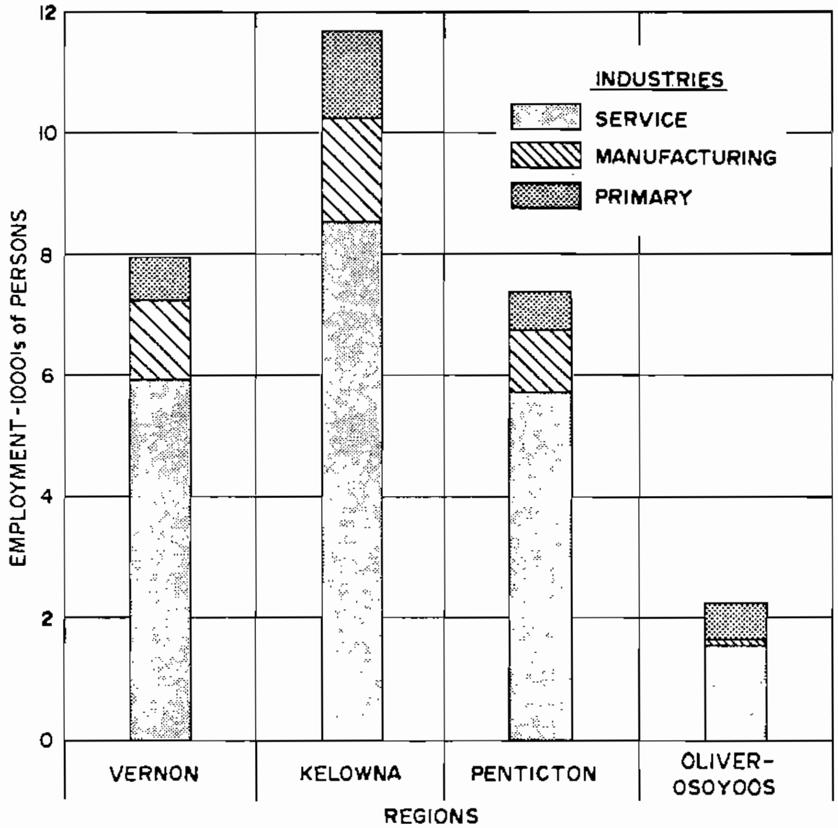
TABLE 3.4

VALUE OF PRODUCTION IN BASIC INDUSTRIES - 1970

SECTOR	VALUE OF PRODUCTION 1961	1970	VALUE OF INCOME[1] 1961	1970
	($1,000 Constant 1970 Dollars)		($1,000 Constant 1970 Dollars)	
Agriculture	31,970	40,300	9,930	11,680
Manufacturing Resource Based	32,940	49,710	10,830	12,160
Non-resource Based	11,290	77,860	5,790	15,610
Tourism	5,530	11,240	2,580	5,160
Other (Service and Retail)	N.A.	319,460	N.A.	153,090
TOTAL	------	498,570	------	197,700

1. Income includes wages, salaries, rents and other income that remains in the Okanagan Basin

SOURCE: Estimated from Questionnaire Survey undertaken by Socio-Economic Task Force, 1971-72.



EMPLOYMENT DISTRIBUTION BY REGION, 1970 Figure 3·4

As expected, the geographical distribution of employment opportunities closely parallels that of population (Figure 3.4). The Kelowna region provides over 40% of all jobs in manufacturing industries, followed by the Vernon region (32%), Penticton region (25%) and Oliver-Osoyoos (3%). This employment pattern is basically the same for the large service industry sectors, but varies somewhat for other sectors such as agriculture in which the Vernon region is of primary importance and the tourist industry which is most highly developed in the Penticton region.

3.3 LAND USE

An understanding of existing landuse is basic to any analysis of the economy of the Okanagan. It affects the availability of water should lands be irrigated, and it affects the quality of water as a result of surface and groundwater run-off from land-based economic activities (deforestation, roads and paving etc.).

TABLE 3.5

LAND USE IN THE OKANAGAN BASIN 1970
(in round figures)

LAND USE	ACRES	SUBTOTAL ACRES	PERCENT
Forests - sustained Yield Units - Tree Farm Licences	 1,067,000 286,000	1,353,000	68%
Agriculture - Irrigated - Dryland Farming - Arable Potential (below 1800 feet in elevation)	 60,000 26,000 71,000	157,000*	8%
Urban - Removed from Agriculture		57,000	3%
Lake Surface Areas		104,000	5%
Other		329,000	16%
TOTAL		2,000,000	100%

* Land capable of being cultivated to elevation 5000 feet is 272000 acres

Table 3.5 presents a breakdown of existing landuse development in the Okanagan in 1970. Out of approximately 2 million acres in the basin over two-thirds (1.35 million acres) are in productive forest, situated above the 2000 foot elevation. Some 157,000 acres of cultivated, or land capable of being cultivated, lie below an elevation of 1800 feet. Above this elevation climatic conditions severely limit agricultural crop production. Of this arable acreage over 60,000 acres are presently irrigated (Figure 3.5) and an additional 26,000 acres are in dryland cultivation, mainly in the northern end of the watershed. Residential, commercial and industrial sub-divisons occupy some 57,000 acres of land in the valley proper much of which was formerly prime agricultural land.

3.4 AGRICULTURAL RESOURCES

Table 3.6, which shows the distribution of irrigated acreage by crop type and region, indicates that the Okanagan Valley is one of the most intensively farmed regions in the Province. Mixed farming, based on dairying and irrigated pasture predominates in the North Okanagan, particularly in the Spallumcheen Valley, while tree fruits and other horticultural crops are grown intensively in the regions to the South. The region produces over 90% of all tree fruits grown in British Columbia and about 10% of provincial vegetable production.

TABLE 3.6

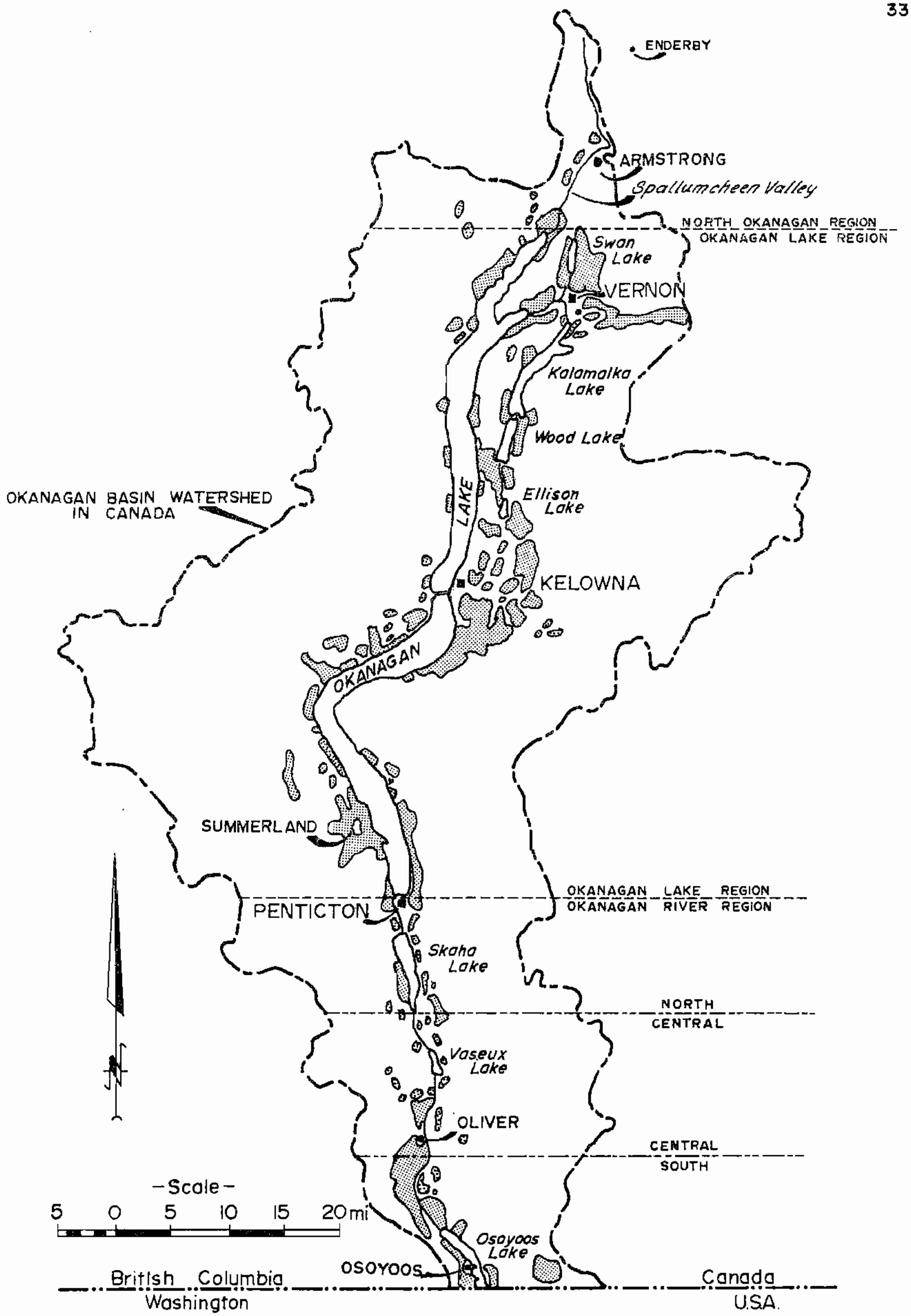
IRRIGATED CROP ACREAGES BY REGION, 1971
(Acres)

REGION	TREE FRUITS	GRAPES	NURSERY CROPS	VEGETABLES	FIELD CROPS	FORAGE CROPS AND PASTURE	TOTAL
Vernon	2,939	129	84	485	344	11,652	15,633
Kelowna	14,259	1,273	441	289	---	5,885	22,147
Penticton	8,905	109	10	20	---	2,290	11,334
Oliver-Osoyoos	5,716	791	165	412	---	3,872	10,956
Basin Total	31,819	2,302	700	1,206	344	23,699	60,070

SOURCE: B. C. Tree Fruits Ltd, Statistics Canada, Canada Land Inventory Landuse Maps.

Principal orchard developments lie on gravel and sand benches and alluvial fans adjacent to Okanagan Lake and River. The area between Vernon and Kelowna, with a relatively low expectation of frost-free days specializes in apple production, while to the south of Kelowna, and particularly in the Okanagan River region, milder winters and earlier springs allow for a more diversified production including soft fruits and grapes. Irrigation of tree fruits and other horticultural crops is important on the heavier soils near the major urban centres, and irrigated pasture is becoming increasingly important to support the ranching and dairying enterprises scattered throughout the valley.

Despite the incresing pressures for sub-dividing orchard lands for residential, commercial and industrial development, tree fruit acreages have remained relatively stable over the past decade. Some declines in orchard acreage have occurred near the major urban centres, but these have been largely compensated for by the rapid increase in grape plantings, particularly in the Kelowna and Oliver-Osoyoos regions.



IRRIGATED LAND IN THE OKANAGAN BASIN. Figure 3.5

Agriculture is one of the major sectors of the Okanagan economy in terms of value of output. Table 3.7 presents the value of production of the major agricultural crops and indicates the dominant position of the tree fruit industry. Apples represent over half of the gross value of tree fruits to the farmer followed by cherries (13%), pears (12%) and peaches (9%) (Table 3.8). Grape production varies considerably from year to year due to winter kills during severe frosts, but in 1970 was valued at about $1.5 million or about 8% of the value of tree fruits. Grapes have only recently gained importance in the agricultural economy of the basin. Because of increasing trends in per capita wine consumption in the Province and the suitability of the Okanagan soils and climate for grape production, this product has considerable growth potential in the basin.

TABLE 3.7

VALUE OF AGRICULTURAL PRODUCTION[1]
IN THE OKANAGAN VALLEY - 1970

ITEM	VALUE OF CROP	PERCENTAGE
Tree Fruits and Grapes	$31,974,200	79.3
Livestock	2,749,900	6.8
Dairying	1,535,500	3.8
Vegetables	1,241,300	3.1
Field Crops	482,200	1.2
Poultry and Eggs	1,304,000	3.2
Nursery Crops	1,021,000	2.6
TOTAL	$40,308,000	100.0

1. Values include packing-house charges for handling, processing and transportation.

SOURCE: Statistics Canada, Agricultural Census.

TABLE 3.8

1970 TREE FRUIT AND GRAPE PRODUCTION
FOR THE OKANAGAN VALLEY

FRUIT	TOTAL PRODUCTION (Pounds)	TOTAL VALUE[1] (Dollars)
Apples	257,700,000	10,690,000
Crabapples	530,000	30,000
Pears	33,300,000	2,180,000
Plums	160,000	18,000
Prunes	7,490,000	570,000
Cherries	12,780,000	2,510,000
Peaches	18,170,000	1,670,000
Apricots	5,500,000	350,000
Grapes [2]	17,330,000	1,500,000
TOTAL	352,960,000	19,518,000

1. Figures represent gross values to farmers and do not include packing house charges.
2. Figures estimated from those prepared for Okanagan-Similkameen District

SOURCE: Okanagan-Shuswap Economic Study, April 1971

Production of beef cattle is a very important part of the agricultural economy, the value of livestock production being the second most important category of agricultural production. There are over 850,000 acres of grazing lands within the watershed, much of this in the lower forested areas, while irrigated pasture lands could significantly increase the potential for livestock production. Table 3.9 indicates that the total number of cattle is increasing in the region, a trend that is expected to continue as population and per capita consumption of beef increase.

TABLE 3.9

NUMBER OF CATTLE AND CALVES, OTHER THAN MILK COWS AND HEIFERS, ONE YEAR AND OVER

CENSUS SUB-DIVISION	1961	1966	1971
3A	25,444	28,332	30,450
3B	16,315	20,741	20,896
TOTAL	41,759	49,073	51,346

SOURCE: Statistics Canada. Agricultural Census Data, 1961-1971.

Under the B. C. Grazing Act, beef cattle are allowed to graze in forested areas of the watershed. Although there is some public concern about the impact of cattle grazing on tributary stream water quality, the number of cattle grazing on Crown Lands has remained relatively constant over the past decade as shown in Table 3.10.

TABLE 3.10

USE OF CROWN RANGE-
O.P.S.Y.U.[1] AND T.F.L.[2] 9 AND 15

YEAR	CATTLE	ANIMAL UNIT MONTHS[3]
1962	11,430	49,380
1969	11,225	48,780
1972	11,270	49,110

1. Okanagan Public Sustained Yield Unit. (O.P.S.Y.U.)
2. Tree Farm Licence. (T.F.L.)
3. One animal unit month is equal to one mature cow on Crown Range for one month.

SOURCE: Grazing Divison, Forest Service, Dept. of Lands, Forest and Water Resources

Although agriculture has declined in relative importance in the Okanagan economy over the past decade, it is still a vital component of the economic and social life-style of the basin. Almost 30% (i.e. $11.6 million) of the total value of agricultural production is spent locally in the Okanagan as shown in Table 3.4, and there are strong linkages between agricultural and manufacturing industries geared to providing materials for farming, processing and marketing of agricultural products. Tourism is greatly enhanced by the beauty of the orchards and the availability of fresh fruit and vegetables in roadside stands.

In addition to these economic and environmental values, farming plays an important social function in the life-styles of many Okanagan residents. Thirty-two per cent of all farms in the three regional districts were under 10 acres and 49% of all farmers earned less than $2500 in 1971 (Table 3.11). While some of these small farms provide sole support for their operators, most provide a secondary source of income and are primarily residential units. In fact, 74% of all non-commercial farms (those with sales under $2500) in 1971 were located in the North and Central Okanagan Regional Districts, which include the more densely settled parts of the basin.

TABLE 3.11
DISTRIBUTION OF FARMS BY SIZE AND
VALUE OF SALES, 1971

SIZE OF FARMS (acres)	NUMBER	PERCENTAGE	VALUE OF SALES	NUMBER	PERCENTAGE
Under 3	331	8.8%	under $2500	1860	49.5%
3 - 9	871	23.2	$2500 - 4999	520	13.8
10 - 69	1795	47.7	over $5000	1379	36.7
70 - 179	378	10.0	TOTAL	3759	100.0
180 - 399	207	5.5			
400 - 759	85	2.3			
760 - 1119	32	0.9			
1120 - 1599	19	0.5			
over 1600	44	1.2			
TOTALS	3762	100.0			

SOURCE: Statistics Canada. Agriculture Census.

3.5 FORESTRY RESOURCES

Productive forests cover over 1.3 million acres or 68% of the Okanagan watershed. Spruce and balsam comprise half the net volume of mature timber, with lodgepole pine, Douglas fir, Cedar and Hemlock constituting the balance. The management of forests on Crown lands is undertaken by the B.C. Forest Service on a sustained yield basis, i.e. the average annual losses due to alienations, logging, fire, decay and waste must not exceed the annual growth increment. Approximately 300,000 acres of forest land is privately managed within two Tree Farm Licence areas, T.F.L.9 and T.F.L. 15 (Figure 3.1).

The potential allowable annual timber harvest from the Okanagan Public Sustained Yield Unit (O.P.S.Y.U.) in 1970 was 25.4 million cubic feet, but actual harvest was only 10.8 million cubic feet, or 42% of potential. However, as timber harvesting methods become more efficient, it is expected that annual cuts will remove a greater proportion of the potential allowable annual harvest.

Almost the complete timber harvest is processed in saw and plywood mills, more than half in the 13 saw and planing mills and two major plywood mills with capacities exceeding 21 million board feet per shift per year. In response to rising labour and other costs, there has been a restucturing of the wood processing sector towards large and more efficient production units, with a parallel decline in the number of small 'bush' mills. In addition, there has been some recent diversification in wood processing with the opening of a $4.5 million corrugated container plant in Kelowna in 1970. This industry serves the local fruit and vegetable packers as well as the distillery at Winfield and various local wineries.

3.6 MINERAL RESOURCES

The Okanagan Basin lies within a larger region of Southern British Columbia which has high mineral potential. Copper and molybdenum are considered the most important of the mineral deposits in the Okanagan, centered at the Brenda Mine near Peachland. The mine, opened in 1970, has an estimated 177 million tons of ore, analyzing 0.15% copper and 0.049% molybdenum, which at current extraction rates should guarantee production for the next 20 years. It is expected that small mines in the region will continue to extract a small amount of other ores including lead, zinc, gold and silver, but rising extraction costs will gradually close most of these operations in the near future.

3.7 TOURISM

The tourist industry is now the third most important growth industry in the Okanagan behind manufacturing and agriculture. Its recent rapid growth is mainly due to the development of three major Provincial highways which permit easy access to the Okanagan from the urban centres in the Lower Mainland, Alberta and Washington State. The basin is extremely well endowed with an excellent climate (over 2000 hours of sunshine annually), and high quality summer and winter outdoor recreation facilities including opportunities for swimming, boating, fishing, skiing and hunting.

Next to good transportation, accommodation is the most important requisite for the tourist industry. With less than 6% of the Provincial population, the Okanagan supports almost 25% of the total Provincial units for tourist accommodation. In 1971, there were 8,983 units of approved accommodation in the basin, almost half of these being camping units and over 43% motel units. Although there has been a rapid increase in accommodation units, there has been a decline in the number of establishments, following a trend towards the development of large and more efficient operations.

The total number of visitors (defined as people who reside outside the Okanagan) to the Okanagan in 1970 is presented in Table 3.12. Almost half a million or 75% of all visitors come to the basin on holiday and 87% of these holiday visitors enjoy their stays during the four summer months of June to September inclusive. Recent development of high quality convention and skiing facilities has begun to provide a more balanced year round flow of visitors.

TABLE 3.12

NUMBERS OF VISITORS TO THE OKANAGAN IN 1970

TYPE OF VISITOR	SUMMER[1]	OFF-SEASON	TOTAL
Holiday	485,400	71,800	557,200
Business	39,000	78,000	117,000
Convention	7,800	24,200	32,000
Sub-Total	532,200	174,000	706,200
Day Trips	116,800	38,200	155,000
TOTAL	649,000	212,200	861,200

[1] June to September inclusive.

Based on surveys of a sample of business operations and Okanagan households, approximately 31% of summer and 18% of off-season visitors stay overnight in non-commercial accommodation, that is with friends and relatives. Of those staying at commercial facilities, about 45% stayed at motels, 45% in campsites and 10% in hotels. The Penticton region was the major tourist area, receiving 45% of all commercial summer holiday visitors and 75% of the basin's convention visitors. The Kelowna and Vernon regions attracted approximately 20% of visitors staying at commercial accommodation while the Oliver-Osoyoos region attracted 13% of the Okanagan total.

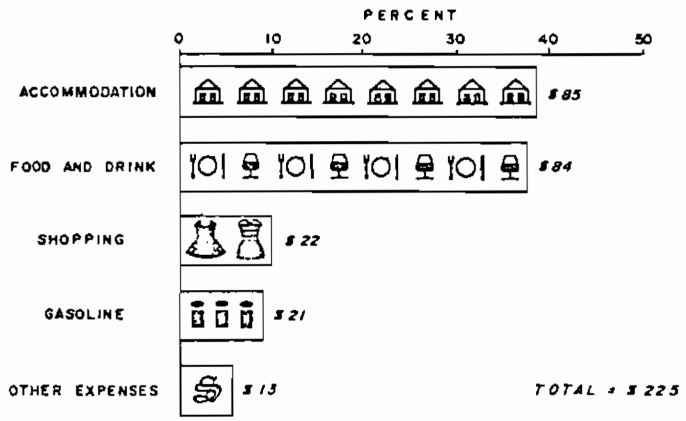
A survey of summer holiday visitors in 1970 indicated that an average group consisted of 4.5 persons and stayed for 6.4 days in the Okanagan. Based on these data, summer holiday visitors spent over 3.1 million visitor days in the basin in 1970 while business, convention and winter holiday visitors spent an additional 600,000 visitor days for a total of 3.7 million visitor-days in 1970 (Table 3.13).

TABLE 3.13

NUMBER OF VISITOR-DAYS IN THE OKANAGAN IN 1970

VISITOR TYPES	SUMMER	OFF-SEASON	TOTAL
Holiday	3,111,400	229,800	3,341,200
Business	78,000	156,000	234,000
Convention	32,400	120,000	152,400
TOTALS	3,221,800	505,800	3,727,600

Visitors spent over $16 million in the Okanagan in 1970, $11 million being spent by summer holiday visitors and over $3 million by convention visitors. The convention visitor spending has increased by 67% over 1967 totals, placing the Okanagan second only to Vancouver among British Columbia convention centres. Three quarters of total expenditures by summer tourists were spent on accommodation, food and beverages and about 10% on general shopping purposes (Figure 3.6). Over $1 million of the money spent by summer holiday visitors was derived from the sales of tree fruits, grapes and vegetables, indicating an important linkage between the tourist and agricultural sectors of the Okanagan economy.



AVERAGE EXPENDITURE PER GROUP OF SUMMER TOURISTS Figure 3·6

3.8 INDIAN RESERVES

Indian reserve lands include some 100,000 acres (See Figure 3.1) of which 13,600 acres lie below 1800 feet with considerable agricultural and recreational potential (Table 3.14). Much of these valuable lands are presently undeveloped, though recently the Indians have leased acreages for fodder crops and grapes (near Oliver) and for summer cottage development (North Arm of Okanagan Lake). In the late 1960's there have been increasing attempts by government agencies and private companies to encourage the Indians to make better use of their prime resource and this led to extensive development plans for residential and recreational development in reserve lands on the east side of Osoyoos Lake.

TABLE 3.14.

IRRIGATED AND POTENTIAL IRRIGABLE LAND[1]

OKANAGAN BASIN INOIAN RESERVES[2]

LOCATION IN BASIN	NAME OF RESERVE	IRRIGATEO OR POTENTIALLY IRRIGABLE LANO		
		IRRIGATED ACRES	POTENTIALLY IRRIGABLE ACRES	TOTAL ACRES
North Okanagan Lake Basin	Okanagan No. 1	400	5135	5535
	Okanagan No. 3	100	25	125
Central Okanagan Lake Basin	Winfield No. 1	0	403	403
	Tisinstekeptum No. 9 & 10	181	1559	1740
South Okanagan Lake Basin	Penticton No. 1 & 3	474	3226	3700
Okanagan River	Osoyoos No. 1	842	1307	2149
	TOTALS	1997	11655	13652

NOTES: (1) Potential Irrigable Land includes all Canada Land Inventory class 1 to 4 land within 500 feet in vertical elevation of potential water source.

(2) Indian Reserves shown in Figure 3.1.

CHAPTER 4

Water Quantity

Water quantity studies as defined under the Okanagan Basin Agreement were required: "to evaluate the existing hydrologic regime of the Basin, including studies of runoff, lake levels, flows, groundwater and geological structure, climatology and meteorology; to evaluate means of regulating flows through storage and diversion; and to evaluate means of augmenting water supplies within the Okanagan Basin."

In order to appraise the hydrologic regime in the Canadian portion of Osoyoos Lake, it has been necessary to extend the Study downstream to the lake outlet at Oroville, Washington. Hence, the Okanagan Basin referred to in this portion of the report includes some 3,250 square miles of drainage area of which 3,165 are in British Columbia (Figure 4.1).

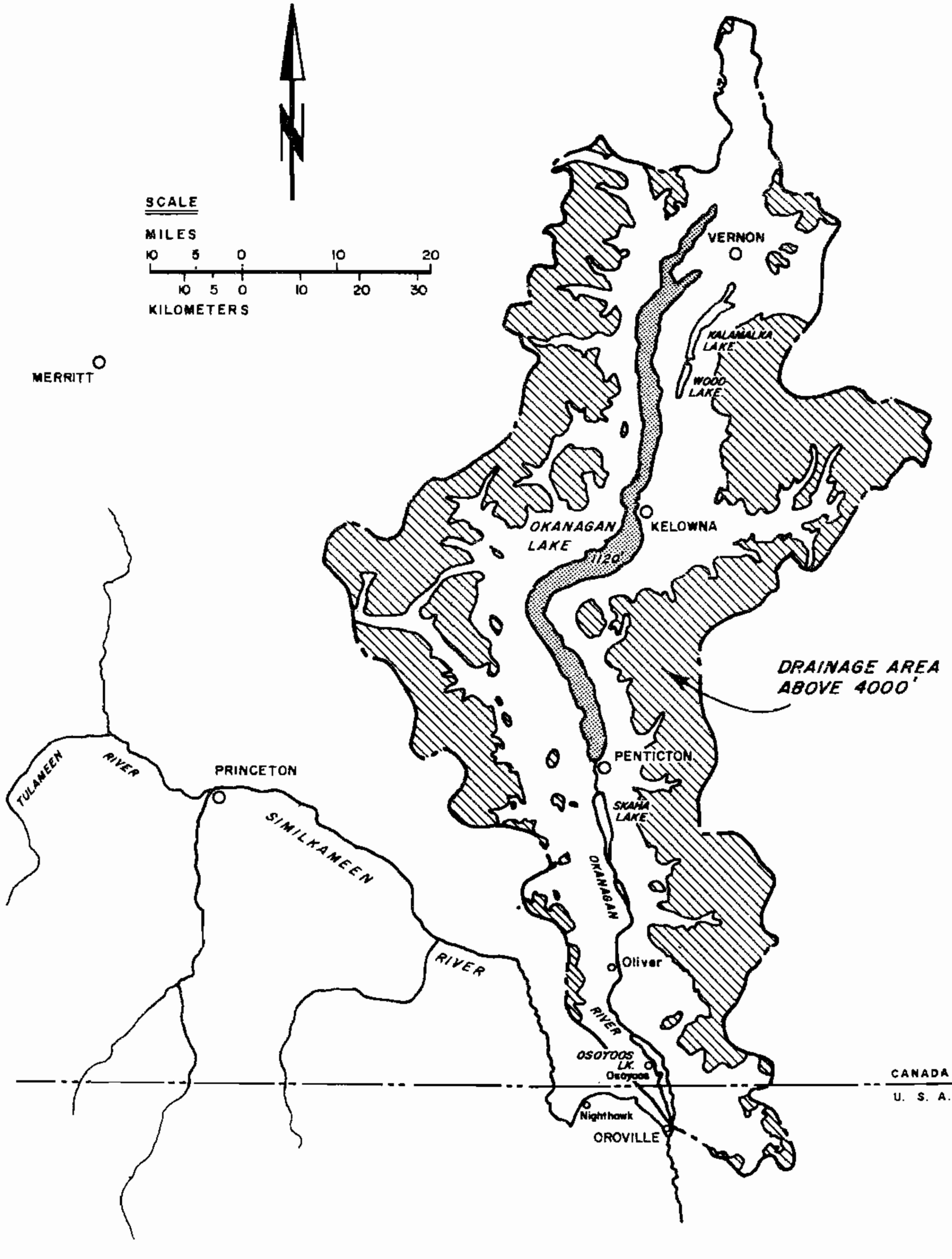
4.1 HYDROLOGY

4.1.1 Mainstem System

The Okanagan Basin hydrology is typical of the interior rivers of British Columbia, where the major portion of the annual runoff occurs during April to July inclusive, due primarily to snow melt in the higher portions of the Basin. Thus, in the Okanagan Lake Basin with an average elevation of 3,900 feet (Figures 4.1, and 4.2), snow accumulates during the winter months in the 4,000 to 7,000 foot band. Commencing in January, snow surveys are conducted at selected stations (Figure 4.3), from which forecasts of inflow to Okanagan Lake are estimated for the upcoming freshet period. Average snow water equivalents of two representative snow courses and accuracy of forecasts are illustrated in Figure 4.4.

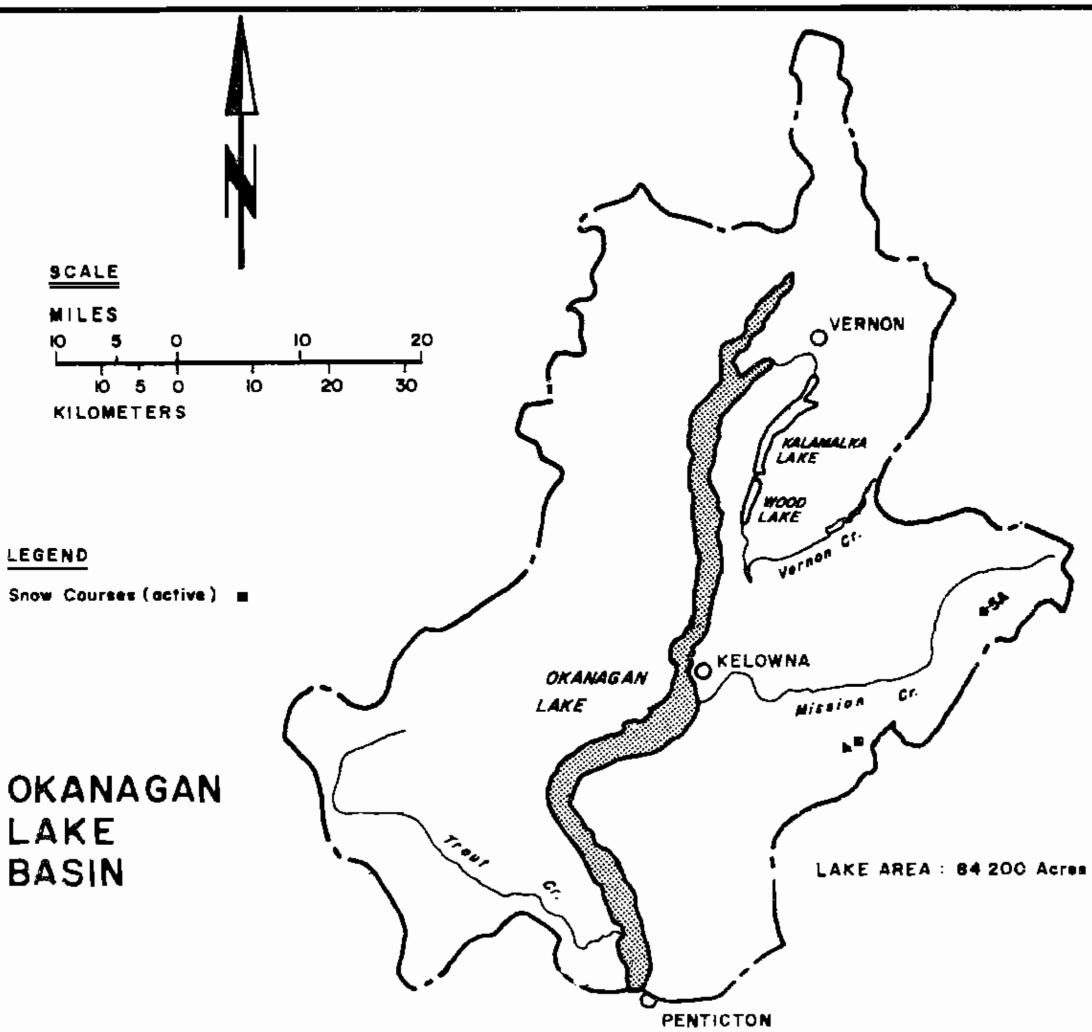
A portion of the gross inflow to Okanagan Lake Basin is retained in 50 headwater reservoirs which have a total active storage of 113,000 acre-feet (see Figure 4.5). The remaining inflow, in it's passage downstream to Okanagan Lake, is partially depleted by diversions from tributaries, primarily for irrigation purposes. The residual water entering Okanagan Lake, either as surface or groundwater flow, is further reduced through evaporation losses from the lake surface by 200,000 to 300,000 acre-feet per year. Thus, the net historic lake inflow, which is the actual water available in any particular year for use within Okanagan Lake or downstream, represents only a portion of the gross inflow to the Basin. Table 4.1 shows that of an average annual gross inflow to Okanagan Lake of 664,000 acre-feet, only about 332,000 are available in Okanagan Lake for use under present day development and operating practices.

819,036,696 m^3 409,518,348 m^3

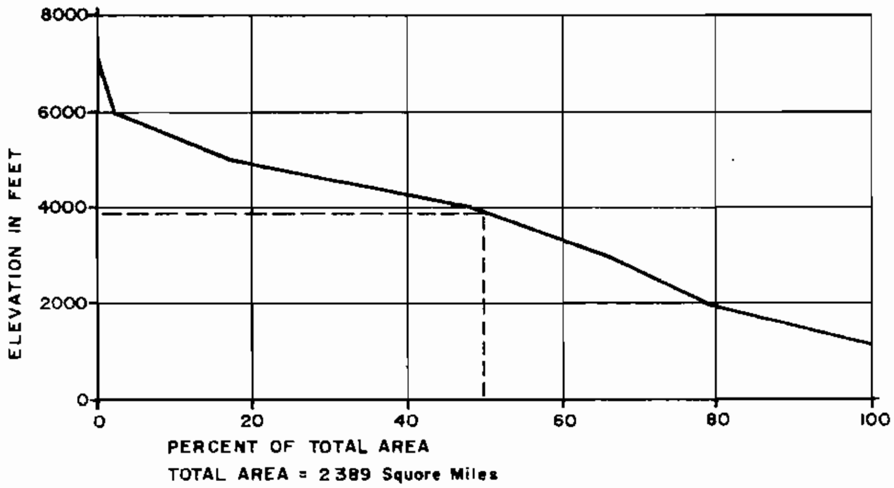


OKANAGAN BASIN NORTH OF OROVILLE
SHOWING UPPER DRAINAGE AREA
ABOVE 4000 FEET ELEVATION

Figure 4.1

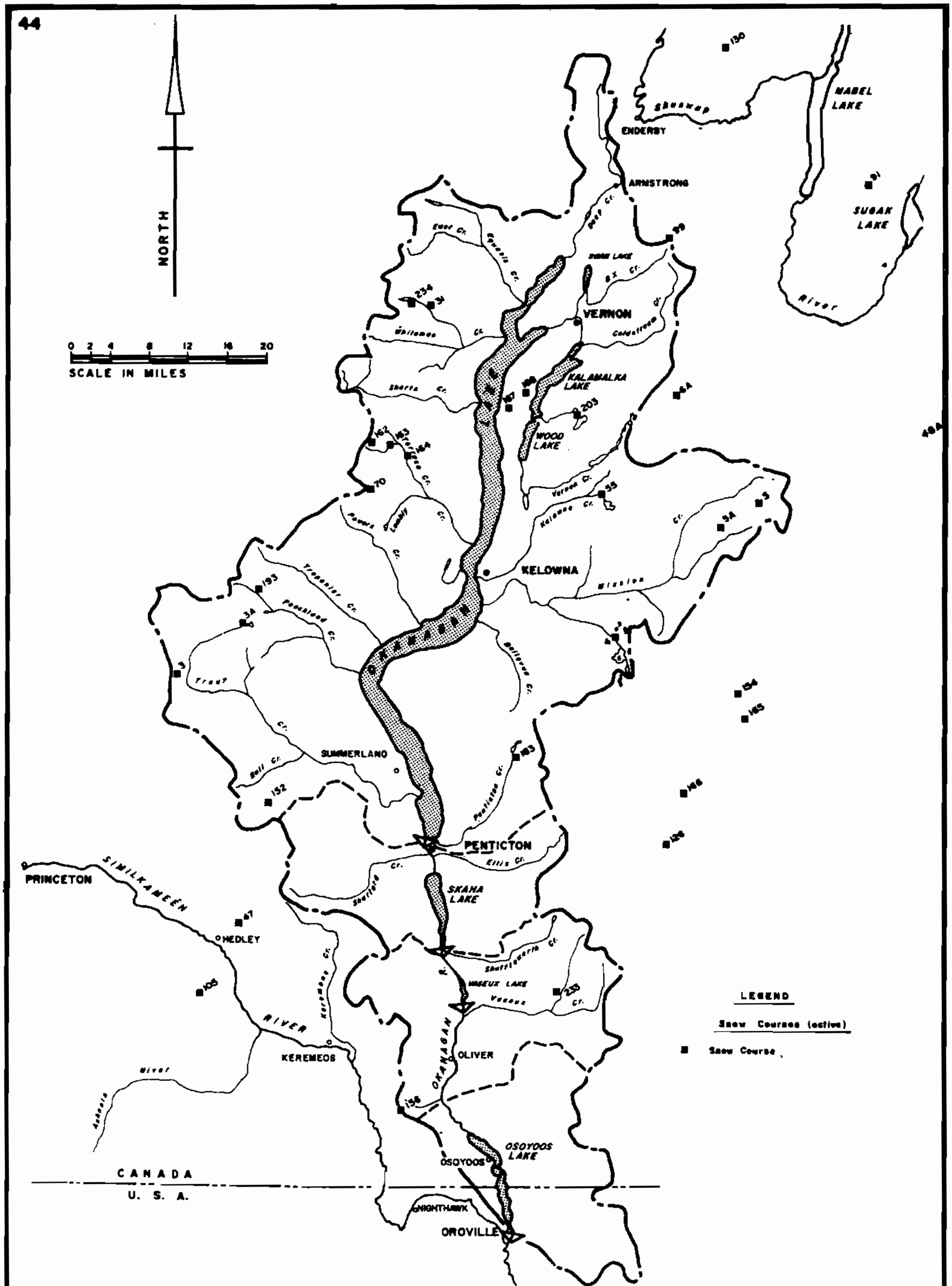


OKANAGAN LAKE BASIN



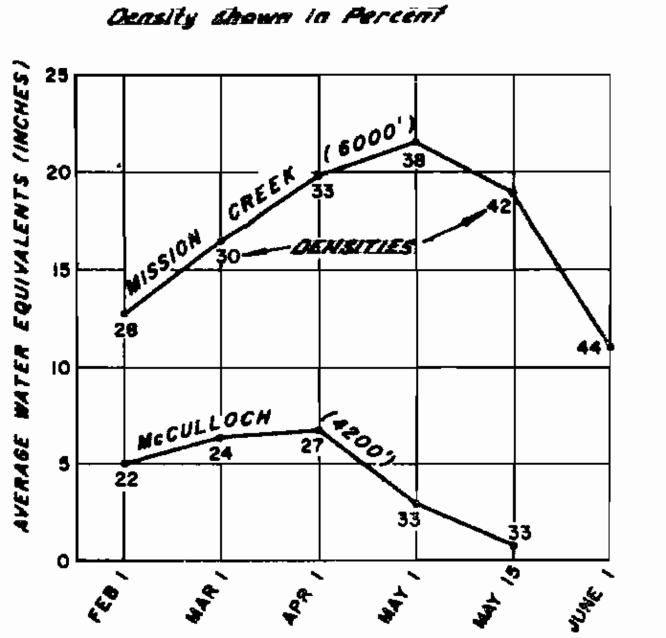
AREA-ELEVATION CURVE
OKANAGAN LAKE BASIN

Figure 4.2

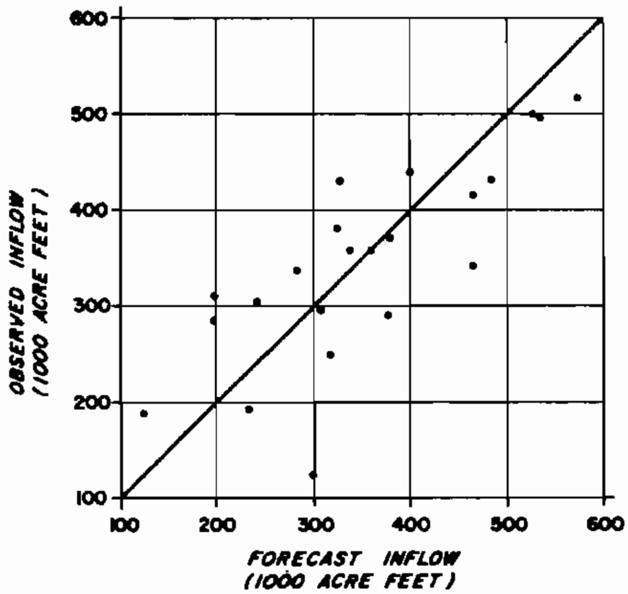


OKANAGAN BASIN
SNOW COURSES

Figure 4.3



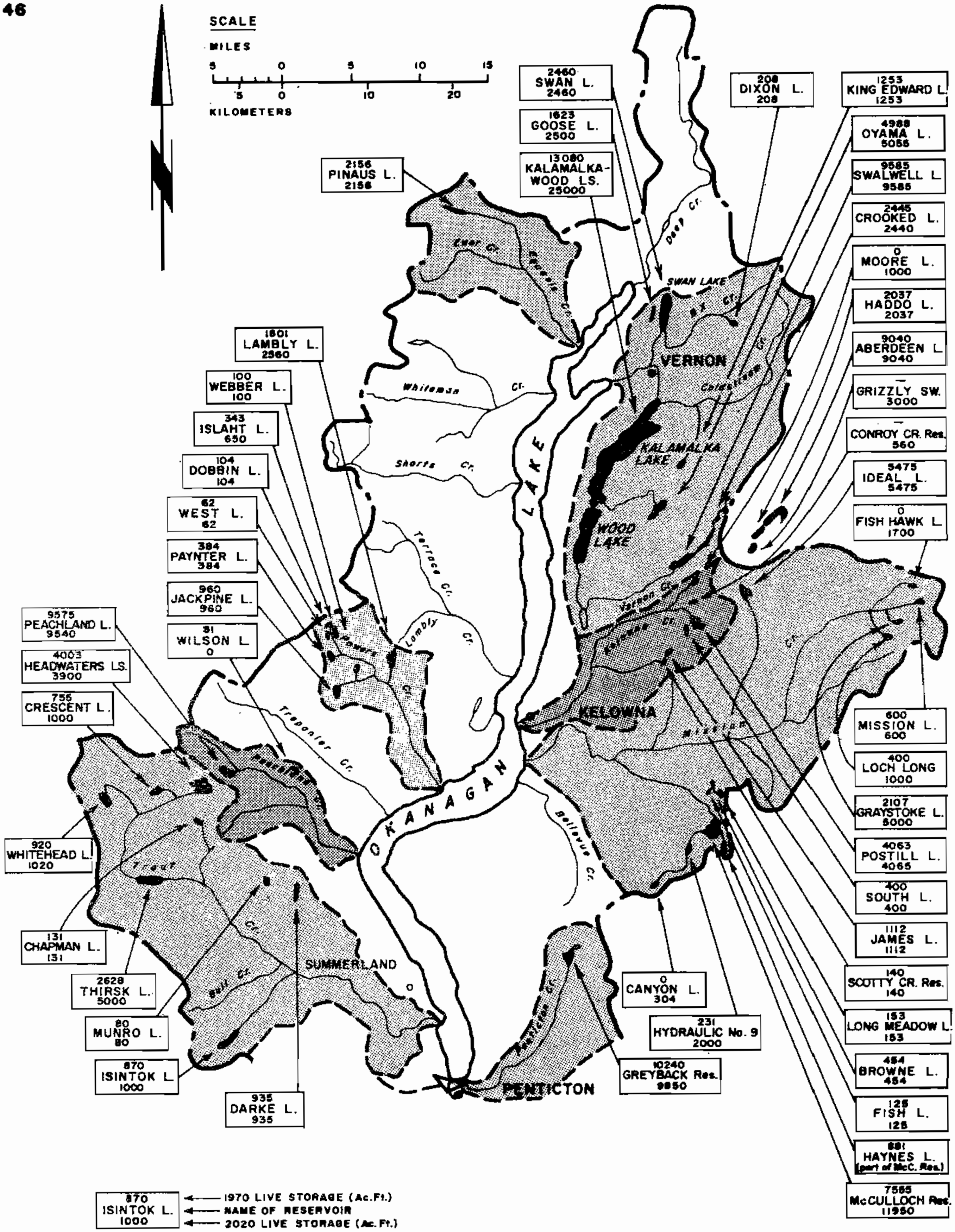
AVERAGE SNOW WATER EQUIVALENTS
MISSION CR. AND McCULLOCH SNOW COURSES
OKANAGAN LAKE BASIN



FORECAST ACCURACY
Without Hindsight Data

INFLOW TO OKANAGAN LAKE APRIL - JULY
YEARS 1950 - 1971

Figure 4.4



HEADWATER STORAGE RESERVOIRS IN 8 SELECTED TRIBUTARIES

Figure 4.5

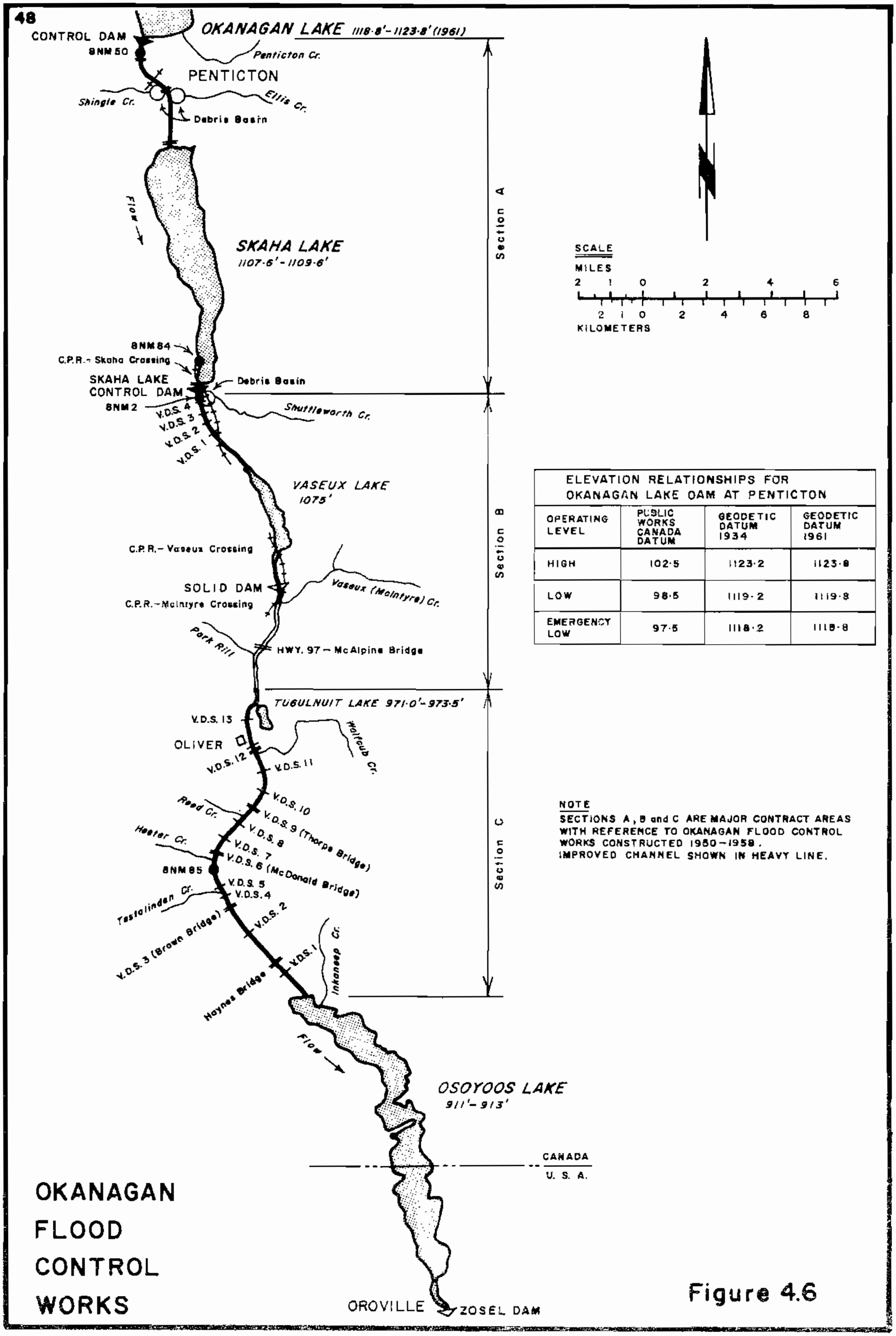
TABLE 4.1

AVERAGE ANNUAL WATER BUDGET-OKANAGAN LAKE BASIN

DESCRIPTION	INCHES ON OKANAGAN LAKE (131 SQUARE MILES)	INCHES OVER OKANAGAN LAKE BASIN (2,340 SQUARE MILES)	THOUSANDS OF ACRE FEET	REMARKS
Precipitation		21.80 554 mm		Period 1931-1960
Evapotranspiration		16.48 418 mm		Period 1921-1970
Gross Historic Basin Inflow		5.32 135 mm	664.0 (819,036,696 m³)	Period 1921-1970
Okanagan Lake Evaporation	38.0	2.14 54.3 mm	266.7	Period 1921-1970
Net Historic Basin Inflow		3.18 80.7 mm	397.3	Period 1921-1970
Consumptive Use under 1970 Development		0.52 13.2 mm	65.0	Irrigation, Domestic, Municipal & Industrial
Net Modified Lake Inflow (1970 Development)		2.66 67.5 mm	332.2 (409,518,348 m³)	Period 1921-1970

The outflow from Okanagan Lake is controlled by a concrete dam at Penticton (Figure 4.6). The normal operating range for Okanagan Lake water levels is 1119.8 to 1123.8 feet (Geodetic Survey of Canada, 1961 Datum), which were established at the time of constructing these works, but lower levels may be reached during prolonged drought periods, and higher levels reached during extreme floods. This four feet of storage on Okanagan Lake is equivalent to 340,000 acre-feet which is approximately the same as the average annual net runoff into Okanagan Lake under present day development. Since about 80% of the inflow to the Okanagan Lake Basin upstream of Oroville, Washington occurs above Penticton, the regulation of Okanagan Lake Dam is of prime importance to the Valley.

The Okanagan Lake Dam, along with other structures and improved river channel between Penticton and Osoyoos Lake, make up the Okanagan Flood Control Works. Ancillary works include the debris retaining basins at the mouths of Shattford (Shingle) Ellis and Shuttleworth Creeks. The operation of these works is under the direction of the B.C. Water Resources Service, Department of Lands, Forests and Water Resources, while maintenance costs are shared between this department and the Federal Department of Public Works. Discharges from Okanagan Lake Dam are limited by the channel capacity of the Okanagan River, which varies from 2,100 cfs. at Penticton to 3,400 cfs. at the inlet to Osoyoos Lake. Only minor regulation (9,400 acre-feet) can be obtained on Skaha Lake (surface area 4,710 acres) which is maintained between elevations 1107.6 and 1109.6 by a concrete dam at Okanagan Falls.



ELEVATION RELATIONSHIPS FOR OKANAGAN LAKE DAM AT PENTICTON

OPERATING LEVEL	PUBLIC WORKS CANADA DATUM	GEODETIC DATUM 1934	GEODETIC DATUM 1961
HIGH	102·5	1123·2	1123·8
LOW	98·5	1119·2	1119·8
EMERGENCY LOW	97·5	1118·2	1118·8

OKANAGAN FLOOD CONTROL WORKS

Figure 4.6

In addition to the Okanagan Flood Control Works, a small concrete dam at the outlet of Vaseux Lake (surface area 690 acres), operated by the Southern Okanagan Land Improvement District (S.O.L.I.D.), maintains a water elevation on the lake of 975 feet and diverts a portion of the flow, up to 150 cfs through a canal to serve irrigation requirements in and around Oliver.

The maximum discharge at Oliver below the Vaseux Lake dam is currently held below 3,000 cubic feet per second (c.f.s.) because of channel capacity limitations, local inflow from tributaries which is not controllable, and high water levels on Osoyoos Lake when flows in the Similkameen River are high.

The level of Osoyoos Lake is normally maintained between 910.0 and 912.0 feet GSC (910.3 and 912.3 USCGS) although the upper level may be exceeded in any flood year due to lack of control of floodwater on the Similkameen River. The lower level is maintained by the Zosel dam which is located at the outlet of Osoyoos Lake in the State of Washington, U.S.A. The original purpose of this structure when built in 1927 by the Zosel Lumber Company, was for the creation of a mill pond for log storage. In 1948 the dam was modified in accordance with the International Joint Commission's order of September 12, 1946 to pass 2,500 c.f.s. at a pool elevation not exceeding 911.0 feet USCGS (910.7 GSC). Because of the age of this structure, there is considerable leakage during low flow periods which has to be compensated for by additional releases from Okanagan Lake to maintain Osoyoos Lake at it's normal summer water elevation of 910.7 GSC.

Map 1 (Map Section) shows the schematic profiles of the main valley Okanagan Lakes and Okanagan River, and Table 4.2 summarizes the operating criteria for the Okanagan Flood Control Works.

4.1.2 Okanagan Lake Basin Water Budget

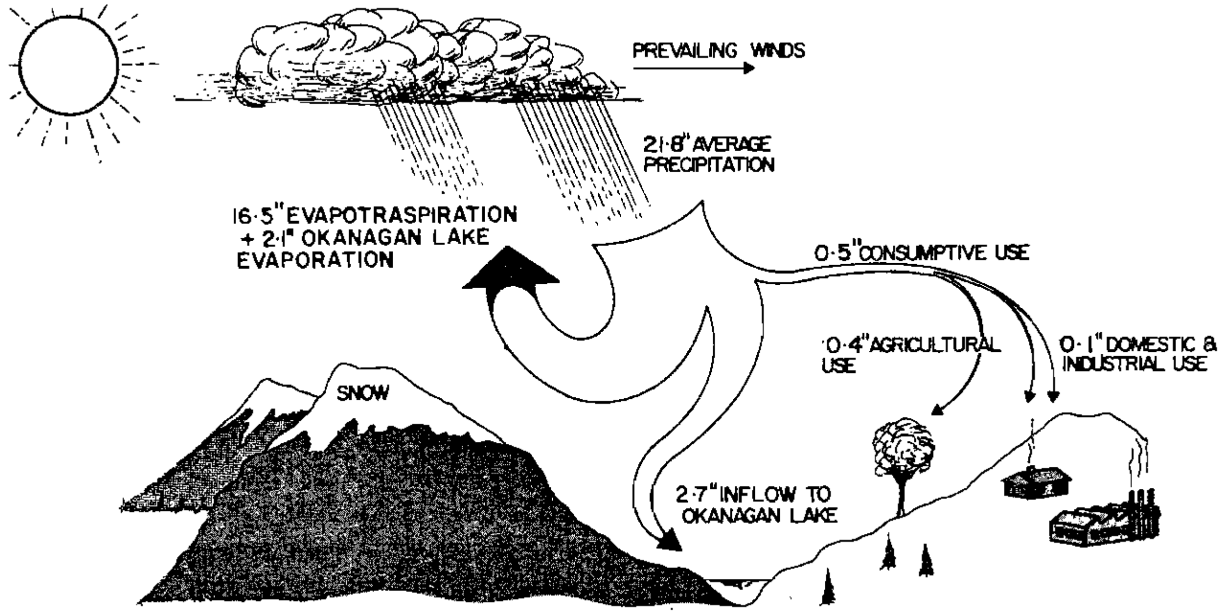
The predominance of Okanagan Lake Basin as a main source of water supply for the area has led to a detailed examination of its hydrology. Through the use of a grid square model technique, it has been possible to develop an isohyetal map showing average precipitation distribution over the whole basin north of Oroville (Figure 1.4). Based on this study, the average precipitation on Okanagan Lake Basin has been estimated at 21.8 inches. A schematic presentation of what happens to this precipitation is presented in Figure 4.7.

The water available in Okanagan Lake in an average inflow year is 332,000 acre-feet under present day (1970) development. This compares with the average net historic inflow of 355,000 acre-feet to Okanagan Lake. Thus, out of an average precipitation of 21.8 inches within the Okanagan Lake Basin, only 25% (5.32 inches) appears as runoff, and only about one half of this runoff is available for use in the mainstem Okanagan Lake and River system. Unfortunately, equivalent precipitation data over the whole basin for dry and wet years are not available, and therefore the more critical water budgets could not be developed.

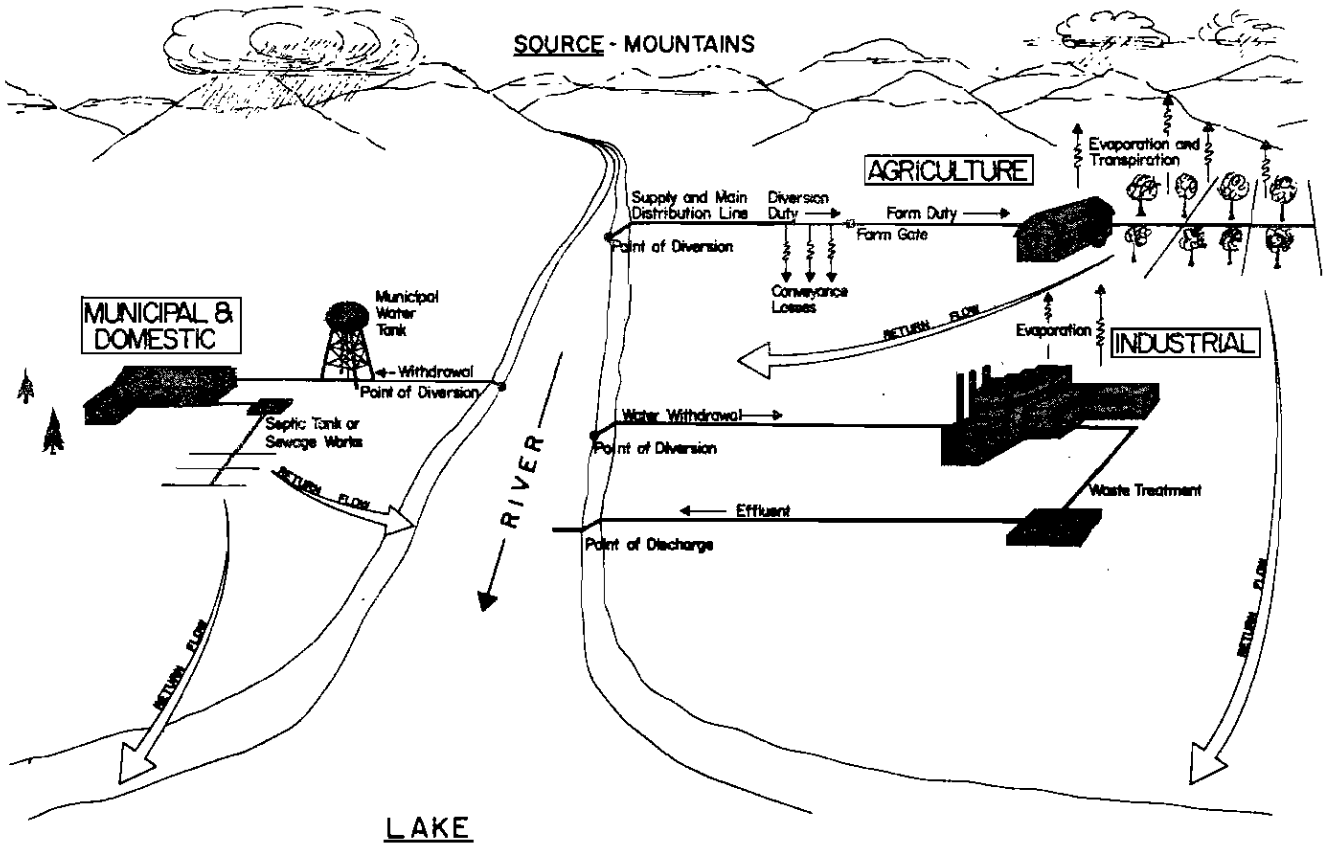
BUT THEY COULD NOW.

TABLE 4.2 ELEVATIONS AND DESIGN DISCHARGES, OKANAGAN FLOOD CONTROL WORKS AND OTHER CONTROL STRUCTURES

Drainage Basin	Drainage Area in sq. mi.		Details of Okanagan Flood Control Works Note: Elevations based on Geodetic Survey of Canada 1961 datum						
	Local	Cumulative	Structure	Operating Level in ft.		Operating Range in ft.	Discharge Capacity in cfs	Lake Surface Area in ac.	Remarks
				High	Low				
Okanagan Lake Hydrometric Sta. No. 8NM-50 at Penticton	2388.7	2388.7	Okanagan Lake Dam at Penticton	1118.8	1123.8	.5	2100 with 2 ft. gate opening and at lake elevation 1119.8	84200	5 sluice gates sill elevation: 1114.6 normal range: 1119.8 - 1123.8 emergency range: 1118.9-1123.8 extreme lake surface area at high water: 86080 ac.
Okanagan River between Hydrometric Sta. No. 8NM-50 at Penticton and Hydrometric Sta. No. 8NM-84 at Okanagan Falls	286.9	2675.6	Okanagan River between Ok.Lk. Dam and Shingle Cr. Shingle Cr. and Ellis Cr. Ellis Cr. and Skaha Lk.				2100 2400 2700		140 ft. base 2:1 side slope approx. 6 ft. fall
			Skaha Lake Dam at Okanagan Falls	1107.6	1109.6	2	2700 at lake elevation 1107.6 (6' above crest)	4710	4 radial gates and 6 stop log bays top gates elevation: 1110.1
Okanagan River between Hydrometric Sta. No. 8NM-84 at Okanagan Falls and Hydrometric Sta. NO. 8NM-85 near Oliver	117.8	2993.4	Okanagan River between Skaha Lake Dam and Vaseux Lake Dam SOLIO Canal				2800 150		Includes 4 drop structures
			Vaseux Lake Dam (SOLIO Diversion Dam)					690	Vaseux Lake normal elevation: 1074.6 flooding starts at lake elevation: 1076.0
			Okanagan River between Vaseux Lake Dam and Osoyoos Lake				3400		channel width varies from 74 ft. to 88 ft. includes 13 drop structures
Okanagan River between Hydrometric Sta. No. 8NM-85 near Oliver, B. C. and International Boundary	172.3	3165.7	Osoyoos Lake					3657	Osoyoos Lake Normal elevation: 912.1
Okanagan River between International Boundary and Hydrometric Sta. NO. 8NM-127 at Oroville, Wash.	89.0	3254.7						2003 Total: 5660	



WATER CYCLE IN THE OKANAGAN LAKE BASIN IN AN AVERAGE RUNOFF YEAR



WATER USE DIAGRAM

Figure 4.7

However, the budget for average conditions does point up the major difficulties in attempting to forecast the annual inflow to Okanagan Lake, particularly during extreme droughts when natural losses through evapotranspiration and lake evaporation make up even a larger portion of the total than those under average conditions.

4.1.3 Hydrometric, Meteorological and Water Use Data

The hydrometric and meteorological data available for the Okanagan Basin has been and still is very limited. Monthly historic inflows from the tributaries to Okanagan Lake for the 50 year study period of April 1921 to March 1971 inclusive have therefore been estimated and adjusted to allow for historic consumptive use, tributary storage changes and evaporation from Okanagan Lake. These calculated inflows provided the "gross" historic inflow to the Okanagan Lake Basin. Equivalent data were also developed for the portions of the Okanagan Basin between Penticton and Okanagan Falls and Okanagan Falls and Oliver. For the section south of Oliver through to Oroville, only the historic records for the period 1943 to 1970 were used.

Over the 50 year historic study period, agriculture has been the major user of water and the requirements for irrigation alone make up 80% of the total consumptive use within the Basin. Most of this development has taken place within the tributaries of Okanagan Lake where some 45,000 acres(out of a total of 60,000 acres for the whole basin) are served from these sources, supported by headwater storage reservoirs.

It has been assumed that 50% of the water diverted from tributary sources as well as that taken from the mainstem system appears as return flow either to Okanagan Lake or to the main river and lake system downstream. Similarly it was assumed that 65% of the water used for domestic and municipal purposes, and 90% of the water used for industrial purposes is returned to the system. These various types of use including diversion, consumptive use and return flow are demonstrated graphically in the water use diagram shown in Figure 4.7. The historic evaporation and precipitation on Okanagan, Skaha, Vaseux and Osoyoos Lakes have also been calculated in order to complete the water cycle budget. (For details, see Technical Supplements I and II).

4.2 PRESENT (1971) WATER REQUIREMENTS

Agricultural water requirements were based on the amount of land irrigated and water duties recommended by the B.C. Department of Agriculture, with all return flow credited to Okanagan Lake or the main river system. Municipal and domestic water requirements as well as industrial withdrawals were determined from municipal records.

In addition to the above consumptive use requirements, are the in-channel flows needed to maintain minimum residual discharges and flows to maintain fisheries. In the operation of the Okanagan Flood Control Works, these non-consumptive requirements have normally been met.

While fishery flow requirements in the tributaries have recently been developed, the management of water in these sub-basins has, to date, been primarily for consumptive use requirements only.

Hence, present water requirements based on historical practices, include all consumptive uses, both in the tributaries and the mainstem system with minimum and fishery flow requirements included only for the latter. Tables 4.3(a), 4.3(b) and 4.3(c) detail these requirements, while Table 4.4 summarizes this data.

From Table 4.4, it can be seen that the consumptive use along the Okanagan River from Penticton to Osoyoos Lake is only about one half that required in the Okanagan Lake Basin. However, residual or minimum flows needed to provide for lake evaporation losses, adequate submergence of intakes during the irrigation season (April to September inclusive), and minimum salmon fishery flows downstream of Vaseux Lake, total about two thirds of the total water requirements for the whole basin.

4.3 WATER SUPPLY AND FLOOD CONTROL

The regulation of Okanagan Lake, the major storage reservoir in the Valley, is the key to water quantity management in the mainstem Okanagan. Its large storage capacity can be used in high runoff years to reduce the threat of flooding and in low runoff years to provide additional water supplies to and around the lake and south of its outlet at Penticton. Indeed, the lake supplies almost all Okanagan River flows which serve consumptive and non-consumptive uses south of Penticton as well as areas adjacent to Okanagan Lake.

This study has been concerned not only with the adequacy of water supply sources to meet present and future needs, but also the management of these systems under extreme flood and drought conditions.

Present day water management practices are based on the "Okanagan Flood Control Report of 1946" prepared by the Joint Board of Engineers formed by the Federal and Provincial Governments. The level of Okanagan Lake is normally maintained within the four foot range - 1119.8 feet to 1123.8 feet GSC - as recommended by the Joint Board of Engineers. However, due to the large variability in annual inflows to Okanagan Lake and the difficulty of forecasting these inflows accurately, fluctuation above and below this four-foot range are possible. Because most shoreline development has adjusted to the normal range of lake levels,

TABLE 4.3 (a)

DIVERSION (WITHDRAWAL), CONSUMPTIVE USE & RETURN FLOW FOR OKANAGAN RIVER BASIN IN B.C. - 1970

I. OKANAGAN LAKE DRAINAGE (Region north of Okanagan Lake Dam at Penticton) Population 102,000; Ac. irrig. 46,000

MONTH	IRRIGATION: Diversion 113,160 ac-ft; Return Flow 56,580 ac-ft; Consumptive Use 56,580 ac-ft					MUNICIPAL & DOMESTIC: Diversion 22,760 ac-ft; Return Flow 14,790 ac-ft; Consumptive Use 7,970 ac-ft					INDUSTRIAL: Diversion 26,500; Return Flow 22,320; Consumptive Use 4,180				TOTAL CONS. USE
	DIVERSION		RETURN FLOW		CONS. USE	DIVERSION		RETURN FLOW		CONS. USE		DIVER-SION	RETURN FLOW	CONS. USE	
	%	ac-ft	%	ac-ft	ac-ft	%	ac-ft	%	ac-ft	ac-ft	%	ac-ft	ac-ft	ac-ft	ac-ft
Apr.	-	-	4	2260	-2260	6	1360	7	1030	330	7	1860	1570	290	-1640
May	15	16970	11	6230	10740	10	2280	9	1330	950	8	2120	1780	340	12030
June	25	28290	14	7920	20370	13	2960	10	1480	1480	9	2390	2010	380	22230
July	25	28290	15	8490	19800	16	3640	13	1920	1720	10	2650	2230	420	21940
Aug.	25	28290	14	7920	20370	16	3640	12	1770	1870	11	2920	2460	460	22700
Sep.	10	11320	12	6790	4530	8	1920	10	1480	340	12	3180	2680	500	5370
Oct.	-	-	9	5090	-5090	7	1590	8	1180	410	8	2120	1780	340	-4340
Nov.	-	-	5	2830	-2830	5	1140	7	1040	100	7	1860	1570	290	-2440
Dec.	-	-	5	2830	-2830	5	1140	6	890	250	7	1850	1560	290	-2290
Jan.	-	-	4	2260	-2260	5	1140	6	890	250	7	1850	1560	290	-1720
Feb.	-	-	4	2260	-2260	4	910	6	890	20	7	1850	1560	290	-1950
Mar.	-	-	3	1700	-1700	5	1140	6	890	250	7	1850	1560	290	-1160
TOTAL		113160		56580	56500		22760		14790	7970		26500	22320	4180	68730

NOTE 1. Irrigation volumes include a 10% allowance for conveyance losses.

NOTE 2. Consumptive Use is calculated from the amount diverted less the return flow, month by month

NOTE 3. No allowance has been made for minimum residual flows or fishery requirements in tributaries of Okanagan Lake

TABLE 4.3 (b)

DIVERSION (WITHDRAWAL), CONSUMPTIVE USE & RETURN FLOW FOR OKANAGAN RIVER BASIN IN B.C. - 1970

II. OKANAGAN RIVER REGION (From Okanagan Lake Dam at Penticton to International Boundary at Osoyoos Lake)

Population - 10,980; Land irrigated - 14,000 acres.

MONTH	IRRIGATION: Diversion 62,860 ac-ft; Return Flow 31,430 ac-ft; Consumptive Use 31,430 ac-ft					MUNICIPAL & DOMESTIC: Diversion 2,110 ac-ft; Return Flow 1,370 ac-ft; Consumptive Use 740 ac-ft					INDUSTRIAL: Diversion 1,500; Return Flow 1,270; Consumptive Use 230				TOTAL CONS. USE
	DIVERSION		RETURN FLOW		CONS. USE	DIVERSION		RETURN FLOW		CONS. USE		DIVER-SION	RETURN FLOW	CONS. USE	
	%	ac-ft	%	ac-ft	ac-ft	%	ac-ft	%	ac-ft	ac-ft	%	ac-ft	ac-ft	ac-ft	ac-ft
Apr.	-	-	4	1260	-1260	7	150	7	100	50	7	110	100	10	-1200
May	15	9430	11	3460	5970	11	230	9	120	110	8	120	100	20	6100
June	25	15710	14	4400	11310	13	270	10	140	130	9	130	110	20	11460
July	25	15720	15	4710	11010	15	320	13	180	140	10	150	130	20	11170
Aug.	25	15710	14	4400	11310	13	270	12	160	110	11	160	130	30	11450
Sep.	10	6290	12	3770	2520	9	190	10	140	50	12	180	150	30	2600
Oct.	-	-	9	2830	-2830	6	130	8	110	20	8	120	100	20	-2790
Nov.	-	-	5	1570	-1570	5	110	7	100	10	7	110	90	20	-1540
Dec.	-	-	5	1570	-1570	5	110	6	80	30	7	110	90	20	-1520
Jan.	-	-	4	1260	-1260	5	100	6	80	20	7	110	90	10	-1220
Feb.	-	-	4	1260	-1260	5	100	6	80	20	7	100	90	10	-1230
Mar.	-	-	3	940	- 940	6	130	6	80	50	7	100	90	10	- 880
TOTAL		62860		31430	31430		2110		1370	740		1500	1270	230	32400

NOTE 1. Irrigation volumes include a 10% allowance for conveyance losses.

NOTE 2. Consumptive Use is calculated from the amount diverted less the retrn flow, month by month.

TABLE 4.3(c)

SUMMARY OF FISHERY AND MINIMUM FLOW REQUIREMENTS
FOR THE OKANAGAN RIVER IN BRITISH COLUMBIA

MONTH	FISHERY REQUIREMENTS				MINIMUM FLOW Okanagan River below Penticton Dam	
	Minimum Flow at Osoyoos Lake outlet	In Okanagan River Channel below S.O.L.I.D. Dam				
		Desirable Range	Maximum (Gravel Scour)	Minimum Fishery Flow	Present Con-ditions	With Improve-ments
	c.f.s.	c.f.s.	c.f.s.	c.f.s.	c.f.s.	c.f.s.
APRIL		175 - 1000		175	300	100
MAY					300	100
JUNE					300	100
JULY 1-15					300	100
16-31	100				300	100
AUGUST	100	300 - 450		300	300	100
SEP. 1-15	100	300 - 450		300	300	100
16-30		350 - 550		350	300	100
OCTOBER		350 - 550		350	100	100
NOVEMBER		175 - 1000	1000	175	100	100
DECEMBER		175 - 1000	1000	175	100	100
JANUARY		175 - 1000	1000	175	100	100
FEB. 1-15		175 - 1000	1000	175	100	100
16-28		175 - 1000		175	100	100
MARCH		175 - 1000		175	100	100

TABLE 4.4

PRESENT (1970) CONSUMPTIVE USE REQUIREMENTS
IN OKANAGAN LAKE BASIN AND TOTAL WATER
REQUIREMENTS OKANAGAN RIVER BASIN IN CANADA

	Acre Feet	Acre Feet	Percent of Total
1 OKANAGAN LAKE BASIN			
(a) CONSUMPTIVE USE from tributaries and directly from area adjacent to Okanagan Lake			
Irrigation	56,580		
Municipal & Domestic	7,970		
Industrial	4,180		
Total Okanagan Lake Basin Consumptive Use		68,730	22.0
2 MAINSTEM OKANAGAN RIVER			
(a) CONSUMPTIVE USE			
Irrigation	31,430		
Municipal & Domestic	740		
Industrial	230		
Total Okanagan River Consumptive use		32,400	10.4
(b) EVAPORATION LOSSES FROM SKAHA Vaseux and Osoyoos Lakes	49,120		
(c) MINIMUM FLOW REQUIREMENTS Intake submergence, flushing, aesthetics additional water to meet salmon fishery flows	122,660 39,320	211,100	67.6
Okanagan Lake Basin consumptive use and main Okanagan River water requirements		312,230	100.0

such extreme fluctuations can cause inconvenience and even damage to shoreline users. In a succession of drought years, there may not be sufficient water to maintain Okanagan Lake within its normal range and at the same time supply all downstream requirements in Okanagan River. Thus, either Okanagan Lake must be drawn down below its normal low water elevation, or water releases to Okanagan River must be reduced.

At the other extreme, Okanagan Lake must be carefully regulated during high inflows. When large runoffs are forecast, the lake is normally drawn down in the early spring to accommodate the freshet. The degree of drawdown possible and the volume of water that can be released during the freshet is dependent on the channel capacity of Okanagan River and the complicated hydrology of Osoyoos Lake. High flows in the Similkameen River can restrict releases from Osoyoos Lake and this, coupled with the need to maintain high discharges down Okanagan River, can create flooding on Osoyoos Lake. In practice, a balance must be sought to minimize the flood damage around both lakes.

A drought year is defined as one in which the net inflow to Okanagan Lake is less than the water requirements (244,000 acre-feet), while a flood year is defined as one with an inflow of 550,000 acre-feet or greater. These volumes can be compared with the normal four foot storage in Okanagan Lake equivalent to 340,000 acre-feet. Thus, the regulation of Okanagan Lake varies from strict conservation to the other extreme of flood control.

The present methods of operating both the mainstem system and the tributaries, were simulated in computer models. The output from the models in the form of water levels and discharges, was used as the basis for comparison of alternative water management options.

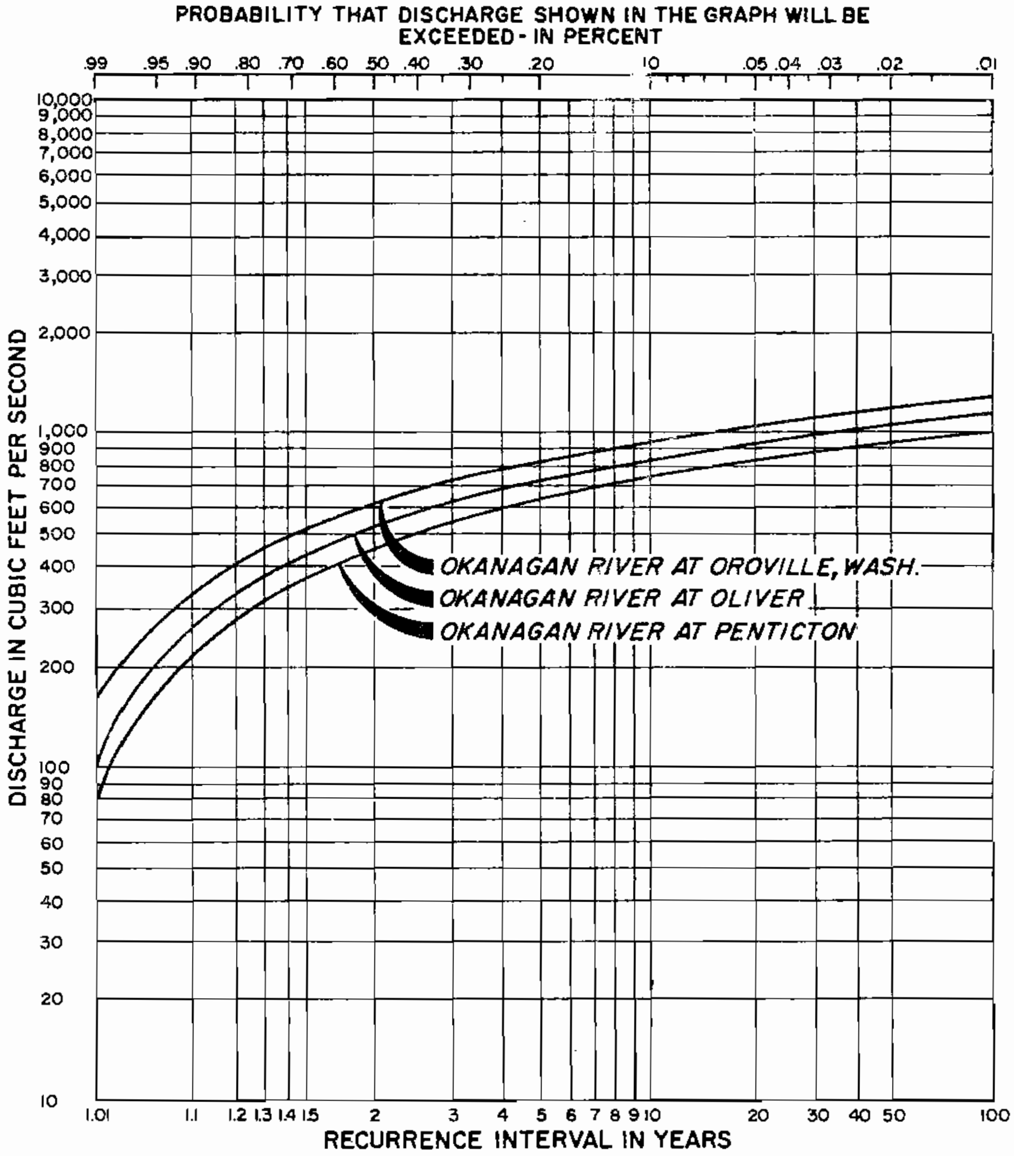
The annual discharges for Okanagan River at Penticton, Oliver and Oroville as similated by the mainstem computer model, are shown in Figure 4.8. These model discharges assume the Okanagan Flood Control Works in operation for the 50 year period of record (1921-1970), and are based on 1970 consumptive demands in the Okanagan Lake Basin.

The model terminates at the hydrometric station four miles south of Oliver and the equivalent discharges at Oroville, Washington have been prepared from the more limited historical data available for the period 1943 to 1970.

The discharges at Penticton are between 81 and 85 percent of the Oliver discharges. The gross local inflow for the Penticton-Oliver and the Oliver-Oroville reaches of the river compared with the gross inflow to Okanagan Lake Basin, for dry, average and wet years (selected from the limited common period of 1943 to 1970) are listed in Table 4.5 and illustrated for an average inflow year in Figure 4.9. This provides further evidence of the dominant role Okanagan Lake Basin

TABLE OF ANNUAL AVAILABLE FLOWS AT VARIOUS PROBABILITY LEVELS

FLOW UNIT	MEAN FLOW	FLOW EQUALLED OR EXCEEDED IN PERCENT OF TIME				LOCATION
		50 Median Flow	80	90	95	
C.F.S. K.A.F.	646 467.7	625 452.5	433 313.5	345 249.8	276 199.8	Okanagan River at Oroville, Wash.
C.F.S. K.A.F.	548.5 397.1	529.6 383.4	353.9 256.2	272.3 197.1	209.9 152.0	Okanagan River at Oliver
C.F.S. K.A.F.	466.0 337.4	449.0 325.4	296.0 214.3	224.8 162.4	170.3 123.3	Okanagan River at Penticton



FREQUENCY CURVE, COMPUTER MODEL SIMULATION OF ANNUAL DISCHARGE, OKANAGAN RIVER AT PENTICTON AND OLIVER AND ANNUAL HISTORIC DISCHARGE, OKANAGAN RIVER AT OROVILLE, WASH.

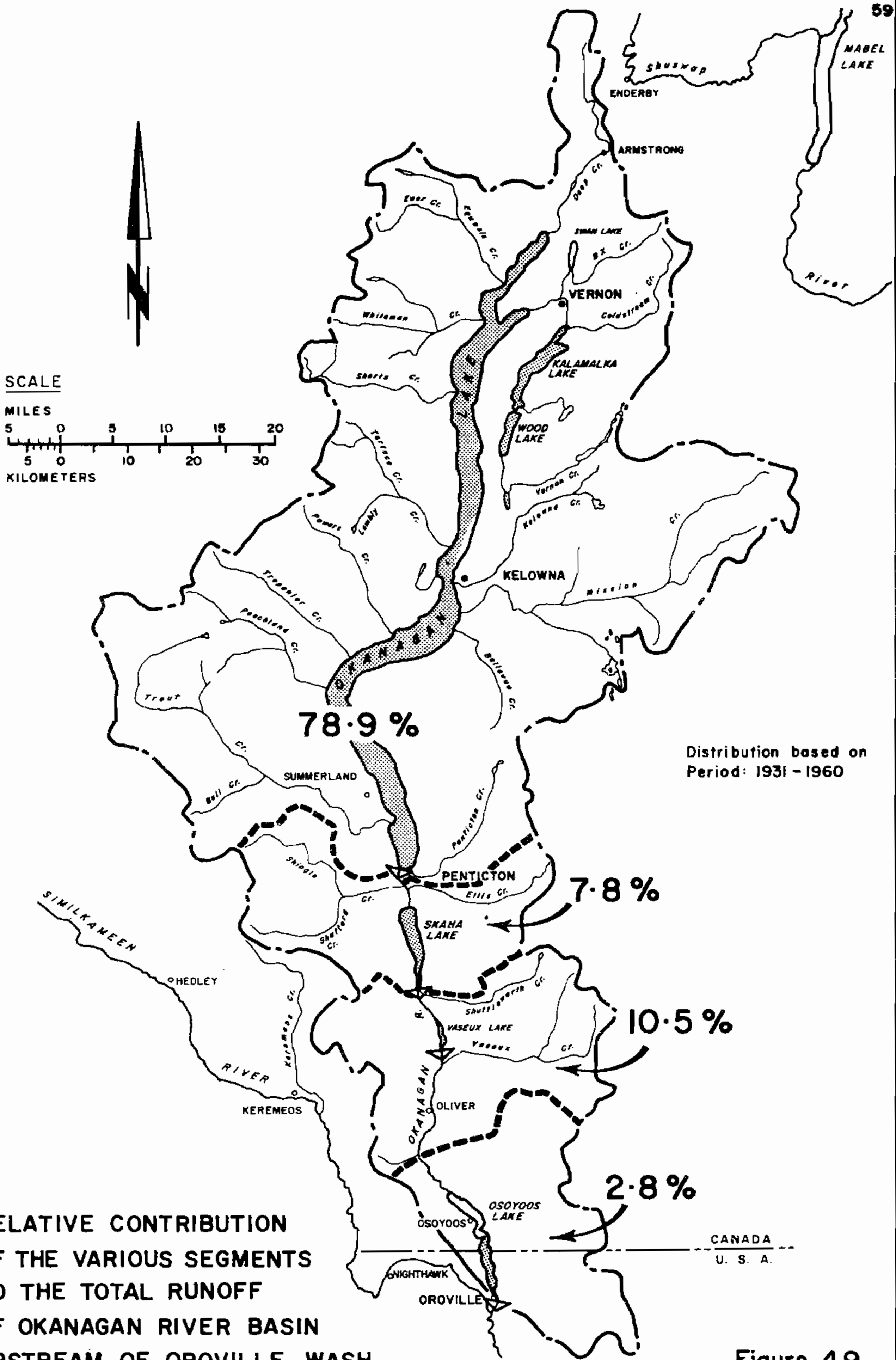
Figure 4.8

TABLE 4.5

COMPARISON OF ANNUAL GROSS HISTORIC INFLOWS TO VARIOUS SEGMENTS OF OKANAGAN RIVER BASIN UPSTREAM OF OROVILLE, WASHINGTON, WITH ANNUAL GROSS HISTORIC INFLOW TO OKANAGAN LAKE BASIN FOR SELECTED YEARS

DRAINAGE BASIN	DRAINAGE AREA		DRY YEAR (1970)			AVERAGE YEAR (1958)			WET YEAR (1959)		
	SQUARE MILE	PERCENT	KILO-SQUARE-FEET	PERCENT	INCHES	KILO-SQUARE-FEET	PERCENT	INCHES	KILO-SQUARE-FEET	PERCENT	INCHES
Okanagan Lake	2388.7	100.0	382.1	100.0	3.06	690.8	100.0	5.54	932.4	100.0	7.47
Okanagan River Between Penticton and near Oliver	604.7	25.3	74.1	19.4	2.30	114.3	16.5	3.54	146.5	15.7	4.54
Okanagan River Between near Oliver and Oroville, Wash.	261.3	10.9	54.3	14.2	3.90	99.5	14.4	7.14	114.0	12.2	8.18
Okanagan River Between Penticton and Oroville, Wash.	866.0	36.2	128.4	33.6	2.78	213.8	30.9	4.63	260.5	27.9	5.64

NOTE: The above table is based on the period 1943-1970



RELATIVE CONTRIBUTION OF THE VARIOUS SEGMENTS TO THE TOTAL RUNOFF OF OKANAGAN RIVER BASIN UPSTREAM OF OROVILLE, WASH.

Figure 4.9

inflow plays in meeting the water requirements of the tributaries and along the mainstem. While Osoyoos Lake was not included in the mainstem model, the minimum releases at its termination point at the Oliver hydrometric station have included what are considered to be adequate allowances for consumptive and natural losses as well as in-channel flows between Oliver and Osoyoos Lake.

4.3.1 Okanagan Mainstem Operation

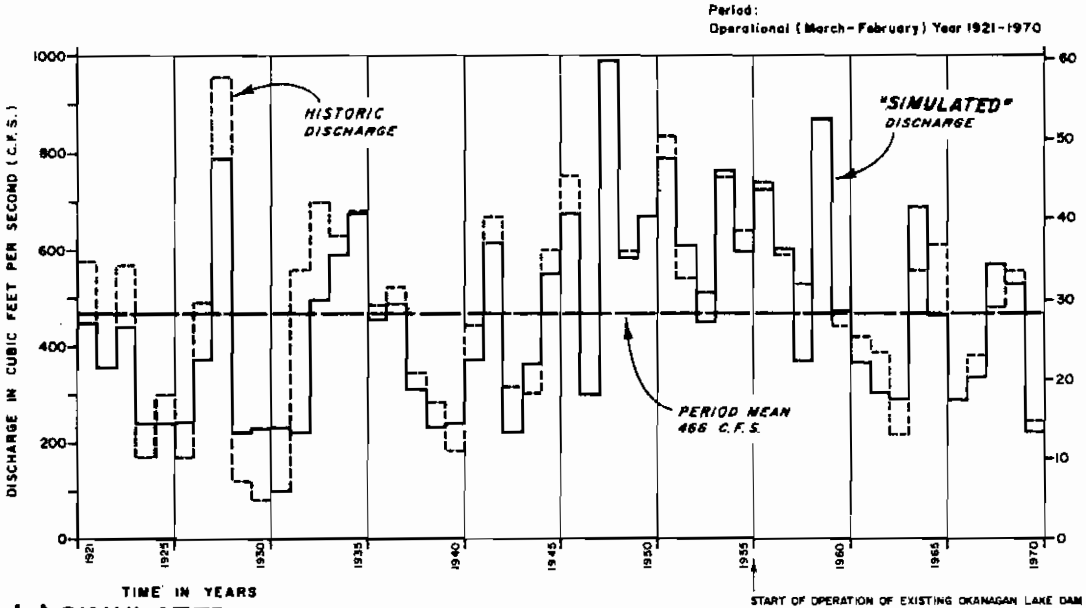
The mainstem computer model which simulated the operation of Okanagan Lake and Okanagan River from Penticton to Oliver required definition of the present water management objectives and policies. Using these and computed inflows, the model was used to simulate operation on a monthly basis over the 50 year period 1921 to 1970. In running the model it was assumed that the Okanagan Flood Control Works (Figure 4.6), which were actually constructed during the period 1950 to 1958, were in operation throughout the period. In each run it was assumed that either the present day water requirements or some projected future set of water demands were met for the 50 year period. The model generated inflow forecasts so that the simulation would have the degree of uncertainty that exists in practice due to the errors inherent in making forecasts.

Since the completion of the Okanagan Lake Dam in 1956, water releases have been based on meeting consumptive use and in-channel minimum flow requirements. In most years, any additional discharges to provide minimum fishery flows required for the successful migration of sockeye salmon through Osoyoos Lake and as far upstream as Vaseux Lake Dam, have also been released.

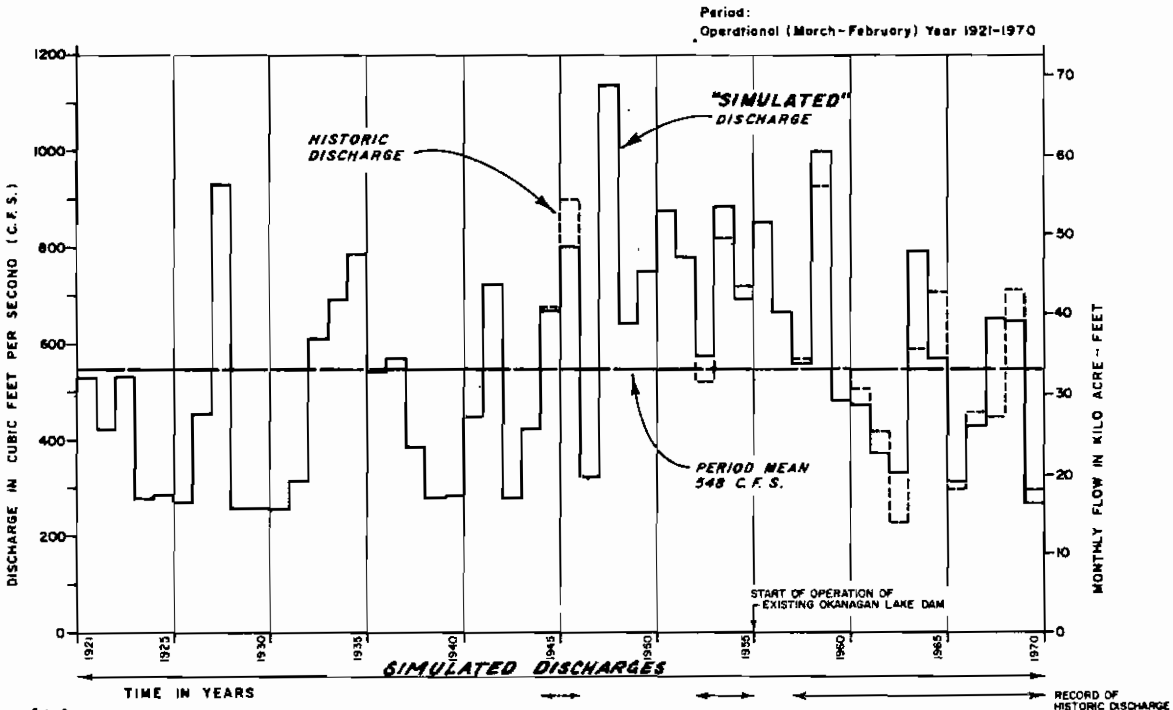
Details of this model can be found in Technical Supplement II "Water Quantity Computer Models".

The degree of success in the operation of the model can be judged by an examination of Figure 4.10 for the period 1956 to 1970 in which the model discharges at Penticton and Oliver compare very closely with the actual discharges which occurred. Similarly, while the model terminated at Oliver, the historic flows at Oroville from 1956 to 1970 (Figure 4.11) reflect the operation of the existing Okanagan Lake Dam. For an exact comparison at Oroville however, all historic discharges since 1956 would have to be reduced by the increase in water consumption between that particular year and 1970.

Figure 4.12 shows the modified inflows, elevations and discharges for Okanagan Lake, resulting from the model operation over the 50 year study period under present operating conditions. A recurrence of the extreme drought conditions of 1929-31 would result in Okanagan Lake being drawn down at least 3.2 feet below its normal low water operating level, assuming all water requirements are met. The lake would drop below its normal low water elevation in the middle of the second year of the drought and not refill to a level of 3.0 feet above the normal low level until three years later. Such a prolonged drought has occurred only

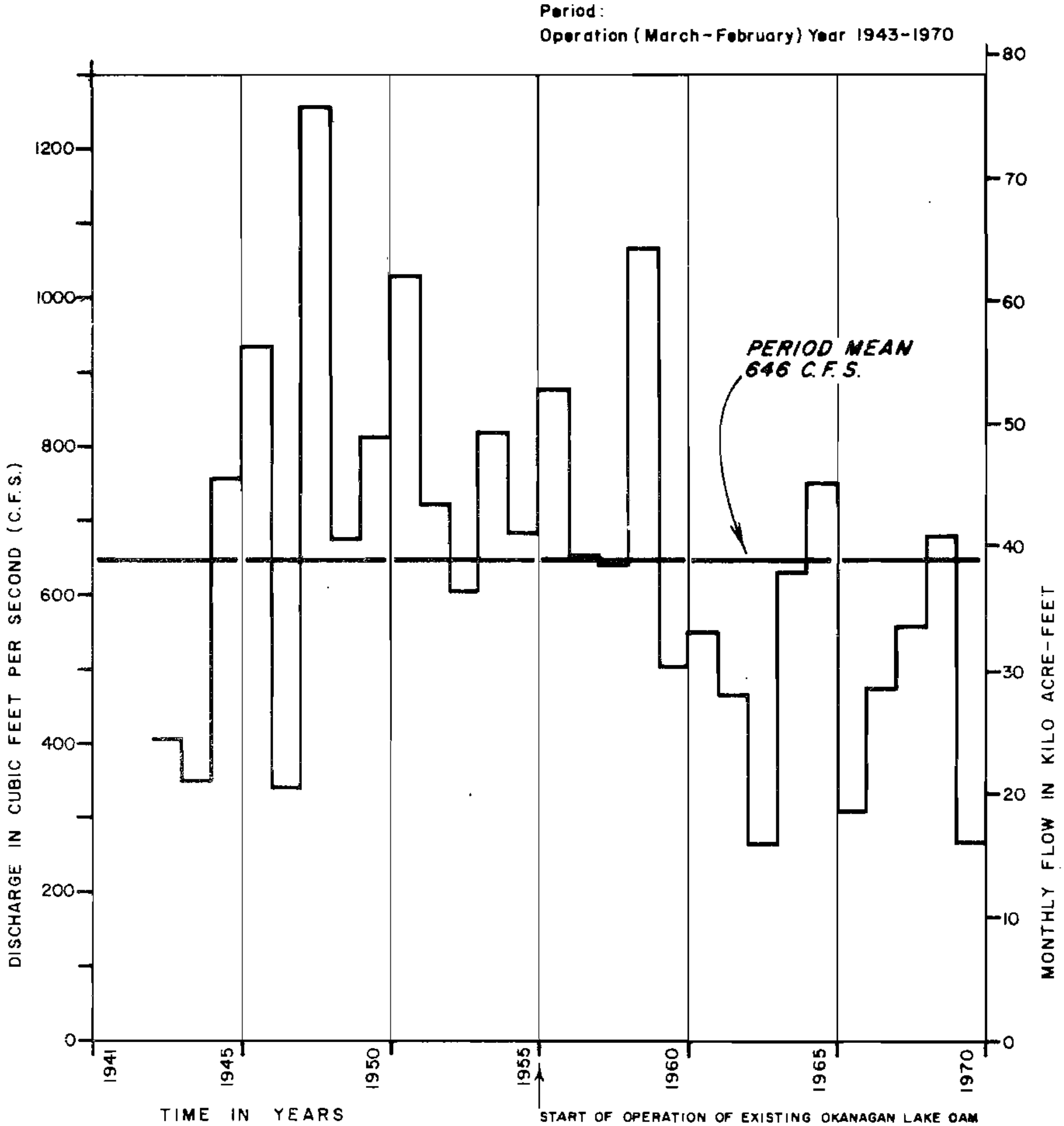


(a) SIMULATED MODEL DISCHARGES OKANAGAN RIVER AT PENTICTON COMPARED TO HISTORIC DISCHARGES.



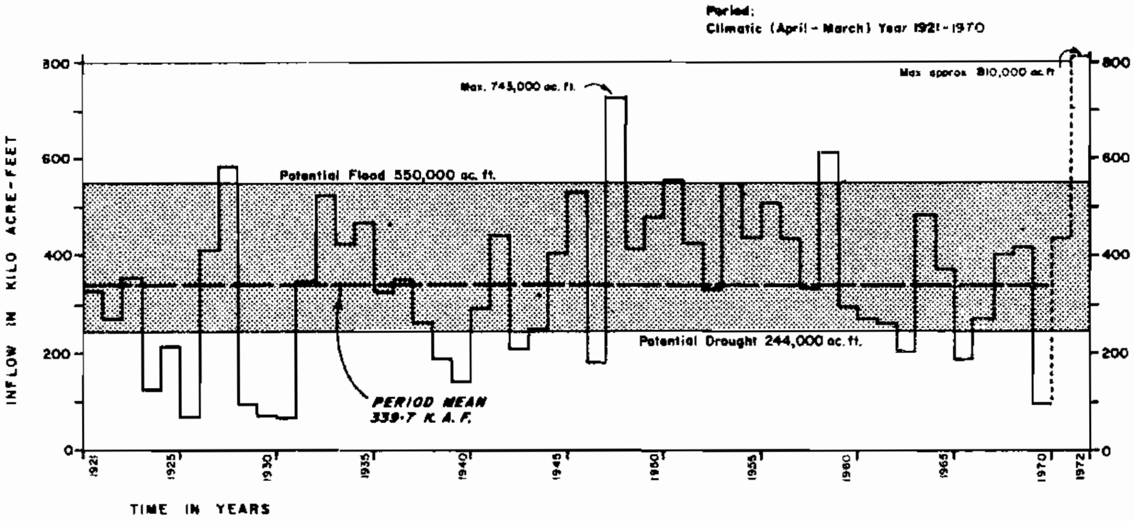
(b) SIMULATED MODEL DISCHARGES OKANAGAN RIVER NEAR OLIVER COMPARED TO HISTORIC DISCHARGES.

Figure 4.10

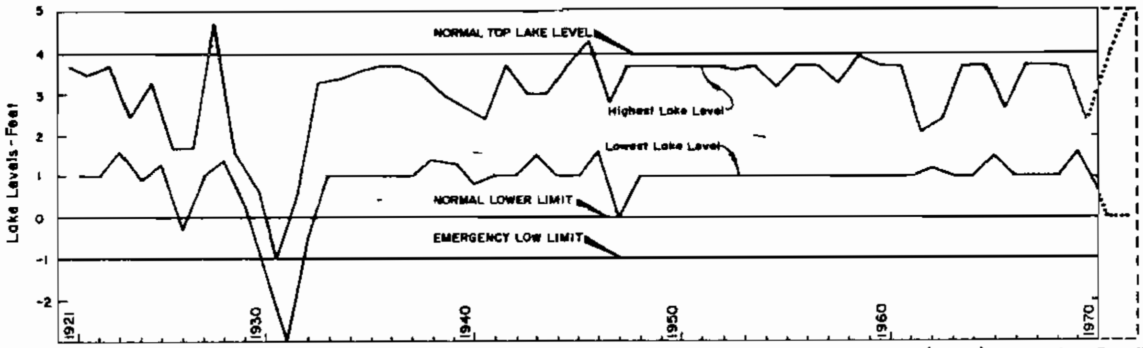


ANNUAL HISTORIC DISCHARGE,
OKANAGAN RIVER AT OROVILLE, WASH.

Figure 4.11

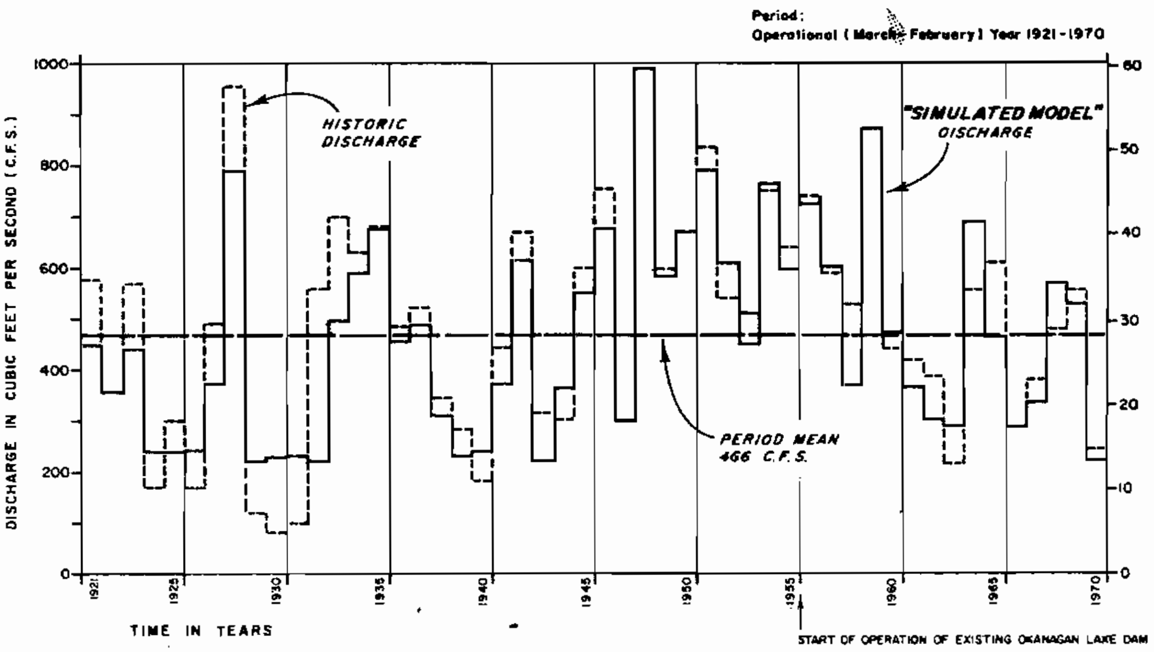


ANNUAL NET MODIFIED (1970 DEVELOPMENT) INFLOW, OKANAGAN LAKE



Computed Variations in Okanagan Lake Levels for the period 1921 - 1970 assuming Present (1970) Operating Conditions and that all Consumptive Demands and Fisheries Requirements are met, when possible.

——— Present Operating Conditions with Residual Flow of 300 cfs in Okanagan River



SIMULATED MODEL DISCHARGES, OKANAGAN RIVER AT PENTICTON COMPARED TO HISTORIC DISCHARGES.

MODIFIED INFLOWS, ELEVATIONS and DISCHARGES for OKANAGAN LAKE BASED on OPERATION of COMPUTER MODEL for PERIOD 1921-70. Figure 4.12

once in this century and was prevalent over much of North America.

The total volume of water required each year to satisfy all uses on Okanagan River, including minimum flows for the salmon fishery, are presently estimated at 244,000 acre-feet. Assuming that all this has to be supplied from Okanagan Lake, this inflow will be equalled or exceeded in all but about one year in four as shown in Figure 4.13. However, lesser inflows do not necessarily mean water shortages, providing Okanagan Lake enters the drought with carry-over storage. If forecasts made from snow surveys and other hydrologic parameters indicate low runoff, Okanagan Lake is operated to retain as much carry-over storage as possible which can amount to a foot or more.

While single-year droughts such as occurred in 1970 and again in 1973 can easily be handled, the possibility of a succession of dry years cannot be overlooked. As mentioned above, if there were to be a major prolonged drought of three years (such as occurred in 1929 to 1931) Okanagan Lake would have had to be drawn down to 1116.6 feet, or some three feet below its normal low water elevation in order to meet present day requirements.

A frequency analysis of both two-year and three-year drought sequences (Figures 4.14 and 4.15), indicates that the 1929-31 drought was exceptionally severe and that it probably has a recurrence interval of about 200 years. A two-year drought of the severity of the 1929-30 inflow (the driest two-year sequence on record) is indicated as having a return period of about 100 years.

At the other end of the spectrum are those years in which excessive inflows or floods occur. In general, a forecast seasonal inflow of greater than 550,000 acre-feet is considered to indicate a potential flood. In years in which high inflows are forecast, Okanagan Lake is drawn down to its normal low water elevation prior to the freshet to provide maximum storage.

During the study period, extreme floods occurred in 1928 and 1948 and the computer simulation of these are compared with the recent 1972 flood in Table 4.6.

TABLE 4.6

COMPARISON OF COMPUTER SIMULATION OF FLOODS OF 1928 and 1948 WITH 1972 FLOOD - PRESENT METHOD OF OPERATION AND EXISTING STORAGE FACILITIES -

	OKANAGAN LAKE INFLOWS		
YEAR	INFLOW APRIL-JULY INCLUSIVE (Acre-Feet)	ANNUAL INFLOW APRIL-MARCH INCLUSIVE (Acre-Feet)	MAXIMUM ELEVATION IN FEET ABOVE NORMAL HIGH WATER OF 1123.8 (Feet)
1928	638,236	615,500	0.9
1948	606,240	742,600	0.5
1972	697,206	742,278	0.9

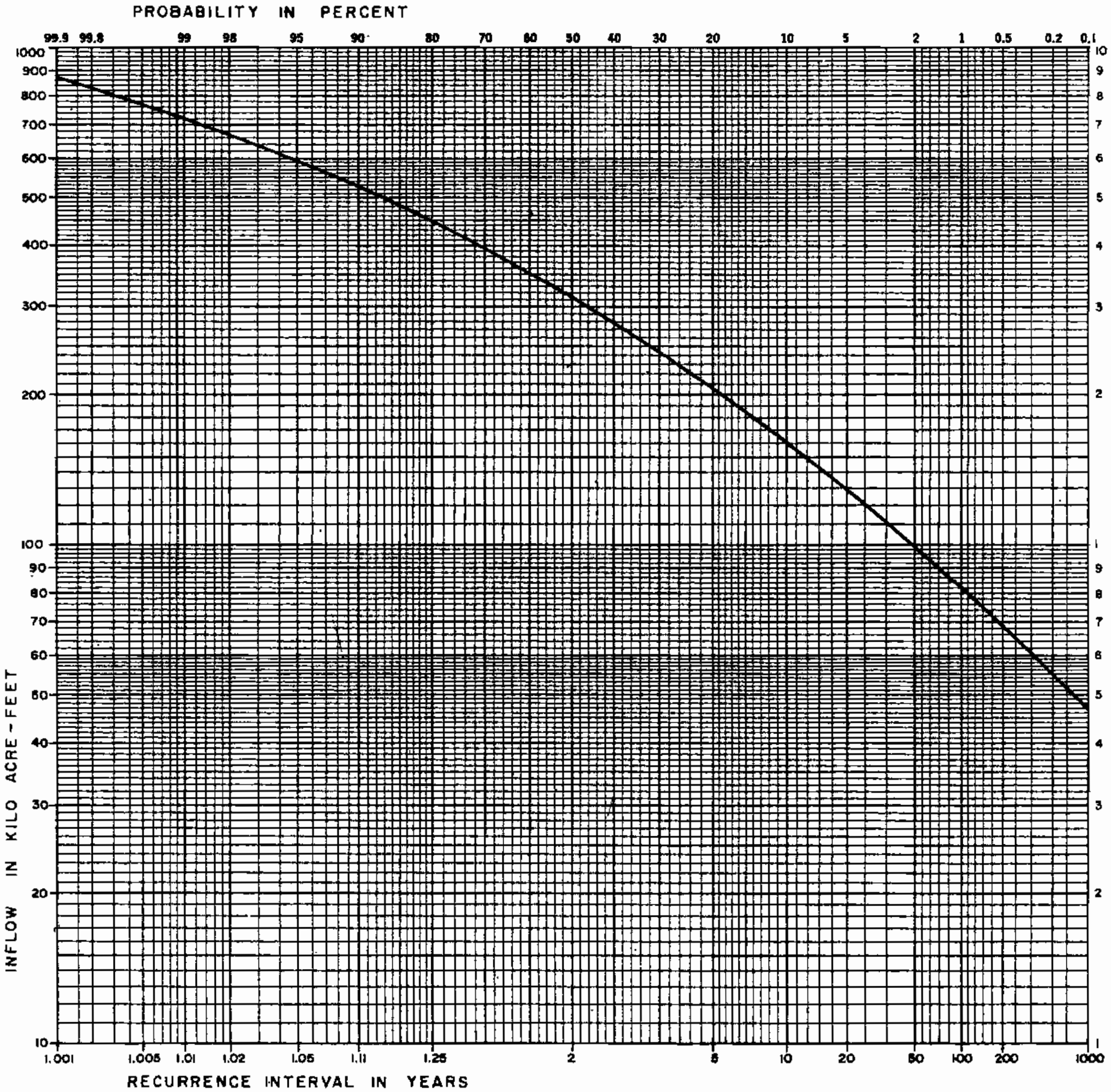
NOTE: Freshet inflow in 1928 greater than annual inflow due to heavy evaporation losses after July.

TABLE OF MOST CRITICAL YEARS

MAGNITUDE (K.A.F.)	YEAR
96.0	1929
116.2	1931
127.4	1970
127.9	1926
131.4	1930
137:2	1973
146.6	1924

TABLE OF CURVE VALUES

PROBABILITY IN PERCENT	50.0	20.0	10.0	5.0	2.0	1.0	0.5	0.1
RECURRENCE INTERVAL IN YEARS	2.0	5.0	10.0	20.0	50.0	100.0	200.0	1000.0
MAGNITUDE IN KILO ACRE-FEET	312.7	205.2	160.2	128.6	98.8	82.1	68.8	46.7



Period: 1921–1973

LOW-FLOW FREQUENCY CURVE, SEASONAL (APRIL-JULY) NET INFLOWS, OKANAGAN LAKE

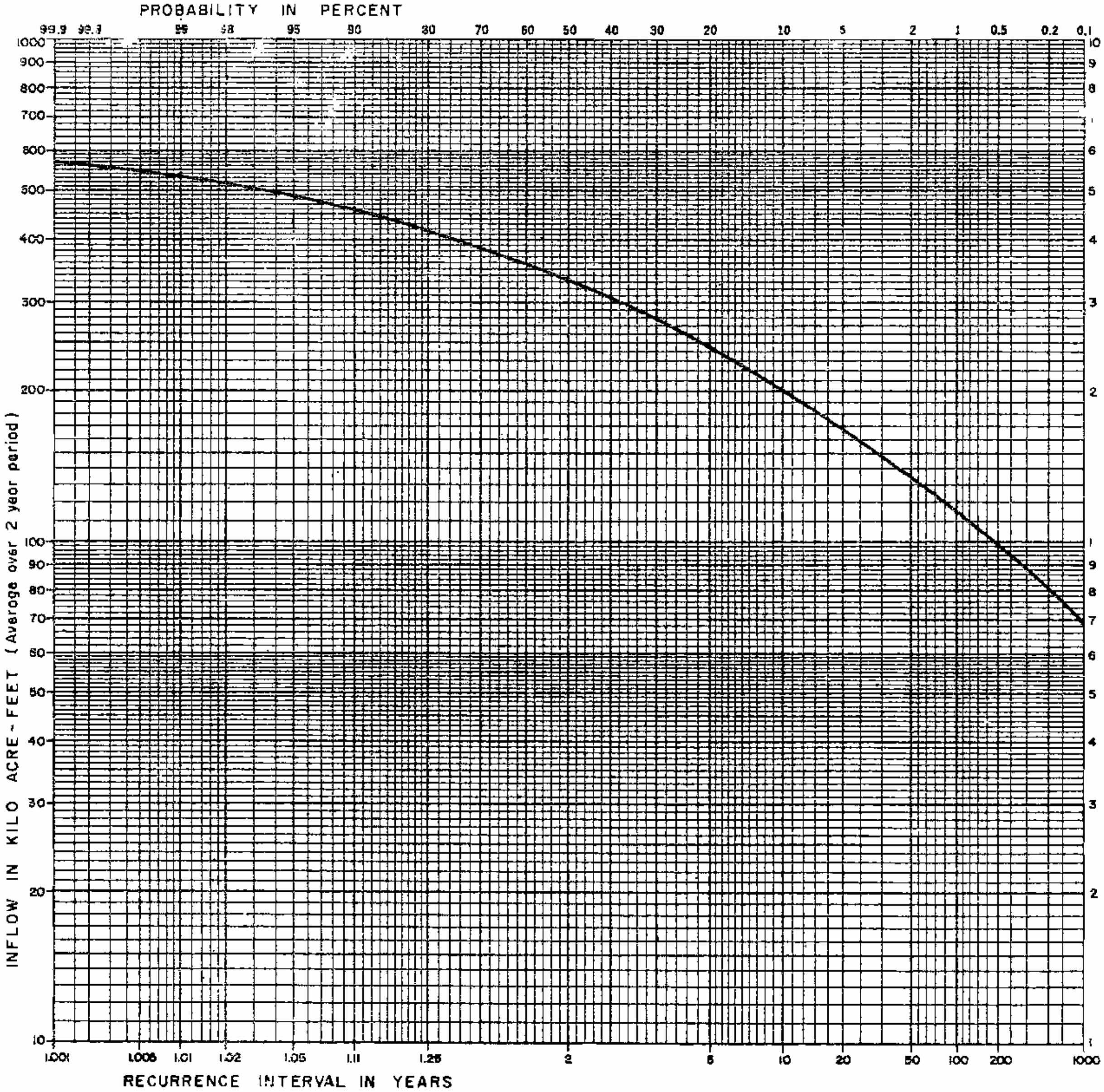
Figure 4.13

TABLE OF MOST CRITICAL YEARS

MAGNITUDE (K.A.F.)	YEARS
113.7	1929-1930
123.8	1930-1931
184.8	1926-1927
192.0	1940-1941
197.0	1939-1940
200.8	1925-1926

TABLE OF CURVE VALUES

PROBABILITY IN PERCENT	50.0	20.0	10.0	5.0	2.0	1.0	0.5	0.1
RECURRENCE INTERVAL IN YEARS	2.0	5.0	10.0	20.0	50.0	100.0	200.0	1000.0
MAGNITUDE IN KILO ACRE-FEET	332.4	244.6	201.5	168.5	135.0	115.0	98.5	69.6



Period: 1921-1973

LOW-FLOW FREQUENCY CURVE, 2 YEAR MOVING AVERAGE SEASONAL (APRIL-JULY) NET INFLOWS, OKANAGAN LAKE

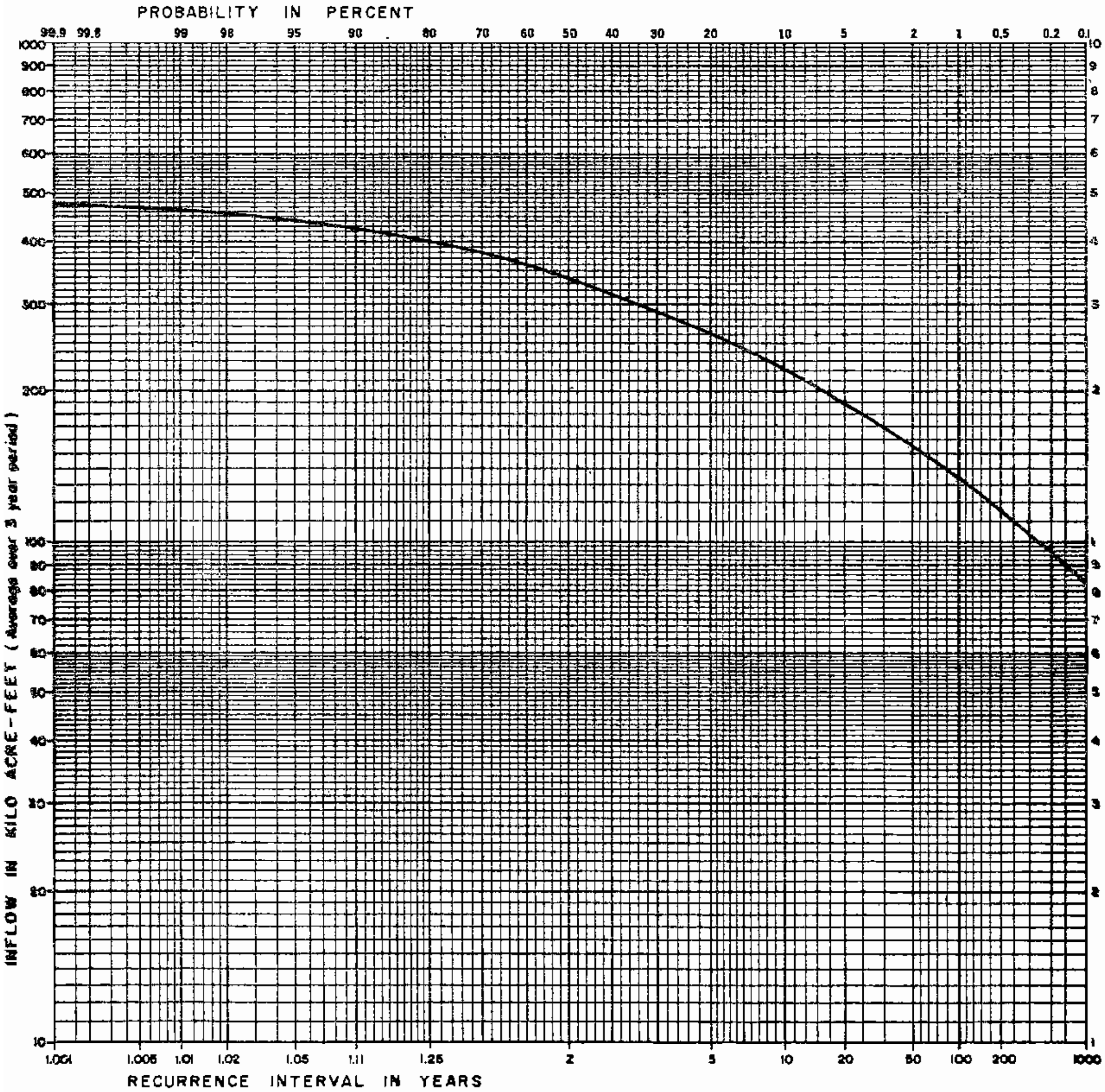
Figure 4.14

TABLE OF MOST CRITICAL YEARS

MAGNITUDE (K.A.F.)	YEARS
114.5	1929 - 1930 - 1931
182.7	1924 - 1925 - 1926
196.2	1930 - 1931 - 1932
200.4	1939 - 1940 - 1941
214.4	1925 - 1926 - 1927
227.9	1938 - 1939 - 1940

TABLE OF CURVE VALUES

PROBABILITY IN PERCENT	50.0	20.0	10.0	5.0	2.0	1.0	0.5	0.1
RECURRENCE INTERVAL IN YEARS	2.0	5.0	10.0	20.0	50.0	100.0	200.0	1000.0
MAGNITUDE IN KILO ACRE-FEET	337.2	262.3	221.8	189.3	154.9	133.7	115.7	83.4



Period: 1921-1973

LOW-FLOW FREQUENCY CURVE,
3 YEAR MOVING AVERAGE
SEASONAL (APRIL-JULY) NET INFLOWS, OKANAGAN LAKE

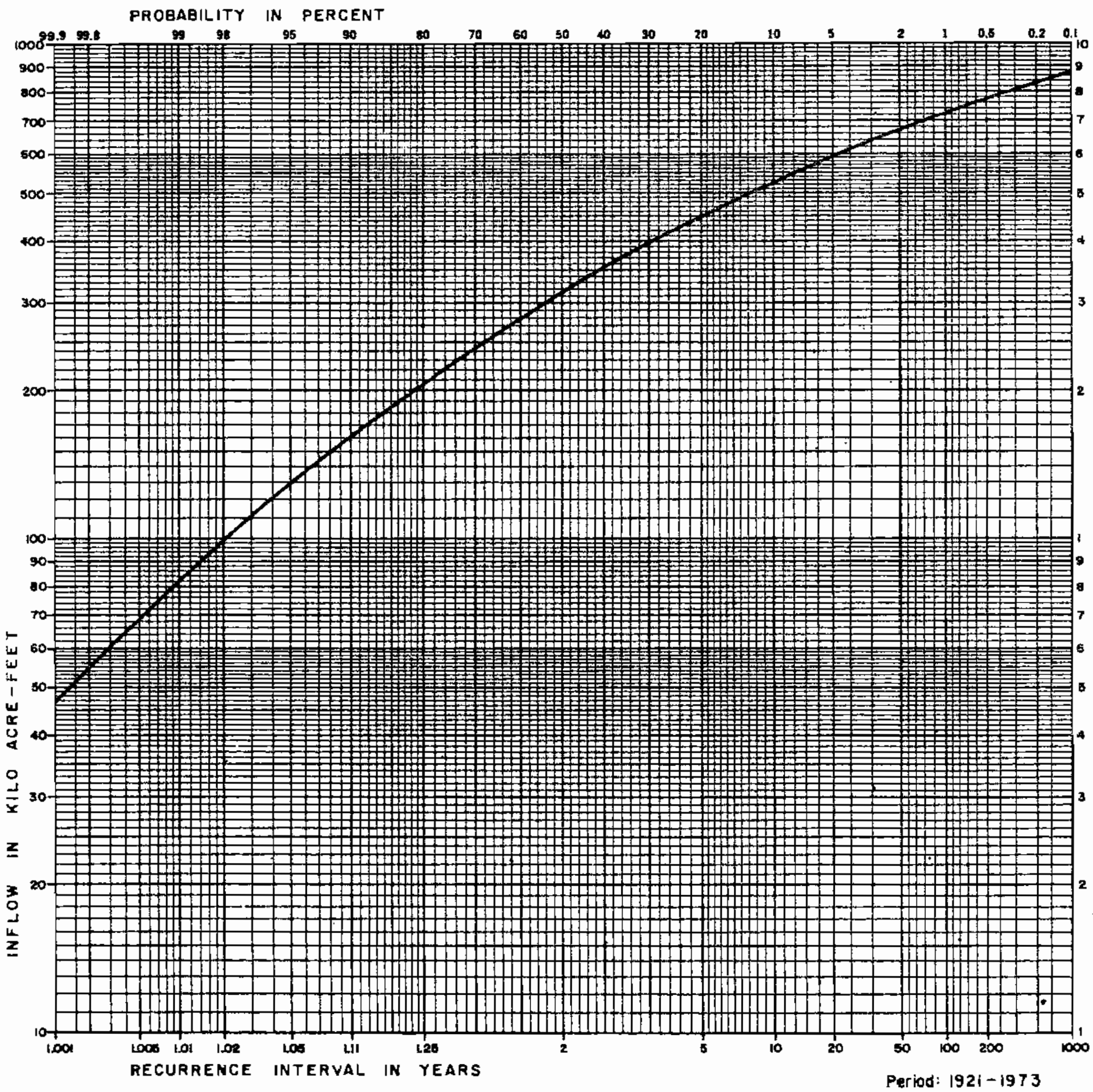
Figure 4.15

TABLE OF MOST CRITICAL YEARS

MAGNITUDE (K.A.F.)	YEAR
697.3	1972
638.2	1928
606.3	1948
547.2	1946
522.9	1951

TABLE OF CURVE VALUES

PROBABILITY IN PERCENT	50.0	20.0	10.0	5.0	2.0	1.0	0.5	0.1
RECURRENCE INTERVAL IN YEARS	2.0	5.0	10.0	20.0	50.0	100.0	200.0	1000.0
MAGNITUDE IN KILO ACRE-FEET	312.7	446.0	523.8	591.2	668.4	720.4	767.9	864.1



Period: 1921-1973

HIGH-FLOW FREQUENCY CURVE,
SEASONAL (APRIL-JULY) NET INFLOWS, OKANAGAN LAKE

Figure 4.16

A frequency analysis (Figure 4.16) that floods with magnitudes greater than 550,000 acre-feet will probably occur on an average, every twelve years, but that the recurrence interval for the 1972 flood is in the region of 80 years. Sequences of successive flood years are not considered as the effects are not cumulative as in the case of successive droughts.

4.3.2 Effect of Droughts and Floods on Shoreline Development

Knowledge of possible damage to shoreline developments around Okanagan and Osoyoos Lakes as a result of extreme lake level fluctuations is essential information in the management of the mainstem system. This section discusses and evaluates the types of damage and inconvenience that can occur to a wide range of shoreline uses, both in economic terms and in social values in the case of recreation and aesthetic uses.

For Okanagan Lake, damage was assessed for 0.5 foot increments up to two feet above the present normal high water elevation of 1123.8 feet and for 0.5 foot increments down to three feet below the present normal low water elevation of 1119.8 feet. For Osoyoos Lake, the shoreline survey was restricted to assessing potential flood damage to 919.4 feet GSC (919.1 feet USCGS), 7 feet above the normal high water elevation of 912.1 feet GSC. No assessment of lake drawdowns was undertaken. These fluctuations are considered to include the maximum likely under extreme flood or drought conditions, assuming existing operating procedures are not drastically changed.

(a) Okanagan Lake

Impacts on shoreline landuse resulting from extreme fluctuations in Okanagan Lake are evaluated in both economic and social terms. Economic impacts include flood damage to properties and structures, adjustments to water intakes and to the Kelowna floating bridge, and loss of revenue at recreation sites. Social and environmental impacts involve loss of use of recreation facilities such as boat docks and boat launching ramps, exposure of unsightly lake bottom and inundation of public recreation sites. In addition, fluctuating lake levels can affect wildlife and fish spawning abilities and these are discussed in Chapters 8 and 9.

(i) Economic Damage

The major aspects of flood damage are shown on Table 4.7. If Okanagan Lake levels were to exceed the normal high water elevation by two feet, (1125.8 feet), approximately $476,000 damage would occur. Much of this damage is due to flooding of landscaped lawns and patios and from 58 private residences which have water in their main floors or basements. Flood damage potential increases rapidly above 1124.8 feet. However, most property owners have not improved their land below this elevation, as Okanagan Lake frequently rose to this level prior to the construction of the Okanagan Flood Control Works in 1956;. Since 1956, Okanagan Lake has only exceeded its normal high water elevation once (1972), and as a result new developments which extend down to the normal high water elevation suffered some flood damage in 1972.

TABLE 4.7

ECONOMIC COSTS OF EXTREME FLUCTUATIONS ON OKANAGAN LAKE

LAKE ELEVATION FEET (G.S.C.)	RELATIVE TO NORMAL MAXIMUM (FEET)	DIRECT DAMAGE (ANNUAL)	REVENUE LOSS (ANNUAL)	KELOWNA BRIDGE (ANNUAL)	TOTAL
1124.3	+0.5	$ 28,300	$ 400	$15,000 e/	$ 43,700
1124.8	+1.0	72,500	1,500	30,000	104,000
1125.3	+1.5	218,900	17,200	30,000 e/	266,100
1125.8	+2.0	420,000	26,000	30,000 e/	476,000

LAKE ELEVATION FEET (G.S.C.)	RELATIVE TO NORMAL MINIMUM (FEET)	KELOWNA* BRIDGE (ANNUAL COST)	LOWER INTAKES	DIRECT LOSS OF REVENUE
1118.8	-1.0	$ 900	0	$ 5,500
1117.8	-2.0	6,900	0	17,800
1116.8	-3.0	8,600	?	28,000
1116.0	-3.8	10,000 e/	10,000 e/	40,000

*NOTE: Costs are not additive because some represent amortized annual costs associated with structural changes, while loss of revenue costs only occur when lake is actually drawn down to elevations indicated.

e/ Estimated - very approximate

As most campsites and motels have been developed back from the lakeshore, only five establishments would suffer direct damage in a two-foot flood, relative to the normal maximum. While there would be little direct loss of revenue at motels and campsites, up to $26,000 of gas and rental sales could be lost at marinas and boat rental facilities due to high water levels.

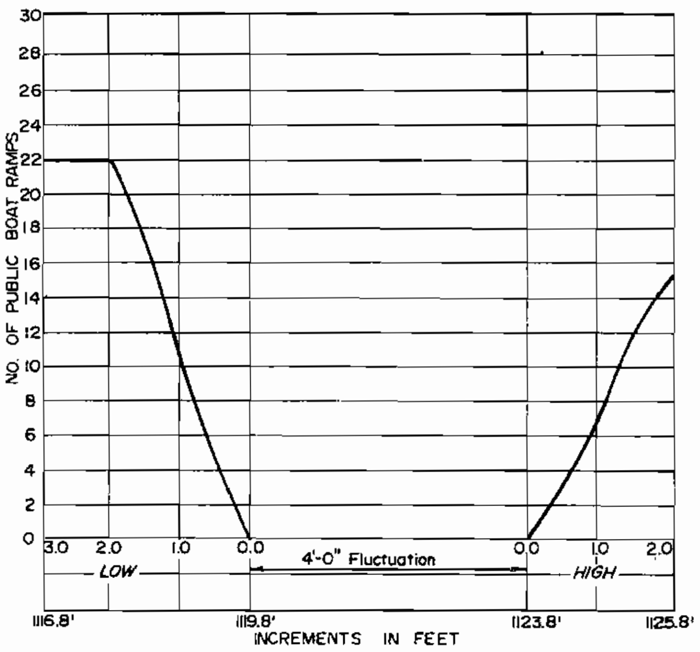
In 1972, when the lake rose to 1124.7 feet, approximately 0.9 feet above normal high water elevation, an estimated $56,500 damage occurred to shoreline development. About 45,500 of this total involved residential properties, the balance of $11,000 involving commercial establishments. This total does not include flood damage and seepage due to high water tables which affected residential properties at the mouths of Mission, Kelowna and Trout Creeks. In addition, there was seepage into basements and crawl-spaces at several lakeshore properties and flooding of septic tank drainage fields. Although little economic damage was reported from these problems during the 1972 flood, they were an inconvenience and could result in more extensive damage during larger floods.

Adjustments to the Kelowna floating bridge are required if lake levels rise above 1123.8 feet. In 1972, approximately $30,000 was spent in ballasting pontoons to accommodate the high water. This cost is not expected to increase significantly at higher water elevations and would be somewhat lower for smaller floods.

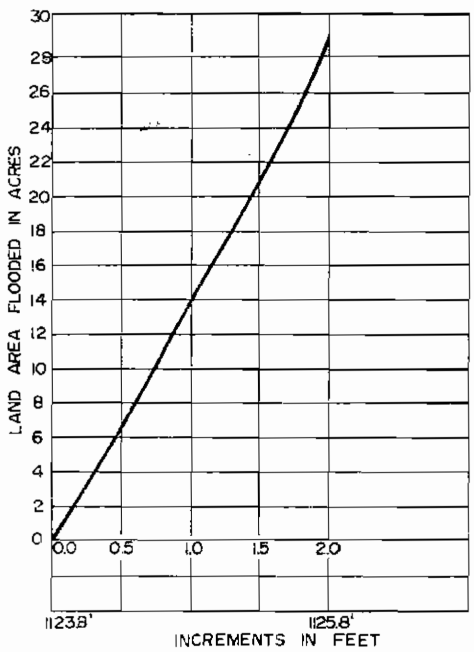
Direct economic costs associated with low water levels could total $200,000 if the lake was drawn down to 1116.0 feet. Indirect costs associated with loss of tourist trade due to low quality beach recreation could be substantial and will be discussed later in this chapter. It should be emphasized that direct and indirect cost estimates are very imprecise as lake levels below 1119.0 feet have not been experienced. This is due to the fact that prior to the construction of the new Okanagan Lake dam in 1956, the crest elevation of the previous dam and/or bar formations downstream did not allow the lake to be drawn down below elevation 1119.0 feet. During the 1929-31 drought, downstream requirements were not met and flows fell to zero at times. The main direct economic costs would involve structural adjustments to Kelowna bridge, estimated at $112,000 to allow the bridge to float at 1116.0 feet, and lowering irrigation and domestic water intakes which would cost about $100,000.

(ii) Non-Economic Impacts

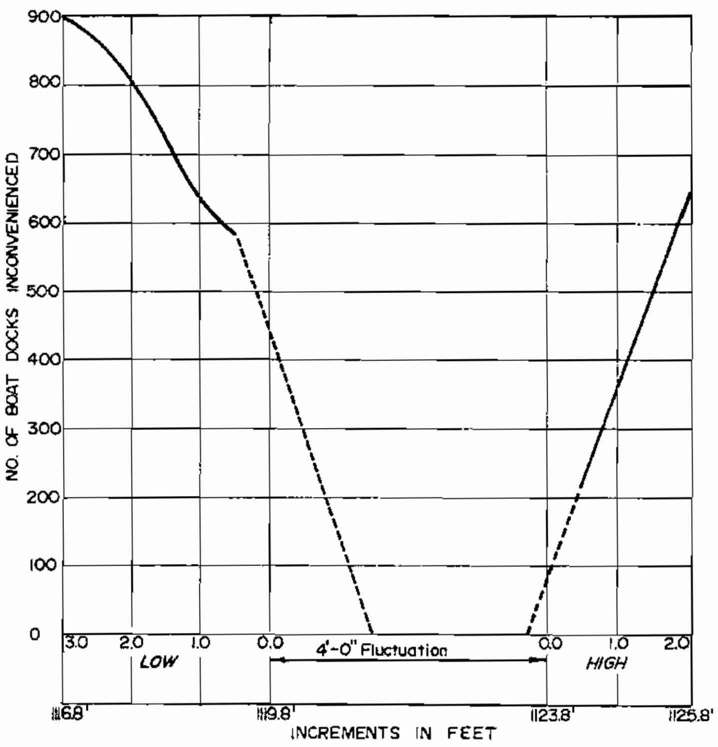
There appears to be a linear relationship between most categories of recreation and aesthetic uses of the shoreline, and lake level fluctuations (Figure 4.17). All 22 public boat launching facilities around Okanagan Lake would be inoperable at lake elevations below 1117.8 feet, but as such low elevations would likely occur in winter and early spring, inconvenience could be relatively small. A large number of private boat docks are used only during the summer months and have been built to accommodate only the relatively small fluctuations in lake levels during this period (approximately 1121.5 to 1124 feet). Consequently, almost 600 boat docks would be inoperable at the normal minimum operating level of 1119.8 feet and almost 900 at an extreme low elevation of 1116.8 feet. Similarly, many boat docks are inundated at levels exceeding the normal maximum of 1123.8 feet, but in most cases this is an inconvenience rather than a loss of use.



OKANAGAN LAKE
a) Public Boat Ramps Inconvenienced
-Cumulative



OKANAGAN LAKE
b) Area of Public Recreation Sites Flooded
-Cumulative



OKANAGAN LAKE
c) Boat Docks Inconvenienced
— Cumulative

EFFECT of LAKE LEVEL FLUCTUATIONS on SHORELINE RECREATIONAL FACILITIES, OKANAGAN LAKE.

Figure 4.17

There appears to be a significant loss of public recreation beach at higher water elevations, totalling almost 30 acres at an elevation of 1125.8 feet. During the 1972 flood, when almost 14 acres of public beach were under water, a survey of beach users indicated that the vast majority did not consider such a loss an inconvenience - many viewing it as a benefit as the shallow swimming area was extended. At some motels and private resorts where beaches almost disappeared, there was a greater loss of opoortunity.

Lake drawdowns could potentially produce greater aesthetic and recreational losses. Soundings down to 1116.0 feet were taken during the shoreline survey and, in many developed area of shoreline, between 500 to 1000 feet of lake bottom would be exposed at such elevations (Map 2: Map Supplement). In most instances, low lake elevations are expected in winter and early spring, so such exposure, although aesthetically displeasing would have little impact on the tourist industry. In a prolonged drought however, low lake levels could persist through the summer and significantly reduce the quality of beach recreation. In the absence of actual experience of such low lake levels, attempts were made to assess their impact on tourism during the beach user questionnaire survey. Although only a few respondents stated that they would not stay in the Okanagan under such conditions, it is believed that lake levels below 1120 feet throughout the summer could have a significant impact on the tourist industry.

(iii) Annual Damage

Fluctuations of Okanagan Lake beyond the normal four foot range occur very infrequently. The mathematical models which simulated operation of Okanagan Lake over the past 50 years indicated that flooding would only have occurred on three occasions (1928, 1948 and 1972) as shown in Figure 4.6 and lake drawdowns below 1119.8 feet on five occasions. Thus, although total damage in any one year could be relatively large, because such extreme events occur relatively infrequently, annual damage is considerably reduced in size and impact.

Estimates of average annual impacts on shoreline landuses are shown in Table 4.8. Non-economic impacts on value, in unit-days, represent the total opportunity lost during a period of extreme high or low water levels. For example, if 10 public boat ramps were unusable for a period of 60 days due to high water, a total of 600 boat launching days would be lost. This figure represents a maximum loss because the ramps may not be used every day, though seasonal useage of these and other recreational facilities was taken into account through the use of monthly weighting factors (see Technical Supplement III).

Annual economic costs due to flooding and lost revenue total some $2,000 though additional costs associated with possible structural adjustments to Kelowna bridge and water intakes could increase this to over $22,000. Likewise, other annual costs are relatively small with the exception of impacts on the use of private boat docks. In this case, many short-term adjustments are available and such costs should be considered an inconvenience rather than a real loss of use. There is little doubt that a recurrence of the 1929-31 drought would have significant impacts on recreation and general aesthetics and these would have to be balanced against the consequences of reducing releases into Okanagan River and the subsequent affects on fisheries and aesthetics in that region.

TABLE 4.8

TOTAL AND ANNUAL DAMAGES FOR SELECTED LANDUSE CATEGORIES AROUND OKANAGAN LAKE FOR SIMULATED OPERATION UNDER EXISTING CONDITIONS, 1921-1970

(a) ECONOMIC

ECONOMIC COSTS	TOTAL DAMAGE	ANNUAL DAMAGE
Property Damage	$ 67,000	$ 1,350
Loss of Revenue	38,750	780
Adjustments to Intakes	100,000 [e/]	10,000 [e/]
Adjustments to Kelowna Bridge	112,000 [e/]	10,000 [e/]
TOTAL COSTS	$317,750	$22,130

(b) NON-ECONOMIC

NON-ECONOMIC IMPACTS	TOTAL DAMAGE	ANNUAL DAMAGE
Public Boat Ramps (Ramp days)	3,920	78.4
Private Boat Docks (Boat Dock Days)	253,430	5,068.6
Public Recreation Sites (Acre-Days)	345	6.9
Private Property Flooded (Acre-Days)	2,642	52.8

[e/] Estimated - very approximate

(b) Osoyoos Lake

In light of the significant flood potential on Osoyoos Lake and the recurrence of a major flood in June 1972, most emphasis in the shoreline survey was placed on damage assessment at high water levels.

Osoyoos Lake usually fluctuates within a two-foot range (910 to 912 feet GSC), the flood stage normally being considered to be 912.1 feet. In early June of 1972, Osoyoos Lake peaked at 917.11 feet USCGS (916.85 feet GSC), the highest level this century and the second highest on record. This event enables a detailed assessment of the economic and social costs of flooding on residential, commercial and recreational landuses.

(i) Economic Damage

As in the case of Okanagan Lake, direct economic damage to property, structures and utilities such as septic tanks is relatively small for the small more frequent floods, but increases rapidly to over $300,000 for a flood of 919.4 feet (Table 4.9). In the 1972 flood, actual damage including costs of flood prevention amounted to $121,000 - approximately $88,000 to residential properties and $33,000 to commercial establishments.

TABLE 4.9

STAGE-DAMAGE FUNCTION FOR 1972 LEVEL OF DEVELOPMENT AROUND OSOYOOS LAKE
(DOLLARS)

STAGE (FEET) G.S.C.	RESIDENTIAL	COMMERCIAL	INDUSTRIAL	AGRICULTURAL	RECREATIONAL	LOSS OF REVENUE	TOTAL
912.9	4	4	-	20	-	-	28
913.4	3,538	41	-	43	-	2,000	5,622
913.9	9,006	5,266	59	117	-	4,900	19,348
914.4	19,899	6,135	59	131	-	11,800	38,024
914.9	31,585	12,829	59	1,081	-	18,300	63,854
915.4	49,904	20,000	178	1,838	514	27,000	99,434
915.9	57,138	22,297	1,013	3,946	680	89,500	174,574
916.4	76,005	27,068	1,013	6,049	905	55,600	166,640
916.9	97,971	36,649	1,013	10,342	905	80,000	226,880
917.4	116,033	53,957	1,013	13,283	1,308	106,000	291,594
917.9	133,247	68,503	1,679	16,071	4,004	130,000	353,504
918.4	152,239	71,350	1,679	18,858	4,315	146,000	394,441
918.9	163,290	100,636	1,679	23,307	,389	155,800	450,101
919.4	168,961	105,737	1,679	25,822	5,752	160,000	467,951

In addition to direct damage, there can be a significant loss of revenue to motels and campsites both during the period of flooding and cleanup. In 1972, for example, it is estimated that the Osoyoos region lost over $86,000 gross revenue due to loss of tourist business at shoreline resort facilities. Very little of this business appeared to move to other motels in the region, most affected tourists avoiding the Okanagan completely. Again, revenue losses are small up to the two-foot flood level ($130,000), and then level off to reach $160,000 at the seven-foot level. This stage-damage relationship should be interpreted with care, as revenue loss also depends on flood durations, but as it was based on the three-month flood of 1972, it probably does not underestimate losses.

(ii) Non-Economic Impacts

There are two public boat ramps on Osoyoos Lake and both are inundated at the 2.5 foot flood level (914.6 feet GSC). Recreation beaches are not seriously affected by high lake levels until the 4.5 foot flood level (916.6 feet GSC), when the causeway to the Provincial Park at Haynes Point would be submerged and most of the usable public beach area flooded. These conditions existed for a short time in 1972, forcing the closure of the Provincial campsite, but although lake levels remained high throughout July, most beach recreationists interviewed did not consider these conditions a major obstacle in their recreational enjoyment (Table 4.10).

In addition to direct economic costs, flooding can result in significant social costs such as loss of opportunity to enjoy one's property, volunteer labor costs and disruption of utilities (Table 4.11). In 1972, 130 private residences were directly affected by high water and over 60 acres (2.1 million square feet) of improved property was submerged. In addition, an estimated 21,000 man-hours of labor was required in flood prevention, evacuation, clean-up and repairs.

High lake levels create high groundwater tables at the shoreline. As the groundwater table rises, it can flood septic tank fields and even domestic water systems. It is estimated that in 1972, 70% of shoreline properties served by septic tanks were affected by seepage, some for as long as two months. In addition, people served by groundwater wells had to obtain alternative domestic water supplies until the wells were cleaned out, after the flood waters had receded.

(iii) Annual Flood Damage

Although flooding on Osoyoos Lake occurs more frequently than on Okanagan Lake, major floods are still a relatively rare occurrence. Figure 4.18 presents a stage-frequency curve for Osoyoos Lake and indicates that minor flooding may be expected every other year, but flood levels of the size occurring in 1972 are only expected once every 50 years. As the small flood produces very little economic damage, annual flood damage around Osoyoos Lake is small, totalling approximately $21,000 for the existing (1972) level of shoreline development.

4.3.3 Tributary Discharges

About 70% of the water consumed in the Okanagan Basin occurs within the tributaries of Okanagan Lake (Figure 4.9). Historically, tributary water has been relatively inexpensive as it provides a gravity water supply to agricultural lands. In order to make full use of these sources, headwater reservoirs have been constructed to regulate the flows during the irrigation season of April to September, inclusive.

TABLE 4.10

AREA OF PUBLIC RECREATION SITES FLOODED

OSOYOOS LAKE

INCREMENT		INCREMENTAL		CUMULATIVE	
Feet GSC	Feet	Sq. Ft.	Acres	Sq. Ft.	Acres
912.1		Commencement of Flood Stage			
912.9	.8	19,265	.442	19,265	.442
913.4	1.3	26,290	.603	45,555	1.045
913.9	1.8	25,530	.586	71,085	1.631
914.4	2.3	17,530	.402	88,615	2.034
914.9	2.8	17,530	.402	106,145	2.436
915.4	3.3	19,195	.440	125,340	2.877
915.9	3.8	33,585	.771	158,925	3.648
916.4	4.3	33,585	.771	192,510	4.419
916.85	4.75		1972 Flood Level		
916.9	4.8	530,571	12.18	723,081	16.599
917.4	5.3	10,530	.241	733,611	16.841
917.9	5.8	7,155	.164	740,766	17.005
918.4	6.3	9,045	.207	749,811	17.213
918.9	6.8	12,015	.275	761,826	17.489
919.4	7.3	11,850	.275	773,676	17.761

TABLE 4.11

AREA OF PRIVATE PROPERTY FLOODED

INCREMENT		INCREMENTAL		CUMULATIVE	
Feet GSC	Feet	Sq. Ft.	Acres	Sq. Ft.	Acres
912.9	.8	83,926	1.93	83,926	1.93
913.4	1.3	158,721	3.64	242,647	5.57
913.9	1.8	162,149	3.72	404,796	9.29
914.4	2.3	102,918	2.36	507,714	11.66
914.9	2.8	321,230	7.37	828,944	19.03
915.4	3.3	250,801	5.76	1,079,745	24.79
915.9	3.8	336,836	7.73	1,416,581	32.52
916.4	4.3	759,401	17.43	2,164,182	49.08
916.9	4.8	527,694	12.11	2,691,876	61.79
917.4	5.3	281,734	6.47	2,987,810	68.59
917.9	5.8	277,025	6.36	3,263,835	74.93
918.4	6.3	293,670	6.74	3,558,505	81.69
918.9	6.8	344,935	7.92	3,903,440	89.61
919.4	7.3	371,515	8.53	4,274,955	98.14

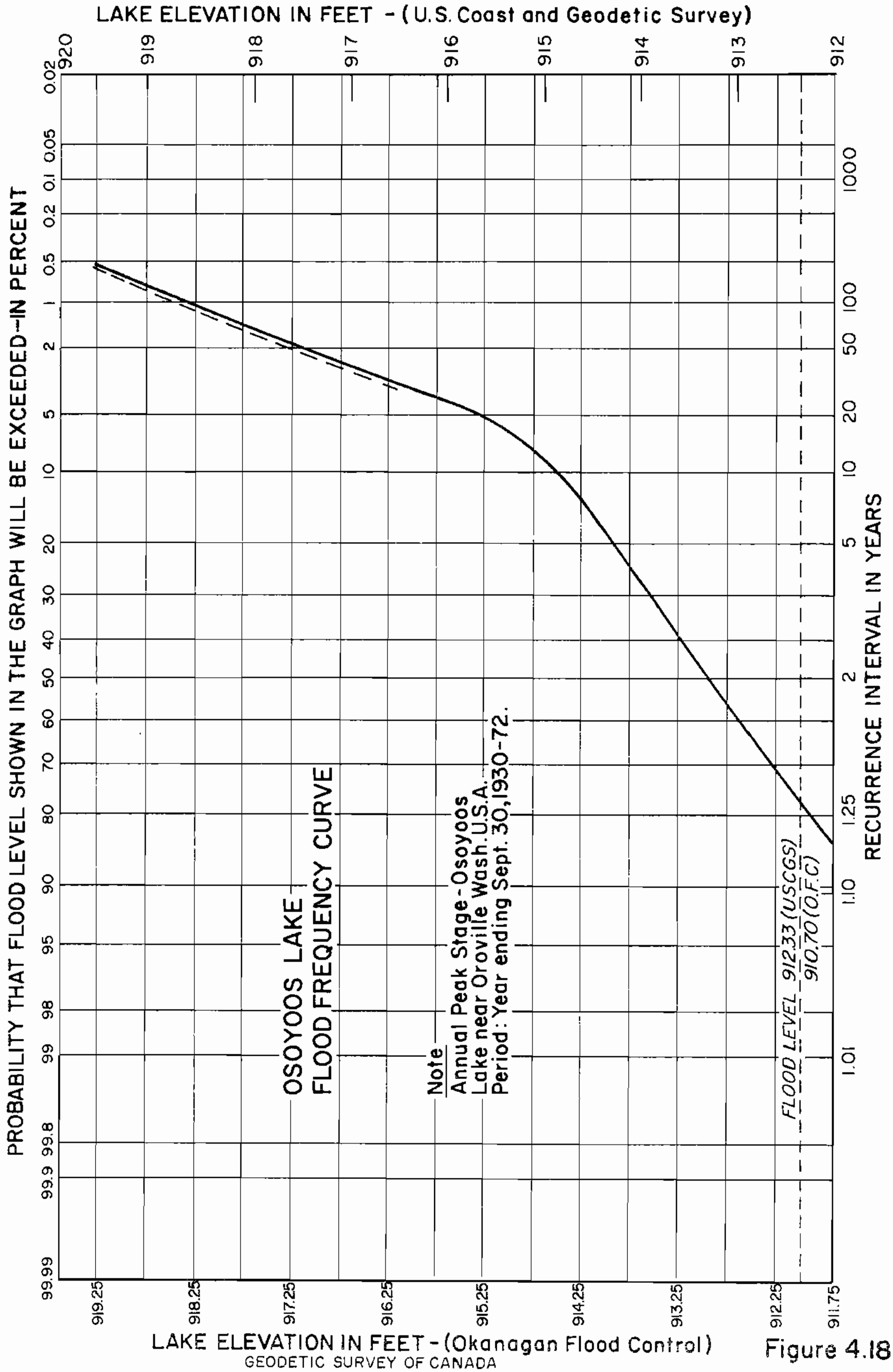

LAKE ELEVATION IN FEET - (U.S. Coast and Geodetic Survey)
920 919 918 917 916 915 914 913 912
PROBABILITY THAT FLOOD LEVEL SHOWN IN THE GRAPH WILL BE EXCEEDED—IN PERCENT
0.02 0.05 0.1 0.2 0.5 1 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.8 99.9 99.99
RECURRENCE INTERVAL IN YEARS
1000 100 50 20 10 5 2 1.25 1.10 1.01
OSOYOOS LAKE
FLOOD FREQUENCY CURVE
Note
Annual Peak Stage - Osoyoos
Lake near Oroville Wash. U.S.A.
Period: Year ending Sept. 30, 1930-72.
FLOOD LEVEL 912.33 (USCGS)
910.70 (O.F.C)
919.25 918.25 917.25 916.25 915.25 914.25 913.25 912.25 911.75
LAKE ELEVATION IN FEET - (Okanagan Flood Control)
GEODETIC SURVEY OF CANADA

Figure 4.18

For the most part, hydrometric and meteorological stations have only been operated in the lower reaches of the tributaries or within the main valley. The irrigation districts and municipalities who own and regulate most of the head-water reservoirs and diversions*, provide the British Columbia Water Resources Service with monthly reservoir water elevations during the freshet, and in a few instances, measure the water diverted. Additional information is also made available each year with respect to the anticipated inflow to Okanagan Lake through regular snow surveys at the higher elevations carried out by the British Columbia Water Resources Service.

The lack of hydrometeorological data has become increasingly significant in the allocation of further water licences by the Water Rights Branch, British Columbia Water Resources Service. Some tributaries are now designated as "fully licenced" pending the attainment of further hydrological records.

It is evident that in order to develop and manage the tributary supplies efficiently for present and future demands, it is necessary to estimate as closely as possible the natural flows occurring in the various reaches of each stream under varying climatic conditions and to compare them with present and future water requirements.

Thus, the objectives of the tributary water quantity study were:

1) The estimation of natural flows under varying climatic conditions (dry year, average inflow year and wet year).
2) Regulation of the natural flows in accordance with present day (1970) procedures for the three types of years in 1), to meet present and future water requirements.
3) Regulation of the natural flows in accordance with improved methods of operation to meet present and future water requirements.

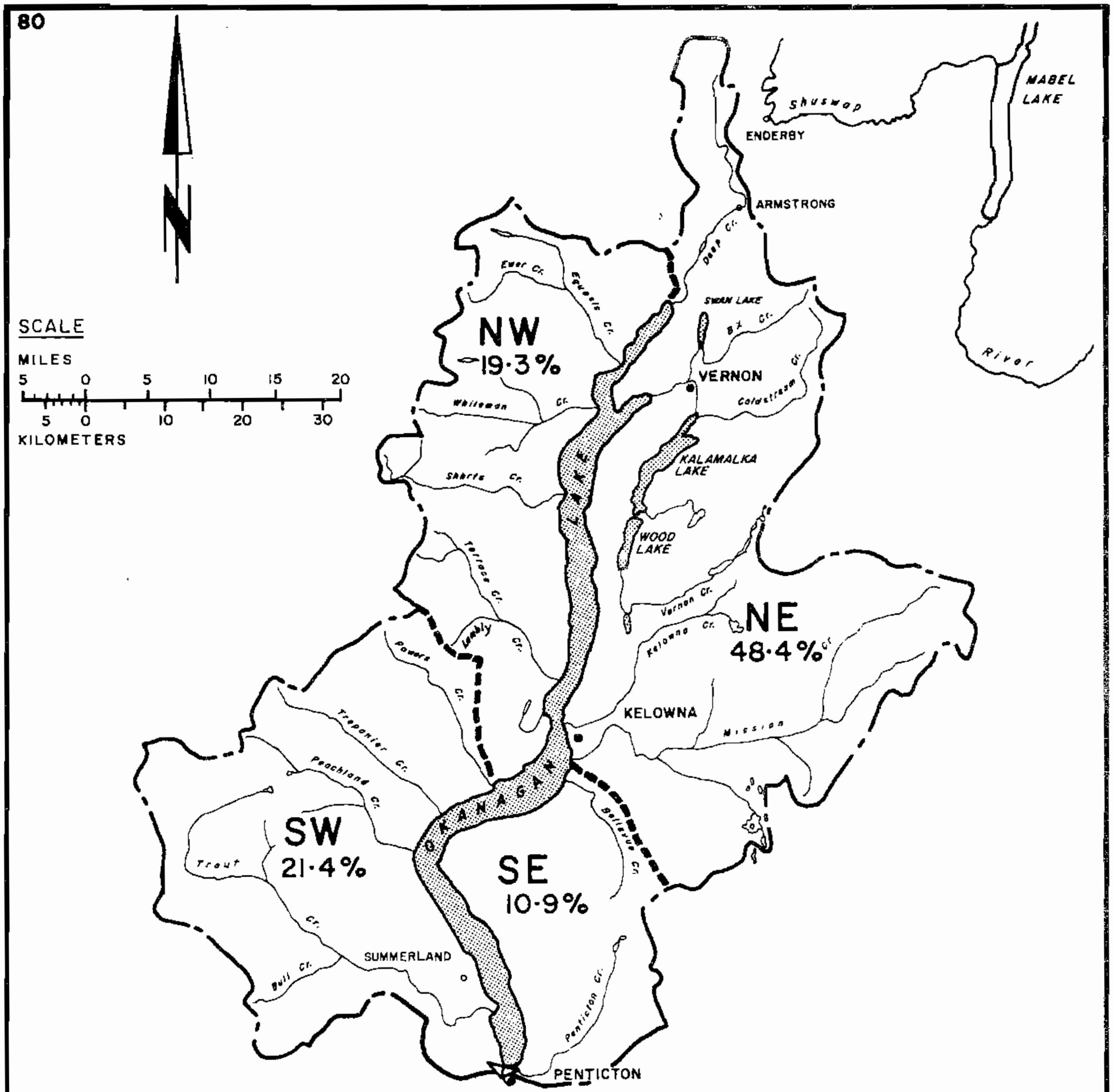
Objectives 1) and first part of 2) are dealt with in this Chapter, while the second part of 2) and objective 3) are covered in Chapter 14.

4.3.4 Distribution of Flows within Okanagan Lake Basin

In Chapter 1, the average precipitation pattern within the Okanagan Basin was illustrated using an isohyetal map which shows lines of equal precipitation. A contrast was also drawn between the precipitation shadow occurring in the western portion of Okanagan Lake Basin and the considerably heavier precipitation occurring to the northeast within the headwaters of Mission Creek.

These conditions, with respect to inflow to Okanagan Lake, are reflected in the average runoff map shown in Figure 4.19, in which Okanagan Lake Basin has been divided roughly into quadrants.

In spite of the unequal area distribution, it is evident that the northeast



NOTE:

Distribution based on Period: 1931 - 1960

RELATIVE CONTRIBUTION OF THE 4 QUADRANTS TO THE TOTAL RUNOFF OF OKANAGAN LAKE BASIN

Figure 4.19

quadrant provides almost 50% of the total inflow, while there is little difference between the northwest and southwest sections.

These figures have been obtained from estimates of the natural monthly inflows to Okanagan Basin for the 50 year study period, broken down within 35 tributaries in accordance with drainage areas and location.

4.3.5 Method of Estimating Natural Flows in Selected Tributaries

Ideally, in order to parallel the computer modelling along the mainstem, it would be necessary to determine the natural flows of tributaries, not only at the mouth, but also at specific points upstream for the same 50 year study period.

Time did not permit the study of all of the 35 tributaries within the Okanagan Basin, and in an effort to concentrate the analysis in areas where it was most needed, the eight tributaries shown in Table 4.12 and Figure 4.20 were selected for detailed modelling. The selection was based primarily on the fact that they are the most heavily used streams within the Basin.

TABLE 4.12

TRIBUTARIES SELECTED FOR DETAILED MODELLING WITHIN OKANAGAN LAKE BASIN*

WEST SIDE		EAST SIDE	
1.	Trout Creek	5.	Vernon Creek
2.	Peachland Creek	6.	Kelowna Creek
3.	Powers Creek	7.	Mission Creek
4.	Equesis Creek	8.	Penticton Creek

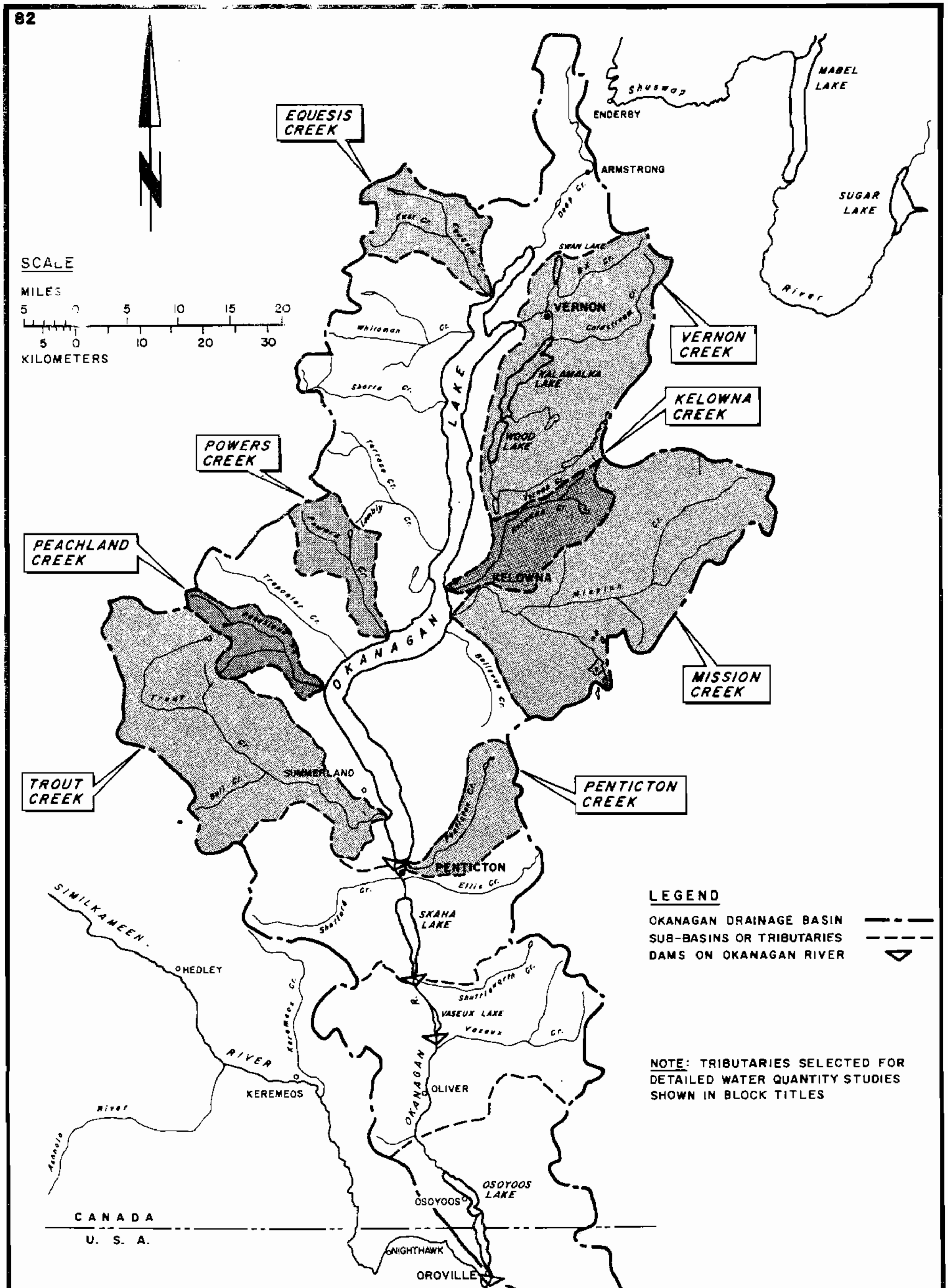
*See Figure 4.20 for Tributary Locations

These tributary watersheds contain 95% of all upland tributary storage within Okanagan Lake Basin and supply 60% of the total inflow to Okanagan Lake. About 37,000 acres out of the 45,000 acres of irrigated land within Okanagan Lake Basin are supplied from these sources.

The study was limited to three types of years:

Dry year - those falling within the five driest of the 50 year study period and roughly equivalent to the 1970 and 1973 runoff conditions.

Average year - those falling within the middle five years of the 50 year study period, and roughly equivalent to 1971 runoff conditions.



OKANAGAN BASIN LOCATION MAP

Figure 4.20

Wet year — those falling within the five wettest years of the 50 year study period and roughly equivalent to 1948 and 1972 runoff conditions.

Using 500 foot elevation band increments, the total annual runoff was computed and distributed by months to provide an estimate of the average monthly natural dry year flow at specific points in each of the selected tributaries. The 1970 runoff was used for comparison. Similar calculations were made with respect to average flows in which 1971 was equated to the long-term average for 1921 to 1970. A record high runoff occurred in 1972, and the flows that resulted agree reasonably well with the estimated flows developed for the flood year prior to it's occurrence.

Normally, natural runoff with minor releases from storage is adequate for water users during April and May. At the same time, the headwater reservoirs are filling and major releases from these reservoirs do not take place until the latter part of June. These releases continue through July and August and in some instances, most of September - at which time releases from headwater reservoirs are discontinued. The remaining carry-over storage water is either retained as a cushion against subsequent droughts, or released in the fall to draw the reservoir down to a predetermined safe level for the winter months. The latter releases could benefit fisheries as discussed in a later section, although additional storage water would also be required.

Estimated natural discharges as well as the regulated discharges, which allow for consumptive uses at the mouths of the eight selected tributaries, are listed in Table 4.13. The nature of these simulated flows are such that they include a groundwater component. However, the extent of groundwater flow within tributary streams is considered minor and less than 10% of the surface flow.

4.3.6 Matching Supply and Demand

In matching supply and demand for a tributary, it has been assumed there is no return flow to the tributary, although such water is included in the inflow to Okanagan Lake as indicated in the description of the mainstem model. There will be return flow to some parts of the tributaries, but where and how much is impossible to assess. Hence, these estimates of tributary discharges at selected points on each stream may be considered conservative.

Even with this rather extreme test, only two tributaries - namely Vernon and Kelowna Creeks - show consumptive use deficiencies (Table 4.14) in a 'dry' year under present (1970) day development.

4.3.7 Summary

Under current management practices, the Okanagan mainstem system is operated primarily for water conservation in drought years, when freshet inflows are less

TABLE 4.13

SELECTED OKANAGAN LAKE BASIN TRIBUTARY DISCHARGES AT MOUTH OF STREAMS

Tributary	Drainage Area in k.ac.	Discharge in K.A.F.					
		Dry Year		Average Year		Wet Year	
		Natural	Regulated	Natural	Regulated	Natural	Regulated
Trout Cr.	185.1	23.7	11.7	44.4	41.2	122.0	108.6
Peachland Cr.	37.8	8.9	6.9	15.0	12.2	27.5	24.3
Powers Cr.	35.3	8.0	2.9	13.8	8.5	25.8	20.5
Equesis Cr.	49.2	10.2	9.2	17.8	16.8	34.1	33.0
Vernon Cr.	228.6	38.5	11.1	67.1	29.0	137.2	80.9
Kelowna Cr.	55.4	9.9	2.1	17.0	7.3	34.3	23.2
Mission Cr.	214.0	97.0	66.0	143.0	107.1	239.3	201.8
Penticton Cr.	44.9	21.9	11.2	34.8	23.7	58.2	47.1

TABLE 4.14

WATER RESOURCE CAPABILITY IN 8 SELECTED TRIBUTARIES OKANAGAN LAKE BASIN UNDER PRESENT (1970) DEVELOPMENT

		TROUT CR.	PEACHLAND CR.	POWERS CR.	EQUESIS CR.	VERNON CR.	KELOWNA CR.	MISSION CR.	PENTICTON CR.	TOTALS
Area	Sq Miles	289	59	56	77	358	86	336	70	1,331
Natural Flow at Mouth Ac. Ft. X 100	Dry Year	237	89	80	102	391	99	969	219	2,186
	Av. Year	544	150	138	178	678	170	1,429	348	3,635
	Wet Year	1,220	275	258	341	1,382	343	2,392	482	6,793
Storage (Ac. Ft.)	1970	10,332	9,656	3,754	2,156	46,719	5,715	17,981	10,240	106,543
Area Under Irrigation (Acres)	1970	4,306	617	1,637	356	14,075	4,848	10,135	1,666	37,640
Population (Persons)	1970	5,960	1,444	3,490	90	24,360	10,420	10,340	18,146	74,250
Water Requirement (Diversion) Ac. Ft.	1970	13,384	3,416	5,293	1,021	33,525	12,888	31,814	11,173	112,514
Consumptive Use Deficiency in Dry Year Ac. Ft.	1970	0	0	0	0	1,540	2,296	0	0	3,836

than 244,000 acre-feet, and for flood control when freshet inflows are greater than 550,000 acre-feet. For years in which inflows fall between these two extremes, regulation tends to follow a more uniform procedure based on historic records of the lake levels and discharges.

The adequacy of the computer model to assess these water management practices in the mainstem is dependent on the quality of the hydrometric records available, and for the studies carried out, many of the monthly flow records were not available and had to be estimated or simulated. It would have been desirable to extend the records back to the 1894 record flood, but information prior to 1920 is very limited. Similarly, had time permitted the inclusion of data from the 1970 drought and the 1972 flood, the analysis would have been improved.

The study period does contain two major floods which occurred in 1928 and 1948, and several droughts including the three years of drought of 1929-31. Within these limitations, there appears to be no cyclic trend in the 1921-1970 period. The last 50 years of inflow in the sequence in which they occurred, does not imply that such a sequence may be repeated in the future.

Lake level fluctuations outside the normal operating range of Okanagan and Osoyoos Lakes have been relatively rare events and, because of this, shoreline developments have adjusted to this normal range. Consequently, extreme lake elevations may result in significant economic, social and environmental costs which must be taken into account in the overall management of the Basin's water resources.

Tributary flows that were developed are approximate and can be considered as 'first estimates' of probable discharges. While they point out the deficiencies under present day development, in the event of a single drought year they include no allowances for in-channel flows, such as are proposed for fisheries. The latter is discussed in more detail in Technical Supplement II and in Chapters 14 and 17 of this report.

4.4 FOREST HYDROLOGY

One forest hydrology study of the Okanagan Basin was carried out to provide a preliminary appraisal of the watershed in terms of cover and characteristics by major biophysical zones, and to outline the effects of timber harvesting on water quantity within these zones.

Prior to undertaking a field investigation, a brief office study was carried out to determine if there was any apparent trend in the 50 years of annual gross historic inflow to Okanagan Lake Basin which might be identified with forest harvesting. These inflows, together with the precipitation on the lake, as well as the nine year moving averages are shown in Figure 4.21 from which no discernable trend in runoff is evident.

While there appears to be no significant change in the overall hydrological conditions within Okanagan Lake Basin, it is possible that local tributary runoff may be affected by forest harvesting and fires. Unfortunately, such studies require a number of years of observations in relatively virgin watersheds which are undergoing forest harvesting. No such background information was available for the Okanagan Basin and in lieu of this a theoretical study was undertaken of Pearson Creek (a tributary of Mission Creek) on the eastern side of the Basin which is shown in Figure 4.22.

4.4.1 Pearson Creek

At present, Pearson Creek, with a drainage area of 120 square miles is relatively undisturbed and has the following desirable characteristics with respect to its use in the development of a simulation computer model on which various degrees of deforestation can be assumed and the resulting changes in runoff determined.

(i) Most of the watershed area is forested and suitable for commercial forest harvesting.

(ii) The area has yet to experience any major land use changes.

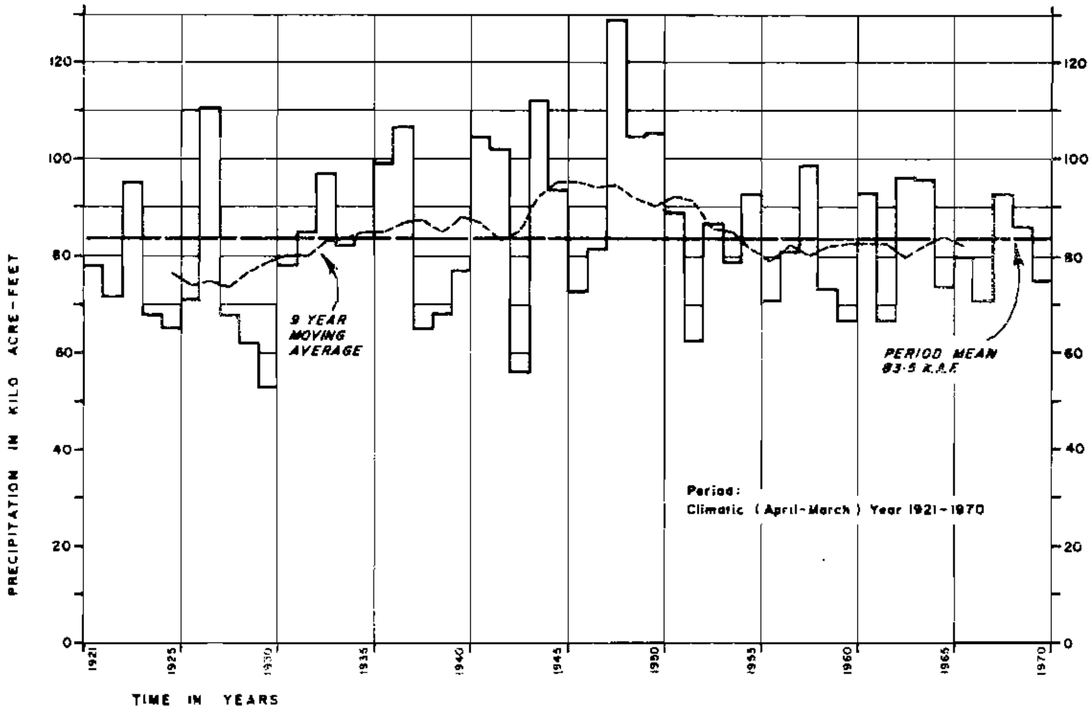
(iii) A reasonable spatial representation of the climate, soils, forest cover and drainage is present.

(iv) Preliminary analysis indicated that the main part of the watershed exhibited conditions of water surplus with no major portion exhibiting water deficits.

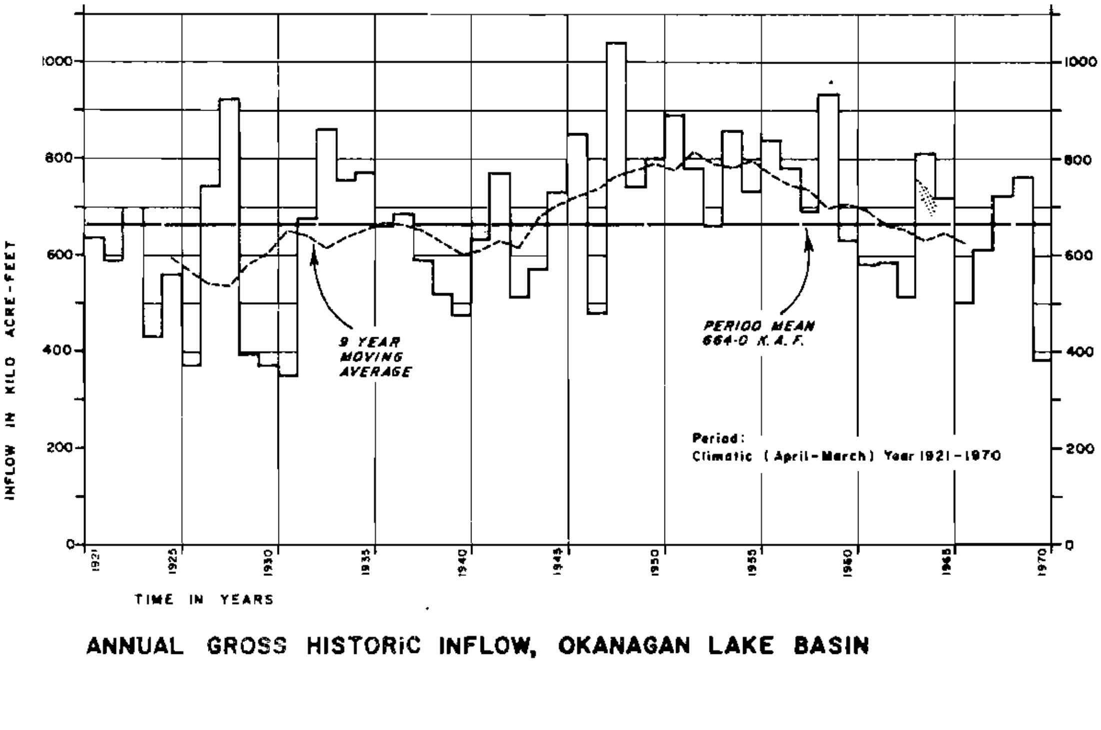
(v) The watershed is of a nature which makes it attractive for the establishment of a research basin for future studies.

Runoff for the period October 1970 to September 1971 was developed in a computer model based on precipitation, computed evapotranspiration and soil water storage changes. The simulated flows compare favorably with the total measured inflow for the year, but showed relatively large differences in April, May and June. These differences were due - in part - to the estimated large groundwater flow at the gauging site, and the crudeness of the model with respect to the rain-on-snow events. For the purpose of simulating the hydrologic effects of landuse, it was felt that the differences in basin yields, as shown by the simulation model, were sufficiently accurate to indicate trends.

In the Pearson Creek Watershed model, a systematic cutting pattern was assumed involving the removal of forest cover at the rate of one grid square of mature forest (640 acres) per year for the 17 years for which mature timber was available for harvesting. Assuming a clearcut and slashburn harvesting system and accounting for sequential changes in regrowth of cut-over areas, the yearly incremental and total basin yield were calculated by the model.

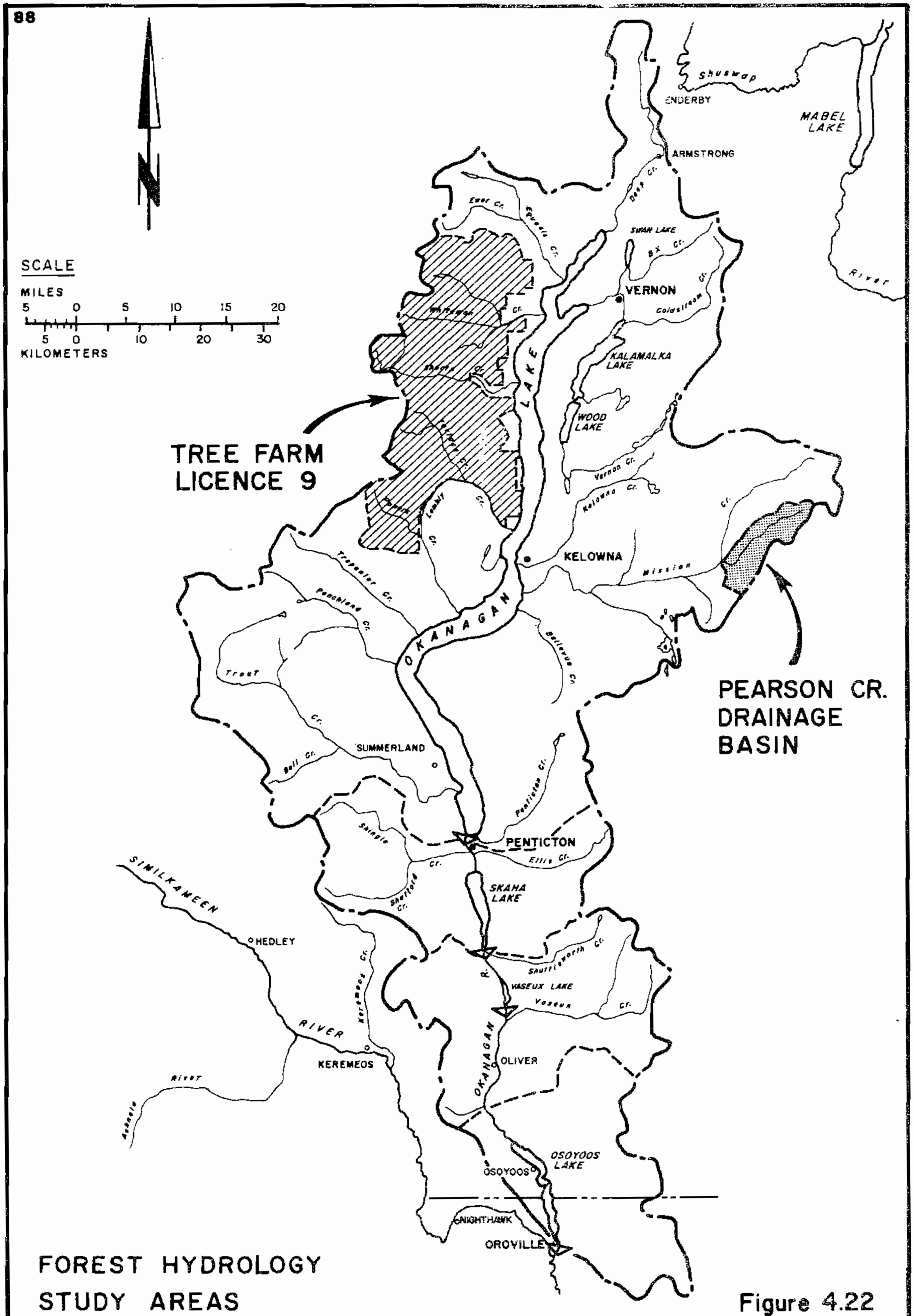


ANNUAL HISTORIC PRECIPITATION ON OKANAGAN LAKE



ANNUAL GROSS HISTORIC INFLOW, OKANAGAN LAKE BASIN

ANNUAL HISTORIC PRECIPITATION AND GROSS HISTORIC INFLOW TO OKANAGAN LAKE. Figure 4.21



FOREST HYDROLOGY
STUDY AREAS

Figure 4.22

After 17 years of sequential forest harvesting in the Pearson Creek watershed, a total basin yield increase of 2.91 inches or 13.68% was obtained. In this particular watershed the estimated streamflow difference from natural conditions would decrease as a result of a gradual increase in the evapotranspiration as forest regrowth occurred. First year yield increase is the largest with subsequent years reflecting the effects of gradual regrowth of the cut-over areas and the redistribution of water surpluses from the cut-over areas to the water deficit areas supporting vegetal growth.

From comparative studies of Terrace and Esperon Creeks, it was estimated that the water yield increases from forest harvesting in Tree Farm Licence No. 9 for different rotation length and also for the simulation model of Pearson Creek, would be as shown in Table 4.15. Tree Farm Licence No. 9 is located between Lambly Creek in the south and Nashwito Creek on the north with Okanagan Lake and Okanagan Lake Basin divide forming its eastern and western boundaries, respectively (Figure 4.22).

TABLE 4.15

WATER YIELD INCREASES FROM FOREST HARVESTING ON FOREST LAND OF TREE FARM LICENCE NO. 9 AND PEARSON CREEK FOR DIFFERENT ROTATION LENGTHS

Rotation Length (Years)	(120 Square Mile Basin) %	Tree Farm Licence No. 9 (309 Square Miles) Basin Yield Increase %
120	3.87	4.9
100	4.64	5.8
80	5.80	7.3
60	7.74	9.8
40	11.60	14.7

4.4.2 Conclusions

In the extrapolation of the above data to the three major zones of the Okanagan Basin, the following water yield increases may accrue:

South of Penticton

In this zone, any water yield increases accruing from high elevation forest harvesting will not be reflected in increased streamflow. This is due to *in situ* redistribution of water from surplus sites to deficit sites. Any increase in harvesting intensity would be reflected in localized site improvement by increasing the available soil water.

North of Penticton below 4,000 feet elevation

This zone is typified as the Ponderosa pine-parkland community and is a water deficit hydrologic system. As such, any forest harvesting would not reflect any water yield increases to streamflow. Localized harvesting is probably best directed towards improving the carrying capacity of incorporated range lands. However, in this region soils are particularly sensitive to the disturbance effects of harvesting activities and extreme caution should be exercised in the location and construction of roads to ensure that adjacent streams do not receive high discharges of sediment. This area, because of its generally close proximity to Okanagan Lake, is particularly sensitive to stream temperature increases (approaching lethal limits for fisheries) following their exposure by forest removal.

North of Penticton above 4,000 feet elevation

It is in this zone that the greatest potential for water yield increases exists, as a consequence of forest harvesting. It is also the region of most intensive forest harvesting, both at present and in the predicable future. Within this zone, snowpack management considerations are an important aspect of landuse hydrology. The zone includes approximately 300,000 acres of merchantable timber.

Water yield increases accruing from forest harvesting in this zone on a 120 year rotation basis, have been estimated to be between 3.31% and 4.20%. These increases would only be realized within this zone (Englemann spruce and subalpine fir forest type) and would likely be consumed in water deficit sites at lower elevations. This includes correction for sequential regrowth effects on increasing evapotranspiration from the time immediately following logging to pre-logging evapotranspiration: a period of approximately 40 years for most sites. Similarly, for a hypothetical 40-year rotation, the increases are between 9.93% and 12.60%.

Forest fires may effect an increase in water yield through reduction of evapotranspiration. The average annual acreage burned over in the Okanagan Basin is 5,377 with a range between 81 acres (1964) and 25,856 acres (1970). Yield increases calculated on the basis of water yield from the area north of Penticton and above 4,000 feet, have been estimated to be between 1.24% and 1.55% annually.

However, as large as these streamflow increases may be, they are only for that area designated as merchantable forest north of Penticton above 4,000 feet (approximately 1/4 of the total merchantable forest and 15% of the total area of the Okanagan Basin). Forest harvesting in other zones of the Basin would have no net effect on streamflow quantity. By adjusting the reported percentage water yield increases to a Basin basis for a 120-year rotation, levels by which comparisons can be made and effects evaluated, are made possible. Thus, on the basis of the total Okanagan Basin, annual water yield increases accruing from forest harvesting range from 0.50% to 0.64%. Similarly, the figures for the effect of fire are adjusted to be between 0.19% and 0.23%. Respective figures for the hypothetical 40-year rotation are 1.50% and 1.91% for forest harvesting and 0.19% and 0.23% for forest fires. These reported annual increases are not cumulative due to the effects of regrowth on evapotranspiration consumption.

The values reported for the 40-year rotation are never likely to be achieved because a 40-year rotation is too close to the regrowth time of 40 years and it is only relevant to discuss the values reported for the existing and future 120-year rotation forest harvesting rates. The following limitations must be noted with respect to the reported increase in water yields following forest harvesting and/or fire:

(a) Reported increases are too small to be measured by existing streamflow measurement techniques.
(b) Total water yield increases in major tributaries of the Okanagan Basin will very likely go undetected due to the low percentage yield increase from sustained yield forest management. Any yield increase would only be reflected in very small (89 square miles) basins, over which significant portions (75%) have been harvested or burned.
(c) Water yield increases accruing from forest harvesting in the area only become usable if they reach a stream channel. Increased water transmitted downslope through the soil mantle would likely be consumed in water deficit sites below 4,000 feet elevation, thereby proving useless in augmenting water supplies for other purposes. It has been shown that most of the annual water yield increases occur in the spring and fall months, thereby necessitating improvement and/or extension of reservoirs to hold water over to peak demand periods in the summer season.

In conclusion, it can be stated that although streamflow increases will accrue from forest harvesting in the Okanagan Basin, the reliability and predictability of these increases will be inhibitory to planning for water supply. Forest harvesting, with respect to water supply should be concentrated in the area of minimizing water quality deterioration and increasing the general environmental stability of those lands upon which forest land management is occurring.

4.5 GROUNDWATER HYDROLOGY

Groundwater investigations and studies within the Okanagan Basin have been carried out to meet the following objectives:

1) Determination of the groundwater contributions from tributary sources.
2) Determination of the extent of and recharge rate to groundwater aquifers in the northern portion of the basin, the sources of recharge water to these aquifers, and whether the yields from such aquifers are large enough to meet water deficits in the Okanagan Basin in a series of drought years.
3) The yield, quality and cost of developing the northern aquifers.

4.5.1 Geology

The Okanagan Basin is underlain by a diversity of rocks. On the east side, hard, resistant, gently dipping metamorphic rocks including gneiss, schist, quartzite, calcareous gneiss and marble, present pronounced gentle slopes due to differential weathering. The west side is underlain by two groups of rocks; one - north of Vernon-includes mostly schists and quartzites with gentle rounded slopes, and the south groups include argillites, andesite lavas and limestone exposed in more rugged relief. In places these rocks are covered by flat lying or gently dipping lavas. In general, storage and movement of groundwater in this complex of crystalline rocks is limited to the interconnected fracture and fault systems. It is realized that major fault zones will provide conduits for the movement of groundwater, but the main concern here is largely with aquifers belonging to the unconsolidated surficial deposits.

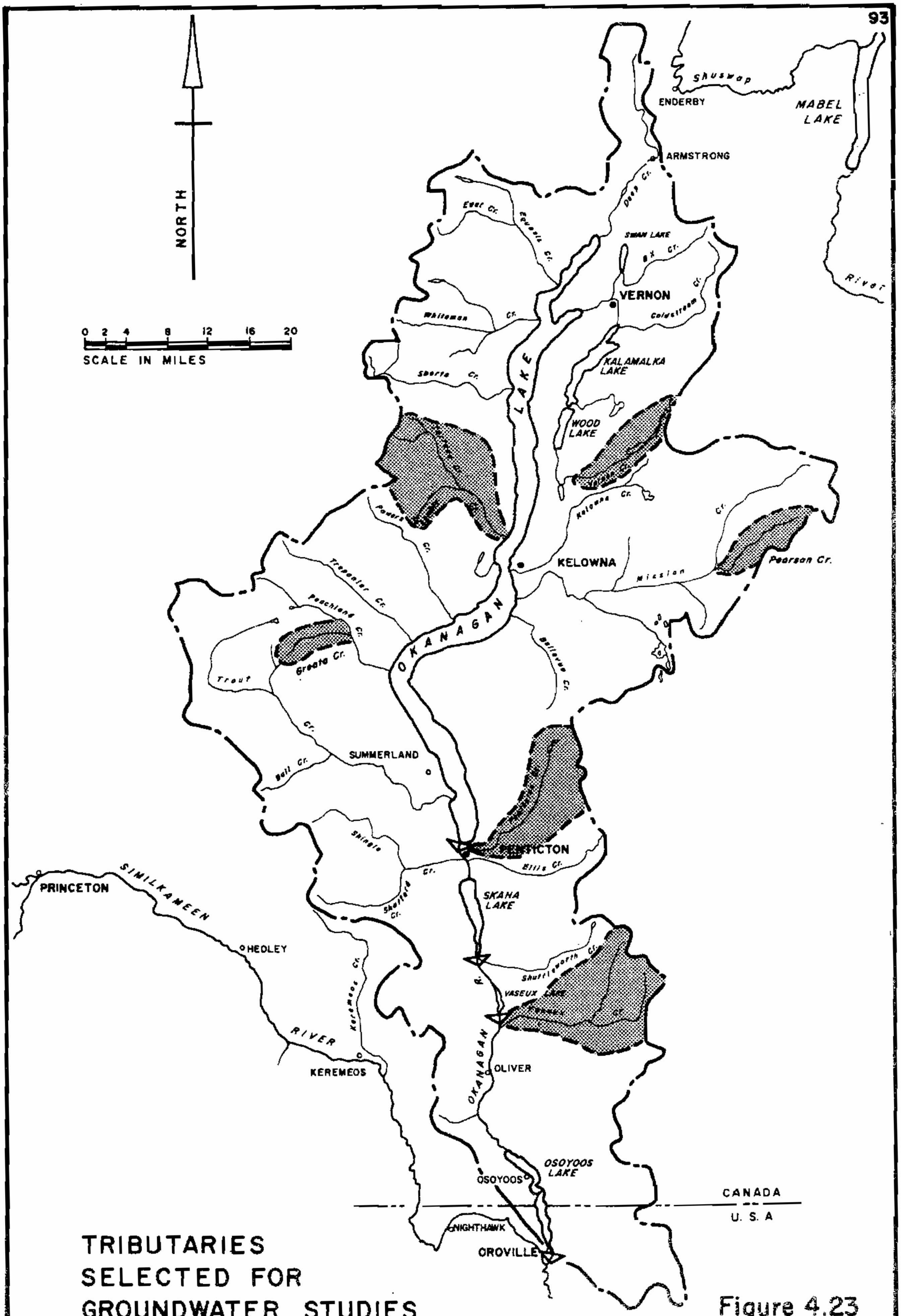
The unconsolidated surficial deposits consist of clay, silt, gravel, sand and mixtures of these that overlie the bedrock. They are of glacial origin and their deposition is related to the glacial ice that occupied the valley or to the meltwaters that issued therefrom during the wasting stages of the ice. Although the glacial ice filling the valley may have reached elevations as much as 7,200 feet, it left only a thin blanket of unconsolidated materials at the higher elevations.

4.5.2 Tributary Groundwater Sources

The following six tributaries to Okanagan Basin were selected for hydrogeological reconnaissance studies (Figure 4.23).

Greata Creek - a tributary of Peachland Creek
Lambly Creek
Upper portion of Vernon Creek above Ellison Lake
Pearson Creek - a tributary of Mission Creek
Penticton Creek
Vaseux Creek

These tributaries are virtually unsettled in their upper reaches and investigations were therefore directed towards a qualitative appraisal and mapping of natural phenomena such as springs. Most of the precipitation in these sub-basins occurs above the 4,000 foot level and most of the groundwater discharge observed was above this elevation. Only small increases in total mineralization to streams in conjunction with only limited increases in streamflow, support earlier opinions that the nature of the bedrock and surficial geology are such that the groundwater component of total runoff is small, and that there is very little groundwater discharge from these sub-basins that is not measured as streamflow. Fan deposits at the mouths of tributary creeks may provide limited sources of groundwater for local use and there is strong evidence to suggest that subsurface flows from tributaries in the southern part of the Basin, such as Vaseux Creek, may contribute a fair portion of that particular sub-basin discharge.



TRIBUTARIES SELECTED FOR GROUNDWATER STUDIES

Figure 4.23

4.5.3 Groundwater Inflow to Okanagan Lake

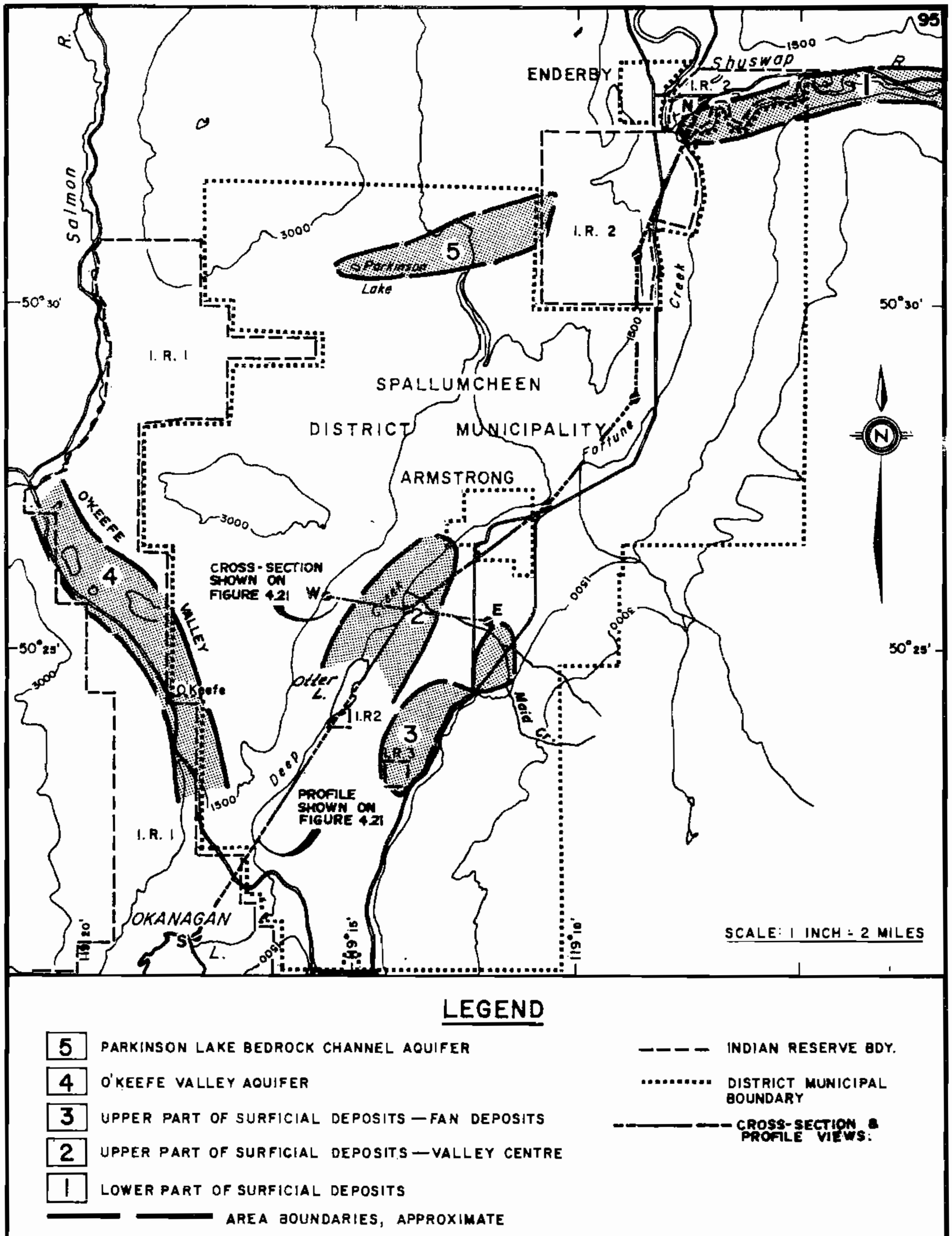
Concurrent with the investigations of the relative magnitude of groundwater flows in selected tributaries, a seismic survey and drilling program was undertaken in the Spallumcheen Valley, between the north end of Okanagan Lake and the Shuswap River at Enderby, and in the O'Keefe Valley extending to the northwest to determine if there was significant groundwater inflows from these areas to Okanagan Lake (Figure 4.24). Some seismic work and test drilling was also conducted in the south end of the Okanagan Valley near Okanagan Falls.

In the northern portion of the Okanagan Basin, bedrock appearing on the surface at about 2,500 foot elevation is covered with thin unconsolidated deposits down to the 1,500 foot ground contour. Below elevations of 1,500 feet numerous fan-delta deposits of gravel and sand occur, particularly on the east side of the Valley. Coarse sand and gravel deposits on the west side are associated almost entirely with the O'Keefe tributary valley and the lower part of the Deep Creek valley. The deposits of the main valley found at or near the surface are commonly silt and some clay.

The thickness of the valley fill is known in the north end of the Okanagan Valley, where seismic profiles were obtained to determine the position and shape of the bedrock beneath the valley floor. The lowest elevation was found to be south of Armstrong, where the bedrock floor is about 600 feet below sea level. The thickness of the valley fill near Armstrong (elevation 1,200 feet), is therefore about 1,800 feet.

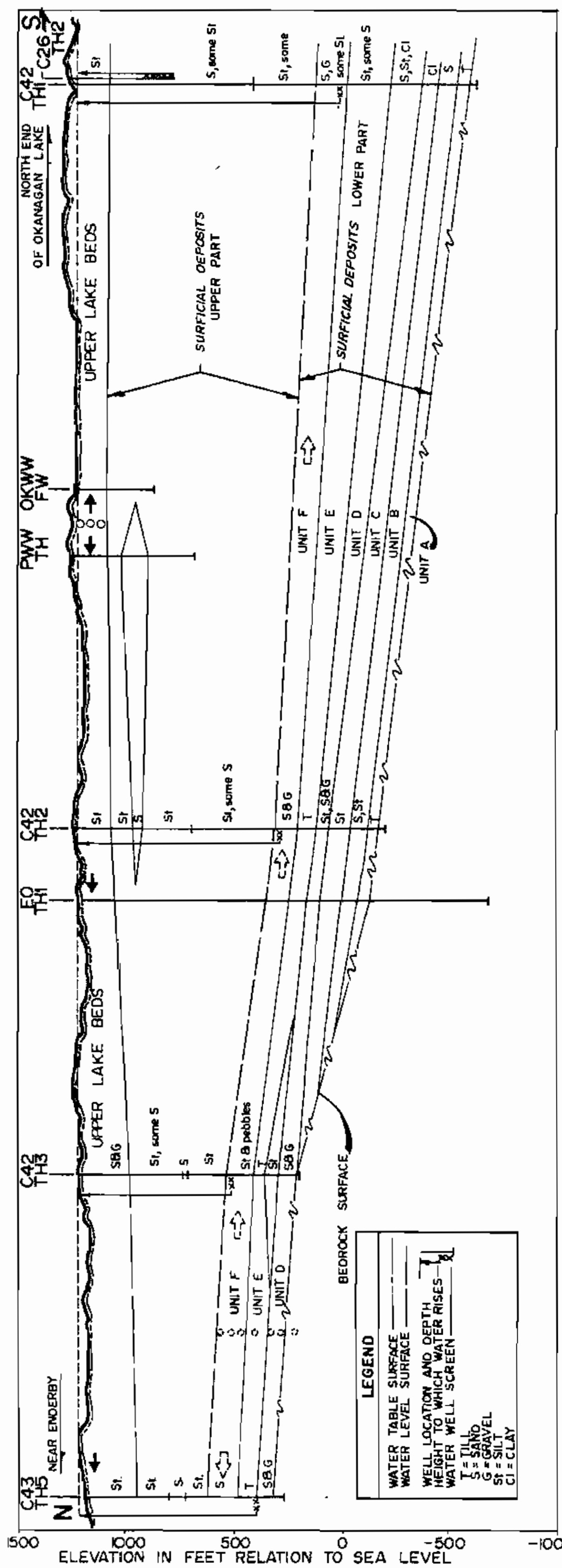
An important result of the test drilling has been the regional picture which can be constructed of the surficial deposits of the main valley (Figure 4.25). These can be divided into a lower and upper part. The lower part of the sediments show an alternating sequence of till, clay and silt, sand and gravel zones divided into units A to F. This sequence ranges from about 300 feet thick in the north near Enderby to about 750 feet thick south of Armstrong. The till zones range from about 40 to 100 feet thick; silt, sand and gravel zones are about 80 to 220 feet thick; and a clay-silt zone is about 100 feet thick. Changes within these layers may be due to non-deposition in some parts of the valley, or to removal and subsequent replacement by later glaciations. The uppermost of these silt, sand and gravel zones is the one in which most of the deep test holes were completed as observation wells. The units A to F have been denoted in ascending order.

Overlying the succession of tills and sands, and comprising the upper part of the main valley deposits, is 500 to 1,000 feet of sediments that are mainly silt. There are some sand beds in the upper part of the sequence, and of particular importance to this study, are the thick sands occurring in the Maid Creek area south of Armstrong. The sands in the upper part of the surficial deposits are commonly fine to medium-grained angular sands.

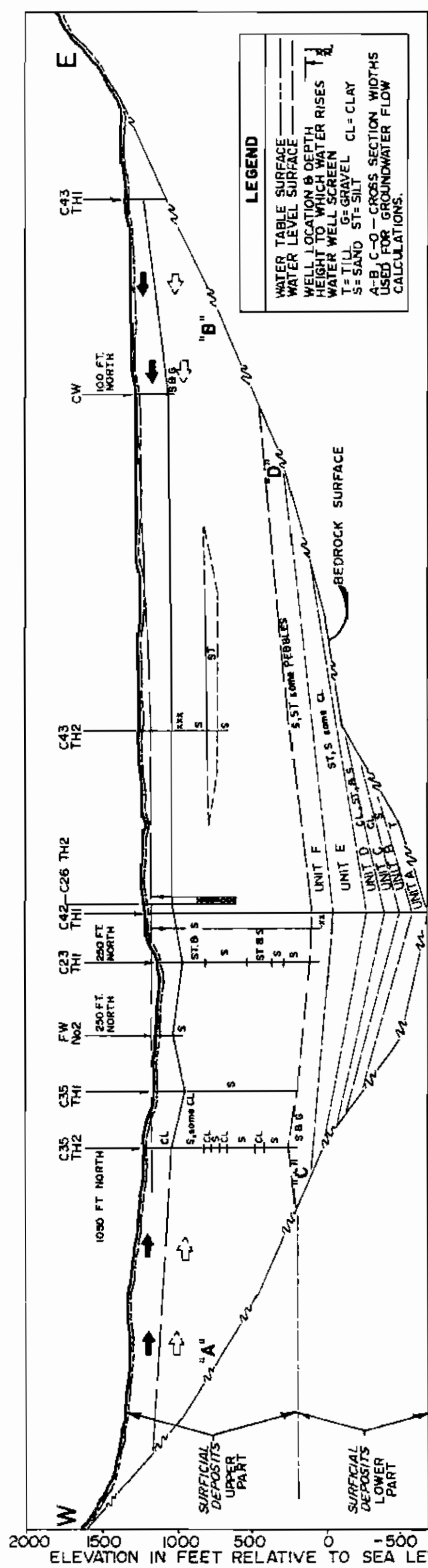


GEOLOGY IN SPALLUMCHEEN VALLEY
NORTH OKANAGAN LAKE

Figure 4.24



SCHEMATIC PROFILE of VALLEY BETWEEN SHUSWAP RIVER AT ENDERBY and NORTH END of OKANAGAN LAKE.
(See Figure 4.20)



SCHEMATIC CROSS SECTIONS of VALLEY SOUTH of ARMSTRONG (See Figure 4.20)

SCHEMATIC OF HYDROGEOLOGICAL SECTIONS SHOWING SURFICIAL DEPOSITS and GROUND-WATER FLOW in the NORTH END of the OKANAGAN VALLEY.

Figure 4.25

Considerable local variations are anticipated within the upper part of the surficial deposits. Local deposits of gravel and sand on the east side of the valley are attributed to melt-waters from tributary valleys, and sands on the west side of the maid creek cross-section may have been derived in association with melt-waters discharging to the south from Deep Creek. It may also be observed that there is down-valley thickening of both the upper and lower parts of the valley fill deposits.

The probability of large quantities of groundwater flow from adjacent valleys, the Shuswap River Valley and the Salmon River Valley, is remote. Some water may enter the Okanagan River Basin down the O'Keefe Valley, but it is unlikely that there is groundwater flow from the Shuswap Valley.

From the underflow calculations, a total rate for groundwater movement towards Okanagan Lake of about 3-1/3 cfs (2,370 acre-feet per year) has been determined. This figure seems reasonable compared to a recharge rate of 6 cfs (4,350 acre-feet per year) from one inch of precipitation, which is assumed to reach the water table over a recharge area estimated as 80 square miles.

4.5.4 Aquifers in the Surficial Deposits

The surficial deposits described in the previous section contain the important aquifers in the area. Aquifers in the units D and F of the lower deposits may extend from Enderby on the Shuswap Rive to Okanagan Lake. The aquifers consisting of sand and gravel with silt, vary in permeability from a low of 10 Imperial gallons per day per square foot, to a high of about 300 Imperial gallons per day per square foot. These variations in permeability occur from localities where the aquifers consist of clean sand and gravel. Aquifer thicknesses range from about 80 to 150 feet.

Aquifers in the upper part of the surficial deposits are smaller in area, but vary more widely in thickness. In the area south of Armstrong, aquifer materials average about 600 feet thick towards the center of the valley. Near the valley sides, fan deposits form sand and gravel aquifers having known thicknesses from 10 to 50 feet and are probably thicker.

The aquifers in both the upper and lower parts of the surficial deposits are confined, and the water level rises above the top of the aquifer. At some locations, the aquifers are artesian. Conditions of local artesian flow are associated with the fan deposits flanking parts of the east valley wall.

The O'Keefe Valley aquifer extends throughout the entire length of the O'Keefe Valley. The maximum known thickness of the deposits in this valley is 575 feet, of which the saturated thickness is close to 350 feet. A second important aquifer trending from southwest to northeast, occurs in a bedrock channel about four and one half miles north of Armstrong. The aquifers in this valley and in the O'Keefe Valley are unconfined (or water table) aquifers.

4.5.5 Well Yields, Quality and Cost

(a) Well Yields

Well yields, in the depth range 700 to 1,200 feet, vary considerably in the main valley area. Yields range up to 10 Imperial gallons per minute for wells suited to domestic supplies, to 500 Imperial gallons per minute or possibly more for wells suited to industrial or irrigation requirements. In the Enderby area, yields of 500 Imperial gallons per minute or over are anticipated from wells 800 to 875 feet deep. Yields from similarly deep wells elsewhere in the main valley are anticipated to be low, from 30 to 250 Imperial gallons per minute.

Wells in the depth range of 300 to 600 feet in the Armstrong area may produce from 200 to 250 Imperial gallons per minute. In the O'Keefe Valley yields of up to 500 Imperial gallons per minute are anticipated from wells completed to depths of about 550 feet. The narrow unconfined aquifer four and one half miles north of Armstrong is expected to have well yields of about 50 Imperial gallons per minute.

The total quantity of recoverable water available by water mining has been calculated as 66,500 acre-feet, most of which is located in the O'Keefe Valley. However, as the recharge from precipitation in the O'Keefe Valley is equivalent to only about 3/4 cubic feet per second (540 acre-feet per year), the length of time required to replenish this supply would be about 100 years.

The potential available for groundwater withdrawal without depleting supplies is estimated at from 3-1/3 to 6 cfs. It is believed that present utilization of groundwater is well below the lower figure. This potential does not include that of the Enderby area which falls in the hydrologic regime of the Shuswap River Valley.

(b) Quality

Analysis of groundwaters sampled in the study area show the chemical quality of the water is very good. The total dissolved solids content is commonly in the range of 200 to 500 parts per million, with the dissolved constituents being primarily calcium and magnesium bicarbonates. The water is quite suitable for human consumption and for irrigation use and should require little or no treatment for industrial purposes.

(c) Cost at Well Head

The economics of groundwater development indicate that for one locality, limited preliminary groundwater investigations, including seismic work, test drilling and pump testing, may cost about $45,000. High yield production wells producing about 800 Imperial gallons per minute, and including pump and pump house, are estimated to cost from $25,000 to $50,000. The actual costs will vary with such factors as drilling conditions and well diameter.

Annual costs including amortization, interest charges over 25 years, and power, operation and maintenance will vary between $3,600 to $7,600. These well costs are based on the production of four acre-feet per day over a period of 90 days, and are equivalent to a cost of $10 to $20 per acre-foot at the well head.

Equivalent capital cost for a small domestic water supply yielding about 10 Imperial gallons per day, may run between $4,000 and $6,000.

4.5.6 Summary

The total quantity of groundwater available from water mining in the North Okanagan is estimated to be about 66,500 acre-feet, most of which is located in the O'Keefe Valley aquifer. However, as the recharge from precipitation to the O'Keefe Valley is only about 540 acre-feet per year, the length of time to replenish this aquifer would be about 100 years.

The potential available for groundwater withdrawal in the North Okanagan without depleting supplies is estimated to be 3-1/3 cubic feet per second, or 2,370 acre-feet per year.

The total groundwater flow in six tributaries examined is small and not considered significant when compared to the surface flows of these tributaries. Fan deposits at the mouths of these creeks may provide limited sources of groundwater for local use.

Groundwater studies within the main valley have been confined almost entirely to the north end, and no studies have been carried out with regard to groundwater return flow from irrigation, nor has any work been done on which to base estimates of groundwater flow at the south end of Okanagan Lake.

CHAPTER 5

Water Quality

Previous sections of this report have discussed the quantity of water available within the Okanagan Basin. Of equal importance is the quality of this resource in the tributary streams, lakes, and rivers as it flows through the basin. The term quality refers not only to the condition of water for drinking purposes and other consumptive uses, but also to the condition of bodies of water as a suitable habitat for aquatic life and for recreation (non-consumptive uses).

Under the Okanagan Basin Agreement, studies were carried out to determine: the present quality of the tributary streams and main valley lakes; the sources and amounts of nutrients and other chemical constituents entering the water of the basin; the extent and range of possible future sources and levels of pollution; and to test and evaluate methods for the control of nutrient discharges through the treatment of municipal and industrial wastes. The purpose of this chapter is to present the results of these quality studies. The results of studies on the main valley lakes, known collectively as limnological studies, are presented in a separate section because of the complex nature of lakes and the different types of studies required to assess their condition. The extent and range of possible future sources and levels of pollution are presented in Chapter 15.

5.1 WATER QUALITY FOR CONSUMPTIVE AND OTHER BENEFICIAL USES

During the period 1969 to 1972 a number of monitoring programs were carried out to determine the concentrations of various chemical constituents in the streams and lakes of the Okanagan Basin, and the number of coliform bacteria as a measure of the presence of pathogenic (disease causing) bacteria. The results of these monitoring programs have been used to evaluate the present condition and suitability of these waters for such designated uses as domestic water supplies, irrigation, recreation, and aquatic life, as well as for estimating present and future loadings to the main valley lakes.

5.1.1 Water Quality Criteria

In water quality the term 'Criteria' may be generally defined as a scientific requirement on which a decision or judgement may be based concerning the suitability of a water to support a designated use. A severe short coming in determining these scientific requirements, as related to water quality, is the lack of adequate knowledge concerning many of the quality characteristics upon which criteria should be based.

The use of water for drinking purposes is generally conceded to be the most essential use of water, however, other designated uses may have water quality requirements which are more stringent than those for drinking water. For example: water that is suitable for domestic supplies often requires further treatment before it can be used in industrial processes; softened water for municipal systems can be detrimental for irrigation; and aquatic life in streams and lakes may be destroyed or inhibited by concentrations of copper and zinc that are permissible in domestic water supplies. Further complicating factors affecting water quality criteria are the variations in natural conditions affecting water quality such as the climate, geography, and geology of a watershed. There is also a lack of adequate knowledge concerning the effect of many of the trace elements on water quality and health.

The water quality criteria presented in Table 5.1 is included primarily for guideline purposes and should only be used in conjunction with a thorough knowledge of local conditions. The criteria embrace a quality level which is generally acceptable for recreation, aquatic life and as a raw water supply prior to treatment to provide drinking water.

5.1.2 Quality of Tributary Streams

Examples of the raw water quality of selected streams are shown in Table 5.2 and the location of sampling stations in Figure 5.1. The streams selected are those in which one or more of the acceptable standards were exceeded during the monitoring period. The ranges shown are the minimum and maximum values obtained over the two year sampling period 1969-71. In general, the maximum values were recorded during the spring freshet period, while the minimum values were recorded during the remainder of the year. On four of the streams - Mission, Kelowna, Vernon, and Deep Creeks, values are shown for two stations, one located at the mouth of the stream and the other above urban development. All other values were recorded at the mouths of the streams.

Almost all streams sampled in the basin exceeded color and turbidity standards during the spring freshet period. The high color levels are due largely to the natural characteristics of the watershed and are undesirable for aesthetic reasons rather than any health hazard.

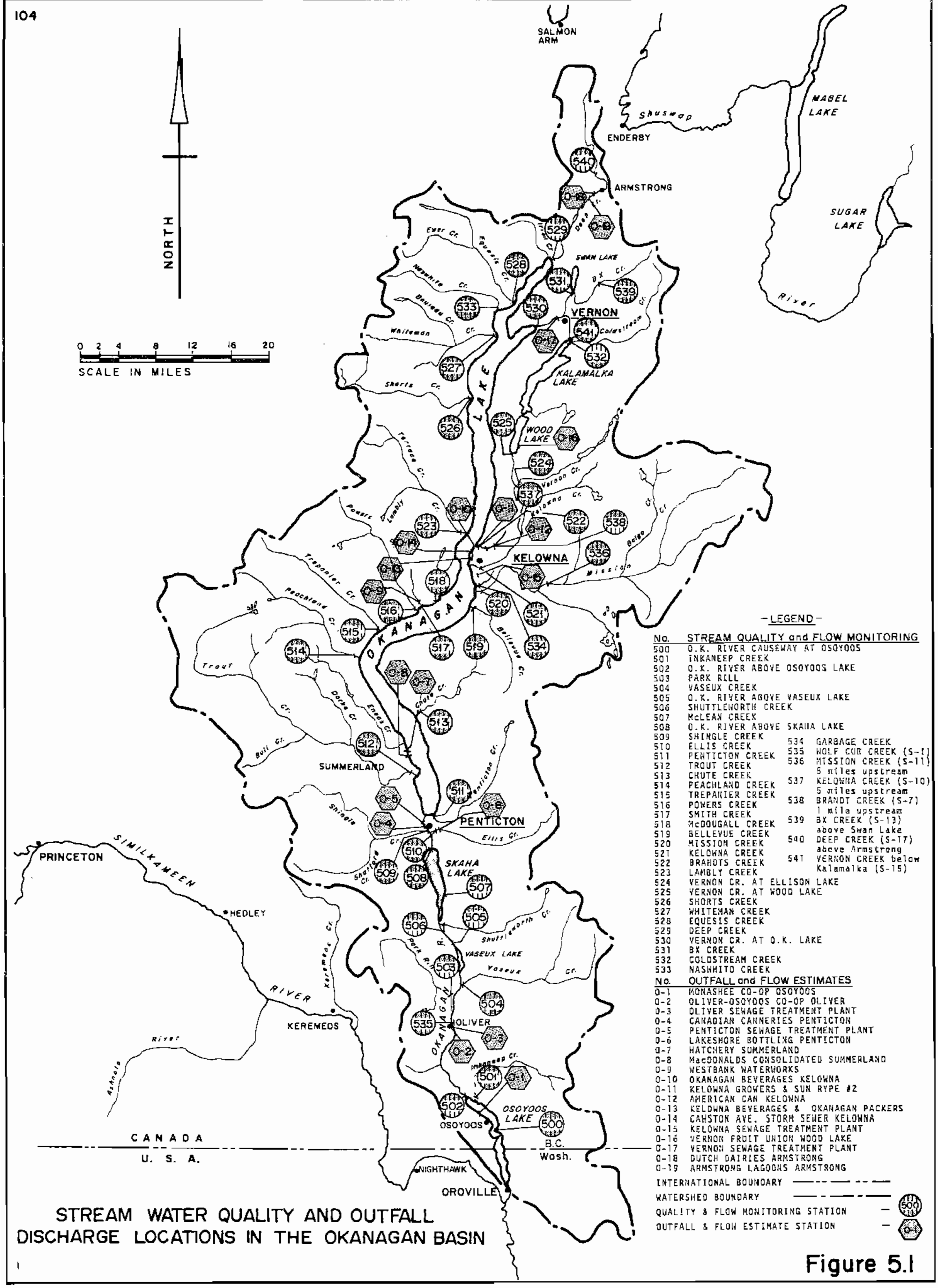
Turbidity results from the natural and induced erosion of the banks of tributary streams and is undesirable from a health point of view because of its absorptive affect on chlorine which is added to outfall effluents to kill pathogenic bacteria.

Manganese and phosphorus levels were also high in many of the streams sampled, particularly during the freshet period. Manganese in natural streamflow comes most often from soils and sediments, in waste effluents from the manufacturing industry (batteries, ceramics, paints, etc.) and agriculture

TABLE 5.1
GENERALLY ACCEPTED ALLOWABLE CRITERIA - RAW WATER SOURCES

FOR DRINKING WATER, AQUATIC LIFE AND RECREATION - FOR SIGNIFICANT WATER QUALITY PARAMETERS IN THE OKANAGAN BASIN

WATER QUALITY PARAMETER AND (REFERENCE)	CRITERIA - MAXIMUM ALLOWABLE CONCENTRATIONS		COMMENTS
	DRINKING WATER	AQUATIC LIFE	
Color (1)	15 units	--	Indicated limits on colour in drinking water are primarily to meet aesthetic satisfaction. Excessive colour may also indicate presence of undesirable organic substances. In excess of 50 Units it tends to block out sunlight and interfere with propagation of fish food organisms.
Turbidity (2,3)	5 J.T.U.	10 J.T.U.	From aesthetic viewpoint turbidity in excess of 1 Jackson Turbidity Unit (J.T.U.) may be objected to by majority of consumers. Excessive turbidity may also interfere with clarification and disinfection processes.
Copper (1,2,4,5,6,7)	1.0 ppm.	0.1	Drinking water limits based on considerations of taste and staining characteristics. Copper concentrations in excess of .02 parts per million (ppm) may be lethal to trout and salmon.
Iron (1,2,4,5,6)	0.3 ppm.	0.2 ppm.	Iron is a highly objectionable element in water supplies for domestic uses and the acceptable limit is based on considerations of effects on household use. In concentrations greater than 0.3 ppm it may impart a brownish colour to laundered goods and stain plumbing fixtures. The taste of water and beverages may be affected by concentrations greater than .05 ppm. A concentration of 0.2 ppm is the lethal threshold for some fish species.
Manganese (1,2,4,5)	0.05 ppm.	1.0 ppm	Excessive concentrations of manganese may cause staining particularly in conjunction with iron, has an unpleasant taste and fosters the growth of some micro organisms in reservoirs, filters and distribution systems.
Dissolved Oxygen	--	5.0 ppm. minimum	A minimum of 5 ppm of dissolved oxygen is considered necessary for all fish populations. The absence of dissolved oxygen promotes an aerobic decomposition which is accompanied by undesirable odors High concentrations of oxygen are beneficial rather than harmful.
Nitrogen (1,8)	10.0	--	The limit on nitrogen (nitrate + nitrite) of 10 ppm is based on the relationship established between this chemical and the possible occurance of infantile methaemoglobinemia. No cases of this disease have occurred where the drinking water consistently contained less than 10 ppm of nitrogen.
Phosphates (1,4,8)	0.2	.05 to .1	Limitations on phophorus concentrations are primarily to prevent excessive growth of photosynthetic organisms (algae and weeds) in reservoirs and the resultant problems of odor and taste. A concentration of 0.2 may be high under some conditions. Preferable limits for aquatic life are .05 ppm in lakes, and 0.1 ppm in flowing streams.
Zinc (1,2,3,4,5,6)	5.0 ppm.	0.1 ppm.	Acceptable limit for drinking water is based primarily on aesthetic effect as excessive amounts may impart milky appearance and a metallic taste to water. This element has no serious effect on human health but may be lethal to fish and other aquatic life in concentrations greater than 0.1 ppm.
Coliform (1) <u>Drinking Water</u> -Total	1000/100ml	--	The acceptable limit for total coliform organisms in untreated water supplies prior to filtration and chlorination as enumerated by the Most Probably Number multiple tube fermentation test should not exceed a density of 1000 per 100 millileters (ml) in 90% of the samples in any consecutive 30 day period should not exceed a density of 100 organisms per 100 ml.
-Faecal	100/100ml	--	
Coliform <u>Water Contact Sports</u> (9-10) -Total	240/100ml	--	Maximum safe levels of coliform for water contact sports such as swimming.
-Faecal	200/100ml	--	



STREAM WATER QUALITY AND OUTFALL DISCHARGE LOCATIONS IN THE OKANAGAN BASIN

Figure 5.1

where it is used to spray manganese deficient trees. Manganese in concentrations in excess of 0.2 parts per million may cause undesirable tastes, stain kitchen utensils and plumbing fixtures, and foster the growth of some micro-organisms in reservoirs, filters and distribution systems. A level of one part per million in raw water supplies is lethal to fish and other aquatic life.

The element phosphorus does not occur free in nature but is found in the form of phosphates in minerals and soils. Phosphorus is a key nutrient in animal and plant life and is extremely important in processes involving the transfer of energy in all living cells.

The high levels of total phosphorus in streams are the result of a combination of natural and urban sources. Watershed deforestation and erosion undoubtedly increase the amount of total phosphorus in streams although most of this is in the form of suspended debris rather than in the soluble orthophosphorus form (Table 6.3 Chapter 6). Industrial and municipal outfalls, and groundwater return flows add to the concentration of phosphorus in the lower reaches of the streams as indicated by the increases in total phosphorus between the upper and lower stations of Mission, Deep, and Kelowna Creeks. The reduction in phosphorus content between the upper and lower station on Vernon Creek is due to the water passing through Ellison, Wood, and Kalamalka Lakes where much of it is deposited or assimilated, before reaching Okanagan Lake. The major problem associated with phosphorus is excessive algae and aquatic plant growth, which can result in undesirable tastes and odors in drinking water.

Low oxygen contents were recorded in Shuttleworth, Ellis, Brandts, Bellevue, Lambly and Deep Creeks. Brandts Creek and Deep Creek are affected by industrial and urban waste discharges which reduce oxygen levels. Most of the other creeks however are in relatively undeveloped areas and the reason for these low readings is not known. Dissolved oxygen concentrations of less than 5 parts per million are lethal to some fish. The high total nitrogen recorded at the mouth of Vernon Creek may be attributed to municipal waste effluent discharge from the City of Vernon.

Other chemical standards exceeded, included iron in Penticton, Ellis and Brandts Creeks, alkalinity in Lambly Creek and hardness in Brandts and Deep Creeks. These represent relatively isolated conditions however, and are not considered a major problem at this time.

One of the most important criteria for raw water supplies, the limits of which are exceeded in many streams, is the presence of pathogenic bacteria (bacteria causing or capable of causing disease). For many years the coliform group of bacteria has been used to indicate the presence of pathogenic bacteria.

Coliform bacteria are themselves harmless to humans, but if present in sufficient numbers, generally indicate the presence of pathogenic bacteria of intestinal origin. The absence of coliform bacteria is the best available evidence that a drinking water is bacteriologically safe. Of thirty streams tested for coliforms levels, 10 exceeded the acceptable criteria for both total coliform and fecal coliform including those of Inkaneep, Westbank, Brandts, Equesis, and Kelowna Creeks as shown in Table 5.2. With the exception of Inkaneep and Equesis Creeks all those shown are affected by urban development and associated waste discharges. Other streams which exceeded acceptable coliform standards include McLeans, BX, and Coldstream Creeks, the latter two of which drain confined farm animal operations. The median values shown are based on approximately 20 or more tests taken over the two year sampling period 1969-71.

In summary the quality of many streams in the lower reaches is not generally acceptable as raw water supply (untreated) for drinking water purposes, due to excess concentrations of color, turbidity, manganese, phosphorus, and particularly coliform densities. The quality of water in the upper reaches of most streams was not determined, but on the basis of the few streams sampled above major urban developments, would appear to be of a higher quality than in the lower reaches. Except for coliform and turbidity, the standards exceeded render the water undesirable for aesthetic and household use purposes, rather than as a health hazard.

5.1.3 Quality of Main Valley Lake Water

(a) Drinking Water and Aquatic Life

Examples of the raw water quality of the main valley lakes and Okanagan River are shown in Table 5.3. Some information on water quality was also obtained for a few of the headwater lakes, and five of these are included for comparison purposes. Osoyoos and Wood Lake have high phosphorus concentrations and Wood Lake has oxygen deficiencies at certain times of the year, but otherwise the water quality of the main valley lakes is generally acceptable for consumptive use purposes.

Ellison Lake, which is a very shallow lake, exceeds most of the limits for acceptable water quality.

It is interesting to note that four of the five headwater lakes shown in Table 5.3 exceed color and total phosphorus criteria. The high color content is considered to be a natural condition of the watershed and indicates the source of the high color content in most of the streams. The total phosphorus is considered to be largely organic matter in the insoluble form.

Okanagan River, which joins the main lakes downstream of Okanagan Lake exceeds acceptable limits for color, turbidity, iron, and total phosphorus

TABLE 5.2

RAW WATER QUALITY OF SELECTED STREAMS IN THE OKANAGAN BASIN (1969-1971 DATA)

CREEK NAME	LOCATION AND STATION	PHYSICAL: COLOR (True Color Units)	PHYSICAL: TURBIDITY (Jackson Turbidity Units)	CHEMICAL CONSTITUENTS: CHLORIDE (as Cl) parts per million	FLUORIDE (as FL) parts per million	IRON (as Fe) parts per million	COPPER (as Cu) parts per million	MANGANESE (as Mn) parts per million	TOTAL PHOSPHORUS parts per million	TOTAL NITROGEN parts per million	OXYGEN (dissolved O_2) parts per million	BIOLOGICAL: TOTAL COLIFORM DENSITY (Organisms per 100 mls)	FECAL COLIFORM DENSITY (Organisms per 100 mls)
GENERALLY ACCEPTED CRITERIA FOR DRINKING WATER STANDARDS		15	5	250	1.5	0.3	1.0	0.05	0.065	10	Should be greater than 5	1000	100
		MINIMUM AND MAXIMUM VALUES FOR PERIOD 1969 to 1971											
Inkaneep	At Mouth (501)	5-75	1.8-165	0.5-2.8	.15-.49	.06-.27	.001-.006	.001-.044	.007-.359	0.01-1.00	8.0-14.1	1,263	116
Vaseux	At Mouth (504)	5-65	0.2-11	0.3-0.6	.13-.35	.01-.13	.001-.006	.001-.010	.003-.039	0.01-1.06	9.8-14.0	70	5
Shuttleworth	At Mouth (506)	0-75	0.2.140	0.5-11.5	.12-.34	.01-.28	.001-.006	.001-.100	.003-.424	0.11-1.56	4.2-16.4	918	65
Ellis	At Mouth (510)	5-85	0.9-260	0.6-10.2	.07-.29	.02-.65	.001-.015	.001-.750	.007-.457	0.03-2.68	2.8-13.9	542	8
Penticton	At Mouth (511)	10-70	0.7-62	0.4-8.7	.05-.15	.09-.68	.001-.008	.001-.090	.003-.359	0.01-9.27	8.0-14.5	516	26
Trout	At Mouth (512)	0-40	0.2-210	0.8-4.4	.09-.24	.01-.12	.001-.015	.001-.060	.003-1.27	0.06-2.86	7.6-15.3	850	20
Peachland	At Mouth (514)	0.65	0.2-57	0.0-1.3	.13-.66	.01-.18	.001-.011	.001-.01	.003-.245	0.18-2.79	8.6-13.7	348	6
Powers	At Mouth (516)	5-65	0.3-60	0.6-2.8	.02-.39	.01-.25	.001-.008	.001-.03	.007-.330	0.14-2.17	8.5-13.9	490	14
Westbank	At Mouth (517)	5-45	4.0-230	5.0-11.0	.29-.50	.01-.10	.001-.007	.001-.018	.038-1.27	.059-4.66	8.6-13.5	5,420	232
Bellevue	At Mouth (519)	0-60	0.2-35	0.7-3.3	.05-.15	.01-.12	.001-.008	.001-.050	.001.1.24	0.06-1.98	1.4-13.3	240	6
Mission	At Mouth (520)	5-50	0.5-43	0.3-1.9	.05-.17	.01-.10	.001-.011	.001-.056	.003-.783	.031-2.08	7.9-15.0	500	88
Mission	Above Urban Area (536)	5-50	0.4-26	0.4-0.8	.05-.15	.05-.08	.001-.004	0.01-.018	.007-.205	.030-.730	8.0-13.7	109	9
Brandt's	On Guy Street (522)	10-70	2.4-115	11.6-41.8	.37-.99	.03-.52	.001-.011	.011-.610	.058-2.70	0.19-7.69	0 -13.8	169,000	980
Lambly	At Mouth (523)	0-75	0.1-16	0.4-1.0	.06-.13	.01-.18	.001-.004	.001-.015	.007-1.79	0.01-6.55	4.7-14.1	86	4
Shorts	At Mouth (526)	0-50	0.2-150	0.2-0.9	.02-.28	0 -.13	.001-.006	.001-.010	.007-3.40	0.01-4.50	6.5-14.1	918	13
Equesis	At Mouth (528)	0-45	0.5-160	0.2-0.8	.12-.29	.01-.10	.001-.006	.001-.047	.009-1.21	0.02-7.15	9.6-13.7	939	123
Kelowna	At Mouth (521)	5-65	3.1-13	3.1-13.0	.13-.27	.01-.21	.001-.007	.001-.230	.020-.750	0.31-4.10	6.9-14.6	5,420	1,122
Kelowna	Above Urban Area (537)	5-90	1.7-44	1.1-419	.10-.23	.04-.19	.001-.010	.044-.200	.072-.300	0.08-3.3	7.0-11.7	800	238
Deep	Above Armstrong (540)	5-75	0.3-11	1.2-1.5	.14-0.3	.03-.09	.001-.005	.014-.210	.033-.108	0.08-9.06	7.6-12.3	1,300	163
Deep	At Mouth (529)	10-110	0.5-70	2.2-43.0	.16-.31	.01-.22	.001-.007	.001-.340	.050-.717	0.22-3.75	3.8-13.5	1,300	129
Vernon	At Okanagan Lake (530)	5-20	1.8-61	1.6-35.0	.15-.31	.01-.18	.001-.009	.001-.330	.039-1.86	0.19-12.0	6.2-12.3	5,420	438
Vernon	Above Ellison Lake (524)	0-110	0.2-1000	0.4-1.7	.060-.15	.01-.16	.001-.013	.001-.130	.007-6.69	0.01-3.61	6.9-14.5	109	8
Coldstream	At Mouth	0-45	0.4-51	0.9-5.0	.13-.38	.01-.08	.001-.012	.001-.060	.016-.750	.140-3.92	4.1-14.1	1,410	377

NOTE: Values underlined exceed acceptable criteria

TABLE 5.3

RAW WATER QUALITY OF - OKANAGAN RIVER AND SELECTED LAKES IN THE OKANAGAN BASIN (1969-1971 DATA)

RIVER OR LAKE	LOCATION AND STATION	PHYSICAL: COLOR (True Color Units)	PHYSICAL: TURBIDITY (Jackson Turbidity Units)	CHEMICAL CONSTITUENTS: CHLORIDE (as Cl) parts per million	FLUORIDE (As Fl) parts per million	IRON (as Fe) parts per million	COPPER (as Cu) parts per million	MANGANESE (as Mn) parts per million	TOTAL PHOSPHORUS parts per million	TOTAL NITROGEN parts per million	BIOLOGICAL: OXYGEN* (Dissolved O_2) parts per million	TOTAL COLIFORM DENSITY	FECAL COLIFORM DENSITY
GENERALLY ACCEPTED CRITERIA FOR DRINKING WATER STANDARDS		15	5	250	1.5	0.3	1.0	0.05	0.065	10	Should be greater than 5	1000 Organisms per 100 ml	100 Organisms per 100 ml
		MINIMUM AND MAXIMUM VALUES FOR PERIOD 1969-1971 (shown where available)											
Okanagan River	1.2 Mi. Upstream from Osoyoos L. (502)	0-35	0.6-9.4	1.1-2.2	0.16-28	.01-.11	.001-.009	.001-.050	.003-.390	.030-2.38	8.2-14.3	348	13
Okanagan River	1.5 Mi. Upstream from Vaseux Lake (505)	0-10	0.3-25	0.7-1.6	0.17-24	.01-.06	.001-.006	.001-.028	.003-.130	.003-1.48	8.5-14.9	40	3
Okanagan River	Entrance to Skaha Lake (508)	0-25	0.3-15.6	0.8-3.4	0.16-.20	.01-.32	.001-.004	.001-.047	.007-.241	.050-2.52	7.9-12.9	109	9
Osoyoos Lake	Mid-Lake at Border	3.4	1.19	1.60	.193	.010	.013	.005	-	-	9.0-9.0	-	-
Osoyoos Lake	Mid-Lake 1 Mi. No. of Mica Creek	-	1.40	1.25	.240	.060	.013	.016	.207	.150	8.0-8.5	-	-
Skaha Lake	Mid-Lake Opposite Kaleden	5.0	0.90	1.40	.119	.080	.018	.006	.052	.250	8.5-9.2	-	-
Okanagan Lake	Mid-Lake Opposute Summerland	10.0	0.40	1.00	.200	.013	.011	.004	.030	.060	8.1-9.1	-	-
Okanagan Lake	Mid-Lake At Kelowna Bridge	0.0	0.60	1.10	.160	-	.014	.004	.020	-	8.5-8.5	-	-
Okanagan Lake	Mid-Lake 3 Mi. So. of Okanagan Landing	5.0	0.60	0.80	.210	.260	.024	.005	.033	.186	-	-	-
Kalamalka Lk.	Mid-Lake Opposite Rattlesnake Point	10.0	1.00	1.50	.330	.047	.015	.003	.022	.204	8.6-9.2	-	-
Wood Lake	Middle of the lake	5.0	2.10	2.65	.340	.007	.016	.008	.134	.387	0.5-13.4	-	-
Ellison Lake	In Vernon Creek Basin	20.0	14.00	0.90	.130	.790	.015	.067	.235	.597	1.4-1.4	-	-
Agur Lake	In Trout Creek Basin-no drainage	-	1.20	2.60	-	-	-	.008	.037	-	-	-	-
Hydraulic Lk.	Headwater of Mission Cr.	65.0	-	0.60	-	-	-	.008	.087	-	8.3-8.3	-	-
Jackpine Lake	Headwater of Powers Cr.	50.0	1.10	0.40	-	-	-	.008	.215	-	8.0-8.0	-	-
Lambly Lake	Headwater of Lambly Cr.	65.0	5.60	0.50	-	-	-	.008	.205	-	9.3-9.3	-	-
Oyama Lake	Headwater of Oyama Creek	30.0	-	0.40	-	-	-	.008	.160	-	8.6-8.6	-	-

NOTE: Lake Oxygen content refers to the bottom waters only.

Values underline exceed acceptable criteria content during the freshet period. Most of the parameters that are exceeded reflect the discharges of tributary streams in the vicinity of the sampling area. For example the high iron content in Okanagan River at the entrance to Skaha Lake is probably a result of the high iron content in Ellis Creek which joins Okanagan River just above the sampling point.

(b) Recreational Bathing Areas

Because of the importance of water-based recreation in the Okanagan Basin, to both residents and tourists, and public concern regarding the quality of bathing areas, a separate study on the coliform levels at three major beaches in the Okanagan was carried out between July and September, 1971. The major objectives of the study were to determine the coliform levels at these beaches; the minimum number of samples required to calculate a meaningful coliform count for closing or opening bathing areas; and the probably source of such coliforms.

The three beaches selected for this study were Kin Beach at Vernon, on the north end of Okanagan Lake; Okanagan Beach at Penticton at the south end of Okanagan Lake; and Skaha Beach at Penticton, on the north end of Skaha Lake. Each beach front was sampled on a grid pattern with sixty sampling sites at three different distances from the shore. These points encompassed the whole swimming area of each beach from the shore to the farthest swimming points, usually marked by buoys. Initially, samples were taken at three different depths; surface, one foot, and mid-depth, but as the results of the initial sampling indicated that coliform levels tended to be higher for the surface samples, the remaining ones were all collected at the surface. Skaha Lake was the only beach area sampled in September.

The results of this study showed all tests for fecal coliform to be less than the B.C. Health Branch standard of 200 organisms per 100 milliliters, and for all samplings of total coliform at Okanagan and Skaha beaches the median coliform levels were less than the standard of 240 organisms per 100 milliliters. At Kin Beach, the acceptable level of total coliform was exceeded in two out of the four sampling periods. It was also found that to obtain a reliable coliform count for any one beach, more than ten random samples encompassing the entire beach area are required for each sampling. Below this number the results become too erratic, and are not representative of the beach area as a whole.

A second test used for the presence of pathogenic bacteria in the Skaha Beach areas was "Moore's Gauge Swab Test" (Ref. No.11). Test installations were secured at various locations in the bathing area. In all cases the swab samples submitted for examination of pathogenic organisms yielded negative results. This is supported by similar studies by Geldrich (12) which showed that there was little evidence of pathogenic organisms in water samples that had fecal coliform tests of approximately 200 organisms per 100 milliliters.

An examination of coliform test on streams and outfalls indicate the main contributors of fecal coliform to be those centers with sewage treatment outfalls as shown in Table 5.4. The contribution from streams was relatively small in comparison to these outfalls. The City of Vernon Sewage Treatment Plant, Dutch Dairies at Armstrong, and the City of Armstrong Lagoons contribute fecal coliform to the Kin Beach area at Vernon, and the City of Penticton Sewage Treatment Plant contribute fecal coliform to Skaha Beach at Penticton.

Insufficient data were obtained in this study to evaluate all of the factors contributing to changes in coliform levels of bathing beaches. Future studies should consider such factors as bathing population, the circulation pattern of lake water in beach areas, and the weather, on coliform densities.

TABLE 5.4

COLIFORM RESULTS - OUTFALL SAMPLING LOCATIONS

Location of Outfall	Point of Discharge	COLIFORM - TOTAL		COLIFORM - FECAL	
		Number of Samples	Median*[1]	Number of Samples	Log Mean*[1]
Village of Oliver S.T.P.	Okanagan River	18	2,000	6	110
Canadian Canners[2] Penticton	Okanagan River	1	2,400,000	-	-
City of Penticton S.T.P.	Okanagan River	20	2,750	9	949
Westbank Lagoon	Westbank Creek	7	54,200	2	110
Calona Wines and O.K. Beverages, Kelowna	Brandt's Creek	1	2,000	-	-
City of Kelowna S.T.P.	Okanagan Lake	18	89,050	6	423,983
City of Vernon S.T.P.	Vernon Creek	25	2,000	7	431
Dutch Dairies Armstrong	Deep Creek	20	160,900	2	987,500
City of Armstrong Lagoons	Deep Creek	21	160,900	4	16,375

*1 Most probable number per 100 milliliters.

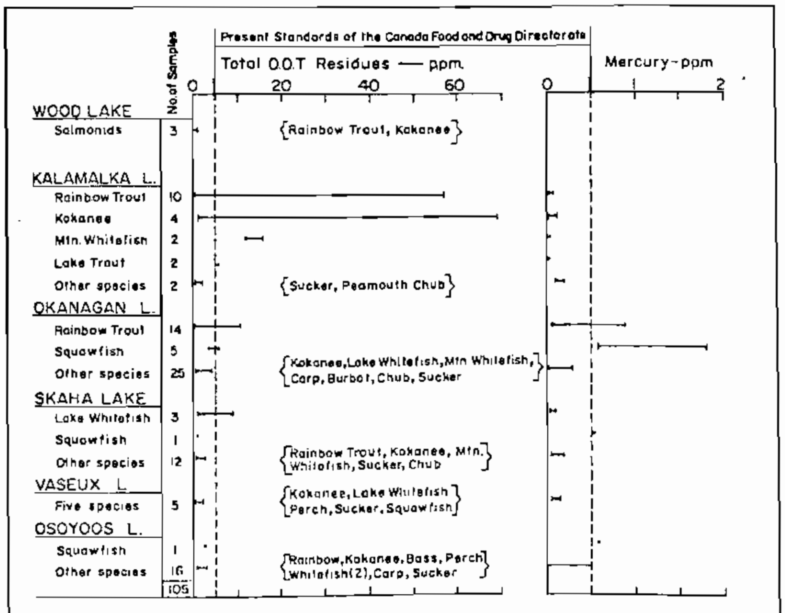
*2 In 1972 Canadian Canners at Penticton commenced discharging effluent to Penticton Sewage Treatment Plant.

5.1.4 Pesticides and Trace Metals

Studies on the use of pesticides within the Okanagan Basin, and on the levels of mercury and the pesticide D.D.T. in fish, were carried out to obtain some preliminary information on this aspect of water quality.

A review of the use of pesticides in the Okanagan Basin over the past 10 years show that the sales of D.D.T. declined from a 10 year peak of 836,000 pounds in 1965 to 27,700 pounds in 1970. The most serious problem associated with D.D.T. and related compounds was their persistance in the environment and accumulation in the food chain, culminating in a provincial (British Columbia) ban on this type of pesticide in 1971. Although a number of new pesticides have appeared in the past 10 years, Entomologists have recognized that pesticides are not the final answer to insect control, and that other forms of control are desirable along with the intelligent use of less persistent pesticides. The recommended use of pesticides in the tree fruit industry and estimated sales are detailed for the period 1960 to 1970 in Technical Supplement IV "Water Quality in the Okanagan Basin".

Levels of the pesticide D.D.T and the trace element mercury, found in the flesh of fish from the main valley lakes, are compared to standards of the Canada Food and Drug Directorate in Figure 5.2. Acceptable levels for mercury are exceeded in squawfish and to a lesser extent in large rainbow trout in Okanagan Lake. Squawfish and large rainbows owe their accumulation of mercury to their heavy utilization of other fish for food. High levels of D.D.T. were also found in rainbow trout and kokanee from Kalamalka Lake.



CONCENTRATION RANGES of DDT and MERCURY in the FLESH of FISHES from the OKANAGAN MAIN VALLEY LAKES, 1971.

Figure 5.2

5.1.5 Summary of Stream Water Quality Problems

Those streams in which major quality problems are evident are reviewed below:

(i) Vernon Creek

Vernon Creek above Ellison Lake had excessive loadings of phosphorus and manganese during the spring runoff period. The amount of total phosphorus in the soluble orthophosphorus form did not at any time exceed a concentration of 0.1 parts per million even though the total phosphorus concentrations reached levels of 6 to 7 parts per million. This indicates most of this was in the form of organic leaves and twigs carried down by runoff in the spring of the year. The source of the high levels of manganese in this and other headwater streams is not known.

Vernon Creek between Kalamalka Lake and Okanagan Lake exceeded the criteria for manganese, phosphorus, nitrogen and total coliform. This portion of the Vernon Creek Watershed includes the drainage from BX Creek. The whole area is highly developed either for agriculture or urban use. The City of Vernon also discharges its treated waste effluent into this section of Vernon Creek.

(ii) Coldstream Creek

This stream drains a large agricultural area before discharging into Kalamalka Lake. Those constituents which exceed acceptable levels include phosphorus and both total and fecal coliforms. Both phosphorus and coliform probably result from the dairy and beef cattle enterprises along this stream which carry some 1200 head.

(iii) Deep Creek

Constituents in this stream that exceeded acceptable levels included manganese, phosphorus, and total coliform. The Deep Creek watershed basically drains the north end of the valley proper and is not representative of other creek basins. The area is extensively farmed with over 50% of the drainage agea in cropland or pasture. The City of Armstrong also discharges its treated effluent from lagoons to Deep Creek along with a number of other agriculturally orientated industries. Deep Creek is one of the few creeks that had dissolved oxygen concentrations of less than 5 parts per million, indicative of the lack of good conventional waste treatment practices in this sub-basin.

(iv) Westbank Creek

This stream had particularly high levels of both fecal and total coliform, due primarily to the discharge of treated effluent from the Westbank sewage treatment plant.

(v) Kelowna Creek

The lower portion of the Kelowna Creek watershed is highly developed (Figure 5.3) for both farm land and urban development. Very high levels of both total and fecal coliform were recorded at its mouth, in addition to excesses of phosphorus and manganese. Two quality stations were located on this stream, one at the mouth and the other above the main urban development. While the creek at the station above the urban area exceeded criteria for fecal coliform, probably as a result of livestock enterprises, this number increases five fold as the stream traversed the urban area of Kelowna as shown by the following results:

	Total Coliform Log Mean Density per 100 ml.	Fecal Coliform Log Mean Density per 100 ml.
Kelowna Creek above developed area (537)	800	238
Kelowna Creek below developed area (521)	5420	1122

This indicates the effect of urbanization on the contamination of streams traversing highly populated areas.

(vi) Brandt's Creek

This is a small creek that passes through the industrial area adjacent to the City of Kelowna and receives most of its waste loadings from industrial sources. The water quality in Brandt's Creek is the lowest in the basin with extremely high coliform dentsities very low oxygen content, and high concentrations of phosphorus, manganese, and iron. An industrial waste treatment plant is now being constructed in this area which should significantly improve the water quality of this tributary.

(vii) Inkaneep Creek

This creek is a tributary of Osoyoos Lake with cattle grazing and feedlots in the lower reaches on Indian Reserve land. Phosphorus and coliform levels in this stream exceeded acceptable water quality standards.

In summary, most of the water quality problems in the tributaries occur either because of the natural characteristics of the watershed, or from point source loadings from municipal waste treatment plants, industries and agricultural operations. Logging operations in the tributary headwaters also contribute excess loadings of total phosphorus to many streams, although only a small percentage of this is normally in the soluble orthophosphorus form.

5.2 EFFECT OF LAND USE ON WATER QUALITY

During the period of July to October, 1972 a detailed but brief water quality survey was carried out on Kelowna and Lambly Creeks to provide a preliminary assessment of the effect of various forms of land use on stream water quality. The choice of these two Creeks was made on the basis of the number of existing hydrometric stations, prior information from water quality monitoring programs and accessibility.

The watersheds of the two creeks are situated directly across Okanagan Lake from one another. Lambly Creek, on the west side of the lake drains an area of 95 square miles and is the more rugged of the two. It is essentially undeveloped except for logging. In contrast the Kelowna Creek watershed, which has a drainage area of 86 square miles, is highly developed in its lower reaches. Although their drainage areas are approximately equal, the quantity of runoff during 1972 from Lambly Creek(58,800 acre feet) was about three times that of Kelowna Creek (18,700 acre feet). Of these total runoffs, 16% or 3,000 acre feet were recorded at the mouth of Kelowna Creek during the study period (July to October) as compared to 7% or 3,900 acre feet from Lambly Creek. This difference is largely due to the storage of water in the Kelowna Creek headwaters in the spring for release as irrigation water in the summer months.

The results presented below should be interpreted with care because of the short monitoring period and low volume of annual runoff which occurred during this period. Larger differences might be expected during the spring freshet or on a yearly basis.

The land use of these two basins, and the sub-divisons used for studying the effect of land use activities on water quality, are shown in Figures 5.3 and 5.4. In general these landuse activities may be summarized as follows:

Kelowna Creek - Range grazing in the upper reaches
- Irrigation for orchards in the lower reaches
- Industry between Rutland and Kelowna
- Domestic discharge to the ground below Rutland

Lambly Creek - Logging in the headwaters of Terrace Creek
- No activity in the remainder of the watershed

The estimated loadings of selected chemical constituents and their drainage area coefficients are shown in Tables 5.5 and 5.6. The drainage area coefficients were obtained by dividing the change in loading between monitoring stations by the area contributing to the creek. The accuracy of these results is largely dependent on the accuracy of stream flow measurements which in many

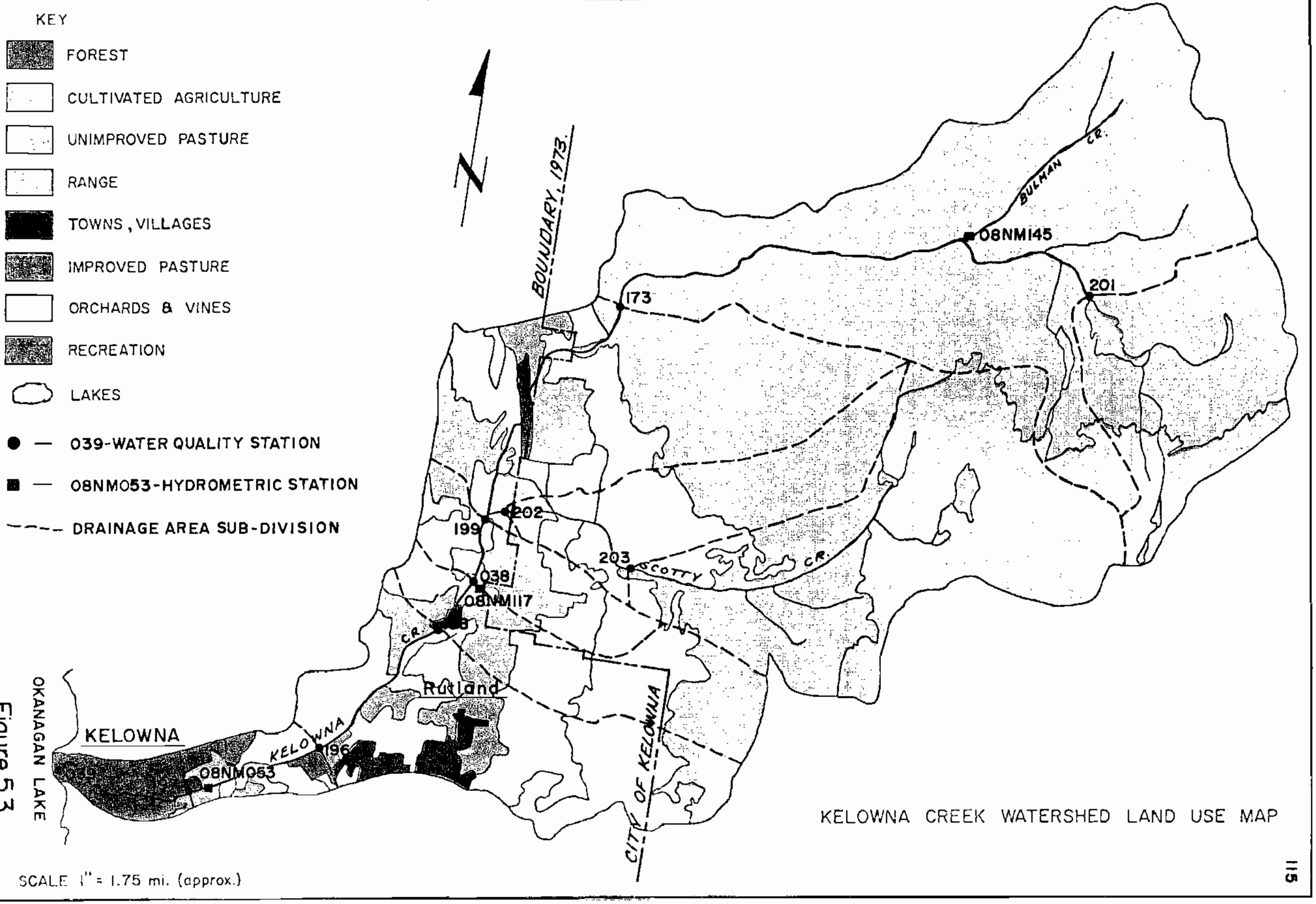

KELOWNA CREEK WATERSHED LAND USE MAP
KEY
FOREST
CULTIVATED AGRICULTURE
UNIMPROVED PASTURE
RANGE
TOWNS, VILLAGES
IMPROVED PASTURE
ORCHARDS & VINES
RECREATION
LAKES
039-WATER QUALITY STATION
08NM053-HYDROMETRIC STATION
DRAINAGE AREA SUB-DIVISION
BOUNDARY, 1973.
CITY OF KELOWNA
BULMAN CR.
08NM145
201
173
202
199
203
SCOTTY CR.
038
08NM117
CR.
Rutland
KELOWNA
196
08NM053
KELOWNA
OKANAGAN LAKE
SCALE 1" = 1.75 mi. (approx.)

Figure 5.3

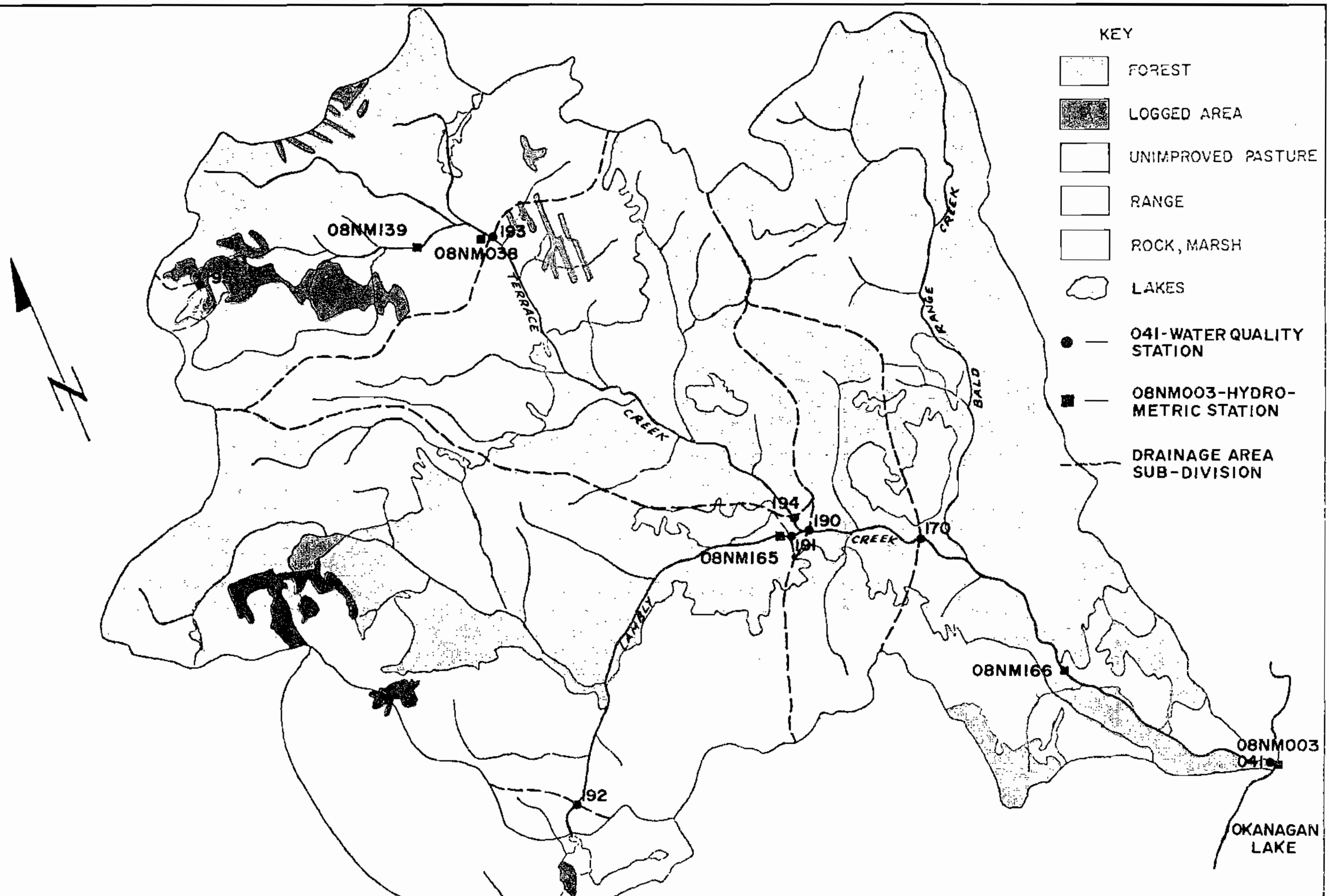
TABLE 5.5

KELOWNA CREEK - INCREMENTAL LOADINGS AND DRAINAGE AREA COEFFICIENTS FOR SELECTED CHEMICAL CONSTITUENTS FROM VARIOUS LAND USE DRAINAGE SUB-DIVISIONS

DRAINAGE AREA SUB-DIVISION (SEE FIGURE 5.3)	DESCRIPTION OF SUB-DIVISION	MAJOR LAND USE	MEAN INCREMENTAL DIFFERENCES IN LOADING BETWEEN WATER QUALITY STATIONS POUNOS X 10^{-6} PER SECOND						DRAINAGE AREA COEFFICIENTS POUNOS X 10^{-6} PER ACRE-SECOND					
			ORTHO PHOS-PHORUS	KJELDAHL NITROGEN	TOTAL INORGANIC CARBON	TOTAL RESIDUE	FILTERABLE CARBON	CALCIUM	ORTHO PHOS-PHORUS	KJELDAHL NITROGEN	TOTAL INORGANIC CARBON	TOTAL RESIOUE	FILTERABLE RESIOUE	CALCIUM
Station 201 to 173	Upper Kelowna Creek	Rangeland	10.07	271	4,770	65,400	57,400	6,240	.00066	.0180	.316	4.33	3.80	.4131
Above Station 203	Upper Scotty Creek	Rangeland and Pasture	5.41	173	3,762	46,900	43,600	7,060	.00061	.0196	.428	5.33	4.96	.8025
Station 203 to 202	Lower Scotty Creek to junction of Kelowna Creek	Orchards and Improved Pasture	7.96	49.7	2,595	22,030	20,300	4,120	.00318	.0199	1.030	8.81	8.13	1.6450
Station 173 to 199	Upper Kelowna Creek to below junction with Scotty Creek	Improved and Unimproved Pasture	5.10	-43.5	5,333	40,200	40,100	11,490	.00071	-.0061	.750	5.65	5.64	1.6160
Station 199 to 038	Mid Kelowna Creek	Improved and Unimproved Pasture	3.34	97.7	2,567	37,600	25,700	4,370	.00177	.5170	1.360	19.90	13.60	2.3130
Station 038 to 198	Lower Kelowna Creek	Orchard and Pasture	12.28	-8.8	2,182	15,700	29,200	3,984	.00369	-.0027	.658	4.74	8.81	1.1860
Station 198 to 196	Lower Kelowna Creek	Orchard, Pasture, Mixed Farming and Residential	1.56	91.1	6,725	69,800	60,900	10,220	.00100	.0098	.724	7.51	6.55	1.0990
Station 196 to 197	Lower Kelowna Creek	Pasture, Parkland and Residential	-8.89	50.5	-1,240	-15,400	-13,900	-410	-.00976	.0553	-1.360	-16.90	-15.20	-.4500
Station 197 to 039	Lower Kelowna Creek to mouth.	Residential	-2.03	-14.1	-597	-2,320	-8,100	-3,073	-.00262	-.0169	-.720	-2.79	-9.76	-3.6900
Station 038 to 197	All of the lower portion of Kelowna Creek [1]	Residential, Industrial, Agricultural	4.95	133	7,667	70,200	76,300	13,900	.00037	.0099	.569	5.21	5.66	1.0200
Above Station 038	All of the upper portion of Kelowna Creek [2]	Agricultural Land Use	33.9D	731	17,985	219,300	192,000	32,460	.00084	.0181	.452	5.44	4.75	.8020

1 Between Established Quantity Stations.

2 Above Established Quantity Station.



SCALE 1" = 1.75 mi. (approx.)

LAMBLY CREEK WATERSHED LAND USE MAP

Figure 5.4

TABLE 5.6 LAMBLY CREEK - INCREMENTAL LOADINGS AND DRAINAGE AREA COEFFICIENTS FOR SELECTED CHEMICAL CONSTITUENTS FROM VARIOUS LAND USE DRAINAGE SUB-DIVISIONS

DRAINAGE AREA SUB-DIVISIONS (SEE FIGURE 5.4)	DESCRIPTION OF SUB-DIVISIONS	MAJOR LAND USE	MEAN INCREMENTAL DIFFERENCES IN LOADINGS BETWEEN WATER QUALITY STATIONS POUNDS X 10^{-6} PER SECOND						DRAINAGE AREA COEFFICIENTS POUNDS X 10^{-6} PER ACRE-SECOND					
			TOTAL PHOS-PHORUS	ORTHO PHOS-PHORUS	KJELDAHL NITROGEN	TOTAL INORGANIC CARBON	FILTERABLE RESIDUE	CHLORIDE	TOTAL PHOS-PHORUS	ORTHO PHOS-PHORUS	KJELDAHL NITROGEN	TOTAL INORGANIC CARBON	FILTERABLE RESIDUE	CHLORIDE
Station 195 to 193	Upper Terrace Creek	Forest and Logging	0.89	0.14	1.5	344	2,390	8.1	.00010	.00001	.00017	.0390	.271	.00092
Station 193 to 194	Lower Terrace Creek to junction with Lambly Creek	Forest and Rangeland	4.02	2.85	72.3	2,748	19,360	87.9	.00051	.00024	.00610	.2660	1.633	.00742
Station 192 to 191	Lambly Creek above Terrace Creek	Forest and Rangeland with some logged areas	8.12	2.04	105.0	6,605	50,900	116.8	.00227	.00013	.00669	.4210	3.241	.00744
Station 190 to 170	Junction Lambly and Terrace to Bald Range Creek	Forest and Rangeland	9.80	2.62	47.6	2,748	16,260	75.2	.00033	.00060	.01106	.6550	3.777	.01749
Station 170 to 041	Lambly Creek from Bald Range Creek to mouth	Range and Unimproved Pasture	2.02	5.56	8.7	-538	38,270	154.3	.00012	.00035	.00054	-.0334	2.421	.00976

cases had to be estimated due to the lack of hydrometric gauging stations. The results for Lambly Creek are probably the more accurate as the five gauging stations on this creek are well distributed throughout the watershed. Negative loadings result either from the failure of the flow estimation model to account for groundwater flow into the creeks in the lower reaches, or from errors in the flow estimates.

5.2.1 Kelowna Creek Results

Analysis of the Kelowna Creek drainage area coefficients showed few significant differences among any of the parameters with the exception of drainage area 199 to 038. This indicates that the make up of different landuse activities has had little effect on water quality for the period sampled. The drainage area between stations 199 to 038 had significantly different coefficients for total residue, total fixed residue, calcium and hardness; and high values of Kjeldahl (organic nitrogen, total inorganic carbon and filterable residue. These observations tend to indicate an inflow of groundwater or return irrigation flow. The Kjeldahl nitrogen loadings from above station 038 were approximately five times greater than that between Station 038 and 197, and locations of livestock confinement losts in area 203 to 202, 199 to 038, and 198 to 196 correspond to the largest Kjeldahl nitrogen loadings recorded. Nitrate-nitrite loadings from area 038 to 197 were approximately six times greater than those from the area above station 038, indicative of groundwater loadings from such sources as irrigation and residential areas. The high occurrence of negative values for drainage area 197 to 039 and 196 to 197 results from negative loadings at these stations and indicates an error in the flow estimates.

5.2.2 Lambly Creek Results

Analysis of the Lambly Creek drainage area coefficients indicate that significant differences among stations occurred only in the four parameters; total phosphorus, total inorganic carbon, filterable residue and chloride. No specific land use activity or point sources were found to explain the higher input of phosphorus between Station 192 to 191. The high drainage area coefficients for total inorganic carbon, filterable residue and chloride for the area between Stations 170 to 190, and to a lesser extent between 192 and 191, are indicative of the effects of soil disturbance in the form of road building, log yarding, landslides, and drainage from the well used logging roads that are tangent to the Creek at many points. On the other hand logging further removed from the Creek in the drainage area between Stations 195 and 193 did not result in higher drainage coefficients for that area over other areas on Lambly Creek.

The largest orthophosphorus loading to Lambly Creek originated from the area closest to the mouth. This could have been introduced to the stream by groundwater flow, or a portion of the total phosphorus solubilized between the last two stations. The differences in nitrogen loadings did not reflect any specific land use activities, the largest loadings occurring in the largest drainage areas.

5.2.3 Comparison of Lambly and Kelowna Creeks

For every parameter the maximum drainage area coefficients for Lambly Creek are lower than the maximums for Kelowna Creek. This is indicative of the different nature of the Creeks in terms of slopes, accessibility, population density, agriculture and near-creek activities. Coefficients for the upper reaches of Kelowna Creek were comparable to those for Lambly Creek where both areas are relatively similar in topography and land use.

5.2.4 Summary

While some general findings can be drawn from the study of land use on Lambly and Kelowna Creeks, it has not been possible to identifiy specific land use activities with specific coefficients that could be used to predict the effect of future economic growth on water quality in the basin as a whole. Conclusions that can be made within the limitations of the study period data are as follows:

(i) That forest-harvesting outside the immediate area of Lambly Creek watercourse has had little effect on stream water quality.

(ii) That logging-road construction and logging activity close to Lambly Creek has caused deterioration of stream water quality, as evidenced by significantly higher drainage area coefficients and high concentrations of indicator parameters.

(iii) That specific point-sources of pollution on Kelowna Creek have more effect on water quality than general land use activities, and sources near the creek have a more direct effect than those located at a greater distance.

5.3 NUTRIENT LOADINGS TO THE MAIN VALLEY LAKES

Monitoring of significant sources of nutrients to the main valley lakes over the three study years has provided the estimate of mean total annual loadings shown in Table 5.7. The term 'nutrients' in this report refers to the elements nitrogen and phosphorus which are consideted the most important elements in respect to the enrichment of the lake waters in recent years, and the resulting increase in biological productivity in the form of algal blooms and aquatic plant growth.

This estimate indicates that tributary streams and municipal outfalls together account for over 55% of the total nitrogen and 75% of the total phosphorus entering the main valley lakes. A brief description of each of these sources is presented below.

TABLE 5.7

SOURCES AND ESTIMATED ANNUAL INPUT
OF THE NUTRIENTS NITROGEN AND PHOSPHORUS
TO THE MAIN VALLEY LAKES

SOURCE	TOTAL NITROGEN		TOTAL PHOSPHORUS	
	Pounds	Percent	Pounds	Percent
Tributary Streams *[1]	628,740	36.6	77,540	31.3
Municipal Outfalls	326,000	19.0	115,120	46.5
Industrial Outfalls	29,200	1.7	1,960	0.8
Storm Sewers	5,700	0.3	700	0.3
Dustfall and Precipitation	216,000	12.6	23,020	9.3
Groundwater				
- Agriculture	192,260	11.2	1,520	0.6
- Septic Tanks	274,280	16.0	25,100	10.0
- Other	28,720	1.7	640	0.2
- Natural	15,520	0.9	2,560	1.0
Subtotal - Groundwater		29.8		11.8
TOTALS	1,716,420	100.0	248,160	100.0

*[1] Includes natural and diffuse loadings from agriculture and septic tank sources.

5.3.1 Tributary Streams

The stream monitoring program carried out over the two year period of July, 1969 to August, 1971 included only those streams considered to be representative of the major streams tributary to the main valley lakes. To provide an estimate of the total contribution of nutrients from all streams, loadings were pro-rated on the basis of monitored and total drainage basin areas for a given lake. A comparison of the number and drainage area of monitored streams, to the total for each of the main valley lakes is shown in Table 5.8.

Streams influenced by municipal and industrial waste discharges to surface waters (Vernon, Deep, Brandt, and Westbank Creeks) and those which connect the main Valley Lakes (Vernon Creek and Okanagan River), were not considered as representative tributary streams in respect to watershed quality and were omitted for this pro-rating procedure.

The annual input or loadings of nitrogen and phosphorus were estimated by first averaging all quality and quantity data obtained for each stream for the two year sampling period. The averaged flow and nutrient concentrations were then used to compute the average annual input (loading) from the stream in question. The loadings to each of the main valley lakes were obtained by

TABLE 5.8

COMPARISON OF STREAMS MONITORED
FOR WATER QUALITY TO TOTAL FOR BASIN

LAKE	MONITORED STREAMS		TOTAL FOR LAKE BASIN		Percentage of Drainage Basin Monitored
	Number	Drainage Area Square Miles	Number	Drainage Area Square Miles	
Wood	1	40	5	78	51
Kalamalka	1	79	5	139	57
Okanagan	21	1,545	47	1,885	82
Skaha	2	205	8	280	73
Vaseux	2	35	3	54	65
Osoyoos	2	75	7	144	52
TOTALS	29	1,979	75	2,580	77

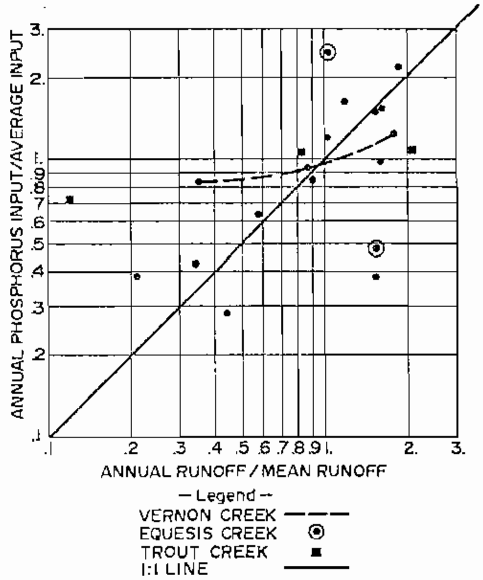
totalling individual stream inputs to the lake including estimates for unmonitored streams as obtained from the above pro-rating procedure.

To provide an estimate of the accuracy of these methods and results, a study was carried out on the variation in annual loadings with runoff for eight major tributaries using 1969-71 data and additional information obtained in 1972. The results of this study (Figure 5.5) indicate that loadings may vary from one half to two and a half times the mean loading between a dry year and a wet year. The nutrient input, based on average stream flows however, varies only by 7 to 12 percent from the 1969-71 estimates used in this report. The estimated annual loadings for tributary streams are therefore considered to be a reasonably accurate presentation of the long term contribution assuming 1971 development conditions.

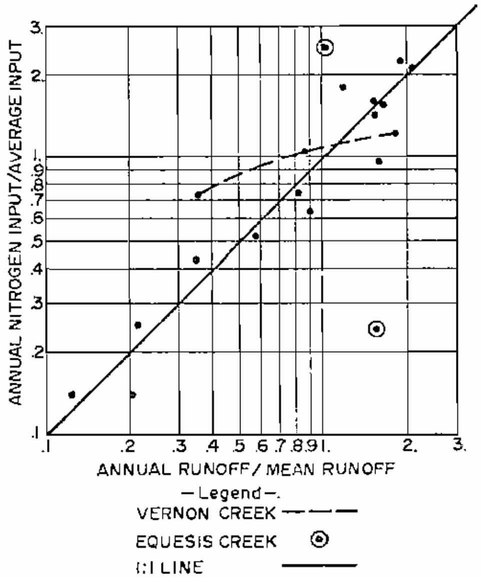
The nutrient input of individual streams was also assessed to determine the relative importance of each stream in the future control of nutrients. Nutrients and other chemicals in streams originate from plant and animal organic matter in the watershed, soil erosion, and dissolved minerals from bedrock and soil formations. Deforestation and other activities in a watershed will affect the rate of snowmelt and runoff to a stream and the amount of organic matter of erodable soils in the stream waters. Groundwater return flows and industrial and urban development will also contribute to stream loadings in the lower reaches.

A review of the estimated annual loadings of the major tributary streams (Figure 5.6) indicates that those streams with larger drainage areas generally contribute higher amounts of nutrients. The eight streams Mission, Trout, Shorts, Lambly, Deep, Kelowna, Whiteman and Coldstream - contributed over 60%

STANDARDIZED NUTRIENT LOADING CURVE FOR EIGHT TRIBUTARIES



STANDARDIZED PHOSPHORUS LOADING CURVE



STANDARDIZED NITROGEN LOADING CURVE

RANGE OF ANNUAL RUNOFFS TO THE MAIN VALLEY LAKES FOR EIGHT MAJOR TRIBUTARIES - 1970 DEVELOPMENT CONDITIONS.

CREEK NAME	DRY YEAR ACRE FEET	AVERAGE YEAR ACRE FEET	WET YEAR ACRE FEET	1969-1971 MEAN ACRE FEET
TROUT CREEK	11,700	41,200	108,600	30,500
MISSION CREEK	66,000	107,300	202,000	116,700
VERNON CREEK	11,100	28,960	80,900	20,700
KELOWNA CREEK	2,090	7,320	23,200	8,400
PEACHLAND CREEK	6,880	12,200	24,300	7,200
PENTICTON CREEK	11,200	23,700	47,060	16,700
EQUESIS CREEK	9,210	16,800	33,000	12,700
POWERS CREEK	2,900	8,530	20,500	14,300
TOTAL FOR 8 CREEKS	121,000	246,000	539,600	227,200
RATIO TO 1969-1971 ESTIMATE	0.54	1.08	2.38	1.00

RANGE OF ANNUAL NUTRIENT INPUTS TO THE MAIN VALLEY LAKES FOR EIGHT MAJOR TRIBUTARIES - 1970 DEVELOPMENT CONDITIONS.

NUTRIENT INPUT	TOTAL PHOSPHORUS				TOTAL NITROGEN			
CREEK NAME	DRY YEAR POUNDS	AVERAGE YEAR POUNDS	WET YEAR POUNDS	1969-1971 MEAN POUNDS	DRY YEAR POUNDS	AVERAGE YEAR POUNDS	WET YEAR POUNDS	1969-1971 MEAN POUNDS
TROUT CREEK	4,600	16,400	43,400	12,200	16,200	57,000	150,200	42,200
MISSION CREEK	9,000	14,600	27,400	15,800	83,800	136,200	256,600	148,200
VERNON CREEK*	800	2,200	6,200	1,600	20,600	56,600	157,800	40,400
KELOWNA CREEK	600	2,200	7,200	2,600	6,800	23,800	75,600	27,400
PEACHLAND CREEK	800	1,400	2,800	800	14,600	25,800	51,400	15,200
PENTICTON CREEK	1,000	2,200	4,600	1,600	14,000	29,800	59,200	21,000
EQUESIS CREEK	1,400	2,400	4,600	1,800	8,200	15,000	29,600	11,400
POWERS CREEK	400	1,000	2,200	1,600	7,000	20,400	49,000	34,200
TOTAL FOR 8 CREEKS	18,600	42,400	98,400	38,000	171,200	364,600	829,400	340,000
RATIO TO 1969-1971 ESTIMATE	0.50	1.12	2.59	1.00	.051	1.07	2.44	1.00

* Does not include loadings from Vernon Sewage Treatment Plant.

SOURCE - Technical Supplement IV Okanagan Basin Study.

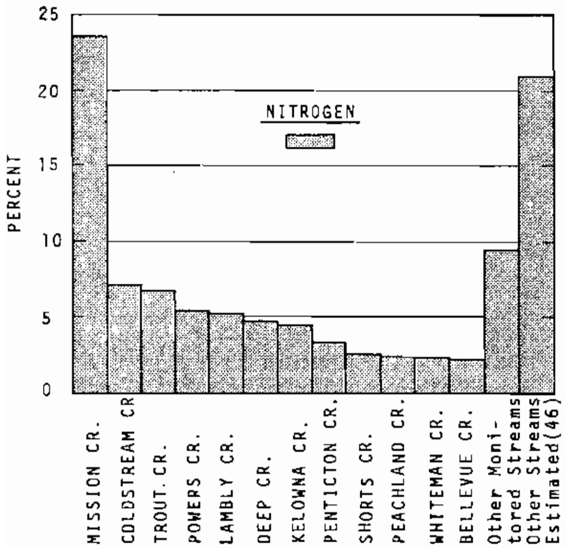
ESTIMATED VARIATION IN ANNUAL NUTRIENT LOADINGS WITH STREAMFLOW FOR EIGHT MAJOR TRIBUTARIES

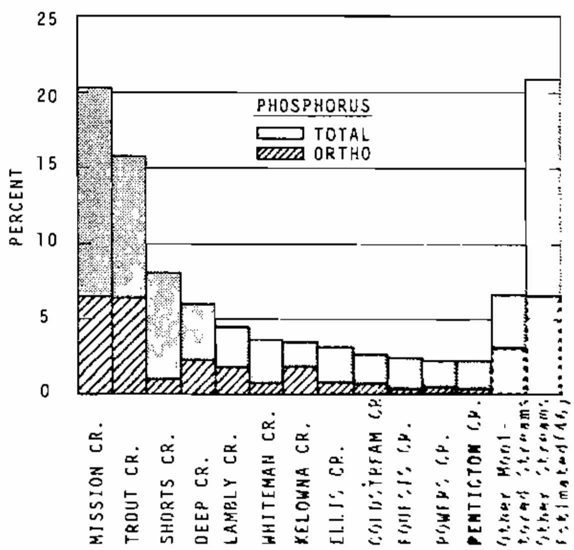
Figure 5.5

TRIBUTARY STREAM AND LAKE BASIN	DRAINAGE AREA IN SQUARE MILES	TOTAL NITROGEN		TOTAL PHOSPHORUS		ORTHO PHOSPHORUS	
		POUNDS PER YEAR	PERCENT OF TOTAL	POUNDS PER YEAR	PERCENT OF TOTAL	POUNDS PER YEAR	PERCENT ORTHO TO TOTAL PHOSPHORUS
WOOD LAKE							
Vernon Cr. (to Wood Lake)	40.0	10,000	1.6%	400	0.5%	160	40%
KALAMALKA LAKE							
Coldstream Cr.	79.3	44,800	7.1%	2,000	2.6%	700	35%
OKANAGAN LAKE							
Deep Cr. *	99.0	29,600	4.7%	4,600	5.9%	1,700	37%
Shorts Cr.	72.0	16,000	2.5%	5,400	7.0%	780	14%
Whiteman Cr.	76.0	14,600	2.3%	2,800	3.6%	1,460	20%
Equesis Cr.	77.0	11,400	1.8%	1,800	2.3%	720	16%
Nashwito Cr.	31.7	600	0.1%	800	1.0%	220	11%
Peachland Cr.	58.9	15,200	2.4%	800	1.0%	300	37%
Trepanier Cr.	99.6	10,000	1.6%	1,000	1.3%	380	15%
Powers Cr.	55.8	34,200	5.4%	1,600	2.1%	860	21%
Westbank (Smith)Cr.*	4.3	1,200	0.2%	0	-	0	-
McDougall Cr.	18.6	1,000	0.2%	200	0.3%	220	11%
Bellevue Cr.	34.0	13,800	2.2%	800	1.0%	340	42%
Mission Cr.	336.1	148,200	23.5%	15,800	20.3%	5,060	32%
Kelowna (Mill) Cr.	85.9	27,400	4.4%	2,600	3.4%	1,320	51%
Lambly (Bear) Cr.	103.3	32,800	5.2%	3,400	4.4%	1,320	39%
Penticton Cr.	69.5	21,000	3.3%	1,600	2.1%	260	16%
Trout Cr.	289.4	42,200	6.7%	12,200	15.7%	4,980	40%
Chute Cr.	34.1	400	0.1%	0	-	0	-
SKAHA LAKE							
Shingle Cr.	117.1	6,000	1.0%	600	0.7%	120	20%
Ellis Cr.	64.6	10,000	1.6%	2,400	3.1%	600	25%
McLean Cr.	23.0	200	-	0	-	0	-
VASEUX LAKE							
Shuttleworth Cr.	35.0	6,200	1.0%	200	0.3%	60	30%
OSOYOOS LAKE							
Inkaneep Cr.	75.3	1,000	0.2%	400	0.5%	120	30%
MONITORED TRIBUTARY STREAM SUBTOTALS	1979.5	497,800	79.1%	61,400	79.1%	21,680	35%
OTHER STREAMS (ESTIMATED)	601.7	131,200	20.9%	16,200	20.9%	5,060	31%
TOTAL - TRIBUTARY STREAMS	2581.2	629,000	100%	77,600	100%	26,740	34%

*Note Figures shown exclude contributions to streams from Municipal outfalls

RELATIVE NUTRIENT CONTRIBUTIONS OF TRIBUTARY STREAMS





ESTIMATED ANNUAL LOADINGS OF NUTRIENTS TO THE MAIN VALLEY LAKES FROM TRIBUTARY STREAMS Figure 5.6

of the total input of nitrogen and phosphorus to the main valley lakes between 1969-71. Those creeks in sparsely developed areas - Shorts, Whiteman, Naswhito, etc, contributed significant amounts of total phosphorus, but less than 20% of this was in the soluble orthophosphorus form.

Estimates of the portion of loadings to streams that occur from agricultural and septic tank sources are shown in Tables 5.9a and b. These loadings are primarily from surface runoff or groundwater which enters the tributary streams and has been measured as a part of the total stream loading.

TABLE 5.9a

ESTIMATED LOADING OF NITROGEN TO STREAMS
FROM NATURAL, AGRICULTURAL AND SEPTIC TANK SOURCES

Pounds Per Year

STREAMS TRIBUTARY TO	NATURAL	AGRICULTURAL SOURCES	SEPTIC TANK SOURCES	TOTAL
Wood Lake	20,000*	Not estimated	Not estimated	20,000
Kalamalka Lake	55,760	14,900	8,340	79,000
Okanagan Lake	344,200	85,220	66,800	496,220
Skaha Lake	3,620	16,060	2,520	22,200
Vaseux Lake	6,340	40	3,220	9,600
Osoyoos Lake	100	1,000	620	1,720
TOTALS	430,020	117,220	81,500	628,740
PERCENT	68%	19%	13%	100%

* Includes inflow to Wood Lake from Vernon Creek and diffuse loadings from agricultural and septic tank sources.

5.3.2 Municipal Outfalls

Six municipalities currently (1971) discharge treated waste effluent into the surface waters of the basin. The estimated annual inputs of nutrients from these municipal discharges is shown in Table 5.10. The figures are based on a two-year monitoring period, the mean concentrations of nutrients from all samples taken, and the mean annual discharge from each treatment plant. Orthophosphorus loadings, which represent the soluble portion of total phosphates, have been included to show the high percentage of this element that is in the soluble form following secondary (biological) treatment as compared to the low percentage that is in the soluble form in tributary stream discharges (Figure 5.6).

TABLE 5.9b

ESTIMATED LOADING OF PHOSPHORUS TO STREAMS FROM NATURAL, AGRICULTURAL AND SEPTIC TANK SOURCES

Pounds Per Year

STREAMS TRIBUTARY TO	NATURAL	AGRICULTURAL SOURCES	SEPTIC TANK SOURCES	TOTAL
Wood Lake	800*	Not estimated	Not estimated	800
Kalamalka Lake	3,080	20	500	3,600
Okanagan Lake	60,500	2,820	4,560	67,880
Skaha Lake	3,640	340	220	4,200
Vaseux Lake	-	-	260	260
Osoyoos Lake	700	60	40	800
TOTALS	68,720	3,240	5,580	77,540
PERCENT	89%	4%	7%	100%

* Includes inflow to Wood Lake from Vernon Creek and diffuse loadings from agricultural and septic tank sources.

TABLE 5.10

ESTIMATED ANNUAL INPUT OF NUTRIENTS TO SURFACE WATERS FROM MUNICIPAL OUTFALLS

		ESTIMATED ANNUAL LOADING Pounds/Year			
Municipality	Point of Discharge	Total Nitrogen	Total Phosphorus	Ortho-Phosphorus	Percent Ortho-phosphorus Total Phosphorus
Armstrong	Deep Creek	10,400	4,140	3,420	83%
Vernon	Vernon Creek	76,320	35,540	29,700	84%
Kelowna	Okanagan Lake	115,540	40,840	34,600	85%
Westbank	Smith Creek	3,460	1,640	1,460	89%
Penticton	Okanagan River	112,180	28,900	23,040	80%
Oliver	Okanagan River	8,100	4,060	3,660	90%

The accuracy of the figures shown in Table 5.10 is dependent primarily on the accuracy of the flow measurements and is considered to be within 10% of the values shown.

During the summer and fall of 1971 the City of Vernon diverted approximately 50% of its treated discharge to a pilot spray irrigation project. This was taken into account when determining the mean annual discharge of nutrients to Vernon Creek from this municipal outfall. In 1971 the City of Penticton completed a chemical tertiary treatment unit for the removal of phosphorus, but this unit was not in operation during the monitoring period and the effect of this facility is not reflected in the values shown. The amount of phosphorus removed by this tertiary unit in 1972-73 has been estimated at 50 to 60%.

5.3.3 Industrial Outfalls

Thirteen major industrial outfalls (waste effluent discharged to surface waters) were monitored on a monthly basis between August, 1969 and July, 1971. These outfalls included all the major industrial waste discharges in terms of volume and organic loads, and several of the small industrial establishments considered to be representative of numberous other plants of the same category. In addition, 36 minor outfalls were sampled at least twice during the monitoring period. Data collected on those industries with positive discharges to surface waters were used to estimate the annual nutrient loadings from each industrial source as shown in Table 5.11. Those industries which discharge their waste effluent into ground disposal systems are considered as groundwater sources. As in the case of streams and municipal outfalls mean concentrations and mean discharges were used to estimate annual loadings for industrial outfalls.

The total contribution of nutrients from industrial outfalls represents less than two percent of the total annual input of nutrients from all other sources and except for local problems which they may cause, are not currently of prime importance in the control of nutrients to surface waters.

The accuracy of the loadings from industrial outfalls is almost directly proportional to the accuracy of flow measurements which could be in error by a factor or 50%. The flows of these outfalls were not monitored on a continuous basis, but rather were estimated at the time of sampling. This percentage error will not seriously affect the results because of the negligible amounts involved under 1971 development conditions.

5.3.4 Storm Sewers

A study to determine the amount of nutrients and other impurities discharging into the surface waters of the Basin from the storm sewers of the cities

TABLE 5.11

ESTIMATED ANNUAL INPUT OF NUTRIENTS TO SURFACE WATERS FROM INDUSTRIAL OUTFALLS

Industrial Source	Point of Discharge	ESTIMATED ANNUAL LOADING Pounds/Year			Percent Ortho-phosphorus To Total Phosphorus
		Total Nitrogen	Total Phosphorus	Ortho-Phosphorus	
Okanagan Beverages and Calona Wines	Brandt's Creek	80	100	26	26
Kelowna Growers Exchange and Sun-Rype No. 2	Brandt's Creek	980	280	66	24
American Can Company	Brandt's Creek	Trace	Trace	Trace	--
Cascade Co-Op	Brandt's Creek	100	20	10	50
S.M. Simpson Ltd.	Okanagan Lake	120	300	2	1
Kelowna Memorial Arena	Kelowna Storm Sewer	Trace	Trace	--	--
B. C. Orchards Co-Op	Okanagan Lake	360	140	78	56
Kelowna Beverages and OK Packers	Okanagan Lake	1,640	160	64	40
Pyramid Co-Op	Okanagan Lake	Trace	Trace	Trace	--
Naramata Co-Op	Okanagan Lake	20	20	6	20
Fish and Wildlife Hatchery*1	Okanagan Lake	14,460	380	134	35
Cornwall Canners Limited	Okanagan Lake	660	220	122	55
McLean & Fitzpatrick	Osoyoos Lake	4,640	20	0	--
Oliver-Osoyoos Co-Op	Osoyoos Lake	5,300	80	56	70
International Curling Club	Osoyoos Lake	380	20	8	40
Monashee Co-Op	Osoyoos Lake	100	80	44	55
Total Other Industries		360	140	--	--
TOTAL POUNDS PER YEAR		29,200	1,960	616	34 (Average)

*1 The Fish and Wildlife Hatchery at Summerland obtains its water from Shaughnessey Spring. This water supply is contaminated by nitrates having a mean total nitrogen concentration of 4 milligrams per liter. This contamination is reflected in the annual effluent loadings from the Hatchery (Ref. Technical Supplement VI).

of Vernon, Kelowna and Penticton, was carried out through the spring and summer of 1972. The storm sewer system in each city is completely separate from the sewage collection system and these three represent the only ones in the basin in 1971. The annual loadings from this source were determined by combining the concentrations of nutrients found in samples of storm sewer water from both snowmelt and rainfall, with the volume of storm water discharged by each city. The volume of storm water was based on annual precipitation, drainage area, and an estimate of the percentage of rainfall actually discharged through the storm sewers (coefficient of runoff). The results of this study are summarized in Table 5.12.

TABLE 5.12

ESTIMATED ANNUAL DISCHARGE OF NUTRIENTS FROM STORM SEWERS TO SURFACE WATERS

CITY	Area Served by Storm Sewers (acres)	Average Annual Precipitation (inches)	Total Nitrogen (pounds)	Total Phosphorus (pounds)	Soluble Phosphorus (Orthophosphorus) Percent
Vernon	1,100	15.22	2,560	380	19
Kelowna	655	12.09	920	180	14
Penticton	1,300	11.32	2,220	140	25
TOTAL IN POUNDS			5,700	700	

The information obtained under this study was considered to be the minimum required to obtain an indication of the order of magnitude of nutrients from this source. The accuracy is therefore limited, but due to the small amount involved compared to the total of all sources (less than one half percent) this source is not considered as significant at this time.

5.3.5 Dustfall and Precipitation

Twenty-three sampling stations for this study were selected on sites adjacent to the main valley lakes and near populated areas and monitored for the period October, 1971 to September, 1972. Samples were collected in tubular plastic dustfall containers and exposed to the atmosphere for monthly periods before retrieval and analysis. The stations selected were considered to be the minimum number to provide an estimate of the nutrient contribution from dustfall and precipitation on the surfaces of the lakes. The median areal distribution of soluble nutrients obtained from the sampling stations was calculated using the analytical results and the monthly wind frequency as measured at Penticton. This wind frequency was assumed to be representative of the wind frequency throughout the Okanagan Valley. The median areal distribution of nutrients was then combined with the surface area of each respective lake to provide an estimate of the annual input of nitrogen and phosphorus from dustfall and precipitation.

The results of this study indicate that this source of nutrients represents a significant input (10%) to the lake system (Table 5.13). The accuracy of these results is considered as acceptable for providing order of magnitude figures only, although they are generally in agreement with other published data on dustfall and precipitation for other lake basins in Canada and the United States. One of the problems encountered with some sampling stations was contamination because of their accessiblity to the public. While the samples were filtered prior to analysis and only the soluble portion of the sample analysed, some error may have been introduced into the results because of foreign material being deliberately introduced into some of the sample containers.

TABLE 5.13

ESTIMATED ANNUAL INPUT OF TOTAL SOLUBLE NITROGEN AND PHOSPHORUS INTO THE MAIN VALLEY OKANAGAN LAKES FROM DUSTFALL AND PRECIPITATION

Main Valley Lake	Lake Surface Area (Square Miles)	Median Areal Distribution Pounds/Square Mile/Month		Estimated Annual Loading (Pounds)	
		Total Phosphorus (PO_4)	Total Nitrogen	Total Phosphorus (P)	Total Nitrogen (N)
Wood	3.46	10	90	140	3,800
Kalamalka	9.68	16	80	600	9,200
Okanagan					
- North	36.12	150	112	5,900	48,600
- Central	63.99	20	74	4,960	56,800
- South	34.10	66	160	8,740	65,400
Skaha	7.58	56	248	1,660	22,600
Vaseux	1.02	8	292	40	3,600
Osoyoos*	5.77	44	88	980	6,000

* Canadian portion of lake only.

5.3.6 Groundwater

Groundwater sources encompass all nutrients transported to the surface water system by groundwater flows. These nutrient sources include agriculture, septic tanks, and other unidentified sources including those which occur naturally through the dissolving of various elements by moving water. These groundwater sources in general represent the greatest unknown of all nutrient sources due primarily to the difficulty in measuring groundwater flows. Part of the water that falls as precipitation on the watershed percolates through the soil to the groundwater table and eventually finds its way to the surface waters of tributary streams and the main valley lakes. In the Okanagan Basin this is augmented by groundwater return flows from irrigation. Studies of the latter indicate that up to 50% of the water applied for irrigation purposes eventually returns to the lake system, and is considered to make up the largest portion of the total groundwater flow in irrigated areas. The transport of this water through the ground is very slow however, and it's ultimate destination very difficult to determine. Part of the return flow from irrigation water applied during April to November, for example, may not return to the surface water system for 6 to 12 months. Therefore while estimates of the concentrations of nutrients in the groundwater can be determined fairly accurately, the groundwater flow and resulting loadings are much more difficult to assess.

Four studies were undertaken in an attempt to provide order of magnitude figures on the amounts of nutrients entering the main valley lakes via groundwater. These groundwater sources include both direct drainage to the lakes as well as groundwater flows to tributary streams. The studies included a theoretical analysis of all potential source loadings, augmented by pilot studies on septic tanks, land fills, and spray irrigation-lysimeter tests. The study on source loadings involved the documentation of all nutrients that might ultimately reach receiving waters in the ground. These included such sources as irrigation water, fertilizers, agricultural animals, wildlife, dustfall and decaying organic matter. A larger percentage of these groundwater loadings return to the tributary streams themselves and therefore have been measured as part of the stream loadings. The remaining groundwater enters the main valley lakes directly. The pilot studies on septic tanks, land fills, and spray irrigation-lysimeter tests were carried out in conjunction with the waste treatment section. Briefly, they provide information on the transport of water and nutrients through various soil types under controlled conditions.

Estimates of the position of groundwater source loadings that return to the tributary streams were presented in Table 5.9. Groundwater source loadings that return directly to the main valley lakes are shown in Tables 5.14a and 5.14b.

These results indicate that groundwater contributes approximately 26% of the total nitrogen and 12% of the total phosphorus entering the main valley lakes. Nitrogen is a transient element which is readily transported by water through the soil, while phosphorus becomes bonded with the soil particles and is transported only when conditions of excess phosphorus occur. Most of the phosphorus that is transported however, is in the soluble (orthophosphorus) form, and the orthophosphorus loadings may be considered equal to the total phosphorus loadings.

The overall accuracy of these results is considered to be correct to within one order of magnitude, but greater variations may occur within the basin as a

TABLE 5.14 a

ESTIMATED ANNUAL INPUT OF TOTAL NITROGEN TO THE MAIN VALLEY LAKES FROM GROUNDWATER

	Agriculture	Septic Tanks	Other	Natural
Wood	9,860	17,160	2,440	1,220
Kalamalka	4,340	10,220	500	440
Okanagan	93,060	129,960	18,240	6,140
Skaha	15,480	27,560	4,520	1,360
Vaseux	4,920	2,980	600	1,620
Osoyoos	64,600	86,400	2,420	4,740
	192,260	274,280	28,720	15,520
Total Nitrogen Input via Groundwater, Pounds per Year				510,780

TABLE 5.14 b

ESTIMATED ANNUAL INPUT OF TOTAL PHOSPHORUS TO THE MAIN VALLEY LAKES FROM GROUNDWATER

	Agriculture	Septic Tanks	Other	Natural
Wood	400	1,660	260	40
Kalamalka	20	940	-	20
Okanagan	520	11,060	240	2,060
Skaha	40	2,600	60	160
Vaseux	20	280	20	80
Osoyoos	520	8,560	60	200
	1,520	25,100	640	2,560
Total Phosphorus Input via Groundwater, Pounds per Year				29,820

whole. Further, since phosphorus has been considered as the key element in controlling lake enrichment, this degree of error will not have the same importance on the overall results as it would had nitrogen been indicated as the controlling element.

5.3.7 Summary

A series of studies were carried out to determine the sources and amounts of the nutrients nitrogen and phosphorus entering the main valley lakes. The results of this study are summarized in Table 5.7 and Table 5.15. The main purpose of these investigations was to identify significant sources of these nutrients and to determine if these can be controlled to maintain or enhance the water quality of the main valley lakes for consumptive use, recreations, and aesthetic enjoyment. Based on limnological findings and recommendations,

TABLE 5.15

MAJOR NUTRIENT LOADINGS TO THE MAIN VALLEY LAKES

ESTIMATED ANNUAL INPUT OF TOTAL PHOSPHORUS INTO THE MAIN VALLEY LAKES -1971

LAKE		ANNUAL LOCAL WATERSHED LOADINGS - POUNDS PER YEAR 1969-1971							
		TRIBUTARY STREAMS *2	MUNICIPAL TREATMENT PLANTS	DUSTFALL AND PRECIPITATION	GROUNDWATER SEPTIC TANKS	OTHER SOURCES *1	SUBTOTAL	CONTRIBUTED FROM UPSTREAM LAKE OUTFLOW (lb/yr)	TOTAL LOADING TO LAKE (lb/Yr)
WOOD		800	-	140	1,660	720	3,320	-	3,320
KALAMALKA		3,600	-	600	940	40	5,180	-	5,180
OKANAGAN	North	19,480	39,680	5,900	1,560	920			
	Central	29,800	42,480	4,960	4,840	2,620	185,720	1,600	187,320
	South	18,600	-	8,740	4,660	1,480			
SKAHA		4,200	28,900	1,660	2,600	500	37,860	10,600	48,460
VASEUX		260	-	40	280	120	700	18,800	19,500
OSOYOOS (Canada)		800	4,060	980	8,560	980	15,380	22,140	37,520
SUB TOTALS		77,540	115,120	23,020	25,100	7,380	248,160	53,140	301,300

*1 Includes Industrial Outfalls, Storm Sewers, and Groundwater from Agricultural Land and Natural Sources.

*2 Includes Natural and Diffuse Loadings to streams from Agriculture and Septic Tank Sources

ESTIMATED ANNUAL INPUT OF TOTAL NITROGEN INTO MAIN VALLEY LAKES - 1971

LAKE		ANNUAL LOCAL WATERSHED LOADINGS - POUNDS PER YEAR (MEAN VALUES)								
		TRIBUTARY*2 STREAMS	MUNICIPAL TREATMENT PLANTS	DUSTFALL AND PRECIPITATION	GROUNDWATER SEPTIC TANKS	AGRICULTURE	OTHER*3 SOURCES	SUBTOTALS	CONTRIBUTED FROM UPSTREAM LAKE OUTFLOW (lb/Yr)	TOTAL LOADING TO LAKE (lb/Yr)
WOOD		20,000	-	3,800	17,160	9,860	3,760	54,580	-	54,580
KALAMALKA		79,000	-	9,200	10,220	4,340	940	103,700	-	103,700
OKANAGAN	North	87,820	86,720	48,600	18,160	12,560	4,880			
	Central	322,400	119,000	56,800	55,600	43,980	12,960	1,142,760	40,400	1,183,160
	South	86,000	-	65,400	56,200	36,520	29,160			
SKAHA		22,200	112,180	22,600	27,560	15,480	7,640	207,660	181,600	389,260
VASEUX		9,600	-	3,600	2,980	4,920	2,220	23,320	268,800	292,120
OSOYOOS (Canada		1,720	8,100	6,000	86,400	64,600	17,580	184,400	317,800	502,200
SUB TOTALS		628,740	326,000	216,000	274,280	192,260	78,800	1,716,420	808,600	2,525,020

*3 Includes Industrial Outfalls, Storm Sewers, and Groundwater from Natural Sources.

phosphorus was subsequently determined to be the element which should be limited to control lake enrichment and biological growth. Studies on loading sources of these nutrients support this choice. The estimated amount of nitrogen entering the main valley lakes is about seven times greater than that of phosphorus, and only about 30% of this loading can be considered as controllable by current technological methods.

Approximately 60% of the phosphorus loadings are considered controllable, the major portion of which comes from municipal outfalls and septic tanks. Further, the evaluations presented later in this report indicate that the control of these two sources will probably meet the desired objective of maintaining or enhancing the quality of the main valley lakes over and in some cases beyond the study horizon of 2020. This does not infer that long-term measures to control other sources of nutrients should not be examined, tested and if feasible, implemented. Tributary streams, for example, represent the second largest source of phosphorus and the protection of major streams by permanent green belts could significantly reduce phosphorus loadings. The implementation and assessment of such a program however, could take a number of years and the effects may take much longer to materialize.

5.4 WASTE TREATMENT PILOT PROJECTS

Waste collection and treatment systems are used to process urban wastes for public health and aesthetic reasons. These wastes are ultimately discharged to the streams and lakes of the valley where they are assimilated as food by plant and animal life. The waters of the basin therefore play an essential role as receiving waters for man's wastes. The assimilative capacity of these lakes however, is limited and increasing levels of treatment are often required to offset increased waste loadings and maintain an acceptable balance of food and biological productivity in the lake environment.

A number of pilot studies and test installations were undertaken as part of the water quality studies to determine the feasibility and value of advanced waste treatment processes for the control of nutrient discharges, and problems associated with waste disposal. These included:

- A review and Evaluation of Advanced Wastewater Treatment Methods.
- A Lysimteter Spray Irrigation Study
- Monitoring of Spray Irrigation of Sewage Treatment Plant Effluent at Vernon.
- Phosphorus Removal by Lime Treatment
- Influence of Septic Tank Effluent on Receiving Water Nutrient Gain from Groundwater
- Nutrient Contributions from Refuse Disposal Sites.

The results of each of these studies are summarized in this section.

5.4.1 Review of Present Treatment Practices

Of an estimated 115,000 people in the basin (1971) 56,000 (50%) were on municipal collection and sewage treatment systems, leaving 59,000 (50%) on septic tank installations. Of a known 52 industrial producers of waste products, 9 discharge through ground filtration systems, 12 are primarily cooling water effluent, and the balance are untreated.

Municipal sewage treatment systems in the Okanagan Basin include secondary treatment plants or lagoons. The primary purpose of both types of systems is to separate the solid wastes from the liquid wastes by biological treatment and settling ponds, so that the clarified effluent can be disposed of to surface waters. The liquid waste represents by far the largest portion of sewage and comes primarily from the water used to transport the solid wastes to the treatment plant. Secondary treatment also reduces organic loadings in the treated effluent which otherwise would reduce or deplete the dissolved oxygen content of surface waters. Before discharging, the clarified effluent is chlorinated to remove pathogenic bacteria. The above is referred to as secondary or 'conventional' treatment in this report, as compared to advanced or tertiary treatment whichis primarily for the removal of nutrients. Tertiary treatment for the removal of phosphates has recently been installed in Penticton, and Vernon has initiated an experimental program of spray irrigation, using secondary effluent as an advanced form of treatment.

While the present level of waste treatment in the Okanagan is equal to or better than that of most other parts of Canada or North America, certain problems do exist in the conventional treatment processes that require correction before advanced or tertiary treatment can really be effective. These include the age and in some cases outdated forms of conventional treatment, and the overloading of the plants in the summer months due to the heavy influx of tourists. The studies and findings on advanced treatment in this report assume that a high standard of conventional treatment is maintained at all times.

5.4.2 Review and Evaluation of Advanced Wastewater Treatment Methods

A literature review of advanced wastewater treatment methods with emphasis on removal of nutrients, was carried out as a prelude to selecting those that seemed most appropriate for testing under local conditions. This review included an assessment of the efficiency, cost and ease of operation of each nutrient removal method. A comparison of these nutrient removal processes and their costs is included in Table 5.16. Based on this review, and the consideration of these processes by a group of consulting engineers on waste treatment for the major urban centers in the Valley, it was recommended that the pilot studies include the monitoring of a pilot spray irrigation system being installed by the City of Vernon, a lysimeter study at Penticton to determine the suitability of Okanagan soils for wastewater treatment, and a pilot study in-

TABLE 5.16

COMPARSION OF NUTRIENT REMOVAL PROCESSES*

PROCESS	CLASS	REMOVAL EFFICIENCY Percent	ESTIMATED COST Dollars per Million Gallons	WASTES TO BE DISPOSED OF	REMARKS
Ammonia stripping	Chemical	80-98	9- 25	-	Efficiency based on ammonia nitrogen only.
Anaerobic denitrification	biological	60-95	25- 30	none	
Algae harvesting	biological	50-90	20- 35	liquid and sludge	Large land area needed.
Conventional biological treatment	biological	30-50 nitrogen 10-30 phosphorus	30-100	sludge	
Ion exchange	chemical	80-92 nitrogen 86-96 phosphorus	170-300	liquid	Efficiency and cost depend on degree of pretreatment.
Electrochemical treatment	chemical	80-85	4-8	liquid and sludge	
Electrodialysis	chemical	30-50	100-250	liquid	Cost based on 1-10 mgd capacity, 1000 p.p.m. solids.
Reverse osmosis	physical	65-95	250-400	liquid	
Distillation	physical	90-98	400-1000	liquid	
Land application	physical	60-90 phosphorus	75-150	none	Large land area needed.
Modified activated sludge	biological	60-80	30-100	sludge	
Chemical precipitation	chemical	88-95	10-70	sludge	
Chemical precipitation with filtration	chemical	95-98	70-90	liquid and sludge	
Sorption	chemical	90-98	40-70	liquid and solids	Cost based on water treatment costs.

* From Eliasson and Tchobanogious (13)

volving lime addition to raw sewage for the purpose of phosphorus removal in the City of Kelowna treatment plant. The latter involved an evaluation of the feasibility for adapting existing facilities in Kelowna to handle this advanced treatment process.

Pilot installations for the removal of nitrogen were considered, but not included because of similar studies being carried out by the Canada Centre for Inland Waters, and because of expected difficulty in controlling sufficient amounts of this element in the basin to warrant its removal from waste effluents only.

5.4.3 Lysimeter Spray Irrigation Study at Penticton B.C.

This study was designed to provide information concerning the ability of three typical Okanagan Basin soils to act as conditioners of secondary effluent from sewage treatment plants, when crops are grown as an integral part of the operation. It was considered that if spray irrigation of treated sewage is to be used as a method of preventing nutrients from reaching the surface waters of the basin, then it must be determined in advance that this is a viable method in those areas of the basin that have nutrient problems. A lysimeter consists of an enclosed unit of soil which permits tests to be carried out under controlled conditions (Figure 5.7).

The parameters considered the most important in these tests were soil type, crop type, and rate of wastewater application. Thirty individual lysimeters were installed in a block on a site of the Penticton Sewage Treatment Plant to provide for the testing of these various parameters. Duplicate lysimeters were used for each set of conditions. The three soil types chosen were considered representative of the soil textures found in the Valley, particularly for locations where full scale spray irrigation projects might be implemented in the near future. These included:

Enderby silt-loam: a fairly prevalent soil type in the valley north of Vernon, and similar to silt loams in the Penticton area.

Armstrong gravelly sandy loam: similar to soils found in all areas of the valley. It is probably representative of the soil type most prevalent in the Okanagan Basin. The collection site is immediately adjacent to the Vernon spray irrigation site.

Osoyoos sandy loam: indicative of the soil commonly found in the area from Okanagan Falls to the United States border. A similar soil is also found in the O'Keefe Ranch area near Vernon.

The two crops used in this study provided extremes in nitrogen utilization, Reed Canary grass being a relatively high nitrogen user, while alfalfa produces most of its own nitrogen through root nodules. Both crops were expected to be about equal in terms of phosphorus uptake.

NUTRIENT INVENTORY FROM LYSIMETER TESTS

LYSIMETER NO.	SOIL TYPE	CROP	IRRIGATION WATER: SOURCE	IRRIGATION WATER: APPLICATION RATE	TOTAL NITROGEN (pounds): APPLIED	TOTAL NITROGEN (pounds): CROP UPTAKE	TOTAL NITROGEN (pounds): LEACHATE	TOTAL NITROGEN (pounds): RESIDUAL (SOIL STORAGE)	TOTAL PHOSPHORUS (pounds): APPLIED	TOTAL PHOSPHORUS (pounds): CROP UPTAKE	TOTAL PHOSPHORUS (pounds): LEACHATE	TOTAL PHOSPHORUS (pounds): RESIDUAL (SOIL STORAGE)
1	Osoyoos Sand	Alfalfa	Domestic Water	High*1	.00022	.016	.00016	-.016	.00049	.0014	.000060	-.0014
2 and 3	Osoyoos Sand	Reed Canary Grass	Treated Secondary Effluent	High	.16500	.052	.00650	.107	.03700	.0076	.000300	.0290
4 and 5	Osoyoos Sand	Alfalfa	Treated Secondary Effluent	High	.16500	.065	.00560	.094	.03700	.0062	.000200	.0310
26 and 27	Osoyoos Sand	Alfalfa	Treated Secondary Effluent	Normal*2	.06400	.051	.00220	.011	.01440	.0054	.000100	.0090
28 and 29	Osoyoos Sand	Reed Canary Grass	Treated Secondary Effluent	Normal	.06600	.026	.00180	.038	.01470	.0042	.000200	.0100
30	Osoyoos Sand	Alfalfa	Domestic Water	Normal	.00045	.016	.00030	-.016	.00004	.0013	.000090	-.0013
6	Vernon Loam	Alfalfa	Domestic Water	High*1	.00110	.042	.00110	-.042	.00010	.0032	.000010	-.0031
7 and 8	Vernon Loam	Reed Canary Grass	Treated Secondary Effluent	High	.15200	.087	.00540	.060	.03420	.0130	.000010	.0210
9 and 10	Vernon Loam	Alfalfa	Treated Secondary Effluent	High	.17000	.082	.00380	.084	.03820	.0085	.000020	.0300
21 and 22	Vernon Loam	Alfalfa	Treated Secondary Effluent	Normal *3	.08400	.079	.00130	.004	.01890	.0072	.000010	.0120
23 and 24	Vernon Loam	Reed Canary Grass	Treated Secondary Effluent	Normal	.08800	.067	.00110	.020	.01980	.0110	.000020	.0090
25	Vernon Loam	Alfalfa	Domestic Water	Normal	.00057	.035	.00065	-.035	.00005	.0026	.000003	-.0026
11	Enderby Silt	Alfalfa	Domestic Water	High*1	.00100	.020	.00320	-.022	.00009	.0023	.000600	-.0029
12 and 13	Enderby Silt	Reed Canary Grass	Treated Secondary Effluent	High	.15100	.076	.00890	.066	.03400	.0040	.001400	.0290
14 and 15	Enderby Silt	Alfalfa	Treated Secondary Effluent	High	.15500	.052	.01400	.089	.03490	.0065	.001000	.0270
16 and 17	Enderby Silt	Alfalfa	Treated Secondary Effluent	Normal*4	.08600	.052	.00360	.030	.01920	.0050	.000400	.0140
18 and 19	Enderby Silt	Reed Canary Grass	Treated Secondary Effluent	Normal	.08600	.055	.00350	.028	.01920	.0088	.000500	.0100
20	Enderby Silt	Alfalfa	Domestic Water	Normal	.00057	.027	.00076	-.027	.00005	.0022	.000200	-.0022

*1 High Rate of Application is 2½ times that of the normal.

*2 Lysimeters containing Osoyoos sand normal application-4.75 imp. gal. every 4-5 days.

*3 Lysimeters containing Vernon loam normal application -16.5 imp. gal. every 14 days.

*4 Lysimeters containing Enderby Silt normal application-24.2 imp. gal. every 21 days.

AVERAGE COLIFORM CONCENTRATIONS IN APPLICATION AND LEACHATE WATERS

(Domestic Water Source)

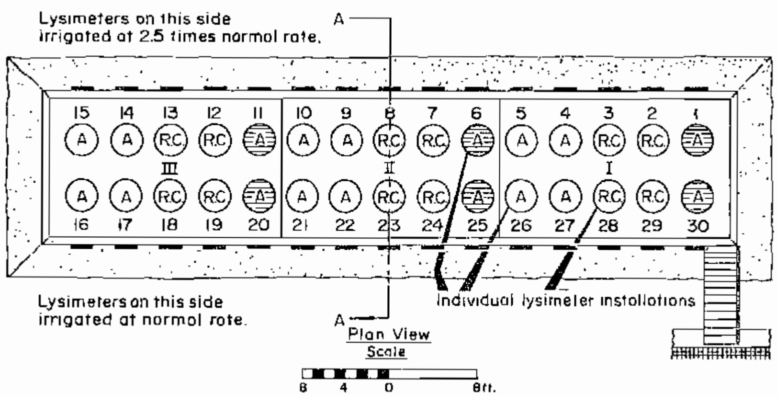
COLIFORM TYPE	APPLICATION WATER	COLIFORMS IN LEACHATE FROM LYSIMETER NUMBER (No./100ml)					
		1	30	6	25	11	20
Total	27	<2	6	<2	2	36	16
Fecal	<2	<2	<2	<2	<2	4	<2

AVERAGE COLIFORM CONCENTRATIONS IN APPLICATION AND LEACHATE WATERS

(Secondary Effluent Source)

COLIFORM TYPE	APPLICATION WATER	COLIFORMS IN LEACHATE FROM LYSIMETER NUMBER (No./100 ml.)					
		2,3 4 & 5	26,27 28 & 29	7,8 9 & 10	21,22 23 & 24	12,13 14 & 15	16,17 18 & 19
Total	746	4	3	3	10	195*	69*
Fecal	28	<2	<2	<2	3	4	<2

* Values dropped to less than 2 per 100 millileters in three out of four lysimeters when short circuiting corrected.



PENTICTON LYSIMETER INSTALLATION
Applied Research Pilot Project

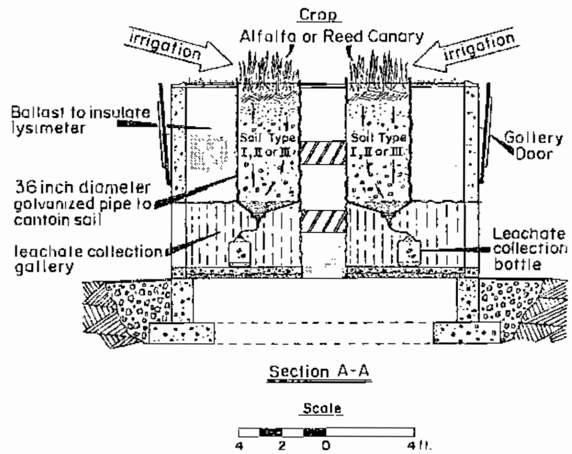


Figure 5.7

Two different rates of effluent application were used, the first being the 'normal' rate as recommended for each soil type, which provides sufficient water to ensure that some passes through the soil column to prevent the buildup of undesirable constituents in the root zone. The second rate was arbitrarily chosen at 2 1/2 times the normal rate, to determine the effect of high rates of application, since the possibility exists that effluent disposal on land may involve higher rates of application than 'normal' due to economic and land availability aspects.

The treated effluent from the secondary clarifiers of the City of Penticton Sewage Treatment Plant was used for most of the tests. In addition, six of the lysimeters were selected as control units for comparison purposes, and irrigated with water from the City domestic supply system.

The testing program was carried out between May and October, 1972. Quantity and quality data were obtained on both the applied liquid and the liquid passing through the soil columns (leachate) to the bottom of the lysimeters, where it was collected. The nutrient uptake by the crops was also measured to provide a nutrient budget for each experiment. Because the survival of pathogenic bacteria in the water passing through the soil column could be of concern to users of groundwater near such a project, monitoring of total and fecal coliform was included as part of the testing procedure.

The results of this study are summarized in Figure 5.7. The values shown under the column 'residual' represent the nutrients which are not removed in the leachate or the crops, and are therefore accounted for by soil storage. These results indicate only a small fraction of the applied nutrients are carried through the soil column in the leachate water.

Phosphorus storage in the Osoyoos sand and Vernon loam amounted to between 50% and 80% of the phosphorus applied in the secondary effluent. The results for the Enderby silt were not considered reliable because of apparent short circuiting (flow of water between the soil column and side of the lysimeter rather than through the soil column) of the applied liquid through the lysimeter. Phosphorus in the leachate from the Osoyoos sand amounted to less than 1.4% of the total applied, and for the Vernon loam, less than o.1%. For Enderby silt, the amount was higher (2 to 4%) due to the higher initial phosphorus content of the Enderby silt, and the apparent short circuiting that occurred in these units. The percentage of phosphorus taken up by the crops was 12 to 22% for the high rate of application, and 26 to 46% for the low rate of application.

With the exception of one set of lysimeters containing Enderby silt, the total nitrogen in the leachate was 4% or less of the total applied.

Results obtained on coliform tests showed levels in the leachate for both the total and fecal types to be less than 10 per 100 millileters for all lysimeters following correction of the short circuiting in the Enderby silt units.

In general, the following conclusions have been reached from these lysimeter tests.

(i) The use of spray irrigation for the reconditioning of secondary effluent appears to be a very acceptable practice for all three types of soils tested. This statement is true for both application rates tested, but is is evident that significant leaching of impurities would occur sooner at higher application rates.

(II) Both Reed canary grass and alfalfa are useful crops for removing nutrient forms from the secondary effluent. With time, the alfalfa will probably allow a larger amount of nitrogen to escape to groundwater because of nitrogen fixing nodules on the roots.

(iii) Storage of excess nitrogen and phosphorus is evidently occurring in the soil. To maintain a balance of nutrients applied vs. nutrients harvested, in the crops, would require the use of a short irrigation season, and hence reduce the effectiveness of this proposed method of nutrient control in the Okanagan Valley.

(iv) The finer soils have a higher storage capacity for the various nutrient forms due to their higher adsorptive capacities.

(v) Good correlation was obtained between the lysimeter study and the full-scale irrigation project at Vernon discussed in the following section. Consequently, the results of the lysimeter investigations of the other soil types should be useful in predicting results from fullscale irrigation of these soils.

(vi) Coliform concentrations in groundwater return flow are very low after passing through four feet of any of the three soil types tested. Hence, there is no apparent concern in full-scale facilities where the travel distances will be much greater before any water is withdrawn from the groundwater regime for use.

5.4.4 Monitoring Spray Irrigation of Sewage Treatment Plant Effluent at Vernon, B.C.

Prior to the beginning of the Okanagan Basin Study, the City of Vernon had elected to initiate a pilot spray irrigation project in an attempt to find and acceptable solution for the disposal of its treated waste effluent. Vernon currently (1973) discharges its treated wastewater into Vernon Creek which flows into the Vernon Arm of Okanagan Lake. The high nutrient input associated with this discharge has resulted in problems of weed and algal growth. The pilot project involved the irrigation of 75 acres of alfalfa and a tract of native hillside located southeast of Vernon. The area is on a high slightly sloping tract of land, has well drained sandy to silty loam soil and was considered ideal for this type of wastewater disposal.

Based on the recommendations arising out of the report on advanced wastewater treatment methods, the monitoring of this project was undertaken by the Study. It was considered complementary to the lysimeter study discussed in 5.5.3, and provided comparative results under actual field conditions. Monitoring of the project was carried out over the two irrigation seasons of 1971 (June 21 to October 26) and 1972 (May 4 to October 25). The irrigation rate for the alfalfa crop was 3.2 inches of water every ten days, however because of shut down periods for harvesting, pump repairs, etc., the average application rate over the entire irrigation season was somewhat less.

To provide the necessary data for calculating a nutrient budget, analyses of samples were carried out on the liquid being applied to field, the excess water not used by the crops (leachate), and the crops themselves. Analyses of the applied liquid and the crops were carried out in the same manner as for the lysimeter study. To monitor the excess water or leachate, small wells (well points) were installed around the lower periphery of the irrigated areas, to the full depth of the soil with the screened bottom of the pipe resting on the impervious glacial till. Selected shallow wells in the Vernon Creek Valley were also monitored to ascertain if the excess irrigation water would measurably affect the quality of groundwater in the Valley. The location of these wells and the results of the monitoring program are detailed in Figures 5.8 and 5.9.

The long term usefulness of spray irrigation as a means of disposal for treated wastewater is dependent upon the amount of impurities that are leached through the soil and upon the change or build-up of nutrient levels and other impurities in the soil. The former is important for estimating the potential pollution of groundwater, while the latter may affect the health of the crops being grown, and their usefulness after harvest.

The results shown in Figure 5.9 indicate only 6% of the nitrogen applied, and 0.3% of the phosphorus are being leached through the soil column to the groundwater table. The percentage losses on native grass hillsides are about the same, but can be expected to increase substantially as slope water wells did not provide any conclusive results on the effect of leachate water on the downslope groundwater, due in part to the small quantity of leachate from the irrigation site. A comparison of concentrations in the leachate from the irrigation site and the downslope groundwater did indicate the only nutrient with a significantly higher concentration in the irrigation leachate is one of the nitrogen forms - kjeldahl nitrogen (Table 5.17). From this it may be

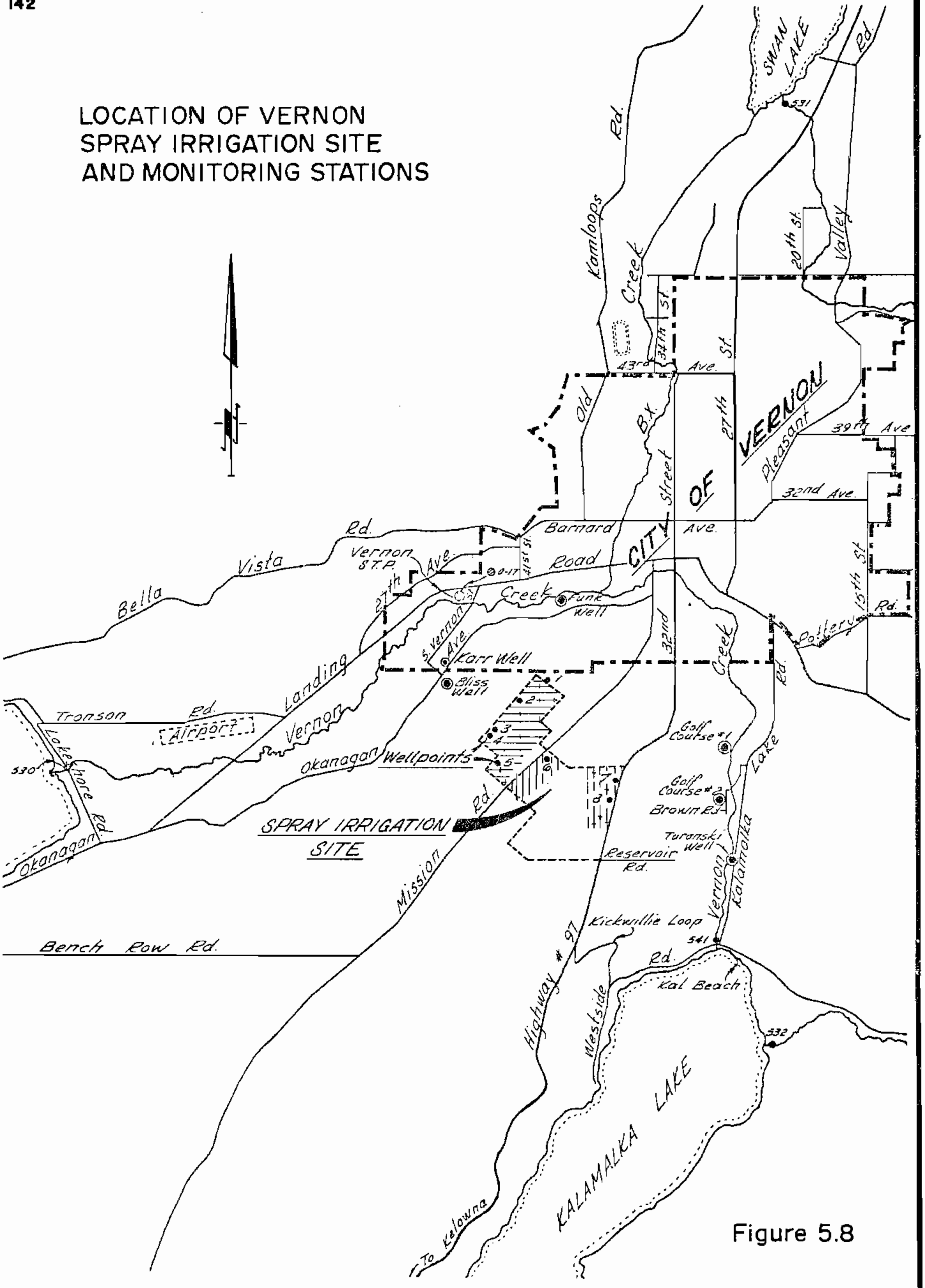
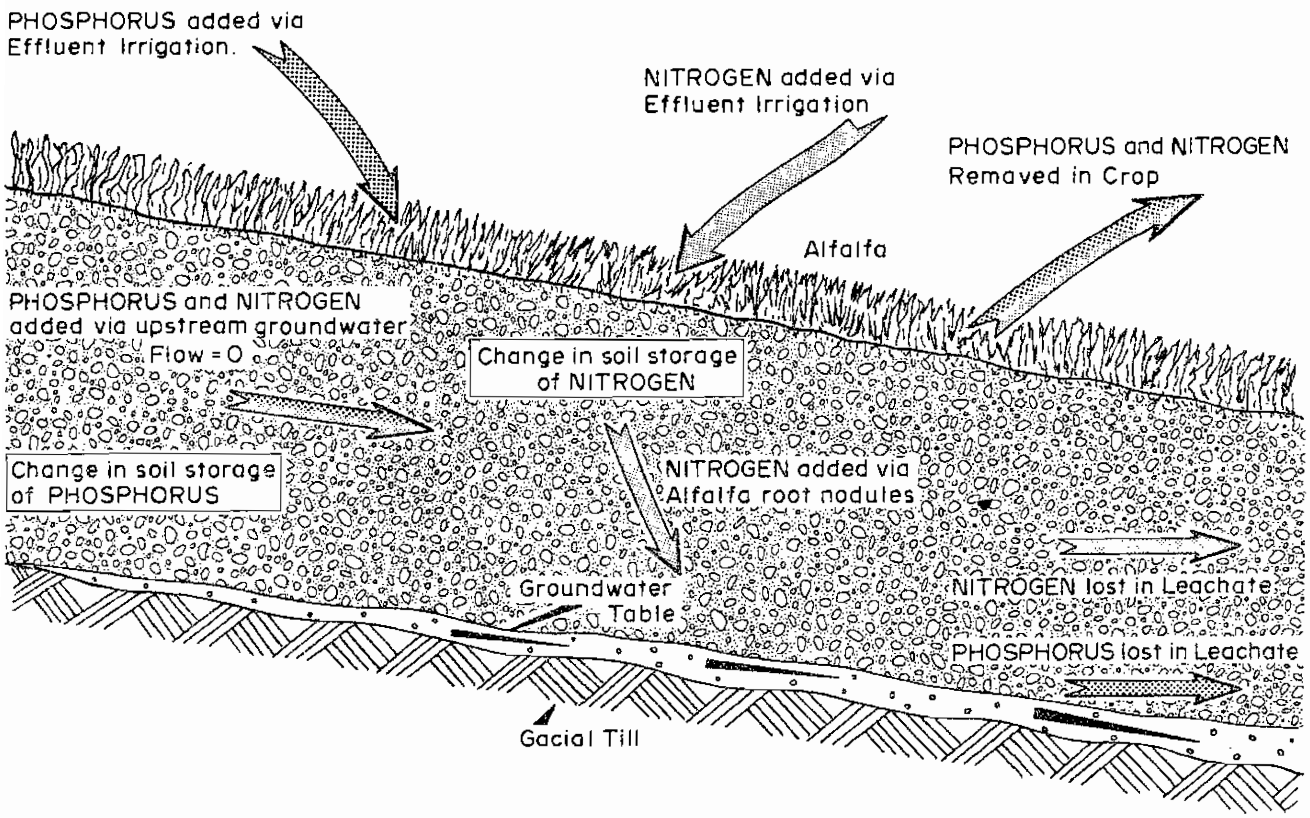

LOCATION OF VERNON
SPRAY IRRIGATION SITE
AND MONITORING STATIONS
SWAN LAKE
Rd.
531
Kamloops
Rd.
Creek
20th St.
Valley
34th St.
43rd Ave.
St.
Old
B.X.
27th
VERNON
Pleasant
39th Ave
OF
32nd Ave.
Street
CITY
Barnard
Ave.
Rd.
Vista
Bella
Vernon S.T.P.
27th Ave.
41st St.
Road
Creek
Funk Well
15th St.
Rd.
Pottery
Landing
S. Vernon Ave.
Karr Well
Bliss Well
32nd
Creek
Rd.
Tronson
Rd.
Airport
Vernon
Lakeshore Rd.
530
Okanagan
Wellpoints
Golf Course #1
Golf Course #2
Brown Rd.
Lake
SPRAY IRRIGATION SITE
Rd.
Mission
Reservoir Rd.
Turanski Well
Vernon
Kalamalka
Kickwillie Loop
Okanagan
Bench Row Rd.
Highway # 97
541
Rd.
Kal Beach
Westside
532
KALAMALKA LAKE
To Kelowna

Figure 5.8



SCHEMATIC DRAWING OF NUTRIENT BALANCE AT VERNON
SPRAY IRRIGATION SITE

NUTRIENT BUDGET SUMMARY FOR VERNON ALFALFA PLOT
(75 Acres)

CROP YEAR	SOURCE (Sink)	TOTAL KJELDAHL NITROGEN pounds per year	NITRATE NITROGEN pounds per year	TOTAL PHOSPHORUS pounds per year	REMARKS
1971	Effluent	6,600	2,460	2,950	
	(Leachate)	(90)	(80)	(10)	
	(Crop)	(12,840)	neg.	(1,830)	
	Nodule Fixation	nil	7,500	nil	Assuming 100 lbs/acre/yr for first year crop
	Increase in Soil Storage	3550		1,110	
1972	Effluent	7,700	2,500	3,700	
	(Leachate)	(130)	(560)	(10)	
	(Crop)	(21,950)	neg.	(2,680)	
	Nodule Fixation	nil	15,000	nil	Assuming 200 lbs/acre/yr for second year crop
	Increase in Soil Storage	2560		1,010	

NUTRIENT BUDGET-VERNON PILOT SPRAY IRRIGATION PROJECT.

Figure **5.9**

TABLE 5.17

COMPARISON OF NUTRIENT CONTENT OF IRRIGATION LEACHATE WATER AND DOWNSLOPE GROUNDWATER IN PARTS PER MILLION

YEAR	PARAMETER	ALFALFA LEACHATE	HILLSIDE LEACHATE	TURANSKI WELL	GOLF COURSE #2 WELL	GOLF COURSE #1 WELL	FUNK WELL	BLISS WELL
1971	Total Kjeldahl Nitrogen (TKN)	0.890	0.750	0.150	0.090	0.130	0.810	0.070
	Nitrate = Nitrogen	0.810	3.700	18.600	0.720	1.080	4.650	0.150
	Total Phosphorus	0.070	0.038	0.020	0.004	0.008	0.097	0.021
1972	TKN	1.030	0.650	0.170	0.080	0.160	0.800	0.300
	Nitrate Nitrogen	4.410	0.800	12.100	0.960	1.070	10.500	0.300
	Total Phosphorus	0.093	0.032	0.014	0.010	0.160	0.160	0.032

assumed that pollution of the groundwater in the area will not occur unless a substantial imbalance of nutrients applied versus nutrients harvested occurs.

Soil storage of both nitrogen and phosphorus increased over the two year study period, although at a slow rate when considered on a per acre basis. This build-up of nutrients was due in part to irrigating the area after the growing season was over. For an irrigation season of six months, the annual phosphorus buildup in the soil was calculated at 13 pounder per acre, or about 25% of that applied in the effluent. The percentage of buildup of nitrogen is considered to be about the same (25% of nitrogen applied), but was difficult to estimate accurately because of the ability of alfalfa root nodules to fix their own nitrogen. No precise estimate of the useful life of the Vernon soil type can be made from the two years of testing, but experience elsewhere over a fourteen year period has indicated no detrimental deterioration of similar soils and crops sprayed with secondary effluent.

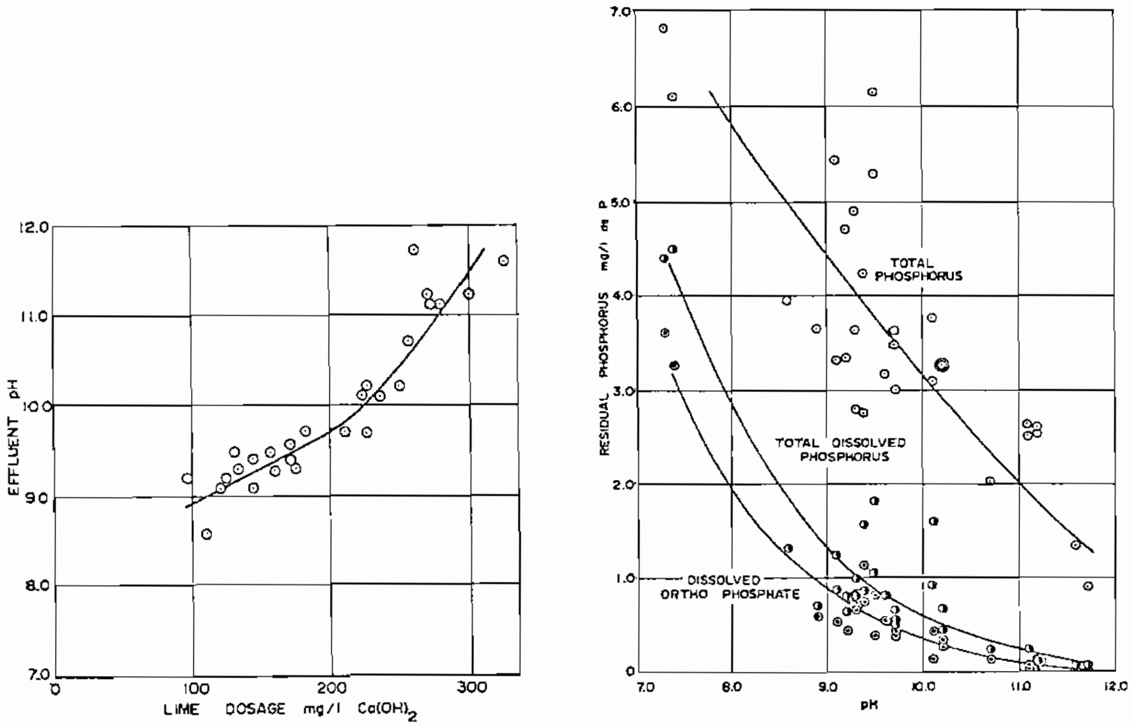
The alfalfa crop grown with secondary effluent was found to be more than satisfactory from a nutritional point of view, and tests for coliform survival in the hay indicated these to be very low within three weeks of baling provided the moisture content of the cut alfalfa was not too high.

5.4.5 Phosphorus Removal by Chemical Treatment at Kelowna

The purpose of this study was to evaluate the chemical process for the removal of phosphorus, in which lime or alum is added to the sewage prior to treatment, in terms of its appicability to the existing Kelowna sewage treatment plant facilities. This type of treatment was investigated because of its economic attractiveness compared to other methods of phosphorus removal.

A pilot scale facility was set up at the Kelowna Pollution Control Centre to enable a controlled investigation of this form of treatment without disrupting the normal day to day operation of the Kelowna Plant. The study itself consisted of the operation of a constant flow primary treatment plant with lime additions, storage of the organic and chemical sludge produced in the pilot treatment unit, and the intermittent disposal of this sludge in the full scale incineration system. Raw sewage from the main plant was used in all tests. Operational data were gathered over the five month period of May to October 1972.

The results of adding lime during primary treatment are presented graphically in Figure 5.10, and show the additon of lime to raw sewage to be effective in removing phosphorus, especially that portion in the soluble form. For example a lime dosage of 250 milligrams per liter resulted in a pH of 10.5 and reduced the total phosphorus concentration from 8.3 to 2.5 milligrams per liter. This dissolved phosphorus for the same dosage was reduced from 5.5 milligrams per liter to 0.4 milligrams per liter.



LIME DOSAGE, pH, and PHOSPHORUS REMOVAL RELATIONSHIPS

Figure 5.10

The second part of the test operation involved the disposal of the lime sludge in the full scale dewatering and incineration system of the Kelowna Treatment Plant to determine the operational characteristics of the lime sludge. During the initial run it became apparent that special precautions would have to be taken to prevent excessive drying of the lime sludge and the attendant possibility of binding and plugging the centrifuge.

These precautions included diluting the lime sludge prior to dewatering to reduce the solids content to between 5% and 8%, and adjusting the centrifuge feed rate during the dewatering process to compensate for a dewatered sludge being either too wet or too dry.

The quantity of phosphorus that can be said to be completely removed from the system is that contained in the settled portion of the incinerator ash. For the test runs this varied from 37% to 80% of the phosphorus initially present in the lime sludge feed. This indicates that phosphorus removal is dependent on the efficiency of the sludge disposal portion of the plant and greater efficiency with respect to particulate removal would result in better phosphorus removal.

One of the problems encountered in this lime treatment process was the accumulation of calcium carbonate in surfaces throughout the pilot facility. This scaling problem could be detrimental to certain parts of the main plant including sewage lift pumps, piping, and trickling filters, and suitable precautions would be required to counteract this effect.

A broad comparison of this type of treatment (pre-recipitation) to that of tertiary treatment (post-precipitation as constructed at Penticton) is as follows:

(i) Pre-Precipitation

- Less capital investment required to convert an existing treatment facility. Post-precipitation requires a duplication of facilities, i.e., additional clarifiers; pre-precipitation utilizes the existing primary facilities.

- Less chemical costs. The amount of lime required to remove phosphorus generally increases exponentially with decreasing phosphorus residual. With pre-precipitation, the activated sludge system can be depended upon to remove a further 1 to 1.5 milligrams per liter of phosphorus and thus as established by this study a final effluent phosphorus concentration of between 1 and 1.5 milligrams per liter could be obtained with a lime dosage of 250 milligrams per liter. Tertiary treatment would probably require a greater lime dose, perhaps 350-450 milligrams per liter, to effect a similar overall removal.

- The removal of organics in the primary stage of treatment is enhanced, thus effectively increasing the capacity of the secondary system. No such advantage is possible with tertiary treatment.

- Less sludge is produced because of the smaller quantity of lime used to remove an equivalent amount of phosphorus.

(ii) Tertiary Treatment

- No chance of upsetting the secondary treatment system. Black (4) reports that pH levels above 9.5 - 10.0 prior to the activated sludge process may result in biological upset with a downgrading of the degree of treatment with respect to biological oxygen demand (B.O.D.) and suspended solids(S.S.).

- Sludge disposal can be kept separate from that used for the normal primary and secondary sludges if desired.

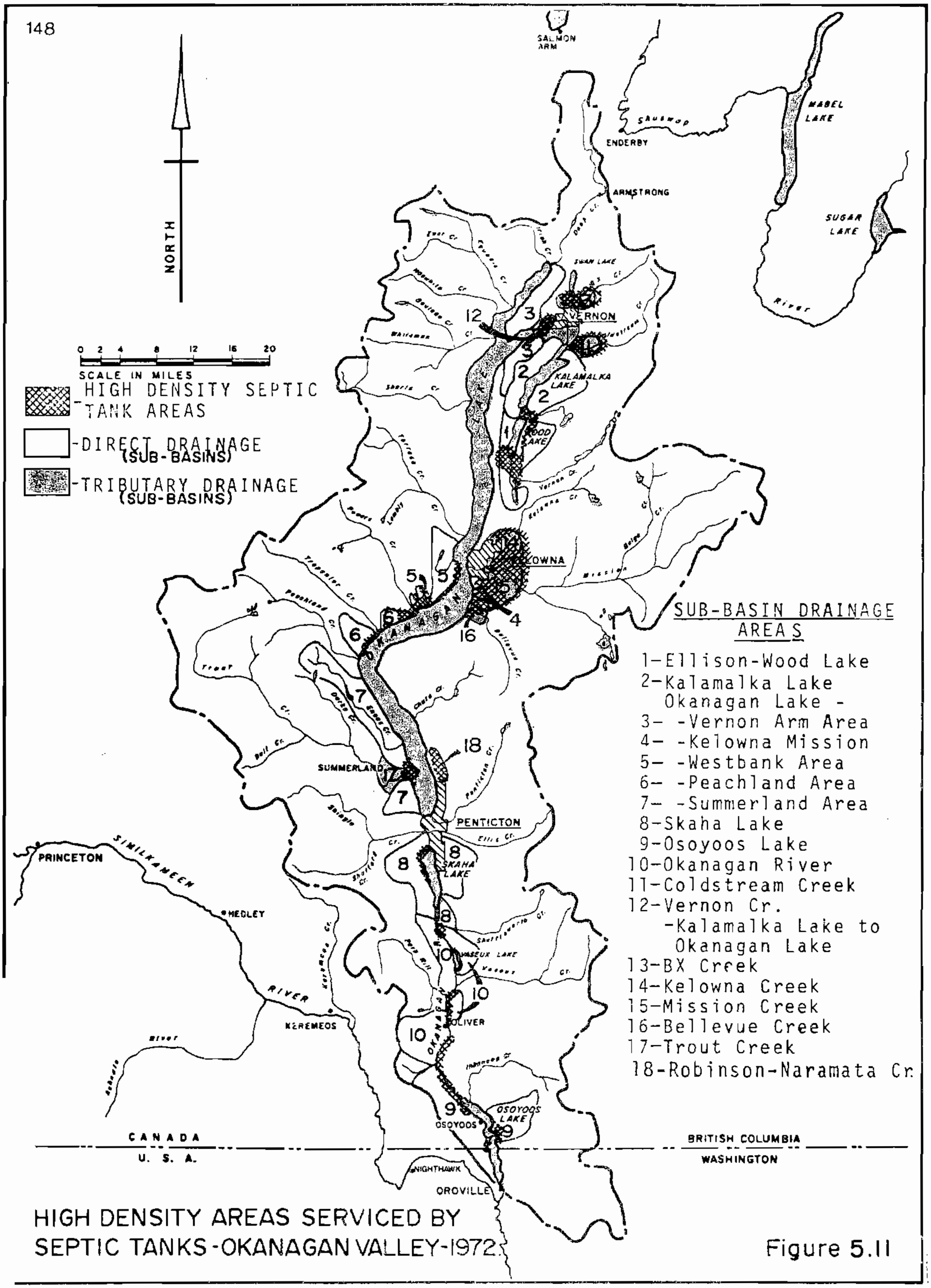
5.4.6 Nutrient Contributions from Septic Tanks

Over 50 % of the population in the Okanagan Valley are serviced by septic tank installations (1972) which contribute to the nutrient loadings of the surface waters of the basin. A septic tank is a simple form of waste treatment unit which primarily conditions sewage for disposal through a field of drain tiles into the ground. Transport of these nutrients involves a downward movement through unsaturated soils to the water table, and then horizontal movement with the groundwaterto a surface water course.

To estimate the influence of this nutrient source on the basin, studies were carried out: to determine the relative density of septic tanks throughout the basin; to assess the parameters that affect the vertical movement of nutrients through unsaturated soil; and to estimate the nutrient loadings that actually reach the main valley lakes and tributary streams. To estimate the nutrient contribution from septic tanks, a test facility was constructed at the site of the Vernon sewage treatment plant, utilizing three different soil types typical of conditions in areas of the Valley where large numbers of septic tanks have been installed. A separate study was alos carried out by the Province of British Columbia on the suitability of soils in the Wood-Kalamalka Lake subbasin for septic tanks and available results of this work have also been considered in estimating the nutrient contribution from septic tank sources.

An enumeration of the number and location of 'equivalent single family units' that are serviced by septic tanks in the valley has provided the information shown in Figure 5.11 and Table 5.18. An 'equivalent single family unit' is defined as that concentration of activity that produces the same annual nutrient loading to a soil as a single family residence. This method was employed to allow the inclusion of apartment blocks, motels, and campsites, etc.

The total population figures shown in Table 5.18 include the equivalent average annual tourist population that contributes to septic tank discharges,



HIGH DENSITY AREAS SERVICED BY SEPTIC TANKS-OKANAGAN VALLEY-1972

Figure 5.11

TABLE 5.18

HIGH DENSITY AREAS SERVICE BY SEPTIC TANK INSTALLATIONS

DESCRIPTION OF AREA (See Figure 5.11)	POPULATION (1972)		EQUIVALENT SINGLE FAMILY UNITS	
	Less than 500 feet from water	Greater than 500 feet from water	Less than 500 feet from water	Greater than 500 feet from water
(1) Ellison-Wood Lake	1,894	2,063	541	589
(2) Kalamalka Lake	774	854	221	244
Okanagan Lake -				
(3) -Vernon Arm	1,271	200	363	57
(4) -Kelowna Mission	2,745	2,363	784	675
(5) -Westbank Area	1,785	1,855	510	530
(6) -Peachland Area	1,763	690	475	197
(7) -Summerland Area	2,726	5,982	493	1,709
(8) Skaha Lake	1,205	1,796	344	513
(9) Osoyoos Lake	1,038	2,956	582	844
(10) Okanagan River	1,209	2,046	342	584
(11) Coldstream Creek	1,033	1,099	295	314
(12) Vernon Creek Kalamalka Lake to Okanagan Lake	809	1,855	231	530
(13) BX Creek	634	1,898	181	542
(14) Kelowna Creek	378	8,481	108	2,423
(15) Mission Creek	910	1,754	260	501
(16) Bellevue Creek	753	273	215	78
(17) Trout Creek	102	942	29	269
OTHER	4200	5900	1146	1684
TOTALS	25229	43007	7120	12283

TABLE 5.19

FRACTION OF NUTRIENT LOADINGS APPEARING IN LEACHATE FROM SOIL COLUMNS

NUTRIENT	SOIL TYPE		
	Silty Loam (Med.-Fine) from Coldstream	Loamy Sand (Medium) Kelowna	Sand from (Coarse) Summerland
Total Kjeldahl Nitrogen	0.05	0.03	0.15
Nitrate Nitrogen	0.01	0.06	0.85
Total Nitrogen	0.06	0.09	1.00
Total phosphorus	0.02	0.40	1.00
Dissolved Orthophosphorus	0.02	0.40	1.00

and the sewered areas of Rutland and Osoyoos because ground disposal of effluent is practices in both cases. The figures do not include houses and septic tank units in the outlying areas of the basin where population is sparse and the distances to ground water or surface water are great.

The test facility constructed at Vernon indicated the two most important factors affecting the vertical movement of nutrients through unsaturated soil were soil type and depth to groundwater. Measurement of the nutrients from septic tank effluent passing through a four foot soil column for three different soil types provided the data shown in Table 5.19.

All of the factors shown in Table 5.19 are based on the more or less steady state conditions that were evident after six months of testing. The results indicate that the Summerland sand had exhausted its adsorptive capacity within three to four months (i.e. through 4 feet of soil depth) and that most of the nutrients were passing through the soil column to the groundwater table. The Kelowna loamy sand also showed a partial breakthrough of phosphorus after about four months at a depth of two and a half feet, while the leachate from the finer silty loam had no appreciable concentration of phosphorus in it after the five months of testing. The question of how long each of the soils would continue to absorb nutrients is difficult to answer although it is obvious the finer soils were fairly effective over the duration of the test period, while the medium and course soils were not. It is also interesting to note that the majority of septic tanks in the valley are located in coarse or intermediate soil areas, and in the shallow or medium depth to groundwater areas.

Results of the more detailed studies on the Wood-Kalamalka Lake sub-basin by the Province of British Columbia support these findings. Most soils in this sub-basin are considered to have only limited suitability for the subsurface disposal of septic tank effluent because of high water tables, proximity to surface waters, imperivous layers, coarse textured subsoils, steep slopes, and seepage water. Based on a classification of the suitability of various soils in this sub-basin for septic tank effluent, only two areas, one at Enderby, and one at Hulcar near Armstrong, met Class 1 standards. Class 1 standards include a depth of greater than 6 feet to the water table and/or impermeable layer, a ground slope of 0 to 5% for single dwellings, a distance of greater than 200 feet to surface water and a soil type consisting of silt loam, clay loam, sandy loam, fine sand or clay.

Selection of coarse soils for septic tank installations has historically been recommended to avoid potential health problems, although the results of this study show that such soils are much less desirable than fine soils when the problem of nutrient transport is considered. Further, because most of the population and development is located in the main valley near surface waters, the depth to groundwater is not great.

Based on the above studies and those of the Province in the Wood-Kalamalka Lake area estimates were made of the total amount of nutrients reaching the groundwater table. To determine the amount of nutrients actually reaching surface waters via groundwater, these assumptions were made:

(i) 100% of all nutrients that reach groundwater within 500 feet of a surface water course will find their way to the surface water;

(ii) 70% of nitrate N that reaches groundwater farther than 500 feet from a surface water course will find its way to that water course; and

(iii) 30% of the other nutrient forms that reach groundwater farther than 500 feet from a surface water course will find their way to that water course.

These assumptions make the results approximate at best, but relatively accurate estimates would have required detailed and expensive studies of the groundwater regime which were not possible within the time limits and resource of this study.

The estimated amount of nutrients reaching surface waters from septic tank sources via groundwater are 25,000 pounds of phosphorus per year and 275,000 pounds of nitrogen per year. While these estimates may be in error by as much as 50%, much more intensive and costly surveys would be required to improve the accuracy of these results.

While septic tank loadings may be small in comparison to municipal loadings, they will have a significant effect on the quality of local waters adjacent to septic tank effluent sources, and consequently may affect adjacent recreational beach areas.

One of the other parameters measured in these septic tank studies was coliform and the efficiency of the three soil types in removing coliform organisms. The application liquid had an average total coliform count greater than 2,400,000 bacteria per 100 milliliters, and a fecal coliform count in excess of 1,000,000 per 100 milliliters. Efficiencies of the three selected soil types in removing coliform organisms fluctuated from day to day, but the following more important long term trends were established:

(i) The removal efficiences of both total and fecal coliforms is in excess of 99.7% for all three soil types;

(ii) The finer textured soil in lysimeter #3 is consistently better than the coarser soils in its ability to remove coliforms; and

(iii) The trends in all four lysimeters is toward an increase in leachate coliforms content with lime.

In summary these studies indicate that most soils in the valley have limited suitability for removing nutrient loadings from high density septic tank areas, because of their coarse nature and the shallow depth to groundwater. While these conditions could be improved by more stringent regulations and installation techniques, existing statutes do not provide for the control of these installations in respect to nutrient loadings to surface waters.

5.4.7 Nutrient Contributions from Refuse Disposal Sites

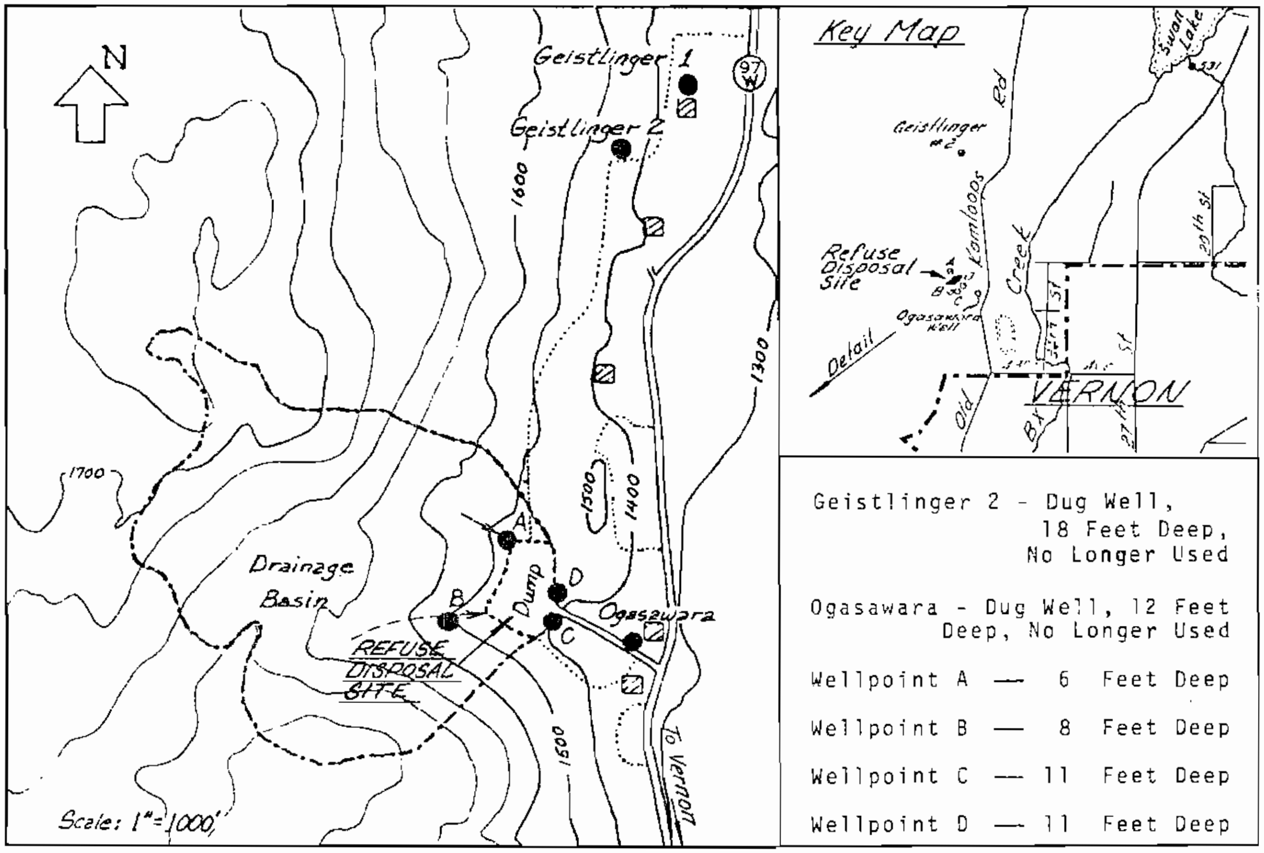
The final study of a pilot nature involved refuse disposal sites (garbage dumps). The purpose of this investigation was to characterize the potential of a representative site, which had been used for some years, as a source of groundwater contamination, and to estimate the nutrient input to groundwater from this source. The study included both a laboratory scale landfill leaching experiment which was conducted at the Vernon Sewage Treatment Plant, and an onsite investigation of an old disposal site about one half mile north east of the City of Vernon, which had been operated as a burning dump over a period of 75 years.

(a) Refuse Disposal Site

The on-site investigation involved the monitoring of two existing downslope wells, two well points installed immediately above the site and two well points directly below the site. (Figure 5.12). Monitoring commenced in July 1971 and continued on a once a month sampling schedule to October 1972. The existing well immediately downslope of the disposal site (Ogasawara Well) was selected to reflect any changes in groundwater quality due to contamination from the disposal site. The Geistlinger Well located 3,500 feet north of the site was selected to indicate the natural quality conditions of the area for comparison purposes.

The average concentrations recorded over the monitoring period are also shown in Figure 5.11. During the winter of 1971-72, 95 inches of snow, or twice the annual average of 48 inches fell in the Vernon Area, and early snowcover prevented the ground from freezing. This had the effect of allowing a greater than normal proportion of spring melt to infiltrate the ground rather than to run off the surface. This was evident at the disposal site where there was very little surface runoff in the area during the spring thaw. Water levels rose in all wells with the exception of wellpoint D in which there was never any water. Nitrate was found to be the dominant form of nitrogen with average concentrations varying from a low of 1.2 milligrams per liter in Wellpoint A to a high of 63 milligrams per liter (parts per million) in Wellpoint C. The average concentrations of phosphorus ranged from .024 milligrams per liter in the Ogasawara Well to 0.61 milligrams per liter in Wellpoint A. Concentrations of various water quality parameters in the Ogasawara Well (1) remained fairly constant throughout the monitoring period, and the quality of the last sample taken from Well point C corresponds closely to that occurring year round in the Ogasawara Well.

GROUNDWATER MONITORING SITES



GROUNDWATER QUALITY

AVERAGE CONCENTRATION OF CONSTITUENTS

Milligrams Per Liter

LOCATION	pH	TOTAL KJELDAHL NITROGEN(TKN)	NITRATE NITROGEN (NO_3-N)	NITRITE NITROGEN (NO_2-N)	TOTAL PHOSPHORUS
Ogasawara[2]	7.7	0.30	5.6	0.009	0.024
Geistlinger #2[1]	8.0	0.48	2.3	0.005	0.031
Wellpoint A	8.3	0.63	1.2	0.005	0.061
Wellpoint B	8.1	0.94	10.8	0.005	0.030
Wellpoint C	8.1	0.06	63.0	0.021	0.029

1. Averages do not include results from the October 5 and October 15 sampling.

MONITORING RESULTS FOR THE VERNON REFUSE DISPOSAL SITE

Figure 5.12

Some contamination of groundwater by the refuse disposal site did occur in the spring of the study period when groundwater levels were at their highest. This contamination was most likely caused by the intrusion of groundwater into a portion of the bottom of the dump rather than by surface water percolating through the fill. The nutrient input from this occurrence was all in the form of nitrate nitrogen and was estimated at 4,900 pounds. No phosphorus contamination was recorded. The quality of water in the existing domestic well 6,000 feet downslope of the dump site was only minimally affected by this contamination.

(b) Column Leaching Experiment

Eight leaching columns were set up at the Vernon Sewage treatment plant to simulate refuse disposal site conditions, and ascertain quality and quantity characteristics of water percolating through refuse material. Eight inch clear tubing was used under the experimental conditions shown in Table 5.20.

TABLE 5.20

EXPERIMENTAL CONDITIONS FOR LEACHING COLUMNS

COLUMN	COLUMN HEIGHT inches	FILL MATERIAL	FILL HEIGHT inches	DISTILLED WATER APPLICATION PER WEEK
I	30	From Vernon Refuse Disposal Site (45 lbs.) (Covered)	20	Equal to actual Precipitation of preceding week.
II	86	From Vernon Refuse Disposal Site (170 lbs.) (Covered)	74	Equal to actual Precipitation of preceding week.
III	86	Same as for Column II.	74	1.5 inches per week.
IV	86	Fresh Refuse (45 lbs.) (Covered)	74	1.5 inches per week.
V	30	Same as Column I except to exposed to atmosphere	20	Natural precipitation only.
VI	86	Same as Column II except to exposed to atmosphere	74	Natural precipitation only.
VII		Same as Column III		
VIII	86	Same as Column III	74	Leacnate from Column VII

The fill from the refuse disposal site was a composite excavated from three locations to a depth of six feet. It was considered to be representative of a fairly homogeneous mixture of ash and decomposed refuse and did not contain any fresh refuse. Large material was screened out, with rocks and large pieces of metal being discarded, and tins and bottles were broken up and returned to the composite. The fresh refuse was composited based on reference material on the makeup of such composites. The results of this column leaching experiment are summarized in Table 5.21.

TABLE 5.21

DATA RESULTS FROM LEACHING EXPERIMENTS

	NO. OF SAMPLES	LEACHATE QUANTITY LITERS	TOTAL ORGANIC CARBON (T O C)	pH	TOTAL KJELDAHL NITROGEN (TKN)	NITRATE NITROGEN (NO_3-N)	NITRATE NITROGEN (NO_2-N)	TOTAL PHOSPHORUS
			ppm		ppm	ppm	ppm	ppm
Column I	2	6.1	14	8.7	2.0	92	0.99	0.05
Column II	1	3.6	9	8.4	0.6	170	1.86	0.03
Column III	8	23.3	15	8.5	1.6	106	1.07	0.27
Column IV	7	21.5	10,400	6.8	712.0	332	6.30	18.00
Column VIII	5	14.1	19	8.5	3.2	530	1.49	0.23

No leachate was collected from the columns exposed to the atmosphere (V and VI) over the period of the study during which these columns received approximately 15 inches of natural precipitation. Leaching from Column I began after the application of 3.5 inches of water; from Column II after 6 inches, from Column III after 16 inches and from Column VIII after 9.5 inches. The leachate from Column VII was added to Column VIII to provide a greater column depth test.

These tests indicate that no leaching of pollutants from refuse disposal sites occurs from the percolation of rain water through the dump material. Since garbage dumps and sanitary land fills in the Okanagan Valley are all subject to about the same or less precipitation than the Vernon area, it is concluded that the potential input of nutrients and other contaminants from refuse disposal sites to groundwater, and hence to surface waters, is negligible. The tests also showed that water percolating through fresh refuse had higher concentrations of organic carbon, total nitrogen, total phosphorus and dissolved heavy metals than did water percolating through an equal depth of decomposed refuse material.

CHAPTER 6

Limnology of the Main Valley Lakes

The main valley lakes are an integral part of the Okanagan Basin drainage system. They provide a temporary storage of water that falls as rain or snow on the watershed, and in turn provide a year-round supply of water for the residents of the basin. The lakes also offer recreational enjoyment in the form of swimming, boating and fishing which is becoming increasingly important to people and provides significant sources of monetary return to the Okanagan economy. The well being or maintenance of the quality of this lake water is therefore an important aspect in the management of the basin's water resources.

The productive capacity of a lake is a key to its beneficial use by people, particularly in respect to recreation and fishing. Lakes that are extremely deep, cold and have few nutrients provide little opportunity for water based recreation and generally are almost desert like. On the other hand extremely warm, shallow enriched lakes are subject to heavy algal blooms, unpalatibility and a lack of aesthetic appeal. These lakes will not produce desired sport fish in spite of their high productivity, and water based recreation is often unpleasant in these instances. A middle approach; moderately productive waters - but not too productive, warm - but not too warm, aesthetically pleasant and good producers of desired fishes is the most beneficial to man.

The biological community of a lake is composed of a very complex system of interdependent populations ranging from microscopic plants and animals to the much larger aquatic plants and fishes. These interdependent populations are very susceptible to subtle changes in their physical-chemical environment, and these changes require specific adaptations by the plants and animals inhabiting such waters. Most of these changes are not noticeable until the quality of lake waters has deteriorated to the point of becoming aesthetically unacceptable for recreation, or the cost of treating this water for consumptive use becomes exorbitant.

Local concern for the present and future trophic state of the basin lakes was one of the primary reasons for initiation of the Okanagan Basin Agreement. The limnological studies undertaken (limnology is the science concerned with the study of physical, chemical and biological conditions in freshwater lakes) provided a historical perspective of the main lakes aging processes, documented as completely as possible the present trophic state of the lakes, and included projections of what might be expected to happen to the water quality of lakes under varying economic growth conditions and water management alternatives. Ten different studies were carried out to determine the chemical and physical distribution of the major chemical elements in each of the main valley lakes, and the effect of these elements on biological populations and communities in these lakes. These results were also compared to past studies, particularly those of Clemens et al in 1935, (15) to assess changes in the condition of the lakes attributable to man's influence since 1935.

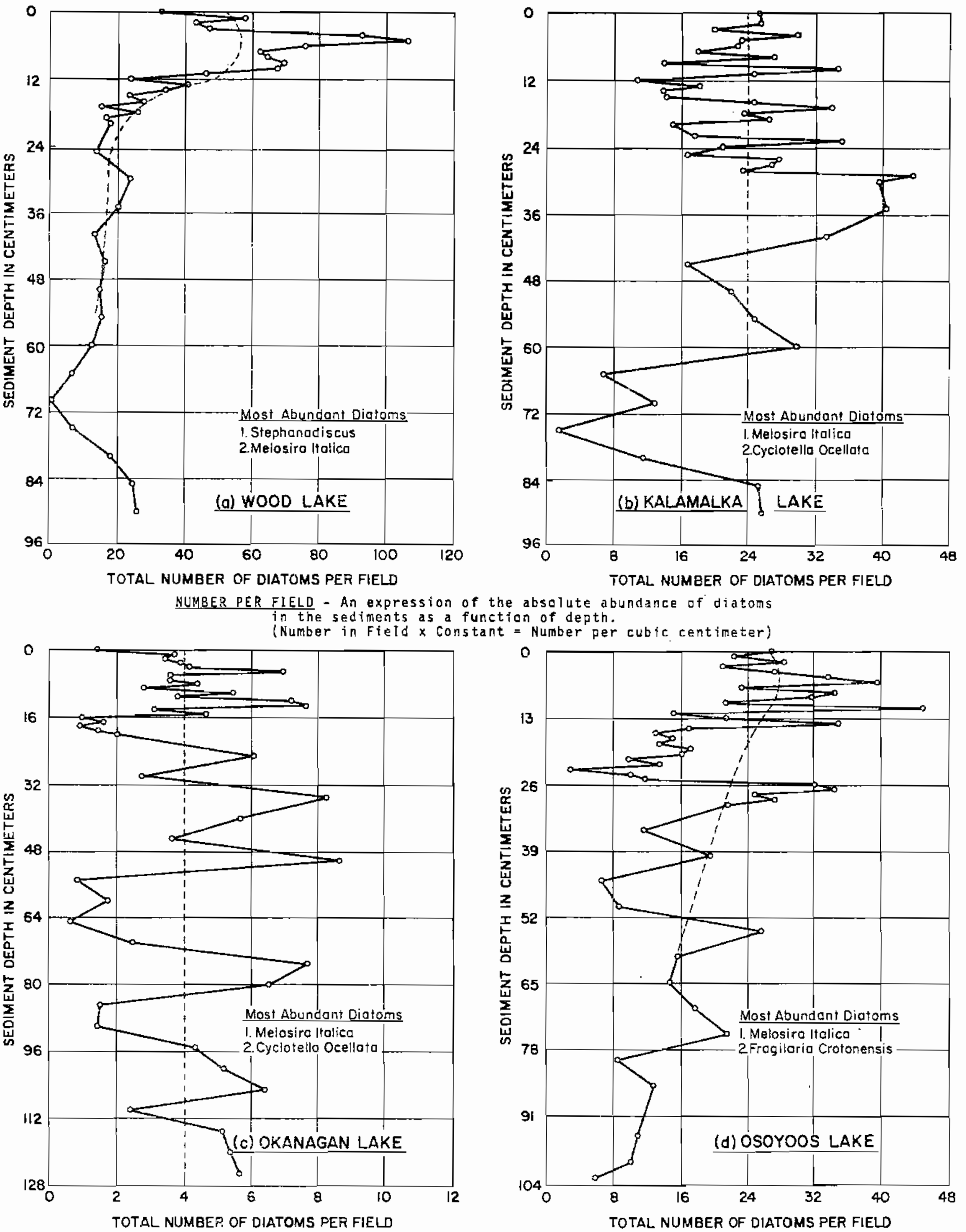
Major findings of these studies are presented in this chapter. Some of the key findings are also presented on drawings M3 to M10 in the Map Section at the back of this report. The effect of future economic growth on the quality of the lakes is discussed in Chapter 15.

6.1 GEOLOGICAL RESULTS

6.1.1 Historical Changes in Biological Growth (Paleolimnology)

Analysis of carbon content and diatom microfossils for sediment and core samples of the main valley lakes indicate that an increased rate of biological production commenced about 100 years ago in Osoyoos Lake and Okanagan Lake. This corresponds to the first major settlements in the valley and the development of land around these lakes for agricultural purposes, particularly beef cattle and horses. This activity is considered to have remained the dominant factor affecting lake productivity until the 1940's when the tree fruit industry became firmly established and orchard cover crops became widespread with the advent of sprinkler irrigation.

In more recent years, the rapid increase in population and resulting waste products, particularly sewage treatment plant and other positive waste discharges to the lake system, have become the dominating factor affecting lake productivity. Skaha Lake, which was not a center for agricultural development has shown a sharp increase in biological production over the past 25 years, with only minor changes before that time. This is considered to be due to urban development in the City of Penticton, and the discharge of it's treated waste effluent into Skaha Lake commencing in 1947. Changes in Kalamalka and Wood Lakes are also of more recent origin. A carbonate cycle in Kalamalka Lake appears to provide a unique self-cleansing system which is considered to have been effective in preventing any noticeable deterioration in the quality of this lake despite nutrient increases. A rapid deterioration in Wood Lake commenced about 40 years ago and is considered due in part to agricultural development in the Wood Lake, Vernon Creek area, and in part to the diversion of water from Vernon Creek upstream at Wood Lake for irrigation purposes. The latter decreased the average inflows to Wood Lake and increased the retention time of water in this lake from approximately 12 years to 30 years. These changes are indicated in profiles of carbon content and diatom abundance from core samples of the sediments of the main valley lakes (carbon content profiles are shown on Maps M2 to M10 at the back of this report, and diatom abundance as a function of depth is shown in Figure 6.1). Diatoms are one of the most ubiquitous forms of microscopic plant life found in freshwater lakes and are



ABUNDANCE OF DIATOMS IN LAKE SEDIMENTS AS A FUNCTION OF DEPTH FOR WOOD, KALAMALKA, OKANAGAN AND OSOYOOS LAKES.

Figure 6.1

generally indicative of oligo-mesotrophic conditions when they are the most abundant species. Other forms of algae such as blue green replace diatoms as the most abundant species in enriched or eutrophic lakes.

The diatom analysis for Wood Lake sediments is the most revealing one in terms of our understanding of the eutrophication of this lake (Figure 6.1a). Above a depth of about 18-20 centimeters, (8 inches) the lake rapidly increases in production to 110 diatoms per field, and then falls again at the sediment surface. The decline of diatoms at the surface is a clear indication of the predominance of blue green algae in recent years at the expense of diatom growth.

Kalamalka Lake (Figure 6.1b) and Okanagan Lake (Figure 6.1c) show a considerable variation in total diatom numbers, but a reasonably constant average of 24 and 4 diatoms per field, respectively. The decline in diatom numbers in Okanagan Lake at a sediment depth of 16 centimeters may be associated with some physical-chemical change in the lake resulting in low nutrient availability.

The number of diatoms in Osoyoos Lake (Figure 6.1d) appear to have increased slowly over a long period of time to a maximum of 44 per field at a sediment depth of 8-12 centimeters. The average number in the surface sediments is about 24 per field, which indicates a decline in diatoms and an increase in blue-green algae in recent years.

6.1.2 Limnogeology of Main Valley Lakes

The Okanagan Valley is a structural trench overlying a system of sub-parallel, linked faults that separate the late Paleozoic or early Mesozoic Monashee groups of metamorphic rocks from the rocks of differing lithology but similar age west of the Valley. This trench is partially filled by several hundred feet of unconsolidated material. The thickness of this unconsolidated material underlying these lakes differs from place to place but typical minimum thicknesses under the centers of the lakes are presented in Table 6.1. The trench is apparently continuous under the Okanagan River between Skaha and Okanagan Lakes as well as under Vernon Creek between Wood and Kalamalka Lakes.

It is likely that the unconsolidated material in the trench was deposited in association with the earlier glaciations of the Pleistocene Epoch. The nature of the deposits is uncertain from seismic records alone, but it seems probable that during the Pleistocene geological period the Valley was the site of deposition resulting from glacial outwash, direct glaciation, and lacustrine fluvial sedimentation. During deglaciation of a number of terraces were formed as the lowering of post-glacial lake levels were repeatedly arrested. A previously undiscovered terrace 50 feet below the present lake level, appears to be a remnant of low stage of Okanagan and Skaha Lakes.

TABLE 6.1

THICKNESS OF UNCONSOLIDATED MATERIAL UNDERLYING MAIN VALLEY LAKES

	THICKNESS IN FEET
Skaha Lake - north of Kaleden	1200
Okanagan Lake - Penticton to Squally Pt.	1500
Okanagan Lake - Squally Pt. to Westbank	1600
Okanagan Lake - Kelowna area	1200
Okanagan Lake - Wilson's Landing-Okanagan Centre	1200
Okanagan Lake - Ok Centre to Vernon	1200-2000
Okanagan Lake - Armstrong Arm	1300 +
Wood Lake	400 +
Kalamalka Lake	300-400

The prominent silt and clay cliffs that border Skaha and southern Okanagan Lake were formed during this period of glacial downwashing and degradation (16). It has been estimated that the deglaciation of the Interior Plateau of B.C. was well advanced by 9,750 B.P. (Before Present) and by 8,900 B.P. all ice was melted and the glacial lakes had been drained (17). From this time to the present day, the main valley lakes of the Okanagan Basin have been in existence. Data from these studies do not allow a direct calculation of total accumulation of recent lake sediment, but if one uses a sedimentation rate of 1 millimeter of compacted sediment per year, this would yield an accumulation of 8.9 meters (29 feet) of sediment in 8,900 years.

Bathymetric charts have been constructed from soundings gathered as part of the geological study (See map section at back of report). Wood Lake is the smallest of the mainstem lakes and consists of a single shallow basin with the maximum depth of 100 feet (34 meters). Kalamalka Lake contains two distinct basins separated by ridge in the unconsolidated material filling the structural trench. The most unusual feature of Kalamalka Lake is the presence of flat terraces of calcium carbonate ($CaCO_3$) in the littoral (near shore) zones that are found chiefly at the southern end of the lake. These terraces are formed by the precipitation of $CaCO_3$ from surface (epilimetic) waters during the summer.

The bottom of Okanagan Lake is characterized by irregular undulations that presumably reflect glacial modifications in the Valley from the last ice age. A large drumlinoid structure exists under 200 feet (61 meters) of water off Squally Point, and an underwater valley 700 feet (213 meters) deep was discovered just north of Trepanier.

Skaha Lake is composed of two distinct basins that are separated by a bedrock sill at a depth of about 80 feet (24 meters). Osoyoos Lake is, in fact, three lakes with sand deposits dividing them. The northern-most of these "lakes" has three distinct basins and attains a maximum depth in excess of 200 feet (61 meters). The central basin (about 100 feet deep) and the southern basin (about 75 feet deep) are hence partially shielded from significant sedimentation by the northern-most basins. This physiographic condition has resulted in greater accumulations of organic carbon and mercury in the sediment samples taken south of Osoyoos.

Approximately 150 surface sediment and core samples from the Okanagan main valley lakes were analyzed to determine particle size distribution. The highest silt content was noted in Wood Lake, while the highest clay content was observed in the deepwater sediments of Okanagan Lake. The sediment of Skaha and Osoyoos Lakes have very similar particle size distributions.

The terraces of Kalamalka Lake contained about 16 percent sand with the remainder essentially silt. Sedimentation rates, and the mean concentrations of carbon and phosphorus in the surficial sediments of the main valley lakes are shown in Table 6.2

Mercury content of the sediments of the Okanagan main valley lakes were determined, and surficial sediments of Wood Lake show the highest mercury content. Most of this mercury occurs as a sulphide and indications are that methylation(chemical process of introducing the methyl groups into) and hence its entry into the food chain, is unlikely to occur. The mercury content of Kalamalka Lake is also relatively high, and presents a potential danger if it enters the food chain. The mercury content in the sediments of most of Okanagan, Skaha and Osoyoos Lakes was considerably lower than values noted in Wood and Kalamalka (Figure 6.2).

6.2 PHYSICAL LIMNOLOGY

The principal physical features of the six main valley lakes are portrayed in Figure 6.3. Wood Lake, considered the most eutrophic of the six lakes, lies at the head of the chain, while Osoyoos Lake at the lower end straddles the International Border. Both Wood and Kalamalka Lakes, in terms of drainage, are part of the Vernon Creek sub-basin, which flows into the Vernon Arm of Okanagan Lake. The watershed of this sub-basin is small and hence most drainage water has had a relatively long residence time in these two lakes - 30 to 65 years respectively (1970 conditions). In 1971 the importation of water from Okanagan Lake to the Vernon Creek Basin, for industrial cooling purposes has significantly increased the flow into Wood and Kalamalka Lakes, lowering these theoretical residence times to 14 years and 45 years respectively. The flow into Okanagan Lake from the Vernon Creek sub-basin represents only about 10% of the total inflow to Okanagan Lake in an average year, so that any effect of this sub-basin on the whole of Okanagan Lake is small.

TABLE 6.2

LIMNOLOGICAL CONDITIONS OF THE MAIN VALLEY LAKES

Recorded from Studies in 1970, 1971 and 1972 *1

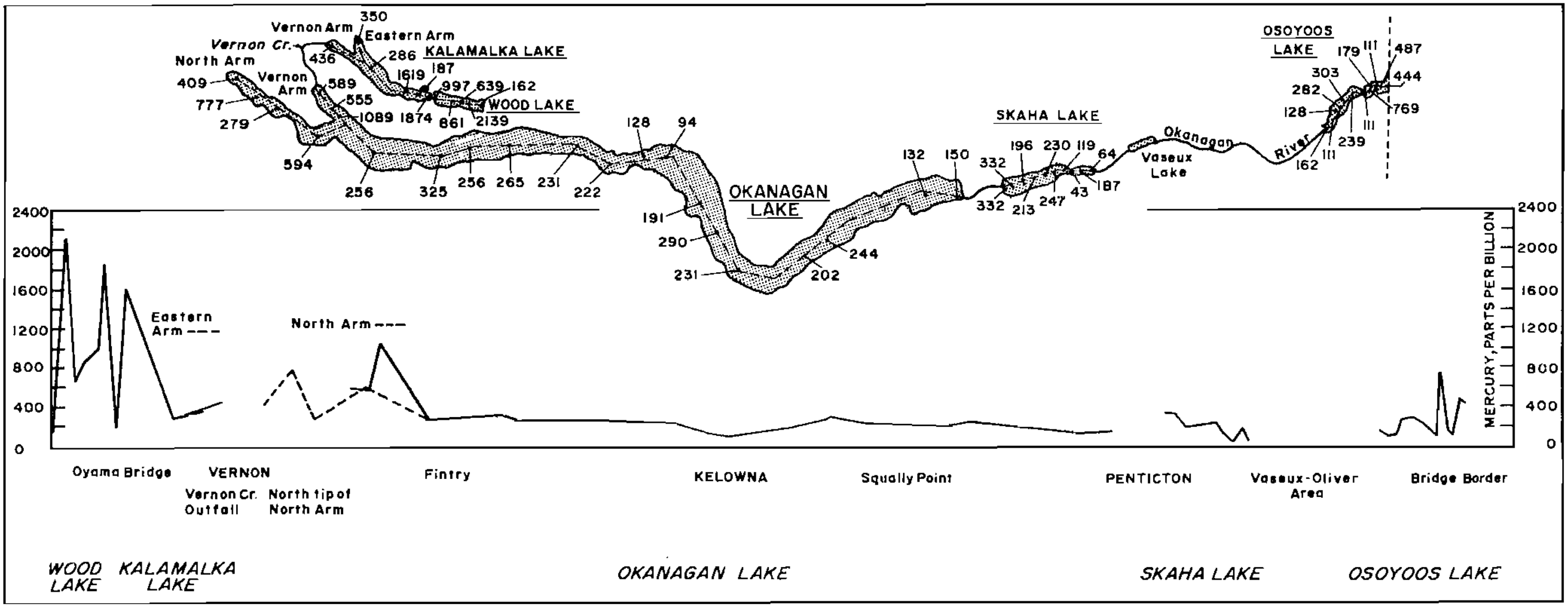
PARAMETER	UNIT OF MEASUREMENT	MAINSTEM LAKES				
		KALAMALKA	OKANAGAN	SKAHA	OSOYOOS *2	WOOD
PHYSICAL						
Secchi Disc Visibility-Seasonal Average *3	feet (ft) and meters (m)	29.5 ft (9 m)	26 ft (8 m)	14.8 ft (4.5 m)	10.8 ft (3.3 m)	8.2 ft (2.5 m)
- 1971 Maximum	feet (ft) and 1971 date	59 ft (Apr 25)	39 ft (Apr 26)	23 ft (Apr 29)	14.7 ft (May 20)	17.2 ft (May 5)
Maximum Summer Surface Temperature	degrees centigrade (C) and Fahrenheit (F)	28°C (82° F)	25.3°C (77° F)	25°C (77° F)	-	27.5°C (81° F)
Hypolimnion Warming Rate	degrees centigrade per month	0.19° C/month	0.06°C/month	0.37°C/month	0.54°C/month	0.26°C/month
Areal Oxygen Depletion Rates	milligrams per sq.cm.per day (mg/1/day)	-	-	0.148	0.038	0.065
Bottom Oxygen Concentrations in Late Summer	parts per million (ppm) with percentage saturation in brackets (% Sat.)	11.3 (89%)	10.7 (78%) Average	8.3 (70%)	4.0 (40%) Central Basin	2.2 (18%)
CHEMICAL						
Average Seasonal Concentration						
- Phosphorus (PO_4-P)	1 milligram per liter = part per million (ppm)	.004	.002	.015	.015	.083
- Nitrogen (NO_3-N)	" "	.023	.020	.010	.016	.026
- Calcium Ca^{++})	" "	37.9	32.9	32.8	34.2	28.8
- Magnesium (Mg^{++})	" "	17.1	8.4	8.4	8.7	17.3
- Sodium (Na^+)	" "	15.9	9.1	9.5	9.9	19.0
- Potassium (K^+)	" "	4.6	2.2	2.1	2.3	4.2
- Bicarbonate (HCO_3^-)	" "	177.3	131.8	129.9	138.1	177.4
- Sulphate (SO_4^{--})	" "	55.7	27.2	27.6	28.5	30.4
- Chloride (Cl^-)	" "	1.3	1.1	1.4	1.6	2.5
- Fluoride (F^-)	" "	0.3	0.2	0.2	0.2	0.3
BIOLOGICAL						
Chlorophyll - Mean Summer	Micrograms per liter (ug/l)	2.5	5.0	31.0	23.0	50.0
Phytoplankton Density, Average Annual *4	number per milliliter (#/ml)	400	1,800	3,740	5,500	7,900
Periphyton Production	milligrams per square meter per day (mg/m^2/day)	124	225	231	258	481
Zooplankton Average Density	number per square centimeter ($\#/cm^2$)	136	101	233	76	139
Bottom Fauna	number per square meter ($\#/m^2$)	1,087	2,178	6,913	5,502	753
Zooplankton Crustaceans	number per square centimeter ($\#/cm^2$)	136	101-188	236-238	76-161	139
Fish Species	number	14	15	15	20	10
Ratio of Coarse Fish to Salmonids	-	1.08:1	1.04:1	2.03:1	1.38:1	7.3 :1
Salmonids	percent (%)	49%	49%	33%	40%	12%
GEOLOGICAL						
Depth to Man's Influence in Sediments	centimeters (cm) and inches (in.)	29 cm (11.5 in)	10 cm (3.9 in)	21 cm (813 in)	28 cm (11 in)	20 cm (719 in)
Rate of Sedimentation	millimeters per year (mm/yr)	2.9	1.0	2.1	2.8	2.0
Carbon Content Surface Sediments-Organic	kilograms (kg)	not estimated	1,750,000	315,000	318,000	98,000
-Inorganic	kilograms (kg)	" "	500,000	71,200	57,700	113,000
Inorganic Phosphorus Accumulation in Surface Sediments	kilograms per year (kg/yr) and pounds per year (lb/hr) based on 1971 data	" "	76,700 kg/yr (170,000 lbs/yr)	11,500 kg/yr (25,300 lbs/yr)	11,800 kg/yr (26,000 lbs/yr)	1,640 kg/yr (3,600 lbs/yr)
CURRENT CONDITION						
Trophic State		Oligotrophic	Oligomesotrophic	Eutrophic	Eutrophic	Eutrophic
Water Quality Based on Present Use		Excellent	Good	Acceptable	Acceptable	poor

*1 - Extracts of Average Lake Conditions Only from Technical Supplement V - See Text

*2 - Portion of Basin in Canada Only

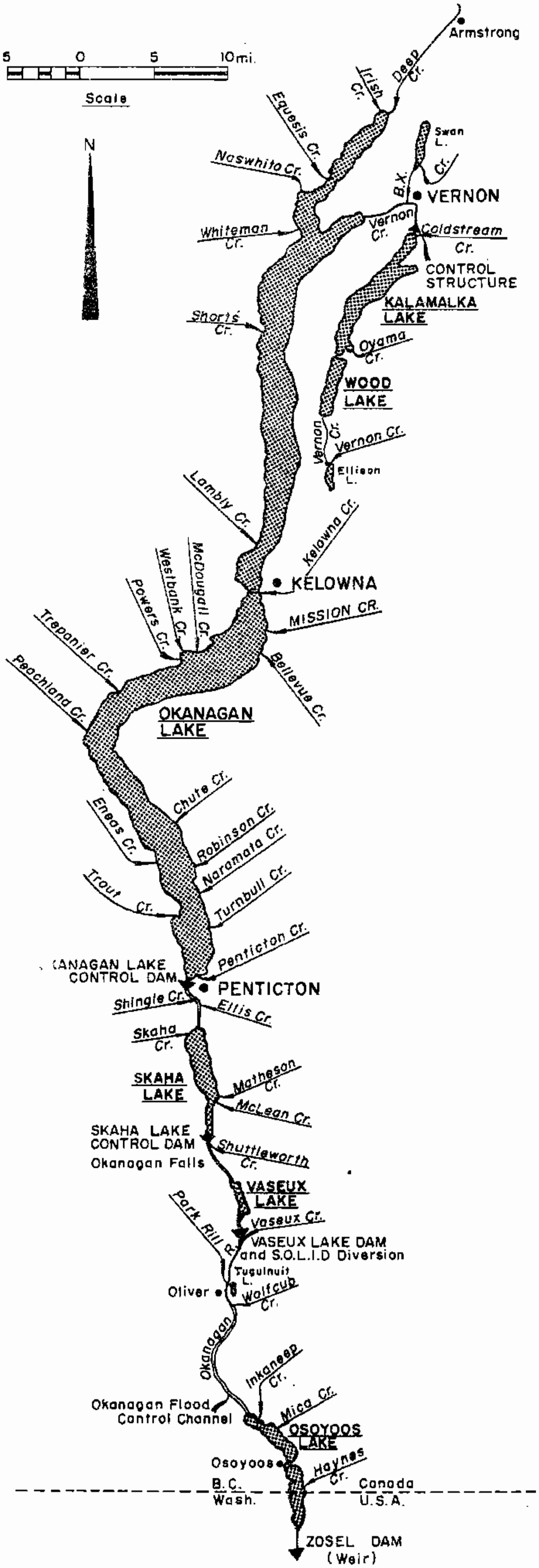
*3 - Monitoring Period Between April and October 1971

*4 - Stein, Coulthard, 1971 (18)



PROFILE OF MERCURY CONTENT OF SEDIMENTS IN THE OKANAGAN LAKES SYSTEM ALONG THE DEEPEST PART OF EACH LAKE. MERCURY IN PARTS PER BILLION.

Figure 6.2



WOOD LAKE	
Surface Water Level - High	1284.0*2
- Low	1282.6*2
Surface Area - Acres	2300
Mean Depth - Feet	72
Maximum Depth - Feet	112
Total Volume - Acre Feet	162,200
Mean Annual Outflow-Acre Feet	14,000 *1
Water Residence or Renewal Time - Years	14 *1

KALAMALKA LAKE	
Surface Water Level - High	1284.0
- Low	1282.6
Useable Storage - Acre Feet	13,100
Surface Area - Acres	6,400
Mean Depth - Feet	193
Maximum Depth - Feet	465
Total Volume - Acre Feet	1,233,000
Mean Annual Outflow - Acre Feet	33,000 *1
Water Residence or Renewal Time - Years	45 *1

OKANAGAN LAKE	
Surface Water Level - High	1123.8
- Low	1119.8
Useable Storage - Acre Feet	337,000
Surface Area - Acres	86,000
Mean Depth - Feet	250
Maximum Depth - Feet	800
Total Volume - Acre Feet	21,250,000
Mean Annual Outflow-Acre Feet	356,000
Water Residence or Renewal Time - Years	60

SKAHA LAKE	
Surface Water Level - High	1108*3
- Low	1106*3
Surface Area - Acres	4,970
Mean Depth - Feet	85
Maximum Depth - Feet	187
Total Volume - Acre Feet	453,000
Mean Annual Outflow-Acre Feet	385,000
Water Residence or Renewal Time - Years	1.2

VASEUX LAKE	
Surface Water Level-Normal-Feet	1073*3
Surface Area - Acres	680
Mean Depth - Feet	21
Maximum Depth - Feet	83
Total Volume - Acre Feet	14,300
Mean Annual Outflow-Acre Feet	429,000
Water Residence or Renewal Time - Years	.03

OSOYOOS LAKE (including portion in U.S.A.)	
Surface Water Level-Normal-Feet	913*3
Surface Area - Acres	5,800
Mean Depth - Feet	49
Maximum Depth - Feet	206
Total Volume - Acre Feet	323,000
Mean Annual Outflow-Acre Feet	479,000
Water Residence or Renewal Time	0.7

*1 Values based on theoretical estimates of average flows in Vernon Creek (Technical Supplement 1) plus effect of cooling water pumped from Okanagan to Hiram Walker Plant and discharged to Vernon Creek (18.5 acft/day)

*2 Includes Surface Storage from Wood Lake

*3 Water Levels not Controlled for Storage

THE MAIN VALLEY LAKES and THEIR PHYSICAL FEATURES Figure 6.3

Okanagan Lake is by far the largest of the main valley lakes in both volume and surface area, and receives the drainage waters from over 75 percent of the watershed of the Basin. While the residence time of this drainage water in Okanagan Lake is approximately 60 years, this water has retained a very high quality with the exception of shoreline areas affected by local waste sources. This lake is also the key with respect to quality in the downstream lakes - Skaha, Vaseux and Osoyoos, because nearly all the water flowing into these lakes is from discharges from Okanagan Lake. Both Skaha and Osoyoos have much smaller volumes and residence times of one year or less. Vaseux Lake is considered more an enlargement of the Okanagan River Channel with a residence time of only a few days.

The residence time of water in a lake has important consequences in terms of water resource management. Large lakes with long resident times (small inflows) will generally take longer to deteriorate because of their size and limited natural stream loadings. However, once they have regressed to a state of poor quality, it will take many years for them to recover, even under rigorous waste control programs. Alternatively, lakes with a short residence time will reflect changes much more quickly, providing the drainage water entering the lake is of a high quality itself. It is therefore important, if not essential, that the quality of Okanagan Lake be maintained in as good a condition as possible, not only to maintain the present value of this lake itself, but also to ensure a reasonable quality of water in the lower lakes - Skaha, Vaseux and Osoyoos. Kalamalka Lake is also in the same category as Okanagan Lake, but it does not have the same effect on the downstream system.

The results of other physical observations are shown in Table 6.2 including water transparency, temperature and heat budgets.

6.3 WATER CHEMISTRY RESULTS

The relative abundance of major ions in a lake is a reflection of natural lake processes modified by the addition of soluble elements and compounds from the watershed. The distribution of ions within a given lake or among lakes is a result of biological activity, surface runoff, groundwater, precipitation and most importantly, the lake sediment-water interaction.

The relative abundance of major ions within each of the main valley lakes was similar to the average of the world's freshwater lakes. Major ions include bicarbonate, calcium, sodium, potassium, magnesium, sulphate, and cloride. Concentrations of major ions in the main valley lakes (1970-71) varied from lake-to-lake but showed little seasonal variation (Table 6.2).

The concentrations of major ions in the lakes of the Okanagan Drainage basin are quite high, an order of magnitude higher than lakes on the Canadian Shield (19), and higher than the world average for fresh water (20). These concentrations normally come from soluble geological materials in the watershed, including limestone, glacial drift, clay-silt terraces and conglomerate rock or basaltic areas, but within the Okanagan Basin, evaporation may also be an important reason for the high concentrations found.

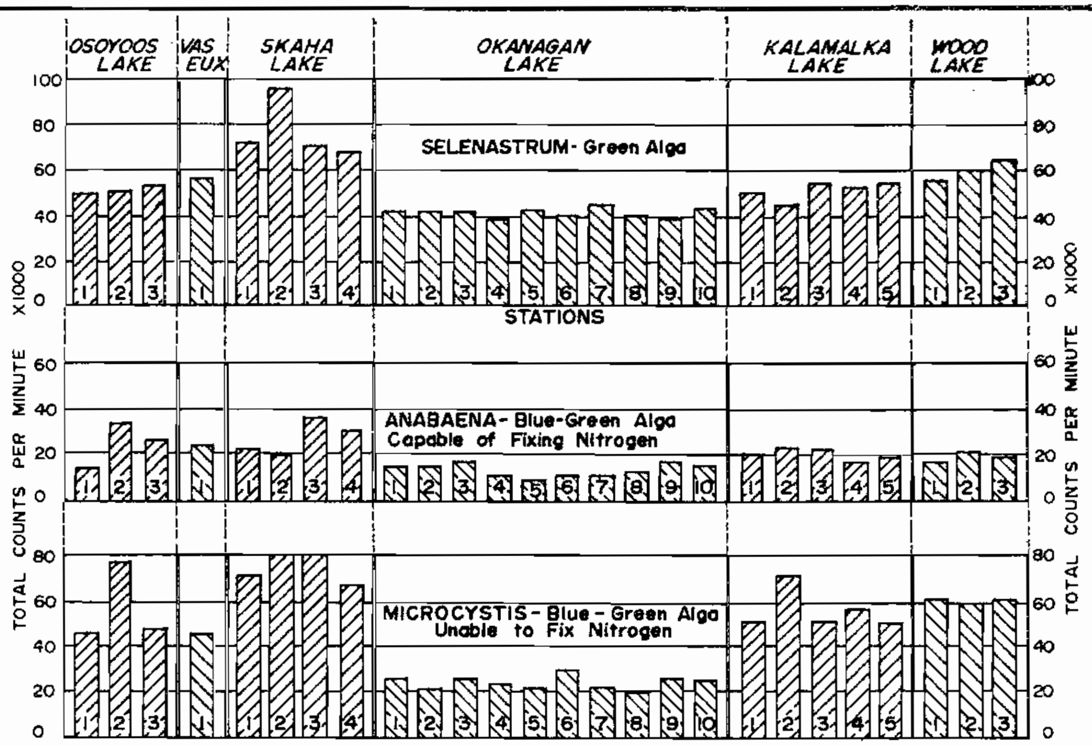
The main valley lakes also exhibit seasonal, and lake-to-lake variation in average nutrient (nitrogen and phosphorus) content. The seasonal variations generally correspond to observed increases in algal biomass. The relative fertility of water from various sampling points in each of the lakes is shown in Figure 6.4a for the three different species of test algae. Skaha Lake appears to possess by far the most suitable conditions for algal growth, while Okanagan Lake has the least potential of the main valley lakes. Of more interest however, is the growth potential of Kalamalka Lake waters under laboratory conditions. The fact that such growth has not occurred under natural conditions support the premise that the quality of Kalamalka Lake has been preserved through its important calcium carbonate cycle. Each summer calcium carbonate is actively precipitated from the surface waters which accumulate on terraces around the shores of the lake. It is likely that the calcium carbonate also co-precipitates an abundance of the trace elements in the lake, including phosphorus, as hydroxyapatite.

There are also indications from sediment studies, that the waters of Skaha Lake may be actively precipitating phosphorus as an apatite at the present time (1971). It is possible therefore that this lake could clean itself of biologically reactive phosphorus if inputs of this element were significantly reduced.

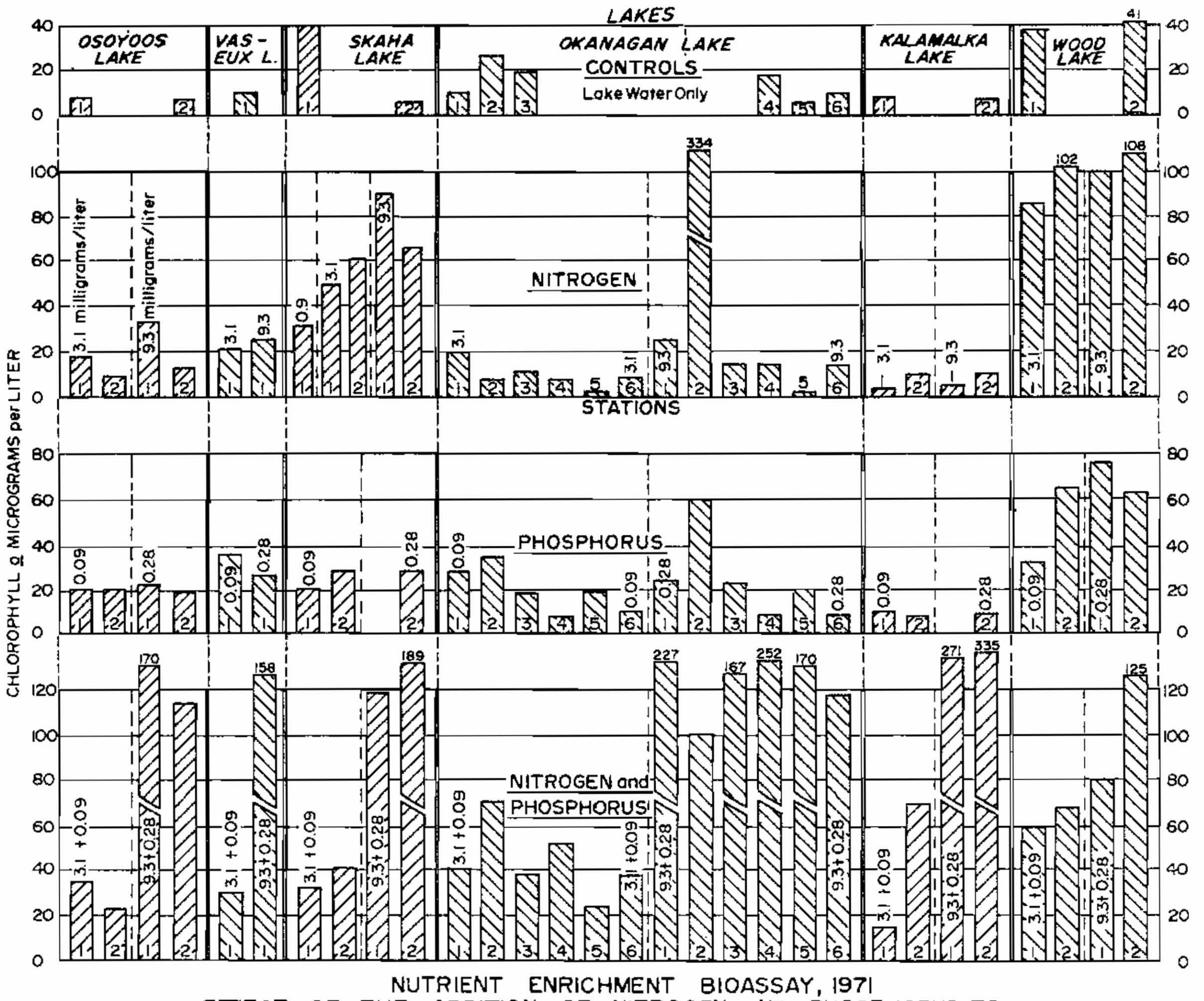
Mean oxygen concentrations in the epilimnion and hypolimnion vary considerably among the main valley lakes. Oxygen concentrations in the epilimnion of all lakes was near saturation throughout the summer season; however, values for the hypolimnion of Osoyoos, Wood and Skaha Lakes were well below saturation levels. Calculation of the areal rate of oxygen depletion (rate per unit of area) of hypolimnetic water during summer stratification provided an estimate of annual biological production for comparison among lakes. Skaha Lake exhibited the most rapid hypolimnetic depletion rate, followed by Wood and Osoyoos Lakes, respectively (Table 6.2). There has been little change in oxygen concentrations in Okanagan Lake since Clemens et al (15) measurements in 1935; however Skaha Lake has exhibited an increase in its oxygen deficit in the bottom waters over the past 25 years. Ferguson (21) in July 1948 recorded an 85% oxygen saturation in the hypolimnion of Skaha Lake, while the current survey showed only 70% saturation. The low oxygen content of the hypolimetic water of Wood Lake has not changed appreciably from values noted by Clemens et al (15) in 1935. Osoyoos Lake has also exhibited low hypolimnetic oxygen values, especially in the central Basin.

6.4 BIOLOGICAL STUDIES

The types and dominance of various forms of plant and animal populations and communities living within the lakes provide a good indication of (a) the present



PURE CULTURE BIOASSAY
RELATIVE FERTILITY of VARIOUS LAKE WATERS to GROW ALGAE in 1971.
Figure 6.4 a



NUTRIENT ENRICHMENT BIOASSAY, 1971
EFFECT OF THE ADDITION OF NITROGEN AND PHOSPHORUS TO VARIOUS LAKE WATER SAMPLES ON CHLOROPHYLL CONTENT. Figure 6.4 b

trophic state of a lake, and (b) changes that have occurred due to enrichment by comparison with previous biological records. The results of biological studies under the Okanagan Basin Agreement are summarized below under the sub-headings of phytoplankton, attached algae and rooted aquatic vegetation, bottom fauna, zooplankton and fish. Each of these communities represent different populations and trophic (food) levels in the environment of a lake, and therefore provide a more detailed assessment of the extent to which eutrophication has occurred in a particular lake. A laboratory nutrient bioassay study was also carried out, which was designed to test the role of nutrients in regulating algal growth.

6.4.1 Role of Nutrients in Biological Production

Photosynthetic plants require light a number of elements for their maintenance and reproduction. The more important requirements are carbon (C), hydrogen (H), oxygen (O), and nitrogen (N), since these elements make up the predominant mass of cellular substance. Of most interest however, are those essential elements that limit plant (algal) growth when in short supply. Past studies indicate overwhelmingly that phosphorus (P) and nitrogen (N)are of particular importance in lakes. Of these P is considered to be the more easily controlled element especially in north temperate lakes, for the following reasons:

(i) The element nitrogen accounts for approximately 75% of our atmosphere by weight, whereas the element phosphorus is a trace element accounting for less than .1% of the earths crustal composition. The control of the element nitrogen is therefore more difficult than the control of trace elements such as phosphorus.

(ii) Certain bacteria and algae are capable of obtaining their nitrogen requirements directly from the atmosphere by the process of nitrogen fixation. Limiting nitrogen therefore would not control such growth and these algae are one of the main types producing nuisance blooms in the Okanagan system.

(iii) Nitrogen is considered a transient element which travels readily through a soil column to groundwater and eventually to surface waters. Conversely, phosphorus is readily bonded into a soil column and leaching or movement of this element occurs only when the amount of phosphorus exceeds the bonding capability of the soil. This difference is evidenced by the fact that most soils in the Okanagan contain adequate phosphorus concentration for plant growth, while nitrogen must be continually added as a fertilizer to ensure normal crop production.

(iv) Invasion of atmospheric nitrogen is constantly occurring in lakes at the air-water interface.

While the control of phosphorus is currently considered to be the most feasible method of regulating biological production in a lake, other elements and compounds may still cause specific problems if their amounts exceed certain safe levels. Both mercury and the pesticide DDT are two materials that have adversely affected the environment of certain Okanagan Lakes. Mercury levels in fish, particularly trout, have reached levels in Kalamalka Lake and Okanagan Lake which are affecting the reproductive capability of this species. High DDT levels have apparently been detrimental to certain animal communities within Kalamalka and Okanagan lakes, while allowing other less desirable species to flourish. The specific effects of all elements must therefore be considered in accessing the condition of a lake, along with the overall biological production that the control of phosphorus may provide.

6.4.2 Phosphorus Forms and Budgets

Phosphorus compounds in water are normally classified on the basis of separation techniques. Data reported in these limnological investigations are in terms of "orthophosphates" (PO_4) and "total phosphorus" (TP). Total phosphorus is a measure of all the phosphorus in the water whether in a soluble form or contained in plant an animal cellular matter or inert particulate matter (insoluble). Orthophosphorus is that portion of total phosphorus which is in a soluble form and immediately available to plant life for synthesis (Table 6.3). While it would have

TABLE 6.3

FORMS OF PHOSPHORUS PRESENT IN SURFACE AND WASTEWATERS

DISSOLVED PHOSPHORUS		PHOSPHORUS IN SUSPENSION	
Ortho-phosphate (PO_4)	As organic colloids and/or combined with an adsorptive colloid.	As mineral particles (e.g. apatite) and/or adsorbed on inorganic complexes such as Fe (OH_3)	Organisms Adsorbed on detritus and/or present in organic compounds.
Dissolved Inorganic Phosphorus			
Total Phosphorus in Filtrate			
TOTAL Phosphorus Content of Unfiltered Water			

been desirable to use orthophosphorus to establish criteria for acceptable lake loadings, this was not possible because of the following factors:

(i) In lakes orthophosphorus is in a perpetual state of flux, with release and uptake occurring in minutes, hence it is difficult to know what percentage of the available orthophosphorus one is measuring at any given time.

(ii) The concentrations of phosphorus required for optimum growth vary with species and environmental conditions. In lakes optimum growth may occur at levels below 0.01 milligrams per liter. This figure corresponds closely to the limit of available analytical procedures used in this study to measure phosphorus. In most instances, values of orthophosphorus in the lakes and streams discharging into the Okanagan Lakes were below this level of sensitivity.

Total phosphorus has therefore been used as an indicator of the biological productivity of each lake, and has been used to establish loading criteria which may achieve, within limits, an optimum level of biological production for multiple water use.

Already in some of the lakes there is an overabundance of phosphorus, and othe nutrients such as nitrogen are actually limiting biological production. In these cases however, phosphorus still is considered the key element and measures must be taken to reduce the supply of phosphorus to these lakes to levels where it again exerts a controlling influence on plant (algal) growth.

6.4.3 Nutrient Bioassy

To obtain a better understanding of the role of nutrients and trace metals in regulating algal growth in the main valley lakes, laboratory studies were designed to test the effect of additions of varying amounts of nitrogen and phosphorus to lake waters under controlled conditions. The results of nutrient studies are given in Figure 6.4b. The greatest growth of algae was observed in flasks receiving moderate additions of both nitrogen and phosphorus - .09 milligrams per liter of orthophosphate and 2.10 milligrams per liter of nitrate. Lower additions, though stimulatory, were well below the optimum level of growth in flasks, as was the addition of only one of these nutrients.

The above studies indicate most lakes are still well below their optimum production level, that both nitrogen and phosphorus are required before increased productivity can occur, and that the control of phosphorus input to the lake system should control biological growth.

In the more eutrophic lakes (Wood and parts of Skaha and Osoyoos) nitrogen additions alone stimulated growth while phosphorus did not. This indicates that phosphorus levels in these lakes is sufficiently high to maintain optimal growth, however nitrogen is in short supply and as such limits growth.

Preliminary tests were also carried out on the effect of four trace metals on algal growth. These four were considered the more important elements other than nitrogen and phosphorus in regulating growth. Additions of boron provided little or no response even when added in combination with phosphorus and nitrogen to the lake waters. The addition of molybdenum increased the growth of algae in Osoyoos and Wood Lake waters but not for Okanagan and Skaha Lake water. Molybdenum is required for nitrogen fixation by algae. The greatest response in all lakes occurred with the additions of EDTA (organic chelating agent) and iron. Osoyoos Lake water in particular responded to the addition of iron and indicates an iron deficiency in this lake. Iron plays a key role in the synthesis of chlorophyll and in some enzymatic reactions and if deficient, may limit algal growth. EDTA additions, separately and in combination with nutrient additions stimulated growth, particularly when added in combination with iron. These trace metal tests were limited in scope, but indicate a secondary role in the control of algae growth to that of phosphorus and nitrogen, as none of the trace metals by themselves stimulated growth of any significance.

.4.4 Phytoplankton

Those lakes dominated by blue green algae throughout most of the summer months e.g. Wood Lake - exhibited eutrophic characteristics (high biological production). Lakes in which diatoms and phyto-flagellates were the most abundant groups - e.g. Okanagan and Kalamalka Lakes - were generally oligotrophic or had a low biological production. In Skaha and Osoyoos Lakes there was normally a rapid growth of diatom in the spring followed by a pulse of blue green algae whose density appeared to a large extent dependent upon the initial concentration of available phosphorus. There was a return to diatoms in the fall period. The productivity of these lakes therefore falls somewhere between the eutrophic and oligotrophic state, with the extent of productivity closely related to the amount of available phosphorus in any one year.

5.4.5 Attached and Rooted Aquatic Vegetation

A marked increase has occurred in the abundance of rooted aquatic plants and attached microalgae (periphyton) along the shorelines of most of the main valley lakes where high biological production is caused by local sources of pollution.

Areas currently exhibiting extensive rooted aquatic plants, where harvesting has either been carried out or has been proposed, are: Vernon Arm and Kelowna shoreline south of the floating bridge on Okanagan Lake; south end of Wood Lake, patches along the east shore of Skaha Lake, Vaseux Lake, and along the west shore north and middle basin of Osoyoos Lake.

Results of periphyton studies indicate that on the average, Wood Lake produces the greatest yield of periphyton per square meter of littoral zone, and the Vernon Arm of Okanagan Lake produces the second highest yield. Growth of periphyton at both stations in Vaseux Lake and off the mouth of the Okanagan River in Skaha Lake and in Osoyoos Lake was also high. The average periphyton growth at other lake stations was substantially less, with values varying from 0.3 to 0.8 milligrams per square centimeter.

The heavy periphyton growth noted in Wood, Skaha, Vaseux and Osoyoos Lakes, was in most cases at stations located either in the vicinity of direct known sewage effluent discharges or very close to the plume of the Okanagan River. The lowest average yield of periphyton was noted in Kalamalka Lake and Okanagan Lake. Low growth was also noted along the east shore of Skaha Lake, probably due to a paucity of nutrients along this shoreline as the main flow of the Okanagan River is directed to the western shoreline by a small training dyke. The situation noted in Skaha Lake, where one sampling station exhibited high growth and others very low growth, is similar to that noted in Okanagan Lake where most stations showed very low growth while those in more eutrophic situations, located adjacent to the Kelowna and Vernon Arm areas, showed much higher growth.

The maximum growth rate of periphyton occurred in May or early June and consisted chiefly of diatoms. A second smaller pulse dominated by green or blue green algae occurred in late August, with a return to diatoms as the dominant species in the fall. Results of tests made to relate the concentrations of nitrogen and phosphorus contained in the attached algae cells to available external supplies, indicated that the ratio of nitrogen to phosphorus was 5 to 1 for periphyton growing in eutrophic waters compared to 14 to 1 in more oligotrophic waters. Highest phosphorus values were noted in the spring samples in eutrophic locations, while nitrogen concentrations in the attached algae cells tended to be higher in late summer and early fall in all lakes.

Periphyton communities play a very important role in the nutrient balance of lakes by trapping considerable quantities of nutrients as they enter a lake. The littoral zone with its diverse biological communities also affords protection and periphyton and associated aquatic insects serve as a valuable food source for juvenile fish. In other areas, shore spawning kokanee utilize the rocky shorelines of Okanagan Lake. Any nuisance growth of attached algae in these locations, resulting from man-made nutrient inputs, would jeopardize the reproductive success of these fish.

Bottom Fauna (Bottom Living Invertebrate Animals)

For several decades limnologists have studied the relation between density and species composition of invertebrates living in the bottom sediments of lakes. Because bottom fauna tend to be sedentary organisms, they integrate temporal and environmental change and as such serve as sensitive barometers of lake change.

A comparison of 1971 data with that obtained by Clemens et al (15) in 1935 indicates that Okanagan Lake has become more productive over the past 35 years. Clemens et al found only 15% of the bottom fauna comprised of oligochaetes, whereas currently they comprise over 50-60% of the fauna. There has also been a significant increase in the total number of chironomids, *Pisidium*, and other miscellaneous groups. The increase in abundance of oligochaetes together with the occurrence of deformed chironomids in certain regions of Okanagan Lake, is suggestive of some degree of insecticide pollution.

The current trophic conditions as deduced by distribution of benthic organisms indicates that the northern region (Vernon and Armstrong Arms) is currently mesotrophic. Evidence of pollution of the Vernon Arm by the Vernon Sewage Treatment Plant effluent was obtained in a series of samples taken from the mouth of Vernon Creek west to the vicinity of Okanagan Landing. The character of the fauna changed from one dominated by oligochaetes - Limnodrilus hoffmeisterii (eutrophic) to more mesotrophic indicators in the station just adjacent to Okanagan Landing. The mid-portion of the north basin between Okanagan Landing and Kelowna showed little change from the condition observed by Clemens et al (15) nearly 40 years ago, and can still be considered oligotrophic. Six stations in Okanagan Lake were located in the vicinity of the pipe which discharges sewage from the City of Kelowna to Okanagan Lake. One station, located very close to the pipe, contained no organisms, but in stations further removed from the pipe, there was a tremendously large number of organisms of the oligotrophic type. The area near the boat landing in Summerland also indicated a source of pollution at this location, but adjacent to Penticton the deeper waters were typically oligotrophic in faunal composition. While the bottom fauna in the littoral zone of Okanagan Lake has shown considerable change since the investigation over 38 years ago (15), the fauna in the deep water sediments have not been affected to the same extent, and the lake as a whole must still be classified as oligotrophic in terms of the distribution and abundance of benthic organisms.

The bottom fauna in Skaha Lake are complicated by the presence of both oligotrophic and eutrophic indicator species. This type of distribution of benthic fauna is not unusual for formerly oligotrophic lakes which are rapidly changed to the eutrophic state by the sudden introduction of nutrients. The unusual occurrence of oligotrophic forms may be explained by the short residence time of water in this lake, with the possibility of continuous re-colonization from outflow water from Okanagan Lake. This, in combination with relatively good oxygen levels in the hypolimnion, may account for the strange faunal distributions noted in Skaha. There was also a predominance of oligochaetes in Skaha Lake. Over 9,000 invertebrates per square meter were noted in 1971, which was the highest density recorded for all lakes sampled. In 1969 the density was 3,892 per square meter which was second only to Osoyoos Lake. Of six chironomid species found, very few were indicative of eutrophic conditions.

The north and central basins of Osoyoos Lake are, according to the composition of the bottom fauna, moderately eutrophic and strongly eutrophic, respectively. The central basin appears to have been enriched by wastes discharged from the surrounding communities. The northern basin is divided into two basins with a pronounced underwater ridge between the two northern sub-basins. The average number of bottom fauna per square meter of sediment surface in Osoyoos Lake was the highest recorded in the main valley lake system in 1969.

In 1935 Clemens et al (15) found Kalamalka Lake to be a typical oligotrophic lake, slightly richer than Okanagan Lake. He also noted that chironomids made up over 95% of the benthic fauna in the lake, while studies in 1971 showed that chironomids made up only 55% of the fauna. Thus, a significant shift in the faunal composition has taken place over the past 35 years. The abundance of organisms per square meter seems to be of the same order of magnitude as those found in 1935. One station, situated near the mouth of Coldstream Creek in the northern part of Kalamalka Lake, showed some degree of mild pollution. This finding correlates well with observations of nuisance weed growth off the mouth of Coldstream Creek in 1971-72. Kalamalka Lake, on the basis of the distribution and abundance of benthic invertebrates, remains a typical oligotrophic lake, relatively rich in calcium. The changes that have occurred in Kalamalka Lake since Clemens et al (15) investigations in 1935, are of much smaller magnitude than those found in Okanagan Lake.

In 1935, Clemens et al (15) found that the benthic fauna of Wood Lake was characteristic of that of a eutrophic lake with very high densities of oligochaetes and chironomids. He noted that in all samples he collected there were always more than 1,000 oligochaetes per square meter, and at a depth of 23 meters he found as many as 23,000 per square meter. Today, the lake has very few organisms in the sediment. In most areas no oligochaetes occur at all, and only a few species of Chironomus attenuatus were found. Two stations located near the outlet are obviously influenced by water from Kalamalka Lake but nevertheless have fauna typical of a eutrophic lake. Even at these stations the number of oligochaetes was very much less than 1,000 per square meter. The current limnological condition of Wood Lake does not alone explain the disappearance of what was undoubtedly a formerly rich fauna. The rate and duration of oxygen depletion is not so high as to explain the apparent paucity of invertebrates in Wood Lake. One possible explanation is the existence of some yet unidentified toxic compound in the sediments.

6.4.7 Zooplankton

Studies of zooplankton populations in Okanagan Lake indicate that little change has occurred in the species composition of crustacean plankton since 1935. The only significant difference involves zooplankton abundance. The average density of settled plankton from eleven vertical hauls taken by Clemens et al (15) between July and August 1935 in southern, central and northern regions of Okanagan Lake was 2.8 cubic millimeters per square centimeter. Samples taken in September, 1969 and in August 1971,using a comparable net showed an average density of 13.3 and 7.8 cubic millimeters per square centimeter, respectively, or approximately 4.8 and 2.8 times more zooplankton now than were present in 1935. Even assuming some sampling error or incompatability of methods, these values do indicate that there has been an increase in abundance of zooplankton in Okanagan Lake since 1935 (15). As noted previously, this increase in the density of zooplankton is paralleled by an 8-fold increase in the total abundance of bottom organisms between 1935 and 1969.

It is of interest to compare the number of crustacean zooplankton in the Okanagan Lakes to those of several Laurentian Great Lakes. Lakes of the Okanagan Valley appear richer in plankton than Lake Superior, but certainly poorer than Lake Erie and Ontario. Figures for Skaha, Osoyoos and Wood Lakes can be interpreted as being quite high if one bears in mind that the very high flushing rate of Skaha and Osoyoos does not favour the accumulation of plankton produced in the lake. In addition, very low oxygen concentrations in the hypolimnion of Osoyoos and Wood Lakes restrict the inhabitable layer to approximately the upper 20 meters as compared to 50 meters in the remaining Okanagan Lakes.

8 Fish

Fish serve as convenient summators both temporally and spatially, of the more general effects of eutrophication in lakes. It has been known for some time that fishes respond to changes in the trophic nature of lakes, but their use as indicators of eutrophication has only recently been developed.

A total of 26 species of fish were taken during the 1971 sampling program on the Okanagan Basin Lakes. Nine of the twenty-six species were caught in all lakes sampled. These nine include mountain whitefish, rainbow trout, kokanee, largescale sucker, carp, squawfish, peamouth chub, chiselmouth, and prickly sculpin. Representatives of the catfish, perch, bass and sunfish families were confined to Vaseux and Osoyoos Lakes, with the exception of the pumpkinseed, which was found in Skaha Lake as well.

There were marked differences among lakes in the total number of fish netted. The lowest catch was from Wood Lake, while catches in Skaha and Vaseux Lakes were almost double those from the other lake sampling points.

The seasonal distribution showed some variation in catch with summer catches tending to be much lower than those in either the spring or autumn. In some cases, notably from central Okanagan stations, autumn catches far exceeded those in spring and summer combined (chiefly because of the domination of mature kokanee in the catch).

A comparison of the relative abundance of salmonids (trout and kokanee) to coarse fish, showed the highest percentage of salmonids in Okanagan and Kalamalka Lakes, while the greatest abundance of coarse fish came from Sakaha, Vaseux and Osoyoos Lakes. This trend applied to catches during each of the three seasons, even when considered separately.

A comparison of 1971 results with those of Ferguson (21) in 1948 for Skaha Lake show the combined catch and the number of salmonids and whitefish to be lower in 1971 than they were in 1948, although several were caught by lake netting in 1971.

The data of Clemens et al (15) indicates marked differences in the relative abundance of fish in Wood Lake between 1935 and 1971. No carp were netted in the summer of 1935, (although they were in the lake) but 12 were caught in 1971. The contribution of salmonids to the total catch in each of the years sampled was small, but about the same.

Comparisons of the relative abundance of fish in Okanagan Lake between 1935 and 1971 showed little difference in total catch (combined stations) between the two years. No carp were netted in any of the stations in 1935, whereas single summer sets in 1971 took carp at three of the four sampling stations. Apparently the change in the trophic structure of the lake since 1935 has not yet affected the fish population. This is to some extent borne out by the fact that many of the eutrophication problems of Okanagan Lake are localized, affecting mostly shoreline areas.

Rainbow trout from Kalamalka Lake were significantly smaller than those from Okanagan Lake, but not significantly smaller than those from Skaha or Osoyoos. Kokanee from Wood and Kalamalka Lakes were significantly smaller than those from the other lakes with the exception of Osoyoos. Kokanee from Skaha were the largest in the system. The average length of whitefish generally increased toward the south. Those from Skaha Lake were significantly larger than any other.

It is informative to compare length estimates of several species from Skaha Lake between 1948 and 1971. Although few kokanee were netted in 1948, even the largest of these did not attain the average length of those netted in 1971. Lake whitefish were also much larger in 1971, as were the large-scale suckers. It should be kept in mind that the sewage treatment plant at Penticton did not commence operation until 1948. Hence, eutrophication cannot be considered to be prevalent in this lake at the time of the 1948 sampling. The increase in average size of these species between 1948 and 1971 is likely a real indication of the effects of lake enrichment from nutrients in the treated sewage effluent being discharged into this lake.

Although present fisheries data do not indicate a significant shift in species composition, the high growth rate of fish in Skaha Lake, particularly kokanee, indicates a rapid increase in the biological productivity of this lake since 1948. Conversely, the decline in the fishery in Wood Lake, along with other biological indicators, suggest that it has reached this condition after passing through a more eutrophic stage, and fish productivity has been limited by undesirable habitat rather than food, e.g. low oxygen in the lower cooler waters, and excessively high temperatures in the upper waters.

6.5 RELATIONSHIP OF NUTRIENT LOAOINGS TO TROPHIC LEVELS

A separate set of tasks under the Okanagan Basin Study involved the monitoring of significant sources of pollutants to the main valley lakes. These studies are discussed in more detail in Chapter 5. The main objectives of these studies were (1) to identify the major sources of various elements including nitrogen and phosphorus, to the main valley lakes, particularly those sources which are controllable, and (2) to provide a b se for projecting future loadings to the system under various economic growth projections and to assess the probable effect of these increased loadings on the lakes. The known sources and their contribution for the two year monitoring peri 1969 to 1971 are shown in Table 5.15, Chapter 5.

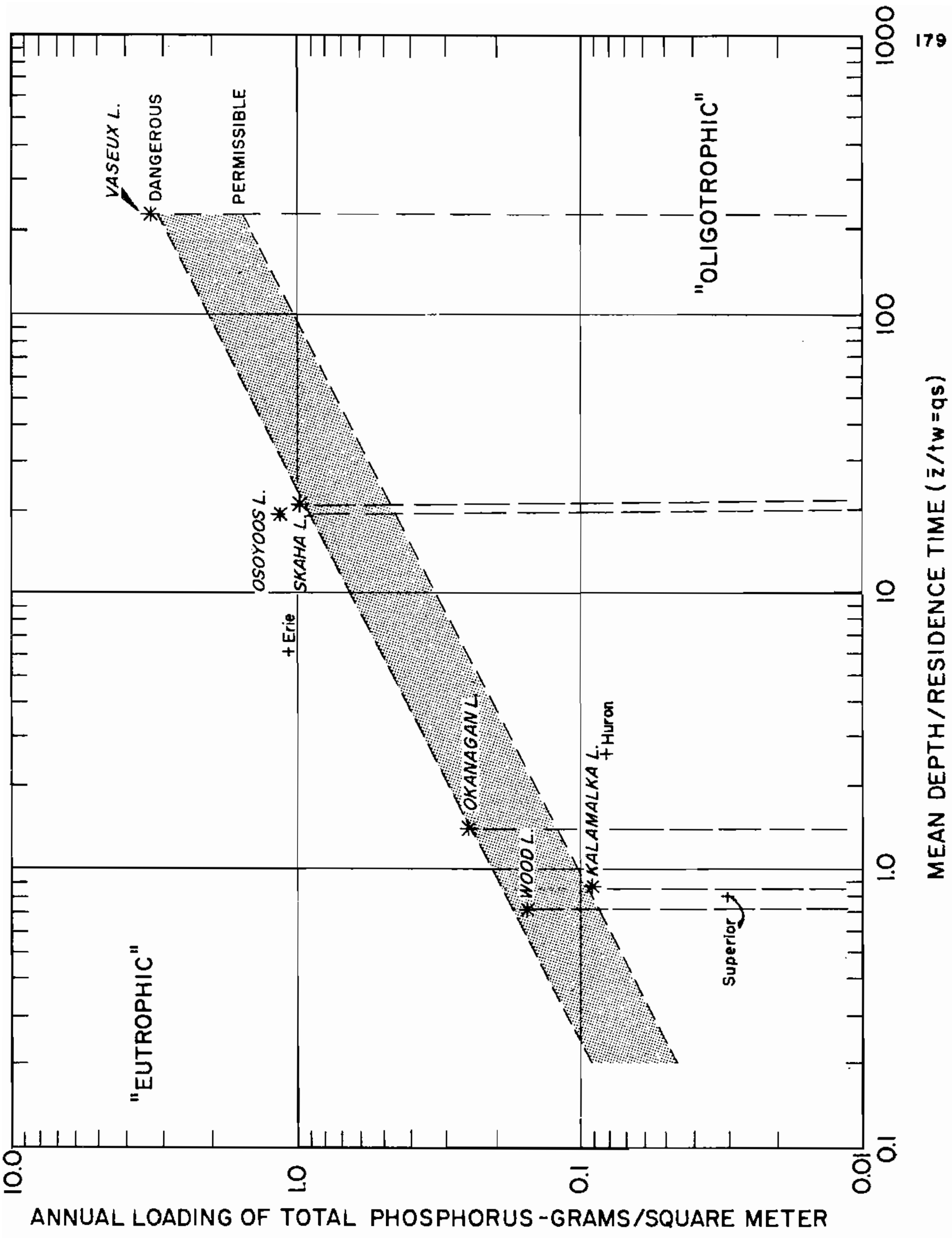
Limnologists have found that the annual input of total phosphorus to a lake is strongly related to the trophic level of a lake (22). These data on annual phosphorus input, when expressed on an areal basis and plotted as a function of lake mean depth and residence time, provide an informative comparison of the current trophic state of the main valley lakes (Figure 6.5). This shows all lakes with the exception of Kalamalka Lake to be in the dangerous zone with respect to the present (1971) total phosphorus loadings to each lake. The plots for three of the Great Lakes are also shown for comparative purposes.

6.6 SUMMARY

Limnological studies of Okanagan, Wood and Osoyoos Lakes indicate an increase in biological productivity (algae and aquatic plant growth) and resultant decline in water quality, commencing about 100 years ago, when the first major settlement and development of land in the Valley occurred. The decline in quality of Skaha Lake, and to a lesser extent Kalamalka Lake, is of more recent origin. This decline in quality is confirmed by recorded changes in the main valley lakes between conditions documented in 1935 (15) and those of the Okanagan Basin Study in 1971. The present (1971) trophic conditions of each of the main valley lakes is summarized in Figure 6.6.

A number of significant points are evident from these limnological studies. Okanagan Lake is the key lake in the basin. It commands over 75% of the tributary runoff; is by far the largest lake in both volume and surface area; and controls the quality of water in the downstream lakes of Skaha, Vaseux and Osoyoos. As long as the central water mass in Okanagan Lake remains in its present excellent condition the downstream system will benefit. However as soon as this central water mass deteriorates, the downstream system will deteriorate with it. Skaha Lake currently has the highest relative fertility and biological growth rate, combined with the highest oxygen depletion rate in bottom waters. Its present level of enrichment may be compared to that of Wood Lake in 1935, when the kokanee caught in Wood Lake were the largest in the system. The existing quality in Skaha however, has so far been maintained by the high quality and quantity of water flowing in from Okanagan Lake, its short retention time in the lake, and the probable precipitation of phosphorus as an apatite by these waters. The reduction of phosphorus inputs to this lake should result in a rapid improvement of its quality.

The relative fertility of Kalamalka Lake water under laboratory conditions is high and yet the lake has a very low biological productivity. This is considered to be due to the important calcium carbonate cycle which co-precipitates large amounts



THE ANNUAL TOTAL PHOSPHORUS LOAD TO THE MAIN VALLEY LAKES OF THE OKANAGAN BASIN, 1969-1971. Figure 6.5

CONDITIONS OF MAIN VALLEY LAKES-1971

LAKE	Trophic Condition	Water Quality	COMMENTS ON 1971 CONDITION
Kalamalka	Oligotrophic	Excellent	Relative fertility of lake is high, but condition has been preserved by unique calcium carbonate cycle which co-precipitates phosphorus and other heavy metals each spring. High mercury content in sediments. High pesticide (D.D.T.) levels found in trout and kokanee over 3 pounds in weight
Okanagan	Oligo - meso-trophic	Good	Central water mass of lake is still in excellent condition but serious deterioration has occurred around shoreline areas of lake which are affected by wastewater outfalls and shoreline development. High mercury content in sediments. The maintenance of a high water quality in this lake is essential if the water quality in the lower lakes is to be maintained or improved from their present trophic levels.
Skaha	Meso-Eutrophic	Acceptable	This lake has the highest relative fertility and biological growth rate of the main valley lakes and consequently its quality has deteriorated the most rapidly. The main cause of this deterioration is considered to have been the effluent from the Penticton Municipal Waste Treatment Plant. The high quality of inflow water to Skaha Lake, its short retention time in the lake, and the probable precipitation of phosphorus as an apatite have kept this lake from deteriorating further, and provide the means for improving the quality in a short period of time if nutrient inputs to the lake are significantly reduced.
Osoyoos	Meso-Eutrophic	Acceptable	Lake first affected by development as early as 1870. Osoyoos Lake is, in fact, three lakes with sand deposits between them with the quality generally deteriorating in a southward direction. Over 65% of all nutrients entering this lake come from Okanagan River including surface and sub-surface drainage to Okanagan River between Skaha and Osoyoos Lakes. The short retention time of the water in this lake may be preventing serious over-enrichment. Low oxygen concentrations in bottom waters during summer months. High mercury levels in sediments. Osoyoos Lake serves as an important rearing ground for small sockeye salmon.
Vaseux	Eutrophic	Acceptable	Vaseux has always been a productive lake and the extensive weed growth covering much of the lake's surface will remain an integral part of the lake's environment regardless of a varying nutrient input from Okanagan River.
Wood	Eutrophic	Poor	Most eutrophic lake in Okanagan Basin. Severe oxygen deficiency in lower waters in summer months along with high temperatures in surface waters provide an unsuitable habitat for most fish. High mercury content in sediments, and paucity of benthic fauna due to unidentified toxic substance. Increased inflow from industial cooling water pumped from Okanagan Lake and discharged to Vernon Creek, commencing in 1971, has reduced renewal time to historical levels and may speed the recovery of this lake.

Figure 6.6

of trace elements including phosphorus to the lake sediments in the early summer. The same cycle does not occur in Wood Lake which has deteriorated in recent years to the point where the severe lack of oxygen is limiting the productivity of certain faunal components,including fish. Increased inflow from industrial cooling water pumped from Okanagan Lake and discharged to Vernon Creek, commencing in 1971, has reduced the renewal time of water in this lake to historical levels (30 years to 14 years) which may speed the recovery of this lake providing phosphorus loadings are reduced. However, the effect of these increased flows and any resulting nutrient transport, on Kalamalka Lake remains a concern and should be closely watched.

Osoyoos Lake has oxygen deficit problems because of its meso-eutrophic condition and natural division of the Lake into small isolated basins. The present quality however, is being maintained by the short retention time of water in the lake.

All the main valley lakes in the basin have shown some increase in biological productivity since the studies of 1935. In the case of Kalamalka and the central mass of Okanagan Lake, the small increase noted may actually be beneficial with respect to sport fishing without impairing the quality of the water. Other increases in biological productivity, especially around the shoreline of Okanagan Lake is definitely detrimental to the quality of that lake and the mainstem system downstream. There will be a continuing decline in quality in all lakes unless condition are corrected by a reductionof phosphorus inputs to the system.

Two other materials that have been found in excess in some of the lakes are mercury and the pesticide D.D.T. The concentration of mercury found in parts of Okanagan, Kalamalka and Osoyoos Lake sediments are extremely high, and when conveyed through the food chain to larger fish, pose a potential health problem. Mercury has also affected the reproductive capacity of the salmonid species. D.D.T. has been found in concentrations exceeding safe levels in larger fish. The use of this pesticide in British Columbia was banned in 1971.

CHAPTER 7

Water Based Recreation

Availability of high quality shoreline recreational opportunities coupled with hot, dry summers and warm lake waters combine to make the Okanagan Valley one of the most popular recreation areas in British Columbia. In addition, there has been a general upsurge in outdoor recreational activities in the Okanagan due to the rapidly growing populations of Western Canadan and the Pacific Northwest United States, coupled with their increasing affluence, mobility and leisure time. Nearly half a million summer holiday visitors were attracted to the basin in 1971, their expenditures providing a substantial economic return to the Okanagan economy. Furthermore, the availability of water-based recreation opportunities provide important social and environmental benefits to Okanagan residents. The management of shoreline recreational resources is included as one of the basic components of a comprehensive framework plan because of their reliance on good water resource planning and because of their potential contribution to the social betterment and economic growth of the Okanagan.

The major water-based recreational activities in the Okanagan basin are swimming, boating and fishing. Fishing is closely related to the availability of fishery resources, and is discussed separately in Chapter 8. Swimming is broadly defined to include all beach-oriented activities such as sun-bathing, beach games, picnicking, and paddling, while boating comprises power boating, sailing and water skiing.

Most of the information used in this report was obtained from studies carried out under the Okanagan Basin Agreement. Virtually no information was available from other sources. Data on shoreline land tenure, landuse and public recreation sites were obtained from large-scale base maps, air photographs and field surveys. Information on water-based recreationists behaviour, participation and attitudes was obtained from a series of questionnaire surveys of both tourists and residents undertaken during the summers of 1971 and 1972, and receipts obtained from a sample of hotels, motels and campsites in the region. The quality of the data base, particularly as it relates to the problems of interpreting information gained from the questionnaire surveys is fully discussed in Technical Supplement VIII.

7.1 SHORELINE LANDUSE AND LAND TENURE PATTERNS

There are 252 miles of shoreline around the main valley lakes of the Okanagan Basin (Table 7.1). Nearly half (47%) of this shoreline is undeveloped land, though little of it has recreational potential because of poor access and

TABLE 7.1

SHORELINE LANDUSE AROUND MAIN VALLEY LAKES

	Miles											
LAKE	RESIDENTIAL	GENERAL	COMMERCIAL MOTELS	CAMP-SITES	INDUST-RIAL	AGRI-CULTURE	WATER USE	RECRE-ATION	ROAD AND RAIL	PUBLIC ACCESS	UNDEV-ELOPED	TOTAL
Okanagan	40.3	0.7	2.3	1.6	2.1	3.4	0.8	9.0	13.8	1.5	91.3	166.8
North[1]	18.3	0.1	0.8	0.5	0.4	1.5	0.2	1.3	0.9	0.5	30.0	
Central[2]	15.4	0.3	1.3	0.8	1.1	0.9	0.2	3.8	7.2	0.8	36.0	
South[3]	6.6	0.3	0.2	0.3	0.6	1.0	0.4	3.9	5.7	0.2	25.3	
Skaha	3.5	0	0.4	0.5	0.1	0.3	0.1	1.2	10.6	0.2	1.2	18.1
Vaseux	0.4	0	0.1	0.3	0	0.3	0	0.5	2.9	0	2.6	7.1
Osoyoos	3.6	0	0.5	0.9	0.2	0.9	0.1	2.1	2.3	0.2	10.2	21.0
Tugulnuit	1.0	0	0.1	0.1	0	0.2	0	0.1	0	0	0.4	1.9
Wood	0.6	0	0.6	0.3	0	0.2	0	0	7.9	0.1	0.9	10.6
Kalamalka	4.4	0	0.5	0.6	0	1.0	0.1	0.2	7.8	0.1	12.6	27.3
TOTALS	53.8	0.7	4.5	4.3	2.4	6.3	1.1	13.1	45.3	2.1	119.2	252.8
PERCENT-AGE	21.3	0.3	1.8	1.7	1.0	2.5	0.4	5.2	17.9	0.8	47.1	100%

[1] Okanagan Centre Northwards [2] Peachland to Okanagan Centre [3] Peachland south

terrain. The developed portions of shoreline are used for residential (21%) and road and rail transportation routes (18%). Approximately 26 miles of shoreline (10% of the total resource) are presently developed for recreational activities with 10 miles of public beaches, 14 miles of motel and campsite developments and about 2 miles of public access points. Although shoreline recreation resources represent a relatively small proportion of the total shoreline area, most of the developments are on prime recreational sites. More information on the location and characteristics of shoreline landuse is presented in a set of large-scale maps contained in the back of Technical Supplement VIII.

Over half (54%) of the shoreline is privately owned and a further 14% is situated on Indian Reserves (Table 7.2). Because most of the unalienated Crown Land is occupied by road and rail transportation, only 7% (20 miles) of the total shoreline is undeveloped and potentially accessible to the public. Almost all the remaining undeveloped shoreline is privately owned. Only 1% (2.2 miles) is owned by municipalities and less than half of this (1 mile) represents undeveloped public access. Although all shoreline areas below the high water mark are public property, public access is restricted by the limited availability of publicly owned recreational lands above high water mark and by the maintenance of high lake levels during the summer months. In addition many public access points are not properly marked and in some cases, are actually used as private property.

TABLE 7.2

SHORELINE LAND TENURE AROUND MAIN VALLEY LAKES

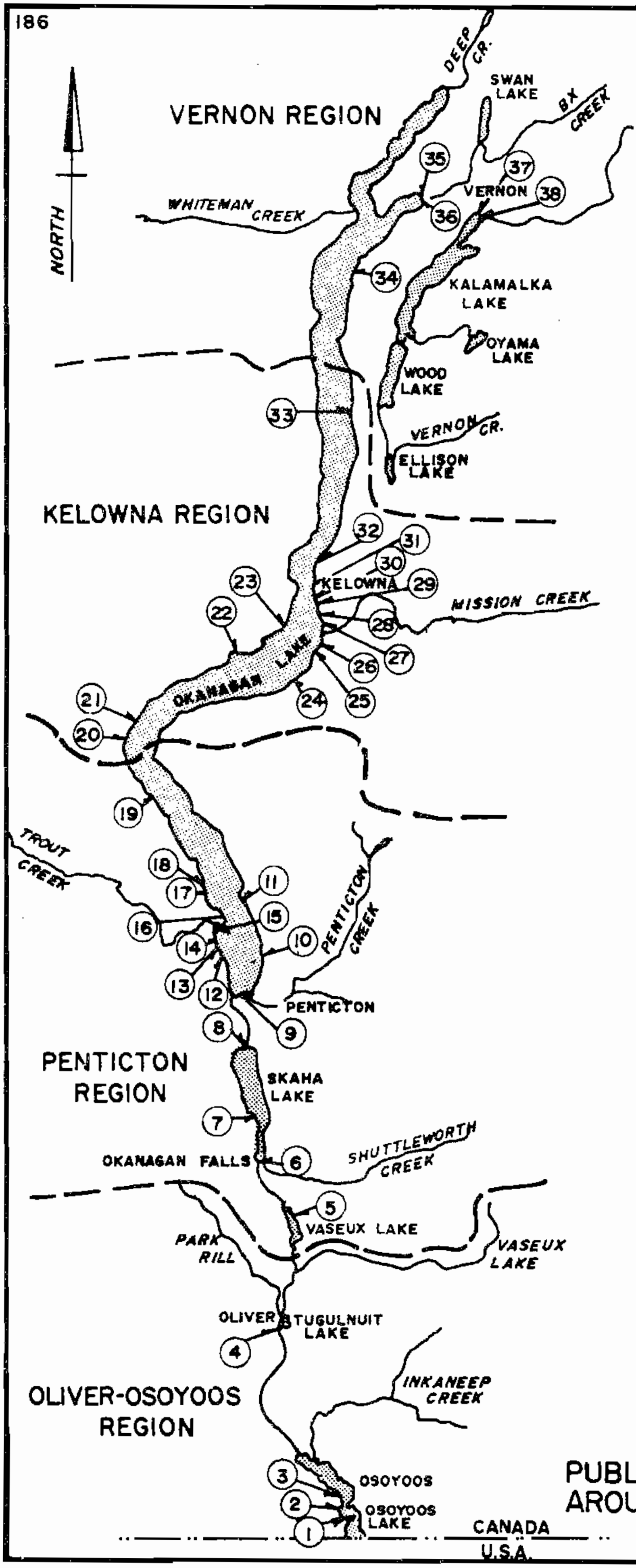
Miles

LAKE	INDIAN RESERVE		PRIVATE		CROWN			MUNICIPAL		PUBLIC ACCESS		ROAD AND RAIL	TOTAL
	DEVELOPED	UNDEVELOPED	DEVELOPED	UNDEVELOPED	DEVELOPED	PARK RESERVE	UNDEVELOPED	DEVELOPED	UNDEVELOPED	DEVELOPED	UNDEVELOPED		
Okanagan	9.8	18.0	40.4	58.8	5.5	6.1	6.8	4.5	1.6	0.9	0.6	13.8	166.8
North	8.8	15.5	13.0	12.8	1.2	1.7	0	0.1	0	0.3	0.1	0.9	
Central	0.6	2.5	18.7	28.8	2.1	2.2	1.5	2.2	0.9	0.5	0.4	7.2	
South	0.4	0	8.7	17.2	2.2	2.2	5.3	2.1	0.7	0.1	0.1	5.7	
Skaha	0.7	0	4.6	1.1	0.1	0	0	0.7	0.1	0.1	0.1	10.6	18.1
Vaseux	0	0	1.2	1.6	0.4	0.8	0.2	0	0	0	0	2.9	7.1
Osoyoos	0	5.7	5.6	4.2	1.5	0.2	0.1	0.6	0.5	0.1	0.2	2.3	21.0
Tugulnuit	0.2	0.2	1.2	0.2	0	0	0	0.1	0	0	0	0	1.9
Wood	0	0	1.8	0.6	0	0.2	0	0	0	0.1	0	7.9	10.6
Kalamalka	0	0	6.4	9.3	0	0.2	3.1	0.3	0	0.1	0.1	7.8	27.3
TOTAL	10.7	23.9	61.2	75.8	7.5	7.5	10.2	6.2	2.2	1.3	1.0	45.3	252.8
PERCENTAGE	4.2	9.5	24.2	30.0	3.0	3.0	4.1	2.4	0.8	0.5	0.4	17.9	100%

7.2 PUBLIC RECREATION SITES

There are 38 public recreation sites located on the shores of the main valley lakes, ranging in size from small picnic sites to large public beach facilities and campground (Figure 7.1). These shoreline recreation sites covering 349 acres, are maintained by the Provincial Government (13 sites) and by local municipalities (25 sites). About 30% (104 acres) of this total area is directly available for beach-oriented recreation, the rest comprising parking lots, campsites or parks.

The availability and nature of public recreation facilities varies from region to region in the Okanagan (Figure 7.2). The Penticton region contains the largest area of public recreation sites (161 acres), followed by the Kelowna region (87 acres), the Vernon region (73 acres) and the Oliver-Osoyoos region (29 acres). Although all regions contain areas of sandy beaches in approximate proportion to the total recreational area, the Kelowna and Penticton regions also have significant amounts of grassed waterfront parks. In terms of beach frontage for public recreation, the Penticton region is the leading region with almost 6 miles, followed by the Kelowna region with 4 miles, Oliver-Osoyoos with 2.2. miles and the Vernon region with 1.9 miles. A more detailed description of the physical characteristics of public shoreline recreation facilities for each main lake is included in Technical Supplement VIII.



VERNON REGION

PROVINCIAL
34 Ellison Park
MUNICIPAL
35 Kin Beach
36 Kin Beach (Indian Reserve Section leased by municipality)
37 Kalamalka Beach
38 Small Park

KELOWNA REGION

PROVINCIAL
20 Antlers Beach Park
22 West Bank Park
23 **Kalamoir Park**
MUNICIPAL
21 Peachland Park
24 Beau Se Jour
25 Small Park
26 Small Park
27 Rotary Park
28 Gyro Park
29 Warlaw Park
30 Strathcona Park
31 Kelowna City Park
32 Sutherland Park
33 Okanagan Centre

PENTICTON REGION

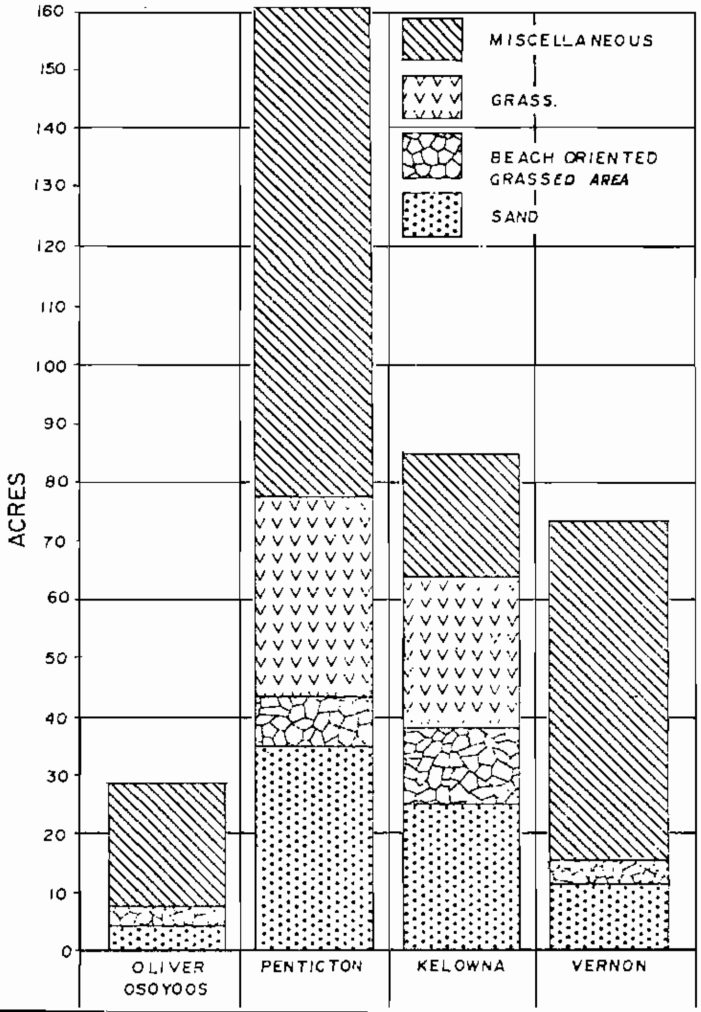
PROVINCIAL
5 Vaseux Prov. Park
6 Christie Memorial Park
11 Manitou Park
12 Kickinee Picnic Ground
13 Soorimpt Picnic Ground
14 Pyramid Picnic Ground
15 Sun-Oka Beach Park
19 Okanagan Lake Prov.Park
MUNICIPAL
7 Kaleden Community Park
8 Skaha Lake Park
9 Okanagan Beach
10 Third Beach
16 Powell Beach
17 Rotary Beach Summerland
18 Kin Beach Summerland

OLIVER-OSOYOOS REGION

PROVINCIAL
1 Haynes Point Prov.Park
MUNICIPAL
2 Community Park (south of Causeway)
3 Osoyoos Community
4 Tugulnuit Park

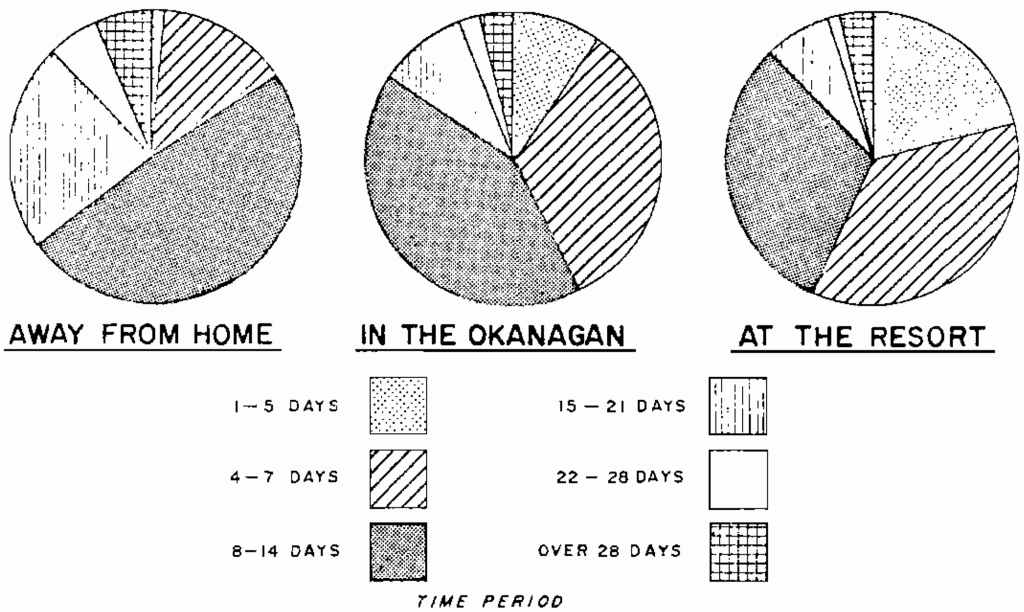
PUBLIC RECREATION SITES AROUND THE MAIN VALLEY LAKES.

Figure 7.1



CHARACTERISTICS OF PUBLIC RECREATION SITES AROUND THE OKANAGAN MAIN VALLEY LAKES.

Figure 7.2



THESE STATISTICS ARE CONSIDERED TO BE BIASED TOWARDS LONGER STAYING VISITORS BECAUSE OF THE GREATER LIKELIHOOD OF CONTACTING THEM IN THE TOURIST QUESTIONAIRE SURVEY

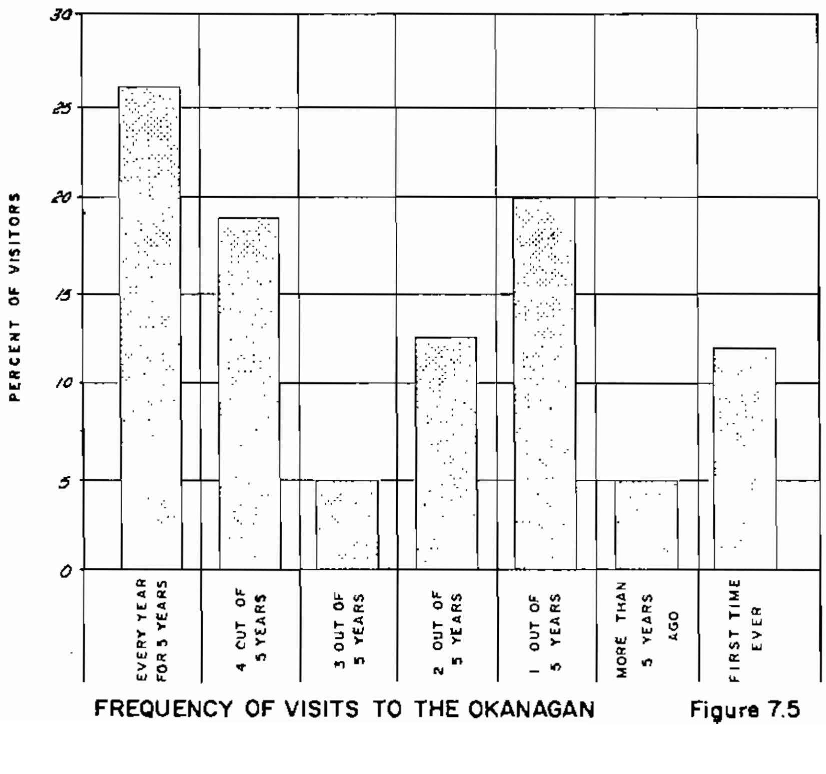
LENGTHS OF STAY OF TOURIST GROUPS Figure 7.3

7.3 TOURIST AND RESIDENT SHORELINE RECREATION PARTICIPATION AND CHARACTERISTICS OF TOURISTS

Of the 700,000 visitors estimated to have come to the Okanagan in 1972, 485,400 or 70% were summer holiday vacationers. The average tourist group consisted of 4.5 people who stayed in the valley for 6.5 days for a total of 3.1 million visitor days. During the summer of 1971, a questionnaire survey of a sample of 1055 summer holiday tourists was conducted to obtain general information on their visits to the basin. Not only did the majority of summer tourists spend most of their vacation in the Okanagan, but they also tended to settle in one part of the valley, rather than travel around (Figure 7.3). Three-quarters of those interviewed stated that they intended to stay at only one motel or campsite during their stay, and only 6% of tourists were en route to another destination. It should be noted that because of the greater opportunity to interview tourists who stay at one spot rather than the mobile visitor, the above statistics may be biased accordingly.

The Okanagan is popular among family group vacationers, nearly three-quarters of the recreational groups consisting of one or more families with children. It is estimated that 43% of all holiday visitors are children under the age of 16. Almost 86% of holiday visitors came from British Columbia or Alberta, particularly from the major urban centres of Greater Vancouver (35%), Calgary (17%) and Edmonton (12%) - (Figure 7.4). Less than 10% of holiday visitors came from the United States. Generally speaking, most visitors from the Lower Mainland stayed in the southern half of the valley, while almost half of the visitors in the Kelowna and Vernon regions were Albertans. Penticton was identified as the center most frequented by tourists.

Nearly 90% of tourists had previously visited the Okanagan and over one-quarter had returned to the valley every year in the past five years (Figure 7.5).



FREQUENCY OF VISITS TO THE OKANAGAN Figure 7.5

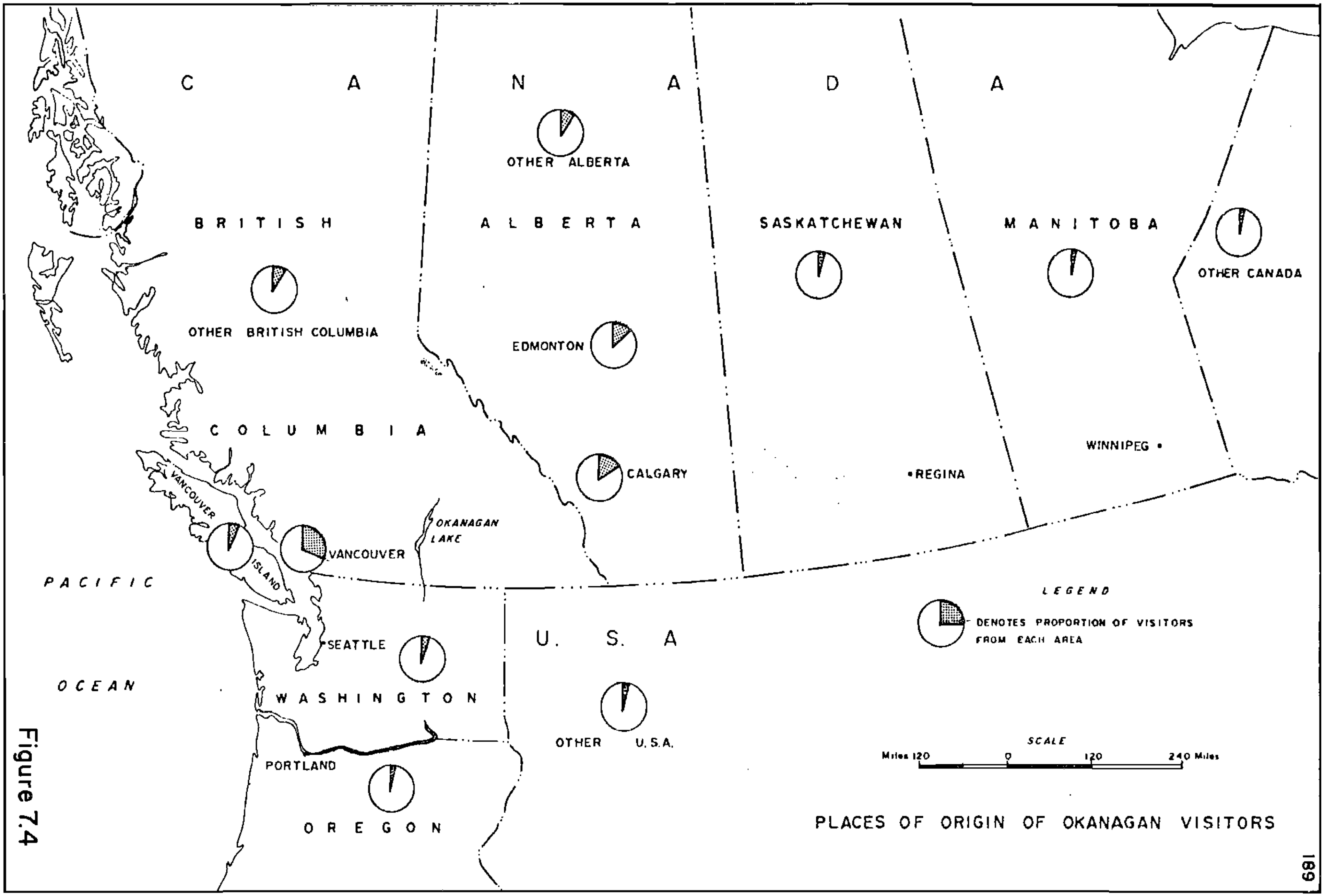

C A N A D A
BRITISH COLUMBIA
OTHER BRITISH COLUMBIA
ALBERTA
OTHER ALBERTA
EDMONTON
CALGARY
SASKATCHEWAN
REGINA
MANITOBA
WINNIPEG
OTHER CANADA
VANCOUVER
VANCOUVER ISLAND
OKANAGAN LAKE
PACIFIC
OCEAN
U. S. A
SEATTLE
WASHINGTON
PORTLAND
OREGON
OTHER U.S.A.
LEGEND
DENOTES PROPORTION OF VISITORS FROM EACH AREA
SCALE
Miles 120 0 120 240 Miles
PLACES OF ORIGIN OF OKANAGAN VISITORS

Figure 7.4

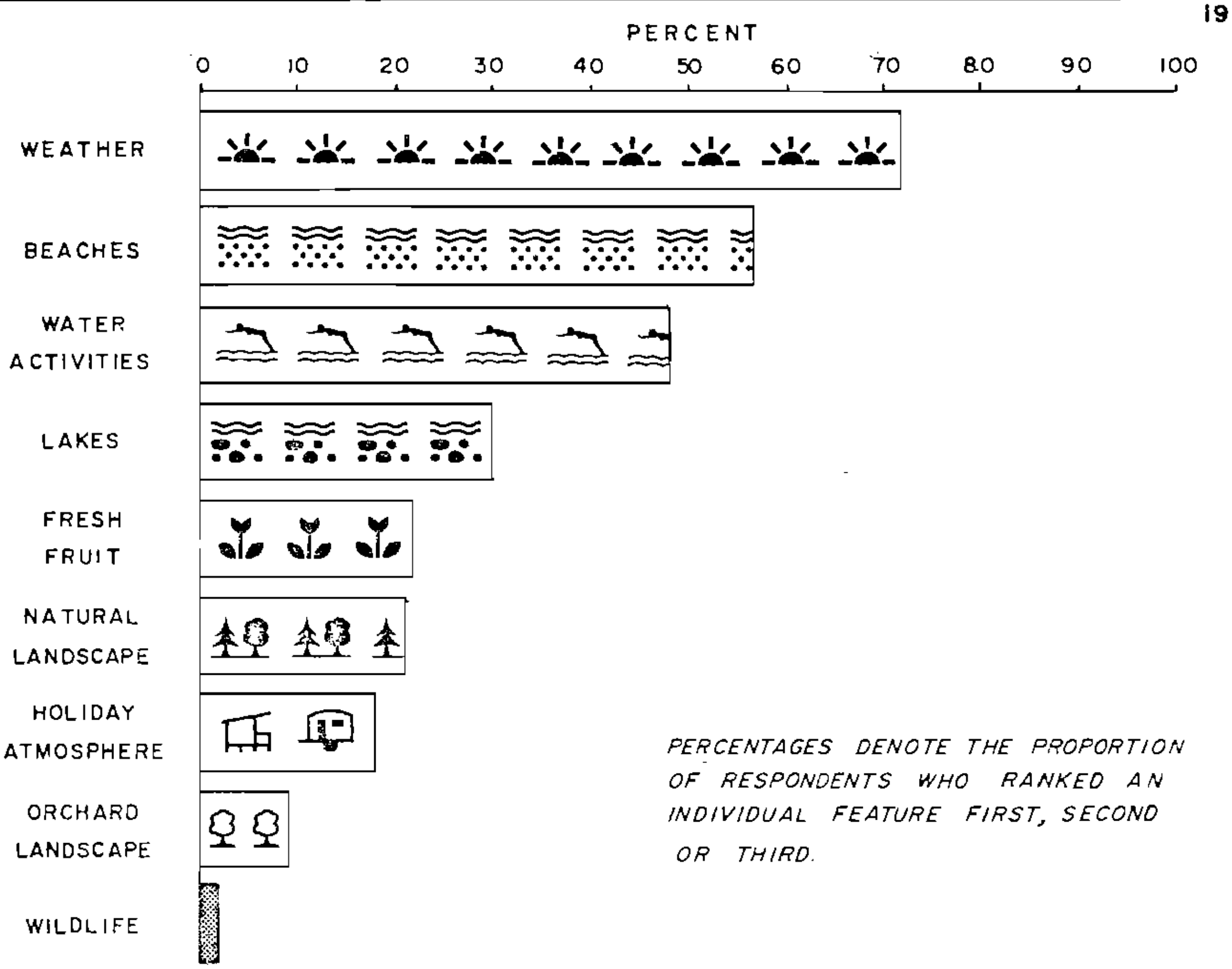
Over two-thirds (68%) of summer tourists cited previous enjoyable experiences in the Okanagan as their main reason for returning, and a further 14% came on the basis of recommendation from friends. Indeed, more than half of those visiting the Okanagan for the first time considered a friend's recommendation as their primary reason for coming. Most tourists interviewed were satisfied with their holiday experiences in the Okanagan, and 54% of them could not identify any unpleasant features associated with their stay.

Summer tourists were asked to rank the major attractions of the Okanagan in order to determine the main reason for their visits and the relative importance of the water resource. Figure 7.6 indicates the proportion of visitors who ranked an individual feature first, second or third out of nine possible rankings, thus indicating it was an important factor. The weather appears to be the most important single attraction of the Okanagan, followed by the opportunity to participate in water-based recreation as illustrated by the high ranking of such features as beaches, water-based activities and lakes. The relatively high ranking of the opportunity to obtain fresh fruit indicates the importance of agriculture to the tourist. No single feature emerged as a major attraction, and it appears that visitors come to the Okanagan to enjoy a holiday 'package' of fair weather, beaches, water activities and rural landscapes.

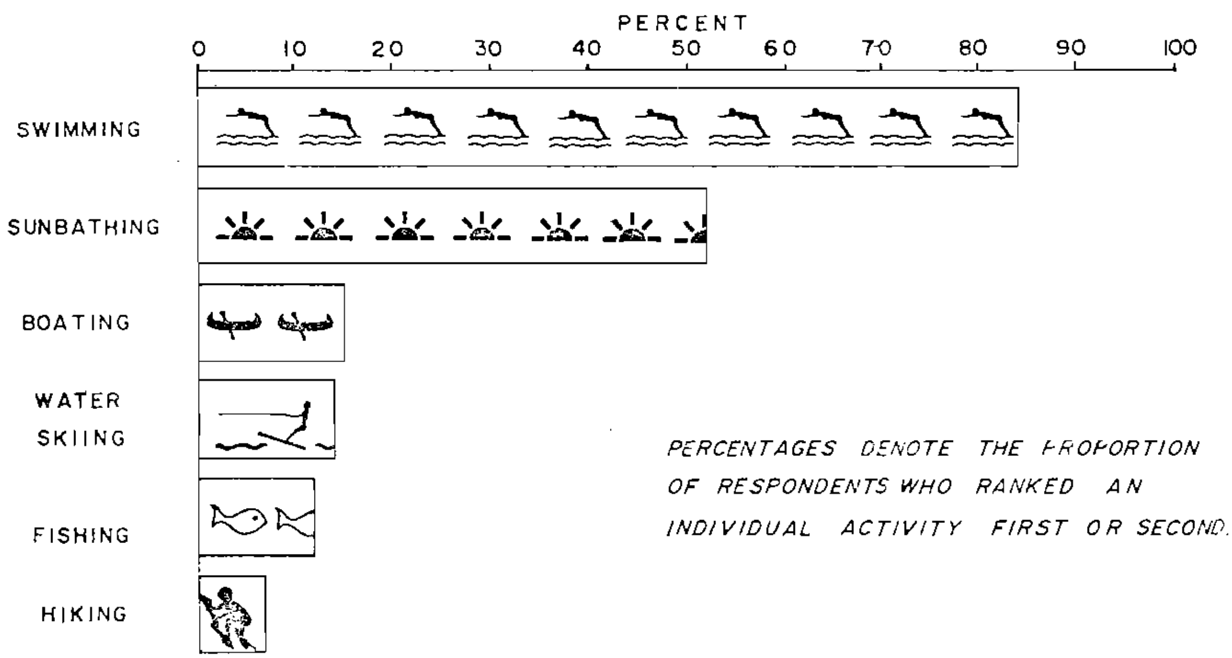
To probe more deeply into the relative importance of shoreline recreational activities in people's decisions to come to the Okanagan, tourists were asked to rank a number of water-based activities in order of importance to them as a group (Figure 7.7). Swimming was by far the greatest activity and was ranked highly important by 84% of the visitors, followed by sun-bathing, a complementary activity, by 52%. Fishing, boating and water-skiing were generally ranked of lesser importance. Consequently, shoreline recreational activities appear to be the major water-based activities enjoyed by the vast majority of summer holiday visitors.

Residents placed a similar emphasis on the importance of water-based recreation in their ranking of outdoor activities. Figure 7.8 indicates the proportion of Okanagan households in which at least one person had participated in selected outdoor activities. Almost three-quarters of all households contained persons who swam, while 68% contained fishermen and over 50% contained boaters.

It is stressed that participation rates for both tourists and visitors may be over-estimated due to the tendency of respondents to exaggerate in replies to such questions.

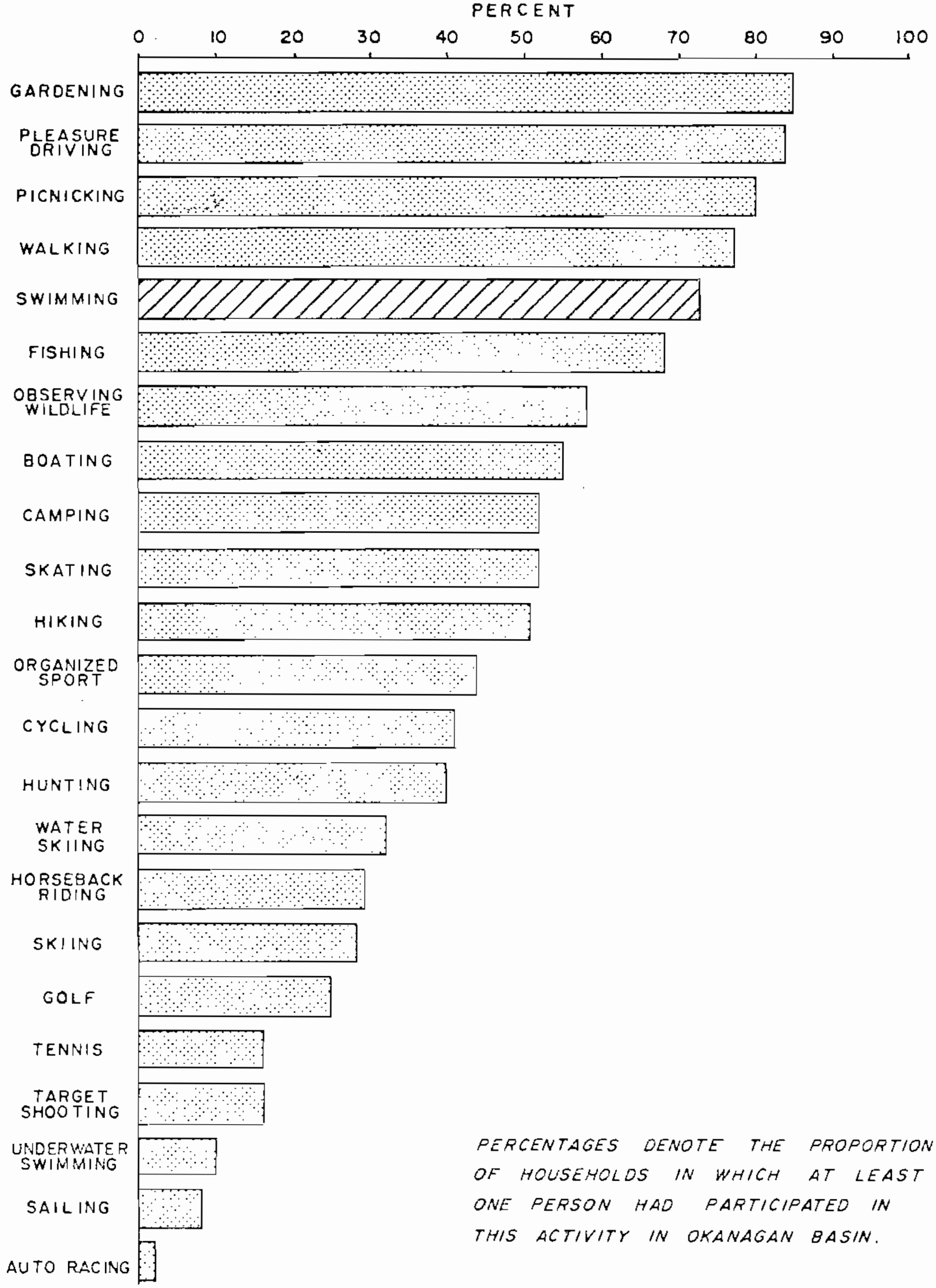


RELATIVE IMPORTANCE OF THE ATTRACTIONS OF THE OKANAGAN Figure 7.6



RELATIVE IMPORTANCE OF VARIOUS RECREATIONAL ACTIVITIES FOR VISITORS

Figure 7.7



PARTICIPATION IN SWIMMING COMPARED WITH OTHER FORMS OF OUTDOOR RECREATIONAL ACTIVITIES BY OKANAGAN RESIDENTS.

Figure 7.8

7.4 BOATING SURVEY

The main purpose of the boating survey was to determine the number, types and seasonal distribution of boating on the main valley and headquarters lakes. Information was gathered from a number of aerial surveys over the watershed during the summer of 1971, supported by ground interviews and boat counts. Details of survey methods and sampling procedures are contained in Technical Supplement IX.

A total of 314,000 boating days were recorded between May 1 and October 31 for all Okanagan Lakes. Approximately 256,000 boating days were spent on the main valley lakes and some 58,000 on the headwater lakes. While all boating activity on headwater lakes is related to sport fishing, a diversity of recreational boating occurs on the main lakes including power boats, sailing canoeing and rowboats.

Almost three-quarters of all boating "days" in the main valley lakes were spent on Okanagan Lake (Table 7.3). The next most popular lake was Kalamalka with 13%, followed by Osoyoos with 9%. Over 60% of all boating activity involved general power boating for water-skiing, pleasure boating or transportation to beaches inaccessible by land. Just over 25% of boating involved angling, though this may be an underestimate as anglers returning to shore could have been counted in the general run-about category.

Most boating activity occurs between early June and mid September, with 110,000 or 40% of the boating days recorded in the month of August.

TABLE 7.3

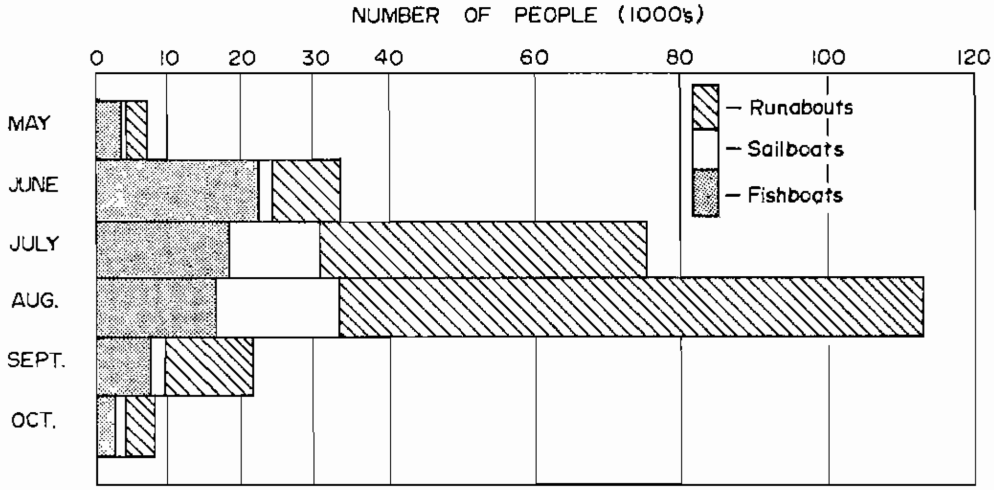
BOATING-DAYS ON MAIN VALLEY LAKES
MAY 1 to OCTOBER 31, 1971

LAKE	FISHING	RUN-ABOUT	SAIL-BOATS	TOTAL	%
Okanagan	56,632	98,085	15,322	170,039	66.3
Skaha	5,446	11,476	2,108	18,930	7.4
Vaseux	458	0	1,352	1,810	0.7
Osoyoos	1,221	19,128	3,122	23,471	9.1
Kalamalka	2,083	19,937	12,268	34,288	13.4
Wood	2,307	5,109	498	7,914	3.1
TOTAL	68,147	153,735	34,570	256,452	100.0

NOTE: Power boats are banned on Vaseux Lake as the area is a waterfowl and bird sanctuary.

General power boating was particularly popular in the warm summer months of July and August, fishing being relatively more attractive in May and June. Although Okanagan Lake remained the most frequently utilized lake throughout the summer period, there were seasonal variations in use between lakes. For example, 13% of all boating activity was recorded on Wood Lake and 11% on

Skaha Lake during May, mainly due to sport fishing opportunities (Figure 7.9).



TYPES OF BOATERS USAGE ON OKANAGAN BASIN MAIN VALLEY LAKES
MONTHLY TOTALS MAY TO OCTOBER 1971.

Figure 7.9

Using on-spot interviews and shoreline boat counts, it was estimated that there was an average of 1.88 persons per fishing boat, 3.25 persons in power boats and 2.0 people in sail boats. Thus, over 100,000 separate boat trips were made on the main valley lakes during 1971 involving over 500,000 hours of leisure time.

This significant time and financial investment provides some indication of the value placed on boating recreation by visitors and residents. Almost all boats are launched from public boat ramps, private docks or marina facilities, many of which are located on Okanagan and Osoyoos Lakes and may therefore be affected by extremely high or low lake levels as discussed in Chapter 4. Although such extreme fluctuations will likely create an inconvenience rather than a loss of opportunity,they could cause important environmental and social costs which will be included in the evaluation of water management alternatives described in Chapter 14.

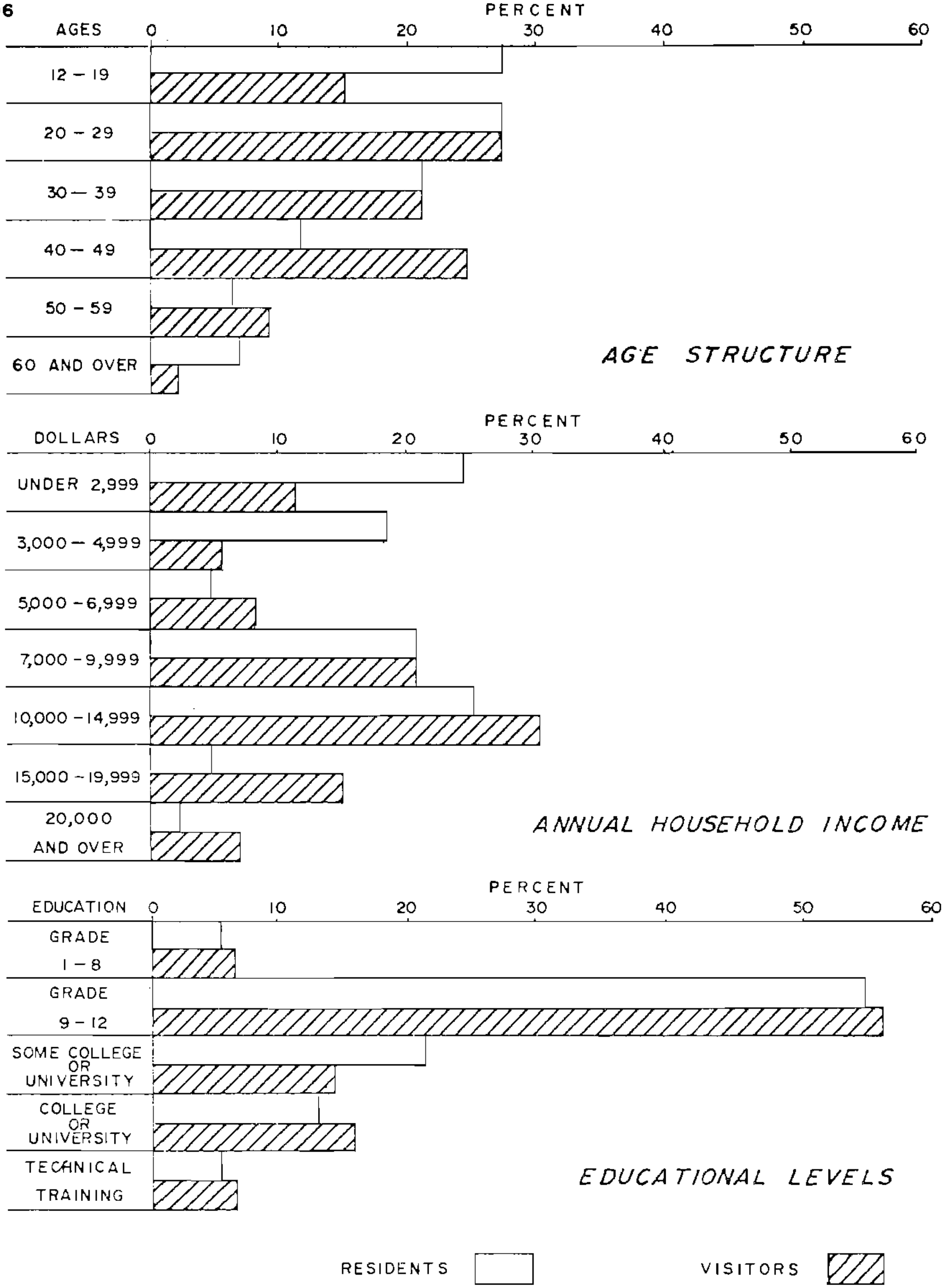
7.5 SHORELINE RECREATION STUDIES

In view of the importance of shoreline recreation (swimming, sunbathing) to both tourists and residents in the Okanagan, more detailed surveys of recreationists were undertaken in the summer of 1972. These surveys probed for participation rates, preferences, attitudes and values associated with shoreline recreation, and attempted to determine on the importance of water quality as a factor in the enjoyment of water-based recreation.

A total of 446 interviews were conducted, 344 with recreationists located at public beaches where the water quality was considered to be good and 102 on public beaches where relatively poor water quality conditions prevailed. The responses of this smaller sample will be analysed in the following section. The sample of 344 respondents located at beaches with high water quality conditions consisted of 230 visitors and 144 residents which was in approximate proportion to the total population of beach users. The major socio-economic characteristics of visitors and residents contacted in both samples are presented in Figure 7.10 to illustrate any important differences that might affect behavioural patterns. More teenage residents than visitors were contacted, while slightly more visitors in the 40-60 age categories were interviewed. Visitors tended to enjoy a higher household income than their residnet counterparts. There were few differences in the level of educational achievement attained by both groups of respondents. These differences were not considered important enough to influence the majority of responses, and occasional exceptions will be noted in the discussion.

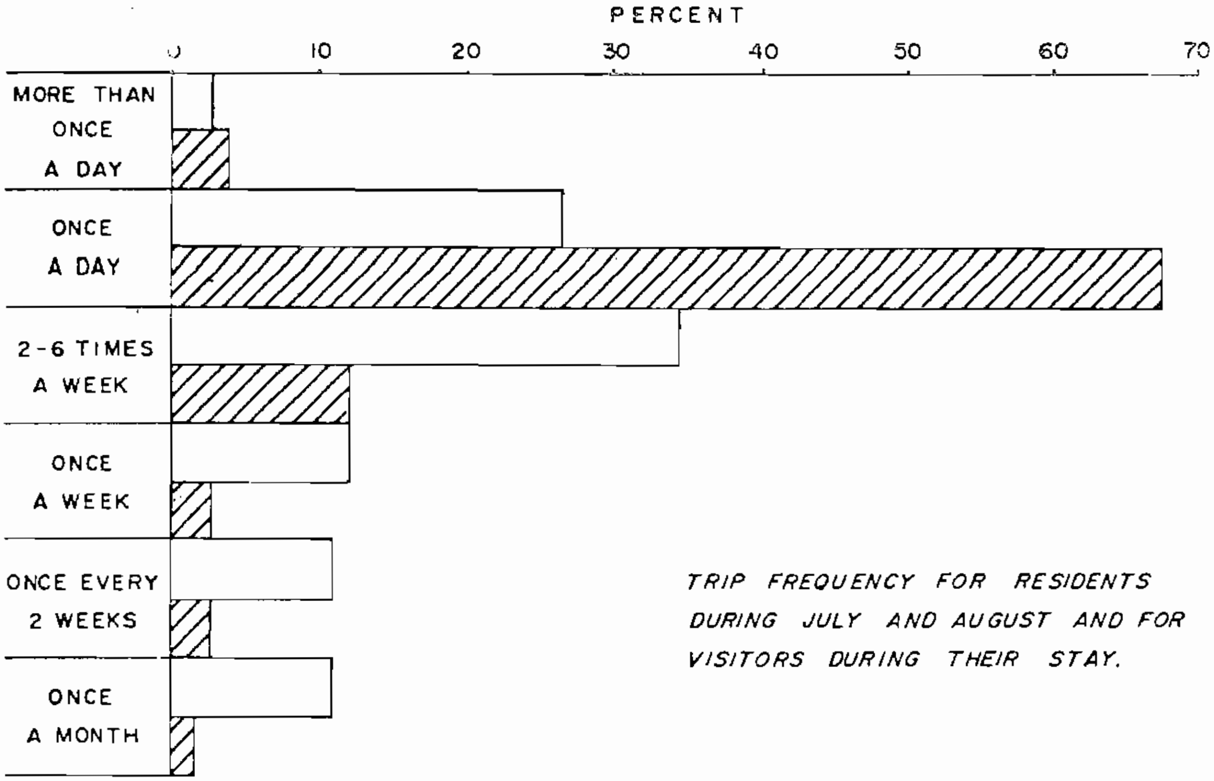
As would be expected, visitors participate in shoreline recreational activities more frequently than residents over a comparable time span. Two-thirds of visitor beach users stated that they went to a beach every day of their stay in the Okanagan while three-quarters of resident beach users went at least once a week during July and August (Figure 7.11). Applying these statistics to the total population of summer tourists, and valley residents, respectively it was estimated that visitors and residents enjoyed 1.7 million and 2.2 million beach days respectively for a total of 3.9 million beach days in 1970. Nearly 80% of both visitors and residents spent more than two hours on the beach, and over one-quarter of the visitors spent all day at the beach (Figure 7.12). Although these statistics may be biased upwards due to the greater likelihood of contacting longer-staying and more frequent beach users, they do not indicate the considerable investment of both resident leisure and visitor holiday time in shoreline recreation.

Beach users were asked to rank in order of importance the attractive features associated with beach recreation (Figure 7.13). Both visitors and residents agreed that high water quality was the most important single feature followed by clean beaches and safe conditions for children. A reciprocal question was asked about unattractive features of Okanagan beaches. Half of the visitors and over one-third of resident beach users had no dislikes, and those that did, were most concerned about crowded conditions and poor water quality. Figure 7.14 indicates that, in general, residents tended to be more critical of these aspects than visitors, perhaps because residents had more experience of crowded conditions and poor water quality - 87% of residents stating they had previous experience of at least one of these problems, compared to 64% of tourists.



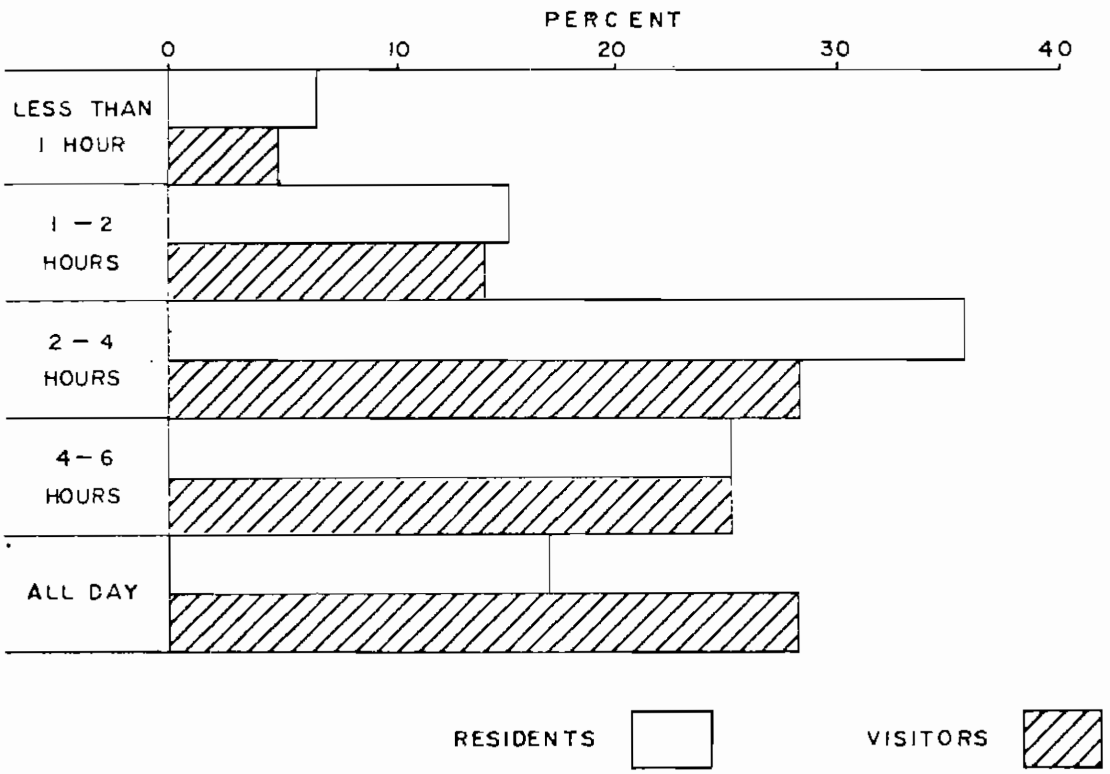
CHARACTERISTICS OF RESPONDENTS IN THE BEACH USER QUESTIONNAIRE SURVEY.

Figure 7.10



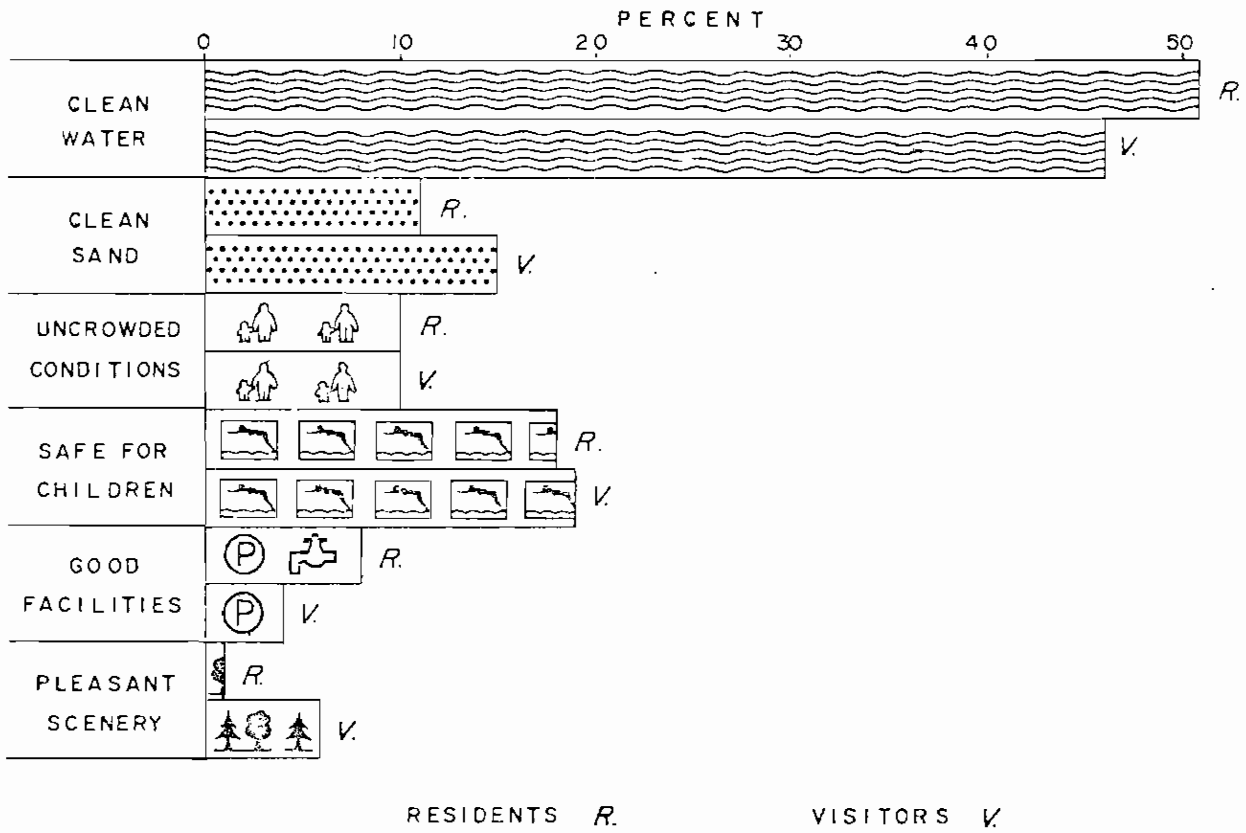
FREQUENCY OF VISITS TO THE BEACH

Figure 7.11

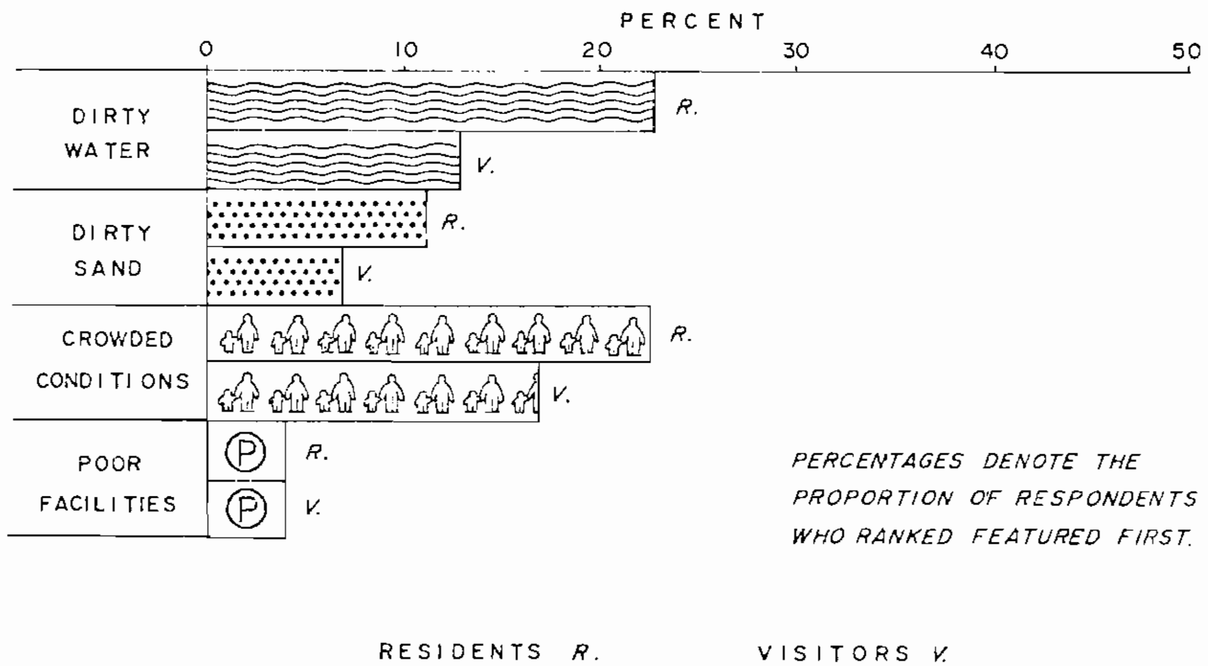


DURATION OF STAYS ON THE BEACH

Figure 7.12



ATTRACTIVE FEATURES OF OKANAGAN BEACHES IN GENERAL **Figure 7.13**



UNATTRACTIVE FEATURES OF OKANAGAN BEACHES IN GENERAL **Figure 7.14**

7.6 WATER QUALITY AND SHORELINE RECREATION

Clean water appears to be the major attraction of Okanagan beaches for both visitors and residents who participate in shoreline recreation.

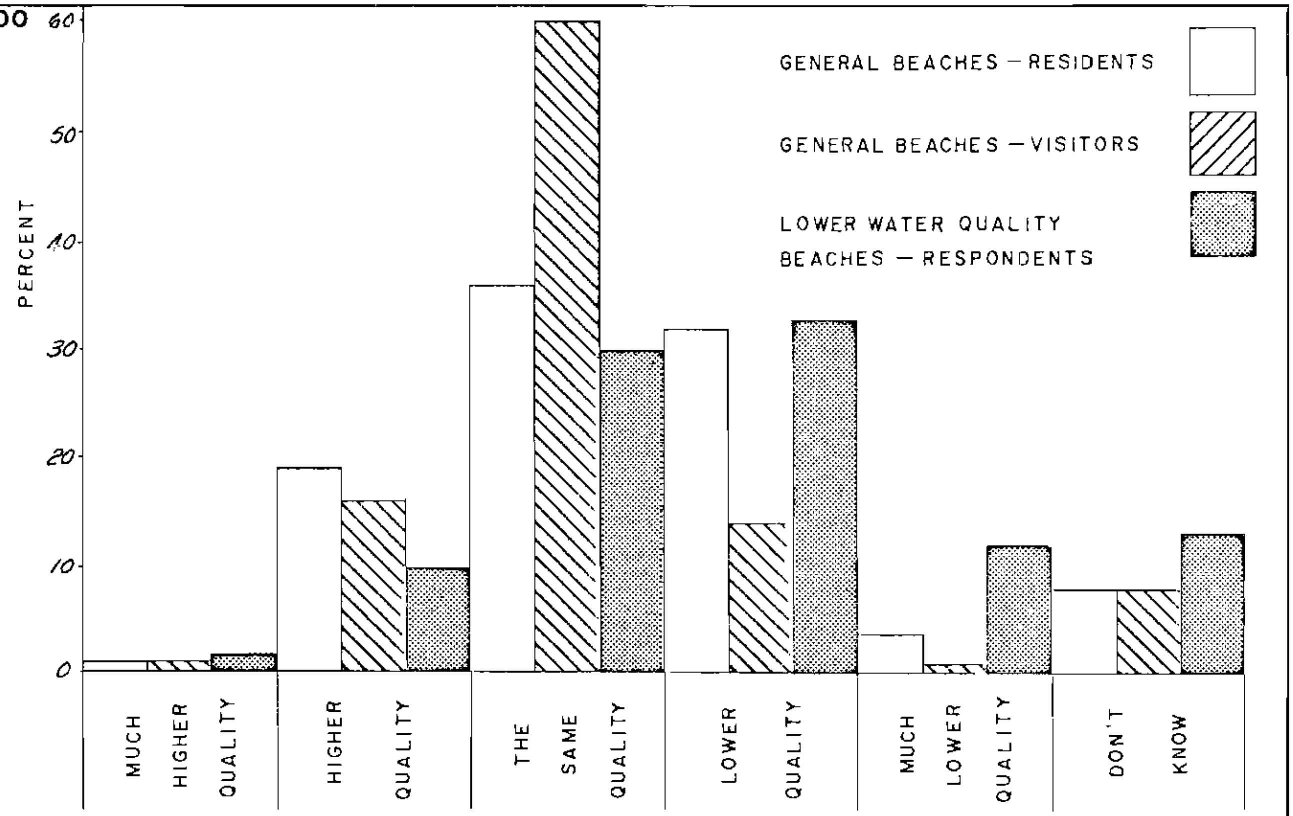
The chapter on Limnology indicated the range of water quality conditions prevailing in the main valley lakes. Okanagan and Kalamalka were classified as oligotrophic, Skaha and Osoyoos as meso-eutrophic while Wood was considered to be eutrophic. A sample of 102 shoreline recreationists were interviewed at public and private beaches around Osoyoos and Wood Lakes and at the North Arm of Okanagan Lake where extensive weed growth flourished during the summer of 1972. Responses from this sample experiencing relatively poor water quality conditions were compared with responses from the sample of beach recreationists interviewed at sites where good water quality conditions prevailed. The two samples displayed similar socio-economic characteristics (age, sex, eductation and household income) which otherwise might have influenced the replies concerning water quality conditions.

Although considerable differences in the biological and chemical qualities of lake water prevailed between the sites where the two samples were obtained, there was little difference in criteria such as odour, murkiness, scum and weeds, which are more readily identified by the public as indications of poor water quality.

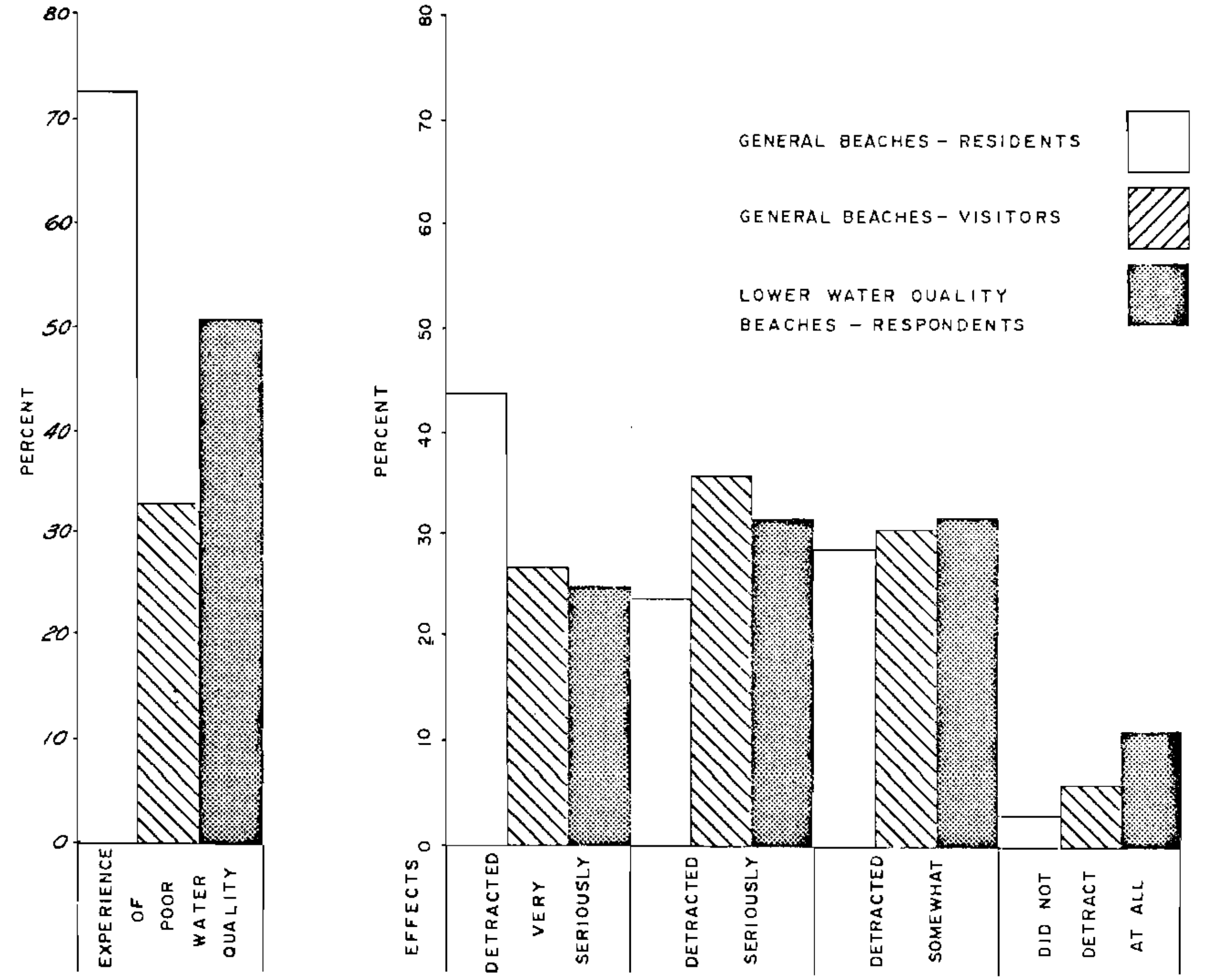
People at most beaches in the Okanagan appeared to have been generally satisfied with the water quality conditions which prevailed during the summer of 1972. Only 3% of the sample located at good water quality sites rated the water quality as low or very low compared to 24% of those located at the poor water quality beaches. Residents were more perceptive of a gradual deterioration in lake water quality (Figure 7.15). At the better water quality sites, 30% of residents noted a decline in water quality compared to 15% of visitors, while 45% of all respondents at the lower quality beaches were aware of such changes.

Residents were more likely than visitors to have had previous experience of poor water quality conditions at Okanagan beaches (Figure 7.16). Nearly three-quarters of residents and one-third of visitors interviewed at the better water quality sites had experienced such conditions compared with about half of the respondents at the lower water quality sites. Residents tended to be more concerned about these conditions as 44% of those with experience of water quality problems stated that these conditions had detracted very seriously from their recreational enjoyment, compared to 27% of visitors. All respondents at the lower water quality sites tended to be less sensitive to these problems than their couterparts at the other beaches.

Generally speaking, the actions of both samples of respondents complied with their responses. Nearly half of the residents interviewed in the good water quality sites indicated they actively avoided poor water quality conditions



ASSESSMENTS OF TRENDS IN WATER QUALITY **Figure 7.15**

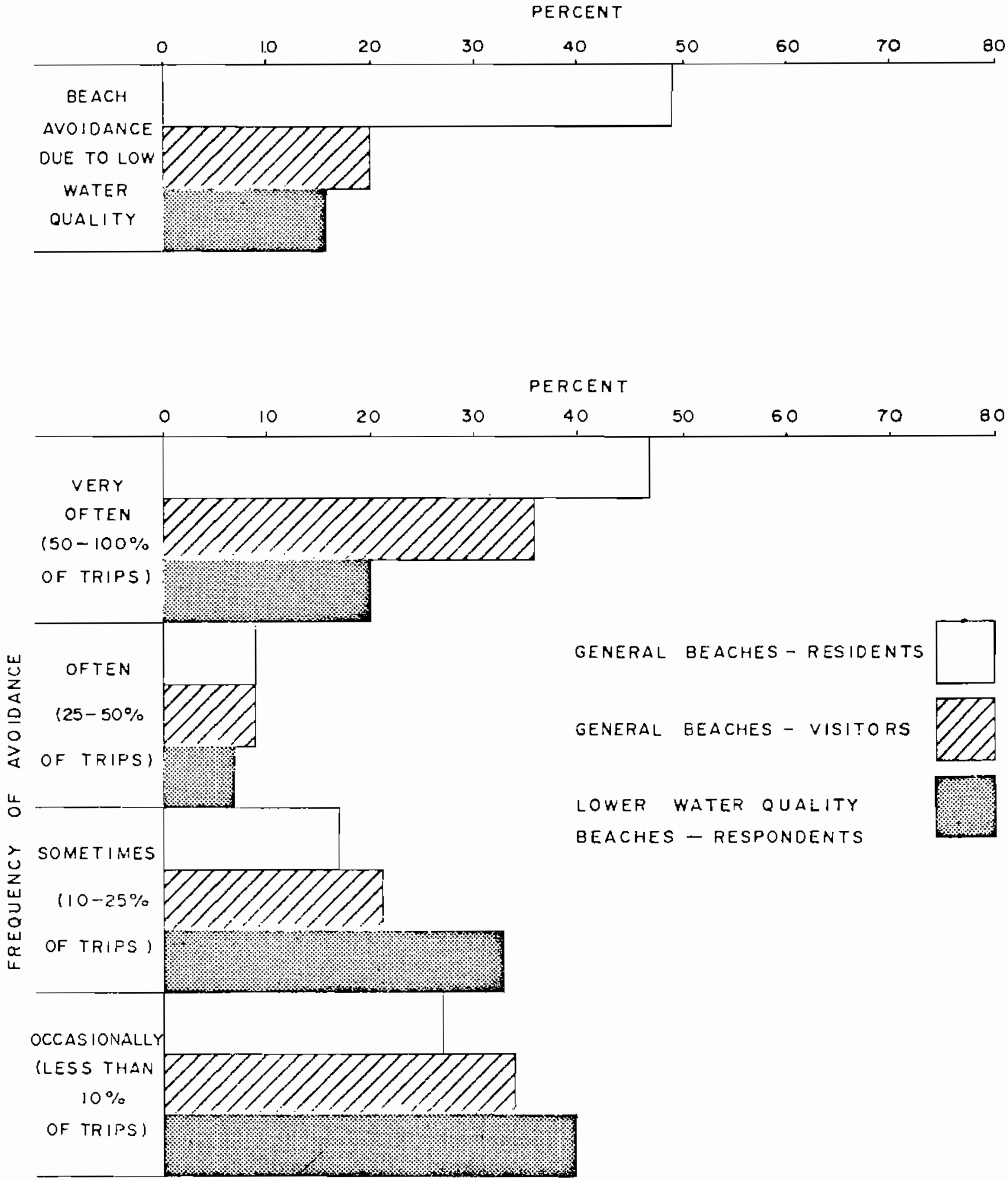


EXPERIENCE OF POOR WATER QUALITY AND ITS EFFECTS ON THE ENJOYMENT OF BEACHES **Figure 7.16** compared to 21% of visitors and 16% of respondents at the lower water quality sites. In general, residents tended to avoid poor conditions more frequently than visitors (Figure 7.17).

The differences between the responses of resident and visitor beach users to questions on water quality are probably due in part to the greater familiarity and experience of Okanagan beaches gained by valley residents. The results do suggest, however, that resident beach users are somewhate more sensitive to water quality problems than visitors and that beach users at poorer water quality sites had generally developed more tolerant attitudes to these conditions. Certainly, many residents and visitors with some previous experience in the Okanagan, reacted by simply avoiding areas where weeds or other nuisance conditions prevailed. It is interesting to note that 62% of all respondents at Wood Lake and 53% at Kin Beach on Vernon Arm, where the most obvious water quality problems existed, were visiting these beaches for the first time. It may be concluded that Okanagan beach users display a range of attitudes towards water quality problems and that, taking other factors such as proximity to home or crowding into account, they tend to migrate to beaches where water quality conditions are in harmony with these attitudes.

The vast majority of beach users indicated their satisfaction with water quality levels in the main valley lakes despite the range of water quality conditions existing during the summer of 1972. Only 1% and 6% of those sampled at good and poor water quality sites respectively mentioned poor water quality conditions as a reason for not swimming. Furthermore, very few people indicated they would not return to any beach because of poor water quality conditions and the vast majority were sufficiently satisfied with their total experience at Okanagan beaches to recommend them to friends.

Beach users were asked how much they would be willing to pay for additional sewage treatment facilities to improve or maintain high lake water quality. To aid their answers, respondents were provided with general information on the existing (1970) contributions of municipal wastes to total nutrient loadings into the Okanagan lakes. This question was hypothetical, but responses were considered as possible indicators of the value placed on maintaining good water quality. Respondents were presented with a list of average monthly and annual expenditures of a typical household for a range of utilities and services in order to place the current costs of secondary treatment of sewage into perspective (Table 7.4). The vast majority of respondents indicated they would be willing to pay at least double the existing sewage tax of $60 per year. While this figure does not necessarily mean that all Okanagan residents and tourist would actually be willing to pay the extra cost, these values are in keeping with projected costs for providing tertiary sewage treatment for the major Okanagan municipalities.



EXTENT AND FREQUENCY OF BEACH AVOIDANCE DUE TO POOR WATER QUALITY

Figure 7.17

TABLE 7.4

MONTHLY AND ANNUAL EXPENDITURES OF A TYPICAL OKANAGAN HOUSEHOLD ON SELECTED UTILITIES AND SERVICES IN 1972

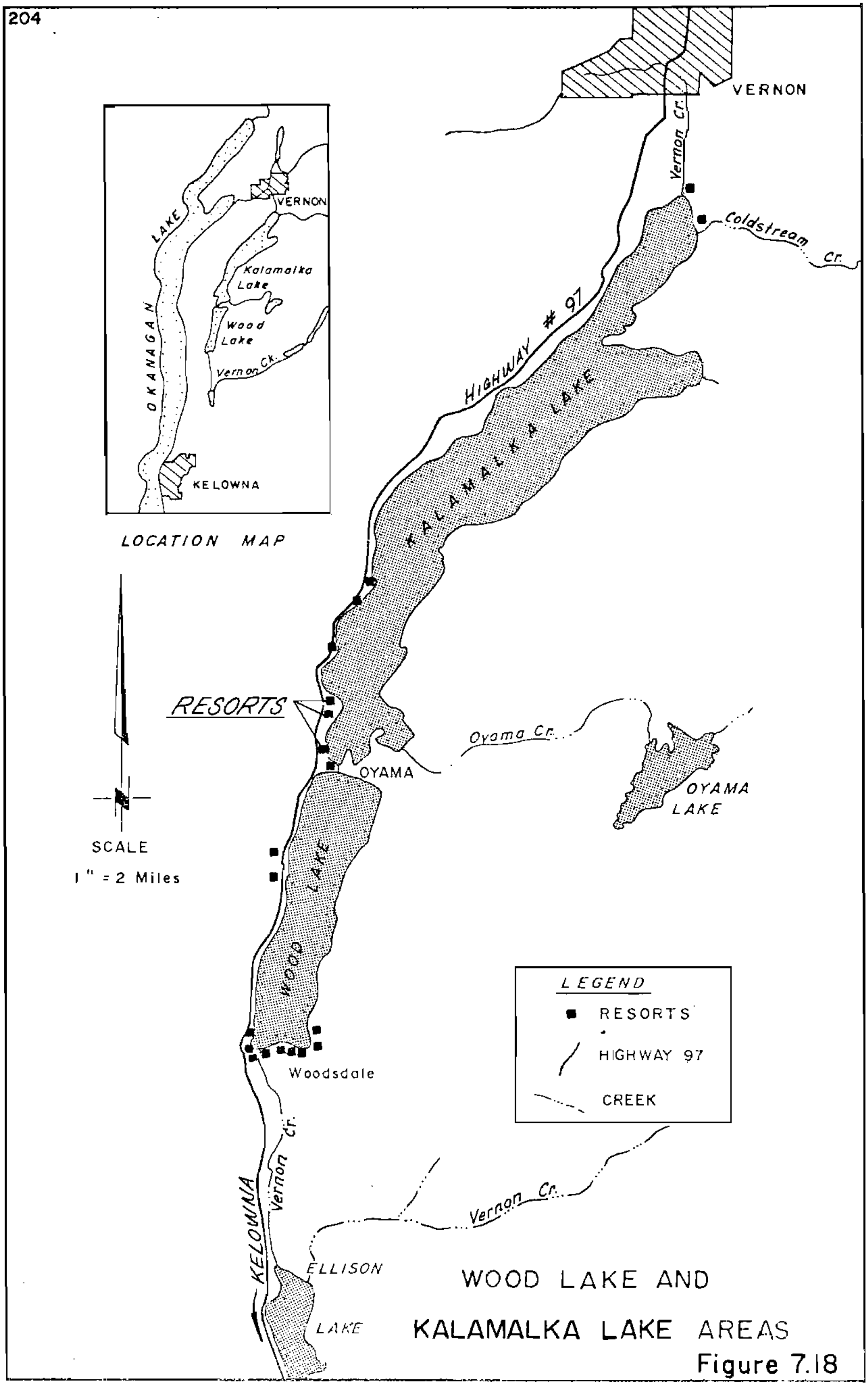
	PER MONTH ($)	PER YEAR ($)
Natural Gas	$ 11.50	$ 138.00
Electricity	8.50	102.00
Telephone	5.50	66.00
Water	5.00	60.00
Sewage Treatment	5.00	60.00
Cablevision	5.00	60.00
Fire Protection	3.00	36.00
Garbage Collection	1.25	15.00

7.7 WOOD AND KALAMALKA LAKE STUDIES

A number of special studies on the impact of water quality problems on beach recreation and the tourist industry were undertaken around Wood and Kalamalka Lakes during the summers of 1971 and 1972. In view of the close proximity of these two lakes (Figure 7.18) and the sharp difference in water quality conditions - Kalamalka having the highest levels of water quality, while Wood Lake experienced, in 1971 the poorest conditions - it was considered possible that contrasts in beach user behaviour and attitudes towards water quality in these two lakes would be highlighted. Furthermore, the succession of algae blooms which occurred in Wood Lake during the summer of 1971 resulted in considerable publicity in British Columbian and Albertan newspapers. This presented an opportunity to evaluate the impact of adverse publicity on the tourist industry around Wood Lake. These studies contributed to the evaluation of the social and economic consequences of possible water quality deterioration in other lakes against which the costs of controlling waste loadings to maintain high water quality could be compared.

There are eleven resorts situated around Wood Lake, seven around Kalamalka Lake and two on the narrow strip of land that separates the lakes. Most resorts contain cabin and motel units while two cater exclusively to campers. The total maximum number of tourists residing in the area at any one time is approximately 1300. Although some of the Wood Lake resorts are situated close to the major highway and cater to the 'passing tourists', most of them rely heavily upon the repeat trade of regular family customers.

Two surveys were undertaken during the summers of 1971 and 1972. In late July and August, 1971, immediately following the major algae bloom on Wood Lake 115 tourists were contacted, (69 around Wood Lake and 52 around Kalamalka) to gain some immediate reactions to the bloom on Wood Lake and compare these reactions with those of Kalamalka resort customers. In July-August, 1972, 35



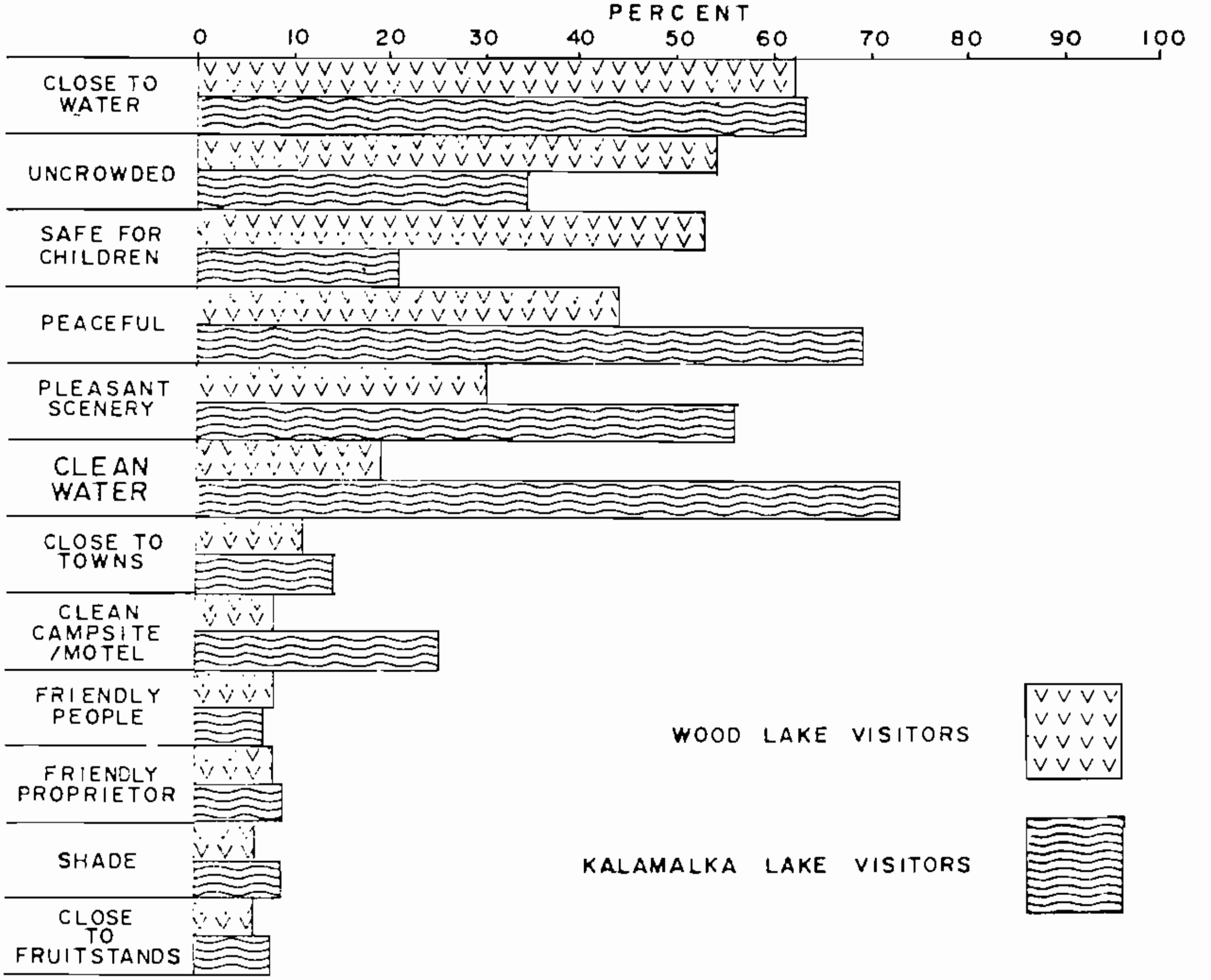
WOOD LAKE AND KALAMALKA LAKE AREAS

Figure 7.18

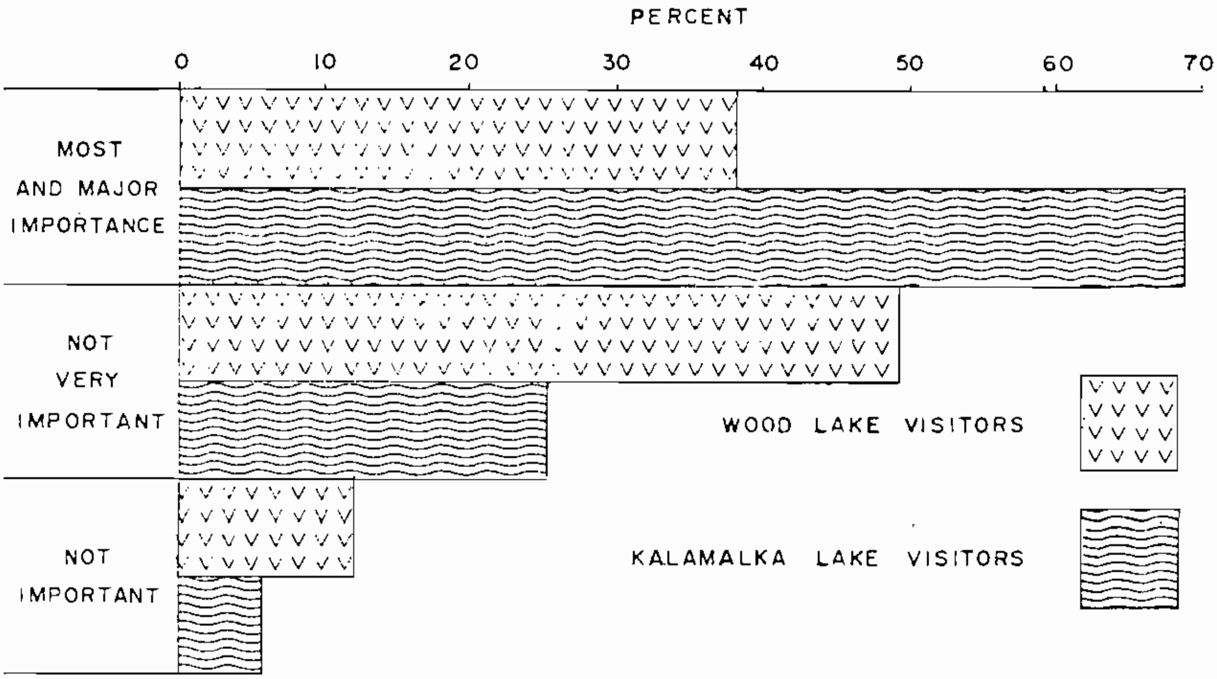
tourists were interviewed around Wood Lake as part of the sub-sample located at poor water quality sites. In addition to providing more information on the reaction of tourists to water quality problems, the responses allowed an assessment of possible changes in the characteristics of the Wood Lake resort customers due to the blooms of the previous summer. Finally, a detailed accounting was made of the revenues received at all Wood Lake resorts to determine any changes in net returns for the summers of 1971 and 1972 compared with those of previous summers before the algae blooms gained widespread publicity. All Wood Lake resort owners were also interviewed to assess the effect of water quality on the economics of their businesses. These three surveys provided a comprehensive information base for evaluation purposes and are discussed more fully in Technical Supplement VIII.

In 1971, respondents at both lakes were asked to identify features that attracted them to the respective lakes. Wood Lake tourists placed most emphasis on the proximity of the resorts to the lake, safe beaches and quiet conditions. Only 18% mentioned water quality while almost 70% of Kalamalka Lake respondents mentioned clean water (Figure 7.19). Following further probing 69% of Kalamalka tourists stated that water quality was the most important factor in their decision to return compared with only 38% of Wood Lake respondents (Figure 7.20). The 1972 survey confirmed the 1971 findings, indicating that Wood Lake tourists, particularly those with previous experience of the lake, appear to be less sensitive to water quality problems than their Kalamalka counterparts. The Wood Lake tourists appeared generally satisfied with water quality conditions prevailing in 1972. In fact, the vast majority of tourists at both lakes indicated their desire to return and to recommend the resorts to friends. Only during the early testing of the 1971 questionnaire, when Wood Lake was still experiencing algae blooms did a significant number of respondents (44%) indicate dissatisfaction with conditions and stated they would not return unless the water quality substantially improved.

As a check on whether Wood Lake tourists did in fact return in 1972 after the blooms of 1971, the responses to questions on the frequency of return to the lake were compared (Table 7.5). Most of the respondents in both surveys had previous holiday experience in the Okanagan. Only 22% and 14% of visitors in 1971 and 1972 respectively were visiting the valley for the first time. In 1972, 62% of tourists were newcomers to Wood Lake area, compared with 27% in 1971. Although some of this difference may be due to slight changes in wording of the question, the results do lead to the conclusion that a large number of regular tourists to Wood Lake had not returned in 1972 and that these had been replaced, at least in part, by newcomers.



ATTRACTIVE FEATURES OF THE WOOD LAKE AND KALAMALKA LAKE AREAS **Figure 7.19**



IMPORTANCE OF WATER QUALITY IN DECISIONS TO RETURN TO WOOD LAKE AND KALAMALKA LAKE **Figure 7.20**

TABLE 7.5

PREVIOUS VISITS TO THE OKANAGAN VALLEY
BY WOOD LAKE VISITORS

1971 SURVEY		1972 SURVEY	
YEAR	% VISITORS	YEAR	% VISITORS
Before 1966	48	Before 1967	59
The Year 1966	35		
" " 1967	41		
" " 1968	51	1967 - 1969	70
" " 1969	57		
" " 1970	44	1970 - 1971	70
1st time 1971	22	1st time 1972	14

PREVIOUS VISITS TO WOOD LAKE BY WOOD LAKE RESPONDENTS

1971 SURVEY		1972 SURVEY	
YEAR	% VISITORS	YEAR	% VISITORS
Before 1966	21		
The Year 1966	17	Before 1967	13
" " 1967	19		
" " 1968	24	1967 - 1969	28
" " 1969	30		
" " 1970	33	1970 - 1971	36
1st time 1971	27	1st time 1972	62

This conclusion was supported by a survey of Wood Lake resort operators. Many of these operators stated that their enquiry rates, advance bookings and number of return customers had declined in 1972 over previous years. They tended to blame publicity in newspapers for this rather than direct experience by tourists. Actual income losses were quite small however, because the return visitor was replaced by 'passing trade'. These are customers who only stay one or two nights while en route to other destinations, the 'overflow' from tourists who could not find accommodation at Kelowna during the annual Regatta, or tourists who were unable to stay at campsites around Mara and Shuswap Lakes due to flooding of such sites during June and July.

Operators of eleven Wood Lake resorts estimated that they had lost $7,440 or 8% of their normal July and August revenues in 1971 as a result of poor water quality conditions and adverse publicity. In July and August 1972, the six resorts for which comparative information was available lost $10,500 or 14% of their expected revenues. Losses varied considerably between resorts, with some sustaining greater losses in 1972 than in 1971, even though water quality conditions had improved substantially in 1972. In contrast, the Kalamalka Lake resorts showed increases in revenue from 1970 to 1972 averaging 7% per year.

These data were confirmed by statistics obtained from the B.C. Consumer Taxation Board which taxes revenues from resorts with motels and cabin accommodation, but not campground units. Table 7.6 indicates revenue trends for Wood Lake and Kalamalka Lake resorts for 1971 and 1972 and confirms that Wood Lake resorts did suffer revenue losses while Kalamalka Lake resorts maintained their income. The addition of campsite revenues at the Kalamalka Lake resorts would undoubtedly have changed the small deficit shown in the table into a gain. It could not be determined whether some of the losses around Wood Lake were made up by gains elsewhere in the Okanagan, in which case there would be no net economic loss to the Okanagan as a whole. Nevertheless, there was considerable social inconvenience to Wood Lake resort operators and this should be accounted under the social well-being goal.

Of the eleven resorts around Wood Lake, six were sold between 1970 and 1972. Three of the operators who sold in 1972 stated that the occurrence of algae blooms of 1971 had been a major factor in their decision to sell. They estimated a combined loss over $80,000, or 20% below their anticipated selling price if good water quality conditions had prevailed in Wood Lake. In addition several of the other resort owners had contemplated extensions or renovations to their properties but had decided to delay these projects indefinitely or until some efforts are made to improve lake quality.

In summary, it appears that the present localised lake water quality problems of weed growth and occasional algae blooms did not seriously affect the enjoyment of shoreline recreation by visitors and residents in 1972. Most beach users are able to locate satisfactory water quality sites or are willing to put up with relatively poor water quality conditions in favour of other benefits such as quiet, uncrowded facilities and safe beaches for children. There are indications that there was considerable dissatisfaction during and immediately after the algae blooms on Skaha Lake in 1967 and Wood Lake in 1971, resulting in the loss of a number of regular tourists to the Okanagan.

TABLE 7.6

REVENUE TRENDS AT WOOD AND KALAMALKA LAKE RESORTS

	SEVEN WOOD LAKE RESORTS	FOUR KALAMALKA LAKE RESORTS
Total Revenue July and August 1971 ($)	51,363	43,041
Total Revenue July and August 1972 ($)	43,702	42,438
TREND	-7,661	-603
Average Revenue July & August 1971 ($)	7,338	10,760
Average Revenue July & August 1972 ($)	6,243	10,610
TREND ($)	-1,095	-150
TREND (%)	-14.9	-1.4

Source: Consumer Taxation Branch, B.C. Department of Finance.

The short term localized algae blooms on Wood Lake during 1971 appear to have resulted in limited direct economic impacts on the resort owners, but created significant social costs due to the greater uncertainty associated with catering to 'passing trade' rather than regular customers and in preparing future plans for their businesses. It seems reasonable to assume however, that if widespread problems of deteriorating water quality were to develop in other lakes in the future, the social and economic consequences on the tourist trade, as well as the well-being of valley residents could be compounded greatly as there would be few of the mitigating factors which apparently offset the potential losses around Wood Lake.

7.8 CROWDING AND SHORELINE LANDUSE CAPABILITY

In addition to water quality, one of the other potentially distracting features of Okanagan beaches appeared to be crowded conditions. Studies of beach users perception and attitudes toward crowding at public beaches were undertaken to assess the adequacy of the existing supply of beach area with current demands. These data were also used to evaluate the capability of shoreline land resources to satisfy projections of beach recreation demands over the next 50 years.

Table 7.7 compares existing demands for shoreline recreation with availability of recreational facilities for each of the four major regions in the Okanagan. In 1970, the estimated 485,400 summer visitors spent 1.7 million visitor days on Okanagan beaches, and residents enjoyed an additional 2.2. million beach days, for a total of 3.9 million beach days. Approximately 35% of this total participation occurred in the Kelowna region, 30% in the Penticton region and 25% and 10% in the Vernon and Oliver-Osoyoos regions respectively. In contrast, the Penticton region contains the largest share (42%) of beach area, followed by the Kelowna region with 37%, the Vernon region (14%) and Oliver-Osoyoos region (7%). Although there is some apparent divergence between the regional distribution of supply of beach area and beach use, particularly in the Penticton and Vernon regions, participation varies considerably at different locations and different times so that inferences about beach crowding cannot be readily drawn from these findings. An assessment of beach users reactions to crowding was therefore undertaken as part of the 1972 questionnaire survey.

The total sample of 446 beach users contacted during the summer of 1972 were asked to rate the degree of crowding at the location of interview. Approximately two-thirds of both visitors and residents considered the level of crowding to be low or very low. The sample of respondents were interviewed under the range of conditions normally experienced by the observed population of beach users. However, about half of both residents and visitors noted that beaches were generally becoming more crowded during the period of their experience in the Okanagan.

TABLE 7.7

RESIDENT AND TOURIST BEACH DAYS BY REGION, 1970

REGION	COMMERCIAL[1] VISITORS	NON-COMMERCIAL[2] VISITORS	RESIDENTS	TOTAL	PERCENTAGE
Oliver-Osoyoos	167,000	31,000	180,800	378,800	9.6
Penticton	578,100	93,200	542,400	1,213,700	30.9
Kelowna	282,600	159,200	926,600	1,368,400	34.8
Vernon	256,900	104,800	610,200	971,900	24.7
TOTALS	1,284,600	388,200	2,260,000	3,932,800	
PERCENTAGE	32.7	9.9	57.4		

AVAILABILITY OF PUBLIC RECREATION SITES BY REGION, 1970

Area in Acres

REGION	SAND	GRASS	OTHER GRASS[3]	MISCELLANEOUS[4]	TOTAL	PERCENTAGE
Oliver-Osoyoos	4.0	3.4	0	22.1	29.5	8.5
Penticton	35.4	8.9	33.5	83.3	161.1	45.9
Kelowna	25.3	13.2	26.3	21.9	86.7	24.7
Vernon	11.3	3.7	0	58.4	73.4	20.9
TOTALS	76.0	29.2	59.8	185.7	350.7	
PERCENTAGE	21.7	8.3	17.0	53.0		

[1] Visitors staying at hotels, motels, campsites

[2] Visitors staying with friends

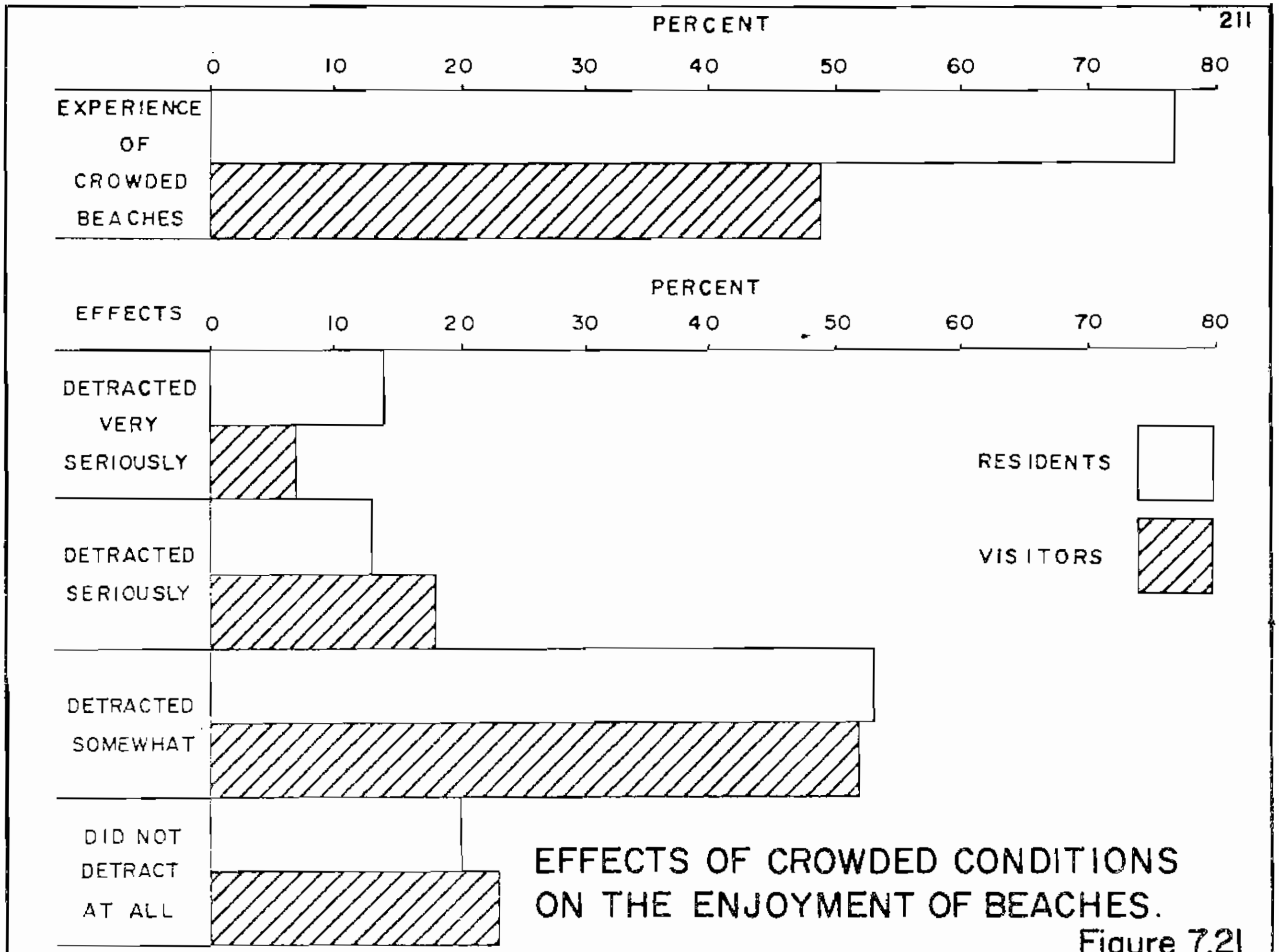
[3] Grass not used for shoreline recreation - parks, etc.

[4] Parking areas, access points

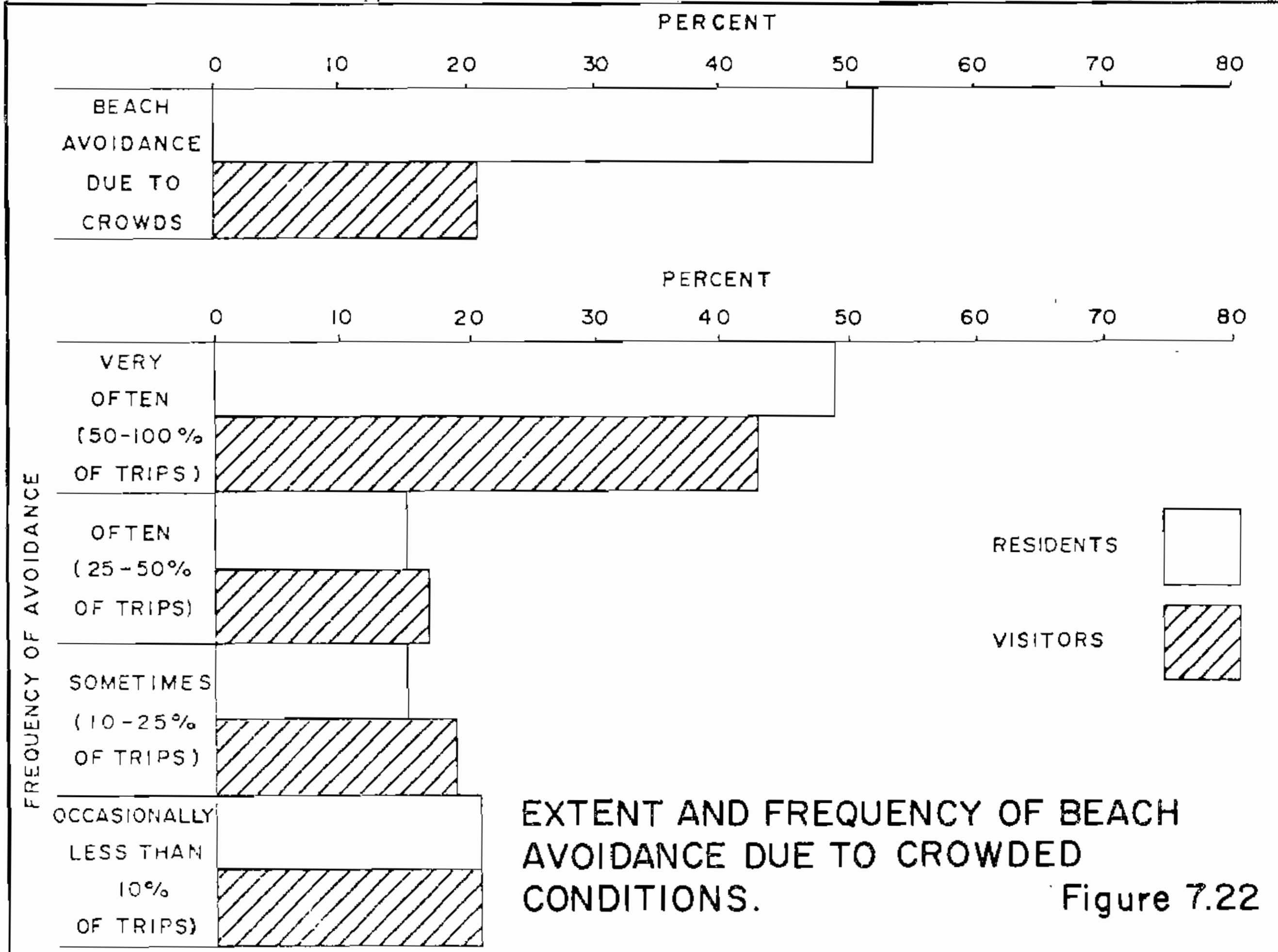
Source: 1. Economic Survey of Holiday Accomodation
2. Tourist and Resident Surveys

Although approximately three-quarters of the residents and over half the visitors stated they had experienced crowded conditions on Okanagan beaches, only 27% and 25% of these respondents respectively considered this seriously detracted from their recreational enjoyment (Figure 7.21). In fact, some respondents (mainly under 25) commented that crowds were an attractive feature of certain beaches.

A much higher proportion of residents as compared to visitors actively avoided going to beaches that they considered crowded. Over half the residents avoided crowded beaches, and only 20% of visitors did so (Figure 7.22), though most of both groups stated they frequently sought quieter beaches. Skaha Beach, Okanagan Beach at Penticton and City Beach at Kelowna were avoided



EFFECTS OF CROWDED CONDITIONS ON THE ENJOYMENT OF BEACHES.
Figure 7.21



EXTENT AND FREQUENCY OF BEACH AVOIDANCE DUE TO CROWDED CONDITIONS.
Figure 7.22

most frequently. People who are particularly sensitive to crowding may have avoided certain beaches where interviews were conducted, with the result that the seriousness of this issue, like the problems of water quality, may be under-estimated.

A limited number of direct observations of density patterns provided additional information on crowding at Okanagan beaches. These observations were obtained by actual counts during afternoons from aerial photographs taken on holiday weekends. The following figures provide an approximate indication of the maximum number of people observed on the sand and grass or in the water at the major public beaches at any one time during the summer of 1972:

Osoyoos Community Park	- 300
Skaha Lake Beach, Penticton	- 3,500
Okanagan Lake Beach, Penticton	- 1,000
Sun-oka Beach, Summerland	- 800
Kelowna City Beach	- 800
Kalamalka Lake Beach, Vernon	- 1,500

7.9 THE VALUE OF SHORELINE RECREATION

Shoreline recreational activities place demands on both water and land resources in the Okanagan. The preceding discussion has indicated the desire of most recreationists for high quality water and to some extent there is also an implicit demand for maintaining lake levels suitable for swimming and paddling. In addition, shoreline recreation places demands on the limited shoreline resources around the main lakes. Other resource uses also compete for the same water and land resources. For example, waste discharges from municipal and industrial sources may reduce the quality of water desired for body contact recreation. Water for irrigation, domestic and municipal use and to support fishery resources in Okanagan River may create drawdowns of Okanagan Lake in drought years (Chapter 4). Increasing demands for private development of shorelines is reducing the available land base for shoreline recreation management.

As these conflicts could increase in the future, some basis for allocating the limited water and shoreline land resources must be devised. Allocation decisions have been traditionally resolved through monetary values with resources being allocated so that the greatest net economic gain will result. Unfortunately, values associated with shoreline recreation cannot readily be put into monetary terms. Recreationists have free access to all public beaches in the valley and the value of a day at the beach through payment of a fee cannot be used as a measure. Thus no data were available to compare the economic and social values of shoreline recreation with the values of other competing uses of shoreline land and water resources. In view of the increasing importance of shoreline recreation to both tourists and visitors, there is now a need to understand some of the values associated with this activity so that allocation decisions on water and land resources can be made as part of the comprehensive framework plan.

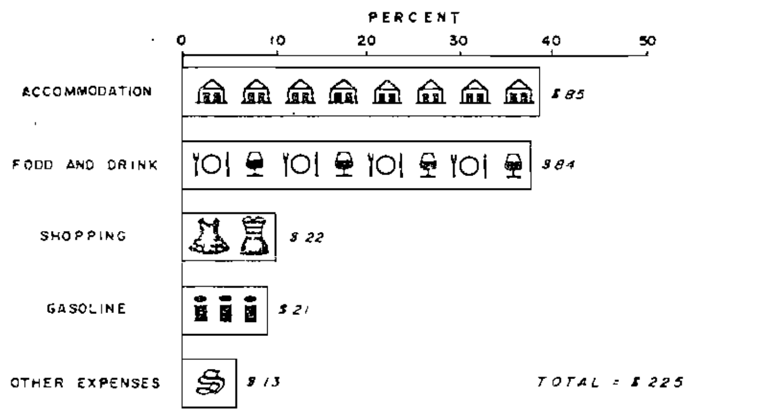
As the viewpoint for economic analysis in this study was related to the Okanagan basin, different methods were used to place values on shoreline recreation for residents and tourists. The value of tourist participation was related to their direct expenditures while in the basin. More specifically, these values were related to the expenditures lost through the reduction in visitor days should shoreline recreation resources not be available in the Okanagan. To obtain the appropriate estimate of net economic value, total costs to the valley residents for providing goods and services to tourists were deducted from gross expenditures. It is worth stressing that net expenditures obtained by this procedure reflected the value of demand and not the beach values per se, but in lieu of any direct measure of the worth of recreational activities, expenditures were used as substitute data.

Resident participation in shoreline recreation contributes to both the economic and social betterment goals of the Okanagan Study. Economic values include expenditures on travel, rentals and equipment. As shoreline recreation is a unique recreational experience in the Okanagan, it seems a reasonable assumption that in the absence of such opportunities in the valley, residents would spend a portion of their recreational budget pursuing such experiences in other regions outside the Okanagan.

In addition to these economic values there are also social or aesthetic benefits associated with beach recreation. Attempts were made to assess these benefits in dollar terms though the questionnaire survey by asking residents to compare the satisfaction gained by all or part of a day at the beach with other recreational experiences for which they are required to pay a fee, such as golf, skiing or skating. These comparisons are discussed more fully in Technical Supplement VIII.

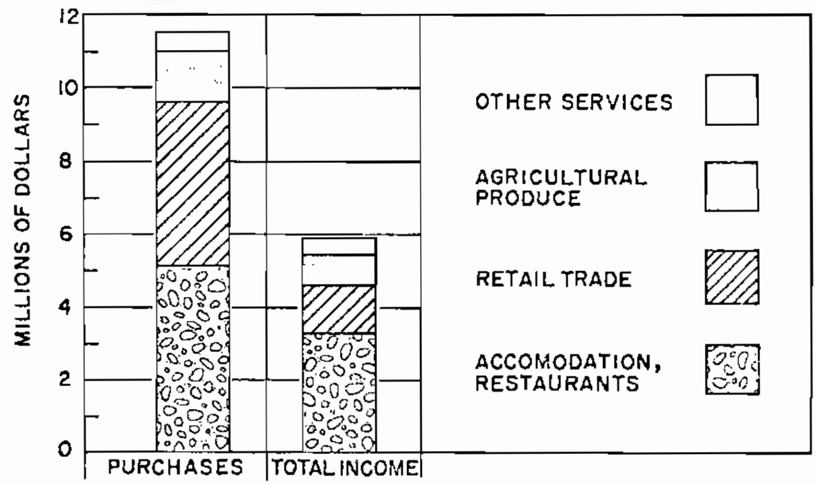
7.9.1 Tourist Expenditures

Average gross expenditures per group of summer tourists amounted to $225, the major items being accommodation at $85, with food and drink $84, (Figure 7.23).



AVERAGE EXPENDITURE PER GROUP OF SUMMER TOURISTS. Figure 7.23

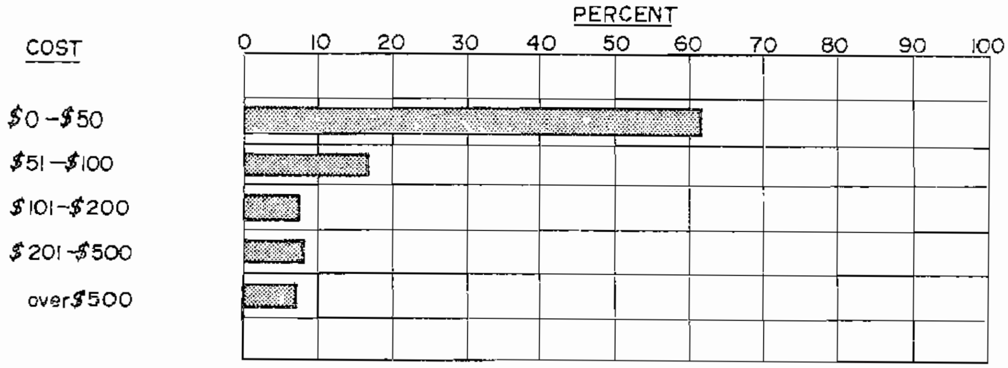
The variation in lengths of stay results in a considerable variation in gross expenditures from group to group. A more useful statistic is the average expenditure per visitor day, which amounted to $4.50. Total spending by summer holiday tourists in 1970 was estimated at $11.5 million (Figure 7.24). Subtracting the costs of providing goods and services to satisfy tourist demands, the net value of this expenditure to the Okanagan residents amounted to $5.9 million. As expected, over half (53%) of this total income was received by accommodation units and restaurants, while nearly a quarter (24%) was claimed by retail outlets. Almost $1 million was earned directly and indirectly through the sale of tree fruits, grapes and other agricultural products at road-side stands, again illustrating the important relationship between tourism and agriculture in the Okanagan. While not all of this economic return can be claimed as representing the value tourists place on enjoying shoreline recreation experiences, it appears that a considerable portion of it waslinked to these activities. The fact that more than 60% of summer tourists spend all or part of every day on Okanagan beaches during their stay, emphasized the importance of this component in their total holiday experience in the Okanagan.



PURCHASES OF GOODS & SERVICES BY SUMMER TOURISTS AND THE RESULTING INCOME TO OKANAGAN RESIDENTS,1970. Figure 7.24

7.9.2 Resident Values

As a result of the close proximity of a variety of water-based recreational resources, residents do not spend much money on such recreational opportunities. Figure 7.25 indicates that over 60% of residents spent less than $50 in 1970 in pursuit of the whole range of water-based recreation activities and almost 80% spent less than $100. During 1970, total gross expenditures by residents were estimated at $2.8 million, of which $1.1 million was spent by resident fishermen (Chapter 8). Of the remaining $1.7 million, approximately $600,000 was returned as net income to the Okanagan economy after deducting the costs of supplying recreational services, mainly travel and equipment purchases.



FINANCIAL EXPENDITURES ON WATER-BASED RECREATION DURING 1970-71

Figure 7.25

Because there is no fee attached to enjoyment of beach recreation, net expenditures by tourists and residents cannot be equated with the total value of such activities. Both residents and tourist beach users were asked how much a day at the beach was worth over and above their estimated expenditures. Because most recreationists do not easily associate economic values with non-priced recreational activities, considerable difficulty was encountered in gaining meaningful responses to this question. About 20% of respondents could not translate their satisfaction into financial terms and an additional 7% could not stipulate specific amounts. Many of these respondents considered their experiences to be 'priceless'. The median value for resident beach users who could provide some estimate was $5.50 per beach day, while the median value by tourists was approximately $5.00 per beach day.

Applying these values to the total number of resident and visitor beach days provided an estimate of the total social value of shoreline recreation in the Okanagan in 1970. The number of beach days enjoyed by residents and tourists respectively in 1970 was estimated from participation rates obtained from the questionnaire surveys and amounted to 1.6 million for visitors and 2.2 million for residents. Thus, the social value of resident participation in shoreline recreation was estimated at $11.1 million and $8.5 million for residents and visitors respectively to totalling $19.6 million for 1970. This figure represents the additional social value shoreline recreationists place on their activities in the Okanagan over and above their direct expenditures. This total gives some expression of the recreationists' willingness to pay for their enjoyment of beach recration. However, as no actual payments are involved, these values should be accounted under the social well-being goal and separated from the expenditure dollars which accrue to the economic growth goal of the Okanagan Study.

7.10 SUMMARY

The opportunity to enjoy shoreline recreation in the hot, dry summers of the Okanagan is undoubtedly a major attraction for tourists and visitors. On average, visitors are estimated to frequent beaches on 60% of the days spent in the Okanagan, while residents are estimated to visit beaches on 20 days between the beginning of June and the end of September. It appears that the existing availability of public and private beaches around the main valley lakes can presently accommodate the 3.8 million beach days enjoyed by residents and tourists during 1970.

Residents tended to be more familiar and more critical of shoreline recreational resources than tourists. Residents had visited more beaches, were more aware of water quality and beach crowding problems and generally took more action to avoid these conditions than visitors, who appeared content to frequent the beach nearest to their place of stay. In general, beach users displayed a relatively wide range of tolerance to water quality and crowding and though there were definite complaints when either problem became prominent, as indicated by the Wood Lake algae blooms in 1971. It appeared that most beach recreationists were generally satisfied with the range of water quality and crowding conditions which existed during the summer of 1972.

Although only a small proportion of the shoreline around the main lakes is actually developed for recreational activities, much of this area is high quality recreational land. Most residents and visitors appeared to be able to find a satisfactory location within a short travel time of their place of stay. As for the future, indications are that high quality recreation sites are potentially available on undeveloped shoreline, provided that appropriate measures are undertaken to protect these from private development.

The net economic value of expenditures by summer holiday visitors totalled about $6 million in 1970. Although this total represents the net value of all goods and services purchased by tourists while in the Okanagan, it does provide some indication of the economic worth of beach recreation to tourists in the absence of any other direct evidence. In addition, there is an unpaid value of beach recreation to residents and tourists estimated at $11.1 million and $8.5 million respectively which is the best estimate of the social and environmental values associated with shoreline resources. Projected values and management alternatives concerning these resources over the next 50 years are presented in Chapter 16.

CHAPTER 8

Fisheries and Water Management

Fishery values, in the Okanagan Basin are dependent on water quantity and water quality within the system. While fish are not consumptive water users, they are demanding in terms of lake level maintenance and tributary and main river flows throughout much of the year. Water quality plays a determining role in the supply of vital life constituents to fish, as do surrounding land use practices. Fish also play a role as indicators of water quality as is outlined in Chapter 6 of this report. Fisheries within the Okanagan system are self supporting with the exception of rainbow trout in the headwater lakes, which are in large part produced in hatcheries and sockeye salmon which spend part of their life at sea. Thus, the future of the fishery, and fishing, in the Okanagan system is closely linked to water management within the basin.

Sport fishing, a significant component of water based recreation, provided approximately 158,000 angler days in the basin in 1971. Over half of this (53.5%) was spent on the main valley lakes and almost half (42%) on the headwater lakes. Stream and river fishing account for the remaining comparatively small amount of time. This recreational pursuit provides a social value to valley residents as well an economic value derived from the tourist sportfishing industry.

A substantial sockeye salmon run (averaging 19,000 spawners annually) use the Okanagan River in Canada for spawning and Osoyoos Lake for rearing. These fish supply a significant portion of the commercial sockeye catch attributed to the Columbia River in the United States and also support a local native Indian ceremonial and food fishery.

The main purpose of fishery investigations under the Okanagan Basin Study has been to determine the existing demand for sport fishing and its value, as well as the capacity of the basin lakes to support sport fisheries so that future management options could be explored. More specifically these fishery studies included the following components:

(a) the role played by each of the four segments of the system; headwater lakes, tributary streams, main valley lakes, the Okanagan River. The inter-relationships of each segment with the whole were also explored,

(b) the effects of water quantity management on fishery resources,

(c) the effects of water quality on mainstem fishery resources,

(d) the determination of fishery capacities in the system,

(e) the social and economic values of the fisheries.

8.1 PRESENT FISHERY RESOURCE (1971) AND UTILIZ TION

The four segments - headwater lakes, tributary streams, main valley lakes, and Okanagan River - while generally discrete within the system, do have certain vital inter-relationships that should be noted (Figure 8.1):

(1) Rainbow trout and kokanee from the main valley lakes utilize tributary streams habitats for reproduction.

(2) Streamflows, generated in part by discharge from headwater lakes and reservoirs, are vital to the production of in-channel stream fisheries, and to reproduction by rainbow trout and kokanee from the main valley lakes.

(3) Many of the headwater lake fi ies are vulnerable to lake draw-down for meeting stream discharge uirements including inchannel fishery needs.

(4) The Okanagan River sport fishery is heavily dependent on the migration of fishes from the main valley lakes, particularly Skaha, Vaseux and Osoyoos.

(5) Propagation of sockeye salmon (and other species) in Okanagan River is dependent on water releases from Okanagan Lake. Such releases will in turn draw down the level of Okanagan Lake which may affect shore spawning kokanee, and access to the tributary streams.

(6) Sockeye salmon, propagated in Okanagan River, rear in Osoyoos Lake.

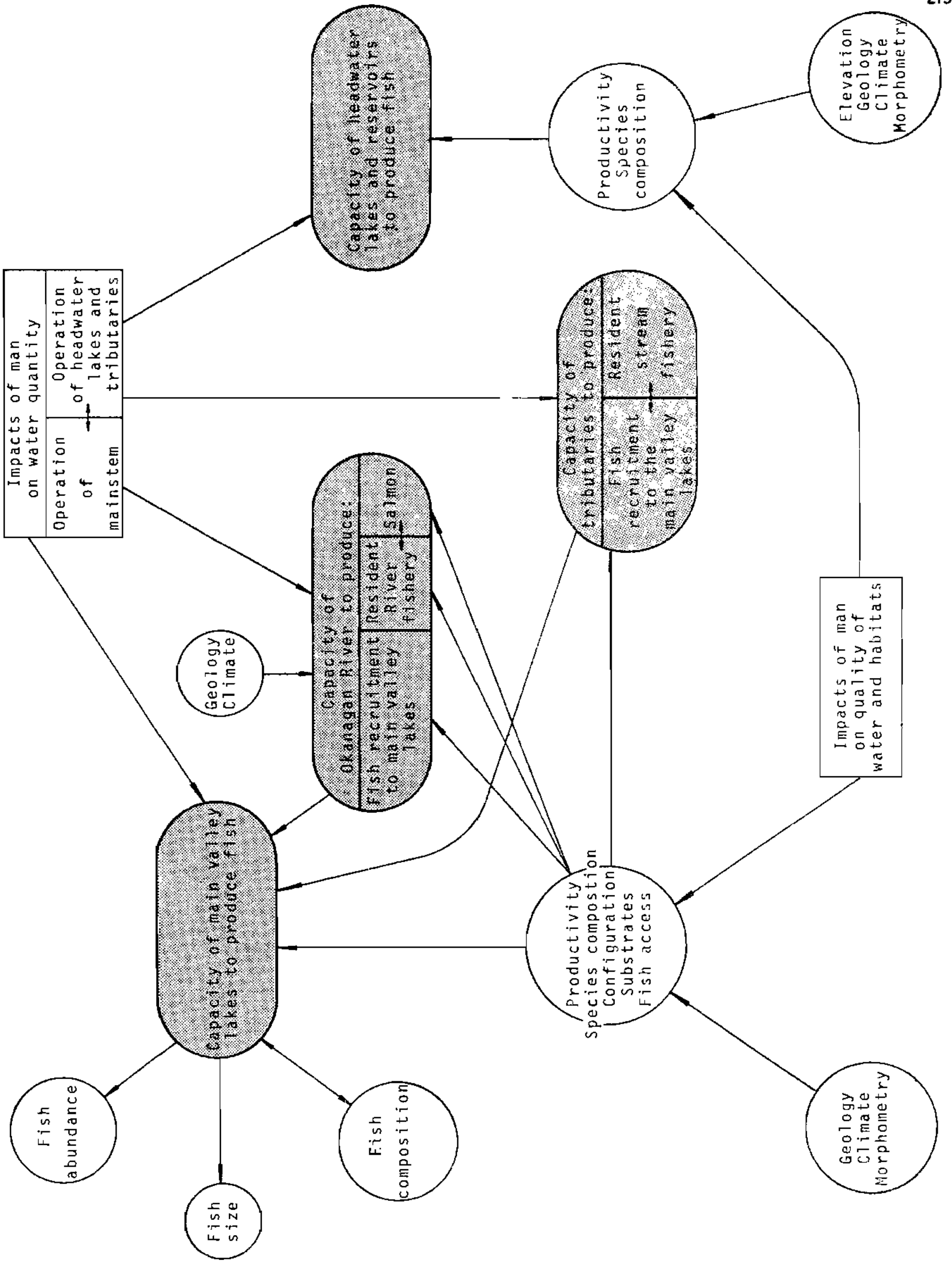
Harvest Capacities of Headwater Lakes and Reservoirs

The headwater lakes support a significant and popular sport fishery primarily for rainbow trout. Headwater lakes for purposes of this study have been defined as all lakes within the basin exclusive of the six main valley lakes.

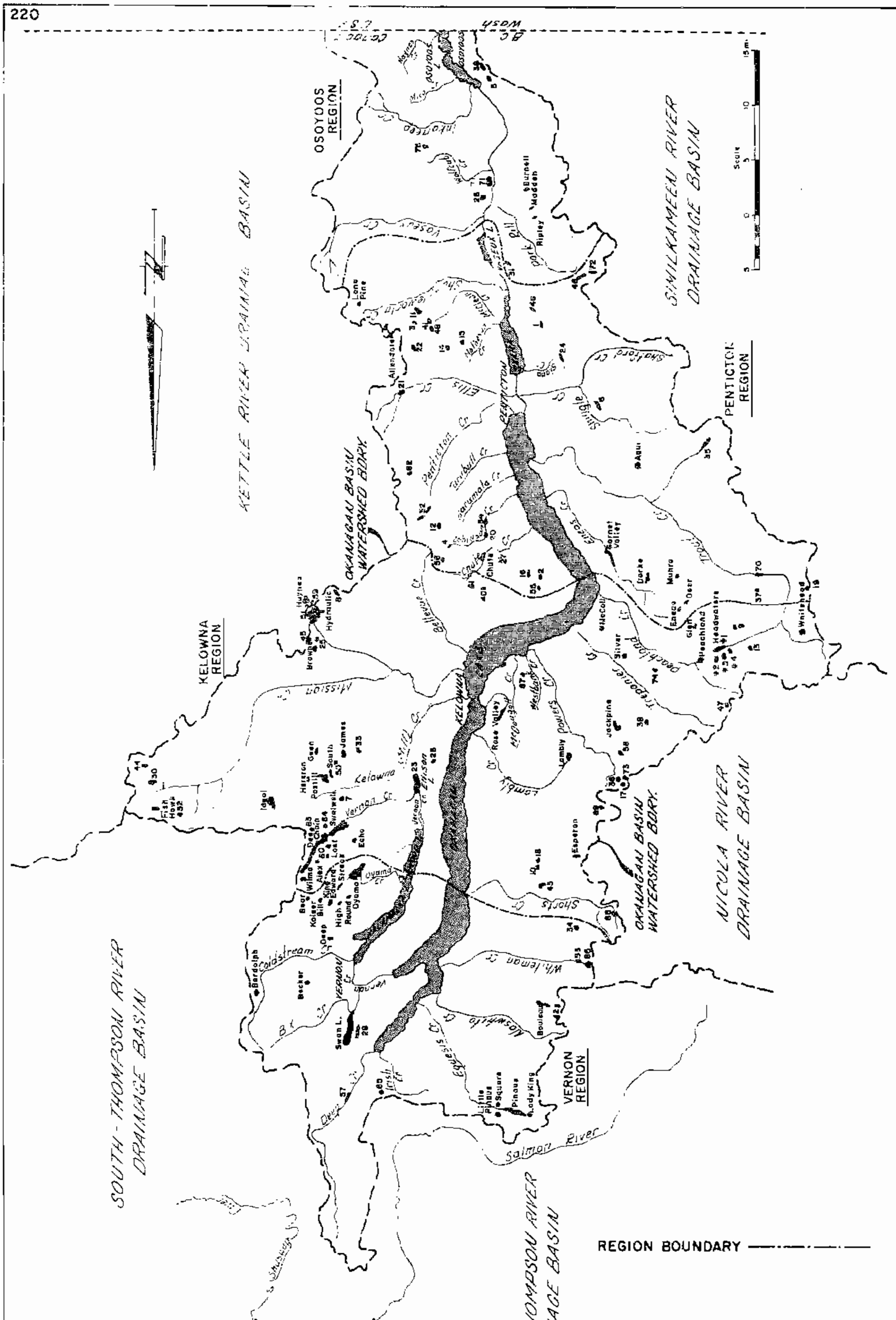
Analysis of fishery capacities of the headwater lakes was derived on the basis of 57 "key" lakes for which creel census data were obtained and which support the bulk of headwater fishing activity (Fig. 8.2).The analysis was extrapolated to 75 "additional" headwater lakes which have sport fishing potential, but are at present only marginally or not utilized (Figure 8.2a).

Elevation plays a predominant role in fish productivity, and the fisheries of the Okanagan headwater lakes have therefore been analysed according to elevation boundaries. Table 8.1 indicates lake distribution according to elevation, and Table 8.2 the basic carrying capacity of these lakes.

With few exceptions the headwater fisheries are heavily dependent on artificial stocking. The ability of a stocked lake to produce catchable sized trout is dependent primarily upon the basic productive capacity of the lakes and the density of competitor and/or predator species. The carrying capacity of British Columbia



BASIC FACTORS AND INTER-RELATIONSHIPS CONTROLLING FISH PRODUCTIVITY IN THE OKANAGAN BASIN. Figure 8.1



LOCATION OF HEADWATER LAKES AND STREAMS IN THE OKANAGAN DRAINAGE BASIN.

Figure 8.2

75 ADDITIONAL HEADWATER LAKES IN THE OKANAGAN BASIN KNOWN TO HARBOUR SPORT-FISHING OPPORTUNITIES-AS SHOWN IN FIGURE 8.2

LAKE	REGION	ELEVATION (in feet)	SURFACE AREA (acres)
1. Aeneas	Penticton	2,400	38
2. Baker	Penticton	4,500	25
3. Big Clarke	Penticton	5,300	13
4. Big Meadow	Penticton	5,400	56
5. Blue	Osoyoos	2,750	5
6. Brent	Penticton	2,700	58
7. Bulman	Kelowna	4,400	62
8. Canyon	Kelowna	5,500	40
9. Chapman	Kelowna	5,600	25
10. Christie	Kelowna	4,400	7
11. Clarke Meadows	Penticton	5,000	19
12. Corporation	Penticton	5,700	12
13. Crescent	Kelowna	4,500	80
14. Culper	Penticton	5,700	8
15. Derenzy	Penticton	5,300	18
16. Divide	Penticton	5,000	14
17. Dobbin	Kelowna	4,800	20
18. Ouo Via	Kelowna	4,400	10
19. Eastmere	Penticton	4,700	30
20. Elinor	Penticton	4,100	20
21. Ellis Reservoir 1	Penticton	5,050	45
22. Ellis Reservoir 4	Penticton	4,400	100
23. Ellison	Kelowna	1,400	520
24. Farleigh	Penticton	2,500	35
25. Fish	Kelowna	4,300	35
26. Gallagher	Osoyoos	1,400	17
27. Gemmill	Penticton	4,700	8
28. Glenmore Reservoir	Kelowna	1,200	18
29. Goose	Vernon	1,600	89
30. Graystoke	Kelowna	6,000	89
31. Green	Osoyoos	1,600	44
32. Greyback	Penticton	5,200	307
33. Guest	Kelowna	4,400	28
34. Hudson Bay	Vernon	5,200	15
35. Isintok	Penticton	5,400	97
36. Islaht	Kelowna	4,800	67
37. Kathleen	Penticton	4,500	5
38. Kilpoola	Osoyoos	2,750	42
39. Lacome	Kelowna	3,500	13
40. Lebanon	Kelowna	4,000	3
41. Little Clarke	Penticton	5,100	11
42. Little Bouleau	Vernon	4,600	40
43. Loch Drinkie	Kelowna	4,600	45
44. Loch Katrine	Kelowna	6,400	30
45. Long Meadow	Kelowna	4,300	60
46. Lower Twin	Penticton	2,700	82
47. MacDonald	Kelowna	5,600	12
48. McLean Clan	Penticton	5,300	25
49. Marron	Penticton	2,000	35
50. Meadow	Kelowna	4,500	12
51. Minnow	Kelowna	4,200	35
52. Mission	Kelowna	6,000	133
53. Morrison	Vernon	4,500	5
54. Naramata	Penticton	4,150	35
55. Norman	Penticton	4,600	3
56. Nuttal	Penticton	5,700	13
57. Otter	Vernon	1,150	120
58. Paynter	Kelowna	4,500	57
59. Pear	Kelowna	4,200	35
60. Rankin	Kelowna	4,800	10
61. Ratnip	Kelowna	4,100	5
62. Reed	Penticton	6,000	8
63. Rod	Kelowna	4,600	10
64. Round	Kelowna	-	-
65. Round	Vernon	-	-
66. Seaton	Vernon	4,550	30
67. Shannon	Kelowna	1,700	54
68. Shorts	Kelowna	4,600	20
69. Tadpole	Kelowna	5,300	17
70. Thirsk Reservoir	Penticton	3,400	148
71. Tugulnuit	Osoyoos	1,100	125
72. Upper Twin	Penticton	2,700	79
73. West	Kelowna	4,900	10
74. Wilson	Kelowna	4,300	12
75. Wolf	Osoyoos	2,250	3

Figure 8.2a

TABLE 8.1

DISTRIBUTION BY ELEVATION OF 137 OKANAGAN HEADWATER LAKES WITH SPORT FISHING OPPORTUNITIES OR POTENTIAL

ELEVATION (FEET)	NUMBER OF LAKES	WATER SURFACE AREA (ACRES, AT FULL SUPPLY LEVEL)
Less than 3501 feet	34	3399
3501-4000	8	987
4001-4500	45	4520
4501- 5000	24	806
5001-5500	16	819
Greater than 5500 feet	10	373
TOTALS	137	10904

TABLE 8.2

BASIC CARRYING CAPACITY FOR TROUT FRY, RECENT (1967-1971) AVERAGE TROUT INTRODUCTIONS, AND PERCENT UTILIZATION OF FRY CARRYING CAPACITY BY STOCKING FOR 57 "KEY" OKANAGAN HEADWATER LAKES

ELEVATION, FEET	NO. OF LAKES	BASIC FRY CARRYING CAPACITY AT 2500 FRY PER POUND OR EQUIVALENT		RECENT AVERAGE ANNUAL TROUT INTRODUCTIONS AT 2500 FRY PER POUND OR EQUIVALENT		PERCENT UTILIZATION OF BASIC CARRYING CAPACITY BY RECENT STOCKING
		NO.X1000	NO./ACRE	NO. X 1000	NO./ACRE	
Less than 3501 feet	14	4,225.2	2355	552.5	308	13.1
3501-4000	7	987.5	1004	160.1	163	16.2
4001-4500	22	3,498.8	906	883.1	229	25.2
4501-5000	8	694.7	1447	91.6	191	13.2
5001-5500	5	262.7	1501	41.1	235	15.6
Greater than 5500 feet	1	63.6	1479	0.0	0	0.0
TOTALS	57	9,732.5		1,728.4		17.8%

lakes for stocked rainbow trout is determined by a formula which takes into account littoral area and total dissolved solids. This formula indicates the number of fry (rainbow trout at 2500 fry per pound or equivalent) that the lake can sustain.

Present utilization of fry carrying capacity, on the basis of stocking practices between 1967 and 1971, ranges from 0 to 25 percent and averages 18 percent amongst the 57 "key" headwater lakes.

From determination of headwater lake capacities to accept fry, harvest capacities were estimated for four different sets of conditions assuming sustained harvest and artificial stocking practices.

(1) Present available harvest capacity. Number of trout harvestable annually based on present management and stocking practices.

(2) Primary potential harvest capacity. Number of trout harvestable annually given that:

(a) Recruitment supplied to the full capacity of the lake as per the stocking formula,

(b) Lake conditions at 50% drawdown for active reservoirs apply,

(c) Volumes and depths maintained are adequate to prevent winter kills,

(d) Predation and/or competition are minimal or absent.

(3) Present potential harvest capacity. The primary potential harvest adjusted downward to take into account the existing negative impact of:

(a) Reservoir manipulation

(b) Winter kill

(c) Predation and/or competition

(4) Ultimate potential harvest capacity. The primary potential harvest capacity adjusted upward in anticipation of:

(a) Nil drawdown (assuming all water retained for fisheries)

(b) Predation and/or competition minimized or eliminated.

From data collected it was found that the average age of trout caught by anglers, was linked to elevation as was average size. The average size bears an inverse relationship to elevation, while age varies directly (Table 8.3). Survival from the fry stage to catchable age is inversely related to elevation.

TABLE 8.3

AVERAGE SIZE AND AGE OF RAINBOW TROUT CAUGHT IN THE OKANAGAN HEADWATER LAKES AND CORRESPONDING SURVIVAL RATE BETWEEN FRY STAGE AND CATCHABLE AGE.

ELEVATION (FEET)	AVERAGE SIZE AT CATCHING		AVERAGE AGE AT CATCHING-YEARS	AVERAGE SURVIVAL (FRY TO CATCHABLE AGE)
	LB.	GRAMS		
< 3501	0.65	295	2	0.090
3501-4000	0.48	218	2	0.090
4001-4500	0.44	200	3	0.056
4501-5000	0.52	236	4	0.042
5001-5500	0.38	172	4	0.042
> 5500	0.24	109	4	0.042

Knowing stocking requirements, the data presented in Table 8.3, and the degree to which reservoir manipulation, winter kill and predation/competition effect various lakes, trout harvests have been computed for the specific conditions previously outlined. These data are presented in Figure 8.3.

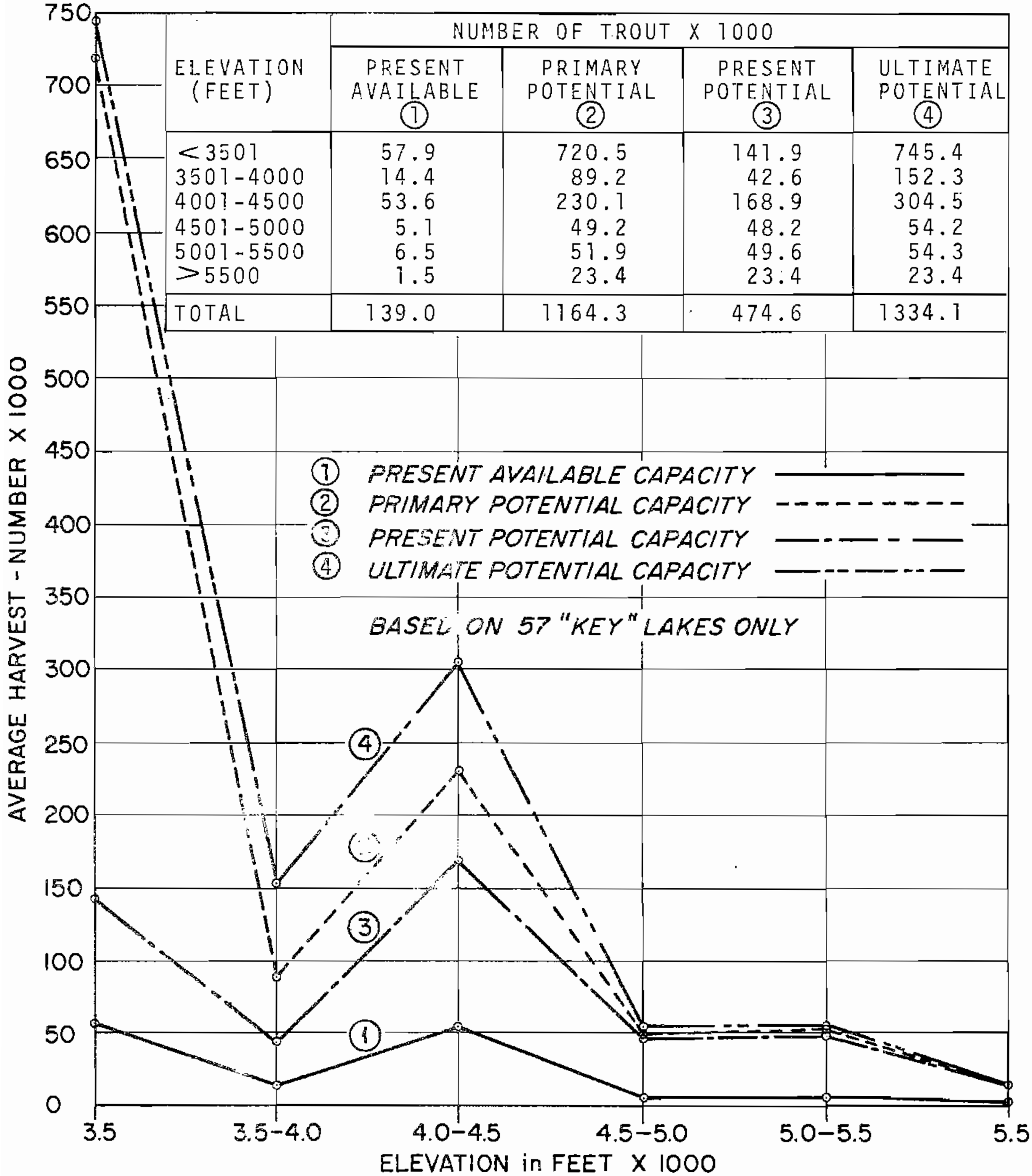
This analysis of trout harvest potentials in the headwater lakes has proceeded from an essentially assumed set of parameters and relationships which are generally true, but have not been proven in detail in this instance. Elevation is the key influence on trout productivity in this situation and has been linked to carrying capacity, harvest potential, special negative influences (drawdown, winter kill, predation) and present realized harvest.

The present potential harvest, based on saturation stocking, is 3.7 times the 1971 realized harvest. Ultimate potential harvest - the lakes abilities to produce without the constraints of limited stocking, reservoir manipulation and predator/competition interaction - is 10.6 times the 1971 realized harvest. Thus the ability of the headwater lakes to produce trout for anglers is only partially being used. Saturation stocking alone could increase yields almost four fold over present success rates, while the lakes could ultimately produce over ten times that which is presently being extracted.

8.1.2 Harvest Capacities of Tributary Streams

Sections of at least 21 tributary streams in the Okanagan Basin support viable rainbow and/or brook trout populations or did so historically. These stocks are entirely supported by natural reproduction. Most of these streams are also utilized for the reproduction, incubation and rearing of salmonid species from the main valley lakes.

ELEVATION (FEET)	NUMBER OF TROUT X 1000 PRESENT AVAILABLE ①	PRIMARY POTENTIAL ②	PRESENT POTENTIAL ③	ULTIMATE POTENTIAL ④
<3501	57.9	720.5	141.9	745.4
3501-4000	14.4	89.2	42.6	152.3
4001-4500	53.6	230.1	168.9	304.5
4501-5000	5.1	49.2	48.2	54.2
5001-5500	6.5	51.9	49.6	54.3
>5500	1.5	23.4	23.4	23.4
TOTAL	139.0	1164.3	474.6	1334.1



DISTRIBUTION BY ELEVATION OF TROUT HARVEST CAPACITIES FOR 57 KEY OKANAGAN HEADWATER LAKES. Figure 8.3

Two types of trout harvest capacity estimates were derived for the Okanagan tributary streams, both reflecting an annual sustainable harvest equilibrium:

(1) Primary potential harvest capacity - the number of trout harvestable annually given a "minimal optimum" discharge regime consistent with average annual discharge volume and present physical stream habitat.

(2) Present potential harvest capacity - the primary potential harvest capacity adjusted downward to account for present discharge regimes.

Estimates for the above are based on reference to published accounts of trout stream yields in other locales and a creel census and trout population sampling program on Trout Creek in 1971.

On the basis of other studies and data derived from the Trout Creek investigation, it was concluded that 12 pounds of trout per acre is a reasonable estimate of the primary potential sustained harvest for Trout Creek. At the small average size of stream resident rainbow trout this amounts to 178 trout per acre or 323 trout per mile. A total of 6132 trout would be available annually from the entire fishable reach of Trout Creek (from Thirsk Reservoir to the Summerland irrigation intake).

Extrapolation of the above data to the other streams was carried out and is presented in Column (2), Table 8.4. Column (3) of the same table indicates available harvest of the 21 streams under present discharge management.

TABLE 8.4

PRIMARY POTENTIAL HARVEST CAPACITIES AND PRESENT AVAILABLE HARVEST CAPACITIES OF 21 OKANAGAN TRIBUTARY STREAMS

COLUMN 1 STREAM & REACH	COLUMN 2 PRIMARY POTENTIAL HARVEST NO. OF TROUT	COLUMN 3 PRESENT AVAILABLE HARVEST NO. OF TROUT	COLUMN 1 STREAM & REACH	COLUMN 2 PRIMARY POTENTIAL HARVEST NO. OF TROUT	COLUMN 3 PRESENT AVAILABLE HARVEST NO. OF TROUT
B-X, Upper	147	32	Powers	889	711
B-X, Lower	135	82	Shingle, A	454	759
Coldstream	307	206	Shingle, B	386	301
Deep	110	76	Shorts	2545	1909
Equesis	736	729	Shuttleworth	196	139
Ellis	546	475	Trepanier	1637	1326
Inkaneep	129	74	Trout, A	711	611
Kelowna	208	183	Trout, B & C	6132	5457
Lambly	2533	1570	Vaseux	1165	1165
Mission,A	1913	1779	Vernon, A	368	320
Mission,B	6169	5552	Vernon, B	1202	829
Mission,C	5690	4893	Whiteman, A	662	629
Peachland	938	816	Whiteman, B	724	695
Penticton	1778	1405	TOTAL	38,410	32,223

Trout fishing in the tributary streams while providing a different type of recreational experience produces much smaller sportfish than any other angling in the basin.

It is noted that the present available harvest of 32,223 trout is only 16% less than the primary potential harvest of 38,410 trout. In general then, water which might be diverted for the particular benefit of resident stream trout will tend to yield greater fishery benefits if applied to maintaining levels of headwater reservoirs or more particularly if applied to propagation of salmonids from the main valley lakes (see next section).

8.1.3 Harvest Capacities of the Main Valley Lakes

(a) General Capacities

The 27 fish species inhabiting the main valley lakes of the Okanagan support a substantial sport fishery (84,600 angler days between June 1971 and May 1972). Gross sustainable fish harvest capacities of the main valley lakes were estimated on the basis of mean depth and total dissolved solid concentration according to Ryder's model (23), developed for north-temperate lakes of comparable latitude.

These gross sustainable fish harvest estimates were further refined by taking into account total phosphorus concentration relative to that of Okanagan Lake. The rationale for this assumption is completely outlined in technical supplement IX. Table 8.5 indicates these primary sustainable (based on Ryder's model) and secondary sustainable harvest capacities (Based on refinement of Ryder's model by accounting for phosphorus concentrations).

TABLE 8.5

ESTIMATES OF PRIMARY AND SECONDARY GROSS SUSTAINABLE FISH HARVEST CAPACITIES OF OKANAGAN MAIN VALLEY LAKES UNDER PRESENT (1971) CONDITIONS

LAKE	ESTIMATED PRIMARY SUSTAINABLE HARVEST CAPACITY POUNDS/ACRE/YR.	AVERAGE PHOSPHORUS CONCENTRATION OF LAKE MICROGRAMS PER LITER	RELATIVE* PHOSPHORUS CONCENTRATION COMPARED TO OKANAGAN LAKE	ESTIMATED SECONDARY SUSTAINABLE HARVEST CAPACITY POUNDS/ACRE/YEAR
Wood	3.0	219	7.30	21.7
Kalamalka	1.9	14	0.47	0.9
Okanagan	1.5	30	1.00	1.5
Skaha	2.5	77	2.57	6.5
Vaseux	5.1	77	2.57	13.2
Osoyoos	3.1	73	2.43	7.6

* Concentration in Comparison to Okanagan Lake, i.e. 7.30 means 7.30 x the concentration shown for Okanagan Lake.

Further refinement of these gross estimates may also be made by relating them to species proportion composition of sampling catches. This was done with the gill net sample data collected during 1971 on the Okanagan main valley lakes. The proportion of the secondary gross annual fish harvest attributable to various species groups in each lake is presented in Table 8.6.

TABLE 8.6

SECONDARY ESTIMATES OF GROSS ANNUAL FISH HARVEST CAPACITIES BY SPECIES GROUPS FOR THE MAIN VALLEY LAKES UNDER PRESENT (1971) CONDITIONS. BREAKDOWNS ARE ACCORDING TO PROPORTIONS BY WEIGHT OF FISH IN GILLNET (SAMPLING) CATCHES

	TOTAL ALL SPECIES	PREFERRED SPORT FISH (TROUT & KOKANEE)	MARGINAL SPORT FISH (MOUNTAIN WHITE-FISH,BASS,ETC.)	LAKE WHITE-FISH	PREFERRED COARSE FISH	MARGINAL COARSE FISH
1. Pounds per acre:						
Wood	21.7	0.93	0.00	0.00	12.59	8.18
Kalamalka	0.9	0.51	0.00	0.00	0.19	0.20
Okanagan	1.5	0.39	0.15	0.22	0.33	0.41
Skaha	6.5	0.76	0.03	2.67	1.40	1.64
Vaseux	13.2	0.34	0.40	4.84	2.02	5.60
Osoyoos	7.6	0.90	0.07	1.05	4.20	1.38
2. Pounds per lake, X 1000:						
Wood	49.9	2.2	0.0	0.0	28.9	18.8
Kalamalka	5.8	3.3	0.0	0.0	1.2	1.3
Okanagan	129.0	33.5	12.9	18.9	28.4	35.3
Skaha	32.3	3.8	0.1	13.3	7.0	8.1
Vaseux	9.0	0.2	0.3	3.3	1.4	3.8
Osoyoos	28.3	3.4	0.3	3.9	15.6	5.1

In view of the particular importance of kokanee and rainbow trout to Okanagan fisheries and also in consideration of their special habitat requirements and vulnerabilities more refined estimates were attempted for productive capacities and sustainable harvests of these two species.

(b) Salmonid Sport Fish Capacities

Anglers are currently attracted to the Okanagan main valley lakes because of their endemic stocks of salmonid species. Kokanee and rainbow trout accounted for 94% and 5% respectively, of the fish harvested by boat anglers in 1971. Not all the main valley lakes are equally suited to salmonid productions. Kalamalka Lake at one extreme, is too oligotrophic for good sustained salmonid production. Conversely, advanced eutrophy has made Wood and Vaseux Lakes poor salmonid habitat due to unfavorable temperatures, low dissolved oxygen content and other conditions acting in concert. The American portion of Osoyoos Lake is also considered to have a poor salmonid habitat.

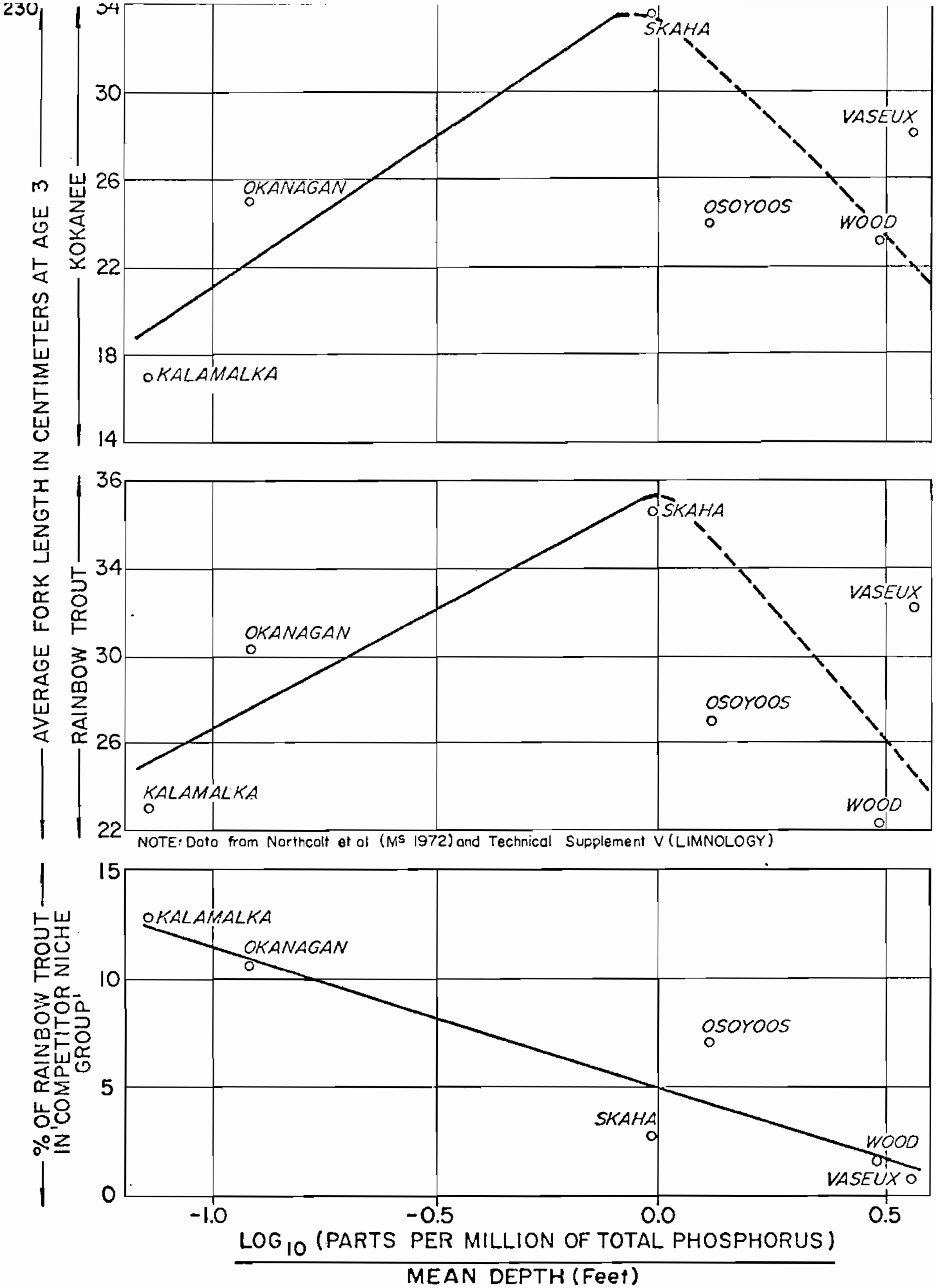
It was found that nutrient availability, (as determined by phosphorus loading) was directly correlated to salmonid growth to a point at which the reverse became the case. The peak point was found to be at about the present Skaha Lake level (Figure 8.4), thus it was assumed that present conditions in Skaha Lake are near optimal for salmonid growth and production. Enrichment beyond this point would probably be detrimental. The bulk of kokanee on these lakes spawn at the same age so their fecundity (egg production) is also linked to trophic conditions by virtue of the dependence of reproduction on fish size. That is, the number of eggs per female varies directly with the size of the fish which is, in turn, dependent on "P" concentration.

Increased nutrient loading may also effect salmonids by enhancing conditions for competition and predator species. In fact, it was found that the percentage of rainbow trout in its "competitor or niche group" was inversely related to phosphorus concentration throughout the Okanagan main valley lakes. (Figure 8.4). It is thus assumed that such interactions contribute substantially to reduced growth and population densities of salmonids in the more eutrophic main valley lakes.

The Okanagan main lake salmonid populations are heavily dependent on in-flowing streams for reproduction. Discharge requirements for kokanee and rainbow trout in streams differ seasonally, but are generally the same in terms of spawning areas. Reservoirs on streams tributary to the Okanagan main valley lakes, are presently operated without particular regard to the migration, spawning, incubation and rearing requirements of salmonids, which causes a considerable loss of reproduction capacity. In addition to stream spawning, kokanee have been found to spawn extensively along the shoreline of some of the main valley lakes. Shore spawners accounted for about 57% of the estimated total kokanee spawning population in 1971. Approximately half of the egg deposition in these shoreline areas during the fall, occurs at lake depths of 1.5 feet or less. Essentially all kokanee shore spawn is deposited in water five feet deep or less.

A survey of the natural reproductive habitat in the accessible lower reaches of streams tributary to Wood, Kalamalka, Okanagan and Skaha Lakes indicates that over 80% of the reproductive capacity of Okanagan streams has been lost due to cultural modifications. These include alterations to access, streambeds, configuration, silt load, stream bank cover, pollution and discharge regimes.

Estimated present (1971) escapement of rainbow trout and kokanee are presented in Table 8.7. It is noted that only in Peachland Creek was there a greater escapement than could be accommodated with existing reproductive habitat. One stream, Coldstream Creek supports essentially the entire salmonid population of Kalamalka Lake. Mission, Equesis and Trepanier Creeks are the principal salmonid producing streams for Okanagan Lake where shore spawning is a major kokanee producing factor. The Okanagan River provides spawning for essentially all the salmonids of Skaha, Vaseux and Osoyoos Lakes.



EFFECT OF TOTAL PHOSPHORUS CONCENTRATION IN CONJUNCTION WITH MEAN DEPTH ON GROWTH OF KOKANEE AND RAINBOW TROUT, AND ON CONTRIBUTION BY RAINBOW TROUT TO ITS COMPETITOR NICHE GROUP IN THE OKANAGAN MAIN VALLEY LAKES.

Figure 8.4

TABLE 8.7

ESTIMATED 1971 SPAWNING ESCAPEMENT OF KOKANEE AND RAINBOW TROUT POPULATIONS OF OKANAGAN MAIN VALLEY LAKES

LOCATION	KOKANEE ESCAPEMENT X 100	RAINBOW TROUT ESCAPEMENT X 100
OKANAGAN LAKE		
Trout Cr.	5	.5
Eneas Cr.	5	.5
Peachland Cr.*	47(362)*	4.2
Trepanier Cr.	104	9.3
Powers Cr.	73	6.5
McDougall Cr.	0	.4
Lambly	5	.5
Shorts Cr.	5	.5
Whiteman Cr.	6	.5
Naswhito Cr.	5	.5
Equesis Cr.	276	24.6
Deep Cr.	5	.5
B-X Cr.	0	.5
Vernon Cr.,Lower	10	.9
Mission Cr.	3121	278.2
Bellevue Cr.	0	.4
Penticton Cr.	5	.5
Shore Spawners	5180	-
Okanagan Lk. Sub-Total	8817	328.6
WOOD LAKE		
Vernon Cr.,Upper	5	1.2
Wood Lake Shore Spawners	33	-
Wood Lake Sub-Total	33+	1.2
KALAMALKA LAKE		
Coldstream Cr.	597	105.6
Kalamalka Lake Shore Spawners	55	-
Kalamalka Lake Sub-Total	652	105.6
SKAHA LAKE		
Ellis Cr.	5	.2
McLean Cr.	5	.2
Shingle Cr.	5	.2
Okanagan River	401	14.9
Skaha Lake Sub-Total	401+	15.5
VASEUX LAKE		
Okanagan River	4	.5
Vaseux Lake Sub-Total	4	.5
OSOYOOS LAKE		
Inkaneep Cr.	5	0
Okanagan River	369	2.9
Osoyoos Lake Sub-Total	369+	2.9
TOTALS	10,276+	454.3

* 36,200 Kokanee spawners ascended Peachland Creek, However, based on reproductive habitat available, it was found only 4,700 could effectively spawn.

The ability of lakes to support a given number of kokanee spawners was determined on the basis of lake productivity (Table 8.8). It is noted that in all cases this ability to support spawners (and by inference harvestable fish) is not currently a limiting factor. Stream habitat or other factors must therefore be the present major limitation to kokanee populations in the main valley lakes.

TABLE 8.8

ESTIMATES OF KOKANEE SPAWNING ESCAPEMENTS SUPPORTABLE ANNUALLY BY OKANAGAN MAIN VALLEY LAKES BASED ON LAKE CARRYING CAPACITY. FOR COMPARISON ACTUAL SPAWNING ESCAPEMENTS ARE INCLUDED

LAKE	NUMBER OF SPAWNERS X 1000		
	SUPPORTABLE BY LAKE	PRESENT ESCAPEMENT	% UTILIZATION OF CARRYING CAPACITY
Wood	802.0	3.3	0.4
Kalamalka	1,139.6	65.2	5.7
Okanagan	7,592.0	881.7	11.7
Skaha	466.6	40.1	8.6
Vaseux	96.8	0.4	0.4
Osoyoos	636.2	36.9	5.8

Minimum and maximum annual sustainable harvests of kokanee were derived for the main valley lakes (Table 8.9). The minimum annual sustainable harvest was deemed to be the present (1971) harvest. The maximum annual sustainable harvest is based on data from the West Arm of Kootenay Lake taking into account different fecundities (rates of egg production) and merely indicates the levels to which Kokanee harvests could be carried on a sustained yield basis. While this maximum sustainable harvest approach is biologically sound from a management point of view, it would undoubtedly result in a decrease in angling success rates (number of fish caught per hour), which may be unacceptable to anglers.

TABLE 8.9

ESTIMATED MAXIMUM AND MINIMUM ANNUAL SUSTAINABLE KOKANEE HARVESTS FROM OKANAGAN MAIN VALLEY LAKES

	NUMBER OF KOKANEE HARVESTABLE ANNUALLY X 1000						
	WOOD	KALAMALKA	OKANAGAN	SKAHA	VASEUX	OSOYOOS	TOTAL
Minimum	1.82	1.24	237.5	5.91	0.01	0.99	247.47
Maximum	5 47	73.02	2,019.9	185.66	1.36	69.13	2,354.54

A key to rainbow trout productivity is the capacity of a lake for fry. These values were arrived at for main valley lakes using (1) the stocking formula developed for headwater lakes and adjusting it to phosphorus concentrations relative to Okanagan Lake, and (2) the amount of competition and/or predation in each of the lakes. The annual carrying capacity for rainbow trout fry based on the above procedure, and the present fry production based on 1971 escapement are compared in Table 8.10. It is noted that in all cases but Kalamalka Lake, only about 5% or less of a lake's capacity to accept rainbow trout fry is presently being utilized. This is evidence in part of the limitations stream spawning habitat is presently placing on these trout populations.

TABLE 8.10

ESTIMATED CARRYING CAPACITY FOR RAINBOW TROUT FRY AND PRESENT UTILIZATION OF CARRYING CAPACITY IN OKANAGAN MAIN VALLEY LAKES

	WOOD	KALAMALKA	OKANAGAN	SKAHA	VASEUX	OSOYOOS
Present Carrying Capacity Fry X1000	756	956	23,377	1,732	501	1,857
Present Fry Production Fry X1000	3.6	297.9	1,197.9	62.3	1.9	11.1
Present Utilization of Carrying Capacity, %	0.5	32.1	5.1	3.6	0.4	0.6

As with kokanee populations, minimum and maximum annual sustainable rainbow trout harvest capacities were determined. The minimum estimate was assumed to be the actual 1971 catch as recorded by creel census (12,800 rainbow trout from all lakes). Maximum sustainable harvest capacity estimates were based on population-age structures, average age at catching and estimated survival rates. (Table 8.11)

TABLE 8.11

ESTIMATED MAXIMUM AND MINIMUM ANNUAL SUSTAINABLE RAINBOW TROUT HARVESTS FOR OKANAGAN MAIN VALLEY LAKES

	NUMBER OF RAINBOW TROUT HARVESTABLE ANNUALLY X1000						
	WOOD	KALAMALKA	OKANAGAN	SKAHA	VASEUX	OSOYOOS	TOTAL
Minimum	0	0.1	11.08	1.35	0	0.25	12.78
Maximum	0.09	7.92	24.65	1.55	0.05	0.22	34.48

The comments with regard to lower angler success and maximum sustainable harvest that were discussed with regard to kokanee also apply to the trout species.

In summary only a small portion of the main valley lakes capacity to grow sport fish is presently being utilized, such production being limited by the ability of the tributary streams and shoreline spawning areas to produce fry. While the maximum sustainable harvest has not been fully exploited to date, any further demand on this resource would undoubtedly result in a decrease in angler success rates which may be unacceptable from a social viewpoint. Enhancement of the main valley lake fisheries to maintain present angler success rates, must therefore be based on the alteration of stream characteristics for improved sport fish fry production.

8.1.4 Harvest Capacity of the Okanagan River

(a) Sockeye Salmon

The Okanagan River between Vaseux and Osoyoos Lake serves as the major reproductive habitat for sockeye salmon ascending the Columbia River. The progeny also spend one year rearing in Osoyoos Lake. The total Columbia sockeye escapement is about 95,000 fish annually of which about 19,000 spawn in the Okanagan River in Canada.

Commercial fishermen in the lower Columbia River (United States portion of River) take an average of 21,600 sockeye annually, of which 70% (15,120 fish) are of Okanagan River origin. An additional 3,100 sockeye (annual average) are taken by Canadian and American Indians for subsistence and ceremonial purposes. The present catch to escapement ratio at the river mouth is 0.3:1. It is suggested this could be safely altered 0.5:1 under present conditions.

(b) Sport Fishery

Because of its use as a flood control channel, the Okanagan River cannot be optimally managed for its indigenous fish fauna. As it is heavily channelized, it lacks the meanders, pool and riffle development and shading characteristics of unaltered streams. Higher temperatures coincident with these modifications may drive salmonids out of the river during the summer months.

The availability of fish in the river appears to be heavily dependent on migration from the mainstem lakes. Thus the population status of lake sport fish populations to a large degree determines the fishery opportunities in the river.

It was estimated that the existing "unimproved" section of the river could support a sustained annual yield of about 500 fish, about 87% of the present harvest. Rather than over exploitation, these values are taken as a reflection of the role played by sport fishes migrating into the river from the mainstem lakes.

8.2 ANGLER USE AND SOCIO-ECONOMIC ASPECTS OF THE SPORT FISHERY

The fishery studies described above indicate that the Okanagan Valley harbours a significant sport fishery resource. This resource has considerable value as an attraction for tourist anglers, as an important recreational pursuit for residents and as an indicator of the environmental health of the basin. However, this fishing resource is dependent on water for spawning, rearing and migration, and consequently must compete with other water uses, such as for irrigation, and domestic purposes.

This information was the objective of a socio-economic survey of sport fishermen, undertaken throughout the summer of 1971. The survey was closely tied to aerial and ground boat-count surveys so that the total population of anglers could be estimated.

2.1 Angler Participation

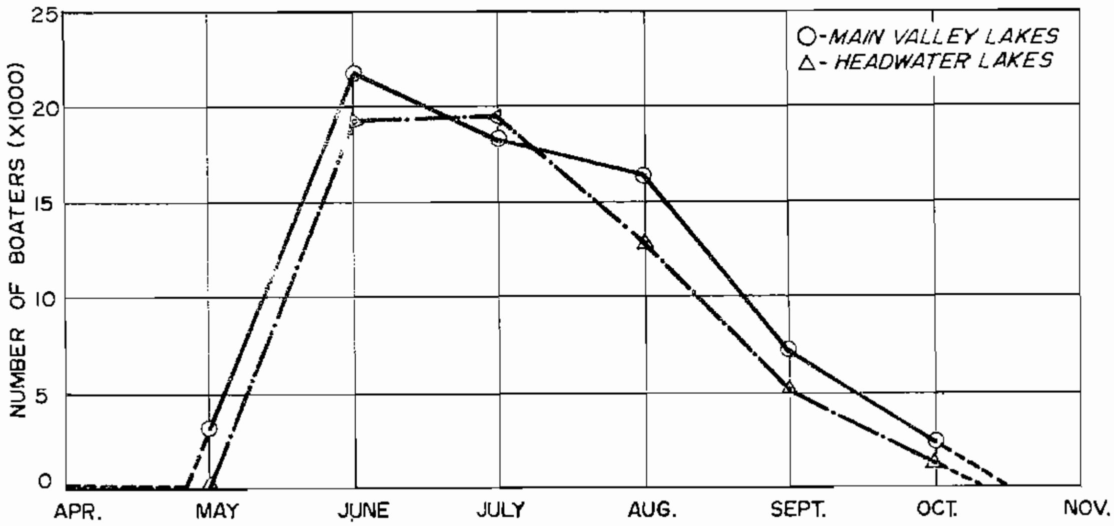
About 157,700 angling days of sport fishing activity were recorded on all surface waters of the Okanagan Basin during the period May 1971 to April, 1972 (Table 8.12). Of this total, an estimated 127,260 angling days were experienced by boaters, almost 27,000 angling days by shore fishermen and 3,460 angling days by ice-fishermen. Slightly more than half the total fishing effort occurred on the main valley lakes, mostly on Okanagan Lake. Similarly, most of the fishing in the headwater lakes was concentrated in relatively few of the 98 lakes surveyed, the most popular lakes being Pinaus, Beaver(Swalwell), Dee-Chain, Lambly, Jackpine and Oyama, which together attracted over 70% of the 65,880 headwater angling days.

TABLE 8.12

SUMMARY OF ANGLER DAYS IN THE OKANAGAN BASIN, 1971

LOCATION	BOAT FISHERMEN	SHORE FISHERMEN	ICE FISHERMEN	TOTAL
Wood	2,300	450	50	2,800
Kalamalka	2,150	450	0	2,600
Okanagan	58,450	11,700	200	70,350
Skaha	5,450	1,100	100	6,650
Vaseux	450	100	0	550
Osoyoos	1,350	250	50	1,650
Total Main Valley Lakes	70,150	14,050	400	84,600
Headwater Lakes	57,111	5,711	3,060	65,882
Tributary Streams	-	2,325	-	2,325
Okanagan River	-	4,900	-	4,900
TOTALS	127,261	26,986	3,460	157,907

Seasonal patterns of participation are similar for both main valley and headwater lakes (Figure 8.5). Little fishing was recorded until mid-May, when there was a surge of participation which was maintained until late July. Fishing activity gradually dropped off throughout the rest of the summer. There was however, significant shore fishing around the main valley lakes in November for both kokanee and whitefish.



SEASONAL PATTERNS OF BOAT ANGLING EFFORT IN THE OKANAGAN BASIN. Figure 8.5

Approximately two-thirds of the angling days (105,860) were recorded by residents and one-third (51,840) by visitors. Over 40% of visiting anglers came from the Lower Mainland. Only 20% of the visiting anglers came from Alberta, relatively lower than the proportion of Albertans in the general population of Okanagan tourists. American anglers represent a higher proportion of visiting anglers than in the general tourist population (Table 8.13).

TABLE 8.13

HOME LOCATION OF NON-RESIDENT ANGLERS AND GENERAL TOURISTS IN 1971

LOCATION	ANGLERS	ALL VISITORS
Lower Mainland	42.1%	35.0%
Rest of B.C.	15.7	13.1
Alberta	19.9	37.5
Sask.-Manitoba	2.6	3.5
Rest of Canada	2.6	1.9
Western U.S.	16.6	8.0
Rest of U.S.	0.5	1.0

As expected, residents fished more frequently than visitors (Table 8.14). The median number of angling days per year for residents and visitors were estimated to be 16, and 7 respectively though some residents (mostly retired) fished over 100 days in 1971. Using these median values, a total of 6,680 residents and 7,620 visitors fished during the census period, May 1971 to June 1972.

Just under one-third (32%) of visitor anglers indicated that fishing was the main and only reason for coming to the Okanagan. This proportion may be an underestimate, as the socio-economic survey was undertaken during the summer months when many tourists enjoy fishing as part of a package of recreational experiences available in the Okanagan.

TABLE 8.14

FREQUENCY OF RESIDENT AND VISITORS PARTICIPATION (ANGLING DAYS) IN 1971

DAYS PER YEAR	RESIDENTS (PERCENT)	VISITORS (PERCENT)
1-5	9	40
6-10	25	50
11-15	14	8
16-20	17	1
21-30	16	1
31-60	12	
61-100	5	
over 100	2	

It is also somewhat lower than that reported in other regions of the Province, suggesting that the Okanagan Lakes do not presently have the quality fishing required to attract the angling tourist.

The fishing survey also compared a number of socio-economic characteristics of resident and non-resident anglers. For both groups, fishing tended to be a family experience, over 76% of visitors and 46% of residents fishing in family groups. Non-resident anglers tended to be younger, better educated and had higher household incomes than their resident counterparts. Resident anglers had more fishing experience in the valley, averaging 8 years compared with only 1.3 years for non-residents. In fact, over 40% of visiting anglers were fishing for the first time in 1971.

8.2.2 Sport Fish Harvest

Fish catch is one of the primary motivations for fishing and a major criterion for assessing the value of the sport fishery in various locations in the valley. Fish harvest in the headwater and main valley lakes were tabulated during the creel census. Results are summarized in Table 8.15. The headwater lakes, on an average tend to provide better quality fishing with high elevations, though data on catch per angling hour for lakes above 5,000 feet are misleading because of the small number of fishing hours censused. It is interesting to note that the more inaccessible headwater lakes tend to offer better fishing than the ones with easy access and high angling pressures.

In the main valley lakes, kokanee represented 80% of total harvest by weight and 94% by number. Despite their small size, an average of more than one was taken each angling hour on Okanagan Lake. This catch per unit effort varied between the north and south portions of Okanagan Lake, however, averaging 1.8 fish per angling hour north of Kelowna bridge and only 0.7 fish per angling hour south of the bridge. This feature, due to the limited spawning habitat in the south, is recognized by anglers judging from the much smaller angling effort observed in the extreme south basin of Okanagan Lake. Larger kokanee, averaging over half-a-pound each were caught in Skaha Lake, though not as frequently as on Okanagan Lake.

Angling success for rainbow trout on the main valley lakes was extremely low (less than one per 16 angling hours), but this is partially compensated by the large size of fish, especially those caught during the winter months (median weight of over 4 pounds).

Newly established lake trout stocks are starting to be exploited in Kalamalka Lake, while bass, yellow perch and crappie constitute the bulk of the game fish caught in Osoyoos and Vaseux Lake.

8.2.3 Angler Behaviour and Preferences

Effective management of the sport fishery resource in the Okanagan should be responsive to the needs and desires of participating anglers. Consequently, part of the socio-economic survey attempted to determine anglers' attitudes and preferences for fishery management in the valley. The major reasons for choosing a fishing site appear to be: (1) ease of access, (2) proximity to place of residence and (3) chance of success. Over 34% of anglers camped at their fishing site and a further 33% spent less than 30 minutes to reach their site. These percentages varied between headwater and main valley lake anglers, however, over 80% of the latter reaching their site within half-an-hour compared to 14% of headwater anglers. Apparently, the higher success ratios, especially for the highly prized rainbow trout in headwater lakes more than compensates for additional travel time. It is worth emphasising that the vast majority of resident anglers preferred fishing in their region of residence both in headwater and main lakes and expressed a strong desire to see this dispersed opportunity maintained in the future.

TABLE 8.15

FISH HARVESTS AND ANGLER SUCCESS RATES IN OKANAGAN BASIN LAKES DURING 1971

(a) Fish Harvest and Success Rates Headwater Lakes

ELEVATION (FEET)	TOTAL AREA AT FULL SUPPLY (ACRES)	TOTAL EFFORT ANGLING-DAYS	PER ACRE ANGLING-HOURS	TOTAL HARVEST	TOTAL WT. (POUNDS)	NUMBER PER ACRE	CATCH PER ANGLING HOUR	POUNDS PER ACRE
Less than 3500	3,399	8.1	32.9	33,686	21,896	9.9	0.30	6.4
3501-4000	987	4.8	19.5	10,264	4,927	10.4	0.53	5.0
4001-4500	4,520	6.4	26.0	65,807	28,955	14.6	0.56	6.4
4501-5000	806	5.0	20.3	12,487	6,493	15.5	0.76	8.1
5001-5500	819	0.7	2.8	2,932	1,114	3.6	1.29	1.4
Greater than 5501	373	0.1	0.4	288	69	0.8	2.00	0.2
TOTALS	10,904			125,465	63,454			

(b) Fish Harvest and Success Rates in Main Valley Lakes

	WOOD	KALAMALKA	OKANAGAN	SKAHA	VASEUX	OSOYOOS	TOTAL
Surface Area (Acres)	2298	6400	84,990	4967	680	3719	104,054
Angling Hours per Acre	2.96	1.00	2.18	3.78	0.96	1.14	
Total Harvest	1817	1409	248,777	7258	270	2516	262,047
Kokanee	1817	1237	237,512	5905	10	991	247,472
Rainbow Trout	0	100	11,083	1353	0	246	12,782
Other	0	72	182	0	260	1279	1,793
Total Harvest lb./acre	0.13	0.10	0.93	0.81	0.19	0.60	
Kokanee	0.13	0.04	0.77	0.62	0.00	0.07	
Rainbow Trout	0.00	0.02	0.16	0.19	0.00	0.11	
Other	0.00	0.04	+	0.00	0.19	0.42	
Catch Per Angling Hour	0.268	0.220	1.325	0.386	0.411	0.590	
Kokanee	0.268	0.193	1.265	0.314	0.015	0.232	
Rainbow Trout	0.000	0.016	0.059	0.072	0.000	0.058	
Other	0.000	0.011	0.001	0.000	0.396	0.300	
Average size of Fish in Angling Catch, lb.							
Kokanee	0.159	0.187	0.278	0.525	0.300	0.262	
Rainbow Trout	-	1.380	1.248	0.696	-	1.616	
Lake Trout	-	3.686	-	-	-	-	

Over 80% of all anglers questioned preferred catching rainbow trout and although kokanee represent 94% of all fish caught in the main valley lakes, almost half (48%) of the main valley anglers stated a preference for trout. Most anglers appeared satisfied with the present availability and harvest of salmonids, though a significant minority did desire to see increased trout harvests in the main valley lakes.

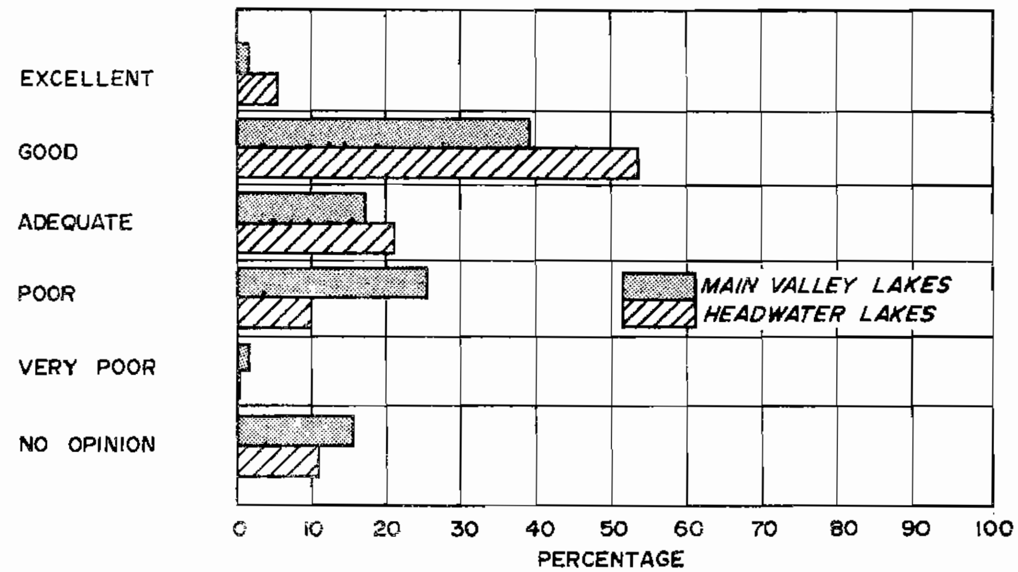
To obtain some idea of the future demand for sport fishing in the Okanagan, anglers were asked if they were generally satisfied with present conditions, and their preferences for angling experience. Sixty percent stated their general satisfaction. Thirty-six percent of the sample had no particular preferences, and 35% stated a preference for headwater angling (Table 8.16). A significant minority (23%) desired more stream fishing. When these responses are compared with the minority of anglers who stated their general dissatisfaction, their main concerns appear to be lack of stream fishing and lakes exclusively reserved for fly fishing. It should be emphasized that few anglers appeared to be particularly concerned about lack of stream fishing, realizing that the Okanagan was not a suitable location for this activity.

TABLE 8.16

PREFERENCES OF ANGLERS FISHING OKANAGAN LAKES AND STREAMS

TYPE OF FISHING	GENERAL SAMPLE %	"UNSATISFIED" SAMPLE %
No Particular Preferences	36.4	-
Headwater Fishing	35.0	48.2
- General	20.4	22.2
- Fly Fishing	10.7	20.4
- Lakes with no Motor Boats	3.9	3.6
Stream Fishing	22.8	51.8
Main Lake Fishing	5.3	1.8

The Okanagan sport fisherman is offered a range of facilities, some public-such as boat ramps and boat docks, and some private-such as marinas, rentals and equipment purchases. Figure 8.6 indicates that while the majority of anglers were satisfied with the services, there was a tendency for main valley fishermen to be less satisfied than those on the headwaters. Most of this dissatisfaction was levelled at poor or inadequate public boat launching facilities, especially around Okanagan and Osoyoos Lakes. A number of anglers also noted problems of launching their boats during the spring of 1971 when Okanagan Lake was drawn down to its minimum operating elevation of 1119.8 feet.



OKANAGAN BASIN ANGLER COMMENTS WITH REGARD TO QUALITY OF EXISTING FACILITIES.

Figure 8.6

8.2.4 Value of Sport Fishing

(a) Economic Values

The approach used to place economic and social values on the Okanagan sport fishery is similar to that described for water based recreation in Chapter 7, In summary, economic values are assumed to equal the net expenditures of visitor anglers while in the Okanagan,plus a portion of net resident fishermen expenditures, under the assumption that some residents would fish outside the Okanagan in the absence of sport fishing in the basin. As many non-resident anglers stated they would have come to the Okanagan even if fishing were not available, only the portion of their total expenditures associated with their fishing activities in the Valley was accounted in the economic analysis.

Table 8.17 shows the breakdown of average expenditures by non-resident anglers during 1971, both for those primarily motivated toward fishing in the valley and for those to whom fishing was part of a recreation "package". Total gross expenditures by the entire population of non-resident anglers amounted to over $500,000, an average of over $65 per angler. Slightly more than half of these revenues were obtained from food and accommodation expenses, about 25% from travel expenses and the rest from equipment purchase, boat rentals, etc. Subtracting the costs to supply the goods and services demanded by non-resident anglers, net expenditures amounted to approximately $260,000, for an average of $34 per angler.

TABLE 8.17

NON-RESIDENT ANGLERS' EXPENDITURES IN THE OKANAGAN IN 1971

	TRAVEL EXPENSES	FOOD & LODGING	EQUIPMENT	RENTALS	TOTAL
Primary-Motivated Anglers					
Total Expenditures	$ 90,170	$191,770	$30,480	$50,800	$363,220
Expenditures per Angler	35.50	75.50	12.00	20.00	143.00
Expenditures per Angler Day					24.00
Other Anglers					
Total Expenditures	$ 38,100	$ 60,900	$12,700	$25,400	$137,160
Expenditures per Angler	7.50	12.00	2.50	5.00	27.00
Expenditures per Angler Day					5.50
TOTAL EXPENDITURES	$128,370	$252,730	$43,180	$76,2D0	$500,380

Resident anglers spent an estimated $1,150,000 in 1971 on sport-fishing, mainly equipment. Of this total expenditure, $400,000 remained as net gain to the Okanagan economy. Assuming that in the absence of a fishery, 50% of this revenue would be lost to the Okanagan as a result of fishermen travelling outside the basin, net income accruing to the Okanagan from resident angler expenditures was estimated at $200,000 in 1971.

Net costs of managing the Okanagan sport fishery should also be subtracted from the total net income estimate to obtain a true measure of net economic benefits. From the viewpoint of the Okanagan economy, these net costs amounted to $15,000 thus net economic benefits associated with resident angler participation totalled some $185,000 in 1971.

In summary, sport fishermen spent $1,650,000 in the Okanagan during the 1971 fishing season. The net economic benefit to the Okanagan resulting from this expenditure amounted to some $445,D00, representing $4.90 per non-resident angling-day and $1.75 per resident angling day. These values will be used in Part IV of this report in which sport-fishery management alternatives are evaluated.

Non-Economic Values

Under a zero pricing policy, net economic benefits derived from angler expenditures may not be equated with total value of the sport. Both resident and non-resident fishermen were asked how much a day's fishing was worth over and above their estimated expenditures. In view of the real difficulties of determining these values, the following results should be interpreted as being very approximate estimates of the social value of sport fishing.

The median value for resident anglers was $310 per year or $13.50 per angler day, while the median value for non-resident anglers was $19.00 per year or $2.50 per angler day. The large difference between these two values appeared to be due to the fact that visitors were more immediately aware of their daily expenditures than residents, who tend to make large single payments for boat or other equipment and whose daily costs are small. Applying these daily values to the total angling population the social value of sport fishing was estimated at $1,888,000 in 1971, approximately $1,830,000 associated with resident angling and $58,000 with non-resident angling. As was the case with shoreline recreation, this figure represents a very rough estimate of the additional value anglers placed on their activities over and above their direct expenditures in 1971. Acknowledging the difficulties associated with evaluating sport fisheries, there is little doubt that this resource contributes significantly to the economic and social life style of Okanagan residents and tourists.

8.3 SUMMARY

Present fish harvest capacities in the Okanagan Basin are based primarily in the headwater and main valley lakes. Opportunities in the streams and rivers are limited. The headwater lakes can be far more heavily stocked than is presently the case as they have an inherent capacity to provide up to 10 times the present harvest of rainbow trout. The ability of the main valley lakes to produce sport fishes is limited by the capacity of the tributary streams and rivers to accept spawners. Man induced changes have destroyed approximately 80% of the original spawning capability of these streams. Phosphorus levels in the lakes were found to be linked to kokanee growth rate and productivity. Phosphorus also has an effect on rainbow trout and the resulting percentage in a "competitor niche group".

Anglers spent 157,700 days fishing in the Okanagan Basin in 1971. Two thirds of the fishing was done by valley residents, one third by non-residents. Eighty percent of the main valley lakes' harvest was kokanee although most anglers stated a definite preference for rainbow trout. Sixty percent of the anglers interviewed were satisfied with present conditions. Thirty-six percent stated no particular preferences.

Sport fishermen spent $1,650,000 in the Okanagan during the 1971 fishing season. The net economic benefit to the Okanagan resulting from this expenditure amounts to some $445,000, representing $4.90 per non-resident angling day and $1.75 per resident angling day. The non-economic social values of sport fishing in the Okanagan amount to $13.50 per angling day for residents and $2.50 per angling day for non-residents. Therefore, the annual social values of sport fishing was estimated at $1,888,000 in 1971.

CHAPTER 9

Wildlife and Water Management

Wildlife is an integral part of the land character of the Okanagan Basin. The variety of land birds and mammals in the Okanagan is extremely diverse. In terms of numbers of species occurring it may be considered one of the richest in the Province. Upland birds, song birds, ungulates and furred small game are present in varying quantity, usually as a direct result of the land use pattern of a particular area. Water dependent wildlife including waterfowl and fur-bearers, have a very limited distribution in the basin. This is in part due to the inherent water limitations in the basin, the generally oligotrophic nature of the larger lakes and the lack of established habitat for wildlife along the shoreline because of natural and man induced "drying" of waterbodies through the summer months.

The headwater areas of the basin support a few waterfowl through nesting to migration, however, water dependent wildlife resources in the upper area are at best described as poor. Oue to time and money constraints plus the low water dependent wildlife potential, the headwater and upland areas were not examined as part of the study. Instead, available resources were channeled into an examination of Okanagan Lake and the Okanagan River system downstream from the lake.

9.1 OKANAGAN LAKE

The general oligotrophic nature of Okanagan Lake, as well as its predominantly rocky littoral shelf limits its capacity for water dependent wildlife. The North Arm, some limited shoreline areas and the mouth of Vernon and Deep Creeks have broad clay and sand littoral shelves which support vegetative cover conducive to wildlife.

Waterfowl nesting on the lake is extremely limited, presumably due to the exposed nature of the shoreline. Only a few nesting pairs are seen throughout the summer. Field notes from the beginning of the Twentieth Century to the present indicate nesting has always been minimal. Ducks are less abundant now than in the early part of the century. Numbers of nesting geese have increased since the beginning of the century, in part due to the creation of artificial nesting facilities.

The more eutrophic areas of Okanagan Lake, particularly the North Arm near Vernon, play host to large numbers of migrating and wintering waterfowl. Practically every species of waterfowl common to Western Canada is found on the lake as a migrant. Of these, coots use the lake extensively for wintering. Pond-weed provides a food source for migrant waterfowl while other plants provide cover and protection. Numbers of ducks using the lake during migration and wintering have decreased since the turn of the century, principally due to the fluctuation of water levels and the negative effect carp have had on the littoral plants of the lake since the introduction of that fish species in about 1917. Numbers of migrant geese have increased since the turn of the century.

Muskrats, the only aquatic mammals of any consequence utilizing the lake have similar habitat requirements to waterfowl, and thus occur in the same areas. The only notable concentration of muskrats observed in 1971 was in the vicinity of the mouth of Deep Creek. The number of muskrats have declined in recent years possibly due in large part to shoreline development and alteration.

9.2 THE OKANAGAN RIVER

The Okanagan River from Okanagan Falls to Oliver is generally unsuitable for water dependent wildlife. The "oxbows" (portions of the original river prior to its "development" as a flood control channel) are not conducive to waterfowl rearing.

Vaseux Lake, due to its eutrophic nature, provides some excellent habitat for nesting Canada Geese. To this end the lake has been declared a wildlife refuge. Large mats of weed and plant growth provide an abundance of food which attracts large numbers of coots and other waterfowl during the fall months.

The oxbows between Oliver and Osoyoos Lake and the marshes at the north end of Osoyoos Lake provide habitat for waterfowl (Figure 9.1). The large oxbows south of vertical drop structure 4 provide good waterfowl habitat. However, since the water level of these oxbows fluctuates with those of the river, the variation is extreme and the effect detrimental to wildlife. Muskrats also exist in the larger oxbows. Limitations to wildlife use of the oxbows include the gravelly substrate in the more northerly oxbows (formerly a portion of the river with a steeper gradient), fluctuating water levels and destruction of habitat adjacent to oxbows.

Oxbows were of two categories; seepage and charged. Seepage oxbows are completely sealed off from the river and dependent upon seepage from the adjacent river channel for water. Flows in excess of 500 c.f.s. in the main channel are required to maintain a reasonable level in these oxbows. Charged oxbows are open to the river channel and are used for irrigation withdrawal, thus water is maintained in them during the irrigation seasons when they are attractive to wildlife. After the irrigation season they become shallow ponds and puddles, essentially useless to wildlife.

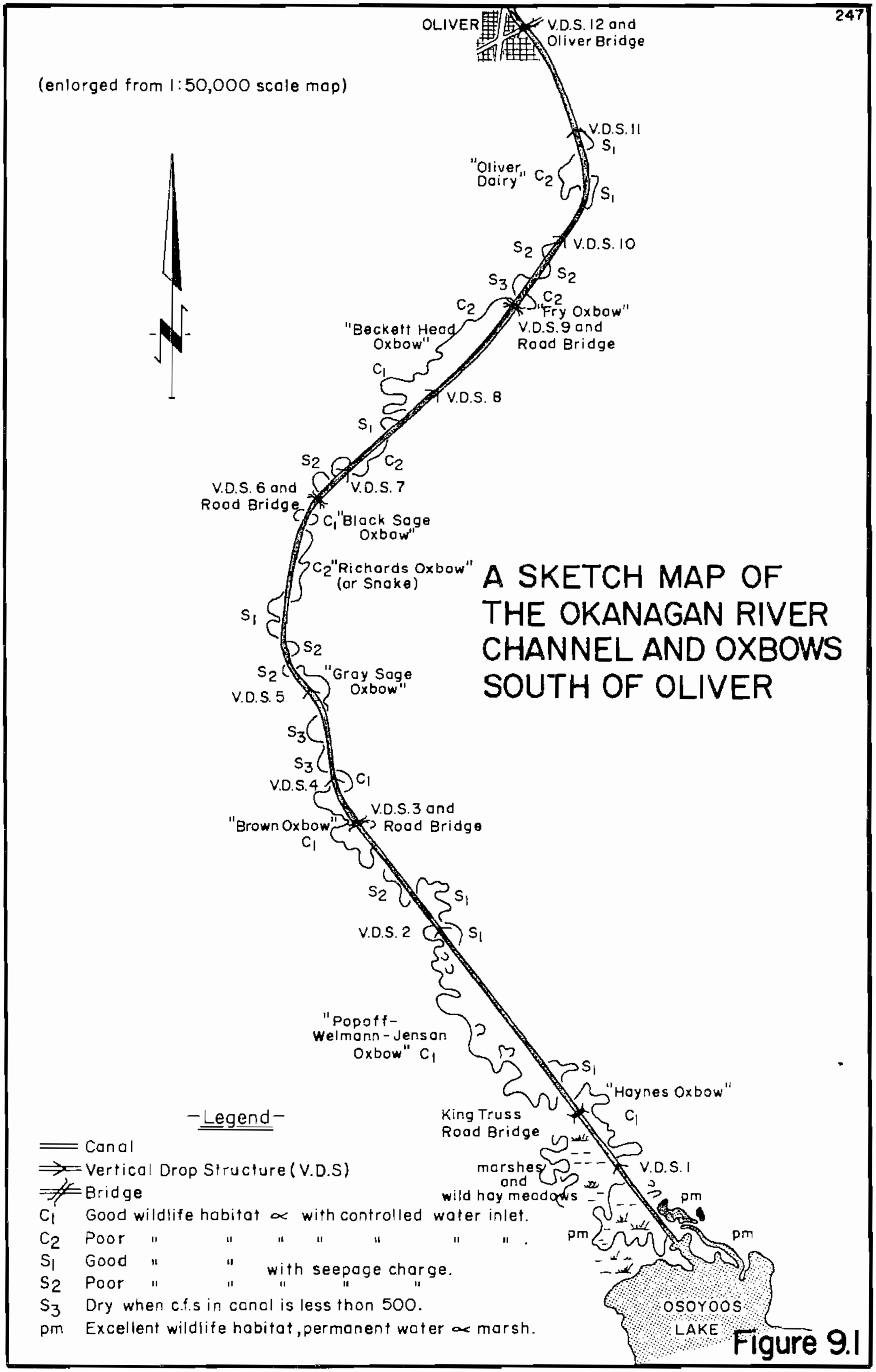

OLIVER
V.D.S. 12 and
Oliver Bridge
(enlarged from 1:50,000 scale map)
V.D.S. 11
S1
"Oliver Dairy" C2
S1
V.D.S. 10
S2
S2
S3
C2
"Fry Oxbow"
V.D.S. 9 and
Road Bridge
C2
"Beckett Head Oxbow"
C1
V.D.S. 8
S1
S2
C2
V.D.S. 6 and
Road Bridge
V.D.S. 7
C1 "Black Sage Oxbow"
C2 "Richards Oxbow" (or Snake)
A SKETCH MAP OF THE OKANAGAN RIVER CHANNEL AND OXBOWS SOUTH OF OLIVER
S1
S2
S2
"Gray Sage Oxbow"
V.D.S. 5
S3
S3
V.D.S. 4
C1
V.D.S. 3 and
Road Bridge
"Brown Oxbow"
C1
S2
S1
V.D.S. 2
S1
"Popoff-Welmann-Jensan Oxbow" C1
S1
"Haynes Oxbow"
C1
King Truss
Road Bridge
marshes and wild hay meadows
V.D.S. 1
pm
pm
pm
OSOYOOS LAKE
-Legend-
Canal
Vertical Drop Structure (V.D.S)
Bridge
C1 Good wildlife habitat ∝ with controlled water inlet.
C2 Poor " " " " " " " .
S1 Good " " with seepage charge.
S2 Poor " " " " "
S3 Dry when c.f.s in canal is less than 500.
pm Excellent wildlife habitat, permanent water ∝ marsh.

Figure 9.1

The marshes from Oliver bridge to Osoyoos Lake provide nesting and migration habitat for waterfowl. Canada geese, three species of grebes and several duck species can be observed regularly. Although a smaller area, it is roughly comparable in quality to the north end of Okanagan Lake.

9.3 SUMMARY

Okanagan Lake and its shoreline and the Okanagan River and its environs, harbour one of the richest faunas in terms of numbers of species, to be found anywhere in British Columbia.

In terms of wildlife productivity, however, Okanagan Lake is low and it is evident that those mammals and birds dependent upon the lake have decreased in numbers since the turn of the century. This decrease is considered to be due to a number of factors, principally the development of the lake shore by man, the introduction of carp to the system in 1917, and the control of the water levels of the lake. It is considered that abnormally low water levels might have a severe effect on wildlife, but this effect would be only temporary provided normal water levels were resumed.

The Okanagan River system and its oxbows, with the exception of Vaseux Lake, the marshes at the north end of Osoyoos Lake and to a lesser extent, Tugulnuit Lake, are not productive in terms of wildlife. The greatest threat to existing wildlife in the area is the loss of natural habitat by the manner in which land in the vicinity of the channel is used and the manner in which water levels in the oxbows are controlled.

PART III

PUBLIC INVOLVEMENT IN PLANNING

CHAPTER 10

The Public Involvement Program

Water and related resource management programs, through their effect on the natural environment and their influence on economic development, can significantly affect the livelihood and life-styles of Okanagan residents. In recent years, particularly with the increasing concern for environmental quality, people have taken a greater interest in resource management and have expressed a desire to become more involved in the planning of water resource management programs. This was recognized and consequently a number of ways of obtaining public participation were incorporated into the Okanagan Basin Study and are reported upon in this chapter.

The analysis of early public response to water management issues served two objectives. First, it provided an overview of the perception and priorities of water resource management problems in the valley, as seen by a sample of residents with some experience in the region. This was considered to be a fundamental information base for the subsequent expansion of the public involvement program. Second, from the Okanagan Basin Agreements' specification that the comprehensive plan "meet the desires of the people for which it is designed", it was considered important to obtain early public reaction to the study plan. This information was used to support and where necessary, expand the initial scope of the study.

This review of public reaction to water and related resource management issues in the Okanagan covers the period from 1965 to early 1973, by which time most of the information on the existing resource base had been analysed and debated with the public. It begins with a discussion of the development of public concerns about water resource problems between 1965 and 1969, which set the stage for the initiation of the public involvement program. This is followed by a review of briefs submitted at public meetings held in the Shuswap and Okanagan Valleys, an analysis of results of a resident survey on water-related issues and a full description of the 'interest-based' planning model which was developed to obtain better communication between the study and the public interest groups.

10.1 EMERGING PUBLIC INTEREST IN WATER MANAGEMENT

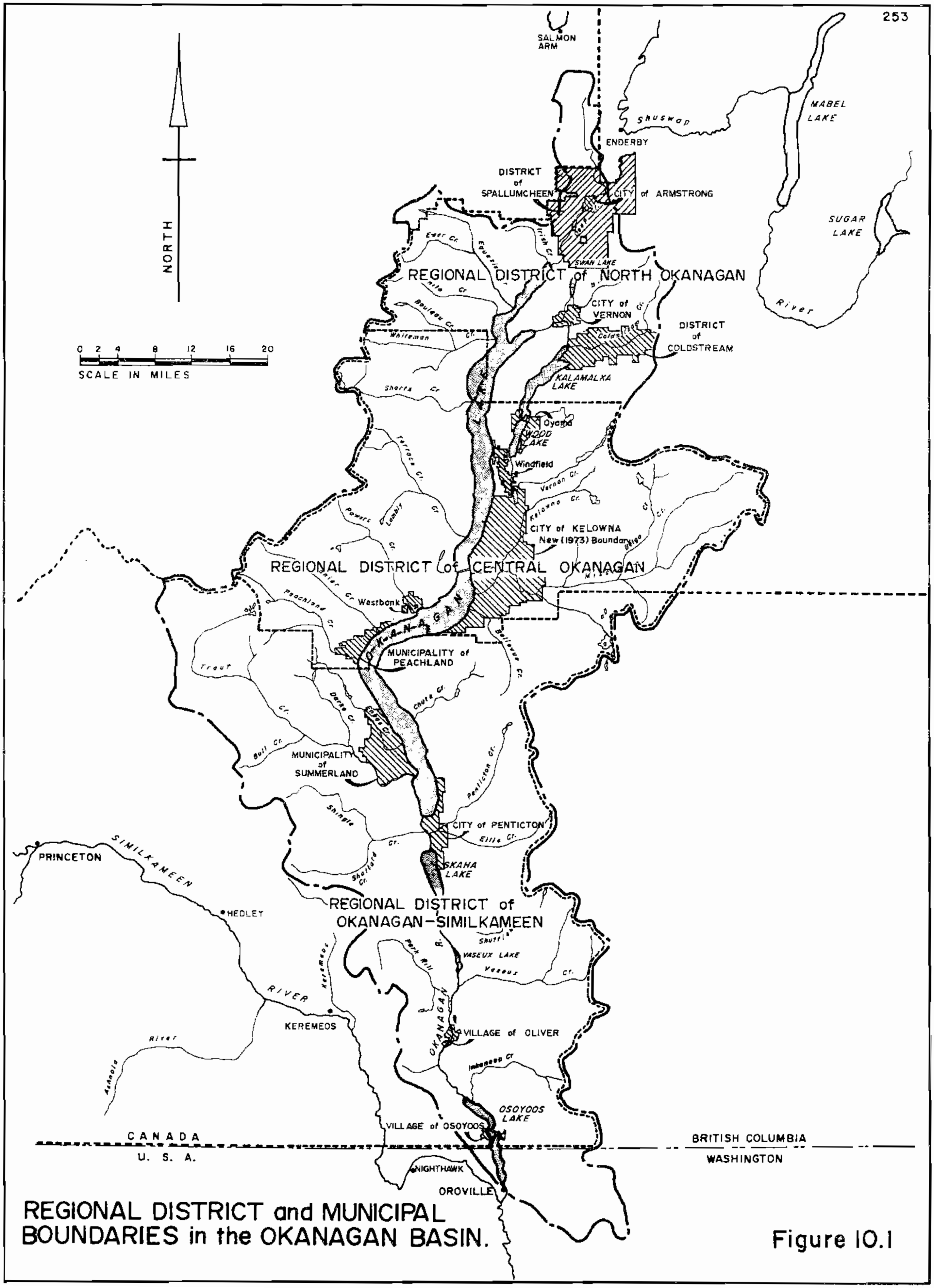
Involvement of Irrigation Districts in the development of water supplies from tributary streams and lakes has been an important factor in water quantity management. Consequently, Irrigation District officials were mainly instrumental in co-operating with the senior governments in the rehabilitation of many of the irrigation supply systems during the latter half of the 1960's. This program significantly reduced the threat of water supply failures in most irrigation systems, served from tributary streams.

Although there was growing concern on the part of many individuals towards water quality deterioration in the main valley lakes in the early 1960's, no important response by local institutions is recorded until early 1965, when the "Kelowna and District Executive Committee for Okanagan Pollution Control" was created. This committee, comprising municipal officials and local representatives of the senior governments discussed the need for water resource planning to study the condition of the main valley lakes and the control of waste disposal into surface waters. Realizing that water quality and waste management were valley-wide problems, the Committee invited officials of the 10 major Okanagan Municipalities to become involved, a move which led to the creation of the Okanagan Watershed Pollution Control Council in 1966 (Figure 10.1).

The Council held four meetings in 1967, in which it debated several proposals for waste management: These included (1) irrigation of Indian Lands with secondary treated effluent from Penticton (subsequently discarded in favour of tertiary treatment by means of chemical precipitation) (2) requests to the Federal government for reduction of phosphate levels in laundry detergents, and (3) discussions with the B.C. Pollution Control Branch on discharge permits for new or expanding industries and residential subdivision. Lacking any legal authority, the Council explored, with the Provincial Government, the concept of establishing a Pollution Control Board composed of Regional District and municipal officials.

The Province responded in June 1968 with a proposal to establish the Okanagan Basin Water Board to advise the Provincial Government on the coordination of both water quantity and water quality management in the valley. The Board would consist of elected officials of the three Regional Districts and would be aided by a technical committee composed of local, federal, and provincial government officials involved in water resource management. Following clarification of its terms of reference, the Board became a legal entity in May 1969, thereby replacing the Okanagan Watershed Pollution Control Council.

The main concept behind the formation of the Okanagan Basin Water Board was to utilize local knowledge concerning water resource management issues in the basin and quickly communicate these to the appropriate government agencies. Specifically, the Letters Patent of the Water Board enable it to "receive proposals from all levels of government concerning water resources utilization and management in the best interests of man", and 'to provide communication and coordination between all levels of government and government agencies involved in water resource utilization and management'. The Water Board can also effect two-way communication by presenting "proposals and recommendations (on water resource utilization and management) to appropriate government agencies". These proposals may originate from the Water Board itself, its technical committee, or from public briefs. With its very obvious interests in good water management in the Okanagan, the Water Board established strong communication



REGIONAL DISTRICT and MUNICIPAL BOUNDARIES in the OKANAGAN BASIN.

Figure 10.1

links with the Study, and held a series of public meetings in 1971 to receive information from individuals and interest groups on their desires for future water resource management and planning. An analysis of the content of these briefs is presented later in this chapter.

Further in response to local representation over a period of some 10 years concerning the adequacy of water supply in the Okanagan Valley to meet future irrigation and other requirements, the province of British Columbia investigated a number of alternatives, including water diversion from the Shuswap watershed, as a research project under the Federal-Provincial ARDA Agreement.

This proposal sparked a response from interest groups in both the Okanagan and Shuswap-Thompson watersheds, although a canal between the Shuswap River at Enderby and Okanagan Lake had been proposed as early as 1886 in connection with navigation problems in the area. In the Okanagan, an Okanagan Water Resources Committee was formed in support of the diversion scheme, in the belief that water diversion would provide for such boat passage, as well as increasing the water supply and improving the quality of the main valley lakes. The use of diversion water for navigation and to combat lake water quality problems, though a misconception in view of the small amount of water that could be diverted without involving water export into the United States, was both popular and topical in 1968 particularly in light of the extensive algae blooms which occurred on Skaha Lake. In the Shuswap-Thompson watershed, the proposed diversion led to the formation of the Shuswap-Thompson Research and Development Association (STRRADA) in January, 1967. The main platform of this and of some other interest groups in that region was that other alternatives including more efficient management of water in the Okanagan should be examined, and there should be better communication between government and public before water resource management decisions were made.

It was in this climate of increasing public awareness and concern about water quantity and water quality management that the Canada-British Columbia Okanagan Basin Agreement was signed in October, 1969. Although the Agreement incorporated many of the interests of public groups in both watersheds, the Consultative Board felt that there was a need to improve communications between the Study and public interest groups as required in the terms of reference of the Agreement, and in 1970 the Board met with both the Shuswap-Thompson watershed interest groups and the Okanagan Basin Water Board.

10.2 PUBLIC MEETINGS

10.2.1 Shuswap-Thompson Public Meeting

The Consultative Board held a public meeting in Salmon Arm on November 6, 1970, and received briefs from 11 public interest groups and five individual citizens. The main concern expressed by most public participants was that diversion from the Shuswap River could have important impacts on the fishery and aesthetic resources of the Shuswap-Thompson system and therefore, the comprehensive water resource study should include both watersheds. The Consultative Board noted that, in fact, the Agreement specified studies would be undertaken of the Shuswap should the diversion prove to be a feasible alternative, but added that the Okanagan Study was mainly oriented toward determining water resource management solutions within the Okanagan Valley.

This latter point was an important pivot in the communication between the Consultative Board and the public interest groups. Some of the interest groups not only opposed diversion, but also challenged the right of one basin to outgrow its own water resource base and then have to rely on adjacent watersheds to supply the necessary water to continue its economic development, possibly to the environmental deterioration of the donor watershed. The Consultative Board assured the meeting that the Okanagan Agreement required it to examine a wide range of pollution control and water quantity alternatives, including management measures that 'insure the subsequent efficient utilization of water resources' within the Okanagan Watershed. It was generally agreed by both the Consultative Board and the public that there had been a useful exchange of ideas and a better mutual understanding about the goals of the Okanagan Study. A commitment was made to keep the STRRADA informed on the progress and results of the Study.

10.2.2 Okanagan Basin Water Board Meetings

The Consultative Board met with the Okanagan Basin Water Board in Kelowna in November, 1970 and during the exchange of ideas on the objectives of the Okanagan Study, the Water Board raised the question of how public interests, values and desires would be incorporated into the development of a framework plan for the management of the water resources of the basin. It was mutually agreed that both Boards had an interest in obtaining public responses to questions of water and related resources management and that they would share the results of their respective programs.

The Okanagan Basin Water Board, in pursuit of one of its goals to promote two-way communication between government agencies and the public, held a series of six public meetings between the end of May and the end of November 1971. The meetings were held in Vernon, Penticton, Princeton, Kelowna, Osoyoos and Enderby and attracted almost 600 people plus 110 written and oral briefs presented by a variety of interested groups and individuals.

Although the original desire of the Okanagan Basin Water Board was to obtain the views of local residents on water resource management issues, the briefs ranged far beyond the confines of the intended subject. However, the views expressed did relate to the broader aspects of resources management and did help to provide both the Water Board and the Consultative Board with a wider perspective of public interest in resource planning. As is the case with most submissions at public meetings, it was not possible to evaluate how well the views expressed by local organizations and individuals represented the feelings of the Okanagan residents as a whole. However, it was assumed that these views did represent the values of a much larger sample of residents than those actually attending the meetings.

On the basis that the number of briefs expressing views on various water resource management issues was an indication of relative public concern on these issues, water quality management was identified as the most important water resource problem facing the valley. Twenty-three briefs commented upon deteriorating water quality conditions in various locations of the basin and 31 briefs supported the need for stricter controls on waste discharge into lakes and streams. In the area of water quantity management, there was concern that increasing water requirements for consumptive use would place a strain on the supply of water to satisfy fishery, wildlife and recreation requirements, and consequently, 24 briefs urged more careful water quantity management to resolve future conflicts in water use. No briefs supported the diversion of Shuswap water and five were opposed to it.

In addition to the immediate concerns for water management, many submissions noted the generally high quality of environment in the Okanagan and expressed forebodings that this quality would not be maintained if the rapid growth of population and industrial development of the past decade continued. Fifteen briefs supported non-resource based industrial development in the valley only while 19 briefs demanded a more planned approach to economic growth. It is interesting to note that several briefs recognized some industrial growth was necessary to maintain a healthy economic environment which, in turn, was an essential ingredient to the full enjoyment of the natural environment.

Several briefs commented on the importance of agriculture in the economic and social life-styles of the Okanagan. Thirty-one statements were made in support of retaining agricultural land for agricultural purposes and/or some controls placed on sub-division of these lands for non-agricultural activities. In addition, 11 briefs noted the present marginal economic situation of some agricultural activities in the Okanagan and felt that economic support was required to supplement protection of agricultural lands. Only two statements specifically connected protection or expansion of agricultural landuse with the need to supply more water which in turn creates increasing problems of managing and allocating the limited water supplies of the Okanagan amongst the competing uses. The future of the agricultural industry was seen as a resource problem in its own right, rather than as a possible problem in water resource management, the central concern of the Okanagan Basin Study.

Some participants addressed themselves to educational and institutional aspects of water management. Six briefs sought improved educational programs in schools and regional colleges, to promote a better understanding of the water resource system in the valley, and more responsible ways of utilizing the resource for conservation and environmental management. Some organizations recognized that the water resource system encompassed the entire basin and that some institutional mechanism, transcending the regional levels of government, was required to effect coordination of water resource management with the related resource uses. It was thought that such co-ordination would be necessary to achieve a balanced approach to economic development, environment and landuse planning. The format of such a body was not clearly articulated at these public meetings but was later to become an important discussion topic in the Public Involvement Program.

In summary, briefs presented at both the Salmon Arm meeting and the Okanagan Basin Water Board meetings recognized that the water was a vital element in the economic development in the basin and a major constituent of its natural environment. Consequently, water resource planning should not occur in a vacuum, but most implicitly involve the broader issues of the type of economic and natural environment desired by valley residents in the future. Although the Consultative Board accepted this premise, it did seek confirmation that the statements on goals and values contained in the briefs did indeed represent the feelings of a majority of Okanagan residents and not just a vocal minority. To test this thesis, the Study undertook a systematic questionnaire survey of a cross-section of Okanagan households during the fall of 1971.

10.3 RESIDENT SURVEY

The main objective of the resident survey was to obtain more background information on Okanagan residents' present knowledge of water resource problems in the valley, their willingness to participate in community affairs and water resource planning in the future, and their attitudes towards certain issues raised in the public briefs concerning the future life-style of the Okanagan. These issues included the balance between economic development and maintenance of high quality environment, the decline in agricultural acreage and the increasing tourist population.

A random sample of 384 households was selected from all parts of the valley and was statistically verified as a representative cross-section of the total population using population census data (see Technical Supplement XII). This general sample was stratified into two major sub-samples. One sub-sample contained responses from residents in each of the three Regional Districts of the Okanagan (North, Central, South); the other sub-sample contained responses from residents in urban (Penticton, Vernon, Kelowna), rural-urban residents (smaller towns such as Summerland) and rural areas. Analysis of the survey results was carried out to test for differences in attitudes and opinions within these sub-samples.

The major findings of the survey are as follows.

10.3.1 Perception of Major Problems Facing Okanagan Residents

Environmental pollution was identified as the single most important problem by almost one-quarter of the sample, followed by population crowding (18%) lack of industry (15%) and decline in agricultural lands (12%). Residents in the North Okanagan tended to be relatively more concerned about pollution while their counterparts in the South Okanagan placed relatively more weight on lack of industry. A more detailed breakdown of the variations in response to this question by sub-group is presented in Table 10.1

TABLE 10.1

OPINIONS ON THE MAJOR PROBLEMS FACING OKANAGAN RESIDENTS IN THE NEAR FUTURE

PROBLEM	GENERAL SAMPLE %	REGIONAL BREAKDOWN %			RESIDENTIAL BREAKDOWN %		
		NORTH	CENTRAL	SOUTH	URBAN	RURAL-URBAN	RURAL
Pollution	24	30	25	18	24	28	15
Population-Crowding	18	10	25	19	20	13	19
Lack of Industry	15	7	13	23	21	10	9
Decline in Agricultural Land	12	10	12	14	6	17	20

*NOTE: Percentages do not add up to 100 as some responses are not included in the table.

10.3.2 Awareness of Water Resource Problems

Almost 80% of residents recognized the existence of water resource problems in the Okanagan and about half of these were most concerned about water quality. This was stated as the most serious issue by all sub-samples except rural dwellers who were more concerned about adequate water supplies. Municipal wastes were the most frequently cited cause of water pollution (38% of the sample), compared with industrial wastes (27%) and agricultural run-off (26%). Urban dwellers tended to place more blame on agricultural practices, while rural dwellers placed most of the responsibility on the municipalities (Table 10.2).

TABLE 10.2

OPINIONS ON MAJOR SOURCES OF WASTES IN THE OKANAGAN

SOURCES	GENERAL SAMPLE %	REGIONAL BREAKDOWN			RESIDENTIAL BREAKDOWN		
		NORTH %	CENTRAL %	SOUTH %	URBAN %	RURAL-URBAN %	RURAL %
Municipal Sewage	38	46	33	36	31	44	45
Industrial Wastes	27	23	35	30	31	33	24
Agricultural Runoff	26	27	22	31	34	20	10
No Response	9	4	10	3	4	3	12

NOTE: Percentages denote the proportion of respondents in any given groups identifying a source as the most important one.

10.3.3 Attitudes on Future Life-Styles

Residents were asked to state their preferences for a range of future projections, similar to those described in Chapter 12. About two-thirds of the general sample stated their desire for planned economic growth, which created employment opportunities and yet maintained an acceptable level of environmental quality. A significant minority of residents (15%) were willing to sacrifice potential economic development in favour of maintaining a high environmental quality, while only 3% were willing to sacrifice environmental quality in order to increase the rate of economic growth.

Opinion on population growth was divided. Generally speaking, over half the sample (62%) wished for some degree of control on population growth, either immediately (44%), or in the more distant future (18%), while 34% of respondents did not want any restrictions placed on population. Relatively more residents in the North and Central Okanagan supported controlled population growth than those in the South (Table 10.3).

TABLE 10.3

OPINIONS ON POPULATION CONTROL IN THE OKANAGAN VALLEY

SOURCES	GENERAL SAMPLE %	REGIONAL BREAKDOWN			RESIDENTIAL BREAKDOWN		
		NORTH %	CENTRAL %	SOUTH %	URBAN %	RURAL-URBAN %	RURAL %
No Restrictions	38	32	34	44	41	34	32
Some Restrictions later	18	19	13	20	18	21	12
Planned Controls now	33	37	38	28	32	34	40
No Population Growth	11	12	15	8	9	11	16

There was a strong desire to place stricter controls on waste discharges to surface waters (69% of sample), thus supporting statements made in public briefs at the Okanagan Basin Water Board hearings. In addition, there was also general agreement to plan future industrial growth carefully thus avoiding undue environmental damage (83% of sample), to protect agricultural lands from municipal and industrial subdivision (80% of sample) and to maintain a viable tourist industry (79% of sample). On this latter issue, there was some divergence of opinion in the public briefs, in which some citizens were concerned about the crowding of facilities during the summer. Relative unanimity amongst resident survey responses on this issue could possibly be a reflection of collecting opinions during the fall when respondents would not be immediately aware of summer tourist pressures, whereas, some public briefs were prepared during the summer months.

Those interviewed were asked whether planned development, with emphasis on maintaining environmental quality, would affect their future taxation payments. Sixty percent of the respondents thought that planned growth could be achieved with no additional taxation, but rather by a re-allocation of the existing tax base. Over 30% (mainly in the higher income groups) recognized and accepted that it would cost more to live in a high quality environment. Only 10% (mainly in the lower income groups) were willing to accept some deterioration in environmental quality in order to keep their taxes down (Figure 10.2).

10.3.4 Attitudes Towards Public Involvement

Some attempt was made to determine residents' willingness to become involved in water resource planning in the Okanagan. Of the large majority of the sample who were aware of water resource problems, about half of them were not particularly concerned about these problems, though 23% were concerned enough to initiate individual or group action. Almost 60% of residents felt that individual and/or group involvement in resource planning would be worthwhile and stated their willingness to participate or at least keep informed about the results of the Okanagan Study. About one-third of the sample was pessimistic about the effectiveness of public involvement in water resource planning, and this group was more likely to be composed of older people or those with low household incomes and levels of educational achievement (Table 10.4).

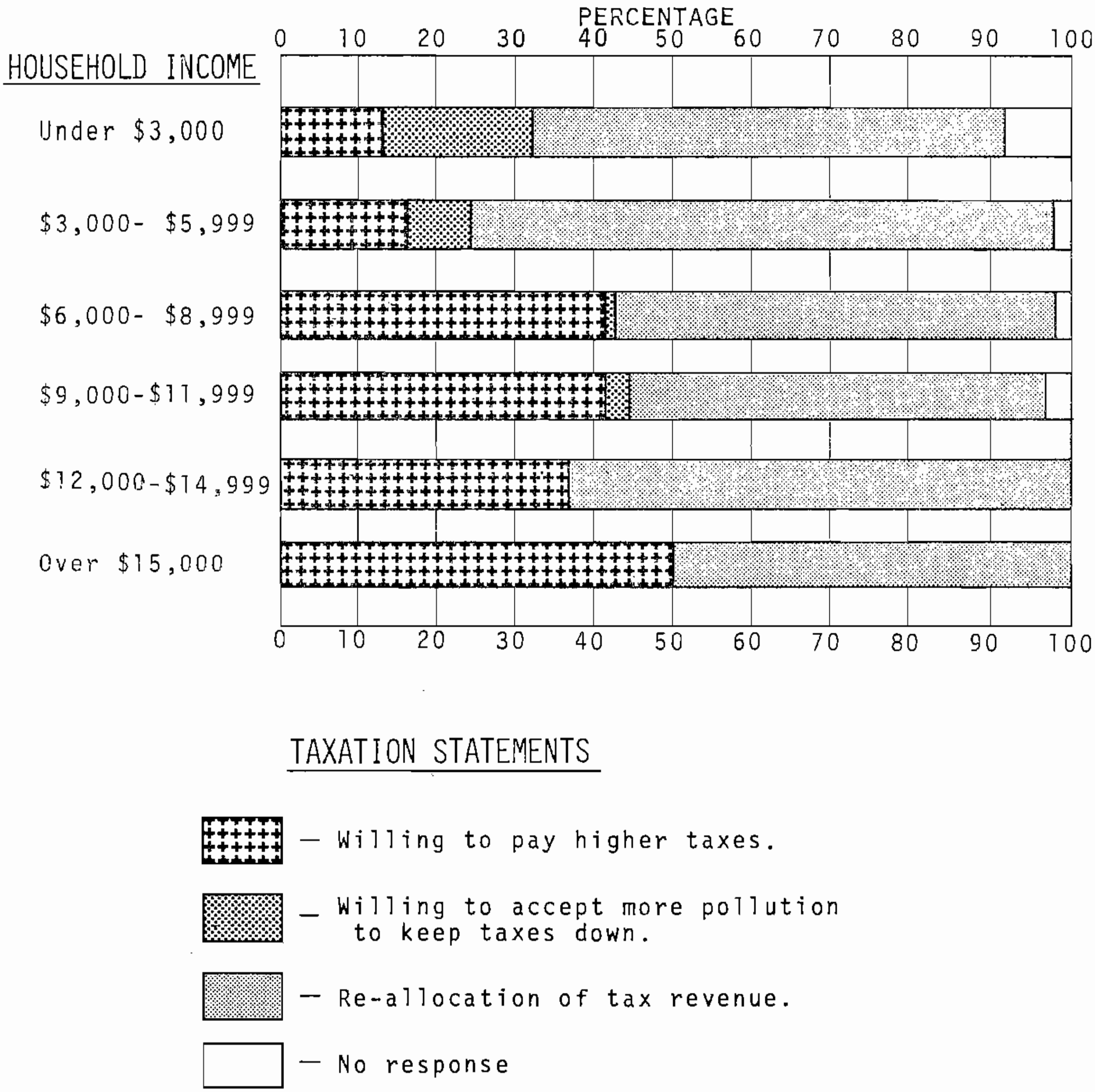
TABLE 10.4

WILLINGNESS TO PARTICIPATE IN THE OKANAGAN BASIN STUDY PUBLIC INVOLVEMENT PROGRAM

	GENERAL SAMPLE %	AGE GROUPS			INCOME BREAKDOWN		
		20-35 %	36-55 %	OVER 55 %	$3-6,000 %	$6-12,000 %	$12,000 & Over %
Would Participate	63	75	69	51	51	70	82
Would Not Participate	29	19	20	41	39	24	12
Uncertain	8	6	11	8	10	6	6

10.3.5 Preferred Institutions for Water Resource Planning

Although there was little awareness of the nature and role of various government agencies involved in water resource management in the Okanagan, almost half of the respondents (46%) believed that more effective coordination of Provincial and local government agencies was required and that citizens should be given some opportunity to become involved in the decision-making process. This latter belief was felt particularly strongly by longer-term residents (over 10 years experience in the valley), and the younger age groups (under 35).



ATTITUDES OF VARIOUS INCOME GROUPS TOWARDS FUTURE TAXES

Figure 10.2

10.4 DISCUSSION OF PUBLIC RESPONSES

Both public meetings and questionnaire surveys exhibit important strengths and weaknesses as vehicles for soliciting public responses to resource management issues. To some extent, the strengths of one compensate for the weaknesses of the other. Public meetings, for example, generally attracted a limited cross-section of viewpoints and opinions from a community, whereas the random sample for the survey contacted a wide cross-section of opinion - old and young, rich and poor, urban and rural dwellers, new-comers and long-term residents.

The main disadvantages of a survey are that residents had little opportunity to ponder responses, had little or no information about many issues posed in the questionnaire and were not obliged to commit themselves to their replies. On the other hand, it is assumed that individuals or groups preparing public briefs had more time and resources to obtain better information on the issues to which they addressed themselves.

Despite these differences, there were many similarities in the responses at the public meetings and from the resident survey. The majority of residents in the Okanagan, and many of those who presented briefs at Salmon Arm, appeared concerned with the rapid pace of economic growth in the Okanagan, and expressed the desire that the Okanagan should grow at an orderly and planned rate to ensure a high quality environment. There was also strong support for maintaining a viable agricultural industry in the valley together with the protection of farm land and the continuation of a large tourist industry, provided this did not lead to over-congestion of local facilities.

In terms of water resource management, most individuals and groups viewed water quality deterioration as the major problem and desired stricter controls on waste discharges. No residents in either the Shuswap or Okanagan valleys expressed their support for water diversion, most favouring more efficient water utilization and management in the Okanagan. It is interesting that none of the public briefs mentioned the problem of flooding around Okanagan and Osoyoos Lakes, undoubtedly due to the infrequent occurrence of this problem in the valley. It should also be noted that these briefs were prepared prior to the 1972 flood, which was one of the highest on record.

The Okanagan Study responded to the viewpoints summarized above by examining a range of future economic growth projections and levels of agricultural landuse development and analysing the impacts of these projections on the quantity and quality of the water resource. In addition, the study continued to develop its approach to public involvement to ensure that two-way communication about water and related resource management issues would be maintained and that Okanagan residents could be given the opportunity to become fully informed as to the consequences of various framework plans for the region.

In summary, the public perceived the concept of comprehensive water resource planning for the Okanagan in somewhat broader terms of reference than those included in the Okanagan Agreement. The Board responded, in turn, by expanding the scope of economic and landuse studies and by launching into an innovative and comprehensive public involvement program.

10.5 THE PUBLIC INVOLVEMENT PROGRAM

In light of growing public interest in the Okanagan Basin Study, a more comprehensive program of public involvement was initiated in 1971. Many problems and misunderstandings were encountered during the development of this program as public involvement was a relatively new experience for both the study personnel and the general public, and, in part, because study data were not yet available in a form that could be easily comprehended. Consequently, the program was developed through trial and error by a number of consultants with different types of experiences and approaches to this most experimental component of the Study.

In February, 1971, the Consultative Board and Study Committee held a two-day seminar in Penticton, at which numerous key individuals from the regional districts and Okanagan Basin Water Board attended. This was the first occasion that preliminary study data were available in a form that could readily be discussed and understood by non-study personnel. As a result of the public response gained at this seminar, expanded studies in the areas of sport fishing and tributary stream management were undertaken.

The Board recognized the need to obtain a wider range of viewpoints in the public involvement program and a survey of public interest groups was therefore carried out in the spring and summer of 1971. This survey provided information on who the 'public' was in the Okanagan, how various community groups were organized and the range of interests that should be involved in the public involvement program. More specifically, the roles, social structure and membership size of each interest group were determined as well as the means of communication between groups and with the various levels of government. In addition, each group's knowledge of the purpose and scope of the Okanagan Study was examined as well as its potential interest in participation with the Okanagan Study in developing the framework plan.

Altogether, 40 community interest groups were identified including regional districts, irrigation districts, service organizations, unions, industrialists conservation-ecologists, tourist facility operators, native people, chambers of commerce and student bodies.

Using this information, a number of interest groups and community leaders were contacted during the remainder of 1971 and supplied with up-to-date information on study progress and results. Video-tape and slide shows were developed to educate community groups on the scope and objectives of the

Okanagan Study and to assist in their understanding of the complexities of the planning process. This phase of the Public Involvement Program culminated with a two-day seminar-workshop held in Naramata in March 1972. Over 100 leaders of interest groups and the general public together with local government officials met with Study personnel to examine and review current information on most of the aspects of water resource management presented in this report.

Although considerable attention had been directed towards involving public groups and individuals in the planning process, by the spring of 1972, the public involvement program was still a long way from its envisaged objective. The Board recognized the need to gain the wider cross-section of public input known to exist within the community if the final plan was to reflect the desires and values of all Okanagan residents. In addition, preliminary study information had to be collated so that it was consistent and in a form that could be understood by the public. Much of this information was developed in summary form and published in six technical data bulletins dealing with most major components of the study program. These data bulletins were published in June, 1972 and were followed by other bulletins and detailed technical reports, prepared by members of the study team.

With factual information available, there was a need to expand the public involvement program and utilize a broader array of communication media to generate mutual education between the study and the total valley community.

The Okanagan Study Committee drew up new terms of reference for the program, which included the following major goal:

> "To report to the Okanagan Study Committee, the preferences of Okanagan valley residents for the future development and management of the basin's water resources, based on their studied consideration of the economic, social and environmental implications of the various alternatives."

The major components of the program were identified:

1. To assimilate the results of various technical studies conducted under the Okanagan Basin Agreement.
2. To acquire, through cooperative involvement with the evaluation team a thorough understanding of water management alternatives for the Okanagan Basin.
3. To develop positive interaction between the valley residents and the Study Committee such that the residents become meaningfully involved in the Study while the Committee becomes aware of the perspectives of the residents.

10.5.1 Interest Based Planning Model

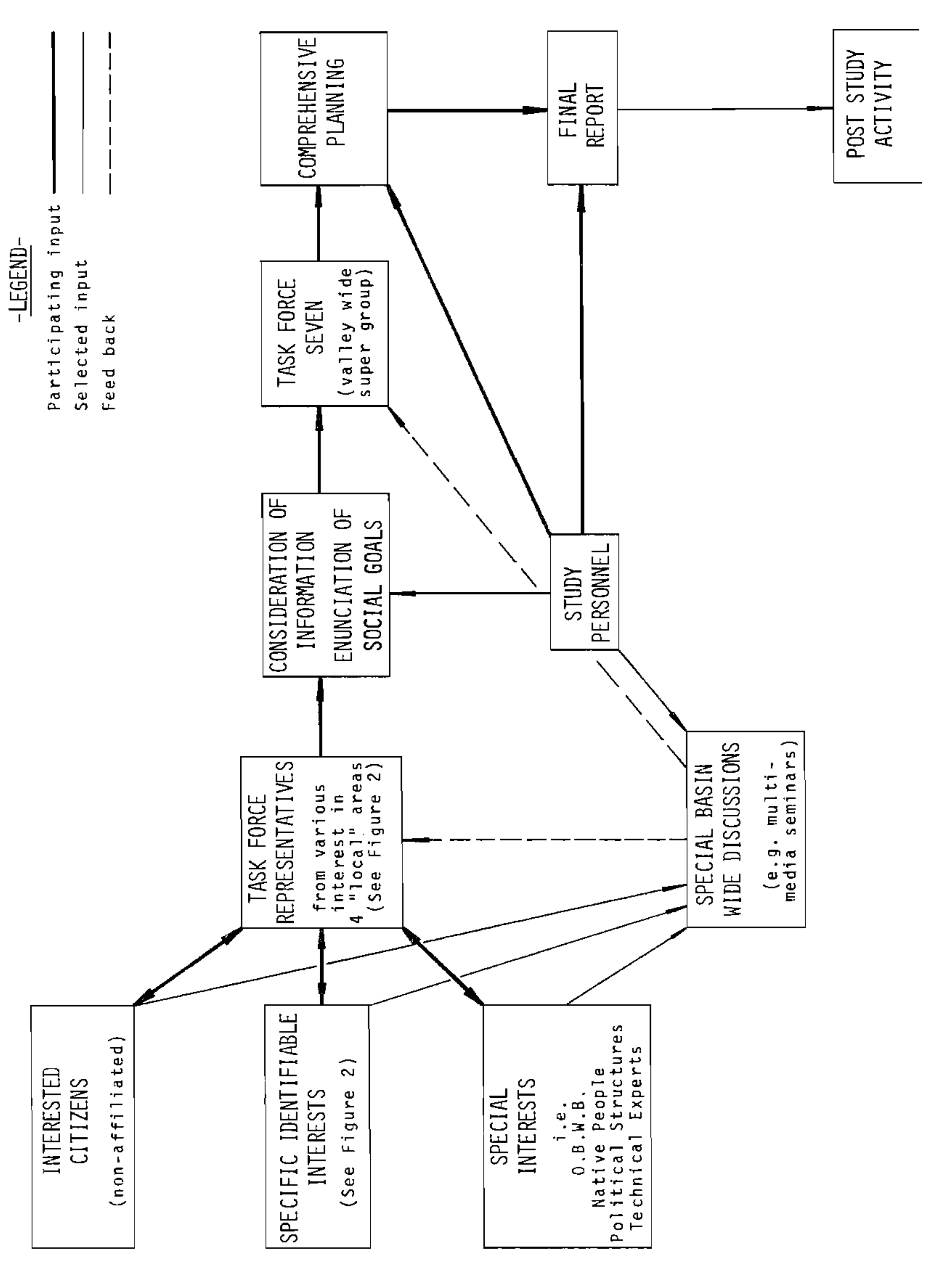
An interest-based planning model (Figure 10.3) was developed to handle information exchange with the public in a systematic and concise manner. The main purpose of the model was to bring together a wide range of community interest groups and their resources to participate in the development of the framework plan. These interest groups included those covered in the opinion survey of the previous summer along with local political structures, private corporations and other concerned individuals (Figure 10.4). Because of time limitations, it was not possible to provide information to all public groups on all the aspects of this complex study, but by establishing a rigorous timetable, a large number of interest groups were able to participate in the planning process.

Following a four month period during which all identified interest groups were informed of the interest-based planning model and brought up to date on study progress, six community Task Forces were formed. Each Task Force consisted of about 15 individuals representing a wide spectrum of community interests, and were considered reflective of the values and desires of a majority of the Okanagan residents. Four of the six Task Forces contained individuals from each of the four economic regions of the basin (Vernon, Kelowna, Penticton and Oliver-Osoyoos regions). One was a political Task Force consisting of various elected officials from the municipal centers and regional districts, and one was a "technical" group of locally based government officials and other individuals with experience in various aspects of water resource management in the Okanagan.

Each Task Force member was provided with a number of technical reports developed by study personnel as well as a series of questions concerning the type of socio-economic life-style desired by Okanagan residents over the next 50 years. Specific information on the projections of economic growth to 1980 was also made available together with the consequences of increased demand for water and waste loadings on water resource management. Using this information base, the six Task Forces produced a preliminary set of recommendations for developing a comprehensive framework plan for the 50 year planning horizon.

In April, 1973, selected members of the six Task Forces joined forces to create Task Force Seven, a valley-wide group consisting of about 24 members. Task Force Seven spent the spring of 1973 reviewing and revising the set of recommendations created by the earlier Task Forces based on new or revised study information and the continuing integration of a wide range of individual preferences and values.

To insure that Task Force recommendations did indeed reflect the values of the community at large, a general public education probram was developed involving both the dissemination of information and public response.



THE "INTEREST-BASED-PLANNING" MODEL

Figure 10.3

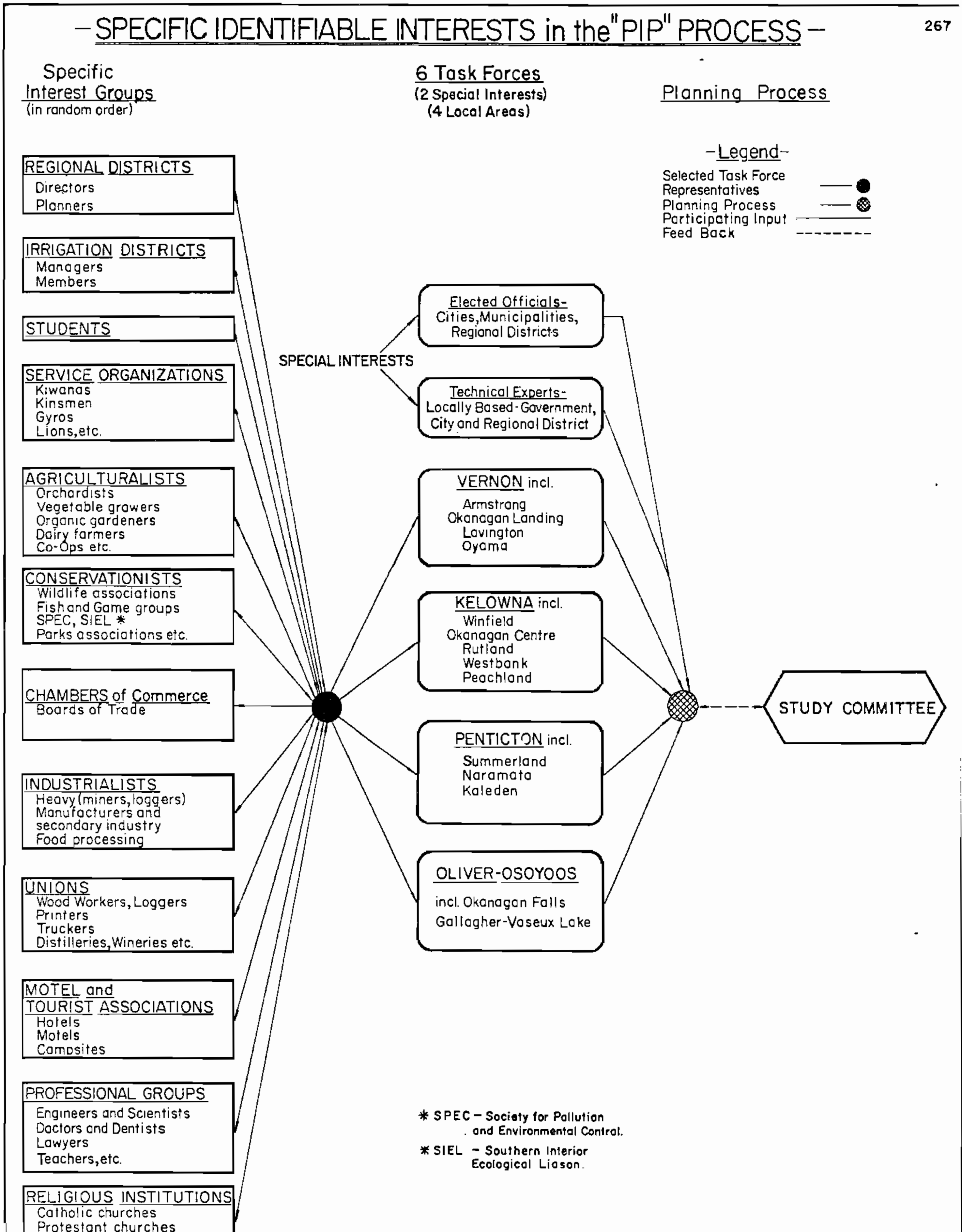

– SPECIFIC IDENTIFIABLE INTERESTS in the "PIP" PROCESS –
Specific Interest Groups (in random order)
6 Task Forces
(2 Special Interests)
(4 Local Areas)
Planning Process
–Legend–
Selected Task Force Representatives
Planning Process
Participating Input
Feed Back
REGIONAL DISTRICTS
Directors
Planners
IRRIGATION DISTRICTS
Managers
Members
STUDENTS
SERVICE ORGANIZATIONS
Kiwanas
Kinsmen
Gyros
Lions, etc.
AGRICULTURALISTS
Orchardists
Vegetable growers
Organic gardeners
Dairy farmers
Co-Ops etc.
CONSERVATIONISTS
Wildlife associations
Fish and Game groups
SPEC, SIEL *
Parks associations etc.
CHAMBERS of Commerce
Boards of Trade
INDUSTRIALISTS
Heavy (miners, loggers)
Manufacturers and secondary industry
Food processing
UNIONS
Wood Workers, Loggers
Printers
Truckers
Distilleries, Wineries etc.
MOTEL and TOURIST ASSOCIATIONS
Hotels
Motels
Campsites
PROFESSIONAL GROUPS
Engineers and Scientists
Doctors and Dentists
Lawyers
Teachers, etc.
RELIGIOUS INSTITUTIONS
Catholic churches
Protestant churches
other religions
other philosophies
SPECIAL INTERESTS
Elected Officials- Cities, Municipalities, Regional Districts
Technical Experts- Locally Based-Government, City and Regional District
VERNON incl. Armstrong Okanagan Landing Lavington Oyama
KELOWNA incl. Winfield Okanagan Centre Rutland Westbank Peachland
PENTICTON incl. Summerland Naramata Kaleden
OLIVER-OSOYOOS incl. Okanagan Falls Gallagher-Vaseux Lake
STUDY COMMITTEE
* SPEC – Society for Pollution and Environmental Control.
* SIEL – Southern Interior Ecological Liason.

Figure 10.4

10.5.2 Public Education (Information Out)

A number of procedures were developed to translate technical information on the water resource into 'lay' terms easily understood by the general public. The most frequently used mechanism involved the use of news releases and news conferences relating to specific aspects of the Study program. In addition, two 'multi-media seminars' were presented in which the major television station and five of the six valley radio stations joined forces with the local newspapers to discuss the major components of the study. Details of the arrangements and format of these media seminars are discussed in Technical Supplement XII. Essentially, these media seminars were conducted as 'town-hall' type meetings with the advantage that no citizen had to leave his home or car, and rather than holding several sessions throughout the valley, one evening would suffice for all. Furthermore, a person at one end of the valley could hear viewpoints of a person at the opposite end of the valley on common interests under discussion.

The first media seminar was held in November, 1972 when aspects of a water management plan to 1980 were debated, and a second seminar was held in April 1973 and dealt with the preliminary recommendations of Task Forces 1 to 6. In addition to these seminars, radio, television and local newspapers prepared several special presentations on various aspects of study results and Task Force deliberations.

The second major education tool was the written word. Beginning in 1972, a series of ten data bulletins were prepared by Study personnel and disseminated widely throughout the valley. In addition, a large number of the preliminary reports resulting from the various studies on water resources were published in limited quantities to provide more technical information to interested citizens. All bulletins were made available to the public through mailing lists or at 'information locales' such as regional libraries, banks, barber shops and other public places where people have time to read. Altogether, 562 information locales were established throughout the basin, and by July 1973, the mailing list contained over 3500 persons. The preliminary reports were made available through the regional libraries in the Valley.

Two other types of documents were prepared by the public involvement personnel to supplement the above study material. The first of these was a "background working paper," containing details of primary water management alternatives written primarily for the task force members but printed in sufficient quantities to supply all libraries. The second was a "white paper" which raised either pertinent questions or provided tentative alternatives that deserved consideration by the public at large. These latter publications were printed in sufficient quantity to be distributed to the public through the mailing lists, information locales, and at group meetings or speaking engagements of P.I.P. personnel.

The placement of this material in 'information locales' also provided the opportunity for personal communication with the valley residents. In many instances, initial contacts were met with skepticism and criticism mainly due to lack of understanding of the scope of the Okanagan Study and its potential impact on the life-style of residents. Through discussions, this initial resistance was often converted into a spirit of co-operation and enthusiasm which led to more speaking engagements and many additions to the mailing lists.

Audio-visual material was utilized extensively during public workshops and at speaking engagements. Through an arrangement with the British Columbia Department of Agriculture, competent technical assistance was provided to the Study for both film and video-tape production. Two color films were produced for the Study by this group. The first dealt with the problems of conflicting use and abuse of water in the valley and was entitled WILL THERE BE WATER TOMORROW? The second film covered the complexities of comprehensive planning in regards to water management in the valley and was entitled,'A FUTURE FOR THE CHOOSING'. These films served as valuable educational tools in the public involvement program. Video-tape and slides were also utilized but to a lesser degree to record task force proceedings for "in house" review.

Speaking engagements provided a third educational means for discussing Study information with the public. These appearances were supplemented by the two films and a slide show which illustrated some of the water resource development and management problems and possible solutions. Over 200 speaking engagements were handled by the Public Involvement Program staff and other study personnel involving high schools, service clubs and a wide variety of special interest groups. One of the benefits of these engagements was the opportunity for members of interest groups to make personal contact with study officials to obtain a better perspective of the complexity of water resource management decisions.

A major effort was undertaken to educate high school students on Study progress as they represent a significant portion of the valley population and they will inherit much of the results of the study plan. Most high schools in the valley were visited more than once and it was estimated that over 3000 students were contacted during the last 19 months of the study. Judging from the response of both students and teachers, this appeared to be a most worthwhile venture with considerable potential for further development when the Study in completed.

10.5.3 Public Response (Information In)

Public response involved receiving ideas, proposals and criticisms from valley residents concerning the development of the framework plan. Because of the extensive nature of the public education program, the public response phase overlapped the dissemination of information and often initial reactions changed in light of new or expanded information.

In a further effort to determine whether the six Task Forces' recommendations did in fact reflect the will of the community, the second multi-media seminar in April, 1973 was used as a means to discuss them publicly. In this media seminar, selected members of the six Task Forces presented and defended their recommendations during two hours of 'openline' radio discussions with the listening public. The Public Involvement Coordinator was the only Study member involved in this seminar. The results of this media seminar indicated there was little difference in the recommendations as prepared by the Task Forces and the views of residents participating in the media seminar.

At the same time a second "White Paper" which outlined, these preliminary recommendations, was also released and distributed throughout the valley. To provide an opportunity for citizens to respond to this White Paper, a series of eleven public meetings were held by the staff of the public involvement program and members of Task Force Seven in eleven valley communities in May. Few of the general public attending these meetings indicated any disagreement with the recommendations, most participants indicating their general agreement or, in some instances, their concern that some recommendations did not go far enough. Most areas of disagreement, were resolved to the satisfaction of both the petitioner and Task Force Seven members at the meeting, otherwise the issue was referred to a full Task Force meeting for further debate.

Following the public meetings, Task Force Seven continued to review and revise the set of recommendations for water resource management. A final public review was undertaken at a public workshop held in Penticton in June, 1973, hosted by Task Force Seven and attended by over 50 concerned individuals representing a broad range of community interests. During this workshop, finishing touches were made to the recommendations with much of the discussion focussing on the implementation requirements and the continued role of public involvement during the implementation phase.

These recommendations were subsequently presented to the Study Committee, representing the major input of the Public Involvement Program to the development of the comprehensive plan.

10.6 PUBLIC INVOLVEMENT PROGRAM AND STUDY COMMUNICATIONS

Good communications between the Study Personnel and the Coordinator of the Public Involvement Program were essential if the program was to be successful. In May, 1972, the Public Involvement Coordinator was named as a member of the evaluation team, an inter-disciplinary group of experts responsible for evaluating water management alternatives. The coordinator thus gained first-hand knowledge and understanding of the study progress and results, while other members of the evaluation team were kept informed of thoughts of the valley community. In addition, the coordinator met regularly with key Study officials to discuss progress, public news releases and on-going plans. He often attended Okanagan Study Committee meetings. As a matter of course, all senior study personnel and evaluators were provided continuing records of all major task force activities plus any special documents of interest such as major news releases.

This policy of maintaining close contact between the Study personnel and the PIP Coordinator was continued within the Task Force process itself. At most Task Force meetings at least one member of the Study team was present. These members came not only to observe the process but also to participate as they wished in the discussions. This increased the communication between the valley community and the Study and broadened the degree of mutual understanding. On the one hand, Study personnel, after attending a task force meeting, became more aware of the sincerity of the task force members and the willingness of these people to try to work out solutions most acceptable to the community. On the other hand, Task Force members, after sharing discussions with Study Personnel,gained a better understanding of the problems encountered by public officials in attempting to execute policies in the best interests of all.

10.7 SUMMARY AND DISCUSSIONS

There were three overlapping phases to the Public Involvement Program - information out, information in, and communicating public responses to the Okanagan Study Committee. These phases more or less paralleled the major steps in the planning process described in Chapter 12, namely analysis of existing conditions, projecting demands for water resources to 2020 and evaluating alternatives.

Technical information in the form of study reports, news releases or data bulletins were disseminated widely throughout the valley using the local media and multi-media seminars for more specific information packages. In addition to the printed work, information was also available on film, video-tapes and slide-shows. These visual presentations were shown at schools, community meetings and to other special interest groups.

The central part of the 'information in' or public response to this information was the Task Force process, where groups of individuals discussed study data and reported to the Study Committee through the Public Involvement Program Co-ordinator. Each Task Force member was expected to report back to his reference group on study issues to obtain greater citizen involvement. The general public also had an opportunity to respond to water management issues through special interest cards available at information locales throughout the valley and at public workshops, meetings and seminars held at various stages in the planning process.

In the past, public input to the planning and management of water and related resources in the Okanagan, as elsewhere in Canada, appears to have occurred on a rather haphazard basis. As a result, the Public Involvement Program associated with the Okanagan Study was both an experiment in techniques as well as a real attempt to gain public participation in the planning process. Many approaches were tried, including public meetings, questionnaire surveys, media communications, but the most innovative and successful in this study appeared to be the creation of community Task Forces.

Although the Okanagan basin forms a unified physiographic and hydrologic unit, it is not generally perceived by valley residents as a single economic and social system. Regional differences and attitudes had developed over time, and not all of these were conducive to the development of a framework plan that served the best interests of the total community. By creating community task forces, first at the regional scale and then on a valley-wide basis, much of the original conflict in interest was overcome and, through mutual education, a broad area of concensus concerning the future of the Okanagan appeared. By providing Task Force members with opportunities to debate their conclusions with other members of the valley community via media seminars, workshops and public meetings, Task Force members, themselves, began to assume a responsibility together with study personnel in preparing a framework plan which would serve the best interests of all Okanagan residents.

In retrospect, it appears that public input must be properly directed, if it is to become an effective part of the planning process. The valley community had developed many informal communication mechanisms between interest groups and to the various levels of government on water resource management issues, and despite the lack of specific knowledge about the Okanagan Basin Study, most respondents in the resident survey had a fair comprehension of many of the real problems discussed in Part II of this report. However, there was no ready access to technical data and no forum at which these views could be debated, until the "interest-based planning model" was developed in 1972. This model provided the vehicle for a systematic and, considering the time limiations, comprehensive exchange of views on all aspects of the Study with a broad range of public interest groups and individuals.

CHAPTER 11

Legal, Administrative and Institutional Arrangements

While the development of resource use plans can proceed under a variety of laws, rules, rights and customs, the implementation of any specific course of public action must conform to law. It must be carried out by administrative bodies created under, and whose actions are bound by, a particular structure of laws and regulations. Before any decisions on the future management of a resource can be made therefore, it is necessary to establish the scope and effect of the existing legal and institutional system on future management options. Assessments can then be made of what changes are desirable and are likely to be acceptable. While some aspects of the legal and administrative system can be changed to suit resource use plans, there are certain fundamental matters that are so basic to our way of life, that, as a matter of practice they cannot be changed.

Although essentially an individual may do what he likes with his own property, in the interest of peaceful enjoyment of life, governments have been given the power to modify, to the extent it is within their jurisdiction to do so, this freedom for the benefit of the community as a whole.

In Canada, the British North America Act,1867 delineates the areas of responsibility of the Federal & Provincial Governments, that is, their jurisdiction (Figure 11.1). In some cases the delineation is clear; in others it is not. Consultation and joint agreement may be one method to effectively clarify and resolve jurisdictional questions where they are unclear.

Within the Province of British Columbia provincial powers can be and have been delegated to various levels and types of local government. These local governments cannot override the provincial government and have no powers except those given them by or under a provincial statute. Questions of what a local government can do or over what geographical area it has authority are also matters of jurisdiction.

Most of the institutional and legal problems concerning water resource management spring from either the basic property rights of the individual or from questions of jurisdiction.

Under the BNA Act, 1867, the federal government has exclusive legislative jurisdiction over fisheries, navigation, Indians and lands reserved for Indians, and certain Federal lands including National Parks, and international water

THE LEGAL AND ADMINISTRATIVE FRAMEWORK AFFECTING WATER RESOURCE MANAGEMENT IN THE OKANAGAN BASIN

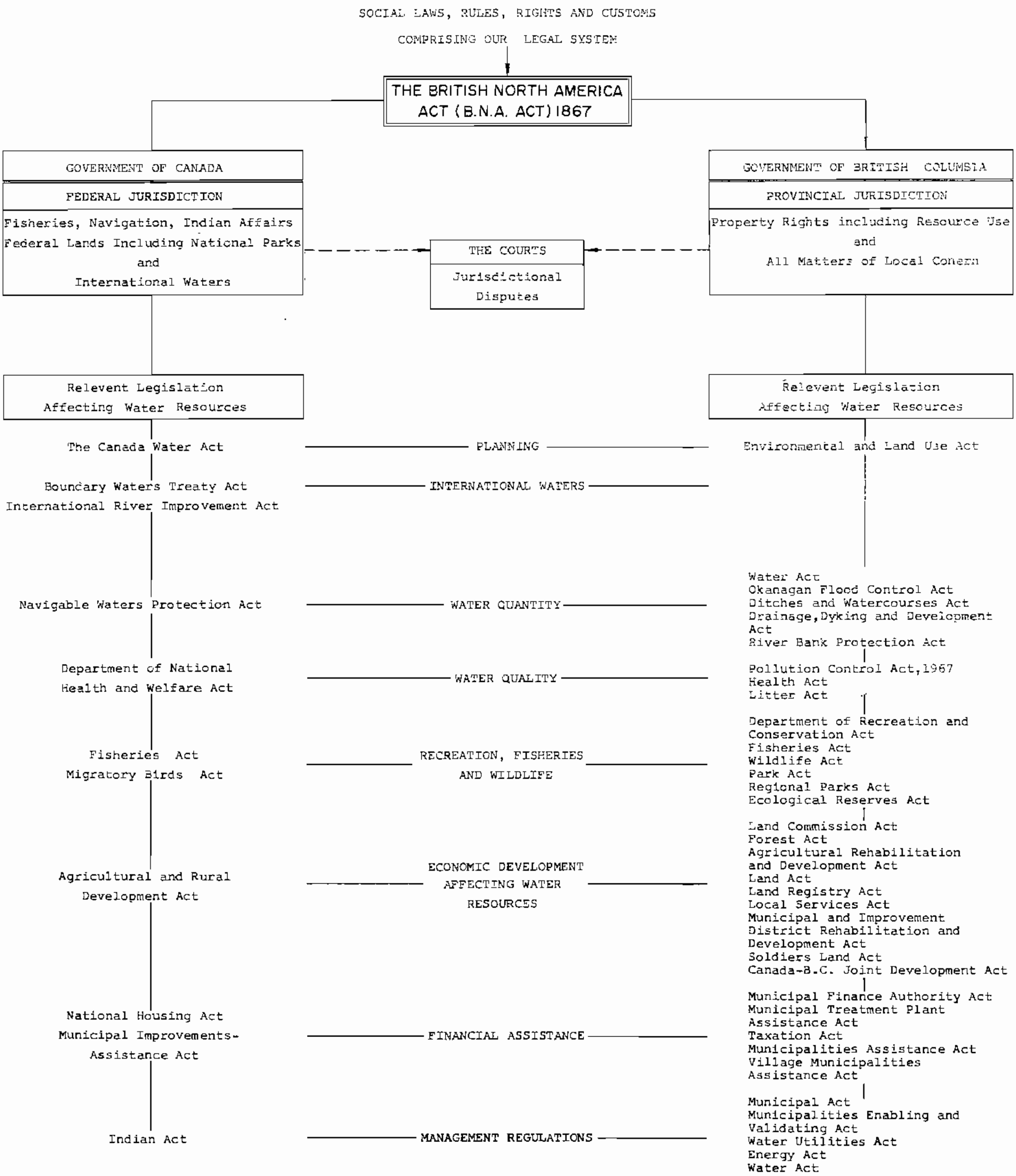


Figure II.1

matters. It shares jurisdiction in agriculture with the provinces.

In water matters it is the Provinces which have principal jurisdiction; such jurisdiction is derived from the exclusive right to legislate in respect of property within the Province, local works and undertakings and generally all matters of a local nature. In addition to such legislative jurisdiction, the Province owns all the natural resources, including water, within its boundaries.

The Provincial government has delegated certain of its functions to local governments to exercise within their defined boundaries.

Most of the statutes which affect water resource management are single purpose in scope. Generally they authorize a particular course of action for a particular purpose. Since water resource management and environmental matters involve a complex of interrelated physical factors, single purpose laws are often insufficient as a basis for comprehensive action. Also there is little provision for the resolution of diverse resource use interests, each governed by different statutes.

All of these aspects are examined below under the headings:

1. Laws Affecting the Use and Management of Water and Water Related Resources.
2. Administration of Water Resources.
3. Discussion of Institutional Arrangements Affecting the Okanagan Basin.

LAWS AFFECTING THE USE AND MANAGEMENT OF WATER AND WATER RELATED RESOURCES

The nature of water is such that, except in artificial containers, it is rarely still; it is always flowing by gravity, falling as precipitation or rising as evaporation. Under Provincial Statute the property in, and right to the use and flow of all the water at any time in any natural water course and any lake, river, creek or spring in the Province are for all purposes vested in the Province. The individual's right to use water is governed by a system of licensing under the B.C. Water Act. The user of the water must have regard to legislation respecting navigation and fisheries, which are under federal jurisdiction. Federal and provincial legislation respecting the use of and management of water, and water related resources is shown in Figure 11.2.

.1 Planning Legislation

The Canada Water Act and the B.C. Environment and Land Use Act are recent statutes which allow for a broad approach to resource planning. Both acts refer to the need for studies and research to provide a better knowledge of our resources. Although differing in emphasis these Acts both recognize the

(Note: Descriptions intended as general information only - Reader should obtain copy of Statute itself for interpretation purposes.)

NAME OF ACT	GOVERNMENT	DESCRIPTION OF ACT
RESOURCE PLANNING		
1. The Canada Water Act	Canada	To provide for the management of the water resources of Canada including research, and the planning and implementation of programs relating to the conservation, and utilization of water resources. It is intended to provide for a greater knowledge of the water resources of Canada, to provide for pollution control and to cooperate with provincial governments in the management of these resources.
2. Environmental and Land Use Act	British Columbia	To provide for broad environmental and land use policies and undertake major land and resource allocation studies in British Columbia. The act authorizes the establishment of an Environment and Land Use Committee with its membership limited to Cabinet Ministers.
INTERNATIONAL WATERS		
1. International Boundary Waters Treaty Act	Canada	This act sets out regulations concerning the use or management of waters on or flowing across the boundary between Canada and the United States, and provides the means for settling differences concerning such boundary waters. Osoyoos Lake falls within the provisions of this Act.
2. International River Improvements Act	Canada	This Act imposes Federal control on International River Improvements in addition to any controls imposed by the Provinces. A special licence from the Federal Government is required before changes can be made in the flow of an International River at the border. The Act expressly does not apply to projects for domestic, sanitary or irrigation purposes.
WATER QUANTITY		
1. Water Act	British Columbia	This is the prime statute governing the use of water in British Columbia and covers the obtaining and exercise of rights to the use of water, the administration and enforcement of the Act, and the establishment of communal organizations for the use of water.
2. Navigable Waters Protection Act	Canada	The purpose of this act is to prevent obstructions to navigable waters. It provides that no one may place wires, pipes, bridges, or other obstructions in or under a navigable water without permission from the Federal Government.
3. Okanagan Flood Control Act	British Columbia	This Statute authorizes the Province, with or without agreement with Canada, to carry out flood protection measures in the Okanagan Basin in Canada.
4. Ditches and Water Courses Act	British Columbia	This Act provides a summary and economical method of procedure to enable a landowner to drain his land by constructing ditches over the lands of others. The act has no application to bringing water to lands.
5. Drainage Dyking and Development Act	British Columbia	This Act is designed to permit the establishment of districts to plan, construct, and operate drainage or dyking works.
6. River Bank Protection Act	British Columbia	This Act provides a procedure whereby landowners may apply for government assistance in river bank work to protect their properties.
WATER QUALITY		
1. Pollution Control Act	British Columbia	This Act provides the means for the control of pollution including water, air and to some extent ground pollution. The Act requires that no person shall discharge sewage or other waste materials on, in, or under any land or into any water, or discharge or emit contaminants into the atmosphere without a permit from the Director. The Act exempts certain minor wastes and operations leaving them subject to control under the legislation.
2. Health Act	British Columbia	The Act is a general on covering the provision and control of health services in the Province.
3. Litter Act	British Columbia	Regulations concerning the use and disposal of containers for beverages, discard and disposal of litter, and discharge of sewage and other waste materials from trailers, campers, and boats.
4. Department of National Health & Welfare Act	Canada	This Act is concerned with the promotion or preservation of the health, social security, and social welfare of the people of Canada over which Canada has jurisdiction. In conjunction with the Indian Act it provides for the inspection of premises and provision of sanitary conditions on reserves. The Act also includes the enforcement of any rules or gegulations made by the International Joint Commission on boundary waters as they relate to public health.
RECREATION, FISHERIES & WILDLIFE		
1. Department of Recreation & Conservation Act	British Columbia	This Act is concerned with the management of all matters relating to parks, fisheries, game, community programmes and recreational facilities. The above includes the stimulation and aid of tourist traffic under the B.C. Government Travel Bureau.
2. Park Act	British Columbia	This Act covers all matters oertaining to parks and recreational areas in British Columbia.
3. Ecological Reserves Act	British Columbia	This Act provides for the establishment of ecological reserves on Crown Lands. Once established the area is withdrawn from any disposition of any right under different statutes including the Water Act. A reserve may be carrelled by Order in Council.
4. Regional Parks Act	British Columbia	This Act permits Regional Districts to combine into a Regional Park District for the puropose of establishing parks.

NAME OF ACT	GOVERNMENT	DESCRIPTION OF ACT
5. Fisheries Act	Canada	This Act governs matters relating to fish and only to fish including both fresh-water and salt water fish. The administration of sport fishing under this Act (by agreement) has been carried out by the B.C. Fish and Wildlife Branch since 1930. The Act includes regulations concerning pollutants harmful to fish, obstructions which hinder the free passage of fish, and the maintenance of flows required for the safe passage of fish and preservation of spawning grounds.
6. Fisheries Act	British Columbia	This Act deals primarily with the licencing of fishermen and fish processing plants.
7. Wildlife Act	British Columbia	This Act deals primarily with regulations concerning game conservation, and the licencing for all forms of hunting.
8. Migratory Birds Convention Act	Canada	This Act describes the regulations concerning the protection of migratory birds that inhabit Canada during the whole or any part of the year.
ECONOMIC DEVELOPMENT		
1. Land Commission Act	British Columbia	This Act provides the means for the preservation of agricultural land for farm use, the preservation of green-belt land in and around urban areas, and the preservation of park land for recreational use. This Act was passed after the major portion of the Okanagan Basin Study had been completed in detail in this report.
2. Agriculture and Rural Development Act (A.R.D.A.)	Canada	This Act authorizes joint projects between Canada and the Province. It provides for joint undertakings or for contributions to projects for rural development, projects to develop rural incom and employment opportunities, and soil and water conservation projects.
3. Agricultural Rehabilitation and Development Act	British Columbia	This Act provides the Minister of Agriculture with the means to enter into and carry out agreements with the Federal Government under A.R.D.A.
4. Land Act	British Columbia	This Statute covers the rules and procedures for obtaining rights to Crown Land.
5. Local Services Act	British Columbia	This Act is to provide for the establishment of unorganized territory into local areas for certain specific purposes such as community plans and recreation.
6. Municipal & Improvement District Rehabilitation & Development Act	British Columbia	This Act is intended to prevent speculation in lands in areas rehabilitated with government funds. A diminishing charge is assessed on an average basis on all land within the area rehabilitated.
7. Soldiers Land Act	British Columbia	This Act permits the government to acquire or to set aside lands for the purpose of settling ex-servicemen and their widows.
8. Canada - B.C. Joint Development Act	British Columbia	This Act provides the means for any Minister to make an agreement with a Federal Minister or authority respecting water and land development, highway construction or improvement, flood control - and other matters in the Province and to implement such agreements.
FINANCIAL ASSISTANCE		
1. National Housing Act	Canada	Part VIII of the National Housing Act provides for loans to a province or a municipality for the purpose of constructing or expanding sewage treatment projects.
2. Municipal Improvements Assistance Act	Canada	This Act authorizes federal loans to almost any level of municipal government to assist in the construction of self-liquidating works including a waterworks system and "other municipal projects".
3. Municipal Finance Authority	British Columbia	This Act establishes an authority to borrow money for water, sewer, and pollution control facilities for Regional Districts and municipalities.
4. Municiapl Treatment Plant Assistance Act	British Columbia	This Act provides assistance to a municipality which has borrowed money for a treatment plant as therein defined.
5. Municipalities Assistance Act	British Columbia	This Act authorizes the government to guarantee Municipal Bonds with the Provincial Guarantee.
6. Village Municipalities Assistance Act	British Columbia	The Act provides for a village to obtain a Provincial Guarantee on bonds issued for water or sewer purposes or for hospital purposes.
ADMINISTRATION		
1. Municipal Act	British Columbia	This Act sets out the responsibilities, powers, duties, and restrictions of municipal organizations, including Cities, Towns, Villages, Regional Districts and Improvement Districts. These regulations include numerous sections pertaining to water resource management.
2. Municipalities Enabling and Validating Act	British Columbia	This Act was passed to remove anomalies created by the repeal of the old Municipal Act in 1957 and the enactment of a new one. It contains specific sections dealing with different municipalities including Pentiction, Spallumcheen, and Summerland.
3. Water Utilities Act	British Columbia	This Statute is intended to regulate,in the public interest, the provision of services which are likely to be monopolistic, such as water supply. Approval is required to construct, operate, extend or close down a public utility and to approve the rates charged to the public for the services offered.
4. Indian Act	Canada	This Act is concerned with the administration of all matters pertaining to native Indians and Indian reserves.

Figure II.2

basic concept of the need for comprehensive resource planning outlined in Chapter 12 of this report, and these two acts are among the first to do so.

11.1.2 International Waters

Osoyoos Lake straddles the international border at Osoyoos and the Okanagan River flows into Osoyoos Lake on the Canadian side and out of Osoyoos Lake on the American side. While it is not specifically a boundary water, certain provisions of the Canada-U.S. Boundary Waters Treaty of 1909 and the International Rivers Improvement Act may apply. The Boundary Waters Treaty provides a means for resolving trans-boundary water conflicts arising from diversions or obstructions in one country which raise water levels or flows in the other. The Treaty created the International Joint Commission which has among its responsibilities the task of advising the two governments and, in certain situations, issuing binding orders. The Treaty also contains a section on water quality in which it is agreed that boundary waters and water flowing across the boundary shall not be polluted on either side to the injury of health or property on the other. The International River Improvements Act requires the permission of the Federal Government for projects which materially alter the flow of an international river at the border. However, the Act expressly does not apply to diversions for "domestic, sanitary or irrigation purposes or other similar consumptive uses". The Act therefore is unlikely to be significant in respect to the Okanagan Basin, except perhaps for flood control.

11.1.3 Water Quantity

(a) Water Act

The fundamental law affecting water use in the Okanagan Basin, as in all British Columbia, is the British Columbia Water Act. The present Act has evolved from water laws and ordinances going back to 1859. The key to the law is contained in Section 3. This section reads:

> "The property in and the right to the use and flow of all the water at any time in any stream in the Province are for all purposes vested in the Crown in the right of the Province, except only in so far as private rights therein have been established under licenses issued or approvals given under this or some former Act. No right to divert or use water may be acquired by prescription."

The term "in any stream" includes, by definition lakes, sources of natural water supply, whether normally containing water or not, and groundwater. Actual use for however long a period or for whatever purpose gives no rights whatever nor priority in the obtaining of a license. Priority in use is determined by the date of application for a license, whether conditional or final.

The effect is to retain in the Crown all rights to water except in so far as the Crown may have granted these rights to some person. The right to use water is granted by and described in a Water Licence issued by an official called the Comptroller of Water Rights. A licence will only be issued for a particular purpose, from a particular source of water and, where applicable, for a specified quantity. This is designed to prevent a license having any instrinsic value; it only has value as a part of some kind of undertaking which makes use of the water. On the transfer of the land, mine or undertaking to which the licence is appurtenant, the licence is automatically transferred.

) Navigable Waters Protection Act

In most parts of the world, th right to navigate on water is a public right totally separate from any rig t to use the wat r for other purposes. In Canada, where much of the early exploration and development depended on the use of water for navigation, the right to navigate is only the right to use what is there: there is no obligation to anyone, Crown or otherwise, to maintain a waterway in a navigable condition. The Courts have held that any water capable of floating logs commercially is navigable.

The Federal Act in this regard is the Navigable Waters Protection Act. It provides that no one may place wires, pipes, bridges or other obstructions over, in or under a navigable water without permission from the Federal Cabinet. A permit will not relieve the obstructor of liability for any loss he causes.

:) Other

The other acts listed under water quantity are primarily arrangements or procedures for the construction and/or administration of specific works. The most important of these with respect to the Okanagan is the B.C. Okanagan Flood Control Act which provided for the construction, and subsequently the maintenance and operation of certain structures and channel improvement between the outlet of Okanagan Lake and Osoyoos Lake. While the name implies a single purpose objective, a 1960 agreement for the operation of the project provides not only for flood control, but also for water conservation, irrigation, fisheries and other affected interests. The Act is administered by the B.C. Minister of Lands, Forests and Water Resources.

1.1.4 Water Quality

(a) Pollution Control Act, 1967

Prior to 1956, control over pollution in B.C. consisted of certain controls under the Water Act, the Health Act, and the common law right of a property owner to sue in court for damages and/or an injunction, any person who damaged his property through pollution. Clearly it was very difficult for an individual to prove damage from pollution and usually even harder to prove who was responsible.

In 1956, the first of British Columbia's Pollution Control Acts was passed. The Present Act (1967) covers pollution to air, water and land. This Act reads in part "on from and after the first day of January 1970, no person shall, directly or indirectly, discharge or cause or permit the discharge of sewage or other waste material on, in, or under any land or into any water without a permit or approval from the Director".

The Act exempts certain minor wastes and operations, leaving them subject to control under other legislation. This act is administered by the Pollution Control Branch under the Director of Pollution Control, who has local representatives throughout the Province. The discharge of pollutants is regulated by issuance of permits to applicants by the Director. No person shall discharge such materials without a permit.

(b) Health Act (British Columbia)

The B.C. Health Act is a general one regulating, among other things sewage disposal systems discharging less than 5,000 gallons per day. Prior approval is required for the construction and maintenance of all sewage disposal systems, and this is required before a municipality may put a borrowing by-law before the electors.

The general powers of the Minister are exercised through local or Union Boards of Health, but only the Minister can approve a sewage disposal plan.

(c) Department of National Health and Welfare Act (Canada)

This Act covers all aspects of health and sanitary conditions on lands under Federal jurisdiction including Indian Reserves. The Act also includes a section covering boundary waters, as they relate to public health, and the enforcement of any rules or regulations made by the International Joint Commission. This section is administered by the Minister of the Environment.

11.1.5 Recreation, Fisheries, and Wildlife

(a) Fisheries Act (Canada)

The major statute affecting fisheries is the Federal Fisheries Act under which the federal government can manage and control the fish resource in any body of water. This includes such matters as the control and prevention of depositing in waters frequented by fish, substances deleterious to fish. The Act also provides for the development of fish stocks. By an understanding in the 1930's the federal government transferred to the B.C. Fish and Wildlife Branch, the administration of the Federal Act in so far as freshwater sport fishing in British Columbia is concerned.

The Act also provides that the Federal Minister may demand plans and specifications of proposed plants which might discharge deleterious substances into water habited by fish. Persons operating plants must provide information and samples when required.

These provisions may be enforced in the courts through fines and imprisonment for violations. The Act also permits Minister to prevent any such discharge.

In addition, the Minister of Environment can require a person to release sufficient water for the safety of fish and for the preservation of spawning grounds.

(b) Other

The Provincial Park Act, the Wildlife Act and the federal Migratory Birds Convention Act are other statutes affecting Recreation and Wildlife. These are all administered under the B.C. Department of Recreation and Conservation. The other acts concerned with recreation, fisheries and wildlife provide for the establishment of ecological reserves and regional parks, and for the licencing of fishermen and fish processing plants. The latter Acts are primarily administrative arrangements and do not affect water resources directly. One exception to this concerns ecological reserves of Provincial Crown land which are withdrawn from any disposition of any right under different statutes including the B.C. Water Act.

11.1.6 Land Development

There are some eight different statutes which are concerned with land and its development in British Columbia. Seven of these statutes are provincial and one is Federal. These are important in water resource management because of the effect of land use on both water quantity and quality. Land use also has an effect on the aesthetic and ecological quality of the Valley in the context that agricultural and forested areas increase the attractiveness of the Valley, both as a residential and recreational area.

The Environment and Land Use Act, is probably the most far reaching in terms of the power in Cabinet relating to the Environment and use of land and other natural resources.

11.1.7 Financial Assistance Statutes

Two federal and four provincial statutes have been passed to assist in financing the development and construction of water resource projects including sewage collection and treatment plants, waterworks systems, and other municipal projects.

The two most important Acts with respect to financing water quality management are considered to be the Federal National Housing Act and the Provincial Municipal Treatment Plant Assistance Act. Both authorize loans to a municipality for trunk collectors and sewage treatment plants. The National Housing Act will provide loans for up to 2/3 of the cost of such a project for 50 years, repayable on terms agreed to by the borrower and the Central Mortgage and Housing Corporation (CMHC). Under certain conditions CMHC may forgive 25% of the principal, and 25% of the interest accruing during construction.

The Municipal Treatment Plant Assistance Act provides assistance on the basis of a 20 year amortization period, and the government will then contribute 75% of the amount by which the annual cost exceeds a two mill levy on all taxable land and improvements.

Other statutes provide a basis for Federal - Provincial financing of water and related resource including the Canada Water Act (planning), A.R.D.A., and other programs administered by D.R.E.E., etc. The federal Income Tax Act provides for accelerated depreciation of the capital costs of industrial pollution control equipment. Similarly the B.C. Taxation Act grants exemption from sales tax on pollution control abatement equipment.

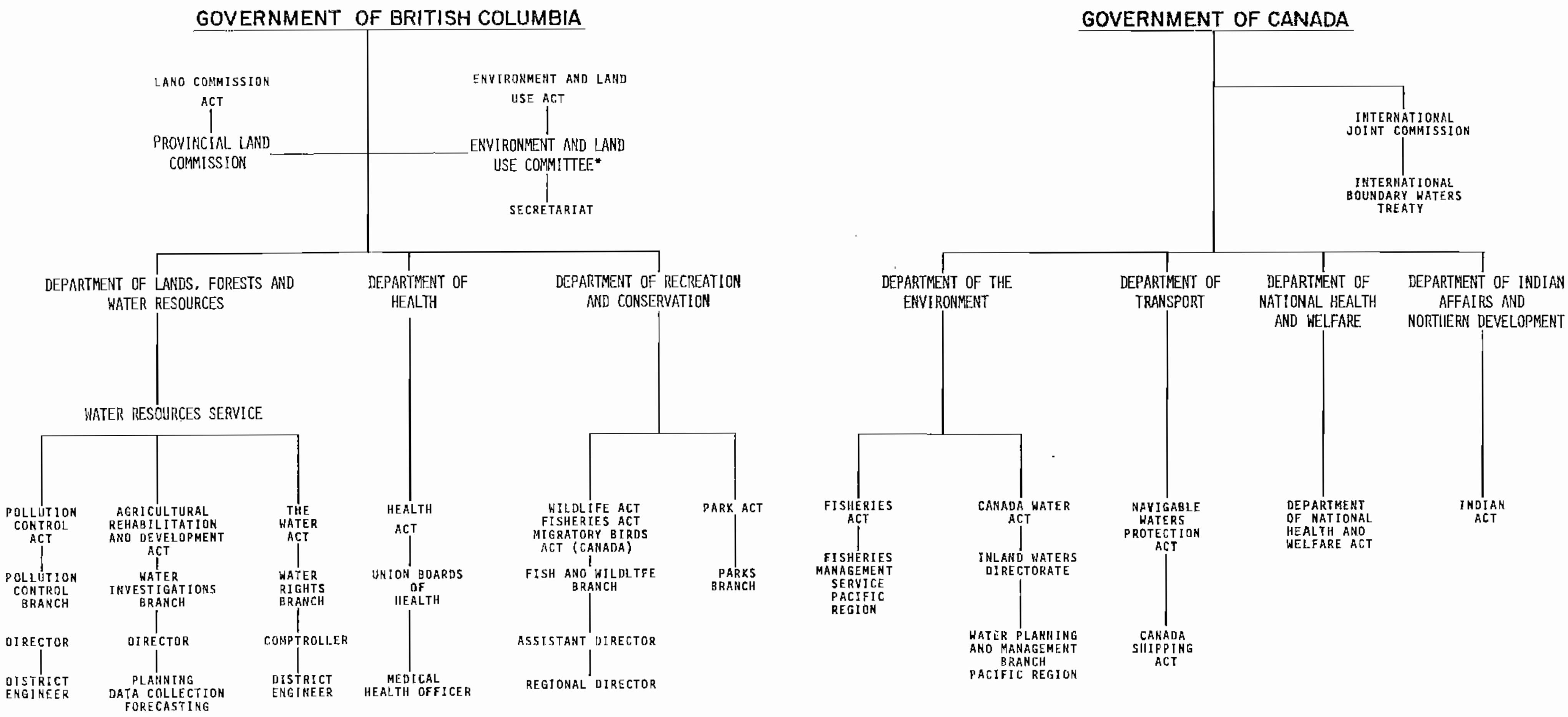
11.1.8 Local Government Functions

The provincial government has delegated certain of its functions to local governments. The Municipal Act sets out the responsibilities, powers, duties, and restrictions of such local governments including cities, towns, villages, regional districts and improvement districts. These include the construction and operation of water resource projects subject to such statutes as the Water Act and Pollution Control Act, 1967. Improvement districts incorporated under the Water Act primarily for waterworks, irrigation, dyking and drainage and land improvement purposes, generally have the same responsibilities in unorganized areas as municipalities with respect to these purposes.

The B.C. Energy Acts and Water Utilities Act are intended to regulate, in the public interest, the provision of services which are likely to be monopolistic, such as water supply. Approval of all plans (with the exception of projects within an Improvement District or other management authority as covered in the Water Act) to construct, operate, extend or close down a public utility and the rates charged to the public for the services offered is required. A public utility is defined to include the diverting, developing, pumping, impounding, distributing, or furnishing of water to or for five or more persons or any corporation for compensation. Sewage disposal systems do not appear to be included in the definition of a public utility.

11.2 ADMINISTRATION OF WATER RESOURCES

The major statutes affecting water resources in the Okanagan Basin are administered by the Water Resources Service, Department of Lands, Forests and Water Resources, and Fish and Wildlife Branch of the Department of Recreation and Conservation, British Columbia, and by the Department of the Environment, Canada (Figure 11.3). These include the Water Act, Pollution Control Act, Okanagan Flood Control Act, Fisheries Act, and the Canada Water Act. A number of other Departments are involved in water related resources, and the Environment and Land Use Committee comprised of Ministers from various departments coordinates multi-discipline resource policies within the Province. Only the administration of the major statutes affecting water resources are discussed below.



* The Environment and Land Use Committee is comprised of the Minister of Lands, Forests and Water Resources, Mines and Petroleum Resources, Agriculture, Municipal Affairs, Health, Highways, and Recreation and Conservation.

ADMINISTRATION FLOW CHART OF WATER AND WATER RELATED RESOURCES

Figure 11.3

11.2.1 Water Act (British Columbia)

The Water Act is administered by the Comptroller of Water Rights, a senior official in the Water Resources Service. The Comptroller of Water Rights is concerned primarily with water quantity and the safety of structures used to impound or divert water. To assist him there are District Engineers with statutory executive authority. The District Engineer in Kelowna has jurisdiction over the Okanagan Basin.

Applications for Water Licences go to the Water Recorder of the area, usually the Government Agent. A copy of the application is posted publicly and objectors qualified under the Act have an opportunity to intervene. The District Engineer is called on for a report on the quantity of water available to the applicant and on the engineering aspects of the application. He also investigates and reports on all objections. The District Engineer also reviews the exercise of the rights of existing licensees and investigates complaints under the Act.

11.2.2 Pollution Control Act, 1967 (British Columbia)

The Pollution Control Branch, under the Director of Pollution Control is responsible for the administration of the Pollution Control Act. The Director has power to determine what constitutes a polluted condition of water, land or air; to prescribe standards of effluent which may be emitted to water, land or air; to conduct tests and surveys to determine the extent of pollution; to examine existing and proposed means of disposal of sewage and contaminants and to approve plans for such undertakings and to issue permits for discharges of contaminants on such terms and conditions as he shall prescribe.

Applications for permits are made to the Director. He has a District Engineer and staff in Vernon who report on the technical aspects of applications in the Okanagan Valley and monitor discharges covered by permits to ensure that the permittee is carrying out the terms of the permit.

11.2.3 Water Resource Planning and Development (British Columbia)

Statutes which are directly concerned with water resource management and planning are administered by the Water Investigations Branch of the Water Resources Service. This includes the administration of the Okanagan Flood Control Act and the Agricultural Rehabilitation and Development Act (ARDA). Seven separate divisions have been set up within the Branch to carry out these functions including those of groundwater, hydrology and the ARDA Construction Division. One of the studies being undertaken by this branch is the water management study of the Kalamalka-Wood Lake watershed which arose as a result of preliminary findings from the Okanagan Basin Study.

One of the important functions of this Branch (Hydrology Division) is to forecast runoff conditions in each of the major watersheds in British Columbia.

Six snow survey Bulletins are issued each year, which include forecasts of the expected spring runoff from the major drainage basins in the Province. These forecasts form the basic information used in controlling the level of Okanagan Lake which may be lowered in the early spring to allow for high runoff conditions, or maintained at a higher level to conserve water in low runoff years.

11.2.4 Water Resource Planning and Development (Canada)

Federal water resource planning and administration lies within the Department of the Environment, and is the responsibility of the Inland Waters Directorate of the Environmental Management Service. This directorate contains four major branches, Water Quality, Water Resources, the Canada Center for Inland Waters, and Water Planning and Management. The first three are mainly concerned with data collection and research in their particular fields, while the Water Planning and Management Branch is concerned with planning, administration of the Canada Water Act and research in various forms.

11.2.5 Fisheries Act (Canada)

Federal administration of fisheries is exercised by the Fisheries and Marine, and Environmental Protection Services within the Department of the Environment. Investigations, monitoring, and control of salmon in the lower Okanagan River are carried out from the Pacific Region offices of the Fisheries and Marine Service, Department of the Environment.

The administration of certain freshwater fisheries in British Columbia is carried out by the B.C. Fish and Wildlife Branch. This branch has a District Office and Regional Director in Penticton whose jurisdiction includes the Okanagan Basin. The function of the Branch is to administer delegated responsibilities of the Fisheries Act (Canada) and Regulations, to carry out investigations, and to advise the appropriate Provincial authority on the probable effects of operations to be licenced under the Water Act and Pollution Control Act, 1967.

11.3 DISCUSSION OF INSTITUTIONAL ARRANGEMENTS AFFECTING WATER RESOURCE MANAGEMENT IN THE OKANAGAN BASIN

11.3.1 General Problems

Water resource management does not fit into any one category of activity, but has an impact on almost every facet of life. Generally, existing legislation has four basic weaknesses which pose limitations in the overall planning for water resource management.

1. Most statutes are single purpose in scope in that they authorize a particular course of action for a particular purpose. This leads to conflicts in the use of a resource which sometimes can be settled only by the courts. At other times such conflicts are irreconcilable unless co-operation and compromise is realized.

2. Many Statutory provisions outline the constraints on a particular course of action, but provide no positive approach to planning or development. Government officials are cast in the role of policing such provision and the initiative for development must normally come from others. While such officials may approve or disallow a proposal, very rarely can they go further. More-over the government cannot issue orders except to someone who has applied for a licence or permit, or who is doing some activity recognized by the Statute to require control.

3. There is little or no provision for the equitable financing of projects which have multi-purpose benefits. There is no power to compel any person except the licencee to contribute to the cost of a multi-purpose water resource development, however much that other person may be benefited. Alternatively, there is no obligation on any municipal organization to install a common water supply or sewage collection or treatment system which may be required for acceptable water quality standards to be realized. While a municipal organization may wish to participate in such a plan, it is limited in its financial capability to construct such works.

4. The multiplicity of laws and statutes and numerous governments and agencies involved in their administration makes comprehensive planning both difficult and frustrating. In addition communication problems exist at all levels of government service and between government agencies and the public. Such problems have increased in recent years due to an expanding population and the need for appropriate governmental activity. Joint activities such as that under the Okanagan Basin Agreement, which provides for public involvement, and formal and informal co-operation among governments and agencies are helping to overcome these problems.

Within the Okanagan Basin more specific problems are evident. These are discussed below under the headings of water quantity, water quality, recreational values and fisheries and wildlife. It should be recognized there are strong interrelationships among these areas of study.

11.3.2 Specific Problems Within the Okanagan Basin

(a) Water Quantity

Osoyoos Lake is an international water subject to an order by the I.J.C. which created the International Osoyoos Lake Board of Control to supervise the operation of the lake's control dam. This structure is located in the United States and its operation has, from time to time, been the subject of dissatisfaction in both countries.

Two other problems concern flooding and fisheries. In high runoff years the waters of the Similkameen River, which joins Okanagan River just below the

International Boundary, cause a backup of water into Osoyoos Lake and consequent flooding. There does not appear to be any simple solution to this problem, especially for Canada acting alone. This matter could be referred to the International Joint Commission for review.

The second problem concerns a run of Columbia River salmon from the United States which spawn in the Okanagan River in Canada. Significant releases of water in Canada which can have a detrimental effect on the water budget particularly in drought years, are required to maintain this run.

Some conflict has developed between water users and fisheries in the right to use water in the tributaries of the lake system. The Water Act is primarily concerned with meeting human consumptive needs for water and places less emphasis on meeting other uses such as fisheries. Applications for new licenses under the Water Act are referred to the provincial Fish and Wildlife Branch and its recommendations are considered in the determination of the application. However, streams can be fully alienated under this system of licensing, in perpetuity, without a sufficient reservation to maintain the fisheries. The Fisheries Act (Canada) may provide an alternative solution. The Department of the Environment has not attempted to invoke this provision although in some parts of the province licencees have been persuaded to release water for fishery purposes. Studies reported in Chapter 8 indicated a definite need for maintaining minimum flows for fish reproduction and in-channel fisheries in certain tributaries, if present and future sport fishing demands in the main valley lakes are to be met. The maintenance of minimal water levels in some of the headwater storage reservoirs would also be beneficial to the sport fishing sector.

There is also the problem that licencees taking water from a stream have no control over other aspects of watershed management under existing legislation. Logging practices may affect the run-off characteristics of the stream which in turn may affect the adequacy and safety of storage and diversion structures. Erosion may be increased causing turbidity in the water and perhaps necessitate expensive clean-out operations in diversion ponds, or screening, before the water can be used. There are no regulations or requirements by which the B.C. Forest Service has to consult with licencees or to control these effects. Neither has provincial legislation been involved to regulate such land use practices.

The termination of barge traffic on Okanagan Lake by the C.N.R. and C.P.R. in 1971 and 1972 has removed some of the problems relating to navigation and the variation of lake levels as maintained under the Okanagan Flood Control Act, though the Okanagan is still a navigable water. Problems may still be encountered with the Kelowna Floating Bridge during prolonged drought periods which result in extreme low water levels. Experience has indicated however, that temporary and economical adjustments can be made to the bridge particularly during high water stages, to allow for most fluctuations beyond the normal operating range.

(b) Water Quality

The control of a number of sources of pollution in the Okanagan Basin does not appear to be adequately accomplished at the present time. This is due in part to exemptions within the acts, the lack of coordination between government organizations administering the acts, and also to the fact that knowledge of the extent and effect of some sources of pollution - groundwater sources particularly - is still very meager.

Presently uncontrolled sources of pollution include lands under federal jurisdiction such as Indian Reserves. Range cattle and agriculture generally, logging practices and septic tank effluents may also affect the quality of stream and lake waters and groundwater.

Indian reserve lands and other lands under federal jurisdiction may not be required to comply with provincial statutes and local by-laws regulating land use. However, this does not rule out the application of provincial statutes generally, including the Pollution Control Act, in so far as their applicability cannot be characterized as regulating land use. Moreover, the Pollution Control Branch may be able to act where land use of reserves has adverse effects on other lands.

Indian reserve lands are used for various purposes including small industries and summer cottages which are managed by non-Indians. Even where there are valid leases from the Department of Indian Affairs, the local municipality and the Provincial Government have no jurisdiction over the use of such lands. If there is not a health hazard on the reserve itself, the federal Health authorities do not intervene.

While the effect of pollutants from lands under federal jurisdiction may be small in the overall picture, this contribution may pose significant problems to local stream and lake areas, particularly if these are recreationally oriented.

The Pollution Control Act, 1967, in its latest regulations exempts from the Act, "all discharges of plant and animal wastes emanating from traditional farming operation". This exemption makes any control of farming operation extremely difficult, where they may be termed "traditional". Animal wastes, particularly from winter feeding areas along water courses, may contribute significant amount of nutrients directly to a stream or lake. The measurement of such loadings is difficult, if not impractical to determine.

Over half the population of the valley is serviced by septic tanks for residential homes. These discharges, generally under 5,000 imperial gallons per day, are exempted from the Pollution Control Act and are in turn regulated under the Health Act. The Health Act is chiefly concerned with the transport of disease-bearing organisms from such units. In rural areas where septic tanks are sparse and considerably above the ground-water table there is no apparent problem. However, there has been an increasing trend to develop housing areas outside of urban centres serviced by septic tank disposal systems, and these developments are usually in low-lying areas where septic tanks are close to or below the ground-water table. In such cases, nutrient contributions of both phosphorus and nitrogen to the lake system become significant. Apart from the health aspects, there is no obligation to protect fisheries or recreational values in such cases.

Cattle grazing under lease on Crown Land may foul local water supplies, as well as adding nutrients to the tributary systems. Logging practices may increase the contribution of soil and nutrients by reason of erosion and faster spring run-offs. Grazing leases and forestry practices are under the control of the Provincial Forest Service. There are no regulations or requirements that the Forest Service has to consult with water users concerning the management of the watershed area.

(c) Recreation, Fisheries, and Wildlife

Except for the anomalies noted previously, provisions of the Fisheries Act (Canada) appear adequate in respect to the protection of the Okanagan Basin.

The Park Act (British Columbia) is administered by the Department of Recreation and Conservation which is responsible for all matters concerning parks and recreational areas. Some question appears to exist concerning the management of water in a Park as opposed to management of water under the Water Act. Administrative procedures have prevented any conflict to date. Of more concern in recreational enjoyment, is the right of access to water and the problem that waterfront property creates in this respect.

The Land Act (British Columbia) sets out what rights the Crown has over disposition of Crown Lands. It provides that the Crown cannot sell its interest in the beds of rivers and lakes. The effect of this amendment has been to ensure that persons cannot acquire ownership of land below the normal high water mark.

Where the Crown owns the bed of the lake, it is a trespass for anyone to put a mooring wharf, fill, or other construction without the Crown's consent. However, an individual wishing to make use of such Crown Land may apply for a use permit, for which a user fee is payable. Such a permit provides the individual with the right to prevent other people using his facilty, whatever it may be, unless the permit requires him to share it with others.

It does not matter that the trespass has been enjoyed without question for a long period of time. It always was and remains an unlawful use of the Crown's property.

Clearly, existing statutes do not provide for the preservation of waterfront property for the enjoyment of the general public. Crown waterfront property should be regarded as property reserved to the use of the general public rather than the individual.

As more and more people come to the Okanagan, the existing access to the waterfront except in established sites, will become increasingly difficult to find, unless measures are taken to increase such access. At present in the case of new sub-divisions, waterfront access is required to be given.

The Department of Recreation and Conservation also administers the provincial Wildlife Act and, by agreement, the Federal Migratory Birds Convention Act. Present and proposed management of the basin's water resource does not appear to have a significant effect on wildlife, except possibly in some of the oxbows along Okanagan River, and these are local problems that may be resolved within the existing legislative framework.

PART IV

EVALUATION OF FUTURE CONDITIONS

CHAPTER 12

Philosophy of Comprehensive Basin Planning in the Okanagan Basin

Comprehensive river basin planning of the nature adopted for the Okanagan Basin is new in Canada - in fact there are few river basins in North America or indeed the world where this planning approach has been undertaken. It is new because it examines together, a broader range of water and related resource uses than has been the case in the past. It is new because it considers a number of future courses for development in the Okanagan, instead of just one projection as was the case in the past in most other studies. It is new because it includes environmental and social values as well as economic values in the assessment of water resource plans and it is new because Okanagan residents have been explicitly invited to share in the development of the framework plan and in preparing specific recommendations. Because comprehensive planning does represent a departure from traditional approaches to planning, this chapter presents the basic philosophy used to develop a comprehensive framework plan for the Okanagan Basin, examines the nature of the planning process and defines the role that water resources management can play in achieving the goals set out in the Canada-British Columbia Okanagan Basin Agreement.

12.1 THE NATURE OF PLANNING

"Why do river basin planning studies need to be undertaken?" First, planning attempts to improve man's ability to make decisions regarding the use or protection of natural resources in the light of two types of unknowns: a lack of knowledge regarding the present values of resources to society and even greater uncertainties concerning the future. The planned use of our resources is therefore necessary to ensure that the widest possible range of options remain open for future generations. Second, past experience in resource management has indicated that choices have to be made, so that water resources can be effectively allocated among competing uses and users. Therefore plans have to be developed as a means of understanding the constraints to efficient resource use, and for resolving conflicts through such methods as arbitration.

Despite the best efforts of previous water resource studies in the Okanagan Basin, there were still many aspects of the resource that were not fully understood at the initiation of the Okanagan Study. The nature of these unknowns are detailed in subsequent chapters of this report and encompass almost every aspect of the Study. Furthermore, it was recognized that there were important linkages between various components of the water resource in the valley. For example, tributary streams flow into the main valley lakes which are themselves connected by Okanagan River. Thus, decisions that affect one part of this resource chain may in turn affect other parts to which it is linked and consequently an understanding of these linkages within the complete Okanagan water resource 'system' as it is called, is necessary before plans can be developed.

12.1.1 Planning for the Future

Water resource planning performs a more useful service if it serves not only the demands of today, but also the desires for tomorrow. Inclusion of the time dimension in the planning process compounds its complexity, for in addition to the relatively unknown response of the Okanagan water resource system to existing demands, is the greater uncertainty of what future generations will desire and the behaviour of the water resource system when subjected to changing demands. In view of these uncertainties, it becomes necessary to prepare several plans which may encompass the actual course along which the Okanagan may develop and to examine in some detail the likely consequences of each path on water resource development and management.

The key to the philosophy of comprehensive basin planning is the realization that it is not desirable to plan only one path for the future. Future generations must not be locked into a single course of action based upon the imperfect perception of what planners and the public today think should be their desires and values. It seems far more preferable to leave as many alternatives open as possible. There are two good reasons for this approach: First, future generations should have the right to select their own course of action for they should have a better idea than we do of the proper course to follow when the time for decision arrives. Second, in view of possible technological changes in living styles, planning for the future is an extremely difficult task and the framework plan should be left as flexible as possible. This approach certainly should not be construed as meaning that nothing should be done now - on the contrary - steps may have to be undertaken to protect future alternatives and to meet the social betterment objective, as stated in the Okanagan Basin Agreement.

12.1.2 The Challenge of Choice

A second basic principle in river basin planning is that choices will have to be made, both now and in the future, between various alternatives for water resource management. Generally, choices have to be made for two reasons: First, there is usually a limited supply of the water resource itself, and of money to finance water management projects to meet the desires of basin residents. Consequently, priorities must be established. Second, water resource uses can often be in direct conflict - for example, discharge of municipal wastes into waters adjacent to public recreational areas - and some means of resolving these conflicts for the betterment of the valley residents must be devised. These decisions are based upon the capacity of various water resource management alternatives to reach the desired goals described in the following section.

12.2 STUDY GOALS

The purpose of the Okanagan Basin Study, as set out in the Canada-British Columbia Okanagan Basin Agreement is:

> "to develop a comprehensive framework plan for the development and management of water resources for the social betterment and economic growth in the Okanagan Basin."

The Consultative Board recognized that the broad policy goals of social betterment and economic growth as stated in the Agreement may conflict. For example, a high rate of economic growth may not be compatible with improved social betterment in the Okanagan, and in fact could detract from it. The Board also recognized that the Agreement made several references to aspects of environmental quality such as:

> "provision for an adequate . . . quality of water in the Basin," and "to determine the effects of water resources development and utilization on the fish and wildlife, and on the aesthetic values of the Basin."

In view of possible conflicts between social, economic and environmental values, it should be understood that river basin planning cannot maximize the achievement of each goal simultaneously, but rather should seek a desirable balance between these three sets of values.

This balance can only be obtained through an understanding of the set of human values - known as criteria - associated with the multiple goals set out in the Agreement. A knowledge of these criteria can enable the decision-makers to make the best selection between various alternatives for the benefit of the basin as a whole. Consequently, for the purpose of evaluating plans, it is important that the multiple goals of the Study be explicitly defined, including the necessary criteria to allow for the proper assessment of any particular course of action.

The three major goals of economic development, social betterment and environmental quality have therefore been defined as follows for this particular study:

1. Economic Development - to increase economic development as measured by net regional income; that is, the economic value of income, goods and services accruing to the residents of the region. The geographic boundaries for economic development should be drawn wide enough to encompass all significant economic impacts of water resource development plans in the Okanagan Basin.

2. Environmental Quality - to maintain and enhance environmental quality through management, preservation and improvement of certain natural resources and ecological systems. Generally, all benefits and costs associated with the environmental quality goal can only be expressed in quantitative units (biological, physical) and/or in qualitative terms rather than dollar values.

3. <u>Social Betterment</u> - to enhance social betterment by providing the opportunity for a more equitable distribution of income, employment, recreational opportunities and environmental quality that will contribute to the security of life and health.

In theory, achieving a desirable balance between these multiple goals involves a broad study of a wide range of social and economic plans for the management of natural and human resources. Within the context of the Okanagan Basin Agreement, water, and water-related resources such as fisheries, wildlife, water-based recreation and shoreline landuse, were the primary areas of study. However, the Board recognized that a broader set of criteria associated with these multiple study goals should be considered in the development of a framework plan. Examples of these general criteria and their relationship to the major study goals are shown in Table 12.1.

TABLE 12.1

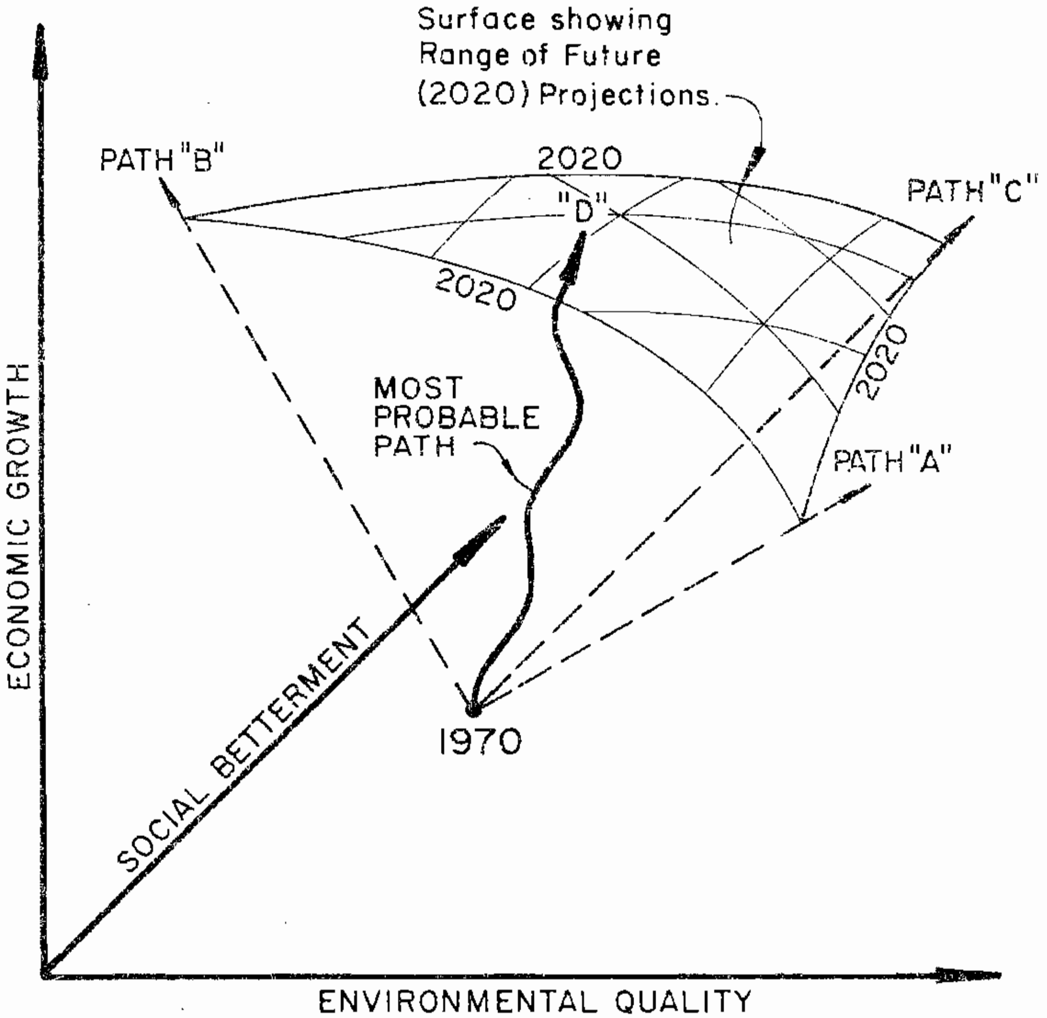
GENERAL FEATURES ASSOCIATED WITH MULTIPLE GOALS
(Assumes adequate supplies of water and other natural resources are available)

GOAL	ECONOMIC GROWTH	ENVIRONMENTAL QUALITY	SOCIAL BETTERMENT
General Features (Criteria)	regional income total employment per capita income	air, water and land quality fisheries production aesthetics wildlife and other ecological systems quietness wilderness areas recreation opportunities	population density job security health education cultural amenities urban conditions communications income distribution

12.3 DEVELOPMENT OF FUTURE PROJECTIONS

The Agreement specified that the planning horizon for the Okanagan Study would be 2020. The broader range of evaluation criteria presented in Table 12.1 resulted through the development of alternative future paths for the valley over the next 50 years. These projections were obtained by varying the emphasis that Okanagan residents place on the criteria associated with economic growth, environmental quality and social well-being. In theory, the mix of features associated with future development in the Okanagan Basin can be illustrated as a three-dimensional surface as shown in Figure 12.1.

Points marked on this surface represent three future development projections which respectively place maximum weights on the set of features associated with each major goal. For example, Point A represents a high concern for environmental quality with minimum emphasis on economic growth. Point B represents an extremely high rate of economic activity with a minimum acceptable level of environmental quality. Point C places most weight on enhancing



EXAMPLES OF POSSIBLE FUTURE DEVELOPMENT PATHS
FOR THE OKANAGAN BASIN

Figure 12.1

social betterment by providing the opportunity for a more equitable distribution of income, employment, and recreational pursuits, between individuals and groups in the basin, with less emphasis on achieving maximum rates of economic growth or enhancing environmental quality. There are an infinite number of future development plans for the Okanagan based on different combinations of weightings on each of the three major goals within this three dimensional surface. Point D represents the most probable path that will be reached due to changing emphasis on each of these goals through time.

Recognizing it was impossible to consider all possible alternatives, the Consultative Board selected three examples to illustrate the range of plans open to future generations and to examine in some detail the consequences of associated future demands on water and related resource management in the Okanagan. More specifically, the projections developed in this study involved the following assumptions:

I Projection of the existing pattern of economic activity as it has developed over the past 10-15 years, with the qualification that water quality will not be degraded below 1971 conditions. This alternative represents the "status quo" against which the other two projections can be compared.

II Creation of a greater level of economic activity than would occur under Projection I described above, limited only by the qualification that environmental quality must be maintained at a level that will not impair human health.

III Reduction of rates of economic activity compared to Projection I with greater emphasis placed upon the enhancement and maintenance of a high quality natural environment in the basin.

It is important to recognize that all three goals are involved in each of the projections. A high economic growth (Projection II) simply places more emphasis on economic growth than on environmental quality and social betterment, while a low economic growth places more emphasis on environmental quality and to some extent social betterment. It is also reemphasized that management of the water resource is only one step towards achieving any of the future projections described above. The inter-dependency of man and other components of the ecological system on water and land resources makes it undesirable to consider alternatives for the management of one resource in isolation from other resources. Present and future values associated with other resource uses could be compromised if framework plans for the Okanagan were based solely on optimizing the use and development of the water resources.

12.4 WATER RESOURCE PLANNING

Complete plans for any one of the future growth projections described above can only be fully achieved through an understanding and management of the diverse mix of resource uses in the basin, including agriculture, forestry, recreation, tourism, mining, industrial development and urban design as shown in Figure 12.2. Such total resource planning was not undertaken for two reasons: First, the Okanagan Basin Agreement specifically stated that the framework plan should be concerned with the management and development of the basin's water resource. Second, multiple resource planning, though desirable may not be realistic at present because of the lack of adequate planning tools and experience to undertake such a large-scale study. As mentioned at the beginning of this chapter, comprehensive planning of a single resource such as water is considered a new and experimental concept in resource planning and much has to be learned from this approach before multiple-resource planning can be attempted in one step. The framework plan developed for water resource management should, however, be flexible enough to allow adaptation into multiple resource plans of the future.

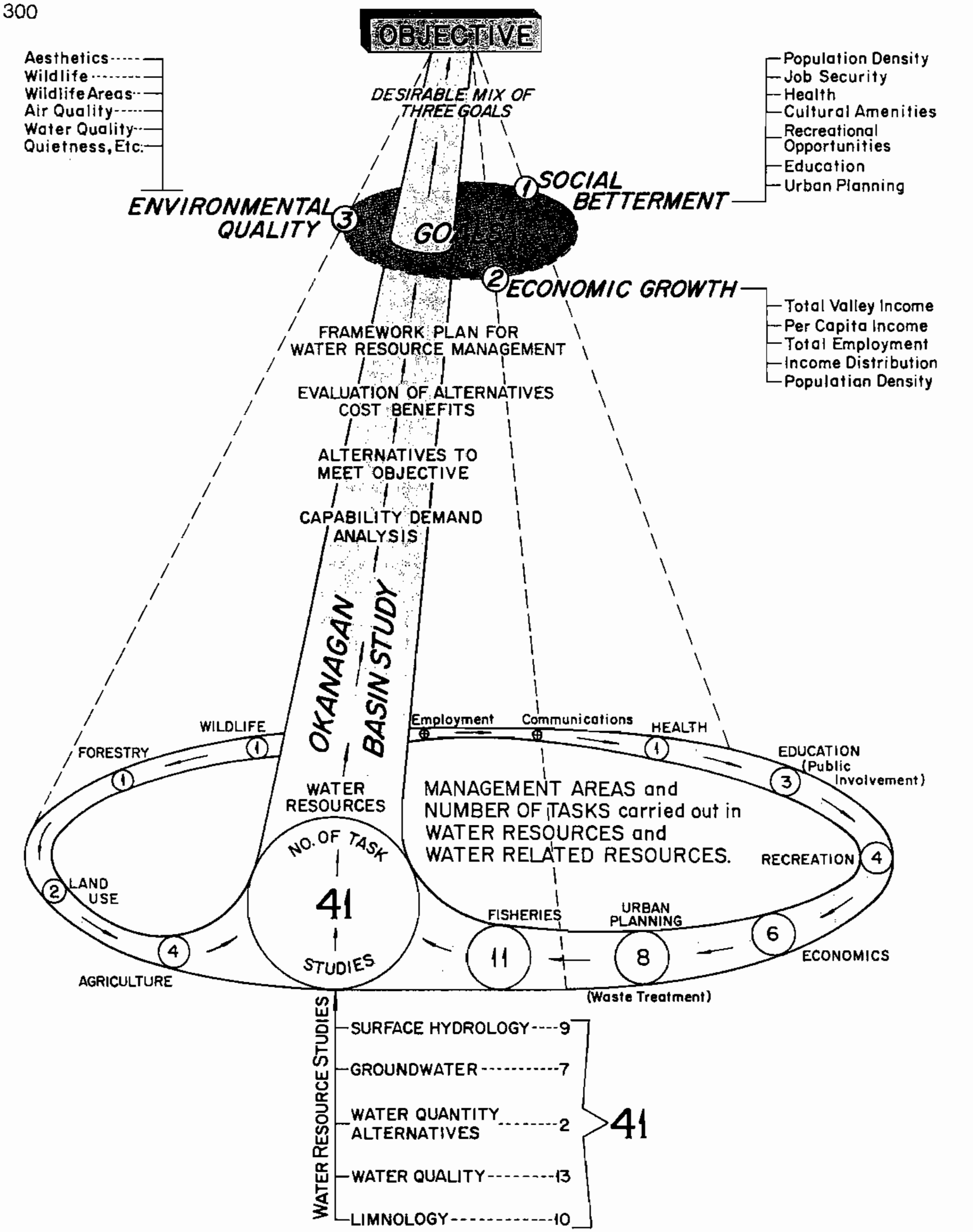
Figure 12.2 relates the scope of the comprehensive water resource planning to the goals of the Agreement. The Figure shows the inter-relationships between three levels of analysis. The first and top level is represented by the three major study goals of economic growth, social betterment and environmental quality. The second level indicates the range of resources that should be managed to achieve a desirable mix of values associated with these multiple goals. This clearly illustrates that water is only one of many resources, although in the Okanagan, one of the most important ones. The third level shows that although most of the attention was placed on water resource management, this did not preclude studies into such water related resources as landuse, economic development, agriculture, recreation and fish and wildlife. Details of the type of studies involved at this third level of the comprehensive planning process are described in the next section.

12.5 COMPONENTS OF THE FRAMEWORK PLANS

It should now be understood that within the context of the Okanagan Study, the social, environmental and economic goals can be partially achieved by developing plans to allocate water and related resources among existing and future uses. These water uses include consumptive demands for agricultural, municipal and industrial purposes, as well as non-consumptive requirements for recreation, aesthetics, fish and wildlife resources. Social and economic values are associated with each of the major uses of water described above and it is through the analysis of these values that the achievement of major study goals can be assessed.

To facilitate the planning process and to specify how each of the major uses of water in the Okanagan can contribute to the multiple goals of the Study, the complex water resource system was broken down into four management components:

(a) Water Quantity Management
(b) Water Quality Management
(c) Sport Fishery Management
(d) Water-based Recreation Management



THE RELATIONSHIP OF WATER RESOURCE MANAGEMENT IN COMPREHENSIVE PLANNING

Figure 12.2

Within each of these management components a number of general planning objectives were established to act as guidelines for developing framework plans. These planning objectives are defined in more detail than the broadly conceived study goals and thus act as intermediary steps to relate the uses of water to the set of social and economic values contained in the major goals.

Examples of such planning objectives include:

(a) Water Quantity Management

- to supply water for all consumptive water requirements for agricultural, residential, commercial and industrial purposes.
- to supply water for all non-consumptive water requirements for fisheries, wilelife, recreation and aesthetic resources.
- to minimize economic and social consequences of floods and droughts in lakes and tributary streams.
- to minimize conflicts between existing and potential uses of water.

(b) Water Quality Management

- to protect the health of Okanagan residents.
- to provide water quality compatible with agricultural, municipal, domestic and industrial uses.
- to provide water quality compatible with water-based recreation, sport fisheries and other non-consumptive uses of water.

(c) Fishery Management

- to preserve, enhance and manage environments suitable for sport fishery development.
- to maintain and orotect the environment for Sockeye salmon stocks in the Okanagan River.

(d) Water-Based Recreation Management

- to provide opportunities for a full range of water-based recreational activities.
- to protect and enhance the aesthetic qualities of the Okanagan Valley.

It is unrealistic to assume that all the requirements of these planning objectives can be achieved for each of the future growth projections described earlier. Because of physical limitations, the quantity and quality objectives of water use interact, with some of these interactions being complimentary and some in conflict. Over the planning horizon of the next 50 years, as values associated with the achievement of these planning objectives change, new inter-actions will become evident. The basic reason for presenting various projections of future growth in the basin is to assess the capability of the water resource base to meet a wide range of potential demands and to develop different weighting systems such that different balances between economic, environmental and social values can be assessed.

This concept represents a fundamental departure from the traditional approach to resource planning developed in the past. First, most planning studies were undertaken to achieve one goal, that of increasing economic growth, and consequently only economic values were explicitly brought into the decision-making process. Second, usually only one projection of future development and attendant resource demand was generated, and thus neither the public nor the planners examined the implications of alternative growth paths on regional resource planning. Third, water resource development plans have usually been prepared without direct involvement of the public. Because of the need to consider a variety of future development paths and to include social values, public input during the preparation of the framework plan is essential.

12.6 REVIEW OF THE PLANNING PROCESS

The major steps in the planning process as illustrated in Figure 12.3. Following the definition of Study Goals and the related water planning objectives, the capability of the water resource base to meet present demands must be assessed (Part II of this report). The third step involves forecasting requirements for both consumptive and non-consumptive uses of water and related resources such as landuse, fishery production and shoreline recreation facilities over the 50 year planning horizon of the study (Chapter 13).

PLANNING AND EVALUATION PROCESS

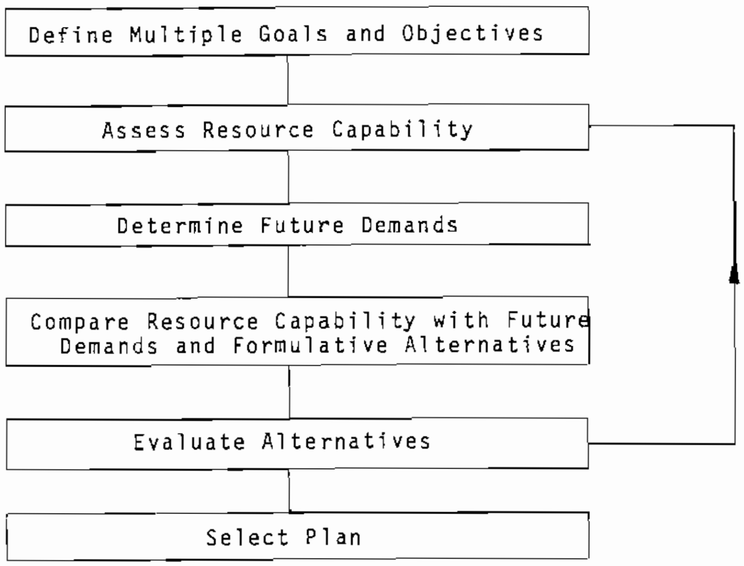


Figure 12.3

Such forecasts must be undertaken for each of the three paths of future development described earlier and then planning objectives for each of the major water uses can be specified for future as well as present conditions.

The fourth step in the planning process is to assess the capability of the water and related land and biological resource base to meet projected demands (Chapter 14 to 17). When conflicts exist, alternative ways of managing the water resource system to enable the achievement of these planning objectives can be devised within established physical and biological limitations of the resource base itself.

These alternative measures for water resource management should then be evaluated in terms of the social, environmental and economic values associated with the major study goals. The benefits associated with achieving certain planning objectives should be weighed against the costs required to meet them and the costs of foregoing the full achievement of other planning objectives because of conflicts in resource use. Framework plans should consist of a combination of water and related resource management alternatives that present a desirable balance between these benefits and costs.

As noted earlier, past water resource planning studies have been mainly concerned with contributing towards the single goal of economic growth and consequently most of the benefits and costs associated with water development plans have been evaluated in dollar terms. It was recognized however, that under the concept of multiple goals stated in the Okanagan Agreement, it was not satisfactory to evaluate all the consequences of water resource plans in solely economic terms. Although the values associated with environmental quality and social betterment goals are difficult, if not impossible to measure in monetary terms, real attempts must be made to include them in the evaluation process so that they can be weighed against economic values. It is only when economic, social and environmental values relating to water management alternatives are compared in total that it is possible to determine whether the residents of the Okanagan are better or worse off.

Finally, framework plans can be assembled through a combination of water and related resource management alternatives for each of the future economic projections. The plan developed by the Consultative Board is based to a large extent on recommendations prepared by the public task forces concerning the type of future life-style preferred by Okanagan residents. This framework plan describes a sequence of steps over the next 50 years for managing both water quantity and water quality to meet future consumptive and non-consumptive requirements as fully as possible, as well as component plans for enhancing sport fishery production and water-based recreation facilities. It is not presented in detail with a view for immediate implementation; rather, it represents a framework of information based upon an understanding of the interactions that exist between the physical limitations of the water resource and the developing social and economic system in the basin. The main intent then of the framework plan is, to map out a range of future projections that may encompass future development in the basin and supply an information base from which detailed water and related resource decisions can be implemented at the appropriate time and place by the appropriate institution.

12.7 SUMMARY OF PLANNING PRINCIPLES

The main planning principles are reviewed here in summary form:

1) The Okanagan Study is concerned with developing a framework plan for the development and management of water and directly related resources

such as sport fisheries, water-based recreation and shoreline landuse over the next 50 years. This plan is designed to contribute to the multiple goals of economic growth, environmental quality and social betterment of valley residents.

2) It was recognized that future development in the Okanagan to the year 2020 cannot be foreseen with any degree of certainty. This problem is compounded by the fact that society's set of values associated with the three goals of the study will change through time. Consequently, the framework plan developed must consider a wide range of paths to cover the breadth of probable public preferences in water resource management. In keeping with this principle, a range of future growth patterns for the basin were considered involving differing rates of economic growth and expected levels of environmental quality.

3) For each of these future projections for the basin, a complete range of demands for water and related resources were assessed and plans developed to meet these demands. To provide some basis for evaluation, a third planning principle was established, namely that all future water management alternatives should be compared with the consequences of doing nothing, i.e. maintaining the status quo.

4) In recognition of the multiple goals of the study, it was considered unsatisfactory to evaluate the consequences of water management alternatives in economic terms alone. Thus, a fourth planning principle was developed requiring assessments be made to evaluate intangible factors associated with environmental quality and social well-being goals and weigh these against economic values.

5) Planning in a vacuum, insulated from the residents of the Okanagan Basin, is unacceptable under the planning process described above because social values and desires must be taken into account in the decision-making process. Consequently, a fifth principle states that involvement of the public is an essential ingredient in the planning process, and also during the implementation of the desired framework plan.

6) The sixth planning principle requires that a range of water resource development and management alternatives be considered in developing framework plans. This principle is in keeping with the intent of the Agreement, which states that "the Study will focus on . . . the evaluation of economic, engineering, ecological, financial and organizational alternatives for water resource utilization". Both structural proposals and non-structural or management alternatives to improve the efficiency of water resource utilization are therefore included in the development of framework plans.

7) In view of the constraints of time and resources imposed on the Study, not all water management alternatives can be examined in depth. Thus, the seventh and final planning principle embodies the concept that framework plans are really a "bag of tools" to indicate procedures and methods for evaluating water management alternatives and to provide a broad information base. It is anticipated these evaluation procedures and the information base can be applied periodically to determine the course to be followed as conditions and desires change in the future. It is also anticipated that these procedures and the information base may be expanded and improved throughout the next 50 years.

CHAPTER 13

Economic Projections

The Okanagan Basin Agreement specifies that the comprehensive framework plan for water resource development and management should encompass the 50 year period to 2020. Consequently it was necessary to develop projections of economic activity and population growth for this planning horizon in order that the capability of the water resource to supply future consumptive and non-consumptive water requirements and to assimilate future waste loadings could be assessed. It is worth emphasizing that these projections were undertaken to provide an information base for forecasting demands for the Okanagan water resource and not to develop regional economic plans for the Okanagan basin. Consequently they lack much of the detail that would be required for the latter purpose.

As stated in Chapter 12, because of the uncertainty in predicting future economic development in a small region such as the Okanagan, the Consultative Board decided that a range of projections of future growth should be prepared, based on three different assumptions. This approach had several advantages over the development of a single projection. First, the projections allowed varying emphasis to be placed on the three major factors which affect lifestyle of the Okanagan resident - economic growth, environmental quality and social betterment - and thus enabling a broad array of criteria associated with the major goals of the study to be implicitly considered in developing a framework plan. Second, it permitted a wide range of future demands for water and related resource use to be prepared so that the capability of the water resource to satisfy demands could be more rigorously assessed. Third, it provided Okanagan residents with an opportunity to consider a range of possible conditions of future economic growth in the valley, and to assess the social and economic consequences of the future growth options available to them.

It was recognized that the Okanagan economy had gained a certain momentum as a result of the Federal Government's economic expansion program during the late 1960's, and it was considered this momentum would continue to at least 1980. Therefore the trends associated with the low and high economic growth projections are not expected to affect current growth patterns until 1980 and afterwards. This statement should not be construed to mean that nothing should be done until 1980 to change economic growth patterns in the Okanagan, but rather that it requires five to ten years for any policy changes to make a marked impact on an economy.

The economic growth projections were prepared both for the entire valley using an economic input-output economic model, and for selected tributaries, based on land capability analysis. The valley-wide projections were developed through an analysis of the internal and external economic pressures that create growth in the Okanagan and are essentially demand-oriented projections. The capability of water, land and other resources required to sustain this economic growth was not considered a constraint in the first stage of developing these projections. In the second stage, both land and water resource requirements were assessed and incorporated into the projections. When predicting population growth in tributary basins however, capabilities of land, water and other resources were taken into account in the first stage since these can be important limiting factors on economic development in small areas. Because tributary basins are too small to be considered as viable economic regions, a wide range of population and irrigated acreage projections based on land capability analysis, were prepared for each of eight major basins as a separate part of the economic growth studies.

This chapter presents a summary of the assumptions and methods used to develop economic growth projections for the entire valley. As growth projections in tributary basins were closely tied to tributary water quantity studies, these projections are described in Chapter 14. Growth patterns of population, employment, agriculture and tourism are compared for each valley wide projection and some of the economic and social consequences of these patterns are described. A more detailed discussion of the methods used to develop the economic model of the Okanagan and an analysis of the facts and figures associated with each projection are contained in Technical Supplement X.

Although a considerable amount of economic data for the Okanagan region was available from both Federal and Provincial government agencies, much of the information used to prepare the growth projections was obtained from studies carried out under the Okanagan Basin Agreement. During 1971-72 a detailed questionnaire survey of a sample of business firms in all sectors of the Okanagan economy was undertaken to obtain an understanding of the economic linkages between sectors within the Okanagan economy and with economic regions outside the Okanagan. The data obtained in these surveys were used to construct an economic input-output model of the present Okanagan economy. This model made possible the assessment of the impacts of projected growth in each economic sector on all related sectors, so that complete economic projections could be developed. The sampling methods used in the economic survey and the quality of the data base are more fully discussed in Technical Supplement X.

13.1 ECONOMIC GROWTH PROJECTIONS

Three economic growth projections for the Okanagan were prepared by varying the emphasis on the economic and environmental goals associated with the Study. Specifically, the following assumptions were used to generate the different projections:

Projection I

Continuation of existing economic policies in the Okanagan. The high rate of economic growth experienced in the valley over the past 10 years was assumed to continue to 1980 and then gradually decline over the next 40 years to 2020. In accordance with present provincial government policy, agricultural lands will be protected from sub-division for residential and industrial purposes, although some limited transfers in the form of land banks can be anticipated.

Projection II

An increase in the rate of economic growth compared to Projection I stimulated by the assumption of further government support for industrial development. Land use policy is similar to that assumed in Projection I, except that greater rates of population and industrial growth will result in increased transfers in landuse from agriculture to residential and industrial development.

Projection III

A decrease in the rate of economic growth compared with Projection I through controls on industrial development. These controls would apply to any economic activity creating employment through the export of goods and services to regions outside the Okanagan. Thus, after 1980 the valley will grow only in response to internal demands from increasing population rather than expansion of the economic base to support growth outside the basin. As the main emphasis in this projection was on maintaining a high level of environmental quality, agricultural lands were assumed to be protected from subdivision and additional agricultural development encouraged.

Methods for developing these three projections were broadly similar. It was mentioned in Chapter 3 that the Okanagan economy grows because areas outside the basin demand goods and services such as agricultural and forest resources, as well as non-resource based manufactured products which are processed in the valley. These industries in turn demand a wide range of locally supplied goods and services for their production processes as well as to service their employees and dependents. As the export-oriented industries grow, so do the local economic sectors that service them. Consequently, the Okanagan economy consists of a large number of closely related and mutually dependent economic sectors. Direct demands for goods and services in one sector of the economy create indirect demands for goods and services in related sectors. For example, increased production of tree fruits (agricultural sector) creates demands for packing cartons (manufacturing sector) which in turn increases demands for pulpwood (logging sector). Furthermore, employees of the industries that create and meet these demands, also require a wide range of services - education, health care, financing, retail (shopping) and construction (housing) - which comprise the major sector of the economy.

An economic (mathematical) model was constructed to trace these inter-sector linkages. This model is known as an input-output model because it describes the inputs and outputs associated with each of 30 major sectors of the Okanagan economy. Through an understanding of the economic linkages within the region, the model can determine total demands for the output of each of these sectors in 1970. Total demands comprise direct demands due to self-generated growth as well as indirect demands due to growth in related sectors of the economy.

Economic growth projections were made for the years 1980, 2000 and 2020. For each of the prescribed years, direct demands for outputs in each of the 30 sectors were estimated using the best economic forecasts available. Additional indirect demands associated with each sector were then determined by tracing the impacts of these direct demands on related sectors by means of the inter-industry economic model. The outputs of the model were specified in constant 1970 dollars of total (direct plus indirect) demands, which could be translated into production units (pounds of tree fruits, number of trailers). An estimate of the total labour force was made by using productivity statistics related to production units per employee, and also taking into account trends in these statistics over time.

Many assumptions had to be used in the development of these economic projections. The most significant one involved changes in labour productivity in each sector and changes in the economic linkages between sectors. Obviously, the relative accuracy of these assumptions decreases rapidly as the length of the planning horizon increases and it should be noted that the economic projections developed can only be assumed to be relatively accurate to the year 1980. Rapidly changing patterns in working hours, leisure demands, industrial and transportation technology can be expected over the next 50 years making projections of economic growth, especially in small regions such as the Okanagan Basin, little more than educated guesses. It can only be hoped that the range of demands for water and related resources associated with these projections encompass the likely resource requirements which will in fact be needed in the future.

13.1.1 Projection I - Continuation of Present Economic Policies

Forecast population growth in the Okanagan for Projection I was based upon population projections for the Province as a whole, prepared by the Provincial Government. Up to 1980, the economic momentum generated in the latter part of the 1960's was expected to enable the Okanagan to grow at somewhat faster pace than the Province in general. After 1980, the Okanagan economy should be well diversified and the region may be expected to grow at Provincial rates. Population totals were distributed into the four economic sub-regions according to recent growth trends, but were adjusted as necessary to account for land capability, transportation routes and other factors.

Forecasts of direct demands in manufacturing and tourist-recreation service sectors of the Okanagan economy were developed. These projections were based to some extent on past trends, particularly since the Federal governments' Industrial Incentive Program was introduced in the mid-1960's, but also took into account potential growth opportunities in the non-resource based manufacturing sector which sells to markets outside the basin. In the mining and logging sectors, limited resource potential will likely act as a constraint, so that maximum levels of economic growth will be attained within the 50 year planning horizon. Projections of employment were obtained from forecasts of labour productivity applied to the output of each economic sector as calculated by the input-output computer model.

Projections of demands for agricultural products were more difficult to assess because of non-economic factors that affect the development of this sector. Provincial government legislation does not allow the transfer of designated agricultural land to non-agricultural purposes except with approval from the Cabinet. Under this policy, small declines of tree fruit acreage around the larger urban areas are forecast. However increased production per acre is expected to more than overcome this loss of acreage, and increased production could be absorbed by continued supply of Western Canadian market demands. The development of grapes, vegetables, and forage crops, especially in the North Okanagan, is expected to compensate losses in tree fruits, resulting in little change in irrigated acreage in agriculture to 2020.

13.1.2 Projection II - High Economic Growth

Higher rates of economic growth for the Okanagan than those anticipated for Projection I were assumed by stimulation of additional investment in the manufacturing sector through a renewed industrial incentives program hypothesised to be in effect between 1980 and 1990. This would create growth in the economy through both direct expansion in the manufacturing sector, and indirect economic effects of this expansion on other sectors of the economy.

Direct demands in the resource and non-resource based manufacturing sectors were increased relative to those in Projection I for each of the designated years (2000 and 2020), approximately in the same proportion as the documented impacts on these sectors resulting from the actual incentives program of the late 1960's. Impacts of this increase growth rate on related sectors of the economy were analysed by the input-output model, and using the same productivity per worker ratios as employed in Projection I, total employment was estimated. These totals were broken down into the four sub-regions according to the distribution trends used in Projection I, with appropriate adjustments for differential employment growth ratios and land resource constraints.

Land use policy is similar to that for Projection I, except that greater population and industrial growth should produce somewhat greater pressure for the creation of larger tracts under residential and industrial reserves, particularly within or immediately adjacent to large urban centres.

As a result, there was a projected decline in irrigated acreage in the Okanagan, especially near the urban centres around Okanagan Lake, where most of the increased population is expected to be located. This decline was calculated on the basis of an average density of 10 persons per acre. There was no significant difference in the irrigated acreage totals for the North and South Okanagan regions, as increased population pressures in these areas do not appear to be sufficient to offset increased agricultural activities.

13.1.3 Projection III - Low Economic Growth

The basic assumption underlying the development of Projection III is that a lower rate of economic development and associated population growth will enable a higher natural environmental quality to be maintained. This perception was apparent from the public briefs submitted to meetings held by the Okanagan Basin Water Board and from an analysis of a questionnaire survey of a sample of valley residents (see Chapter 10). In addition, the public involvement task forces placed emphasis on environmental protection and preserving the quality of life in the valley with economic growth occurring only within this framework. Task force members agreed that a relative slowing down in the rate of economic growth over the next 20 years or so would not only provide a better opportunity for planning growth within the environmental framework, but also allow the option of increasing the rate of growth at some future date should economic hardships result. This approach would be less easily achieved if the rapid rate of growth forecast in Projections I and II were to occur.

To provide a reasonable range in economic growth rates between Projections, it was felt that population growth should be as low as was realistically possible considering the existing growth potential of the region and its attraction as a retirement centre. In addition, due to the present momentum in the Okanagan economy, it was assumed that significantly slower rates of economic growth would not occur until after 1980.

Between 1951 and 1961, before the stimulation of the Okanagan economy through industrial incentives, population growth in the valley averaged about 1.5% per annum, or about 12% lower than the Provincial average. The Okanagan valley is not an economic island, but is closely interlinked with other regions of the Province and as the Provincial economy and population grows, it is inevitable that the Okanagan, through these economic links, will also grow.

No realistic economic policy can prevent such growth. Thus, it was assumed that population growth in the Okanagan between 1980 and 2020 would grow at a constant rate based on that which prevailed between 1951-1961 in the Province and averaging about 1.3% per annum over the 40 year period. Sub-regional population totals were then obtained using similar distribution patterns as those used in Projection I.

The procedure for assessing the economic consequences of a slower rate of population growth throughout the Okanagan economy was somewhat different than that used in Projection I and II. Using target levels of population for 2000 and 2020 based on proportional increases tied to projected Provincial growth rates, the size of the labour force was determined by using population to labour force ratios employed in Projection I. Total employment in agriculture, tourist and service sectors related to householders expenditures were calculated using the input-output model and forecasts of total demands in these sectors. These labour totals were then subtracted from the total labour force to determine employment in the manufacturing and other service sectors. Direct demands for goods in the manufacturing and service sectors, which promoted most growth after 1980 under Projection I, were revised downwards, so that total employment in both the manufacturing sector and the support industries as calculated from the model would be consistent with the required employment levels. As these reductions in final demands for manufactured goods would, in turn, affect demands for related goods and services provided by other sectors of the economy, the procedure described above had to be repeated a number of times until the outputs of the economic model were consistent with labour force and target populations for the years 2000 and 2020. Because of a possible under-estimation in the rates of increased productivity per worker in some sectors, total employment, and hence population, may be over-estimated in this projection.

Forecasts of tourism were revised downwards compared with Projections I and II to remain consistent with lower resident population totals and the concept of a slowing down of the pace of economic growth. This applied to all types of tourist activity; commercial holiday visitors staying at hotels, motels and campsites; holidav visitors staying with friends and relatives (due to lower resident population) and business and convention visitors due to lower levels of business activity (for more details see Chapter 16).

To provide contrasts with other Projections, irrigated acreage was forecast to increase over existing levels. In view of the fact that public involvement task forces and residents appear to place considerable emphasis on the value of irrigated agriculture in maintaining the high environmental quality of the region, it was assumed that not only would agricultural lands continue to be protected from residential or industrial sub-divisions, but that senior governments would promote economic incentives designed to encourage farmers to remain on and develop the land. Thus, though there would be some loss of agricultural acreage in areas already zoned for sub-division, these would be more than offset by gains in other regions. Indeed, it was initially assumed that all remaining available medium and high quality irrigable land in the basin would be developed for agricultural purposes, though in many areas such developments may not be economically justified.

13.2 POPULATION GROWTH

Table 13.1 compares population growth for all three projections to 2020. In all cases, population is forecast to increase from 114,500 in 1971 to 162,000 in 1980 at an annual growth rate of 3.9%. This growth rate, which is somewhat slower than that experienced during the 1966-71 period is based on the assumption that the pace of economic investment will decline following the termination of the industrial incentives program in 1971.

After 1980, population growth under Projection I is expected to increase to 262,000 by the year 2000 (2.4% per annum) and to 391,000 by 2020 (2.0% per annum). In Projection II, the simulated industrial incentives program for the Okanagan is forecast to attract an additional 22,000 people to the valley by 2000 compared to Projection I, and thereafter population is projected to grow at a similar rate as Projection I, resulting in total population of 430,000 by 2020.

Despite assumptions designed to slow down population growth through curtailing industrial expansion in Projection III, population totals in 2000 are expected to total 237,000, only 25,000 fewer than the total for Projection I in the same year. By 2020 however, a more significant decline is forecast resulting in 101,000 fewer residents compared to Projection I. It is worth re-emphasizing that these totals may over-estimate possible population growth should attempts be made to control employment opportunities. For all projections, immigration patterns were estimated since this could be an importan factor in population growth due to the region's popularity as a retirement area.

13.3 REGIONAL GROWTH PATTERNS

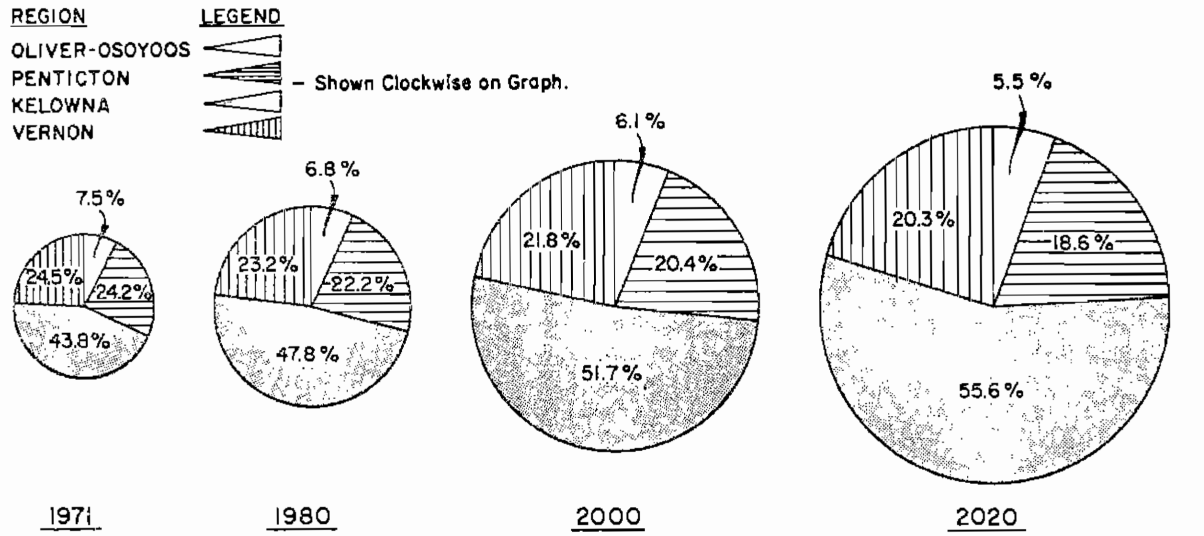
Population growth rates are expected to vary from region to region in the Okanagan. Figure 13.1 and Table 13.1 show that the Kelowna region will continue to grow faster than other regions, increasing its share of valley population from 44% in 1971 to 56% in 2020. This rapid population growth is due to the region's high potential for attracting non-resource based manufacturing industries and attendant services. As transportation improves, the region is expected to provide relatively more service to industries and population in other regions of the Okanagan and in adjacent watersheds.

TABLE 13.1

POPULATION BY SUB-REGION, OKANAGAN BASIN 1961 to 1971, AND PROJECTED 1980, 2000 AND 2020

SUB-REGION	1961	1966	1971	PROJECTED	PROJECTION I PRESENT ECONOMIC POLICIES		PROJECTION II HIGH ECONOMIC GROWTH		PROJECTION III LOW ECONOMIC GROWTH	
				1980	2000	2020	2000	2020	2000	2020
OLIVER-OSOYOOS										
Oliver-Urban	1,774	1,563	1,598	1,700	2,000	2,200	2,200	2,400	1,800	1,800
Osoyoos-Urban	1,022	1,166	1,279	1,600	2,300	3,000	2,500	3,300	2,100	2,200
Rural	3,964	4,732	5,775	7,700	11,800	16,400	12,700	18,000	10,700	12,000
Sub-Total	6,760	7,461	8,652	11,000	16,100	21,600	17,400	23,700	14,600	16,000
PENTICTON REGION										
Penticton-Urban	14,516	16,157	18,955	24,400	35,800	48,100	38,800	52,900	32,400	35,700
Skaha Lake-Rural	736	775	1,036	1,400	2,100	2,900	2,300	3,300	1,900	2,200
Summerland-Urban	4,307	4,585	5,551	7,100	10,400	13,900	11,200	15,100	9,400	10,300
Naramata-Summ.-Rural	848	815	1,141	1,500	2,300	3,200	2,500	3,500	2,000	2,300
Vaseux Lake-Rural	551	904	996	1,600	2,800	4,500	3,100	5,100	2,600	3,400
Sub-Total	20,958	23,236	27,679	36,000	53,400	72,600	57,900	79,900	48,300	53,900
KELOWNA REGION										
Kelowna-Urban	20,809	26,266	35,852	52,800	87,600	132,200	94,900	145,400	79,200	93,000
-Rural	3,195	4,217	8,152	14,800	30,100	55,800	32,700	61,400	27,300	41,400
Wood Lake-Urban	1,857	2,089	3,000	4,500	7,400	11,000	8,000	12,100	6,700	8,200
Peachland-Urban	641	709	1,446	2,500	4,900	8,700	5,300	9,600	4,400	6,400
Westbank-Urban	728	755	1,620	2,800	5,500	9,900	6,000	10,800	5,000	7.300
Sub-Total	27,230	34,046	50,160	77,400	135,500	217,600	146,900	239,300	122,600	161,400
VERNON REGION										
Vernon-Urban	13,697	15,149	18,845	25,200	38,000	52,400	41,200	57,600	34,300	38,800
-Rural	3,247	3,211	3,955	5,000	7,100	9,200	7.700	10,200	6,400	6,900
Kalamalka Lake-Rural	2,161	2,660	3,617	5,300	8,800	13,400	9,500	14.700	8,000	9,900
Armstrong-Urban	1,228	1,426	1,631	2,100	3,100	4,200	3,400	4,600	2,800	31,00
Sub-Total	20,338	22,446	28,048	37,600	57,000	79,200	61,800	87,100	51,500	58,700
TOTAL	75,281	87,179	114,539	162,000	262,000	391,000	284,000	430,000	237,000	290,000

Source: 1. Economic Studies - Okanagan Basin Study
2. Statistics Canada



SHARE OF POPULATION BY SUB-REGION - OKANAGAN BASIN 1971 AND PROJECTED 1980, 2000 AND 2020 FOR ALL PROJECTIONS

Figure 13.1

Most of the growth in the Kelowna region is expected to occur within the boundaries of the expanded City of Kelowna, which in 1971 contained a population of 36,000, and which is projected to increase to over 130,000 under Projection I and II and to almost 100,000 under Projection III. Other economic nodes in the region, such as Westbank, Peachland and Winfield are expected to grow to medium-sized communities of 8 to 10,000 people, but this pattern could be changed if policies to regionalize industrial growth throughout the Kelowna region were implemented. Policies of this nature could encourage some industrial development in the smaller centers in an attempt to control the growth of the City of Kelowna.

The Vernon region is expected to experience the next largest increase in population over the 50 year period. This growth is directly related to anticipated increases in employment in resource-based manufacturing such as wood products and processing; dairy and beef products and associated primary industries, as well as non-resource based industries such as glass and metal fabricating. Again, most of the population growth is forecast to occur in the Vernon urban area, where present totals of almost 20,000 could increase between two or three-fold over the next 50 years.

Due to more limited employment potential, population growth in the Penticton and Oliver-Osoyoos regions is expected to increase at a lower rate than the rest of the valley. Emphasis will continue to be placed on tourism and retirement services, some light manufacturing industries and agricultural production, while Penticton will likely remain as the major service center for the South Okanagan, Similkameen and Kettle River basins.

13.4 EMPLOYMENT

Much of the anticipated variation in population growth can be accounted for through an analysis of projected changes in employment opportunities for each Projection (Figure 13.2). The number of people employed in the Okanagan totalled 29,700 in 1970 and this is expected to increase to 104,900 and 118,500 in 2020 for Projections I and II respectively, compared to 76,400 for Projection III (Figure 13.2). The major thrust of this employment growth lies in the export-oriented manufacturing industries, the non-resource based manufacturing and to a lesser extent, resource-based manufacturing, and in the service trades, which serve the growing Okanagan population. In fact, the service industries, which presently employ 71% of the valley labour force are expected to increase their share of employment to 88% by 2020. Job creation in these service sectors is relatively higher than manufacturing and primary industries, as most services are labour intensive and are consequently less subject to labour productivity increases over time. On the other hand, employment in the primary industries (agriculture, logging, mining) is expected to decline gradually to 2020 due to increasing labour producitivity and, in the case of mining and logging, limitation in resource potential. Under Projection III agricultural employment is forecast to remain almost constant to 2000 due to assumed economic incentives to create growth in this sector, but could decline thereafter due to anticipated increases in labour productivity.

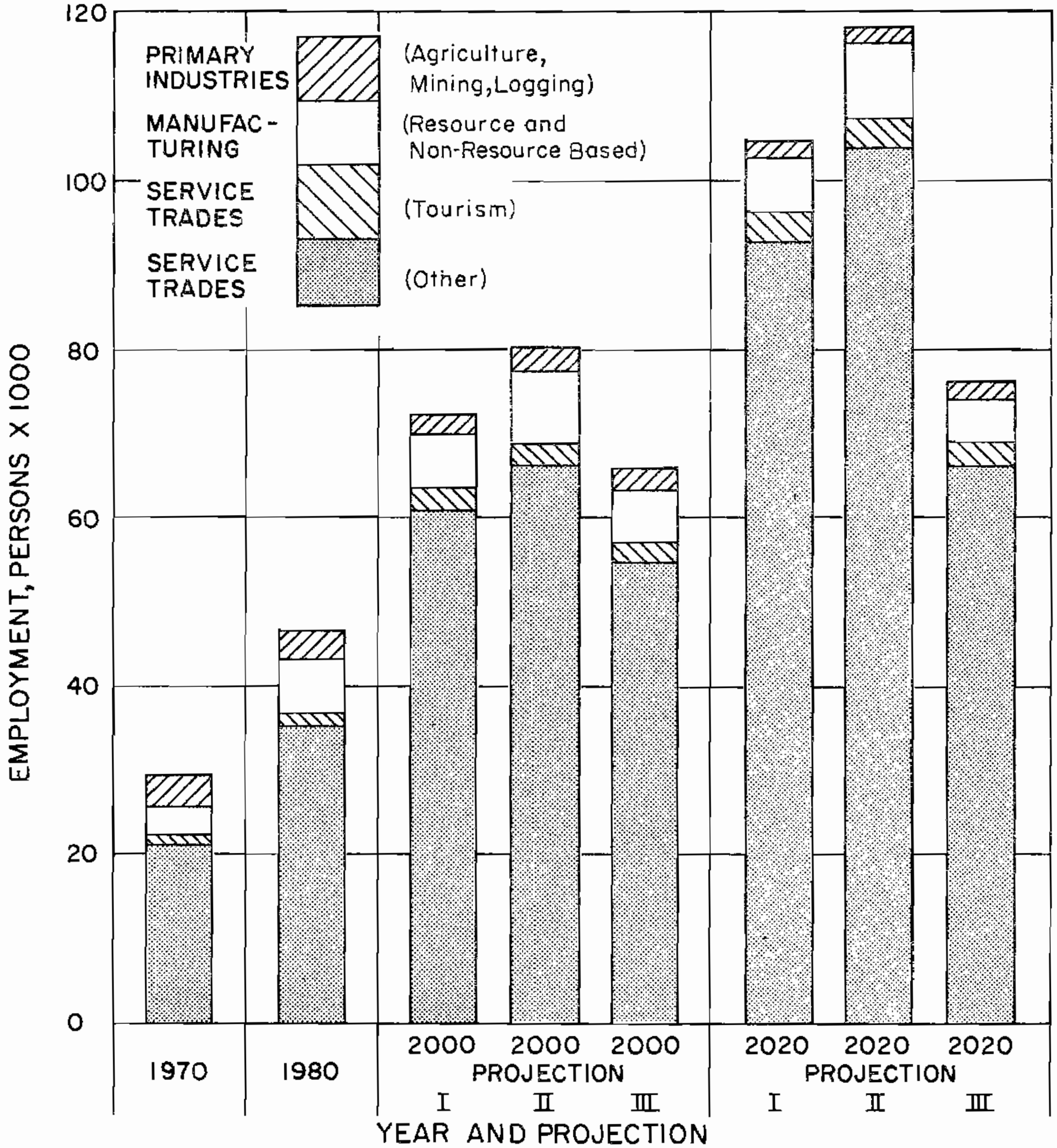
The rapidly increasing importance of non-resource based manufacturing and service sectors of the economy expected over the next 50 years is illustrated in Table 13.2. The value of production in non-resource based manufacturing is

TABLE 13.2

VALUE OF OUTPUT BY MAJOR ECONOMIC ACTIVITY
OKANAGAN BASIN 1961, 1970, AND PROJECTED 1980, 2000 AND 2020
(IN THOUSANDS OF CONSTANT 1970 DOLLARS)

	AGRICULTURE	MINING & LOGGING	MANUFACTURING		SERVICES		TOTAL
			Resource Based	Non-Resource Based	Tourism	Other	
1961	31,785.3	N/A	32,937	11,291	5,526	N/A	N/A
1970	40,212.2	29,495.8	44,356.4	84,190.6	11,093.1	306,789.6	516,137.7
1980	61,311.3	36,858.4	88,728.3	273,917.4	18,352.5	758,759.5	1,237,927.4
2000 I	76,335.8	9,979.7	142,959.7	456,537.1	40,460.1	2,037,136.4	2,763,408.8
2000 II	76,073.6	10,802.8	155,069.7	659,287.8	40,460.1	2,273,992.2	3,215,686.2
2000 III	81,581.1	9,838.5	141,244.7	438,301.5	34,600.1	1,816,266.8	2,521,852.7
2020 I	89,025.1	12,188.5	188,238.8	748,539.4	74,733.5	4,871,954.2	5,984,679.5
2020 II	89,711.2	13,458.3	197,087.2	1,050,373.9	74,733.5	5,436,780.5	6,862,144.6
2020 III	98,570.8	11,284.7	182,249.6	597,701.6	63,584.7	3,479,339.6	4,432,731.0

SOURCE: I/O Tables



EMPLOYMENT BY MAJOR ECONOMIC SECTOR IN THE OKANAGAN BASIN FOR 1970 AND PROJECTED 1980, 2000 AND 2020.

Figure 13.2

predicted to expand over 12-fold by 2020 under Projection II (which assumes incentives to encourage such growth) and nine-fold under Projection I. Even higher rates of expansion in output are forecast for the service sectors. In comparison, the value of production from resource-based manufacturing is only expected to grow four times over the same 50 year period. Despite a possible reduction in actual employment in the agricultural sector, the value of agriculture production should more than double by 2020 in all Projections.

The geographical distribution of employment opportunities closely parallels that of population (Table 13.3). The Kelowna region presently provides about 40% of all jobs in the manufacturing and service industries, but this share is expected to increase to between 45 and 50% for manufacturing and to 60% for services by 2020 in all Projections. The total Kelowna regional labour force of just over 12,000 is estimated to increase between four and five times over the 50-year period for all Projections to between 40,000 and 62,000. By comparison, the Vernon total is expected to grow from 7,500 to between 16,000 and 25,000 depending on the Projection, the Penticton total from 7,700 to between 15,000 and 24,000 and the Oliver-Osoyoos total from 2,300 to between 4,400 and 6,800. Variations in the relative share of employment in the agricultural and tourist sectors between regions can be expected and these are discussed in more detail in the following sections.

13.5 AGRICULTURE

When discussing agricultural potential in the Okanagan, it must be stressed that projections of irrigated acreages and crop production are relatively more uncertain than projections of growth in other sectors. In view of the recent introduction of the B.C. Land Commission Act, which protects agricultural land from sub-division, no assessment can yet be made of its effectiveness in achieving its goal. Consequently, a range of assumptions on future changes in irrigated landuse was made to provide some variation in the future water requirements by agriculture and thus expose the capability of the water resource to meet these demands to a sterner test.

Table 13.4 presents the distribution of irrigated acreage by crop type and region for each Projection. In Projection I, the existing total of 60,000 acres is expected to decline slightly to 59,600 increased pasture acreage in the North Okanagan mainly offsetting declines in agricultural acreage within the urban areas of the basin. Acreage in the Penticton and Kelowna regions will likely decline more significantly from present levels due to land banking for industrial, commercial and residential purposes, while acreage in the Oliver-Osoyoos regions will probably increase due to increasing demands for grapes and soft-fruits which are particularly suited to this region.

TABLE 13.3

OKANAGAN BASIN

EMPLOYMENT BY MAJOR ECONOMIC ACTIVITY AND REGION, 1970 & PROJECTED 1980, 2000 & 2020

YEAR	REGION	AGRICULTURE	MINING & LOGGING	MANUFACTURING Resource Based	MANUFACTURING Non-Resource Based	SERVICES Tourism	SERVICES Other	SERVICES Other (Incl. Gov't)	TOTAL
1970									
	Oliver-Osoyoos	551	33	47	88	126		1,461	2,306
	Penticton	659	48	438	554	441		5,524	7,664
	Kelowna	1,024	471	680	1,021	360		8,673	12,229
	Vernon	398	112	599	744	194		5,527	7,574
	Total	2,632	664	1,764	2,407	1,121		21,185	29,773
1980									
	Oliver-Osoyoos	700	20	50	280	170	1,980		3,200
	Penticton	660	40	410	860	620	8,510		11,100
	Kelowna	1,060	320	600	2,010	550	16,560		21,100
	Vernon	450	90	970	1,200	280	8,410		11,400
	Total	2,870	470	2,030	4,350	1,620	35,460		46,800
2000	Projection I								
	Oliver-Osoyoos	640	20	20	290	360		3,270	4,600
	Penticton	460	30	300	950	940		13,220	15,900
	Kelowna	830	80	400	2,360	940		30,990	35,600
	Vernon	440	70	800	1,390	460		13,440	16,600
	Total	2,370	200	1,520	4,990	2,700		60,920	72,700
2000	Projection II								
	Oliver-Osoyoos	620	20	20	360	360	3,620		5,000
	Penticton	440	30	290	1,210	940	14,690		17,600
	Kelowna	780	80	400	3,430	940	33,770		39,400
	Vernon	480	70	900	2,000	460	14,490		18,400
	Total	2,320	200	1,610	7,000	2,700	66,570		80,400
2000	Projection III								
	Oliver-Osoyoos	690	20	20	270	320	2,880		4,200
	Penticton	500	30	300	890	730	11,950		14,400
	Kelowna	890	80	400	2,210	850	27,970		32,400
	Vernon	450	70	790	1,310	430	12,050		15,100
	Total	2,530	200	1,510	4,680	2,330	54,850		66,100
2020	Projection I								
	Oliver-Osoyoos	490	10	10	300	490		4,700	6,000
	Penticton	320	10	170	1,030	1,240		18,230	21,000
	Kelowna	590	30	220	2,670	1,310		50,680	55,500
	Vernon	400	30	510	1,480	620		19,360	22,400
	Total	1,800	80	910	5,480	3,660		92,970	104,900
2020	Projection II								
	Oliver-Osoyoos	500	10	10	390	490	5,400		6,800
	Penticton	290	10	170	1,300	1,240	20,690		23,700
	Kelowna	560	30	230	3,880	1,310	56,690		62,700
	Vernon	460	30	660	2,160	620	21,370		25,300
	Total	1,810	80	1,070	7,730	3,660	104,150		118,500
2020	Projection III								
	Oliver-Osoyoos	530	10	10	230	400	3,220		4,400
	Penticton	360	10	170	800	1,050	12,910		15,300
	Kelowna	680	30	220	2,050	1,110	36,310		40,400
	Vernon	380	30	480	1,080	520	13,810		16,300
	Total	1,950	80	880	4,160	3,080	66,250		76,400

TABLE 13.4

IRRIGATED ACREAGE BY SUB-REGION, 1970-2020

SUB-REGION	1970	1980	PROJECTION I		PROJECTION II		PROJECTION III	
			2000	2020	2000	2020	2000	2020
OLIVER-OSOYOOS								
Tree Fruits	5,716	5,270	5,220	5,080	5,160	4,960	5,460	5,460
Pasture	3,872	3,580	3,550	3,460	3,510	3,380	3,560	3,550
Other	1,368	3,240	4,330	5,460	4,330	5,460	5,180	6,390
TOTAL	10,956	12,100	13,100	14,000	13,000	13,800	14,200	15,400
PENTICTON								
Tree Fruits	8,905	7,510	6,400	5,680	6,190	4,880	7,520	7,660
Pasture	2,290	2,650	2,970	3,090	2,970	3,090	3,150	3,310
Other	139	240	350	430	330	430	330	430
TOTAL	11,334	10,400	9,700	9,200	9,500	8,400	11,000	11,400
KELOWNA								
Tree Fruits	14,259	13,190	12,010	11,200	11,510	9,730	14,170	15,160
Pasture	5,885	5,860	5,690	5,510	5,590	4,980	6,630	7,050
Other	2,003	2,050	2,600	3,190	2,600	3,190	2,600	3,190
TOTAL	22,147	21,100	20,300	19,900	19,700	17,900	23,400	25,400
VERNON								
Tree Fruits	2,939	2,720	2,500	2,290	2,500	2,290	2,560	2,440
Pasture	11,652	11,890	12,440	12,750	12,440	12,750	16,180	17,600
Other	1,042	1,290	1,360	1,460	1,360	1,460	1,360	1,460
TOTAL	15,633	15,900	16,300	16,500	16,300	16,500	20,100	21,500
BASIN								
Tree Fruits	31,819	28,690	26,130	24,250	25,360	21,860	29,710	30,720
Pasture	23,699	23,990	24,650	24,810	24,510	24,200	29,520	31,510
Other	4,552	6,820	8,620	10,540	8,620	10,540	9,470	11,740
TOTAL	60,070	59,900	59,400	59,600	58,490	56,600	68,700	73,700

Despite increasing pressures for sub-dividing agricultural land under Projection II, total irrigated acreage is expected to decline only about 4,400 acres to 56,600 by 2020. Assuming there will be some relaxation of the controls on agricultural lands consistent with a general policy for encouraging economic growth in the valley, there could be significant decline in orchard land, however, especially in the Kelowna and Penticton regions, where almost 5,000 and 3,000 acres could be lost respectively. These acreage declines would be partially compensated for by increases in grape acreages, particularly in the Oliver-Osoyoos region, and pasture in the North Okanagan. It is worth noting that according to land capability studies, the Okanagan appears to be able to support 430,000 people and over 55,000 acres of irrigated agricultural lands, which, assuming relatively modest increases in productivity, could supply the Western Canadian agricultural market potential.

In Projection III, it was assumed that all medium and high quality agricultural lands (Canada Land Inventory Classes 1,2 and 3) would be developed for irrigated agriculture. This assumption allowed for a maximum projection of possible irrigation development and because irrigated agriculture is the largest consumer of water (see Chapter 4), resulted in a high estimate of future water requirements. Although irrigated acreage totals presented in Projection III are not necessarily supported by economic principles, they did permit the Consultative Board to check whether water and land resources in the valley are capable of supporting these projections in competition with other demands.

According to the assumptions discussed above, by 2020 irrigated acreage in the valley could total 73,700 acres. Although there would be average increases in each sub-region, the most extensive new developments would take place in the Oliver-Osoyoos region (grapes) and the Vernon region (pasture), though there is also potential for developing new orchards in the Kelowna region. Much of this increased acreage would occur on Indian Lands, in fact about 13,000 acres of Indian Reserve land situated mainly at the head of Okanagan Lake and in the Oliver-Osoyoos region consists of prime agricultural land. Whether or not this land will be developed for agricultural purposes depends on future landuse policies of the Indian Bands, but in lieu of any definite plans for this land, it was assumed under Projection III that it would be irrigated, and thus the availability of water to supply this expanded irrigated acreage could be assessed (see Chapter 14).

In all three Projections, agriculture continues to play an important role in the valley economy. Table 13.5 presents the value of production of major agricultural crops for each Projection to 2020. Although tree fruit production will continue to dominate the agricultural economy of the Okanagan, its share of the total crop value is expected to decline from 75% at present to between 65 and 70% depending on the Projection. The value of grape, livestock and dairying production is anticipated to increase at a relatively faster pace than other agricultural products. Indeed, by 2020 it is possible that the Okanagan

TABLE 13.5

VALUE OF AGRICULTURAL PRODUCTION IN THE OKANAGAN VALLEY, 1970-2020*

PRODUCT	1970	1980	2000			2020		
			Projection I	Projection II	Projection III	Projection I	Projection II	Projection III
Tree Fruits	30,380	46,700	53,030	50,800	57,180	56,100	53,330	65,590
Grapes	1,500	3,290	5,850	5,850	6,690	7,610	7,610	8,530
Livestock	2,750	3,120	4,530	5,030	5,390	6,470	7,490	8,150
Dairying	1,540	2,480	4,915	5,915	4,680	8,020	9,610	6,990
Vegetables	1,240	1,770	2,130	2,130	2,130	2,390	2,390	2,390
Field Crops	480	680	1,050	1,280	1,040	1,540	1,890	1,380
Poultry Eggs	1,300	2,100	3,560	3,800	3,210	5,510	6,000	4,150
Nursery	1,020	1,170	1,270	1,270	1,270	1,390	1,390	1,390
TOTALS	40,210	61,410	76,335	76,075	81,590	89,030	89,710	98,570

Sources: B.C. Department of Agriculture
B.C. Grape Marketing Board
B.C. Interior Vegetable Marketing Agency
Economic Studies, Okanagan Basin Study

*Data in Thousands of Constant 1970 Dollars

could become an important supplier of meat and dairy products for the growing urban populations in the Lower Mainland of British Columbia.

In Chapter 3, it was mentioned that 70% of farms in the Okanagan Valley are presently under 70 acres and that almost half the farm units earned under $2,500 per year. These basic characteristics of farming are expected to continue to 2020 in Projection I and III, though it could be anticipated that under the more rigorous economic assumptions prevailing in Projection II, there would be some attempt to increase farm sizes and gross value of production in order to remain competitive with other claims for the limited land and water resources in the basin. In the other two Projections, particularly Projection III, it can be assumed that small farms will continue to provide large social benefits but limited economic returns, which will be, in all likelihood, supplemented by other sources of income. Under these assumptions, large increases in productivity and the development of more efficient farming methods including water application schedules cannot be anticipated on a widespread basis.

13.6 TOURISM

Visitors come to the Okanagan for three principal reasons - on holiday, business, or to attend conventions. Because of the relatively small difference in future estimates of visitor days between Projections I and II, only two projections of growth after 1980 were analysed, known as high growth (Projections I and II) and low growth (Projection III). The provision of a range of future tourist demands emphasizes the uncertainty associated with predicting tourist visits to the Okanagan over the next 50 years and serves as a more rigorous test for the evaluation of shoreline landuse and water resource management needs. In the case of business and convention visitors, forecasts for future demands were tied to the growth of business activity in the valley for each Projection. Variation in the levels of business opportunities and availability of suitable sites for conventions formed the basis for the regional distribution of these projections.

Because of the importance of holiday visitors in the tourist industry, relatively more detailed estimates of future participation were attempted. The questionnaire surveys described in Chapter 7 indicated the places of origin of tourists staying in commercial accommodation and hence the proportion of Okanagan tourists in the total population of the area of origin could be determined. For example, the Lower mainland of British Columbia contained a population of 1,160,000 in 1971 and contributed an estimated 198,400 holiday tourists to the Okanagan or 171 tourists per 1000 population. Appropriate visitation rates were then applied to projected populations in each of the regions from which tourists originate for 1980, 2000 and 2020 respectively. The estimated numbers in the various regions were then integrated to provide an estimate of the total number of holiday visitors staying at commercial accommodation. In the case of visitors staying with friends and relatives, a visitation rate of 1.3 visitor days per resident was determined, and this rate was applied to projected resident populations in Projection I and for the high growth estimates of summer tourism.

In the case of the low growth projection, no rational basis for estimating reduced holiday tourist participation could be determined, and consequently, an arbitrary procedure was employed. Projected increases in the number of tourists staying at commercial accommodation between 1980 and 2000 and 2020, under the high growth Projection were simply halved, under the assumption that the future supply of commercial accommodation could be limited to act as a constraint on tourist population. Reductions in the growth rate of visitors staying at private households were obtained by applying current visitation rates to the lower population totals associated with Projection III.

In all cases, the present average length of stay of convention and business visitors (2 0 days) and holiday visitors in the Okanagan (6.4 days) was assumed to continue over the next 50 years. Thus, the total numbers of visitor-days could easily be obtained from the estimated number of visitors by multiplying by the appropriate factor. There are possible indications that the length of stay could vary over time, but no data were available to check this premise. Sensitivity tests on a range of participation rates for beach and angler days were employed to test the capability of the land and water resources to support a wider range of demands, and these are reported upon in Chapter 16.

TABLE 13.6

VISITOR DAYS IN THE OKANAGAN, 1970-2020

1970	KELOWNA	PENTICTON	OLIVER-OSOYOOS	VERNON	TOTAL
Holiday	909,200	1,285,200	375,900	749,000	3,319,300
Business	95,000	54,300	20,000	63,900	234,000
Convention	8,600	126,100	---	17,900	174,300
TOTAL	1,012,800	1,465,600	418,400	830,800	3,727,600
1980					
Holiday	1,336,300	1,800,900	539,100	1,051,200	4,727,500
Business	151,500	75,900	23,300	91,300	342,000
Convention	11,500	170,600	---	24,400	206,500
TOTAL	1,499,300	2,047,400	562,400	1,166,900	5,276,000
2000 High Growth					
Holiday	2,207,400	2,650,800	1,104,900	1,673,200	7,626,300
Business	245,600	107,000	32,000	137,000	521,600
Convention	87,200	199,500	---	55,900	342,600
TOTAL	2,540,200	2,957,300	1,136,900	1,866,100	8,500,500
2020 High Growth					
Holiday	3,113,000	3,606,100	1,539,800	2,293,300	10,552,200
Business	413,800	156,200	46,800	219,000	835,800
Convention	144,700	241,100	---	96,500	482,300
TOTAL	3,671,500	4,003,400	1,586,600	2,608,800	11,870,300
2000 Low Growth					
Holiday	1,873,900	2,245,300	952,300	1,414,300	6,475,800
Business	239,600	102,800	32,000	132,200	506,600
Convention	199,500	---	55,900	242,600	342,600
TOTAL	2,313,000	2,348,100	1,040,200	1,789,100	7,325,000
2020 Low Growth					
Holiday	2,638,000	3,024,200	1,266,200	1,934,600	8,863,000
Business	309,200	115,200	34,200	161,200	619,800
Convention	144,700	241,100	---	96,500	482,300
TOTAL	3,091,000	3,380,500	1,300,400	2,192,300	9,965,100

Projections of holiday, business and convention visitor-days for the four sub-regions of the Okanagan basin are shown in Table 13.6. The total number of visitor-days under the 'high growth' Projection is expected to triple from 3.7 million in 1970 to 11.9 million in 2020, and to more than double under the 'low growth' projection to 9.9 million. Almost 90% of these visitor days will continue to be enjoyed by holiday visitors, about 7% by business visitors and 4% by convention delegates. This distributional pattern should remain basically the same for both projections.

Summer holiday visitors, that is those visiting the Okanagan during June, July, August and September presently represent over 90% of all holiday visitors and this trend is expected to continue unless there are persuasive efforts by the Okanagan communities to increase non-summer activities such as skiing, fishing and hunting. During the questionnaire survey, the vast majority of summer tourists indicated their preference to holiday during the four summer months.

Projections of summer holiday tourists are shown in Table 13.7. It is estimated that by 1980 there will be almost 684,000 summer tourists compared to 485,400 in 1970. According to the high growth projection, this total will

TABLE 13.7

SUMMER HOLIDAY VISITORS 1970-2020

YEAR	COMMERCIAL[1]	NON-COMMERCIAL[2]	TOTAL	GROWTH INDEX
1970	334,000	151,400	485,400	100
1980	472,500	211,200	683,700	141
2000 Hi	763,300	322,100	1,085,300	224
2020 Hi	1,054,700	516,100	1,570,800	324
2000 Lo	617,893	312,800	930,700	192
2020 Lo	908,986	382,800	1,291,800	266

1 Visitors staying at motels, hotels, & campsites

2 Visitors staying at private residences

exceed 1 million by 2000 and reach 1.5 million by 2020. Even in the low growth projection, over 1.2 million summer visitors are forecast to enter the Okanagan by 2020. Table 13.7 also differentiates the total number of summer tourists by type of accommodation. Approximately two-thirds of the total number of summer visitors are expected to stay at commercial accommodation. There are some changes in the proportion of summer tourists staying at private homes between the two projections in keeping with the differences in projections of total population. Assuming the current average lengths of stay of summer tourists continues in the future, 4.4 million summer holiday visitor-days are expected to be spent in the Okanagan in 1980, compared with 3.1 million in 1970, rising to over 10 million and 8 million by 2020 in the high and low projections respectively (Table 13.8.)

TABLE 13.8

SUMMER HOLIDAY VISITOR DAYS 1970-2020

YEAR	COMMERCIAL	NON-COMMERCIAL	TOTAL	GROWTH INDEX
1970	2,141,100	970,500	3,111,600	100
1980	3,028,800	1,353,800	4,382,600	141
2000 Hi	4,892,500	2,064,500	6,957,100	224
2020 Hi	6,760,600	3,308,300	10,069,000	324
2000 Lo	3,960,700	2,005,300	5,966,000	192
2020 Lo	5,826,600	2,453,700	8,280,300	266

Some shifts in the relative regional shares of visitor participation are anticipated. For example, Penticton's share of holiday visitor-days is forecast to decline from 39% of the basin total in 1970 to 34% by 2020, while the Oliver-Osoyoos regional share could increase from 11% to 15% over the same period. This increase is based on anticipated improvements in transportation links between the region and the Lower Mainland and development of the recreational potential around Osoyoos Lake, especially on Indian Lands. Similarly, relative increases in holiday visitor-days in the Kelowna region are expected due to the region's growing share of residential population and consequent increase in visitors staying at private homes. Convention and business visitor-days in the Kelowna and Vernon regions are predicted to increase relative to those in the Penticton region, reflecting increased economic activity in the northern parts of the basin.

13.7 PROJECTIONS OF THE SUMMER VISITOR EXPENDITURES

In Chapter 7, expenditure by holiday visitors was shown to be an important component of the Okanagan economy and a possible indicator of the value tourists place on water-based recreational activities. Summer visitors spent an estimated $11.5 million in 1970, approximately $5.9 million of which remained in the Okanagan as direct income to valley residents. Future estimates of summer holiday visitors expenditures were calculated by multiplying average per capita purchases in 1970 by projected visitor populations and adding 15% of the real value per decade to take into account anticipated increases in per capita spending. These total expenditure estimates were broken down into four categories consisting of purchases of accommodation and food, retail goods, agricultural products (mainly tree fruits, grapes and vegetables) and other services. The net income remaining in the Okanagan was calculated from the input-output economic model.

Total purchases and net income received from summer holiday visitors to the Okanagan are presented in Table 13.9. Under the high growth Projection, current expenditures of $11.5 million are anticipated to increase over six times to almost $70 million by 2020 and by more than five times to $59 million under the low growth projection. Net income derived by Okanagan residents from these expenditures should increase relative to total expenditures due to increased per capita spending.

TABLE 13.9

PURCHASES BY SUMMER HOLIDAY VISITORS AND
TOTAL INCOME DERIVED BY OKANAGAN RESIDENTS
(Constant 1970 Dollars)

YEAR	PURCHASES	INCOME	NET INCOME PER VISITOR DAY
1970	$11,511,800	$ 5,883,700	$3.50
1980	18,918,700	11,393,700	4.83
2000 Hi	39,901,000	28,084,300	7.46
2020 Hi	69,395,400	53,062,900	7.31
2000 Lo	32,996,500	23,231,300	9.86
2020 Lo	59,072,900	45,171,400	10.09

The major social and economic characteristics of the three economic projections in the year 2020 are compared in Table 13.10. In essence, there are few significant differences in Projections I and II suggesting that considerably greater investments in industrial development than occurred during the Industrial Incentives Program of the late 1960's would be required to increase the pace of economic growth significantly. This conclusion is more indicative of the present healthy state of the Okanagan economy than the inability of the basin economy to absorb a faster pace of investment.

Under Projection III, population growth rates could be significantly reduced by a reduction in the availability of job opportunities, and thus, a slowing down in the rate of economic investment. It should be emphasized that if population totals are to be constrained, investment in the so-called 'clean' industries, such as carpet, trailer and glass manufacturing may be necessary in addition to controls on development of resource-based industries such as wood products and food processing which are more usually associated with public concerns about pollution.

Reduction of the rate of employment growth appears to be the only realistic way of controlling the pace of economic growth and consequent population increase. Other approaches,such as placing quotas on migration into the basin, do not appear practical at this time. Placing some restrictions on job availability, however, may in turn create other social problems in the valley. There is

TABLE 13.10

EXAMPLES OF RANGE OF ECONOMIC GROWTH THAT MAY OCCUR IN THE OKANAGAN VALLEY TO THE YEAR 2020

PROJECTION	DESCRIPTION OF PROJECTION	POPULATION	EMPLOYMENT	TOTAL VALUE OF BASIN INCOME (millions)+	VALUE OF BASIN INCOME PER PERSON (dollars)+	IRRIGATED ACREAGE* (acres)	TOURISTS
1970 Situation		115,500	29,800	$ 280.8	2,590	60,000	700,000
Projection I Continuation of Existing Economic Policies	Continuation of existing economic growth policies in the valley. The high rate of population, employment and industrial development experienced in the past 10 years is expected to continue until 1980 and then gradually decline over the next 40 years to 2020. In accordance with present government policy, agricultural lands in the valley will be protected from subdivision for residential and industrial purposes.	391,000	104,900	5,060.3	12,900	59,600	2,300,000
Projection II High Economic Growth	Growth that may be realized if the Okanagan economy is stimulated through senior government support for industrial development and employment-creating activities. To provide a contrast with the first projection described above, it is assumed that existing controls on subdivision of agricultural land would be relaxed and some transfers of land-use from agriculture to residential and industrial development would result.	430,000	118,500	5,682.6	13,200	56,600	2,300,000
Projection III Low Economic Growth	Growth that may be realized if there is a retardation of the current economic trends through controls on industrial development These controls would apply to both non-resource based, or clean industries, such as trailer manufacturing, as well as resource based industries such as lumber mills and pulp mills. In this projection the emphasis would be on environmental quality, agricultural lands would be protected from subdivision, and additional agricultural development encouraged.	290,000	76,400	3,725.1	12,800	73,700	1,800,000

*Totals for Irrigated Acreage in 2020 are preliminary and subject to revision.

+Figures shown based on 1970 Dollars

already a relatively larger proportion of older people (over 50 years) in the Okanagan compared to the Province as a whole, and restricting the pace of employment can only aggravate this situation as the younger age groups seek employment outside the basin. This, in turn, could lead to a continued decline in the rate of natural births in the valley. In addition, due to the attractiveness of the area for retirement and the gradual reduction in the retirement age, it may be expected that relatively more middle-aged and older people will decide to move to the valley.

Residents will have to compare these consequences of a low growth policy with some of the social and environmental benefits, such as lower population densities, especially in urban areas and greater greenbelt and recreational space. Some of these characteristics are compared in the three Projections in Table 13.11. Presently, average urban population densities average about 5.6 people per acre, but this density could almost double to 10.6 people per acre, in 2020 under Projection I, in which agricultural land is preserved and higher urban densities can be anticipated. Urban densities under Projection II may be expected to be somewhat lower than in Projection I, because of the small increase of sub-division of agricultural lands, but there would be less green space in the basin. Under Projection III, urban densities would be the lowest of all three Projections, together with the lowest ratio of population per acre of irrigated land compared with the other projections.

Under Projection III, due to the relative decrease in the rate of economic growth compared with Projections I and II, total income in the valley and per capita income could be lower. This impact is not expected to be significant, however, as the generally buoyant and diversified economy in the Okanagan under all three Projections is expected to result in large increases in income per capita over current levels.

In conclusion, the Okanagan Valley has a soundly based economy, which is expected to grow steadily over the next 50 years. Only through careful economic planning, however can the present healthy balance between economic growth and high environmental quality be maintained. The opportunities for water and related resource management necessary to achieve the economic, environmental and social goals for the Okanagan within this framework of economic growth are discussed in detail in the following chapters.

TABLE 13.11

POPULATION AND AGRICULTURAL STATISTICS, 1970-2020

FEATURE	1970 (1971 Census)	1980	PROJECTION I		PROJECTION II		PROJECTION III	
			2000	2020	2000	2020	2000	2020
1. Population								
Urban	89,861	124,700	197,000	285,000	213,800	314,400	177,900	211,900
Rural	24,672	37,300	65,000	105,700	70,200	115,600	59,100	78,100
TOTAL	114,539	162,000	262,000	391,000	284,000	430,000	237,000	290,000
2. Population Density (People per acre)								
Urban	5.65	6.24	8.21	10.57	7.91	9.83	7.73	8.48
Rural	0.27	0.39	0.63	1.05	1.00	1.92	0.54	0.67
3. Urban Area (Acres)	15,910	20,000	24,000	27,000	27,000	32,000	23,000	25,000
4. Agricultural Area								
Irrigated (acres)	60,070	59,500	59,400	59,600	58,500	56,600	68,700	73,700
Pop. per Irrigated Acre	1.91	2.72	4.41	6.56	4.85	7.60	3.44	3.93

CHAPTER 14

Water Quantity Evaluations

The planning objectives in water quantity management, as laid out in Chapter 12 are:

1) to supply water for all consumptive and non-consumptive uses;
2) to minimize economic and social consequences of floods and droughts, and
3) to minimize conflicts between existing and potential uses of water.

Projections of water requirements for the entire Okanagan Basin to the year 2020 for the three economic growth projections are compared in Table 14.1. Only consumptive water demands for agricultural and domestic use have been projected for tributary streams, while both consumptive and non-consumptive uses (total water requirements) are shown for the mainstem system. It is anticipated that in the future, selected tributary creeks will support both consumptive and non-consumptive water requirements are described later in this chapter.

There is a lack of sensitivity between the various 2020 projections with total water requirements ranging from 344,000 to 347,000 acre-feet for all projections examined, compared to 312,000 acre-feet under present day development. The main reason for the small variation in future water requirements is the relatively small change in agricultural landuse development over the next 50 years. Irrigation makes up over 75% of total water consumption to the Basin at present, and this pattern is expected to continue assuming that most agricultural land is protected from sub-division for residential and domestic purposes.

Although total water requirements are not expected to increase significantly over present-day figures, conflicts in water use, especially in tributaries, will likely increase in magnitude over the next 50 years.

While the building of headwater reservoirs has created or enhanced recreation and fisheries at some of these headwater locations, the rapid drawdown or these storages to supply irrigation requirements adversely affect fishery and recreation potential in these lakes. Similarly the lack of adequate minimum flows in the lower reaches of the tributaries in the summer and fall months seriously affects the reproduction of kokanee and rainbow trout from Okanagan Lake.

In contrast to the tributaries (which are regulated primarily for consumptive use and in total supply about 22% of the water requirements for the Basin), the mainstem system consisting of the Okanagan Flood Control Works and the Vaseux Lake (SOLID) Dam provides for multiple water use including conservation, flood

TABLE 14.1

CONSUMPTIVE USE REQUIREMENTS IN THE OKANAGAN LAKE BASIN AND TOTAL WATER REQUIREMENTS FOR OKANAGAN RIVER BASIN IN CANADA

A. PRESENT OPERATING CONDITIONS with 300 cubic feet per second minimum flow in the Okanagan River between April September inclusive, and 100 c.f.s. min. flow between October and March inclusive

	1970		2020					
			GROWTH PROJECTION 1 Continuation of Present policies		GROWTH PROJECTION 2 High Economic Growth (Low Agriculture)		GROWTH PROJECTION 3 Low Economic Growth (High Agriculture)	
Population	113,480		391,000		430,000		290,000	
Irrigated Acres	60,070		59,600		56,600		73,700	
	acre-feet	%	acre-feet	%	acre-feet	%	acre-feet	%
1. OKANAGAN LAKE BASIN								
(a) Consumptive Use from tributaries and directly from areas adjacent to Okanagan Lake								
- IRRIGATION	57,000		52,000		48,000		66,000	
- MUNICIPAL & DOMESTIC	8,000		35,000		39,000		26,000	
- INDUSTRIAL	4,000		18,000		20,000		13,000	
TOTAL CONSUMPTIVE USE - OKANAGAN LAKE BASIN	69,000	22.0	105,000	30.5	107,000	30.9	105,000	30.3
2. MAINSTEM OKANAGAN RIVER								
(a) Consumptive Use - Okanagan River	32,000	10.4	44,000	12.8	43,000	12.4	46,000	13.3
(b) Evaporation Losses from Skaha, Vaseux and Osoyoos Lakes and from Okanagan River channel	49,000 }		49,000 }		49,000 }		49,000 }	
(c) Minimum In-Channel Needs for intake submergence and flushing	123,000 }	67.6	107,000 }	56.7	108,000 }	56.7	108,000 }	56.4
(d) In-Channel Fishery Requirements additional to min. flows in (c)	39,000 }		39,000 }		39,000 }		39,000 }	
TOTAL CONSUMPTIVE USE, LOSSES, MINIMUM FLOW FOR OKANAGAN RIVER REGION	243,000		239,000		239,000		242,000	
TOTAL BASIN CONSUMPTIVE USE + MAIN OKANAGAN RIVER WATER REQUIREMENTS	312,000	100.0	344,000	100.0	346,000	100.0	347,000	100.0

control, recreation, fisheries and aesthetics. The heart of this system is the Okanagan Lake Storage Dam at Penticton which controls about 80% of the inflow to the Basin.

In the Okanagan, water flows down the tributary streams into the mainstem and then down Okanagan River to cross the international border at Osoyoos Lake. The evaluations presented in this chapter follow this hydrologic sequence, starting with an examination of future water management options on the tributaries.

14.1 TRIBUTARIES

Water is required in tributary streams to supply consumptive uses (irrigation and domestic users) and sport fisheries in both the headwater storages and in the streams themselves. At present, however, tributaries are principally managed to meet consumptive use requirements, with water supply systems developed originally through private initiative and recently with help from the Federal and Provincial governments under the Agricultural Rehabilitation and Development Act (ARDA).

14.1.1 Future Water Requirements in Tributaries

Under tributary flows in Chapter 4, the eight most heavily utilized streams were selected for detailed study with the objective of determining the adequacy of the existing tributary supplies to meet present and future water requirements. As these tributaries included over 60% of the present consumptive use requirements in the Okanagan Lake Basin they are considered to be a good representative sample.

In the initial studies of tributary stream management, a computer model was developed based on the present method of operating the headwater storage releases to meet consumptive use demands only at the various diversion points in each selected tributary. This model was used to match supply and demand under dry, average and wet years for 1970, 1980 and 2020 levels of development. No return flows from irrigation were credited to the stream although such water was assumed to return to Okanagan Lake.

Each of the eight selected tributary basins are too small to be considered independent economic units, so reliable projections of future growth potential were not possible. Consequently, a range of growth patterns in population and agricultural landuse based on landuse capability were developed for each basin for the year 2020. This range included three projections of water demands; 1) a high projection based on maximum agricultural landuse development plus maximum likely population growth on non-agricultural lands; 2) a low projection based on minimum population growth rates with a reduction of agricultural lands due to subdivision, and 3) a minimum projection representing the arithmetic mean of the two extreme projections.

TABLE 14.2

BASIC DATA SHEET FOR EIGHT SELECTED TRIBUTARIES - OKANAGAN LAKE BASIN

		TROUT CREEK	PEACHLAND CREEK	POWERS CREEK	EQUESIS CREEK	VERNON CREEK	KELOWNA CREEK	MISSION CREEK	PENTICTON CREEK	TOTALS
Area	Sq. Miles	289	59	56	77	358	86	336	70	1,331
Natural Flow	Dry Year	23,700	8,900	8,000	10,200	39,100	9,900	96,900	21,900	218,600
at Mouth	Av. Year	54,400	15,000	13,800	17,800	67.800	17,000	142,900	34,800	363,500
Acre-feet/Year	Wet Year	122,000	27,500	25,800	34,100	138,200	34,300	239,200	58,200	679,300
Storage	1970	10,332	9,656	3,754	2,156	46,719	5,715	17,981	10,240	106,543
(Acre-Feet)	2020	13,066	9,540	4,820	2,200	62,578	7,277	28,761	9,850	138,048
Area	1970	4,306	617	1,637	356	14,075	4,848	10,135	1,666	37,640
Under	2020 High	6,274	1,591	1,818	1,282	23,157	8,176	12,371	1,433	56,102
Irrigation	2020 Med	5,354	1,236	1,719	1,189	20,021	5,905	9,678	1,464	46,566
(Acres)	2020 Low	3,918	514	1,432	355	13,410	4,446	8,501	1,426	34,002
	1970	5,960	1,444	3,490	90	24,360	10,420	10,340	18,146	74,250
Population	2020 High	21,360	4,670	6,510	410	100,050	15,335	48,940	51,850	249,125
	2020 Med	17,380	3,105	5,450	345	83,020	11,802	41,090	48,055	210,247
(Persons)	2020 Low	13,400	1,540	4,390	280	65,990	8,270	33,240	44,260	171,370
Water	1970	13,384	3,416	5,293	1,021	33,525	12,888	31,814	11,173	112,514
Requirement	2020 High	25,169	7,527	7,372	3,613	72,887	26,432	51,315	19,036	213,351
(Diversion)	2020 Med	21,221	6,143	6,757	3,340	62,994	19,086	41,142	18,083	178,766
Acre-Feet/Year	2020 Low	15,718	3,536	5,576	1,027	46,115	13,704	35,377	16,924	137,977
Consumptive	1970	0	0	0	0	1,540	2,296	0	0	3,836
Use Deficiencies*	2020 High	2,059	0	111	0	26,301	12,946	8,103	1,517	51,037
In Dry **Year**	2020 Med	715	0	0	0	18,598	5,781	0	766	25,860
Acre-Feet/Year	2020 Low	0	0	0	0	5,649	1,093	0	0	6,742

* Annual consumptive use deficiencies determined from summation of deficiencies at various use points. The natural flow at the mouth cannot be compared directly to total water requirements because the natural flow recorded at the mouth is not necessarily available at specific use points on the tributary stream.

The capability of the eight tributary basins to supply the water demands of these three projections was assessed on the computer model. This model assumed that the present works would remain in operation to 2020 and that headwater storages would be increased in accordance with present planning as indicated by the various water users. It was also assumed that there would be no change in the location or number of diversion points over those used in 1970. Details of water use projections for the eight tributaries are included in Table 14.2.

Tributary flows developed by the model can be considered as preliminary estimates of the probable monthly discharges under varying climatic conditions. Such monthly flows do not define the sharp peaks that may occur within a few days particularly on the small tributaries. With no allowance for return flow and the assumption that agriculture consumptive use is in accordance with the recommendations of the B. C. Department of Agriculture the residual flows are probably underestimated. The computer model is assumed to have an accuracy of ± 20% of actual flows.

In addition to the consumptive water requirements discussed above, minimum flow requirements are required to satisfy sport fish spawning and incubation in the lower portions of the tributaries. These minimum flow requirements are outlined in Table 14.3. Existing and potential headwater storages and costs are detailed in Table 14.4.

TABLE 14.3

ESTIMATED MINIMUM WATER REQUIREMENTS FOR FISHERIES IN ACRE-FEET AT MOUTHS OF SELECTED TRIBUTARIES IN OKANAGAN LAKE BASIN

	TROUT	PEACHLAND	POWERS	EQUESIS	BX UPPER	VERNON UPPER	VERNON LOWER	COLDSTREAM	KELOWNA	MISSION
Jan	600	150	240	360	150	420	480	360	240	1,800
Feb	600	150	240	360	150	420	480	360	240	1,800
Mar	600	150	240	360	150	420	480	360	240	1,800
Apr	600	150	240	360	150	420	480	360	240	1,800
May	900+	300+	300+	600+	240+	600+	600+	480+	300+	2,700+
June	600	150	240	360	150	420	480	360	240	1,800
July	600	150	240	360	150	420	480	360	240	1,800
Aug	600	150	240	360	150	420	480	360	240	1,800
Sep	600	270	300	360	150	420	480	360	240	2,400
Oct	900	270	300	480	240	480	600	480	300	2,400
Nov	600	150	240	360	150	420	480	360	240	1,800
Dec	600	150	240	360	150	420	480	360	240	1,800
TOTAL	7,800	2,190	3,060	4,680	1,980	5,280	6,000	4,560	3,000	23,700

TABLE 14.4

POSSIBLE STRUCTURAL DEVELOPMENTS IN SELECTED OKANAGAN LAKE TRIBUTARIES

TO MEET AGRICULTURAL AND FISHERY WATER REQUIREMENTS

TRIBUTARY	RESERVOIR	1973 STORAGE ACRE-FEET	2020 STORAGE (AGRICULTURE) ACRE-FEET	2020 STORAGE (FISHERIES) ACRE-FEET	TOTAL ACREAGE SERVED		AGRICULTURE			SPORT FISHERIES		
					1970	2020	COSTS OF STORAGE (DOLLARS)	ANNUAL COSTS[*1] (DOLLARS)	ANNUAL BENEFITS (DOLLARS)	COSTS OF STORAGE (DOLLARS)	ANNUAL COSTS (DOLLARS)	ANNUAL BENEFITS (DOLLARS)
TROUT	Crescent	755	1,000	-	4,306	5,000				250,000	25,000	32,600[*2]
	Whitehead	920	1,020									
	Thirsk	2,628	4,000	1,000								
	Isintok	570	1,000				193,700	20,000	43,000	1,000,000	110,000	221,000[*2]
	Subtotal	4,873	7,020	1,000	4,306	5,000	193,700	20,000	43,000	1,250,000	135,000	253,600
MISSION	Mission	600	650	Storage	10,135	12,371						
	McCulloch	12,231	14,000	Locations								
	Others	-	4,000	not Identified			1,450,000	153,000	97,000	175,000	18,000	26,600[*2]
	Subtotal	12,831	18,650	3,600	10,135	12,371	1,450,000	153,000	97,000	175,000	18,000	26,600
EQUESIS	Pinaus	2,156	2,156	150	356	356	-	-	-	-	-	-
	Other	-		550								
	Subtotal	2,156	2,156	700	356	356						
VERNON	Crooked	2,460	3,374	-	14,075	17,300						
	Swan	2,460	3,512	-								
	Other	-	3,834				1,450,000	153,000	280,000	-	-	-
	Subtotal	4,920	10,720		14,075	17,300	1,450,000	153,000	280,000			
KELOWNA	Moore	-	1,000	-	4,848	8,176						
	Other	-	560	-			390,000	40,000	93,000			
	Subtotal	-	1,560		4,848	8,176	390,000	40,000	93,000			
Powers	Lambly	1,801	2,560	-	1,637	1,990						
	Islaht	343	650	-			266,500	27,000	66,000	-	-	-
	Subtotal	2,144	3,210		1,637	1,990	266,500	27,000	66,000			
	TOTALS	26,924	43,316	5,300	35,357	45,193	3,750,200	393,000	579,000	1,425,000	153,000	280,200

*1 Benefits and costs not discounted

*2 Includes improvements to spawning habitat.

14.1.2 Alternatives

There are four management options for tributary streams in the Okanagan to meet projected consumptive and non-consumptive uses.

1) Continuation of the present method of operation with existing storage development.
2) Continuation of present operation with increased storage development
3) Modification of present operation with present storage development.
4) Modification of present operation with increased storage development in the headwaters or by pumping water from Okanagan Lake.

In addition to these structural alternatives, two non-structural measures for improving the efficiency of water use in tributary systems were examined, including the efficiency of irrigation systems and metering and pricing.

(a) Tributary Storage Alternatives

(i) Existing Storage and Operating Practices

If present water management and storage development remained unchanged, only Peachland and Equesis Creeks could meet future consumptive uses under the high growth projection. This would also be at the expense of providing minimum flows for fisheries and thus would increase conflicts between consumptive and non-consumptive water uses.

(ii) Increased Headwater Storage and Present Operating Practices

Increases in headwater storages appear hydrologically feasible on the six major creeks other than Peachland or Equesis and such increases would allow all projected future consumptive water demands to be met in all except Kelowna and Vernon Creeks (Table 14.2). It appears that the costs of headwater storage increases could be justified by the economic returns from increased agricultural development, but the costs of distributing water from headwater storage to the farm plus development costs of preparing agricultural acreage are not included, so total costs may well exceed benefits. Average capital costs of reservoir development are estimated at $250 per acre-foot with annual costs of $26 compared with average annual benefits of $63 per acre-foot. These benefits include both direct and indirect monetary returns from the expansion of agricultural production within the Okanagan economy. Non-monetary, social and environmental benefits were not estimated for agricultural development, because of the difficulty in quantifying such benefits.

Under maximum development of agricultural lands and population, consumptive use deficiencies increase significantly in Vernon and Kelowna Creeks and small deficiencies appear in Mission, Trout and Penticton Creeks. In the cases of Vernon and Kelowna Creeks, headwater storage increases would have to be supplemented by pumping from Okanagan Lake. This is already in effect on Vernon Creek, where water is pumped from Okanagan Lake to supply industrial use at Winfield. The return flow is discharged to Vernon Creek immediately upstream of Ellison

Lake. This additional water, if supplied continuously at a rate of 10 c.f.s.* would remove all present and future water deficits in the lower main portion of Vernon Creek (Ellison Lake to mouth) and would in addition, meet fishery flow requirements at the mouth.

Kelowna Creek in the past, has provided water for the Rutland area, which was incorporated into the boundaries of the City of Kelowna in 1973. If the present population of the Rutland region could be served by an expanded municipal water system which pumps from Okanagan Lake, then other potential agricultural lands in this sub-basin could be supplied from headwater storages on Kelowna Creek.

Detailed costs of a pumping scheme for Kelowna Creek are not available, but would be two to three times the costs of developing headwater storages. Such a pumping scheme would not be economical for agricultural development, but might be justified for domestic use, with headwater storage reserved for irrigation.

Trepanier Creek (not listed in tables) was subsequently considered as a desirable fishery stream. However, because of the lack of any suitable storage site, the alternative of pumping from Okanagan Lake to the lower reaches of the stream was investigated. This alternative is discussed further under Fishery Evaluations, Chapter 17.

It should be emphasized that the models have been limited to operation over single drought years and it has not been possible, because of lack of hydrometric data, to run through the standard study period 1921 to 1970 (which contained the 1929 to 1932 drought), as was done for the mainstem computer model. Thus, while the tributary models indicate that there would be carry-over storage in the larger reservoirs at the end of one drought year to augment the flows should a second successive drought year occur, a continuation of such conditions into a third year as happened in the 1929-1932 drought period, could prove very critical. These limitations in headwater storage are in sharp contrast to Okanagan Lake which, as a source of water to the mainstem, can be drawn down below its normal low water elevation by several feet under a severe three year drought.

The above alternatives assume that only consumptive demands will be met. Conflicts between water withdrawals for irrigation and required in-channel minimum flows would continue and possibly increase. Alternatives for resolving such conflicts were examined and are summarized here, but are evaluated in more detail in Chapter 17.

(iii) Modified Operation of Headwater Storages

This alternative involves modifying the existing operation of headwater storage reservoirs to meet both consumptive and non-consumptive (fishery) flows

---

* Continuous rate of 10 cubic feet per second provides a volume of 600 acre-feet per month. The present rate of diversion for industrial use provides a volume of approximately 400 acre-feet per month.

at the creek mouth. At present, water is retained in the headwater reservoirs at the end of the irrigation season to provide carry-over storage in the event of a succeeding dry year. Under modified operations, some or all of this storage would be released during the fall and winter months to support kokanee and in the summer months, rainbow trout.

A comparison of the historic and modified methods of operation are shown in the graphs (Figures 14.1 and 14.2) covering flows and deficits in Trout, Peachland, Powers, Equesis, Vernon, Kelowna and Mission Creeks. Penticton Creek has been omitted as it has only a small fishery potential.

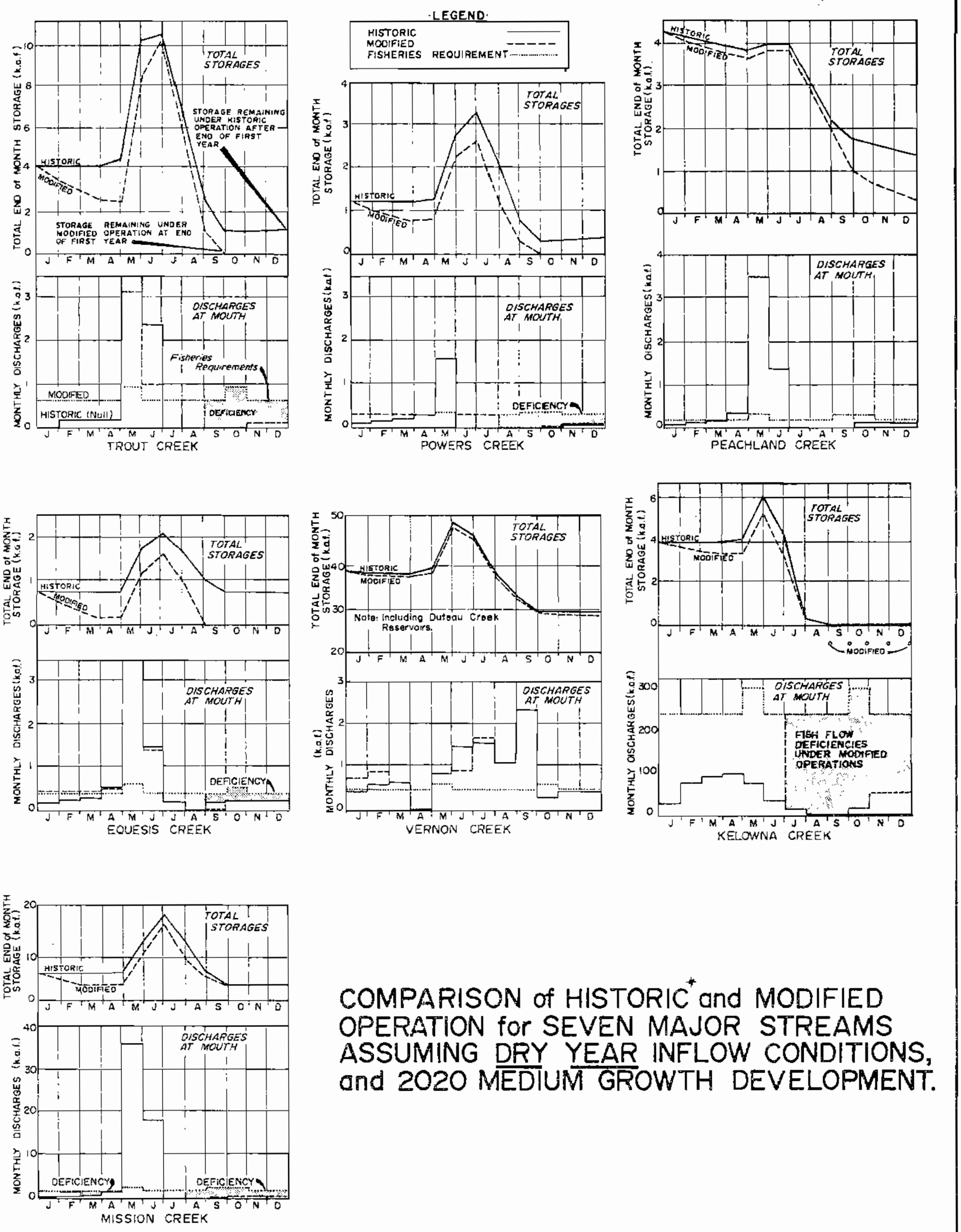
The modified flows as shown in the graphs under 2020 medium development for dry and average inflow years and existing storage conditions, would reduce the fishery flow deficiencies at the mouths of the tributaries appreciably and in the cases of Peachland and Vernon Creeks practically eliminate such conditions. However, in order to produce these improved fishery flows, a portion of the carry-over storage which is normally retained in the event of an ensuing drought year would have to be used up. The effect of increases in headwater fluctuations on fisheries and other types of water based recreation in these reservoirs is not known.

(iv) Modified Operation and Increased Storage

The need for retention of reserve storage capacity in the tributaries led to an examination of the possibilities of increasing 2020 storage over those presently planned with the objective of meeting the fishery flows while still retaining proposed carry-over storage. For these additional storages to be effective, they must be physically and hydrologically feasible so that any enlarged or new storage sites developed can be filled each year. Preliminary investigations indicated that there were no additional sites that could be developed without exceeding inflows during dry years. It therefore appears more practical to allocate some of the planned development of headwater storages for fishery water requirements in certain key tributaries with high fishery potential and allocate the remaining supplies to consumptive uses.

(b) Efficiency of Irrigation Systems

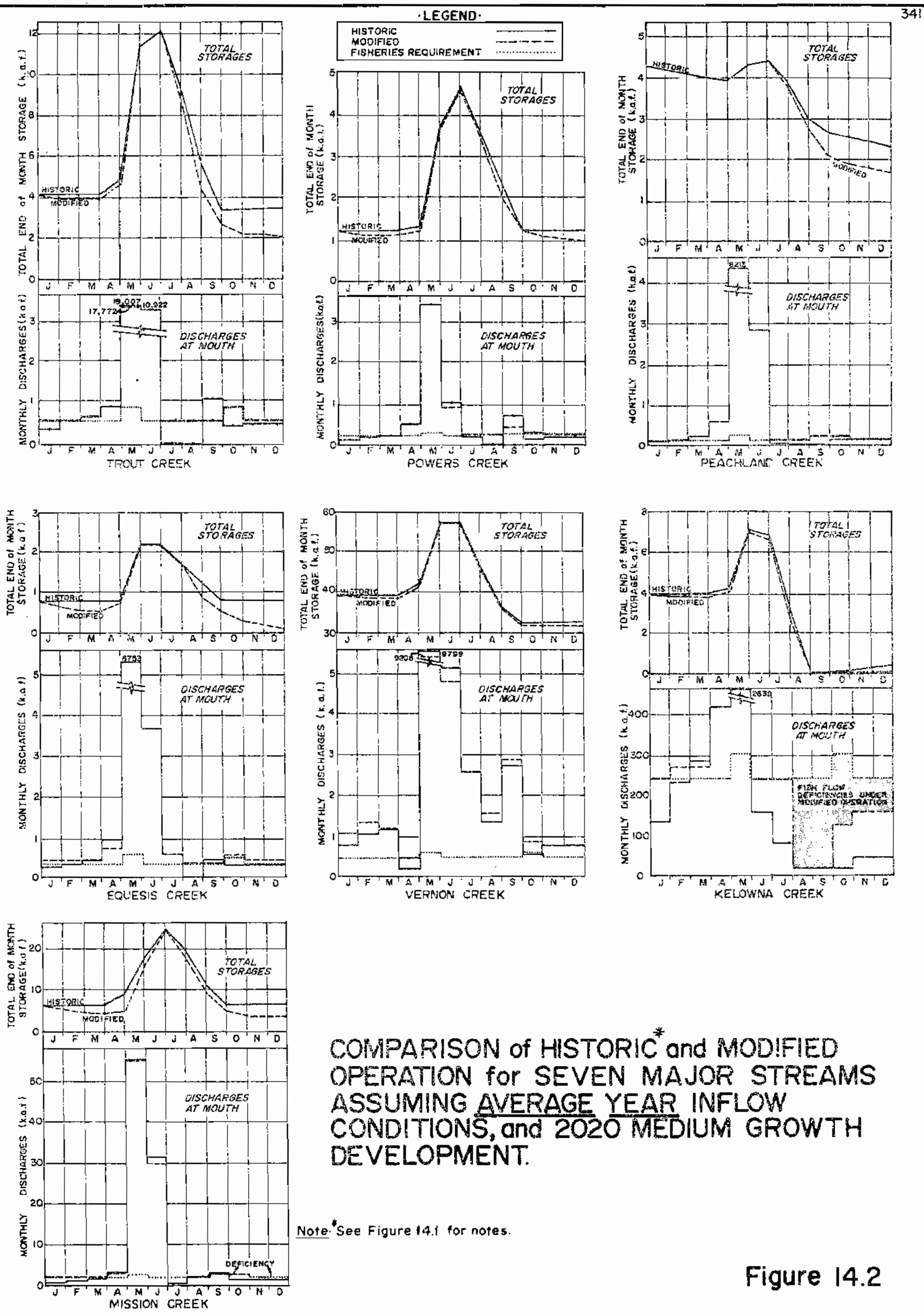
In the last ten years, primarily through the Agricultural Rehabilitation and Rural Development Act, most of the irrigation systems have been modernized through reconstruction of headwater reservoirs, diversion dams and the replacement of earth ditches with pipelines and lateral feeders to sprinklers through pressure regulating valves. It has been estimated that gross water requirements have been reduced by as much as 30% through reductions in conveyance losses and more uniform application. With equal flow from each sprinkler through the use of pressure regulating valves, it is easier to control water application.



COMPARISON of HISTORIC* and MODIFIED OPERATION for SEVEN MAJOR STREAMS ASSUMING DRY YEAR INFLOW CONDITIONS, and 2020 MEDIUM GROWTH DEVELOPMENT.

Notes: 1. Graphs actually show simulated historic* values. There are few actual historical records for the tributary streams.
2. Penticton Creek omitted because of limited fishery potential.

Figure 14.1



COMPARISON of HISTORIC* and MODIFIED OPERATION for SEVEN MAJOR STREAMS ASSUMING AVERAGE YEAR INFLOW CONDITIONS, and 2020 MEDIUM GROWTH DEVELOPMENT.

Note *See Figure 14.1 for notes.

Figure 14.2

Flow meters are now located at pumped diversions and provide data on total water withdrawals. Extension of this type of metering for gravity supplies will provide irrigation districts and municipalities with basic data needed for future planning of tributary water supplies.

While better monitoring of water use for agriculture and domestic and industrial purposes is needed, it is possible that in the future these uses may be reduced through improved methods of irrigation and recycling.

One promising new method is trickle irrigation, which applies water through very small diameter tubing to the roots of individual plants at a low pressure range of 10 to 30 pounds per square inch (compared to a range of 60 to 125 pounds per square inch for existing systems). By providing water directly to the root zone, direct evaporation of water from the ground surface which occurs under springling systems, is eliminated. Depending on the soil type, up to 30% of diverted water requirements can be conserved by trickle irrigation, assuming no groundwater return flow.

The main requirement in trickle irrigation is the availability of a clean source of water free from solid particles, to prevent clogging of the small aiemeter drip tubes. For most systems some form of filtration or solid settlement must be used by the farmer or by the central distribution agency. The determination of the optimum amount of water needed is still in the experimental stage, as some return flow may be desirable for soil leaching to prevent the accumulation of salts in the soil.

(c) Metering and Pricing

In addition to the more efficient use of water by improved types of irrigation, reductions may be achieved through metering and pricing. It is probable that metering and pricing would be most effective in local areas receiving water from the smaller tributaries where shortages are presently occurring. However, it is anticipated that such savings would not be significant with respect to conserving water for in-channel flows for fisheries or other non-consumptive uses. Moreover the water quantity modelling developed in this report is not sensitive enough to attempt such a detailed analysis.

Metering of all future water diversions is encouraged, as it allows for better management, especially during drought conditions. As the urban population grows in the Okanagan, pricing mechanisms can be more effectively employed to reduce consumptive uses in tributary watersheds and consequently reduce conflicts with non-consumptive uses for fisheries and recreation.

14.1.3 Discussion of Tributary Alternatives

The following discussion is limited to methods of operating upstream storage to meet consumptive and non-consumptive requirements, assuming present day water use efficiencies. Undoubtedly these will improve in the future as will the accuracy of the simulated tributary discharges which for the present can only be considered as first estimates.

Studies on fish spawning potential around Okanagan Lake indicate that three creeks-Mission, Trepanier and Equesis contain the best spawning areas. (Chapter 17). These creeks should be managed for the multiple use of agriculture and fisheries. The other creeks have limited fishery potential and with the exception of Vernon and Peachland Creeks which support small fish runs, can essentially be managed for consumptive uses only. An outline of water management proposals on the eight selected tributaries over the next 50 years follows.

(a) Mission Creek

1) Attempts should be made to modify headwater storage discharges to improve fishery flows in the fall and winter. This measure could conserve up to 4000 acre-feet for fishery purposes.
2) An additional 3600 acre-feet of storage should be licenced and developed or existing storage purchased for fisheries. The cost of this storage has been estimated at $900,000.
3) Studies indicate there is an additional 3600 acre-feet of potential firm storage in the upper reaches of Mission Creek. The development of this storage may involve the construction of several dams.
4) The management of Mission Creek as a multipurpose stream to meet both consumptive and non-consumptive uses may require limitations on future agriculture development in this tributary.

(b) Equesis Creek

There is limited opportunity for increased headwater storage on this creek, and in view of significant fishery potential, all future storage development on Pinaus Lake (estimated at 550 acre-feet) should be allocated to supply fishery flows. Further development of agriculture in this basin should be discouraged.

(c) Vernon Creek

1) The present pumped diversion from Okanagan Lake to Vernon Creek near Winfield should be continued, and if necessary, operated on a continuous basis to meet future potential demands in the Ellison Lake to Okanagan Lake portion of the sub-basin.
2) Additional potential storage in the headwaters of Vernon Creek should be developed to meet existing shortages in other parts of this sub-basin, and future agricultural development should be limited to the capability of the basin to supply additional water for such development. The latter requires more detailed water quantity modelling to evaluate the limitations of such future development.

(d) Trout Creek

Additional storage of 2,700 acre-feet appears to be available in this creek and can be reserved for municipal and agricultural expansion. If artificial spawning facilities can be constructed in the lower part of the creek, 1,000 acre-feet of this storage would be required to support the fishery.

(e) Powers Creek

Additional storage of some 1,100 acre-feet could be developed in headwaters for irrigation and domestic uses.

(f) Peachland Creek

There is little or no additional storage potential so agricultural development should not expand above current development levels. As this creek supports a significant run of kokanee to Okanagan Lake, withdrawals and habitat should be carefully controlled to protect this run.

(g) Kelowna Creek

1) Urban development in lower parts of the creek should be serviced within the municipal water supply system of Kelowna if potential agricultural development in the tributary is to be realized.
2) Additional storage of 1,500 acre-feet would be available to service potential expansion of agricultural lands.

(h) Penticton Creek

Penticton Creek appears to have reached its ultimate development with respect to water regulation. Limited irrigation is provided from this source and by 2020 the predominant use may be for municipal purposes.

14.2 MAINSTEM WATER QUANTITY EVALUATIONS

14.2.1 Alternatives

The development of mainstem alternatives has been based on meeting present and future water requirements (Table 14.5) while at the same time maintaining satisfactory lake elevations and river elevations and discharges.

With limited water available in the system, particularly when two or three drought years occur consecutively as happened in 1929-1932, it is important that water be conserved through efficient use in order that reasonably adequate water elevations may be realised, particularly on Okanagan Lake. In contrast to this are the flood years when the lakes and rivers must be controlled within their normal high water elevations.

These problems led to an examination of three different approaches to managing the mainstem system:

1) Continuation of the present operational procedures (Alternatives (a) and (b), Table 14.6).

TABLE 14.5

WATER REQUIREMENTS-MAINSTEM OKANAGAN RIVER FOR 1970 DEVELOPMENT AND 2020 GROWTH PROJECTIONS FOR PRESENT AND IMPROVED OPERATING CONDITIONS

	1970		2020 GROWTH PROJECTION 1 Continuation of Present Policies		2020 GROWTH PROJECTION 2 High Growth		2020 GROWTH PROJECTION 3 Low Growth	
A. PRESENT OPERATING CONDITIONS - with 300 cubic feet per second minimum flow in the Okanagan River between April & September inclusive, and 100 c.f.s. minimum flow between October & March inclusive.								
Population	11,000		51,000		55,000		37,000	
Irrigated Acres	14,000		16,000		15,000		18,000	
	Ac-Ft	%	Ac-Ft	%	Ac-Ft	%	Ac-Ft	%
MAINSTEM OKANAGAN RIVER								
(a) Consumptive Use - Okanagan River	32,000	13.2	44,000	18.4	43,000	18.0	46,000	19.0
(b) Evaporation Losses from Skaha, Vaseux & Osoyoos Lakes and from the Okanagan River channel	49,000)		49,000)		49,000)		49,000)	
(c) Minimum In-Channel Needs for intake submergence & flushing	123,000)	86.8	107,000)	81.6	108,000)	82.0	108,000)	81.0
(d) In-Channel Fishery Requirements additional to min. flows in (c)	39,000)		39,000)		39,000)		39,000)	
TOTAL CONS. USE, LOSSES, MIN. FLOW FOR OKANAGAN RIVER REGION	243,000	100.0	239,000	100.0	239,000	100.0	242,000	100.0
B. IMPROVED OPERATING CONDITIONS - with 100 cubic feet per second minimum flow the year round in the Okanagan River channel.								
MAINSTEM OKANAGAN RIVER								
(a) Consumptive Use - Okanagan River	32,000	15.8	44,000	22.1	43,000	21.6	46,000	22.8
(b) Evaporation Losses from Skaha, Vaseux & Osoyoos Lakes and from the Okanagan River channel	49,000)		49,000)		49,000)		49,000)	
(c) Minimum In-Channel Needs for intake submergence & flushing	50,000)	84.2	34,000)	77.9	35,000)	78.4	35,000)	77.2
(d) In-Channel Fishery Requirements additional to min. flows in (c)	71,000)		72,000)		72,000)		72,000)	
TOTAL CONS. USE, LOSSES, MIN. FLOW FOR OKANAGAN RIVER REGION	202,000	100.0	199,000	100.0	199,000	100.0	202,000	100.0

TABLE 14.6

MAINSTEM SUB-ALTERNATIVES

(1) ALTERNATIVE	(2) OKANAGAN FLOOD CONTROL WORKS[1] AMORTIZED 7%-50 YRS. ON $8,800,000	(3) FLOOD CONTROL WORKS OPER-ATIONAL	(4) OKANAGAN LAKE INTAKES	(5) OKANAGAN R. INTAKES & SPAWNING CHANNEL	(6) KELOWNA BRIDGE AND OTHER FLOOD CONTROL WORKS	(7) DIVERSTON COSTS	(8) TOTAL COSTS	(9) INCREMENTAL CAPITAL COST (1970 $)	(10) INCREMENTAL COST LESS ALTERNATIVE COST (1970 $)	(11) FLOOD BENEFITS	(12) RECREATTON BENEFITS	(13) TOTAL BENEFITS	(14) INCREMENTAL BENEFITS
(a) Present Operation-Fishery Flows met Incidentally. Water Reqts.1970-273 KAF 2020-306-317 KAF	$755,000	$102,000	$10,000	0	$ 10,000	-	$ 877,000	0	0	-$4,860	-$15,000	-$19,860	0
(b) Present Operation-Fishery Flows met all times Water Reqts.1970-312 KAF 2020-345-356 KAF	$755,000	$102,000	$10,000	0	$ 10,000	-	$ 877,000	0	0	-$4,860	-$37,500	-$42,360	-$22,500
(a) Water Conservation-Fishery Flows met Incidentally Water Reqts.1970-200 KAF 2020-254-261 KAF	$755,000	$70,000?	$10,000(2)	$23,000	$ 10,000(2)	-	$ 868,000	$ 375,000	+ $9,000	-$4,860	0	-$ 4,860	+$15,000
(b) Water Conservation-Fishery Flows met all times Water Reqts.1970-271 KAF 2020-325-332 KAF	$755,000	$70,000?	$10,000(2)	$23,000	$ 10,000	-	$ 868,000	$ 375,000	+ $9,000	-$4,860	-$ 7,500	-$12,360	+$ 7,500
(c) Water Conservation-Spawning Channel-OK River Fishery Flows met all times Water Reqts.1970-256 KAF 2020-307-314 KAF	$755,000	$70,000?	$10,000(2)	$23,000 +$54,000	$ 10,000	-	$ 924,000	$ 913,000	-$54,000	-$4,860	-$ 7,500	-$12,360	+$ 7,500
(d) Flood Control-Measures Structural Alterations to OK.River, Regulation of OK. Lake. Fishery Flows met Incidentally Water Reqts. 1970-273 KAF (Null 2020-306-317 KAF operation)	$755,000	$70,000?	$10,000	0	$ 13,000	-	$ 848,000	$ 984,000	-$2,9000	-$2,580	-$15,000	-$17,580	+$ 2,280
(a) Maintenance of Okanagan L. Levels. Importation of Water Fishery Flow met all times Water Reqts.1970-312 KAF 2020-345-356 KAF	$755,000	$102,000	0	0	$ 10,000(2)	$1,176,000	$2,043,000	$10,725,000	-$1,166,000	-$2,440	0	-$ 2,440	+$ 2,420 +$15,000
(b) Maintenance of Okanagan L. Levels. Importation of Water Improved Intakes Flood Control Measures Fishery Flows Met all times Water reqts.1970-312 KAF 2020-345-356 KAF	$755,000	$70,000?	0	$23,000	0	$1,176,000	$2,024,000+	$12,084,000	-$1,147,000	-$2,440	0	-$ 2,440	+$ 2,420 +$15,000

NOTES: (1) Cost of existing Okanagan Flood Control Works, exclusive of Zosel Dam was $8,800,000 (1970 dollar value)

(2) While Okanagan Lake intakes and Kelowna Bridge would not require adjustments under 1970 development such will be needed before 2020. Hence these costs are included here.

(3) For continuation of this Table see Table 14.10.

(4) For detailed estimates see Figure 14.6.

2) Examination of a number of water conservation and flood control measures within the Okanagan Basin (Alternatives 2(a), 2(b), 2(c) and 2(d), Table 14.6).
3) Importation of water into the Okanagan during drought years (Alternatives 3(a) and 3(b), Table 14.6).

As is the practice in this evaluation chapter, all alternatives are compared with the existing operational procedures. When possible each alternative will be broken down into separate components, but in some cases the alternatives are not mutually exclusive and in fact structural and non-structural changes in one alternative may be useful in meeting the objective of others.

A number of sub-alternatives have been identified within each of the three management approaches described above. A summary of these sets of sub-alternatives is contained in Table 14.6, together with associated capital and annual costs based on 1970 prices and financing over 25 years at 7%. Detailed costs are shown in Table 14.7. These costs can only be considered approximate and would have to be revised upward to consider present day prices.

(a) Alternative 1 - Continuation of Present Operation

(i) Sub-Alternative 1(a) - Fishery Flows Met Incidentally

This alternative simulates the existing operation of the Okanagan Mainstem system which is operated primarily for water conservation in drought years when freshet inflows are less than 244,000 acre-feet (present day water requirements) and for flood control when freshet inflows are greater than 550,000 acre-feet. For the near normal inflow years which fall between these two extremes, regulation tends to follow a more uniform procedure based primarily on historic records of lake levels and discharges for average inflow years. In drought years (net inflows less than 244,000 acre-feet), minimum flows for the Sockeye salmon run in Okanagan River are reduced to conserve water in Okanagan Lake.

The extremes between droughts and floods are illustrated in Figure 14.3 for the period 1925 to 1935 under the present operation, assuming both existing and future developments.

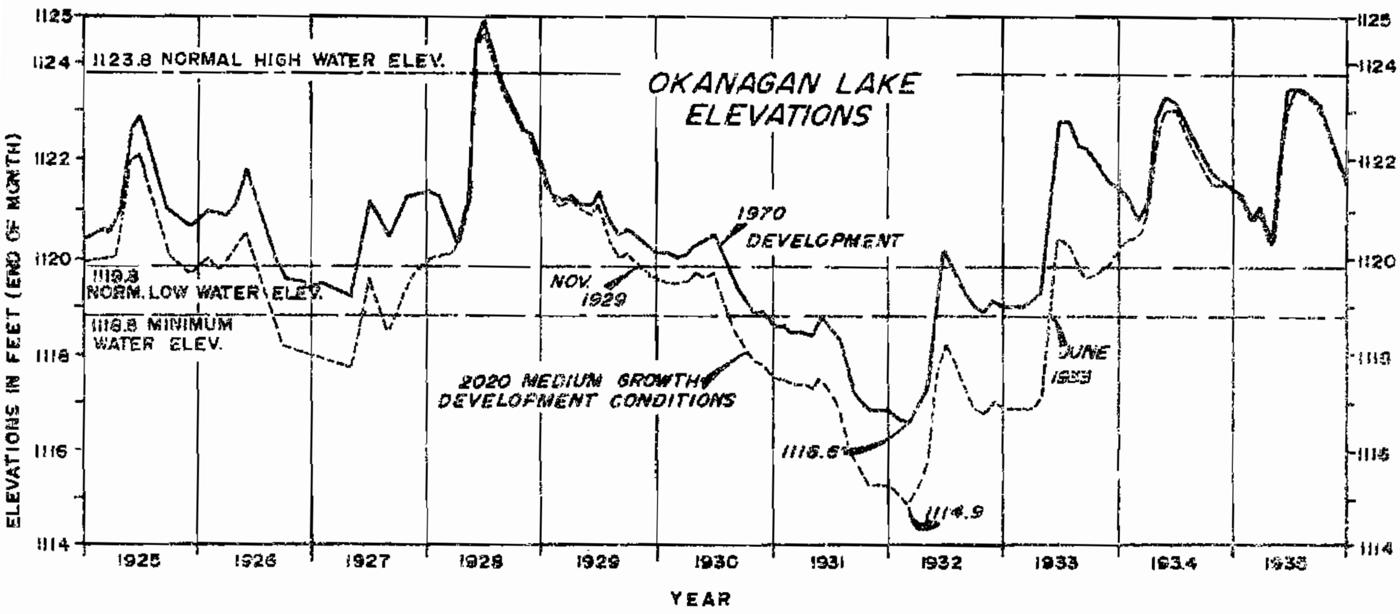
Under such conditions, Okanagan Lake would be drawn down to at least 1116.8 feet in severe droughts, necessitating ajustments to the Kelowna Floating Bridge and to intakes around Okanagan Lake totalling $132,000 and $100,000 in capital costs respectively (Table 14.7). In addition some $102,000 are required annually to operate the Okanagan Flood Control Works. There are also $15,000 of recreation benefits foregone annually due to drawdowns on Okanagan Lake and $4,860 of flood damage, (property, ballasting Kelowna Bridge, revenue lost at marinas and campgrounds). Okanagan Lake drawdowns under extreme drought conditions could result in important environmental and social costs, particularly in relation to shoreline recreation, boat launching and general aesthetics.

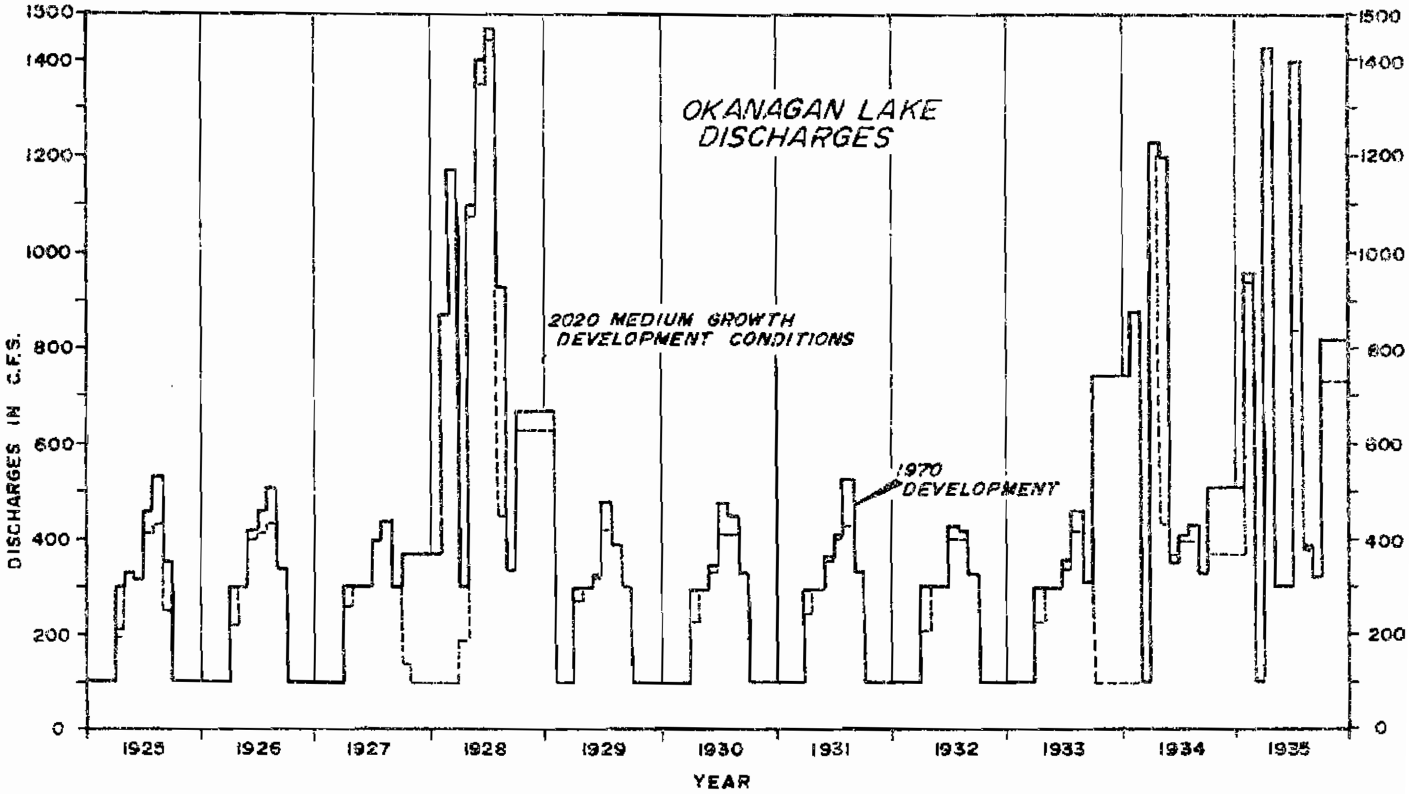
TABLE 14.7

ECONOMIC EVALUATIONS

Mainstem Water Quantity Alternatives
(Based on 1970 Development Only)

DESCRIPTION OF SUB-ALTERNATIVE	ITEM	CAPITAL COST	ANNUAL COST	WATER BASIN REQUIREMENTS 1970		WATER BASIN REQUIREMENTS 2020						COMPUTER RUNS				RANGE OF WATER CONSERVED IN YEAR 2020 FOR 3 GROWTH PROJECTIONS OVER NULL OPERATION		REMARKS
						ECONOMIC GROWTH PROJECTION 1		ECONOMIC GROWTH PROJECTION 2		ECONOMIC GROWTH PROJECTION 3		1970		2020				
		1970 Costs Includes 25% for Engineering & Contingencies	7% - 25 yrs. Plus Operation & Maintenance	Salmon Fishery Requirements Met Incidental to Other Uses	Salmon Fishery Requirements Met at All Times	Fish Incid.	Fish All Times	Fish Incid.	Fish All Times	Fish Incid.	Fish All Times	Fish Incid.	Fish All Times	Fish Incid.	Fish All Times	Fish Incid.	Fish All Times	
		$	$/Year			KAF	KAF	KAF	KAF.	KAF	KAF					KAF	KAF	
2 CONSERVATION OF WATER by lowering Okanagan River & Okanagan Lake intakes; & making improvements to Kelowna Floating Bridge.	Lower Okanagan River intakes Lower Okanagan Lake intakes Kelowna Floating Bridge Sub-Total	143,000 120,000 112,000 375,000	23,000 10,000 10,000 43,000	200	271	258	329	254	325	261	332	3	4		38	24-52	16-24	Some difficulties in controlling Tuguinuit Lake low water level in 1973 (normal range is elev. 971.0 to elev. 973.5) may indicate need for pumping for conservation as well as to control floods. Costs of pumping for conservation not included here.
2 (c) CONSERVATION OF WATER by constructing spawning channels in the lower Okanagan River to reduce salmon fishery flow requirements.	Spawning channels in Lower Okanagan River	600,000	54,000	200	256	243	314	239	310	246	307	NO RUN				63-71	31-49	Saving of 30,000 acre feet in drought year equivalent to about 1/3 of foot on Okanagan Lake.
2 (d) FLOOD CONTROL by increasing Okanagan Lake normal high water elevation by 1 foot in flood years; adjusting Kelowna Floating Bridge; channel & gate structure improvements; replacing McAlpine Bridge (Highway 97); building Tuguinuit Lake control works; improving inflow forecasts; flood plain zoning for Osoyoos Lake.	Adjustments to Kelowna Floating Bridge Improvement Okanagan & Skaha Dams (gates; prevention of icing) Replacement McAlpine Bridge Tuguinuit Lake control works Osoyoos and Okanagan Lake flood plain zoning Improved Forecasting Procedures Channel: Excavation & removal of temporary rock weirs Fill in over-excavation & erosion holes in channel Bank errosion protection Total	34,000 25,000 166,000 45,000 ? ? 7,000 317,000 390,000 904,000	3,000 4,000 14,000 8,000 ? ? 1,000 51,000 63,000 144,000	273	312	306	345	310	349	317	356	3	4		38	0	0	Okanagan Lake normal range 1119.8-1123.8 (GSC 1961 DATUM) Osoyoos Lake desirable range 910.7-912.3 (USCGS DATUM) Replacement of highway bridge may not be warranted on the basis of improved hydraulic conditions only. Bank erosion protection is required if flood discharges to be sustained at 80% of channel design capacity.
3 MAINTENANCE OF OKANAGAN LAKE LEVEL in drought periods though importation of water - Null method of operation	Diversion of up to 36,000 acre-feet per month in drought years from the Shuswap River	10,725,000	1,176,000	273	312	306	345	310	349	317	356	30		40	42	0	0	Diversion costs extremely high assuming no irrigation along diversion canal.





SIMULATED OKANAGAN LAKE ELEVATIONS and DISCHARGES– 1925 to 1935. BASED on COMPUTER MODEL DATA ASSUMING PRESENT OPERATING PROCEDURES and 2020 MEDIUM GROWTH DEVELOPMENT CONDITIONS.

Figure 14.3

(ii) Sub-Alternative 1(b) - Fishery Flows Met All Times

An additional 39,000 acre-feet must be released from Okanagan Lake to meet all Okanagan River fishery requirements in all years. In drought years, this release would result in greater drawdowns of Okanagan Lake with increased impacts on shoreline recreation, wildlife and aesthetics. It is extremely doubtful that benefits to fisheries would outweigh the increased damage to Okanagan shoreline uses.

(b) Alternative 2 - Water Management Options Within Okanagan Basin

(i) Sub-Alternative 2(a)

Objective - Water Conservation (Fishery Flows Met Incidentally)
Method - Lower Okanagan River Intakes
- Contingency Plan for Modifications to Kelowna Floating Bridge
- Lower Okanagan Lake Intakes
- Zosel Dam Regulation
- Tugulnuit Lake Water Management

Lower Okanagan River Intakes

The Okanagan Flood Control Works included the straightening and improvements to the Okanagan River channel. This resulted in the cutting off of a number of meanders or oxbows which contained irrigation and domestic water intakes. In order to service these intakes, each oxbow was connected to the main channel at its upper and lower ends by culverts.

When the Okanagan Flood Control Works were completed, it was found that the river water elevations at normal summer flows did not provide adequate submergence for the intake culverts, nor for some of the intakes located directly on the river due, primarily, to lower water profiles than those anticipated. This problem was remedied by the placing of stop logs across the weir openings at the drop structures, thus raising water elevations at these points by some two to three feet. Normally the stop logs are placed immediately after the freshet and remain there until the end of the irrigation season in September when they are removed.

Even with the addition of stop logs up to the top of the weirs, it has been necessary to maintain a minimum residual flow of 300 cfs during the irrigation season to provide adequate submergence. After mid-September, releases are normally governed by fishery requirements in the lower portion of the Okanagan River although in a drought year it may be necessary to reduce the minimum flows to 100 cfs depending upon the amounts of carry-over storage available in Okanagan Lake.

Studies were undertaken to determine if the oxbows might be deepened and the culverts and intakes lowered so that the required discharges (the greater of the fishery requirements or the minimum flows) could be met without the need for stop logs.

From limited field investigations it would appear that this sub-alternative is feasible and could result in the saving of 40,000 acre-feet per year during drought periods, assuming fishery requirements are met at all times. A saving of up to 70,000 acre-feet could be made in a drought year if fishery flows were not met (i.e. if operation were similar to the present operation). Prior to the implementation of such a proposal, it should be tested in the field to ensure a base flow of 100 cfs plus consumptive use requirements will meet the needs of the water users along Okanagan River. This test would also indicate the improvements required to various intakes should this proposal be implemented.

Kelowna Floating Bridge and Okanagan Lake Intakes

In severe droughts, similar to that which occurred between 1929 and 1932, Okanagan Lake would drop to 1119.2 feet (0.6 feet below normal low water elevation) under present levels of development, and to 1116.8 feet under 2020 conditions of development. The present minimum operating level of the Kelowna Floating Bridge is 1118.8 feet. Therefore, while no immediate adjustments are needed, a contingency plan should be prepared to cover any future adjustments and dredging required should these conditions occur. Water intakes on Okanagan Lake would also have to be lowered so that they are operable at elevation 1116.8 feet. The lead time required to lower Okanagan Lake intakes prior to the occurance of a major drought (1-1/2 to 2 years) is such that this work should be undertaken immediately. The capital cost of the bridge modifications and the lowering of Okanagan Lake intakes have been estimated at $120,000 and $112,000 respectively.

By reducing Okanagan Lake drawdowns in drought years, this sub-alternative also would lessen potential negative impacts on shoreline recreational resources around Okanagan Lake, effectively eliminating these in all but the most severe drought on record (1929-32). These economic and environmental benefits would have to be weigned against the increased damage to both the sockeye and sport fishery resources due to the lower minimum Okanagan River flows and greater fluctiations of Okanagan Lake during kokanee shore spawning and incubation. In view of the importance of these resources to the economic and environmental health of the Okanagan, other water conservation sub-alternatives that attempt to meet fishery water requirements should also be considered.

Zosel Dam at Osoyoos Lake

Experience during the 1970 and 1973 droughts indicates that Osoyoos Lake levels cannot be maintained at 911 feet (USCGS) when inflows from Okanagan River drop below 270 cfs. This is due to considerable leakage from Zosel Dam, which normally controls the outlet of Osoyoos Lake in the United States. Reductions of Okanagan River inflows to 100 cfs would cause Osoyoos Lake levels to drop below the elevation of Zosel Dam until the lake was controlled by gravel bars upstream of the dam. The precise elevation at which these gravel bars take control is not known and thus the consequences of Osoyoos Lake drawdowns on recreation and aesthetics in the area cannot be fully assessed.

Because Osoyoos Lake is an international waterway, any further consideration of the effects of this water conservation sub-alternative should be referred to the International Joint Commission.

Tugulnuit Lake Water Management

Pumping from Tugulnuit Lake is needed to supplement gravity drainage when Okanagan River is high. The pumping system would operate during the freshet periods and at other times when high discharges much be maintained in Okanagan River (See Sub-Alternative 3). It is estimated that the cost of the pumping system would be $45,000, with annual costs including amortization at about $8,000. These costs together with a discussion of benefits are included in Sub-Alternative 3 rather than with the other costs of the sub-alternative.

(ii) Sub-Alternative 2(b)

Objective - Water Conservation (Fishery Flows Met At All Times)
Methods - Lower Okanagan River Intakes
- Modifications to Kelowna Floating Bridge and Okanagan Lake Intakes

If full fishery flows are met in Okanagan River at all times, and intakes are adjusted to allow minimum flows of 100 cfs during the irrigation season, water requirements for the basin would total 271,000 acre-feet under the 1970 level of development, which is the same as under the present operation, when fishery flows are not met in drought years. Equivalent requirements under 2020 levels of development could increase to 307,000 acre-feet.

Thus the saving of water during the irrigation season could be transferred directly to meeting fishery flows. However, Okanagan Lake levels would drop 3.5 feet below the normal low water elevation during prolonged droughts and adjustments to Kelowna Bridge and Okanagan Lake intakes would again be required.

As a compromise, it would be possible to meet fishery flow requirements in all single drought years, which cannot be achieved under the present operation, and reduce flows in the second and third years of prolonged droughts. The amount of reduction would depend on the size of the salmon run and the magnitude of the drought, but could be negotiated by Federal Fishery officials and B.C. Water Resources Service.

(iii) Sub-Alternative 2(c)

Objective - Water Conservation (Fishery Flows Met At All Times)
Methods - Lower Okanagan River Intakes
- Construction of Spawning Channels on Okanagan River

Construction of a spawning channel for sockeye salmon near Okanagan River would enable additional water conservation in drought years. Because full channel water requirements would be necessary to enable the salmon to migrate to and from the channel, savings could only be realized during the period of October to February 15 inclusive (Table 14.8).

Also while flows could be reduced to 75 cfs during the period of November to February 15, it is considered that the minimum residual flow in Okanagan River should be 100 cfs. The amount of water conserved in a drought year by the construction of a spawning channel would therefore be approximately 30,000 acre-feet.

TABLE 14.8

COMPARISON OF FLOW REQUIREMENTS IN OKANAGAN RIVER FOR SALMON WITH AND WITHOUT PROPOSED SPAWNING CHANNEL

MONTH	PRESENT SALMON REQUIREMENTS		REQUIREMENTS WITH SPAWNING CHANNEL	
	Minimum (cfs)	Maximum (cfs)	Minimum (cfs)	Maximum (cfs)
August	300	350	300	450
September	350	550	350	550
October	350	550	100	-
November 1 to February 15	175	1000	75	-
February 16 to April 30	175	1000	175	-

* Flows exceeding the maximums shown cause scouring and loss of spawning habitat.

The capital cost of this sub-alternative has been estimated at $600,000 with an annual cost of $54,000.

(iv) Sub-Alternative 2(d)

Objective - Flood Control

Methods
- Increase Okanagan Lake Elevation by One Foot in Flood years.
- Adjust Kelowna Floating Bridge
- Tugulnuit Lake Pumping and Erosion Control
- Replace McAlpine Bridge
- Improved Inflow Forecasts

Provision for flood control within the mainstem includes some four feet of storage on Okanagan Lake equivalent to 340,000 acre-feet as well as design channel discharges ranging from 2100 cfs at Penticton to 3400 cfs at Osoyoos Lake. Because of the limited channel capacities and the high freshet during April to July, it is necessary to plan the regulation of Okanagan Lake well in advance of an impending flood.

Under normal winter conditions, Okanagan Lake can be lowered about one foot a month although operations in February and March may be impeded by icing conditions on the gates of Skaha Lake Dam as well as at the inlet to Osoyoos Lake where ice can plug the river channel.

During past floods such as occurred in 1975, it was found that Okanagan Lake average discharges were limited to about 70% of the channel capacity at Penticton to allow for local channel inflows downstream, limitations in the safe discharges into Osoyoos Lake, local channel restrictions such as McAlpine pile trestle highway bridge north of Oliver and the need for gravity drainage from Tugulnuit Lake.

Increase Okanagan Lake Elevation by One Foot in Flood Years

With the present limited channel capacity of Okanagan River, net inflows exceeding 600,000 acre-feet cannot be contained within the normal four foot operating range on Okanagan Lake. Experience with the 1972 flood indicated that if Okanagan Lake is allowed to rise to one foot above normal maximum elevation, about $50,000 of damage to shoreline property will occur. As such events occur very infrequently, annual costs are estimated at $4500. When possible, Okanagan Lake should be drawn down below its normal minimum elevation when larger runoff is forecast. This would reduce the impact of flooding above the normal high lake elevation.

Without expensive structural adjustments to Okanagan River, this sub-alternative appears inevitable and should be accompanied by flood plain zoning around Okanagan Lake to elevation 1127.5 feet (200 year flood elevation, plus two feet of freeboard) to reduce any potential damage from flooding.

Adjust Kelowna Floating Bridge

During the 1972 flood, approximately $30,000 were spent on ballasting the Kelowna Floating Bridge to accommodate the extreme high water elevations. This investment would have to continue in the event of subsequent floods, as such floods are too infrequent to support more permanent adjustments.

Erosion Control and Tugulnuit Lake Pumping

Erosion protection around the drop structures on Okanagan River and adjustments to the gates on Okanagan and Skaha Lake dams to prevent icing could permit continuous discharges down Okanagan River at 80% channel capacity, compared to 70% at present. These measures would allow the evacuation of an additional 12,000 acre-feet per month prior to and during the freshet and thus would improve the flexibility of operating Okanagan Lake. Capital costs are estimated at $739,000 (Table 14.7).

Increased discharges down Okanagan River would cause local flooding around Tugulnuit Lake, the natural drainage of which can be impeded during high flows in the main channel. Improvements to prevent such flooding should include the addition of a pumping unit to supplement the existing improved channel way between Tugulnuit Lake and Okanagan River. This improvement will allow sufficient flexibility to control lake water levels within the desirable range and in the event of a mechanical failure, still allow some inflow or outflow as required.

McAlpine Bridge

Replacement of McAlpine Bridge on Highway 97, to eliminate the trestles which presently trap debris, would cost an estimated $166,000 or $14,000 annually. This investment cannot be justified on the basis of flood control, unless it can be demonstrated that the debris pile-ups at the bridge seriously threaten the structure.

Improved Inflow Forecasts

The value of improved forecasting models both for the total freshet inflow corecasts and for the short term forecasts a few days in advance are recognized. Forecasting models are presently in operation and their performance is under review by the British Columbia Water Resources Service.

Volume inflow forecasts to Okanagan Lake for the freshet period April to July inclusive are published in the April 1 Snow Survey Bulletin of the British Columbia Water Resources Service, who with the assistance of the Department of Highways, operate the Okanagan Flood Control Works. These forecasts are made on the assumption that normal weather conditions will prevail during the freshet period, and have a standard error of forecast of some 84,000 acre-feet, equal to about one foot of storage on Okanagan Lake. In subsequent revisions of the forecasts during the snow melt period up to the end of July, about one half the error can be explained by variations from the normal weather pattern. The remaining half of the forecast error can be attributed to the limited understanding of the hydrology of the basin, particularly with respect to changing soil moisture conditions. The elimination of this portion of the error would conserve up to 40,000 acre-feet, which represents half a foot of storage on Okanagan Lake. However, in drought and flood years this may not be too important because conservation or flood control action is normally taken well in advance of inflow forecasts and is based primarily on the accumulated snow pack data. Nevertheless, for a better understanding of the hydrology of the basin and the contribution to be expected from its major tributaries, it does appear that the continuous monitoring model has much to offer.

(c) Alternative 3 - Water Importation

For all the above sub-alternatives, Okanagan Lake would be drawn down below its normal low water elevation of 1119.8 feet should the 1929-32 drought recur. It appears that this situation can only be avoided by importation of water. The periods over which the diversion would take place within the study period 1921-1970 are shown in Table 14.9.

Although maximum diversion shown in Table 14.9 is 500 crs, it is now considered that a 600 cfs capacity canal would be required for diversion of water from the Shuswap River near Enderby over a seven month period (March to July inclusive and October and November) in drought years.

Over the 50 year study period, diversion would only be required for a total of 20 months on nine different occasions, assuming 2020 development conditions - a frequency of about one year in eight. The maximum diversion would occur with conditions similar to the 1929-32 drought, with up to 167,000 acre-feet required in 1931. However, the average annual volume diverted over the 50 years would be less than 10,000 acre-feet.

TABLE 14.9

IMPORTATION OF WATER REQUIRED TO MAINTAIN OKANAGAN LAKE ABOVE NORMAL LOW WATER ELEVATION 1119.8 (C.F.S. - MONTHS)*

YEAR	M	A	M	J	J	A S	O	N	TOTAL
1926					500		500	500	1,500
1927	110	247							
1929					500				500
1930		500	500	500	500			106	2,106
1931	208	500	500	500	500		191	379	2,778
1932	401	500							901
TOTAL C.F.S. MONTHS	719	1,747	1,000	1,000	2,000		691	985	8,142
TOTAL MONTHS	3	4	2	2	4		2	3	20

* 1 c.f.s. (cubic feet per second) - month is equivalent to approximately 60 acre-feet.

Under these conditions, energy costs for pumping are not significant when compared to annual interest and amortization charges on the $10 million capital costs. Total annual costs are estimated at $1.2 million, assuming no irrigation in the areas adjacent to the canal.

The diversion canal could be used to irrigate adjacent lands in the Spallumcheen Valley, but due to pumping requirements, the annual cost per acre-foot (excluding water costs at the canal side and local distribution costs) are estimated at $60-70. As annual net benefits from tree fruits and pasture range from $63 to $18 per acre-foot respectively, such pumping systems would not be economical, especially as most agricultural production in this section of the valley would be mainly forage crops because of climatic conditions.

Because water conservation sub-alternatives within the Okanagan do significantly reduce lake drawdowns in such extreme droughts, the investment of over $10 million, or $1.2 million annually to avoid such infrequent droughts does not appear to be justified. Although water importation would basically eliminate all social and environmental consequences of extreme Okanagan Lake level fluctuations, it could have a detrimental effect on shore-spawning kokanee. This is because Okanagan Lake would be regulated less conservatively and therefore be subject to greater drawdowns than at present with the knowledge that there was additional water available in the event of a drought. Large lake level drawdowns during the spawning and incubation period (September to February) would expose fish eggs, resulting in a significant fish mortality. Because more than half the total kokanee population is dependent on shore-spawhing habitats, such events could have serious consequences on the quality of angling on Okanagan Lake.

14.2.2 Discussion of Alternatives

A number of possible solutions to water management problems along the mainstem have been outlined. The evaluation of these alternatives is complex because economic and social values must be placed on a wide range of water uses. Such costs and benefits are summarized in Tables 14.7 to 14.10), which compare all benefits and costs for each sub-alternative according to economic, environmental and social goals. The matrix has been prepared for 1970 and for 2020 development, where changes are significant.

Economic impacts include flood damage to shoreline property and developments, loss of tourist resources due to lake drawdowns, adjustments to water intakes around Okanagan Lake and along Okanagan River and adjustments to Kelowna Floating Bridge.

The environmental impacts involve loss of public beaches, loss of use of launching and mooring facilities, exposure of lake bottom, reduction in kokanee and rainbow trout shore spawning habitats, and inundation or desiccation of wildlife nesting grounds.

Social impacts include loss of opportunity to use private boat docks due to high or low water levels.

TABLE 14.10

ENVIRONMENTAL AND SOCIAL EVALUATIONS

Mainstem Water Quantity Alternatives

(Based on 1970 Development Only)

ALTERNATIVE	SOCKEYE SALMON	SPORT FISH	WILD-LIFE	OKANAGAN LAKE RECREATION BEACHES	OKANAGAN LAKE PRIVATE BOAT DOCKS	OKANAGAN LAKE PUBLIC BOAT DOCKS	OKANAGAN LAKE PRIVATE PROPERTY FLOODED	OKANAGAN LAKE LAKE BOTTOM EXPOSURE	RECREATION ACRE DAYS	PRIVATE BOAT DOCK DAYS	PUBLIC BOAT DOCK DAYS	PRIVATE PROPERTY ACRE DAYS	LAKE BOTTOM EXPOSED AREA-DAYS
1(a) Null Operation Fishery Flows met Incidentally Water Reqts.1970-273 KAF 2020-306-317 KAF	0	0	0	0	0	0	0	0	64.0	6023	109.4	106.5	950
(b) Null Operation Fishery Flows met all times Water Reqts.1970-312 KAF 2020-345-356 KAF	+7	+2	-2	0	-4	-4	0	-8	64.0	8208	153.5	106.5	1679
2(a) Water Conservation Fishery Flows met Incidentally Water Reqts.1970-200 KAF 2020-254-261 KAF	-2	-10	+5	0	+8	+9	0	+9	64.0	1129	13.0	106.5	77
(b) Water Conservation Fishery Flows met all times Water Reqts.1970-271 KAF 2020-325-332 KAF	+8	+2	+2	0	+6	+2	0	+1	64.0	2538	91.4	106.5	850
(c) Water Conservation Spawning Channel-Ok.River Fishery Flows met all times Water Reqts.1970-256 KAF 2020-307-314 KAF	+10	+2?	+2?	0	+7	+3	0	+2	64.0	1500 e/	80.0 e/	106.5	800 e/
(d) Flood Control Measures Structural Alterations to Ok.River.,Regulation of Ok.Lake. Fishery Flows met Incidentally. Water Reqts. 1970-273 KAF (Null 2020-306-317 KAF Operation)	0	0	0	+10	+2	+3	+10	+2	43.3	5000	78.4	52.0	840
3(a) Maintenance of Okanagan Lake Levels. Importation of Water Fishery Flow met all times Water Reqts.1970-312 KAF (Null 2020-345-356 KAF Operation)	+7	-5	+4	0	+10	+10	0	+10	64.0	650	6.9	106.5	.24
(b) Maintenance of Okanagan Lake Levels Importation of Water Improved Intakes Flood Control measures Fishery Flows met all times Water Reqts.1970-312 KAF 2020-345-356 KAF	+8	-5	+2	+10	+10	+10	+10	+10	43.3	284	5.6	52.0	.24

NOTE: For commencement of this Table see Table 14.11.

K.A.F. - Kilo Acre Feet

'e' - estimated

To account for seasonal variation in use (for example, boat docks are mainly used during the summer months), each social and environmental landuse category was adjusted by a monthly weighting factor (Table 14.11). These factors were based on observed or estimated seasonal use patterns obtained from the creel census, socio-economic fishing survey and rec eation studies (Table 14.12). For each sub-alternative, total damage in dollars or other units for all extreme events in the 50 year study period was summed and divided by 50 to obtain average annual damage values.

Although there is little doubt that Okanagan Lake drawdowns below the minimum low water elevation of 1118.8 feet during the summer would have significant implications on the economics of the tourist industry, it is almost impossible to quantify this effect. During the 1972 beach-user survey, shoreline recreationists were asked for their possible reaction to such drawdowns, but responses were not enlightening because they had not experienced such conditions.

The Okanagan tourist trade has considerable resilience to single events which whicn effect recreation quality. This has been demonstrated by the effect of the Skaha and Wood Lake algae blooms of 1967 and 1971 respectively. Although some long-term Okanagan tourists did avoid the basin, they were replaced by others who either had not known about these blooms, or who placed less emphasis on water quality as a factor in their recreational enjoyment.

However, water quality deterioration in a small portion of the Basin over a single year is of limited value in anticipating loss to the tourist industry as well as the environmental and social impacts of Okanagan Lake levels remaining below normal low water elevations for periods up to three years (See Figure 14.3).

To provide some estimate of economic impacts, it was assumed there would be a 10$ reduction in the tourist trade in two consecutive drought years, under normal operating conditions. Based on the 1979 net income from tourists expenditures of $4.5 million, this impact is valued at $450,000, which is again reduced to $15,000 on an annual basis, assuming an average return period of one in 50 years. The capitalized value of this loss to 2020, discounted at 7% per annum, would be $400,000.

Incremental impacts for each sub-alternative relative to simulated historic inflows regulated by Okanagan Lake Dam were scored according to the following procedure: -

The extreme range in annual damage values for each landuse category was noted and the difference between the annual value for the simulated operation and both extreme values (above and below the historic) was calculated. The larger difference, whether positive (benefit) or negative (cost) was scored at 10. Differences between the annual values for the simulated operation (based on computer model data) and the respective annual values for all other sub-alternatives were then scored as a percentage of this maximum difference, decreases

TABLE 14.11

MONTHLY WEIGHTINGS IN DAYS FOR SHORELINE DAMAGE

	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
Public Boat Access Ramps	0	0	5	10	15	25	31	31	20	10	5	0
Private Boat Docks	0	0	5	10	15	25	31	31	20	10	5	0
Public Recreation Beaches	0	0	0	0	5	15	31	31	10	0	0	0
Marinas	0	0	0	0	20	30	31	31	20	10	0	0
Campgrounds	0	0	0	0	10	20	31	31	10	0	0	0

TABLE 14.12

IMPACTS ASSOCIATED WITH MAINSTEM OKANAGAN WATER MANAGEMENT ALTERNATIVES

ASSOCIATED GOAL	IMPACT CATEGORY	LOCATION	UNIT OF MEASUREMENT
Economic	Kelowna Floating Bridge Flood damage to private property Revenue lost - marinas - lake drawdowns Intake adjustments	Okanagan Lake Okanagan Lake Okanagan Lake Okanagan Lake Okanagan River Okanagan Lake	dollars dollars dollars dollars dollars dollars
Environmental	Recreation beaches flooded Public boat ramps inoperable Shoreline exposed by lake draw-down Sockeye salmon Sport fisheries - Kokanee (shore spawning) - trout & Kokanee Wildlife	Okanagan Lake Okanagan Lake Okanagan Lake Okanagan River Okanagan Lake Okanagan River Okanagan Lake Okanagan River	acre days ramp days area-days *1 spawning fish spawning fish spawning fish
Social	Private property flooded Private boat docks inoperable	Okanagan Lake Okanagan Lake	acre days boat-dock days

*1 "Area-Days" - Due to the difficulty in surveying lake bottom area exposed at various drawdowns below the minimum level of 1119.8 feet, a dimensionless index of "area-days" was developed. The maximum extent of shoreline exposed at any location around the lake at 1116.8 feet was rated at 100, and incremental drawdowns between 1119.8 and 1116.8 feet for this and other sections of the shoreline were pro-rated to 100. The pro-rated numbers were then multiplied by the number of days the drawdown at each 0.5 foot increment occurred to produce the index "area-days".

in annual damage being scored positively and increases scored negatively. In most categories of landuse, as at least one sub-alternative effectively eliminated the damage due to high or low water, a score of +10 means that the planning objective was fully achieved.

In the case of sockeye salmon, an approximate relationship between Okanagan River discharges and spawning success was generated and the discharge regime of each sub-alternative was then analysed to project sockeye production. Discharges which enabled optimum production of salmon (average escapement of 51,000) were scored as 10, while those that effectively eliminated the run were scored as zero. Socres were pro-rated according to the estimated success of sockeye reproduction associated with various minimum flows for each alternative.

Other impacts on sport fishing resources in the mainstem included Okanagan Lake fluctuations on shore spawning kokanee and Okanagan River discharge regimes on kokanee and rainbow trout spawning habitat in Okanagan River, and subsequent rearing success in Skaha, Vaseux and Osoyoos Lakes.

A single score represented an integration of impacts on each sport fishery component. This score was based on the magnitude of impacts due to lake level fluctuations or Okanagan River flows falling outside desirable ranges and weighted according to the size of the fishery supported by shore or main river spawning, incubation and rearing. Because angling for large rainbow trout in the lower Okanagan River was known to be a highly prized recreation, impacts on this resource were weighted three times that of other sport fishery components.

Although cultural changes in shoreline landuse have significantly reduced natural wildlife habitat, potential threats to remaining habitat due to alternative operation of the Okanagan mainstem system could occur in the north arm of Okanagan Lake and in the oxbows adjacent to the Okanagan River Flood Channel. Impacts on wildlife habitats around Okanagan Lake were not scored, as no alternative created prolonged changes in the present operating range which would seriously affect natural habitat. Scoring of the effects of various minimum flow regimes in Okanagan River was based on a qualitative relationship between flow and wildlife breeding success.

14.2.3 Conclusions

By 2020, growth in population and irrigated acreage could change total basin water requirements for both consumptive and non-consumptive uses to between 344,000 and 347,000 acre-feet under the three projections examined, compared to 312,000 acre-feet at present (1970). Although these possible increases are not considered large enough to affect mainstem operation significantly, they will further aggravate the potential drought problems in the system. Thus, should the present method of operation be continued, recurrence of prolonged droughts would result in greater drawdowns of Okanagan Lake in the future than those anticipated when the Okanagan Flood Control Works were constructed, and have relatively greater impacts on shoreline recreation and could threaten the viability of the sockeye salmon fishery over the next 50 years.

It is also apparent that importation of water to the Okanagan Basin cannot be justified on either economic or environmental considerations. Inflows to Okanagan Lake are sufficient to meet all water requirements in most years with proper management and the environmental costs associated with a prolonged drought such as occurred in 1929 to 1932 appear to be preferable than annual expenditures of over $1 million to pay the costs of importation.

To provide greater flexibility for operating the system during such droughts, one of the water conservation sub-alternatives should be implemented. Lowering the irrigation intakes on Okanagan Lake and River will produce economic and environmental benefits that appear to outweigh their relatively modest annual costs, though further consideration would have to be given to the consequences of minimum flows of 100 cfs on Osoyoos Lake levels and the possibility of replacing Zosel Dam.

Discussions with public task forces, indicate that the Okanagan residents place highest priority on maintaining water supplies to domestic and irrigation uses followed by recreation and fishery requirements. Consequently, in extreme and prolonged droughts, operating procedures would have to be developed so that consumptive uses were met at all times, and some fishery requirements in Okanagan River foregone to the point where reductions of negative impacts of Okanagan and Osoyoos Lake drawdowns balance the losses of fishery production.

Because Okanagan Lake would only fall below its extreme minimum elevation of 1118.8 feet very infrequently, actual adjustments to Kelowna Floating Bridge might best be undertaken when Okanagan Lake approaches its minimum elevation of 1118.8. A contingency plan should be prepared for this however, so that such modifications can be carried out without delay. In the case of the Okanagan Lake intakes, it would not be feasible to wait because of the number involved, and such improvements should be undertaken at the same time as the Okanagan River intakes are lowered.

Flooding around Okanagan Lake only occurs about once in 15 years and cannot be considered a serious problem. Improvements in forecasting resulting from an increased understanding of tributary hydrology and soil moisture balance will assist in better flood regulation. Some of the real physical constraints of maintaining maximum discharges in Okanagan River should be overcome, such as control works for regulating Tugulnuit Lake levels and some bank and erosion protection measures.

It does not appear that the costs of constructing fish spawning facilities adjacent to Okanagan River to maintain the sockeye salmon run can be justified solely by the amount of water conserved and associated environmental benefits around Okanagan Lake in drought years. An additional problem with respect to salmon is the adequacy of the Zosel Dam fish ladders. The release of water specifically for fisheries to the lower reaches of the Okanagan River upstream is contingent on adequate upstream and downstream migration at Zosel Dam.

14.3 OSOYOOS LAKE ELEVATIONS

14.3.1 Statement of Problems

The objective of water management in the Okanagan Basin is to provide adequate water of good quality at satisfactory elevations.

Through structural improvements and good water management is is possible to approach these objectives for the mainstem system to the inlet of Osoyoos Lake. This is due primarily to the large storage capacity of Okanagan Lake (340,000 acre-feet) which can retain a major portion of the freshet inflows while tributaries downstream of Penticton are peaking and filling the river channel to capacity.

Similarly, in dry oeriods releases from Okanagan Lake can sustain consumptive use and minimum residual flow requirements through to Osoyoos Lake.

In contrast, Osoyoos Lake with about 7% of the area of Okanagan Lake, has very limited storage capacity in its desirable operating range of 1.6 feet as outlined in Table 14.13. This desirable range can only be positively controlled by Zosel Dam at the lake outlet, when near average flow conditions are occurring. There are no obstructions upstream of the dam which affect Osoyoos Lake high water elevations.

In the past, Osoyoos Lake outflows during heavy floods have been retarded or sometimes reversed by backwater from the Similkameen River, while under less severe conditions the control has shifted to the channel upstream of Zosel Dam when delta material from Tonasket Creek has built a bar across the main channel.

TABLE 14.13

DESIRABLE ELEVATIONS FOR OSOYOOS LAKE

Geodetic Survey of Canada 1961 Datum	Okanagan Flood Control Datum	United States Coast and Geodetic Survey Datum
(G.S.C. feet)	(O.F.C.feet)	(U.S.C.G.S. feet)
910.4	909.0	910.7
912.0	910.6	912.3

NOTE: Preferred summer elevation of Osoyoos Lake is 911.0 feet (USCGS) or 910.7 feet (GSC).

In summary, the two water quantity problems that can be identified with respect to Osoyoos Lake are:

1) Maximum elevations occurring above 912.0 GSC (912.3 USCGS).
2) Minimum elevations occurring below 910.4 GSC (910.7 USCGS).

14.3.2 Maximum Elevations of Osoyoos Lake

Serious flooding occurs around Osoyoos Lake on average about once a decade, resulting in an average annual cost of $26,000. During extreme flood conditions such as occurred in June 1972, Osoyoos Lake rose over 5 feet above the normal maximum, causing $212,000 of damage to shoreline property or lost revenue to the local tourist industry. However, this size of flood is only expected to occur about once every 45 years.

Extreme flooding on Osoyoos Lake results from high flows on the Similkameen River which back up into Osoyoos Lake, effectively stopping any outflow of water. Since inflows to the lake during such runoff periods come largely from tributary inflows between Okanagan and Osoyoos Lakes, the control of Okanagan Lake outflows has little effect on Osoyoos Lake levels (Figure 14.4).

14.3.3 Alternatives

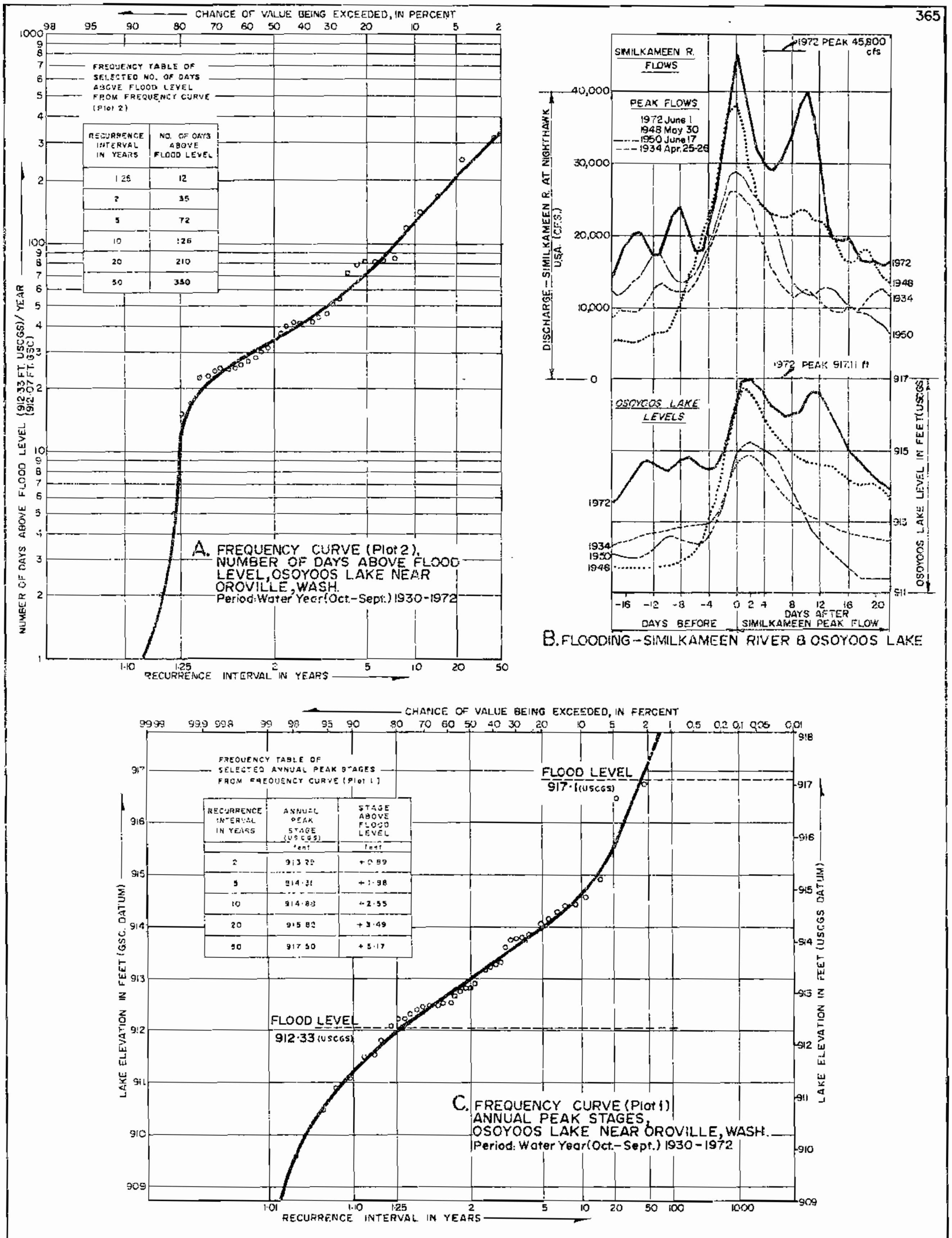
Structural and non-structural alternatives for controlling Osoyoos Lake water elevation or preventing flood damage are as follows:

Structural

- Flood storage on Similkameen River of sufficient capacity to reduce maximum flows on the Similkameen River to 17,000 cfs or less at the Nighthawk gauge.
- Construct a dam at the outlet of Osoyoos Lake to prevent backwater effect and reverse flow from the Similkameen River at high stage, together with a pumping station to carry the discharge of Okanagan River over the dam. This would also maintain Osoyoos Lake at a desirable summer water elevation which cannot be done with the present structure.
- Replacement of Zosel Dam with limited flood control features.
- Construct permanent dykes to protect affected built-up areas around Osoyoos Lake
- Construct emergency dyking to protect affected built-up areas around Osoyoos Lake.
- Channel improvements below Zosel Dam in the United States.

Non-Structural

- Forecasting and Flood Warning Systems
- Plan and Implement emergency preventative measures, together with a program of educating residents in flood fighting techniques.
- Flood plain zoning.



FREQUENCY TABLE OF SELECTED NO. OF DAYS ABOVE FLOOD LEVEL FROM FREQUENCY CURVE (Plot 2)

RECURRENCE INTERVAL IN YEARS	NO. OF DAYS ABOVE FLOOD LEVEL
1·25	12
2	35
5	72
10	126
20	210
50	350

FREQUENCY TABLE OF SELECTED ANNUAL PEAK STAGES FROM FREQUENCY CURVE (Plot 1)

RECURRENCE INTERVAL IN YEARS	ANNUAL PEAK STAGE (USCGS)	STAGE ABOVE FLOOD LEVEL
	feet	feet
2	913·32	+0·99
5	914·31	+1·98
10	914·88	+2·55
20	915·82	+3·49
50	917·50	+5·17

FREQUENCY and DURATION of FLOODING on OSOYOOS LAKE

Figure 14.4

(a) Structural Sub-Alternatives

(i) Flood Control Storage on the Similkameen River

Although the Similkameen River is not within the terms of reference of the Okanagan Basin Study, the river in flood stage certainly has an effect on Osoyoos Lake, which is within the Study area. Storage at upstream sites on the Similkameen River in the United States and further upstream in Canada, could be a solution to the flood problem at Osoyoos.

For the purpose of this report it has been assumed that discharges into Osoyoos Lake as well as the local inflow (which is relatively small) will not be greater than 3,000 cubic feet per second. With free flow out of Osoyoos Lake (that is, no backwater effect from the Similkameen River) the maximum lake level would be 913.8 (USCGS) to achieve a discharge of 3,000 cubic feet per second. This free flow would be achieved if the discharge of the Similkameen River at Nighthawk could be held to 14,000 cubic feet per second or less during the freshet period (April to July inclusive). Lesser degrees of control (to 17,000 or even higher) would also be worthy of consideration.

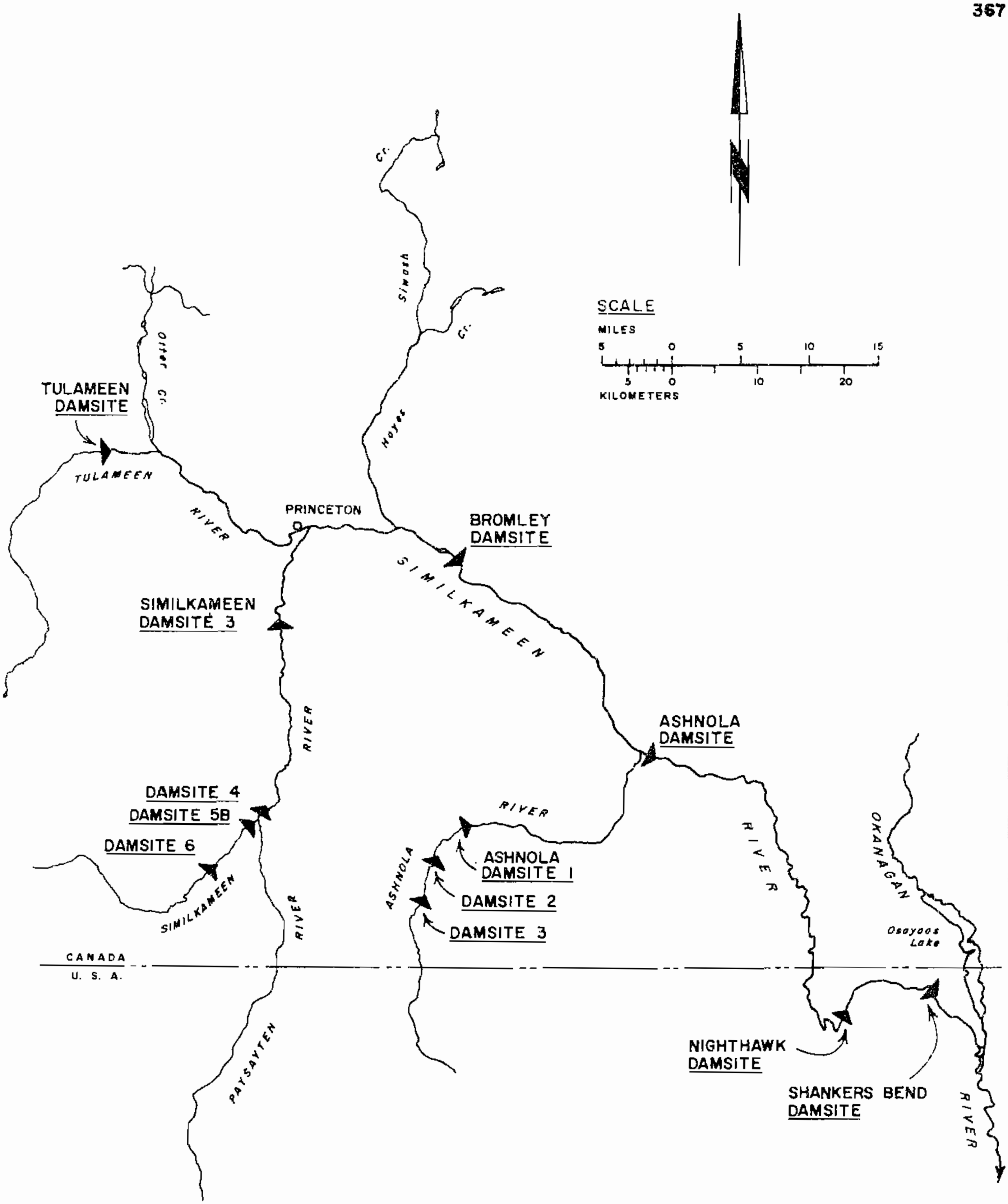
The retention of all flood water on the Similkameen River in excess of 14,000 cubic feet per second, would require the following upstream storage requirements:

TABLE 14.14

STORAGE REQUIREMENTS-SIMILKAMEEN RIVER IN CANADA

LOCATION	STORAGE REQUIRED In Acre-Feet		POTENTIAL STORAGE In Acre-Feet		
	1948	1972	Tributaries	Mainstem	Totals
Above Princeton	463,000	895,000	158,000	273,000 (Bromley)	431,000
Below Princeton	197,000	384,000	70,000	62,000	132,000
TOTALS	660,000	1,279,000	228,000	335,000	563,000

It is evident from Table 14.14 that the total potential tributary storages on the Similkameen in Canada of 228,000 acre-feet would not be nearly sufficient to meet the 1948 flood storage requirements of 660,000 acre-feet and would be totally inadequate in meeting the 1,279,000 acre-feet required to control the 1972 flood. Even with the addition of the mainstem storages at Bromley and Ashnola, the total potential storage of 563,000 acre-feet falls short of the 1948 requirements and is only about 44% of the 1972 requirements (Figure 14.5).



STORAGE SITE LOCATION MAP
SIMILKAMEEN RIVER

Figure 14.5

In a report to the International Joint Commission (24), reference is made to a potential damsite on the Similkameen River at Shankers Bend in the State of Washington. The Shankers Bend High Dam, some five miles upstream from Oroville, would provide storage between elevation 1,150 and 1,289 feet, equivalent to 1,310,000 acre-feet. This would back water almost to Cawston in Canada (Figure 14.5) and would appear to be the size of storage needed to control the record runoff of 1972.

While any significant reduction in the peak flow of the Similkameen River would have a beneficial effect on Osoyoos Lake in years of high runoff, it is obvious that the cost of providing such storage on the Similkameen River either in Canada or the United States, cannot be justified solely on the basis of benefits in flood relief around Osoyoos Lake.

At the present time, the U.S. Army Corps of Engineers are carrying out a study of the Okanogan River in Washington with respect to flood control, which in time, should provide more information on the regulation of the Similkameen.

(ii) <u>Osoyoos Lake Dam and Pumping Station</u>

Flooding on and around Osoyoos Lake could be effectively prevented by constructing a dam below the outlet of Osoyoos Lake at Oroville (near existing Zosel Dam) of sufficient height to prevent any reverse flow from the Similkameen River into Osoyoos Lake. A pumping station would be a necessary part of the project in order to lift water entering Osoyoos Lake from the Okanagan River and other tributaries and discharge it over the dam.

The dam would need to be constructed to elevation 925 feet. This would afford protection against backwater from the Similkameen River to elevation 920 (about one foot higher than the level reached on May 29, 1894 - the highest known), and give a margin for wave action.

As the annual flood damages around Osoyoos Lake amount to about $25,000, such a project would not be economically justified and has not been given further consideration.

(iii) <u>Replacement of Zosel Dam</u>

The present 140 long Zosel Dam, which accords some degree of low-level control for Osoyoos Lake, is nearing the end of its useful life and will probably have to be reconstructed or replaced by a more satisfactory structure. The original purpose of the structure in 1927 was to create a mill pond for log storage. In 1948 it was modified to increase its capacity for passing large flows. The mill pong is no longer used, and the control structure is operated by the company as a public service to maintain the level of the lake during periods of low flow. During flood periods, the structure is inundated and lake levels are controlled by the level of the Similkameen River.

Since regulations concerning the operation of this structure come under the International Joint Commission, further studies of Osoyoos Lake level regulation should be referred to this group to determine what measures need to be undertaken either in Canada or the United States to -

1. maintain Osoyoos Lake levels during drought periods
2. reduce flood damage around Osoyoos Lake.

(iv) Permanent Dykes to Protect Built-up Areas Around Osoyoos Lake

Dyking around high value properties on the lakeshore was explored as a possible solution to the threat of flooding, but was dismissed because of the obviously high cost of construction in relation to the infrequent need for protection. Further, there is little material locally suitable for building dykes and it would be difficult to prevent water seeping through the sandy soil on which the dykes would have to be built unless extensive and expensive grouting was carried out. When considered with the length of shoreline that would need protection, the cost of dyking could be far more than property owners might be prepared to pay. The cost of building some 23,300 linear feet of permanent dyke is estimated to be $450,000.

(v) Emergency Dyking to Protect Affected Built-up Areas Around Osoyoos Lake

This option envisages hastily-built dykes of local material to protect high-value properties when a flood threat develops. The same problems apply to emergency dykes as to permanent dykes. Seepage becomes even more of a problem with emergency construction, even if polythene sheets were available to provide an impervious core, since it would still occur through the underlying porous soils. Emergency dykes would only be effective if used directly against a house as a support for a water-proof membrane, and under these conditions seepage under basement floors becomes a problem. Experience during the 1972 flood emergency showed that when water was pumped out of flooded basements, the uplift caused by water pressure below the basement floors caused damage by c acking the floor slabs.

It is estimated that some 27,000 feet of temporary dyke would be required, and including the restoration of the beach after the flood, the total cost has been placed at $180,000. The equivalent figures excluding the north end of Osoyoos Lake are 23,300 feet of dyke and $160,000 respectively.

This is considerably more than the damage sustained in 1972. Further, even using six construction crews working around the clock, it would require 32 days to built the 27,000 feet of dyke, which is clearly impractical when only one or two days' warning may be possible.

(vi) Channel Improvements Below Zosel Dam

One of the flood control studies proposed by the U.S. Army Corps of Engineers is to deepen and widen portions of the Okanogan River. This would improve local conditions in the United States but would not appreciably change the overall river gradient, which is only two feet per mile between the confluence of the Similkameen and the Columbia River, a distance of approximately 68 miles. The cost of the local improvement proposal for flood control is estimated at about 5 million dollars. To effectively control Osoyoos Lake elevations, however, major excavation to increase this river gradient would be required, costing many times this amount.

(b) Non-Structural Sub-Alternatives

(i) Forecasting and Flood Warning Systems

As discussed in Chapter 4, Section 4.3, forecasts of the volume inflows to Okanagan Lake are made each year by the British Columbia Water Resources Service. The more accurate and reliable these forecasts are, the easier is the management of the system, including that of Osoyoos Lake. If the likely inflow to the Basin could be predicted accurately, then the releases from Okanagan Lake could be scheduled to have the least detrimental effect on Osoyoos Lake levels. For the most effective scheduling of releases from Okanadan River however, a reliable short-term quantitative forecast of Similkameen River flows would be required. At the present time it is possible to predict fluctuations in the Similkameen River flows only qualitatively, and thus predict whether Osoyoos Lake is likely to rise or fall.

These combinations of Basin volume inflow forecasts and the short-term qualitative forecasts enable flood warnings to be disseminated to community leaders, local authorities and the media. While this has been done in the past, a more effective means of communicating with the residents in the area appears necessary in years of anticipated high runoff.

(ii) Emergency Preventative Measures and Education in Flood-fighting Techniques

The 1972 flood damage survey around Osoyoos Lake indicated that about 80 percent of lakeshore residents attempted some type of emergency action to reduce flood damage. These measures ranged from removal of contents to higher elevations in the house, to properly placed sandbags wrapped in impervious polyethylene sheeting, supplemented by pumping. In the 1972 flood, much of this emergency work was ineffective due to lack of knowledge of effective techniques and lack of available materials. The rapid rise of Osoyoos Lake in the critical three days prior to the peak (daily increases of 0.65, 0.87 and 0.52 between May 30 and June 2, for a total rise of 2.04 feet in three days) was virtually indefensible for householders trying to keep sandbag defences above the water line.

Unless positive flood prevention measures can be achieved for the Osoyoos Lake area, a program of educating residents in flood-fighting techniques under emergency conditions should be instituted well in advance of any flood threat.

It must also be recognized that an education program of this nature would have to be repeated year after year, when conditions warranted it, as a refresher to long-time residents as well as to educate new arrivals.

A supply of materials (sandbags, impervious sheeting, etc.) should be stockpiled locally in anticipation of emergency needs.

Civil Defence and local government officials, profiting from the experience of the 1972 situation, should be in a position to plan for similar emergencies and devise methods of coordinating volunt er and employed workers, and providing logistical support.

(iii) Flood Plain Zoning

The most realistic solution in the long tarm to the flood problem around Osoyoos Lake appears to be flood plain zoning, under which any construction on lakeshore land subject to inundation would be regulated to prevent damage from floods. While the details of the flood plain zoning will require further field investigatons, it is evident that it would have to extend to about elevation 921 with certain horizontal limits set for buildings and other improvements above this level.

14.3.4 Minimum Elevations of Osoyoos Lake

The low lake levels experienced in Osoyoos Lake in 1973 have resulted in several complaints from residents of the area. The following discusses some possible reasons for the low levels and courses of action that could be followed to remedy the situation both now and in the future.

Records of Osoyoos Lake levels are available as far back as 1928, with discharge measurements in the reach between Osoyoos Lake and the junction with the Similkameen River since 1942. As the Zosel dam was constructed in 1927, this means that there are no records available of the Osoyoos Lake fluctuations prior to construction of the dam. It is not easy to determine the control which regulates Osoyoos Lake and it is probable that the control changes both according to lake elveation and from year to year. Other than during very high flows in the Similkameen River, the control would appear to be either:

(a) the bar at the south end of the lake
(b) the bar at Tonasket Creek, or
(c) Zosel's dam.

The first two will no doubt, vary from year to year and the Zosel dam is probably the control either when the lake is fairly low or when the stoplogs in the dam are sufficiently high to cause a backwater to the lake.

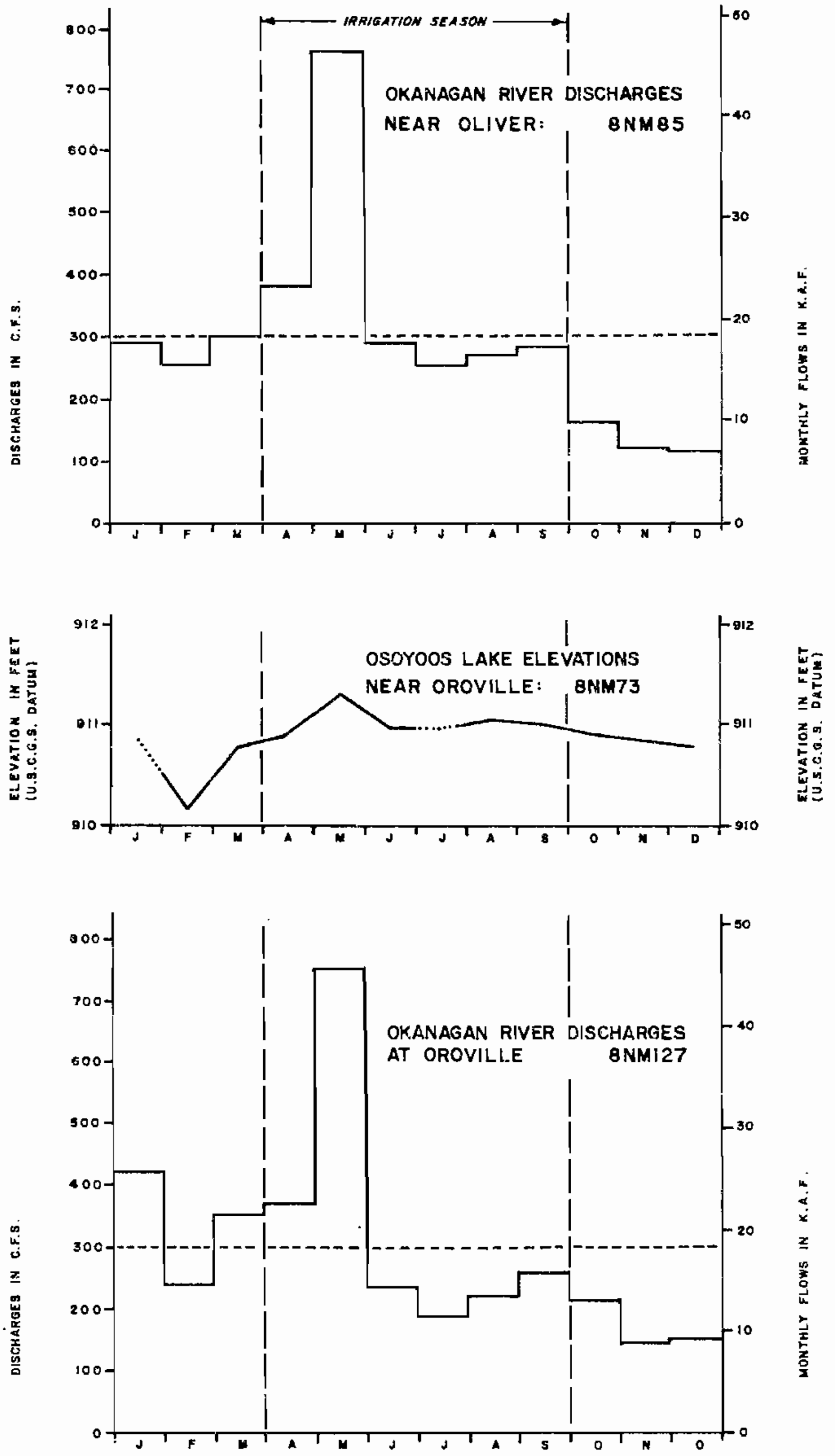
The question of the effect of the Zosel dam on the level of Osoyoos Lake was brought before the IJC (by the State of Washington, on behalf of the town of Oroville, and the County of Okanogan), in late 1942 as the result of many complaints about high water levels in Osoyoos Lake. During the course of the hearings held in 1943, it became apparent that Osoyoos Lake had increased in level by about two feet in the period 1934 to 1942, with the biggest change occurring in 1939. It seems almost certain that during this period, the bars at the mouth of the lake and at Tonasket Creek accumulated material resulting in the higher lake levels. The argument was made that the Zosel dam, by reducing the velocity of flow in the river, stopped the bars being washed away as had happened previously. Other factors may have helped make the bars more stable at this time; a temporary fish screen was placed across the mouth of the lake to stop salmon escapement and a flash flood in Tonasket Creek brought down large amounts of apple tree prunings amongst the granular material, making the bar much more cohesive.

The 1943 IJC hearings resulted in the appointment of a Board of Engineers to study the problems raised. The Board reported in 1945 with further public hearings being held in 1946. This resulted in the IJC issuing an "Order of Approval" in which they found that the Zosel dam "sometimes raises the level of Osoyoos Lake" and which ordered alterations to the spillway of the dam such that it would be capable of discharging 2,500 cfs with a headwater elevation of 911 feet. The Order says nothing about how the dam should be operated, although it is implied that it would be desirable to keep Osoyoos Lake below elevation 911 feet (USCGS).

Some alterations were made to the dam in the late 1940's as a result of the IJC Order, but even prior to this in about 1945, Osoyoos Lake levels dropped by about two to two and a half feet. This may have been due to dredging, but no record can be found of this. It appears that the dam is not capable of passing the 2,500 cfs at elevation 911 (USCGS) required by the IJC Order, although without knowing how many flashboards, (if any) are installed at any time, it is not possible to be sure. Some further modification to the fishways were undertaken in 1965-66, but these probably had little effect on the dam's control of the river.

Because of the difficulties of maintaining Osoyoos Lake at its desirable summer elevation of 911 in 1973, a study was undertaken of a similar drought year - namely 1970.

In Figure 14.6, the discharges at Oliver, Osoyoos Lake elevations and the discharges at Oroville are shown for 1970. With discharges of some 300 cfs at Oliver during the irrigation season, Osoyoos Lake remains at or near elevation 911. Assuming no other inflow, this can be equated with evaporation and consumptive use of 70 cfs plus the discharge at Zosel dam.



OKANAGAN RIVER DISCHARGES AT OLIVER AND OROVILLE, AND OSOYOOS LAKE ELEVATIONS FOR 1970 Figure 14.6

Under similar conditions in August 1973 with measured flow downstream of the dam of 230 cfs, the apparent discharge over the stop logs at Zosel dam was estimated at 60 to 70 cfs leaving a residual flow of some 160 cfs which can only be accounted for by leakage through the dam.

Any water conservation scheme which would reduce the minimum residual flow from 300 cfs to 100 cfs during the irrigation season may result in lower Osoyoos Lake elevations. With continuing leakage through Zosel dam, it is probable that as Osoyoos Lake drops below elevation 911 (USCGS) control may shift from Zosel dam to the Tonasket Creek fan upstream.

The problems of low water elevations on Osoyoos Lake have been evident in the last three years and will remain a problem unless a structure can be built at the lake outlet which can properly regulate water with little or no loss by seepage. Such a dam should be able to maintain Osoyoos Lake summer elevations at 911 feet with inflows from Oliver of 100 cfs (rather than the 300 cfs presently required). Stringent operation would be required to conserve water under conditions similar to the 1929-32 drought.

14.3.5 Discussion of Alternatives

Although Osoyoos Lake fluctuates outside its desirable range of 910.7 to 912.3 feet, the economic and social consequences of these extreme fluctuations are not large. Annual flood damage under 1972 levels of development is estimated at $25,000 although in extreme floods, such as occurred in 1972, over $100,000 damage can occur.

No structural alternatives on Similkameen River or around Osoyoos Lake can be economically justified. Thus, non-structural alternatives involving flood plain zoning to 921 feet, flood warning systems, education and emergency preparations, will be necessary to reduce the potential damage when floods occur. Furthermore, it is also apparent that management of Okanagan Lake and Okanagan River discharges to Osoyoos Lake will not significantly reduce flood levels caused by backflows in the Similkameen.

As noted in Section 14.3.4, reductions of minimum flows down Okanagan River from 300 cfs to 100 cfs would cause Osoyoos Lake to drop below 911 feet until the Tonasket Creek sandbar became the control. Replacement of Zosel dam by a structure that did not leak whould maintain Osoyoos Lake levels close to 911 feet, but as the benefits of such a structure affect both Canadian and American interests, this sub-alternative should be referred to the International Joint Commission for further study.

CHAPTER 15

Water Quality Evaluations

The planning objectives for water quality management in the Okanagan Basin, as outlined in Chapter 12, are two-fold:

1. To provide a raw water quality compatible with consumptive uses of water for domestic, municipal, agricultural, and industrial purposes, with primary emphasis on protecting the health of Okanagan residents.
2. To provide a water quality consistent with a high quality environment for protection of the ecology and for water based recreation and aesthetics, particularly in the main valley lakes.

While these objectives are similar, the criteria and methods for achieving the objectives differ. The first requires limiting chemical elements and bacterial content in raw water supplies to levels that are not injurious to the health of man, or plants. The second requires controlling the amount of nutrients in surface waters to limit biological productivity (aquatic plant and algal growth) to levels that are acceptable for recreational and aesthetic pursuits, and for protection of the natural environment.

This chapter reviews the existing quality of water in the basin, discusses the effect of continued economic growth on water quality to the year 2020, and examines alternative ways in which these planning objectives may be achieved.

15.1 REVIEW OF EXISTING CONOITIONS

The results of water quality and limnology studies under the Canada-British Columbia Okanagan Basin Agreement (Chapter 5 and 6) have provided the following findings on the existing (1971) quality of water in the basin:

1. Most streams in the basin have one or more constituents which exceed acceptable concentrations based on health standards for drinking water and other consumptive uses. These include color, turbidity, iron, manganese, phosphorus, nitrogen and coliform. Streams in which major quality problems are evident include Vernon, Coldstream, Deep, Westbank, Kelowna, and Brandt's Creek. The main valley lakes meet acceptable raw water quality standards for drinking purposes and most other consumptive uses with the exception of Wood Lake which exhibits a low oxygen concentration in the summer months, and high phosphorus levels throughout the year.

2. Nutrient enrichment, and resulting increases in aquatic plant and algal growth, has occurred in varying degrees in all of the main valley lakes

over the past 50 to 100 years. The major source of these nutrients has been identified as tributary streams and municipal outfalls, although other sources including septic tanks, agriculture, and soil erosion, also affect local shoreline areas. Wood Lake in particular has declined to the point that recreational and social benefits have been adversely affected.

3. Phosphorus has been identified as the nutrient which may most successfully be controlled to limit algal and aquatic plant growth. This finding was based on limnological studies, the fact that tecnological means are available to remove this nutrient through waste treatment processes, and the fact that limiting this nutrient has proved successful in the control of weed and algal growth in other lakes in North America. While the control of phosphorus through waste treatment processes is considered the most important single measure that can be implemented to enhance the quality of the main valley lakes, decreasing other sources of phosphorus and eventually other nutrients through the control of stream erosion, green belts, and other measures outlined herein must also be considered over the long term.

4. While the level of waste treatment in the Okanagan Basin is considered comparable to or better than that in all other parts of Canada, some major problems are still evident. The influx of tourists in the summer months overloads existing waste treatment facilities resulting in a decline in the efficiency of waste treatment when it is most required. Existing waste treatment plants do not include facilities for the removal of phosphorus, with the exception of Penticton (and to some extent Vernon) where such facilities were initiated in 1971.

Over 50% of the population of the Valley are serviced by septic tank installations, yet most soils, adjacent to the main valley lakes where the bulk of this population is located have very limited suitability to remove nutrient loadings because of the coarse nature of the soils, and the shallow depth to groundwater.

One over-riding factor concerning the above findings and following evaluations, is the limited accuracy of some of the loading data, and the uncertainty involved in establishing phosphorus loading criteria for the main valley lakes because of their complex nature and the many factors that are difficult to quantify. Therefore while the basic objective of controlling phosphorus levels to acceptable assimilative capacities for each lake is considered a valid approach, the effect of implementing specific controls should be carefully monitored to ensure the desired results are being achieved.

15.2 PROJECTIONS OF WASTE LOADINGS

Future loadings of phosphorus to the main valley lakes have been estimated from present loading data, and from economic growth projections for the years 1980, 2000 and 2020 (Tables 15.1 to 15.6). Only the high and low projections are included to provide a range of potential future loadings, assuming a continuation of existing treatment policies. These tables also show the effect of various levels of phosphorus removal for the urban centers of Vernon, Kelowna, Penticton, and Oliver on total loadings from all sources.

Projections for municipal waste effluent discharged to the main valley lakes are based on a per capita loading of .008 pound of phosphorus per day (See Technical Supplement XI) and estimates of future populations for a low economic growth rate (Projection III) and a high economic growth rate (Projection II).

Industrial loadings are projected on the basis of dollar value and pounds or tons of output and have been broken down into the following categories for each of the four economic regions:

(1) Fruit and Vegetable Canners
(2) Wineries, Distilleries and Soft Drink Plants
(3) Sawmills and Plywood Mills
(4) Fruit Packers
(5) Ice Rinks and Fish Hatcheries

Projections for categories (1), (2), and (3) are on the basis of dollar values, category (4) is based on tons of product packed, while the loadings for category (5) are not assumed to change on the basis of current information.

The projection of waste loadings from storm sewers in the major centers of Vernon, Kelowna and Penticton is based on population increases.

Projected contributions from groundwater sources are based on the acreage of land under agricultural production for agricultural sources, and the projected rural population for septic tanks. Contributions from 'other' sources due to man's influence include such sources as: (1) fertilizers used in industrial operations such as airport runway de-icing; (2) household pets; (3) fertilizers used on lawns and gardens, and (4) ground discharge of industrial wastes. Projected contribution from these other sources, is based on factors similar to that of agricultural and septic tank sources.

No significant changes are expected to occur in the natural loadings from streams and groundwater, or in dustfall and precipitation loadings.

Part of the groundwater return flow from agriculture and septic tank sources returns to surface waters in streams and has been measured as tri-

TABLE 15.1

PRESENT AND PROJECTED LOADINGS OF TOTAL PHOSPHO[illegible]
TO KALAMALKA LAKE FROM EXTERNAL SOURCES (IN POUND[illegible].

(Loading Criteria for Acceptable Water Quality = 6600 to 8800 Pounds Total Phosphorus per Year.)

SOURCE / PROJECTION	ESTIMATED LOADINGS IN 1971 BASED ON 1969-71 DATA POUNDS	PROJECTED LOADINGS POUNDS 1980	PROJECTED LOADINGS FOR THE YEAR 2000		PROJECTED LOADINGS FOR THE YEAR 2020	
			Low Economic Growth (III)	High Economic Growth (II)	Low Economic Growth (III)	High Economic Growth (II)
1. TRIBUTARY STREAMS						
- Excluding Agriculture and Septic Tank Sources	3080	3080	3080	3080	3080	3080
- Agricultural Source Loadings to Streams *1	20	20	20	20	20	20
- Septic Tank Source Loadings to Streams *1	500	760	1220	1360	1580	2400
Sub-total - Tributary Streams	3600	3860	4320	4460	4680	5500
2. DUSTFALL AND PRECIPITATION	600	1600	1600	1600	1600	1600
3. INDUSTRIAL	-	-	-	-	-	-
4. GROUNDWATER						
- Agricultural Sources	20	20	20	20	20	20
- Septic Tank Sources	Range*2 440 to 940	1460	2300	2560	3000	4540
- Natural Sources	20	20	20	20	20	20
- Other	-	-	-	-	-	-
Sub-total Groundwater	980	1500	2340	2600	3040	4580
TOTAL - ALL SOURCES	5180	6960	8260	8660	9320	11680

*1 Groundwater and surface runoff loadings which return to stream surface waters and were measured as tributary stream loadings.

*2 Estimated range of probable loadings from septic tanks. Maximum values based on per capita contribution of phosphorus from standard septic tank installations and have been used in all projections. Minimum values are based on short duration pilot study results.

TABLE 15.2

PRESENT AND PROJECTED LOADINGS OF TOTAL PHOSPHORUS TO WOOD LAKE FROM EXTERNAL SOURCES (IN POUNDS)

(Loading Criteria for Acceptable Water Quality = 2000 to 3000 Pounds Total Phosphorus per Year.)

SOURCE / PROJECTION	ESTIMATED LOADINGS IN 1971 BASED ON 1969-71 DATA POUNDS	PROJECTED LOADINGS POUNDS 1980	PROJECTED LOADINGS FOR THE YEAR 2000		PROJECTED LOADINGS FOR THE YEAR 2020	
			Low Economic Growth (III)	High Economic Growth (II)	Low Economic Growth (III)	High Economic Growth (II)
1. TRIBUTARY STREAMS*3						
- Excluding Agriculture and Septic Tank Sources	800	800	800	800	800	800
- Agricultural Source Loadings to Streams *1	-	-	-	-	-	-
- Septic Tank Source Loadings to Streams *1	-	-	-	-	-	-
Subtotal - Tributary Streams	800	800	800	800	800	800
2. DUSTFALL AND PRECIPITATION	140	140	140	140	140	140
3. INDUSTRIAL	20	20	20	20	20	20
4. GROUNDWATER						
- Agricultural Sources	400	360	360	260	300	220
- Septic Tank Sources	Range*2 780 to 1660	3080	5900	6560	9120	13440
- Natural Sources	40	40	40	40	40	40
- Other	260	480	920	1000	1440	2100
Subtotal Groundwater	2360	3960	7220	7860	10900	15800
TOTAL - ALL SOURCES	3320	4920	8180	8820	11860	16760

*1 Groundwater and surface runoff loadings which return to stream surface waters and were measured as tributary stream loadings.

*2 Estimated range of probable loadings from septic tanks. Maximum values based on per capita contribution of phosphorus from standard septic tank installations and have been used in all projections. Minimum values are based on short duration pilot study results.

*3 Includes inflow from Vernon Creek to Wood Lake

TABLE 15.3

PRESENT AND PROJECTED LOADINGS OF TOTAL PHOSPHORUS
TO OKANAGAN LAKE FROM EXTERNAL SOURCES (IN POUNDS)

(Loading Criteria for Acceptable Water Quality =
135000 to 185000 Pounds Total Phosphorus Per Year)

PROJECTION / SOURCE	ESTIMATED LOADINGS IN 1971 BASED ON 1969-71 DATA POUNDS	PROJECTED LOADINGS POUNDS 1980				PROJECTED LOADINGS FOR THE YEAR 2000 Low Economic Growth (III)				High Economic Growth (II)				PROJECTED LOADINGS FOR THE YEAR 2020 Low Economic Growth (III)				High Economic Growth (II)			
DEGREE OF PHOSPHORUS REMOVAL		1971	30%	80%	90%	1971	30%	80%	90%	1971	30%	80%	90%	1971	30%	80%	90%	1971	30%	80%	90%
1. TRIBUTARY STREAMS																					
- Excluding Agricultural and Septic Tank Sources	60500	60500				60500				60500				60500				60500			
- Agricultural Source Loadings to Streams *1	2820	3480				5000				4840				6450				6260			
- Septic Tank Source Loadings to Streams *1	4560	6720				10060				11380				12820				19040			
Subtotal - Tributary Streams	67880	70700				75560				76720				79780				85800			
2. MAIN VALLEY STREAM (Vernon Creek from Kalamalka Lake excluding Vernon S.T.P.)	1600	1600				1600				1600				1600				1600			
3. MUNICIPAL - 1971 Treatment - 30% Phosphorus Removal - 80% Phosphorus Removal - 90% Phosphorus Removal	82160	114940	102220	29200	14680	158800	140740	40200	20120	190440	168780	48220	24100	181520	160140	45740	22880	26940	237540	67860	33920
4. DUSTFALL AND PRECIPITATION	19600	19600				19600				19600				19600				19600			
5. INDUSTRIAL	1600	2720				4200				4100				5400				5060			
6. STORM SEWERS	600	780				1020				1180				1160				1720			
7. GROUNDWATER																					
- Agricultural Sources	520	500				520				400				520				380			
- Septic Tank Sources	Range*2 5360 to 11060	11960				17240				19450				20980				31200			
- Natural Sources	2060	2060				2060				2060				2060				2060			
- Other Sources	240	300				460				500				540				800			
Subtotal - Groundwater	13880	14820				20280				22420				24000				34440			
TOTAL - ALL SOURCES	187320	225160	212440	139420	124820	281060	253000	172460	142380	316060	294400	173840	149720	313060	291680	177280	154420	417460	385760	216080	182140

*1 Groundwater and surface runoff loadings which return to stream surface waters and were measured as tributary stream loadings.

*2 Estimated range of probable loadings from septic tanks. Maximum values based on per capita contribution of phosphorus from standard septic tank installations and have been used in all projections. Minimum values are based on short [illegible]
[illegible]

TABLE 15.4

PRESENT AND PROJECTED LOADINGS OF TOTAL PHOSPHORUS TO SKAHA LAKE FROM EXTERNAL SOURCES (IN POUNDS)

(Loading Criteria for Acceptable Water Quality = 30000 to 40000 Pounds Total Phosphorus Per Year)

SOURCE / PROJECTION	ESTIMATED LOADINGS IN 1971 BASED ON 1969-71 DATA POUNDS	PROJECTED LOADINGS POUNDS 1980				PROJECTED LOADINGS FOR THE YEAR 2000 Low Economic Growth III				PROJECTED LOADINGS FOR THE YEAR 2000 High Economic Growth II				PROJECTED LOADINGS FOR THE YEAR 2020 Low Economic Growth III				PROJECTED LOADINGS FOR THE YEAR 2020 High Economic Growth II			
DEGREE OF PHOSPHORUS REMOVAL		1971	30%	80%	90%	1971	30%	80%	90%	1971	30%	80%	90%	1971	30%	80%	90%	1971	30%	80%	90%
1. TRIBUTARY STREAMS																					
- Excluding Agricultural and Septic Tank Sources	3640	3640				3640				3640				3640				3640			
- Agricultural Source Loadings to Streams *1	340	340				340				340				340				340			
- Septic Tank Source Loadings to Streams *1	220	300				420				480				480				720			
Subtotal - Tributary Streams	4200	4280				4400				4460				4460				4700			
2. MAIN VALLEY STREAM (Okanagan River from Okanagan Lake)	10600	10600				10600				10600				10600				10600			
3. MUNICIPAL																					
- 1971 Treatment*3	28900	37120				49280				59020				54300				80460			
- 30% Phosphorus Removal			49020				65100				77940				71720				106280		
- 80% Phosphorus Removal				14000				18600				22280				20500				30360	
- 90% Phosphorus Removal					7000				9300				11140				10240				15180
4. DUSTFALL AND PRECIPITATION	1660	1660				1660				1660				1660				1660			
5. INDUSTRIAL	140	260				320				300				340				300			
6. STORM SEWERS	100	120				160				200				180				280			
7. GROUNDWATER																					
- Agricultural Sources	40	40				40				40				40				40			
- Septic Tank Sources	*2 1260 to 2600	3480				4780				5520				5520				8280			
- Natural Sources	160	160				160				160				160				160			
- Other Sources	60	120				120				120				120				180			
Subtotal - Groundwater	2860	3800				5100				5840				5840				8660			
TOTAL - ALL SOURCES	48460	57840	69740	34720	27720	71520	87340	40840	31540	82080	101000	45340	34200	77380	94800	43500	33320	106600	132480	56560	41380

*1 Groundwater and surface runoff loadings which return to stream surface waters and were measured as tributary stream loadings.

*2 Estimated range of probable loadings from septic tanks. Maximum values based on per capita contribution of phosphorus from standard septic tank installations and have been used in all projections. Minimum values are based on short duration pilot study results.

*3 Values based on 1972-73 Efficiency of Penticton Tertiary Treatment Unit

TABLE 15.5

PRESENT AND PROJECTED LOADINGS OF TOTAL PHOSPHORUS TO VASEUX LAKE FROM EXTERNAL SOURCES (IN POUNDS)

(Loading Criteria for Acceptable Water Quality = 17500 to 22000 Pounds of Total Phosphorus Per Year)

SOURCE \ PROJECTION	ESTIMATED LOADINGS IN 1971 BASED ON 1969-71 DATA POUNDS	PROJECTED LOADINGS POUNDS 1980				PROJECTED LOADINGS FOR THE YEAR 2000								PROJECTED LOADINGS FOR THE YEAR 2020							
						Low Economic Growth III				High Economic Growth II				Low Economic Growth III				High Economic Growth II			
DEGREE OF PHOSPHORUS REMOVAL		1971	30%	80%	90%	1971	30%	80%	90%	1971	30%	80%	90%	1971	30%	80%	90%	1971	30%	80%	90%
1. TRIBUTARY STREAMS																					
- Excluding Agriculture and Septic Tank Sources	-	-				-				-				-				-			
- Agricultural Source Loadings to Streams *1	-	-				-				-				-				-			
- Septic Tank Source Loadings to Streams *1	260	380				640				720				840				1240			
Subtotal - Tributary Streams	260	380				640				720				840				1240			
2. MAIN VALLEY STREAM																					
- Okanagan River at Vaseux Lake - Base Loading	18800	18800				18800				18800				18800				18800			
3. EFFECT OF DEGREE OF TREATMENT AT PENTICTON ON BASE LOADING (Phosphorus Removal)																					
- Present level of Treatment (1971)		+8220				+19900				+30120				+25400				+51560			
- 30% Removal			+20120				+35460				+49040				+42820				+77380		
- 80% Removal				-1540				-1100				-80				-880				+1460	
- 90% Removal					-2280				-2040				-1900				-1940				-1400
4. OUSTFALL AND PRECIPITATION	40	40				40				40				40				40			
5. GROUNDWATER																					
- Agriculture Sources	20	20				20				20				20				20			
- Septic Tank Sources	*2 140-280	420				700				760				900				1300			
- Natural Sources	80	80				80				80				80				80			
- Other Sources	20	-				-				-				-				-			
Subtotal - Groundwater	400	520				800				860				1000				1400			
TOTAL - ALL SOURCES	19500	27950	39860	18200	17460	40180	55740	19180	18240	50540	69480	20340	18520	46080	63500	19800	18740	73040	98860	22940	20080

*1 Groundwater and surface runoff loadings which return to stream surface waters and were measured as tributary stream loadings.

*2 Estimated range of probable loadings from septic tanks. Maximum values based on per capita contribution of phosphorus from standard septic tank installations and have been used in all projections. Minimum values are based on short duration pilot study results.

TABLE 15.6

PRESENT AND PROJECTED LOADINGS OF TOTAL PHOSPHORUS TO OSOYOOS LAKE FROM EXTERNAL SOURCES (IN POUNDS)

(Loading Criteria for Acceptable Water Quality = 26000 to 37000 Pounds Total Phosphorus Per Year)

SOURCE / PROJECTION	ESTIMATED LOADINGS IN 1971 BASED ON 1969-71 DATA POUNDS	PROJECTED LOADINGS POUNDS 1980				PROJECTED LOADINGS FOR THE YEAR 2000								PROJECTED LOADINGS FOR THE YEAR 2020							
						Low Economic Growth (III)				High Economic Growth (II)				Low Economic Growth (III)				High Economic Growth (II)			
DEGREE OF PHOSPHORUS REMOVAL		1971	30%	80%	90%	1971	30%	80%	90%	1971	30%	80%	90%	1971	30%	80%	90%	1971	30%	80%	90%
1. TRIBUTARY STREAMS																					
- Excluding Agricultural and Septic Tank Sources	700	700				700				700				700				700			
- Agricultural Source Loadings to Streams *1	60	60				60				60				60				60			
- Septic Tank Source Loadings to Streams *1	40	60				60				80				80				100			
Subtotal - Tributary Streams	800	820				820				840				840				860			
2. MAIN VALLEY STREAM																					
- Base Loading of Okanagan River excluding Oliver S.T.P.	22140	22140				22140				22140				22140				22140			
3. EFFECT OF DEGREE OF TREATMENT AT PENTICTON ON BASE LOADING - Present Level of Treatment - 30% Phosphorus Removal - 80% Phosphorus Removal - 90% Phosphorus Removal	-	+8220	+20120	-1540	-2280	+19900	+36200	-1100	-2040	+30120	+49040	- 80	-1900	+25400	+42820	-880	-1940	+51560	+77380	+1460	-1400
4. INCREMENTAL LOADING TO OKANAGAN RIVER ENROUTE	-	1480				2880				3460				3640				6440			
5. MUNICIPAL - Loadings from Oliver Treatment Plant to Okanagan River and Osoyoos Lake - 1971 Treatment - 30% Phsophorus Removal - 80% Phosphorus Removal - 90% Phosphorus Removal	4060	4340	3580	1020	520	4600	3780	1080	540	5620	4620	1320	660	4600	3780	1080	540	6120	5040	1440	720
6. OUSTFALL AND PRECIPITATION	980	980				980				980				980				980			
7. INDUSTRIAL	200	300				380				360				420				360			
8. STORM SEWERS	-	-				-				-				-				-			
9. GROUNDWATER																					
- Agricultural Sources	520	540				500				480				520				500			
- Septic Tank Sources	Range*2 4160 - 8560	12240				16760				17860				17940				25660			
- Natural Sources	200	200				200				200				200				200			
- Other Sources	60	80				80				140				120				140			
Subtotal - Groundwater	9340	13060				17540				18660				18780				26500			
TOTAL - ALL SOURCES	37520	51340	62480	38260	37020	69240	84720	44720	43240	82180	100300	47680	45200	76800	93400	47000	45400	114960	139700	60180	56600

*[1] Groundwater and surface runoff loadings which return to stream surface waters and were measured as tributary stream loadings.

*[2] Estimated range of probable loadings from septic tanks. Maximum values based on per capita contribution of phosphorus from standard septic tank installations and have been used in all projections. Minimum values are based on short duration pilot study results.

butary stream loadings. Estimates of these contributions were therefore made and deducted from the tributary stream total to provide the figures shown under tributary streams in Tables 15.1 to 15.6.

The amount of phosphorus carry-over in Okanagan River between Skaha Lake and Osoyoos Lake has been estimated from the graph shown in Figure 15.1. The assumptions used in developing this graph are as follows:

(1) Depletion of phosphorus occurs with time, below the major source.
(2) The variables - stream flow, time, and distance are interchangeable.
(3) Under present conditions the river has assimilated total phosphorus and nitrogen to a minimum level. Any loading higher than present (1969-71) conditions is therefore represented by a parallel curve.
(4) Any loading less than the present one (1969-71) may be estimated by interpolation between the present and natural state curve.
(5) The minimal loading possible increases to a maximum of ten per cent under zero municipal input.
(6) The input from Okanagan Lake is relatively constant.

The carry-over values as calculated represent the change from present loadings that may occur with future increases or decreases in the amount of nutrient loading from the City of Penticton Sewage Treatment Plant. Negative values of carry-over therefore represent a decrease in the loadings to be expected from this source.

Projected nitrogen loadings have also been calculated and included in Technical Supplement IV.

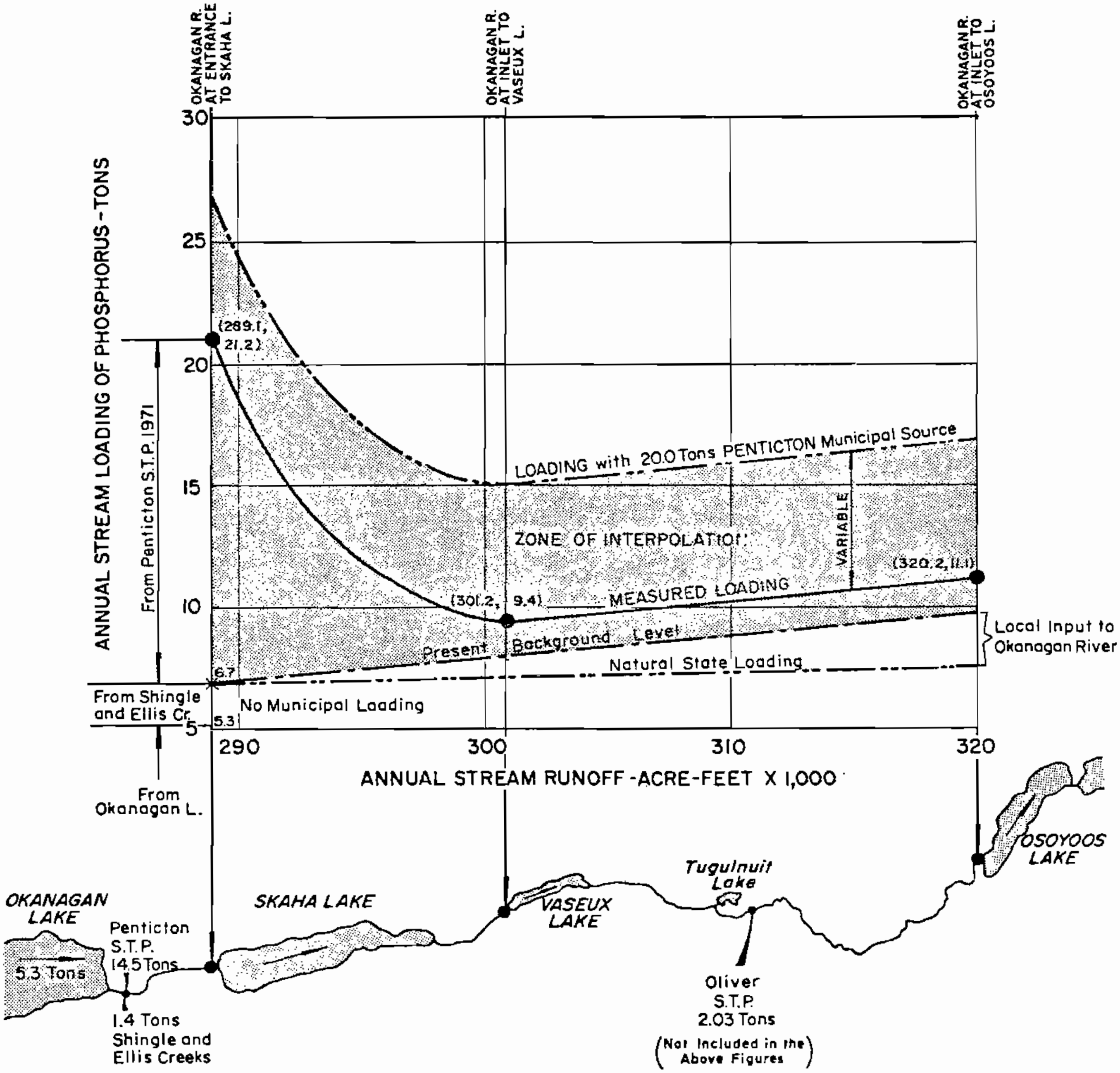
5.3 WATER QUALITY FOR CONSUMPTIVE USE

This analysis is primarily concerned with water quality alternatives to meet consumptive use objectives in tributary streams. The quality of the main valley lakes is either acceptable for consumptive use purposes, or can only be controlled through limiting pollutants entering the lakes from tributary streams and direct waste outfall discharges. The latter will be discussed under Section 15.4.

Because of the diffuse nature of most pollutants entering the streams, and the difficulty in controlling these, the evaluations for quality control in streams are highly subjective.

15.3.1 Rationale for Stream Water Quality Evaluations

The generally accepted allowable criteria for raw water sources was presented in Table 5.1, Chapter 5. Many streams are approaching or now exceed these criteria for specific quality parameters. Of most concern are those pollutants which are harmful to the health of man, or injurious to fish,



PHOSPHORUS CARRYOVER IN THE OKANAGAN RIVER SYSTEM

Figure 15.1

such as high coliform levels, and high nutrient levels. The origin of these pollutants is primarily from point sources in the developed areas of the basin including industrial and municipal waste discharges to streams and cattle feedlots, riding stables, and poultry farms adjacent to streams. Soil erosion resulting from forestry and agricultural operations, particularly logging road construction, also contributes a significant amount of sediment containing nutrients to tributary streams. Because the amount of waste material that various streams can assimilate varies from creek to creek, from month to month, and from year to year, depending on the size of the sub-basin and the amount of available runoff, it is difficult if not impractical to establish general stream loading or effluent standards to meed acceptable criteria for stream water quality in the Okanagan Basin. Also, there are few streams in the basin that carry sufficient water on a year round basis to assimilate any waste products other than natural pollutants from the basin itself. Therefore the removal of all municipal and industrial discharges containing pollutants is required to achieve established water quality standards in most streams. However, where such waste discharges can be proved acceptable and free of pollutants, the additional water provided by such discharges is often beneficial, and should be encouraged. Community or regional treatment plants would be the most suitable in achieving the above objective particularly in respect to industrial outfalls.

Logging-road construction and land cultivation adjacent to streams are major sources of soil erosion from surface runoff. Eroded soils greatly increase the turbidity of water, and provide a base in lakebeds for rooted aquatic vegetation. They also contribute a substantial amount of nutrients and other chemical elements to the main valley lakes. Improved landuse managment over a period of time may reduce such erosion, but continued monitoring and surveillance of stream water quality may also indicate the need for appropriate green belts (Strips of permanent vegetation) along the entire course of streams where logging and cultivation are practiced. Such green belts must be maintained to ensure their effectiveness in minimizing soil erosion and stream pollution.

The remaining increases in stream loadings are expected to come from forestry operations, diffuse agricultural sources, and septic tanks. No estimate of the future contribution from forestry operations has been made, but if there is no increase in the annual amount of timber harvested, there should be no significant increase in loading from this source to the basin as a whole. The tributaries affected, however, will depend on the areas being logged and the care taken to keep logging road and other construction away from streams.

Projections of phosphorus loadings from diffuse agricultural sources and septic tanks to tributary streams are included in Table 15.1 to 15.6. These show significant increases to the year 2020 for streams tributary to Okanagan Lake. Agricultural source loadings are expected to increase from 2800 pounds in 1971 to 6500 pounds per year in 2020. Septic tank loadings are expected to increase from 4500 in 1971 to 13,000 pounds per year in 2020 under a low economic growth rate, assuming no change in waste treatment policy. Projected phosphorus loadings from septic tank sources located near streams tributary to Kalamalka Lake are also expected to increase from 20 pounds in 1971 to 1600 pounds per year in 2020 under a low economic growth rate. Changes in source loadings to streams tributary to the other main valley lakes are estimated to be relatively minor.

Livestock may also contribute high levels of fecal coliform from feedlots and confined animal housing units. Future levels of coliform from these operations will be dependent on the numbers of livestock in a sub-basin, and farm management practices, but no projection has been made on this aspect.

One additional source of stream pollution which has not been estimated is the effect of the use of the headwater lakes for angling and recreation. The number of angler days on these lakes is expected to increase from 71,000 in 1971 to between 190,000 and 246,000 by 2020, which will greatly increase the opportunity for increased waste disposal and pollution of these waters. The headwaters of the basin have not been used extensively for other forms of recreation to date, but this may change as access improves and the population of the valley increases.

15.3.2 Alternatives (Stream Water Quality)

The continuation of present management practices for water quality in the tributary streams, while an option, would mean that most stream water would not be acceptable for consumptive use purposes without prior treatment. A continued decline in the existing quality should also be expected with economic growth over the next 50 years, resulting in more expensive treatment of these raw water sources with time if they are to be used for consumptive purposes.

The implementation of management policies to meet the objective of providing a water quality compatible with various consumptive uses, would require positive steps in the control waste discharges and land use practices. Alternatives considered include the following:

(a) Removal of Positive Waste Discharges

The removal of all direct municipal and industrial waste discharges causing pollution may be the only way in which the quality of many of the streams in their lower reaches can be improved to a level that will meet acceptable water quality standards. However, because the flow in the majority of streams during the greater part of the year is small, the return of unpolluted water from waste outfalls could help support fishery and other recreational uses. Waste treatment facilities that provide a high quality effluent should therefore be encouraged where such discharges can be proved acceptable and free of pollutants.

(b) Green Belts

The primary purpose of green belts is to prevent surface runoff, from urban and agricultural areas, reaching tributary streams directly. Green belts along the periphery of all tributary streams through developed areas could help reduce stream oxygen deficits and high coliform levels resulting from agricultural and urban developments. These green belts in the form of natural cover, grass, and trees, and elevated where necessary would ensure that all surface runoff waters pass through a soil column before reaching a stream. This would provide a filter and form of treatment for surface runoff from cattle feedlots, riding stables, poultry farms, and pastured grassland, etc. located near streams but outside of the green belt area. While this form of treatment would reduce coliform levels and oxygen deficits, the effect on nutrient loadings would be dependent on the soil type and cover crop and in most cases may be minimal.

Green strips between streams and logging roads would also reduce loadings from logging and other forestry operations in the headwaters of the basin. Streams on which these should be given special consideration are those that are important to the fishery resource including Mission, Vernon, Equesis and Trepanier Creeks.

(c) Agricultural and Watershed Management Practices

Certain land use practices in stream sub-basins may have a detrimental effect on stream water quality. In foresty operations these may include poor harvesting practices, forest fires, logging road construction adjacent to streams, erosion, and the application of chemicals for insect or growth control. Clear-cutting of forest areas causes accelerated nutrient loss to streams and effects the runoff by increasing the intensity of spring melt and storm runoff.

Logging methods which greatly disturb the soil cause increases in stream turbidity, nutrient concentrations, and sediment loads. Disturbance of stream banks and subsequent land slides caused by road construction expose soil to erosion and leaching.

Various agricultural practices affect stream quality through erosion or groundwater flow. Excess applications of fertilizers and manure, or application at the wrong time of the year, and excess irrigation can all result in increased nutrient loadings through groundwater return flows.

All of the above reflect management practices over which there is little direct control by governments. Education along with positive incentives for improving such landuse practices may be the only alternative for reducing loadings and improving stream quality in these management areas.

15.4 CONTROL OF AQUATIC PLANT AND ALGAL GROWTH IN THE MAIN VALLEY LAKES

Aquatic plant growth and algal blooms have become visually evident in parts of all the main valley lakes in recent years. These conditions will continue to worsen under existing waste management practices and will have an increasing detrimental effect on the enjoyment of these lakes from an economic, recreational and aesthetic viewpoint. The cause of this type of quality impairment has been identified as nutrient loadings in excess of that which the lake can assimilate, particularly those resulting from man-induced sources.

15.4.1 Rationale for Lake Water Quality Evaluations

To provide a basis for projecting the effect of nutrient loadings on each of the main valley lakes over the next 50 years, the maximum desirable concentration of phosphorus in each lake at spring overturn has been related to lake water quality and annual phosphorus loadings. This in turn, has provided tentative standards for the control of aquatic plant and algal growth in each of the lakes.

Reasons for the selection of phosphorus as the key nutrient in biological control were outlined in Chapter 6.

The 'assimilative capacity' of a lake may be defined as the percent of total energy intake required for the growth, respiration, and reproduction of plant life. This relationship may be expressed as:

$$\text{Assimilative Capacity} = \frac{\text{Nutrients required for plant growth, respiration and reproduction}/t}{\text{Total Nutrient Input}/t}$$

Where t - time in years

For each nutrient, trace element, and organic factor required for plant growth there is a relationship between supply and demand that can be expressed by the assimilative capacity. In oligotrophic lakes, the nutrient supply is so low that the input limits plant populations and seasonal growth is balanced by loss. In these cases the input is equal to the amount required to sustain existing plant life and the assimilative capacity approaches 1. In eutrophic lakes, supplies of most nutrients are in excess of demand and values of the assimilative capacity are less than 1. In these cases, factors such as available light, competition, or predation often limit growth to a greater extent than available nutrient supply. Wood Lake is an excellent example of this condition where phosphorus is super-abundant and other nutrients, or the above mentioned controls, regulate plant populations before the external supply is exhausted. Unfortunately this type of control is not imposed until nuisance levels of algal blooms and weed growth have been reached.

By limiting annual loadings of phosphorus to a lake, to that which can be assimilated within an acceptable level of biological production, high water quality can be maintained and future quality predicted, based on annual loadings. This approach has been used in establishing acceptable loading criteria for each of the main valley lakes. Since each lake will respond differently to a given nutrient load because of differences in mean depth, water renewal rates and other factors, these loading criteria will vary from lake to lake.

Values were set so as to achieve, within limits, an optimum level of biological production for multiple water use without the occurrence of nusiance algal blooms and extensive aquatic plant growth (Figure 15.2). These criteria apply primarily to macro-sources of nutrients and the lake as a whole, rather than to localized micro-sources of nutrients.

The values selected were based on information gained over the period 1969 to 1972 including the following:

(1) Current average load of total phosphorus to each lake.
(2) Present mean concentration of total phosphorus and orthophosphorus at spring overturn.
(3) The sediment retention of phosphorus and internal loading where applicable,
(4) Average algal biomass based on chlorophyll a determinations,
(5) Average biomass of zoobenthos (bottom organisms) and zooplankton (suspended or free floating organisms) in relation to (1) and (4) above.

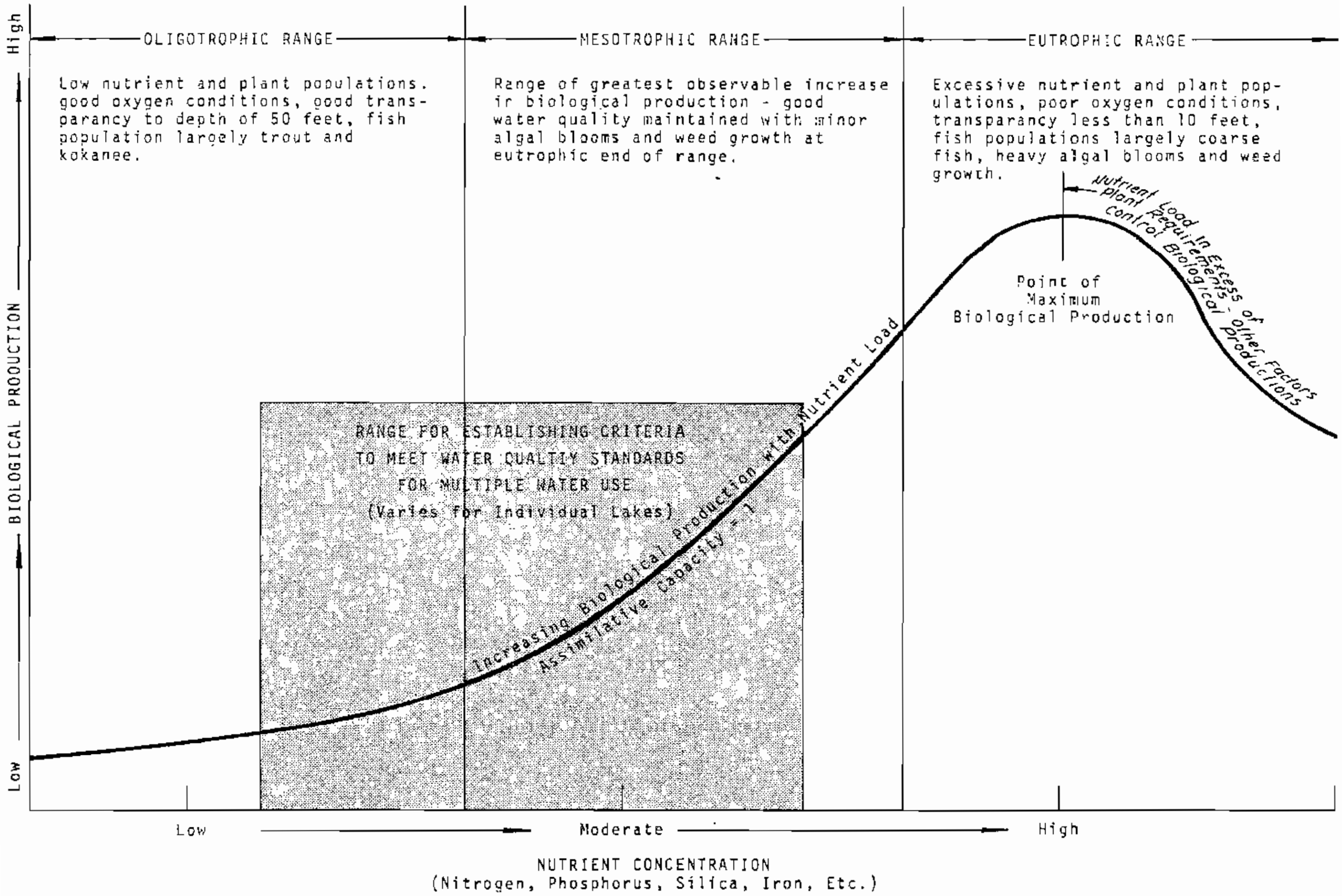
The present (1971) average concentrations of phosphorus at spring overturn, and suggested criteria for miltiple water use are shown in Table 15.7. The rationale for establishing specific criteria for each of the main valley lakes is summarized below:

(a) Okanagan Lake

The acceptable range for phosphorus loading to Okanagan Lake has been established at 135,000 to 185,000 pounds per year. Because certain areas of the lake exhibit eutrophic characteristics while the main body of the lake is oligotrophic, suggested maximum loadings to the north, central and south sections of the lake have also been computed. This separation was not based on any natural state, but was introduced to facilitate water quality evaluations for this lake.

(i) North Basin

Acceptable limits for phosphorus loading to this basin were set at 55,000 to 75,000 pounds per year. These loadings are considered to be approximately equal to the assimilative capacity of existing plant biomass in the central portion of the basin which still exhibits excellent water quality A loading of 66,000 pounds per year should be considered the maximum, recognizing that in any given year the load may reach 75,000 pounds due to uncontrollable sources of phosphorus. These values apply to the entire north basin and should not be



SCHEMATIC DRAWING OF RELATIONSHIP BETWEEN NUTRIENT LOADINGS AND BIOLOGICAL PRODUCTION, AND RANGE FOR SELECTING LOADING CRITERIA FOR MAIN VALLEY LAKES.

Figure 15.2

TABLE 15.7

TOTAL PHOSPHORUS CONCENTRATIONS AND LOADING CRITERIA - MAIN VALLEY LAKES

LAKE	AVERAGE CONCENTRATION OF TOTAL PHOSPHORUS AT SPRING OVERTURN 1971		MAXIMUM DESIRABLE CONCENTRATION OF PHOSPHORUS AT SPRING OVERTURN FOR MULTIPLE WATER USE QUALITY STANDARDS		LOADING CRITERIA TO ACHIEVE DESIRABLE CONCENTRATIONS OF TOTAL PHOSPHORUS EQUALS	TROPHIC CHARACTER BASED ON NEW LOADING CRITERIA
	MICROGRAMS PER LITER		MICROGRAMS PER LITER		(ASSIMILATIVE CAPACITY)	
	Average	Range	Average	Range	Pounds per year	
Wood Lake	104	83-125	20	10-30	2,000 - 3,000	Meso-Eutrophic
Kalamalka Lake	8	4-12	5	1-10	6,600 - 8,800	Oligotrophic
Okanagan Lake (as a Unit)	7	2-12	5	1-10	135,000 - 185,000	Oligotrophic
-North Basin	-	-	-	-	55,000 - 75,000	"
-Central Basin	-	-	-	-	55,000 - 75,000	"
-South Basin	-	-	-	-	25,000 - 35,000	"
Skaha Lake	24	15-32	12	10-15	30,000 - 40,000	Mesotrophic
Vaseux Lake					17,500 - 22,000	Eutrophic
Osoyoos Lake	12	10-15	10	5-15	26,000 - 37,000	"

confused with point source loadings to small regions which may exhibit local effects of nutrient enrichment. The shallow North and Vernon Arms will continue to exhibit some aquatic plant growth due to basin characteristics and continuing diffuse loadings from the Armstrong and Vernon areas respectively.

(ii) Central Basin

Criteria for the central basin are the same as for the north basin and the same comments apply. Localized problems are expected to continue along the Kelowna foreshore.

(iii) South Basin

Values for this basin have been set lower than the previous two basins so that this relatively large section of the Okanagan Lake can act as a buffer for lakes below. Positive point sources are few in this section of the lake and the very large volume of excellent quality water should protect Penticton beaches from any nuisance aquatic plant growths and insure a low nutrient discharge from Okanagan Lake to Skaha Lake. Any proposed point sources should be kept out of this basin to maintain a sizeable reservoir of good quality water between Kelowna and the lake outlet at Penticton. A loading of 35,000 pounds per year should be considered an absolute maximum, again recognizing that values below this will further insure the maintenance of good water quality.

(b) Skaha Lake

Acceptable limits for phosphorus loadings to Skaha Lake range from 30,000 to 40,000 pounds per year. These somewhat high values take into account the very short retention time of water in this lake (one year) and the excellent source of good quality water flowing into Skaha Lake from Okanagan Lake.

If values remain within these established limits, good water quality should be achieved. Sporadic algal blooms may continue to occur along with moderate aquatic plant growth on the eastern shoreline, however the annual occurrence of heavy blue-green blooms will be eliminated.

(c) Osoyoos Lake

Phosphorus loading limits established for this lake range from 26,000 to 37,000 pounds per year. These values allow for the very rapid water renewal rate (residence time) which prevents the accumulation of large amounts of nutrients. The maintenance of phosphorus loads below 37,000 pounds per year should prevent extensive algal blooms and control aquatic plant growth to within manageable limits. Osoyoos Lake is largely dependent on the quality of water in Skaha Lake and in Okanagan River, and improvement in the quality of these lake and river waters will also benefit Osoyoos Lake.

(d) Kalamalka Lake

Loading limits for Kalamalka range from 6,600 to 8,800 pounds per year. This is much lower than for the other lakes because of the small volume of inflow and the long retention time of water in this lake. Its calcium carbonate cycle may partially buffer it from nutrient overload, but any large increase in phosphorus loadings may cause this carbonate system to collapse. The lake is already an effective plankton producer as evidenced in bioassay studies and recent paleolimnological investigations. If phosphorus loadings can be curtailed to within these proposed limits, the lake should maintain its present excellent condition.

(e) Wood Lake

Acceptable loadings established for Wood Lake are 2,000 to 3,000 pounds of phosphorus per year. These annual rates are no doubt above historical values, but below present levels. If these limits are met, and a continual source of good quality water reaches this lake, the occurrence of annual blue-green algal problems should be eliminated, as well as the need for periodic aquatic plant harvest. The lake will continue to be a productive lake,but not in the sense of objectionable nuisance organism. Clarity and oxygen levels will be improved and fisheries enhanced if these criteria are met. Because of the existing high internal loading of phosphorus in this lake a significant decrease in phosphorus loadings will be required initially to effect any change in its condition. The lower loading criteria value of 2,000 pounds should therefore be used until a significant improvement in the quality of Wood Lake has been achieved.

The higher inflows and reduced retention time of water in this lake, due to industrial cooling water discharge, should speed the recovery of this lake, but will have no immediate effect on its quality.

(f) Vaseux Lake

Acceptable loadings for this lake range between 17,500 and 22,000 pounds of phosphorus per year. The achievement of these standards depends primarily on improving the quality of Skaha Lake and Okanagan River water. Extensive aquatic plant growth will always be an integral part of this lake, due to its shallowness and rich bottom sediments. This habitat is considered suitable for this lake as it has been established as a wildlife sanctuary.

15.4.2 Alternatives (Lake Water Quality)

As stated previously, the continuation of existing waste management practices will result in a continuing decline in the water quality of the main valley lakes from a recreation and aesthetic viewpoint.

Waste management alternatives reviewed in this report to meet the objective of a water quality consistent with a high quality environment are as follows:

(1) Waste Export from the Basin

(2) Outfall Discharge Locations

(3) Green Belts

(4) Flushing through Increased Flows

(5) Waste Treatment
   - Phosphorus Removal
   - Costs and Benefits of Phosphorus Removal
   - Waste management

Discussion of the first four alternatives is subjective because of the difficulty in quantifying benefits and costs. The first is a direct alternative to waste treatment, while the latter three provide methods for improving water quality either alone or in combination with other alternatives.

The fifth alternative involving advanced waste treatment processes is considered the most important in terms of maintaining or improving water quality in the main valley lakes for recreation and aesthetic purposes. Discussions on this alternative include preliminary estimates of the cost and benefit of various levels of phosphorus removal, and waste management requirements.

(a) Waste Export from the Basin

This method of controlling nutrient input to the Main Valley Lakes would involve pumping treated effluent from municipal sewage treatment plants to a remote area of an adjacent drainage basin for disposal. Only the three major centers of Vernon, Kelowna and Penticton have been considered for a preliminary review of this concept. The proposal would require the construction of pumping stations and transporting pipelines for each municipal regions.

Disposal sites which could be used for the three centers are as follows:

- City of Vernon - 12 1/2 miles east near Spider Creek in the South Thompson River Drainage Basin; 580 feet above Vernon.
- City of Kelowna- 20 miles east near Hydraulic Lake in the Kettle River Drainage Basin. The elevation above Kelowna is 2950 feet.
- City of Penticton - 14 miles southwest near Green Mountain in the Similkameen River Drainage Basin. The elevation above Penticton is 1850 feet.

Preliminary cost estimates for simply transporting treated effluent from the urban treatment plants to the point of disposal, show these to be comparable to spray irrigation for phosphorus removal and about twice the cost of phosphorus removal by chemical precipitation.

Excluding the above cost comparison, major disadvantages associated with waste export are:

(i) The effect these discharges would have on the quality of water in adjacent basins is unknown but could be just as detrimental as it has been in the Okanagan Basin. In this case the problem would have just been transferred from one basin to another.

(ii) The export of such wastes would remove as much as 20,000 acre feet of water per year from the basin, which in low flow years could present a significant amount in terms of water supply. The loss of such water would represent a cost against the waste export alternative.

(iii) Problems of waste export disposal in the winter months may be the same as for spray irrigation. This factor has not been taken into account in estimating waste export costs.

Based on the above considerations waste export has not been entertained as a **viable alternative to waste treatment** within the Okanagan Basin.

(b) Outfall Discharge Locations

This alternative considers the effect of existing outfall locations on local water quality, and the value, if any, of relocating these discharges. While this alternative would not reduce the total nutrient load to a lake, it could provide for short term improvements to the water quality of public beaches, which may have limited use for recreation because of poor water quality. Only the outfalls from the six major municipal centers of Armstrong, Vernon, Penticton, Kelowna, Oliver and Westbank have been considered in this evaluation. The existing locations of these outfalls and the problems that arise from their locations in respect to recreation and aesthetic values are shown in Table 15.8 .

The effects shown apply only to the main receiving body of water and not to the creeks themselves.

From a limnological standpoint, extending or deepening out-fall discharges or adding diffusers simply moves the problem of nutrient enrichment and biological production from one point in a lake to another. Disposing of wastes to deep water locations does avoid unsightly scum and may keep the nutrients away from sunlight and algae during the summer months, but during spring and fall overturn these nutrients will become equally distributed throughout the water column. Problems with plant growth may then be magnified in the following year in direct proportion to the annual increase in nutrients. Any proposal for relocating outfall discharges for improvement of public beaches or for other reasons, should therefore be considered only in conjunction with the removal of major nutrient sources.

TABLE 15.8

EFFECT OF OUTFALL LOCATION ON LOCAL WATER QUALITY

MUNICIPALITY	OUTFALL LOCATION	EFFECT ON LOCAL LAKE QUALITY
Armstrong	Deep Creek which empties into North Arm of Okanagan Lake.	The North Arm has had extensive weed growth for many years and supports a varied population of wildlife. Since not developed for recreation no change in location is warranted.
Vernon	Vernon Creek which empties into Vernon Arm of Okanagan Lake	Extensive weed growth which requires harvesting. Affects Kin Beach and extensive private shoreline development. Coliform counts on Kin Beach sometimes exceed acceptable criteria.
Kelowna	Okanagan Lake	Nuisance weed growth along shoreline. continued enrichment of this area will have increasing affect on Kelowna City Beach.
Westbank	Westbank Creek which flows into Okanagan Lake	Nuisance weed growth along shoreline of Okanagan Lake.
Penticton	Okanagan River which flows into Skaha Lake	No effect on Skaha Beach - some weed growth effect on undeveloped shoreline on west side of lake.
Oliver	Okanagan River	No visual detrimental effects on Okanagan River.

The one area that would appear to benefit from a change in outfall location is that of the Vernon Arm, particularly in respect to Kin Beach, which is one of the few large public beaches in this area. The relocation of the Vernon sewage Treatment Plant outfall would mean removing the discharge from Vernon Creek and using land disposal or constructing a new discharge line to a deep section of Okanagan Lake. The cost of this relocation is estimated at $1,000,000. This can be compared against other alternatives such as spray irrigation of secondary treated effluent.

The other existing outfall locations appear acceptable providing treatment and phosphorus removal requirements meet established criteria.

c) Green Belts - Main Valley Lakes and Okanagan River

While very limited research has been carried out on this aspect certain general comments may be made.

Three main sources may be identified as contributing nutrients and excessive coliform counts to the main valley lakes and Okanagan River from surface runoff in areas immediately adjacent to the lakeshore:

- The erosion of soils from cultivated agricultural lands, and road and other forms of construction adjacent to surface waters;
- Surface runoff from confined livestock enterprises, such as cattle feedlots, riding stables, and poultry farms;
- Surface runoff from highly populated areas which is not collected by storm sewer systems:

No estimate has been made of the overall nutrient contribution of these sources although from limited field studies, the amounts from erosion and animal wastes would appear to be significant. Good management practices should include containing the surface runoff from such sources so that it will receive some treatment by filtration through the ground before reaching surface waters. The simplest way of achieving this would be to move these sources away from surface streams and provide greenbelts between these sources and surface waters. These green strips could be used for park areas, trees and open pasture provided they were properly managed.

While it may not be feasible to consider greenbelts around all of the main valley lakes and along Okanagan River they could be considered for all undeveloped areas to ensure there is no additional loadings from such sources. It is also suggested that the construction of future main highways be kept away from the lake shoreline to avoid erosion problems and discourage associated urban and industrial development of the lake and river shoreline areas.

(d) Flushing Through Increased Flows

This proposal involves using additional water to increase the outflow of nutrients from a lake, thus lowering the concentration of nutrients and their retention time in a lake. Additional water would have to come from large scale importation, or in the case of Wood and Kalamalka Lakes by pumping from Okanagan Lake. The proposal assumes that the additional water use for flushing would have a higher quality than that existing in the lake which is being flushed.

This proposal is not considered viable for Okanagan Lake, because of the very large volume of the lake in relation to the limited amount of water that could economically be imported, and because of the present high quality of this lake compared to the quality of any imported water which might be available. The downstream lakes of Skaha, Vaseux and Osoyoos already have renewal times of one year or less, and it is considered unlikely that small additional flows would improve the quality of these lakes.

The explanation for the apparent insensitivity of these lakes to higher inflows, lies in part in the dynamics of the phosphorus cycle. Simply stated, phosphorus is taken up within minutes by algae, retained in the cell for a matter of hours or days, depending on the species, and then either sedimented or re-cycled. Thus the ebb and flow of phosphorus in the plant biomass can be measured in minutes or days, while the exchange of water in these lakes is measured in months or years. It therefore appears unlikely that minor changes in residence time for these lakes would play a substantial role in altering the present quality in Skaha or Osoyoos Lakes.

Wood Lake in the Vernon Creek sub-basin has a very small outflow (1971), long water retention time, and currently exhibits the poorest quality of the main valley lakes. Increased inflows of a reasonable magnitude and good quality would greatly reduce the renewal time of water in this lake and reduce the time required to improve its quality based on other nutrient control measures. This has already been accomplished to some extent by one of the industries in the Wood Lake area which commenced pumping cooling water from Okanagan Lake in 1972 and discharging it back into Vernon Creek above Wood Lake.

Historically, Wood Lake had a water renewal time of approximately 12 years. The construction or enlargement of storage reservoirs on the headwaters of Vernon Creek in 1908, 1931 and 1944, and the diversion of much of this water from Vernon Creek for irrigation purposes, reduced the inflow to this lake and increased the renewal time of water in Wood Lake to approximately 30 years. It is during this period of increased renewal time that Wood Lake is considered to have deteriorated the most rapidly. The recent addition of cooling water to this system again reduces the renewal time to approximately 13 years, which over a period of years should be of considerable value in improving the quality of water in this lake, providing other suitable measures are also taken to control nutrient input.

Kalamalka Lake, with an extremely good water quality, would not benefit from increased inflows, and in fact, these may be detrimental if the source is Wood Lake. If suitable nutrient control measures are undertaken to limit the total input of nutrients to this lake to the criteria outlined previously in this section, the present quality should be maintained.

(e) Waste Treatment

Nutrient sources to the main valley lakes are many and varied (Table 15.1 to 15.6) but one source - namely municipal outfalls - currently contributes approximately 50% of the total phosphorus loading to Okanagan, Skaha, and Osoyoos Lakes. Loading projections also indicate this percentage contribution will exceed 60% under a low economic growth rate, or 65% under a high economic growth rate, by the year 2020, assuming a continuation of current waste management practices.

Urban developments adjacent to Kalamalka and Wood Lake are serviced by septic tanks and it is estimated this source currently contributes 50% of the total phosphorus load to Wood Lake and 20% to Kalamalka Lake. Loading projections also indicate this percentage will increase to 75% by the year 2020 for Wood Lake and to 50% for Kalamalka Lake, based on a continuation of current waste treatment methods, and a low economic growth rate. Septic tank sources also contribute significant loadings to the other lakes which cause local nuisance conditions in areas of the lakes adjacent to these sources. The main alternative for improving or maintaining an acceptable level of water quality in the main valley lakes for multiple use purposes therefore involves advanced waste treatment processes for phosphorus removal. Multiple use is considered to include water for drinking purposes, irrigation, water contact sports and other forms of water-based recreation, fisheries and wildlife. The success of such advanced treatment processes is dependent on first attaining good conventional treatment, and where applicable, costs for upgrading existing facilities have been included. The three levels of phosphorus removal considered for municipal centers are as follows:

- Good conventional (secondary) activated sludge processes which removal approximately 30% of the phosphorus entering a sewage treatment plant:

- Physical or chemical precipitation of phosphorus following conventional treatment, which may remove up to 90% of the phosphorus input, depending on the degree of treatment required. Similar efficiencies may be obtained in lagoons, using chemical precipitation for phosphorus removal, where this form of treatment is more economical especially in the smaller urban centers.

- Spray irrigation of secondary effluent. The degree of removal in this case will depend on the location of the spray irrigation site, in respect to the groundwater table, the soil type, the crops grown, and the management care received. Under good conditions, removal of phosphorus by spray irrigation may be expected to be in excess of 90%. This form of advanced treatment also has the advantage of removing some other undersirable elements in the waste effluent including mercury and other trace elements.

The above forms of treatment are for macro-sources of nutrients which may affect a lake as a whole. Various combinations of these treatment processes for different muncipal centers may be used to reduce present or projected loadings to levels required to meet the criteria established for each of the main valley lakes.

The second form of waste treatment alternative involves septic tanks which may cause localized problems or in large numbers may contribute a significant nutrient input into a lake. In the case of single or small numbers of septic tank units adjacent to surface waters, it is proposed that these be upgraded to ensure that no more than 20% of the phosphorus in the effluent reaches groundwater where soil conditions are such that special measures are required to control nutrients from this source. Upgrading would include insuring tile fields are well above groundwater levels, a desirable distance from lake shorelines, and the importation of fine soils where necessary to prevent excessive percolation. For urban areas adjacent to Kalamalka, Wood, and Osoyoos Lakes, septic tanks would have to be replaced by sewage collection systems and waste treatment facilities (including phosphorus removal) to ensure that the necessary reductions in phosphorus loadings are achieved.

Minimum phosphorus removal requirements by advanced waste treatment processes to meet standards established for each of the main valley lakes are outlined below. It is re-emphasized that the accuracy of the loading data and the uncertainty of the loading criteria are such that continued monitoring of both loadings and lake quality are an essential part of this alternative to ensure that the desired results are being realized.

Regulations concerning the amount of phosphorus in household detergents were initiated by the Federal Government during the tenure of the Study, but the effect of these regulations on reducing phosphorus loadings to the main valley lakes has not been analysed.

(i) <u>Wood Lake</u>

The present condition of this lake is very poor with almost continuous algal blooms in the summer months and heavy aquatic plant growth along the shorelines. The current phosphorus loading has been estimated at 3300 pounds per year (average) of which approximately 50% is attributed to septic tank sources. Future loadings for both low and high economic growth projections (Projections II and III) for this area are shown in Table 15.9.

TABLE 15.9

PROJECTED PHOSPHORUS LOADINGS - WOOD LAKE

YEAR	PROJECTED AVERAGE ANNUAL PHOSPHORUS LOADINGS (pounds)		MINIMUM REDUCTION REQUIRED TO MEET ESTABLISHED CRITERIA (pounds)
	Low Economic Growth	High Economic Growth	
1980	5000	5000	3000
2000	8200	8800	6200 to 6800
2020	11900	16800	9900 to 14800

Because of the existing high internal loading of phosphorus in this lake - due in part to historical changes in the retention time of water in this lake - a significant decrease in the current phosphorus loadings is required to effect any change in its condition. Therefore the lower loading value of 2000 pounds has been used in estimating minimum phosphorus reductions required for Wood Lake. Due to its physical characteristics (volume, mean depth, and low volume of inflow) and the many diffuse nature of most nutrient sources, the lake will continue to be a biologically productive lake, but clarity and oxygen levels will be improved, and fisheries enhanced if the above reductions in phosphorus loadings are achieved.

The installation of a sewage collection and treatment plant in the urban center of Winfield, with facilities for 80% phosphorus removal would reduce present loadings by 1300 pounds, and 1980 loadings by 2400 pounds. Other forms of nutrient control such as eliminating outfall discharges and point source loadings to streams by 1980 should reduce total loadings to acceptable levels.

The higher inflows and reduced retention time of water in this lake, due to the recent additional industrial cooling water discharged to Vernon Creek should speed the recovery of this lake, but will have no immediate effect on its quality.

(ii) Kalamalka Lake

The relative fertility of this lake is high, but good quality conditions have been preserved by a natural self-cleansing system. Some aquatic plant growth is now occurring at the mouth of Coldstream Creek and in the south end of the lake. The present (1971) phosphorus loading to this lake has been estimated at 5200 pounds per year, of which approximately 20% is from septic tanks. These septic tank installations are nearly all in the Coldstream Creek area at the north end of the lake, and along with nutrients from Coldstream Creek itself are the main reasons for aquatic plant problems in this area. Future loading projections for this lake are shown in Table 15.10.

TABLE 15.10

PROJECTED PHOSPHORUS LOADINGS - KALAMALKA LAKE

YEAR	PROJECTED AVERAGE ANNUAL PHOSPHORUS LOADINGS (pounds)		MINIMUM REDUCTION REQUIRED TO MEET ESTABLISHED CRITERIA (pounds)
	Low Economic Growth	High Economic Growth	
1980	7000	7000	-
2000	8300	8400	600 - 700
2020	9300	11700	1600 - 4000

The acceptable limits for phosphorus loading to Kalamalka Lake have been established at 6600 to 8800 pounds per year, (average 7700 pounds). This should maintain an excellent quality of water in the lake as a whole particularly for recreation and aesthetic purposes, but will not protect shoreline areas from declining in quality due to local nutrient inputs from such sources as septic tanks. These loading limits are much lower than for the other lakes because of the small volume of inflow and relatively long retention time of water in this lake.

While total present loadings are below the established standards, curtailment of local sources of nutrients from septic tanks is considered necessary to protect beach and other recreational areas at the north end of the lake. A sewage collection system for the urban center of Coldstream with a trunk transport line to a central treatment plant at Vernon is considered the most practical solution for this local problem. This would effect 100% phosphorus removal in serviced areas and substantially reduce nutrient loadings to the Kalamalka Beach area.

(iii) Okanagan Lake

The main water mass of Okanagan Lake is still in excellent condition, but serious deterioration has occurred around shoreline areas of the lake which are affected by wastewater outfalls and shoreline development. Present and projected loadings to this lake are shown in Table 15.3. Because of the varying trophic conditions in this lake, this total loading has also been broken down to show the approximate contributions to the north central and south basins (Table 15.11). This breakdown does not take into account any internal exchanges of nutrients between lake sections resulting from physical or biological processes.

Over 40% of the current (1971) phosphorus loading comes from the two municipal outfalls of Vernon and Kelowna, while an additional 10% may be attributed to septic tank sources.

TABLE 15.11

PROJECTED PHOSPHORUS LOADINGS - OKANAGAN LAKE

(From External Sources)*1

YEAR	PROJECTED AVERAGE ANNUAL PHOSPHORUS LOADINGS (pounds)		MINIMUM REDUCTION REQUIRED TO MEET ESTABLISHED CRITERIA (pounds)
	Low Economic Growth	High Economic Growth	
North Section			
1971	69,000	69,000	3000
1980	82,000	82,000	16,000
2000	100,000	110,000	34,000 to 44,000
2020	107,000	146,000	41,000 to 80,000
Central Section			
1971	85,000	85,000	19,000
1980	107,000	107,000	41,000
2000	140,000	151,000	74,000 to 85,000
2020	161,000	220,000	95,000 to 154,000
South Section			
1971	33,500	33,500	3,500
1980	35,500	35,500	5,500
2000	38,500	40,000	8,500 to 10,000
2020	40,000	45,500	10,000 to 15,500

*1 Breakdown does not take into account any internal exchanges of nutrients between lake sections resulting from physical or biological processes.

A high quality of water in Okanagan Lake is the key to good water quality in the downstream lakes and loading limits for the south basin (Table 15.7) have therefore been set lower than the rest of the lake to provide an increased margin of safety against water quality degradation. The present (1971) loadings in all three areas either exceed or equal the established standards. The removal of 80% of the phosphorus loading from the two municipal outfalls (Kelowna and Vernon) will reduce these loadings within acceptable limits beyond 1985, but local areas may still exhibit eutrophic characteristics due to local phosphorus loadings from urban shoreline development.

Sewage collection and treatment including phosphorus removal is considered necessary for the urban center of Okanagan Landing if local conditions in the Vernon Arm of Okanagan Lake are to be improved. Treatment with 80% phosphorus removal for the centers of Armstrong, Westbank, Peachland, Summerland, Naramata and other urban shoreline areas, but the implementation of these is not currently critical to the quality of the main body of Okanagan Lake itself.

(iv) Skaha Lake

This lake has the highest relative fertility and biological growth of the main valley lakes, and its quality has deteriorated the most rapidly. High quality inflows from Okanagan Lake, and annual renewal of water in this lake have prevented a more rapid deterioration. The estimated loading in 1971 was 48,000 pounds. This figure takes into account the 1972-73 average efficiency of the tertiary unit at the City of Penticton Sewage Treatment Plant of approximately 60% phosphorus removal. Projected loadings are summarized in Table 15.12.

TABLE 15.12

PROJECTED PHOSPHORUS LOADINGS TO SKAHA LAKE

YEAR	PROJECTED AVERAGE ANNUAL PHOSPHORUS LOADINGS (pounds)		MINIMUM REDUCTION REQUIRED TO MEET ESTABLISHED CRITERIA (pounds)
	Low Economic Growth	High Economic Growth	
1980	58,000	58,000	23,000
2000	71,000	79,000	36,000 to 44,000
2020	77,000	107,000	42,000 to 72,000

Over 50% of the phosphorus loading in 1971 came from the municipal treatment plant at Penticton even after 60% phosphorus removal had been achieved. Phosphorus loading standards for Skaha Lake have been established at 30,000 to 40,000 pounds per year. These somewhat high values take into account the very short retention time of water in this lake (one year) and the excellent source of good quality water flowing into Skaha from Okanagan Lake. If these limits are met a good quality water should be achieved for recreation and body contact sports.

The attainment of an average of 80% phosphorus removal at Penticton throughout the year will reduce phosphorus loading levels within acceptable standards to 1980. Increased removal of phosphorus may be necessary after 1980 as indicated by an ongoing monitoring program. Treatment and phosphorus removal of Okanagan Falls and other urban shoreline line developments on Skaha Lake would improve local recreational areas but are not critical in respect to the lake as a whole.

(v) Vaseux Lake

Vaseux is a productive lake because of its shallow nature and rich bottom sediments. While criteria have been established for this lake (Table 15.7) its quality is almost completely dependent on the quality of water from Skaha Lake and Okanagan River. The quality of Vaseux waters may be expected to improve somewhat with improvements in Skaha and Okanagan River water, but the shoreline areas will continue to exhibit heavy aquatic plant growth. This habitat is considered suitable for this lake as it has been established as a wildlife sanctuary.

(vi) Osoyoos Lake

Approximately 60% of the nutrient loadings to Osoyoos Lake come from outflows from Skaha Lake and nutrient additions to Okanagan River between Skaha and Osoyoos Lake including the village of Oliver, drainage waters from agricultural lands and septic tank sources. The remaining loadings come primarily from groundwater return flows to the lake itself. The 1971 loading has been estimated at 37,500 pounds, which takes into account the 1972-73 effect of the tertiary treatment unit at Penticton. Projected loadings to Osoyoos Lake are shown in Table 15.13.

TABLE 15.13

PROJECTED PHOSPHORUS LOADINGS TO OSOYOOS LAKE

YEAR	PROJECTED AVERAGE ANNUAL PHOSPHORUS LOADINGS (pounds)		MINIMUM REDUCTION REQUIRED TO MEET ESTABLISHED CRITERIA (pounds)
	Low Economic Growth	High Economic Growth	
1980	51,700	51,700	20,000
2000	70,200	79,500	38,000 to 48,000
2020	78,200	115,800	47,000 to 84,000

Acceptable phosphorus loadings to Osoyoos Lake have been established at 26,000 to 37,000 pounds. These values allow for the very rapid water renewal rate of less than one year which prevents the accumulation of large amounts of biomass and nutrients. The maintenance of phosphorus loadings below 31,000 pounds per year should provide a reasonably good water quality for recreation and body contact sports but somewhat lower than that of Skaha Lake and Okanagan Lakes.

The achievement of 80% phosphorus removal at Penticton will improve the quality of inflow water to Osoyoos Lake but this in itself will not be sufficient to lower phosphorus levels within acceptable limits. Phosphorus removal at the Oliver Treatment Plant and at Osoyoos is also required, along with the inclusion of urban developments adjacent to Osoyoos Lake in the area serviced by sanitary sewers and waste treatment at Osoyoos, to ensure local quality objectives are achieved.

(f) Benefits and Costs Associated with Improvements in Water Quality

The costs associated with water quality management are related to investment in waste treatment facilities which reduce the contribution of nutrients and other wastes to the surface waters of the basin. The benefits of these measures involve the improvement or maintenance of high water quality for consumptive and non-consumptive uses. These in turn, may be translated into social and economic values through an estimation of the opportunities for water-based recreation that would be foregone because of deteriorating water quality, should waste inflows not be reduced, and the additional costs of treating water to make it suitable for consumptive uses.

In this report cost and benefit studies have been limited to nonconsumptive uses in the main valley lakes (recreation and aesthetics). The cost of limiting phosphorus loadings to the main valley lakes through advanced waste treatment processes to control aquatic plant growth and algal blooms are compared with the opportunities for water based recreation and aesthetic enjoyment that would be foregone because of deteriorating water quality - increased aquatic plant growth and algal blooms, if phosphorus inputs are not reduced.

(i) Costs of Waste Treatment

The cost of various types of waste treatment and phosphorus removal at major centers in the valley are shown in Table 15.14 to the year 1985 assuming a low economic growth rate. The year 1985 was selected as the limit to which treatment requirements and cost estimates could be projected and still provide meaningful results based on existing quality data. All costs have been reduced to 1970 dollar values based on the Engineering News Record (E.N.R.) cost index.

Because sanitary sewers and conventional treatment are prerequisites to advanced treatment for phosphorus removal, estimates of the capital cost for selected installations are included for information purposes. These figures however, should be considered only as order of magnitude costs. Detailed surveys are required for each urban center to determine the most appropriate and economical form of conventional treatment for that particular center, and the cost, based on local conditions such as topography and housing density, etc. The type of conventional treatment will in turn affect the cost of phosphorus removal facilities and a range of costs has therefore been shown for phosphorus removal for some centers.

Based on the estimates shown in Table 15.14 the total capital costs for waste treatment facilities to 1985 for all the urban centers noted would be as follows:

Sanitary Sewers	$12,700,000	58%
Secondary Treatment	$5,500,000 to 8,700,000	32% (Ave.)
Phosphorus Removal	$2,000,000 to 2,300,000	10% (Ave.)

The major cost item in any waste treatment programs is for sanitary sewers, which represents approximately 60% of the total capital involved. This is based on an average cost of $500 per lot. Septic tanks, if constructed to meet 80% phosphorus removal requirements could range in cost from $1,000 to $5,000 per home or lot.

TABLE 15.14

ESTIMATED COSTS OF WASTE TREATMENT TO 1985 FOR MAJOR URBAN CENTERS IN THE OKANAGAN

AREA	1971 POPULATION	EXISTING TREATMENT	1985 POPULATION	POPULATION AT MIDDLE OF DESIGN PERIOD (1971-1985)	TREATMENT OPTIONS WITH DESIGN CAPACITY ADEQUATE TO AT LEAST 1985	ESTIMATED CAPITAL COSTS (to 1985)			ANNUAL COSTS-PHOSPHORUS REMOVAL				
						THOUSANDS OF DOLLARS			TOTAL ANNUAL			AVERAGE ANNUAL COST PER HOUSEHOLD	
		CURRENT TREATMENT TYPE				SANITARY SEWERS	TREATMENT PLANT COSTS (Secondary)	PHOSPHORUS REMOVAL FACILITIES	80% PHOSPHORUS REMOVAL $000's	90% PHOSPHORUS REMOVAL $000's	TOTAL POPULATION SERVICED	80% PHOSPHORUS REMOVAL $	90% PHOSPHORUS REMOVAL $
Vernon including Coldstream	18,200	Trickling Filter	32,500	32,500	Spray Irrigation (excluding land cost)		1,800	330	- 51.0 -		32,500	- 5.40 -	
				32,500	Activated Sludge Plant (All new)	2,100	1,800	440	110.0	134.0	32,500	11.60	14.10
				32,500	Renovation of Existing Plant and Construction of New Activated Sl.		1,100	410	103	134	32,500	10.80	14.00
Okanagan Landing	700	Septic Tanks	1,000	900	Batch Lagoon	135	90	3	-	2.5	900	-	9.25
				900	Trunk Mains to Vernon Plant		230	25	10	13.5	900	39.80	51.00
Armstrong	1,600	Aerated Lagoon	2,350	2,180	Batch Lagoon	110	270	6	-	6.5	2,180	-	9.90
				2,170	Activated Sludge		240	50	10	13.5	2,170	16.40	21.20
					Trunk Main to Vernon Plant		Not Economical until 1985						
Kelowna & Rutland	19,500 K.only	Activated Sludge	63,000	35,200	Activated Sludge	6,400	2,300	880	203	258	55,400	12.40	15.80
Winfield	2,200	Septic Tanks	3,600	3,100	Batch Lagoon	530	220	6	-	11	3,100	-	12.10
				3,100	Activated Sludge		270	80	15	19	3,100	16.80	21.10
				3,100	Trunk Main to Kelowna Plant		520	80	11	14.5	3,100	12.70	15.90
Westbank	1,600	Facultative Lagoon	3,500	2,700	Activated Sludge	220	280	70	15	18	2,700	18.30	22.20
Peachland	1,500	Septic Tanks	3,100	2,500	Activated Sludge	450	270	55	20	23.5	2,500	26.60	32.00
Summerland		Septic Tanks	7,900	7,200	Activated Sludge	1,150	490	120	28	36	7,200	13.20	16.90
				7,500	Trunk Main to Penticton Plant		1,600	130	38	41	7,500	17.30	18.60
Penticton	19,000	Activated Sludge & tertiary	27,000	3,600	Activated Sludge	1,200	230	320	84	99	28,400	10.05	11.85
Naramata	460	Septic Tanks	700	600	Batch Lagoon	100	60	3	-	2	600	-	10.30
				600	Trunk Main to Penticton Plant		980	11	3	3.5	600	19.00	20.40
Okanagan Falls	620	Septic Tanks	1,200	1,000	Batch Lagoon	180	100	3	-	3	1,000	-	9.40
					Trunk Main to Penticton Plant		Not Economical to 1985						
Oliver	1,600	Package Act'd. Sl.	1,800		Present Facilities - Sun-Rype removed	30	Facilities Adequate to 1985	70	9	14	1,700	18.20	27.60
Osoyoos	1,300	Facultative Lagoon	1,800	880	Spray Irrigation	75	90	120	16.0		1,600	35.00	

The capital cost of phosphorus removal facilities are relatively small once secondary treatment facilities are available. The annual cost of phosphorus removal including capital amortization, materials and operating costs ranges from $5.00 to $35.00 per lot per year, depending primarily on the type of phosphorus removal selected and the size of plant or population served.

(ii) Benefits Associated with Improvements in Water Quality

There are two major problems in assessing the economic and social benefits associated with maintaining or improving water quality in the main valley lakes. The first is that there are no readily available measures of the value of water-based recreation; the second is that the relationship between water quality deterioration and recreation participation is not clearly understood.

In this Study, it has been assumed that from the viewpoint of the Okanagan, the economic value of water-based recreation contributing to the economic growth of the basin is related to tourist expenditures while in the valley. It is recognized that these expenditures in reality represent the tourists' willingness to pay for services such as accommodation, food and travel. Due to the importance of water-based recreation as a motivation to come to the Okanagan, however, the net income returned to the valley economy from such expenditures appears to be an appropriate base for estimating the minimum value of such activities. This value was estimated at $4.50 per beach day. As tourists spend approximately 60% of their days in the Okanagan visiting public or private beaches, potential economic values of shoreline recreation can be obtained by multiplying future estimates of net income derived from tourist expenditures by 0.6.

In addition to this net income measurement, there is an unpaid surplus known as a consumer surplus which is the net value of the recreational opportunities over and above expenditures. Because recreationists' access to public beaches in the Okanagan is free of charge, they are not required to express any willingness to pay for such opportunities. In this Study, attempts were made to measure this consumer surplus by questioning a sample of beach users directly on their willingness to pay. Such values were estimated at $5.50 and $5.00 per beach day for residents and visitors respectively.

The above established the total value of shoreline recreation in the Okanagan. The next step was to estimate the proportion of this total value that would be lost due to deteriorating water quality in the event that present waste treatment facilities are not improved. It was assumed that in the absence of any improvement in waste treatment facilities, economic and social impacts would compound over the next 30 years, by which time waste treatment measures would probably have to be introduced to maintain the economic and social viability of the region. These assumptions are presented in Figure 15.3.

ASSUMED RELATIONSHIP BETWEEN WATER QUALITY ANO WATER-BASEO RECREATION
FOR ESTABLISHING BENEFITS FOR WASTE TREATMENT ALTERNATIVES

YEAR	LAKE	WATER QUALITY CONOITIONS	IMPACTS ON WATER-BASED RECREATION DEMANOS
1980	Wood Lake	Annual algae blooms, extensive weed growth around shorelines.	Additional costs involved in harvesting weeds. Annual decline of 10% in tourism to 1975 rising to 25% by 1980
2000	Wood Lake	Annual algae blooms and extensive weed growth around shorelines.	Continued decline in tourism estimated at 50% per annum after 1985
1980	Kalamlka Lake	Localized weed growth at Coldstream Creek spreading towards Kalamalka Beach	Additional costs of weed harvesting. Little impact on recreation due to availability of clean water at Cozen's Bay and at Kalamalka Beach
2000	Kalamalka Lake	Increased weed growth at north end of lake. Uncertainty about occurrence of algae blooms due to the unusual phosphorus ppt. cycle in lake discharge of Wood Lake water will affect resorts at south end of lake	Increased costs of weed harvesting. Estimated 10% decline in recreation after 1980 rising to 50% after 1990 due to adverse publicity from Wood Lake experience.
1980	Okanagan Lake	Continued weed growth in Vernon Arm and around Kelowna shoreline. Infrequent algae blooms in both locations. Weed growth at other local areas such as Westbank outfall and around Summerland.	Additional costs of weed harvesting At least 10% of Vernon area recreation would be reduced each year to 1980; reduction of 10% in Kelowna area after 1975 rising to 20% after
2000	Okanagan Lake	Continued weed growth and frequent algae blooms in Vernon Arm and around Kelowna area. Weed growth will continue to extend around Summerland and Westbank	50% loss of recreation opportunity in Vernon Arm after 1985. Estimated 50% reduction in Kelowna tourism by 1990 - similar reduction in resident beach-days; 10% reduction in recreation demand in south basin
1980	Skaha Lake	Occasional algae blooms in late summer, weed growth increase in south basin	Little reduction in recreation demand forecast provided Penticton attains 80% removal of phosphorus
2000		Frequent algae blooms and extending weed growth.	A 10% reduction in annual recreation demands after 1980 rising to 30% in 1985 and 50% by 1990.
1980	Osoyoos Lake	Occasional algae blooms, increase in weed growth	A 10% reduction in recreation demand after 1975
2000	Osoyoos Lake	Frequent algae blooms and increased weed growth	A 20% reduction in annual recreation demands after 1980 rising to 30% in 1985 and 50% in 1990.

Figure 15.3

The annual reductions in beach-day participation indicated in Figure 15.3 was assessed in the economic and social values associated with such recreation opportunities. It appears possible that the value of a beach day may increase faster than general living costs in future, especially as people have more leisure time available. Lacking any empirical data on this however, it was assumed that the real values would remain constant.

Present worth of total benefits associated with maintaining a high water quality for recreation and aesthetics in the main valley lakes to the year 1985, as determined from the assumed relationship between water quality and water-based recreation are:

Estimated Economic benefits - $4,100,000
Estimated Social benefits - 9,200,000

(iii) Annual Benefits and Costs

The estimated benefits and costs for improving or maintaining a high water quality in each of the main valley lakes are shown in Table 15.15. The costs shown are for phosphorus removal only, which will control aquatic plant and algal growth in the lakes to levels that permit maximum recreational and aesthetic benefits to be derived.

TABLE 15.15

ANNUAL COSTS OF PHOSPHORUS REMOVAL ANO BENEFITS TO WATER BASEO RECREATION TO 1985

LAKE	ANNUAL PHOSPHORUS REMOVAL COSTS RANGE DEPENOING ON TYPE OF TREATMENT	ANNUAL BENEFITS	
		ECONOMIC	SOCIAL
Wood	$10,000 to 20,000	$ 36,000	$ 69,000
Kalamalka	5,000 to 13,000	12,000	60,000
Okanagan*	305,000 to 385,000	136,000	710,000
Skaha	84,000 to 99,000	48,000	135,000
Osoyoos	25,000 to 30,000	33,000	95,000
TOTALS	$429,000 to 547,000	$265,000	$1,069,000

* Includes Phosphorus Removal at centers of Vernon, Kelowna and Okanagan Center only. Additional cost of including Armstrong, Westbank, Peachland, Summerland and Naramata would be approximately $75,000 annually.

The ratio of annual benefits (social and economic) to costs is approximately 3:1. The total economic benefits derived from water based recreation only, are not sufficient by themselves to justify the cost of phosphorus removal. However, these do not consider the economic benefits (or costs) of treating water for consumptive use due to a decline in water quality induced by heavy aquatic plant and algal growth. The major cost for phosphorus removal is for the City of Kelowna where over 30% of the Valley population is centered and which accounts for approximately 50% of the total annual cost of phosphorus removal.

(g) Waste Treatment Management

While any of individual treatment schemes outlined in Table 15.14 could accomplish the desired results in the control of biological production in the main valley lakes, there are many problems associated with such ventures. Waste treatment itself is not a simple process, and just providing the required works will not necessarily ensure good conventional treatment, or the removal of the required amounts of phosphorus. Smaller treatment plants in particular may have problems attaining the desired efficiencies. Different management philosophies of local governments may also affect the degree of treatment obtained and the costs involved for such treatment, and there will be many residents who may benefit from treatment but not be required to pay because of location. Local governments may also be more concerned about the local effect of phosphorus removal rather than the effect on a lake as a whole. Spray irrigation of secondary effluent may be more feasible in some centers than in others. This form of advanced treatment may, however, be more expensive than chemical precipitation because of land costs and in the case residents may be required to pay more than in areas using chemical precipitation.

The above problems could be resolved by placing the control for waste treatment in the basin under one Regional authority, and emphasizing the use of regional treatment facilities where these are practical. A regional waste treatment authority would be better equipped to arrange suitable financing, and to stage the development of regional treatment systems to allow for economic growth, and to meet the criteria for acceptable water quality in the basin as a whole. Regulatory powers should also include monitoring of phosphorus loadings to the main valley lakes and the quality of the lakes themselves, to ensure the desired results are being realized, even though such monitoring may be carried out by others.

Regional treatment facilities refer to large central plants that could service a number of communities in the same area, as opposed to individual treatment plants in each urban center. Large treatment plants allow improved operational techniques and generally higher treatment efficiencies, and could be adapted to include industrial wastes, many of which are not now treated.

15.4.3 Discussion of Results

Based on the various alternatives examined, the removal of phosphorus through advanced waste treatment processes is considered the most practical for the control of aquatic plant and algal growth in the main valley lakes to levels that will allow maximum recreational and aesthetic benefits to be derived. Location of outfall discharges, and green belts, should also be considered in combination with phosphorus removal in the long term management of water quality in these lakes. Flushing through increased flows will not improve the quality of any of the main valley lakes, although for Wood Lake it could reduce the time required to improve its quality based on other nutrient control measures. The effect of these increase flows through Wood Lake on Kalamalka Lake, due to resulting nutrient carry-over, cannot be stated at this time. Careful monitoring should therefore be carried out on this aspect to ensure such practices do not endanger the quality of Kalamalka Lake water. The alternative of waste export from the basin is not considered viable.

The removal of 80% of the phosphorus loading by chemical treatment or spray irrigation from the municipal effluents of Vernon and Kelowna would reduce the total known loadings to Okanagan Lake as a whole to within the established safe loading criteria to the year 1985 for both low and high economic growth projections, but reductions in other sources may be required beyond this date.

The removal of 80% of the phosphorus from the Penticton Sewage Treatment Plant effluent is sufficient to meet safe loading criteria for Skaha Lake to 1980, but increased removal may be required before the year 2000 for either low or high growth projections.

The benefits from reduced input of phosphorus to Okanagan River from the City of Penticton will not be sufficient to bring the loadings to Osoyoos Lake within the acceptable criteria for this lake, even if 80% removal at Penticton is attained by 1980. Other sources that must be reduced to achieve the loading limits set include the City of Oliver Treatment Plant, and septic tank installations at Osoyoos and adjacent to Okanagan River.

The upgrading of septic tank units or communcal sewage collection and treatment systems for urban developments adjacent to Wood and Kalamalka Lakes would reduce the phosphorus loadings to these two lakes within acceptable criteria.

Because the estimated phosphorus loadings to each of the main valley lakes are already close to, or exceed acceptable loading criteria, and because of the time still required to plan, implement, and construct or expand waste treatment facilities to reduce these loadings (3 to 5 years), any recommendations on timing for various works becomes somewhat arbitrary. It is considered necessary that most of the treatment works proposed for treating existing waste loadings be in operation not later than 1980. The expansion of these facilities along with sewage collection systems, to meet expanding populations should obviously be staged to meet expansion growth rates. The inclusion of smaller urban areas in any regional treatment schemes might also be staged, but this could involve some degree of risk that continued loadings from these sources might seriously degrade lake water quality, particularly in local shoreline areas.

The estimated social and economic benefits inherent in attaining acceptable quality levels in the main valley lakes to the year 1985, outweigh the costs of phosphorus removal by a factor of approximately 3:1. Equitable distribution of phosphorus removal costs among the beneficiaries, and assurance that the treatment levels required are met, appear to be the major problems in any wastewater management program. One basin-wide authority is therefore considered essential if the planning objective of providing lake water quality consistent with a high quality environment for recreation and aesthetic purposes is to be met.

While these benefits are based more on indirect rather than on direct economic benefits, the projections for the future indicate that waste treatment costs may represent a very small sum compared to the benefits gained. Also the present condition of the lakes is such that any delay in initiating at least minimal programs to meet the criteria for acceptable water quality might result in a further decline in quality, which in the case of Okanagan Lake may not be recoverable to acceptable standards within our lifetime.

The uncertainty involved in the accuracy of nutrient loading data, and loading criteria established for the main valley lakes requires that an on-going water quality monitoring program be implemented to ensure that the desired effects of any waste treatment program are being realized, and to modify the criteria or program as necessary based on the monitored results. In this respect the minimum phosphorus removal requirements outlined in this report may be considered as an interim program for quality control, as compared to a continuation of existing waste management policies, or the desired objective of the public task forces of eliminating all positive discharges to the lakes.

The above discussion has outlined the problems in meeting standards for the main valley lakes as a whole. Small local sources including those from industry, septic tanks, agriculture and other sources may also adversely affect local beaches and shoreline areas without affecting a lake as a whole. The economics of preventing aquatic plant growth in all areas of the lakes would certainly be questionable and in some areas (Vaseux Lake and the North Arm of Okanagan Lake) some aquatic plant growth is considered beneficial to wildlife. The preservation of public beaches and recreational areas should not be questionable however, and the control of local sources of pollution to these areas should be an important requirement of any waste management program. Again, a regional authority would appear best suited to carry out and manage the program in the most equitable manner and to the greatest benefit of all concerned.

CHAPTER 16

Water Based Recreation Evaluations

Questionnaire surveys of beach users carried out during the Okanagan Study and reported on in Chapter 7 have indicated that shoreline recreation is a major factor in the economic and social life styles of Okanagan residents and tourists. High quality water and the availability of clean, uncrowded beaches were identified as the key factors contributing to the enjoyment of beach recreation. Consequently, careful management of both the water quality and shoreline land resources will be necessary to ensure future demands for this important recreational activity will be satisfied.

This chapter discusses future demands for shoreline recreation and boating in the Okanagan over the next fifty years and examines the capability of shoreline land resources around the main valley lakes to cater for these demands. For each of the four economic regions, areas with high potential for shoreline recreation are identified and additional beach and boating facilities required to meet regional demands indicated.

16.1 PROJECTIONS OF DEMAND

16.1.1 Beach Recreation

Projections of demand for beach recreation for both visitors and residents were developed from anticipated growth in tourist and resident populations. In 1972, visitors frequented Okanagan beaches on average for 60% of all visitor days in the valley, while each resident was estimated to visit beaches on an average of 20 days during the summer months. Demand for beach recreation to 1980 was simply calculated by applying these participation rates to the estimated tourist and resident populations for 1980.

Two projections of growth in beach recreation days between 1980 and 2020 were developed, one high and one somewhat lower to provide a range of demands in keeping with the concept of providing alternative economic growth projections to improve the capability of the framework plan to meet a range of future conditions. The high demand for beach recreation assumed increasing resident participation rates and the high growth in resident population prepared for Projection II. Because visitors are already experiencing a very high average participation rate, no increase in this rate was forecast and current rates were applied to projected tourist populations. In the lower growth projection, 1972 participation rates for both visitors and residents were applied to the low population forecasts of Projection III. Regional distribution of beach-days for these projections was assumed to reflect the regional distribution of tourist and resident populations as most shoreline recreation occurs close to places of stay and residence.

Projections of shoreline recreation demands are presented in Table 16.1. Visitor participation is expected to increase 41% between 1970 and 1980, rising from 1.7 million to over 2.3 million beach days and by 2020 could range between 5.4 million and 4.5 million beach days for Projection II and III respectively. Resident participation, totalling 2.3 million beach days in 1970 is estimated to increase 40% to 3.2 million in 1980 and to range between 5.8 and 8.6 million by 2020. Total participation by both visitors and residents is expected to rise from almost 4 million beach days in 1970 to 5.6 million in 1980 and could reach between 10.3 million and 14 million beach days by 2020.

TABLE 16.1 PROJECTIONS OF SHORELINE RECREATION

HIGH PROJECTION

Beach Days	1970	1980	2000	2020
Resident	2,290,800	3,240,000	5,240,100	8,602,000
Visitor	1,678,900	2,358,800	3,767,200	5,379,700
Total	3,969,700	5,598,800	9,007,300	13,981,700
Growth Index	100	141	227	352
1970 Visitor Beach Days = 42.3%			2020	= 38.5%
Resident Beach Days = 57.7%				= 61.5%

LOW PROJECTION

Beach Days	1970	1980	2000	2020
Resident	2,290,800	3,240,000	4,740,000	5,800,000
Visitor	1,678,900	2,358,800	3,178,400	4,477,000
Total	3,969,700	5,598,800	7,918,400	10,277,000
Growth Index	100	141	199	259
1970 Visitor Beach Days = 42.3%			2020	= 43.6%
Resident Beach Days = 57.7%				56.4%

Current patterns in the regional distribution of shoreline recreation demand is expected to continue over the next decade (Table 16.2). Kelowna, the major population centre and Penticton, the major tourist centre accounted for over two-thirds of beach days in 1970, while Vernon and Oliver-Osoyoos accounted for 25% and 10% respectively. Beyond 1980, Kelowna's share of shoreline recreation could increase substantially due to the anticipated high growth rate of resident population and the possibility of more direct transportation links with Vancouver and the Lower Mainland area of British Columbia.

TABLE 16.2

PROJECTIONS OF BEACH DAYS BY SUB-REGION 1970-2020

Sub-Region		1970	1980	High Projection 2000	High Projection 2020	Low Projection 2000	Low Projection 2020
Oliver-Osoyoos	Visitors	198,100	274,100	437,100	593,400	357,000	503,000
	Residents	173,000	220,000	322,100	475,200	292,000	320,000
	Total	371,100	494,100	759,200	1,068,600	649,000	823,000
Penticton	Visitors	671,300	936,900	1,494,400	2,076,800	1,237,800	1,759,700
	Residents	553,600	720,000	1,068,000	1,597,200	965,000	1,078,000
	Total	1,224,900	1,656,900	2,502,400	3,674,000	2,203,800	2,837,700
Kelowna	Visitors	447,800	638,100	1,033,900	1,554,100	899,800	1,259,900
	Residents	1,003,200	1,548,000	2,710,000	4,787,200	2,452,000	3,228,000
	Total	1,451,000	2,186,100	3,743,900	6,341,300	3,351,800	4,487,900
Vernon	Visitors	361,700	509,700	801,800	1,155,400	683,800	954,400
	Residents	561,000	752,000	1,140,000	1,742,400	1,030,000	1,174,000
	Total	922,700	1,261,700	1,941,800	2,897,800	1,713,800	2,128,400
BASIN TOTALS							
	Visitors	1,678,900	2,358,800	3,767,200	5,379,700	3,178,400	4,477,000
	Residents	2,290,300	3,240,000	5,240,100	8,602,000	4,740,000	5,800,000
	Total	3,969,700	5,598,800	9,007,300	13,981,700	7,918,400	10,277,000

16.1.2 Boating Days

Projections of boating day demands for both the high and low projections are shown in Table 16.3. In absence of any other data, it was assumed that participation in all forms of recreational boating for each region would grow at the same rate as general beach recreation in the region. To the extent that residents and tourists will become relatively more affluent and spend relatively more on boat purchases, these projections may be underestimated. Few tourists bring boats to the valley at present however, and as increasing resident participation rates are built into the high growth projection, this factor should not be significant.

As growth rates in boating days are based on beach day projections, somewhere between a three and four-fold increase in boating days is anticipated over the next fifty years. The vast majority of future boating activity will probably continue to occur on Okanagan Lake. It is also realistic to assume that the Central portion of Okanagan Lake will capture an increasing share of boating days, as the Kelowna area is predicted to contain the most developed economic base in the valley.

TABLE 16.3

PROJECTIONS OF BOATING DAYS IN THE MAIN VALLEY LAKES

1970 to 2020

Region	1970	1980	High Projection		Low Projection	
			2000	2020	2000	2020
Oliver-Osoyoos	23,500	31,000	48,000	67,000	41,000	52,000
Penticton	77,000	104,000	160,000	231,000	140,000	180,000
Kelowna	85,000	133,000	220,000	350,000	200,000	260,000
Vernon	76,000	104,000	160,000	230,000	140,000	175,000
TOTAL	261,500	372,000	588,000	878,000	521,000	667,000

Whether these projected demands will actually occur will depend partially on the availability of shoreline recreation facilities and the existence of other constraints such as accommodation and traffic congestion which could affect the tourist industry in the basin.

16.2 SHORELINE CAPABILITY TO SUPPORT RECREATIONAL DEMANDS

Shoreline capability to support future demands was assessed through an examination of Canada Land Inventory maps of the region. Areas with high or moderately high recreation potential were mapped (See M11 to M14 map section), though these maps should be interpreted with care because the CLI classification system only includes natural sites and yet there are several areas where high quality beaches can be developed through clearing and transporting sand. Also, the classification system is based on the ability of an area to support intensive recreational use. Consequently secluded, but attractive sites which may only support a limited number of beach users could be rated with a low or moderate capability, yet such sites are highly valued by those recreationists who prefer quiet, uncrowded conditions. The analysis of shoreline recreation capability was restricted to the main valley lakes. Although the headwater lakes have limited potential for intensive shoreline recreation, their development for angling, hiking and other water-oriented activities could help reduce pressures on the beaches around the main valley lakes.

More detailed analyses of the capability of shoreline resources to support projected beach and boating demands were undertaken for each economic region in the basin. This analysis was supported by detailed maps of shoreline landuse and tenure patterns as well as recreation capability information, all of which are appended to Technical Supplement VIII. A summary matrix of shoreline recreation management requirements is presented in Table 16.4.

16.2.1 Oliver-Osoyoos Region

Beach and boating day demands in this region are expected to nearly triple by 2020, reaching about 1 million beach days and around 65,000 boating days. As a significant proportion of this increase is due to growth in tourism, private recreation developments (campsites, motels, marinas) will likely be developed, probably at the north end of Osoyoos Lake and on Indian Lands on the east side of the lake. Because of flood plain zoning requirements (see Chapter 14), future developments should be set back from the lake. Public access points should be clearly marked and developed to allow maximum use of available foreshore.

Assuming that the Osoyoos Community beach is fully committed for recreation and that private resorts will be developed on Indian Lands and on other available lands near Osoyoos, it appears that future recreation demands in this region can be satisfied. At least four new boat ramps may be required to meet the increasing demands for power boating and angling, especially as the fishing in this lake may be improved in the future due to improved water resource and fishery management in the basin. These ramps should be constructed to accommodate the extreme range of Osoyoos Lake fluctuations probably up to 921 feet and down to 909 feet (G.S.C.).

16.2.2 Penticton Region

Penticton area is presently well-endowed with high quality shoreline recreation at Penticton and Sun-Oka beaches on Okanagan Lake and Skaha and Christie beaches on Skaha Lake. These beaches are expected to accommodate the anticipated doubling of beach-day demands by 2000, providing both Penticton and Skaha beach areas are fully developed. After 2000, with the increasing urban populations of Summerland and Naramata, beaches and public access points in these areas may have to be improved and expanded. Reclamation of shallow bays in the Summerland basin could provide high quality recreational areas and also avoid unsightly exposure of lake bottom in the event of a severe drought (Chapter 14).

Assuming that the fishery in the southern section of Okanagan Lake will be rehabilitated through the construction of artificial spawning facilities on one of the tributary streams, increases in boating days can be anticipated in this part of the lake. Additional public boat launching facilities may therefore be required around Summerland and Naramata as well as at Skaha Lake, where water-skiing, fishing and sailing activities will likely have a three-fold increase. These boat ramps should be constructed to accommodate the expected variations in Okanagan Lake levels as outlined in Chapter 14.

Generally speaking, there appears to be available recreational space to meet anticipated demands, though beach crowding at the major beaches will almost certainly increase during the summer months. Other constraints such as traffic, parking, accommodation availability and urban crowding may limit tourist growth in this region. Some of these are already becoming apparent during holiday weekends.

TABLE 16.4
DEVELOPMENT OF SHORELINE RECREATION FACILITIES BY SUB-REGION
1970-2020

OLIVER-OSOYOOS REGION

Year	Projected Demands	Public Beach Access				Public Beach Area		Public Boat Ramps		Comments
		Requirements		Additional to Present		Requirements	Additional to Present	Required	Additional to Present	
		No.	Feet	No.	Feet	Feet	Feet			
1970	371,100 beach days 23,500 boating days	10	250	-	-	12,000	-	2	-	Present Facilities generally adequate to meet demand Boat ramps crowded during summer months
1980	494,100 beach days 31,000 boating days	12	300	2	45	13,500	1,500	3	1	2,400 feet of beach north of Osoyoos Community Beach has high potential capability. Small private developments on Indian Lands also have moderate and high potential. Improved public access required both north and south of Osoyoos.
2000	649,000-759,000 beach days 41,000-48,000 boating days	15	400	4	100	20,000	9,000	4	2	Full development of potential recreation sites on Tugulnuit Lake plus development of 3 public access points Full development of potential recreation sites around Osoyoos. Continued expansion of facilities on Indian Lands.
2020	823,000-1,068,600 beach days 52,000-67,000 boating days	20	600	10	350	20-25,000	14,000 -19,000	4-6	2-4	Full development of recreation sites on private land around North Osoyoos Lake and on Indian Lands Full development of public sites around Osoyoos Maximum potential recreation demands probably sustained through development of existing public and private lands

PENTICTON REGION

Year	Projected Demands	Public Beach Access				Public Beach Area		Public Boat Ramps		Comments
		Requirements		Additional to Present		Requirements	Additional to Present	Required	Additional to Present	
		No.	Feet	No	Feet	Feet	Feet			
1970	1.2 million beach days	20	1150	-	-	31,000	-	6	-	Present range of facilities more than adequate to meet demands. Additional development of Penticton Beach on Okanagan Lake in progress.
1980	1.7 million 104,000 boating days	20	1150	-	-	35,000	4,000	6	-	Continued development of Penticton Beach towards Penticton Marina. Small expansion of private camping facilities around Vaseux Lake Limited availability of public access points
2000	2.2-2.6 million beach days 140,000-160,000 boating days	25 25	1400 1400	5 5	250	45,000	14,000	8	2	Development of public access around Summerland and Naramata Beach development at N-E corner of Skaha Lake and at Naramata Additional Boat Ramps at Summerland and on Skaha Lake as sport fishing improves.
2020	2.8-3.7 million beach days 180,000 to 231,000 boating days	30	1750	10	600	45-55,000 -	14-24,000	10	4	- Large increase in resident demand will require more public beaches at Summerland, Naramata. Extensions of beach on Skaha Lake, possibly involving shoreline reclamation may be required. Due to increase sport fishing opportunities in S.Okanagan, more launching facilities may be req'd at Penticton, Summerland and Naramata.

TABLE 16.4 (cont'd)
DEVELOPMENT OF SHORELINE RECREATION FACILITIES BY SUB-REGION 1970-2020

VERNON REGION

Year	Projected Demands	Public Beach Access: Requirements No.	Public Beach Access: Requirements Feet	Public Beach Access: Additional to Present No.	Public Beach Access: Additional to Present Feet	Public Beach Area: Requirements Feet	Public Beach Area: Additional to Present Feet	Public Boat Ramps: Required	Public Boat Ramps: Additional to Present	Comments
1970	0.9 million beach days 76,000 boating days	22	1800	-	-	10,000	-	10^e	-	Recreation potential in Vernon Arm inhibited by low water quality and need growth. No public recreation sites on Wood Lake.
1980	1.3 million beach days 104,000 boating days	25	2000	3	200	12,000	2000	10	-	Development of Cozens Bay at N.E. end of Kalamalka Lake. Improvement to Kin Beach on Vernon Arm through weed harvesting and upgrading sewage treatment. Improved beach access.
2000	1.7-1.9 million beach days	30	2500	8	700	14,000	4000	12	2	Full development of Cozen's Bay as a public recreation site. Full development of beach access points to Wood and Kalamalka Lakes (additional 40 and 240 feet respectively). Development of beach access around Vernon Arm.
2020	2.1-2.9 million beach days 175,000 -230,000 boating days	38	2900	15	1100	15-20,000	5-10,000	14	4	Full development of all public access points to all main lakes in the region. Maximum development of public recreation sites in region. Additional launching facilities at Cozen's Bay, Vernon Arm and Ellison Area.

KELOWNA REGION

Year	Projected Demands	Public Beach Access: Requirements No.	Public Beach Access: Requirements Feet	Public Beach Access: Additional to Present No.	Public Beach Access: Additional to Present Feet	Public Beach Area: Requirements Feet	Public Beach Area: Additional to Present Feet	Public Boat Ramps: Required	Public Boat Ramps: Additional to Present	Comments
1970	1.4 million beach days 85,000 boating days	22	2200	- -	- -	21,400	-	10^e	-	Boat launching facilities in immediate vicinity of Kelowna appear to be inadeqnate Beach area adequate at present
1980	2.2 million beach days 133,000 boating days	25	2500	5	300	25,000	3.600	11	1	Beach access in Kelowna area developed, improved and clearly identified Additional beach area developed in Kelowna and to support rapid population growth. At least one more boat ramp near Kelowna
2000	3.4-3.7 million 200,000-220,000 boating days	30	3000	10	800	30,000	8,600	12	2	Additional beach area available near Westside on Indian Reserve Lands. Improved access to beaches at Okanagan Center and around Kalamoir Park Additional boat ramp required on West side of lake
2020	4.5-6.3 million	40	4000	10	1800	30-40,000	8-18,000	15	5	Maximum development of public ascess points due to large increases in resident demands. Developmentof all beach potential, both public beaches near urban centres and quiet bays. All potential recreational lands should be reserved for recreation

[e] Estimated

16.2.3 Kelowna Region

Because of the rapid urban growth in this region, additional beach area and boat launching facilities will be required over the next ten years. These should be developed near Kelowna, as most recreationists place a high value on proximity of shoreline recreation. As there appear to be few natural sites with undeveloped recreation potential in the immediate vicinity of the city, beaches may have to be created by clearing land or through reclamation of shallow foreshore areas. There are some areas near Kelowna where over 1,000 feet of lake bottom would be exposed should Okanagan Lake be drawn down three feet below the normal low water elevation. Filling in some of these areas and developing them for recreational purposes could produce the dual benefit of meeting recreation demands and reducing potential aesthetic problems associated with lake drawdowns.

Immediate attention should be given to improving public access points in the Kelowna region. Many are almost hidden by residential developments, and should be cleared and plainly identified to provide the growing urban population access to the foreshore.

Additional natural beach potential lies on Indian Reserve Land on the west side of the lake and near the smaller communities such as Okanagan Centre and Gellatly Bay. Because of the shortage of natural beaches in this region, all undeveloped areas with recreational potential should be reserved for public use.

16.2.4 Vernon Region

At present, the only major public beach supporting high quality shoreline recreation in the Vernon region lies at the head of Kalamalka Lake. The other major recreation area at Kin Beach on Vernon Arm of Okanagan Lake is affected by heavy weed growth. Future demands in the region should be accommodated by cleaning up Vernon Arm and through the development of Cozens Bay on Kalamalka Lake. Indeed, these are the only areas in the neighbourhood of Vernon where there is potential for high density public recreation. Secluded bays on Okanagan Lake should be reserved for public use where possible to allow people to enjoy access to less crowded conditions.

16.2.5 Summary

In summary, it appears that both high and low projections of recreation demands could be satisfied provided that all natural sites are exclusively reserved for public or private recreation and that the appropriate authorities are willing to develop some foreshore areas in the Kelowna and Penticton regions where natural sites are lacking. Attention must be given to clearing public access points around all main valley lakes and to providing more launching facilities as boating demands increase. For Okanagan and Osoyoos Lakes such ramps should be constructed to accommodate maximum expected lake level fluctuations.

16.3 EVALUATION OF ALTERNATIVES

A proper evaluation of the shoreline management measures discussed above would require a comparison of the costs of providing the facilities and the benefits associated with the increased number of beach days. The costs of providing recreational facilities involve the investment required to reclaim and develop the shoreline or the net benefits foregone from alternative use of the shoreline land resources. Because of the need for flood plain zoning up to two & eight feet above normal high water on Okanagan and Osoyoos Lakes respectively, opportunities for land development apart from recreation would appear to be limited. No cost estimates of shoreline reclamation are available for this report.

Net economic benefits associated with beach recreation are related mainly to tourist expenditures, as residents spend little money in their pursuit of this form of recreational experience. Estimates of total future net income derived from summer holiday tourism was provided by the economic model presented in Chapter 13. As tourists on average spend approximately 60% of visitor days on the beaches, maximum net economic benefits accruing to beach recreation was obtained by multiplying future net income from tourist expenditures by 0.6. These results are presented on Table 16.5(a).

In addition to these economic benefits, which contribute to the economic growth goal, considerable social values were placed on shoreline recreation by both residents and visitors. These values were estimated from survey questionnaire (Chapter 7) at $5.50 and $5.00 per beach day for residents and visitors respectively, and are shown for both high and low projections in Table 16.5.

TABLE 16.5a

ANNUAL NET ECONOMIC VALUE ATTRIBUTED TO SHORELINE RECREATION 1970-2020

X 1000 - (Constant 1970 Dollars)

Year	High Growth Projection II	Low Growth Projection III
1970	$ 4,500	$ 4,500
1980	7,400	7,400
2000	15,500	12,500
2020	27,400	23,600

TABLE 16.5b

SOCIAL VALUES ASSOCIATED WITH SHORELINE RECREATION, 1970-2020

X 1000 - (1970 Constant Dollars)

Year	High Growth Projection			Low Growth Projection		
	Visitors	Residants	Total	Visitors	Residents	Total
1970	8,500	11,100	19,600	8,500	11,100	19,600
1980	11,800	17,800	29,600	11,800	17,800	29,600
2000	18,800	28,800	47,600	15,900	26,000	41,900
2020	26,900	47,300	74,200	22,400	31,900	54,300

The economic and social benefits discussed above represent maximum benefits associated with beach recreation and should be discounted to represent present values at a rate of 7% per annum. Thus, the total potential value to the year 2020 of shoreline recreation in 1970 dollars is estimated at 128 million dollars in economic terms and 470 million dollars in social values. Only a portion of these benefits should be compared with costs of shoreline management. This factor would be equivalent to the number of projected beach-days which would not occur because of crowded conditions.

Unfortunately, this proportion is almost impossible to determine because of changing and diverse public attitudes towards beach crowding. There is evidence that users accept increasingly crowded conditions provided these occur gradually and are accompanied by other experiences in crowding.- in urban environments or in traffic. In addition, as some beach users avoid certain beaches or the Okanagan completely due to crowded conditions, their place is taken by others who place less emphasis on crowding as a negative feature of shoreline recreation. Finally, other constraints such as limited accommodation, parking and traffic congestion could be important factors restricting potential demands.

To provide some idea of the value of providing additional shoreline facilities, it was assumed that in their absence there would be a gradual but increasing reduction in projected demands resulting in an overall loss of 10% in the present worth of such activities. Accumulated economic and social values of such a reduction to 2020 would amount to 12.8 million dollars and 47 million dollars respectively. In view of the important values associated with beach recreation, it appears that the costs of providing additional facilities to accommodate future demands is well justified.

CHAPTER 17

Sport Fishery Evaluations

It was pointed out in Chapter 8 that the fishery resource base in the Okanagan Basin consists of four components:

1. Headwater Lakes Sport Fishery
2. Tributary Stream Sport Fishery
3. Main Valley Lakes Sport Fishery
4. Okanagan River - Sport Fishery
   - Salmon Fishery

Although there are several important relationships between these components such as main valley lake fishes spawning in tributary streams, their separation aids the evaluation of management alternatives.

17.1 REVIEW OF EXISTING CONDITIONS

In 1971, an estimated 12,000 anglers spent 157,000 angling days in the Okanagan lakes and streams. Approximately 45% of this fishing effort or 66,000 angling days were recorded in the headwater lakes where 125,000 trout were harvested. This headwater lake harvest is slightly less than one-third of the estimated 474,600 fish that could be caught in these lakes under present water management practices, if stocked to capacity. Because demand was not distributed in proportion to the present harvest potential of each headwater lake, some of the more popular lakes were close to being fully utilized while a large number were under-fished.

Tributary stream fishing accommodated 2300 angling days in 1971 with an estimated harvest of 13,700 trout. This is less than half of the potential harvest under existing discharge regimes, estimated at 32,200 trout, but the fish only average seven hundredths of a pound and are not generally attractive for anglers.

The sport-fishing effort in the main valley lakes totalled 84,600 angling days in 1971, over 80% of which were recorded on Okanagan Lake. The fish harvest was 262,000 fish; 94% kokanee, 5% Rainbow trout and 1% lake trout and bass. This was less than one-fifth of the potential harvest of kokanee (estimated at 1.3 million) but over half of the potential harvest of Rainbow Trout (estimated at 22,500).

Potential harvest is an estimate of the maximum number of fish that could be removed from the lakes or streams without affecting the reproductive viability of the species. Due to the intangible nature of sport fishing which make it more challenging and enjoyable, these potential harvests would probably never be realized because of decreasing angling success rates (frequency of catch designated in terms of the number of fish caught per hour by one angler) as the potential harvest is exhausted. Consequently, the important criterion regarding the viability of the sport fishery is not the ratio between potential and actual harvest but the frequency and size of fish caught. The present (1971) success rate varies ranging from 1.3 kokanee caught per angling hour in Okanagan Lake to 0.5 trout per angling hour in headwater lakes and less than 0.06 trout per angling hour in the main valley lakes. This present success rate is important as it appears to provide a frequency of catch that is socially acceptable to anglers, and has therefore been used as a guide in determining stocking and spawning requirements to meet future angling demands. The one exception to this is the success rate for trout in the main valley lakes which is very low, and should be increased.

Angler participation was valued highly in both economic and social terms. Sport fishermen spent an estimated $1.65 million in 1971, resulting in a net economic benefit to the Okanagan community of $446,000. In addition, resident and non-resident anglers stated that their sport was worth 1.9 million dollars in terms of social values, over and above these expenditures.

In summary, the Okanagan sport fishery offers a variety of angling opportunities to both residents and visitors, providing significiant social and economic returns. In view of the increasing consumptive demands for water, especially in the tributary streams, there is a need for careful management of the fishery resource over the next 50 years to ensure its continuing viability and value to both resident and non-resident anglers and the general Okanagan community.

17.2 DISCUSSION OF ASSUMPTIONS

One fundamental assumption underlies all biological analyses and evaluations in future fishery management in the Okanagan. This is that all significant cause and effect phenomena, identified and inferred, are assumed to be related on a simple linear and independent basis. Although this is undoubtedly a gross oversimplification of reality, data were not available to derive a more rigorous set of assumptions. The major assumptions are as follows:

(1) That recruitment from natural reproductive systems will be altered in direct proportion to:

   (a) changed discharge regimes,
   (b) changed quantity and quality of reproductive habitat.

(2) That carrying and productive capacities of lakes and streams will be altered in direct proportion to a complex of positive and negative factors discussed later in this section.

(3) That catch per unit fishing effort and/or available fish harvest will be altered in direct proportion to:

   (a) changed recruitment,
   (b) changed reproductive and carrying capacity.

(4) That distribution of fishing effort will reflect fishing quality measured in terms of success rate and size of catch.

FUTURE ANGLING DEMANDS

The first step in the fishery evaluation process was to estimate potential angling demands in the four components of the sport fishery resource base. These projections were based on anticipated growth of tourist and resident populations, with high and low growth estimates prepared after 1980 in keeping with the concept of providing alternative choices for future growth in the basin. The major assumptions associated with each projection are discussed below.

High Growth Projection

Under the assumption of maximizing economic growth in the valley, it appears that, from a sport fishery viewpoint, net economic benefits could be increased through the attraction of non-resident anglers, whose prime reason for coming to the basin is to fish, and by a continued high rate of resident angler participation. Thus, the basic assumptions underlying the development of a high projection of angling days include an increased rate of non-resident angling participation, accompanied by a continuation of the present rate of resident angler participation associated with the high rate of population growth in Projection II. As both resident and non-resident anglers appear to be attracted to headwater lake fishing, relative rates of headwater angling are expected to increase to the year 2000, followed by a relative decline due to a decrease in angling success rates as the limits of the potential harvest are reached. As a result, relatively more pressure will be placed on main valley lake fishing after the year 2000. Projections of angling days in headwater and main valley lakes shown in Table 17.1 indicate that total angler demands will increase almost four-fold from 160,000 in 1971 to 602,000 in 2020.

17.3.2 Low Growth Projection

The basic assumption underlying Projection III was to improve the natural environmental quality of the valley, even if this means sacrificing some proportion of potential economic gains. Sport fishing can contribute to this goal by maintaining high quality fishing opportunities throughout the basin and by placing greater emphasis on resident rather than tourist angling participation. These assumptions are based on the greater recreational (social) values placed on sport fishing by residents compared with non-residents, particularly in headwater lakes.

TABLE 17.1

PROJECTIONS OF ANGLING-DAY DEMANDS

(a) Residents and Non-Residents

		HIGH GROWTH PROJECTION			LOW GROWTH PROJECTION		
	1971	1980	2000	2020	1980	2000	2020
Non-Residents	52,700	82,300	156,900	241,800	74,000	100,800	140,000
Residents	105,300	156,600	234,800	360,600	148,000	217,800	266,500
Total	158,000	238,900	391,700	602,400	222,000	318,600	405,600

(b) Main Valley and Headwater Lakes

		HIGH GROWTH PROJECTION			LOW GROWTH PROJECTION		
	1971	1980	2000	2020	1980	2000	2020
Headwater	65,900	114,300	187,700	246,800	100,000	150,000	191,000
Main Valley	84,600	114,300	190,000	336,700	112,000	155,000	200,000
OK. River & Streams	7,500	10,300	14,000	18,900	10,000	13,000	15,500
Total	158,000	238,900	391,700	602,400	222,000	318,600	406,500

(c) Main Valley Lakes

		HIGH GROWTH PROJECTION			LOW GROWTH PROJECTION		
	1971	1980	2000	2020	1980	2000	2020
Okanagan	70,350	95,000	158,000	281,000	93,200	128,900	166,300
Skaha	6,650	9,000	14,900	26,400	8,800	12,200	15,700
Vaseux	550	700	1,200	1,300	700	1,000	1,300
Osoyoos	1,650	2,200	3,700	6,600	2,200	3,000	3,900
Wood	2,800	3,800	6,300	11,000	3,700	5,100	6,600
Kalamalka	2,600	3,600	5,900	10,300	3,400	4,800	6,200
Total	84,600	114,300	190,000	336,700	112,000	155,000	200,000

Angling demands projected under this low growth policy are based on reduced resident and visitor population growth rates developed under Projection III with the following participation rates:

(1) An increase of 2.5% per decade in resident participation rates. This figure includes both more anglers and more angling days per resident.

(2) Continuation of existing rates of tourist participation.

(3) Relatively greater emphasis on headwater lake angling throughout the 50-year planning period.

The results presented in Table 17.1 indicate that total angling-day demands could increase almost three-fold over the planning period, totalling 406,500 by 2020. Over 74% of this fishing effort could be enjoyed by residents compared with 60% at present and 64% in the high growth projection.

HEADWATER LAKES

Harvest Capacities

Headwater lakes are defined as all lakes and reservoirs in the basin excluding the six main valley lakes. There are some 137 of these lakes with present or potential fishing opportunities and having a combined surface area of 10,900 acres at full supply level. Although there is some natural reproduction of trout in the higher elevation lakes, almost all the present harvest is obtained from Rainbow trout stocking programs. During the period 1967-71, an annual average of 1.7 million trout at 2500 per pound equivalent weight were introduced into the 57 'key' headwater lakes where most of the headwater fishing was recorded. This stocking program provided an annual harvest of 119,400 trout and was supplemented from natural reproduction by 6,100 trout.

Among the many factors which influence trout productivity in the headwater lakes, four are of particular importance. These are (1) elevation (influencing temperature, length of growing season and drainage), (2) total dissolved solids (an index of nutrient availability), (3) water level fluctuation (influencing bottom fauna production, available habitat area, over-wintering depth and oxygen parameters) and (4) presence or absence of predator and competitor fish species. Because elevation is the major factor of the four mentioned above, productivity estimates have been prepared for 500-foot elevation increments.

Estimated potential harvest capacities of the 137 headwater lakes are presented in Table 17.2 assuming continuation of existing water management practices, such as lake drawdowns. This harvest potential is estimated at 474,600 trout compared to the estimated harvest of 125,500 trout taken in 1971. Increased stocking programs required to realize this potential harvest were extrapolated linearly from data derived from the 1971 stocking program and estimated harvest.

On this basis, realization of potential harvest capacities would require an annual stocking rate of some 5.4 million trout at 2500 per pound equivalent weight.

TABLE 17.2

DISTRIBUTION BY ELEVATION OF POTENTIAL INCREASES IN AVAILABLE TROUT HARVEST AND CONSEQUENT STOCKING PROGRAMS FOR 137 HEADWATER LAKES

ELEVATION FEET	1971 AVAILABLE HARVEST CAPACITY NO.X 1000	1971 REALIZED HARVEST NO.X 1000	1971 UTILIZATION OF AVAILABLE HARVEST(%)	POTENTIAL AVAILABLE HARVEST* CAPACITY No.x 1000	POTENTIAL INCREASE IN 1971 AVAILABLE HARVEST NO.X 1000	RECENT(1969-71) STOCKING RATE AT 2500/lb. EQUIVALENT NO. X 1000	RATES OF STOCKING TO AVAILABLE HARVEST	POTENTIAL INCREASE IN STOCKING PROGRAM NO. X 1000
3500	57.8	33.7	58.3	126.6	68.8	552.5	11.12	935.2
3500-4000	14.4	10.3	71.5	32.9	18.5	160.1	11.12	313.6
4001-4500	53.6	65.8	100+	168.9	115.3	883.1	17.80	1764.0
4501-5000	5.2	12.5	100+	48.2	43.0	91.6	23.49	808.0
5001-5500	6.4	2.9	45.3	49.6	43.2	41.1	24.18	1015.6
over 5500	1.5	0.3	20.0	23.4	21.9	00.0	25.00	540.0
TOTALS	138.9	125.5	90.3	449.6	310.7	1728.4	---	5376.4

Higher estimates of harvest potential were also made on the basis of improved water management (decreased lake drawdowns) resulting in an 'ultimate' potential harvest capacity of 1.3 million trout or some 2.8 times the estimate based on present conditions. Stocking programs would have to be increased from the present 1.7 to 5.4 million trout per year as part of this improved managemen proposal for this harvest to be realized.

Fishery Management Alternatives (Headwater Lakes)

Because of the limited availability of natural spawning habitat, the only real sport fishery management alternatives to meet projected angler demands in addition to continuing existing programs are to increase the stocking rate and/or to improve water management practices including increasing reservoir capacities. Due to the limited availability of increased storage (see Chapter 14) and the small impacts of water management practices on headwater fisheries (see Technical Supplement IX), only an increased stocking program was evaluated in detail.

Based on responses from the questionnaire survey of headwater anglers, it was assumed that the existing success rate (measured as the number of trout caught per hour) was the minimum required to maintain a reasonable quality of sport fishing in the headwater lakes. If the annual rate of stocking headwater lakes remained the same over the next 50 years, the average annual success rate would be expected to decrease after 1980 under both Projections, resulting in declines in angler satisfaction and participation as shown in Table 17.3.

TABLE 17.3

PROJECTED ANGLER SUCCESS RATE UNDER EXISTING STOCKING PROGRAM

	PROJECTED DEMAND		SUCCESS RATE	
	HIGH	LOW	HIGH	LOW
	ANGLING DAYS		TROUT PER ANGLING HOUR	
1971	67,900	67,900	0.57	0.57
1980	114,300	100,000	0.42	0.49
2000	187,700	150,000	0.24	0.30
2020	246,800	191,000	0.19	0.24

To maintain present success rates of catch throughout the headwater lakes, the stocking program would have to be increased up to four times present levels (Table 17.4). By the year 2020, the number of trout introductions required to satisfy high and low projections of angling demands is estimated at 4.7 and 3.6 million respectively at an equivalent size of 2500 fry per pound. The upper figure is close to the 'best' estimate of the resource capability of all 137 lakes, placed at 5.4 million fish.

TABLE 17.4

ESTIMATED BENEFITS AND COSTS OF STOCKING PROGRAM IN HEADWATER LAKES TO MEET PROJECTED ANGLING DEMANDS, 1970-2020

YEAR	PROJECTED DEMAND		TROUT HARVEST REQUIRED		TROUT INTRODUCTIONS REQUIRED AT 2500 FRY PER POUND		TOTAL COSTS (1970 DOLLARS) INCREMENTAL		TOTAL BENEFITS			
									ECONOMIC		SOCIAL	
	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW
	ANGLING DAYS		NO. X 1000		No. x 1000		$1000		$1000		$1000	
1970	65,900	65,900	125.5	125.5	1728.4	1728.4	0	0	0	0	0	0
1980	114,300	100,000	217.2	190.0	2382.9	2085.7	31.4	21.0	22.5	19.7	56.6	49.6
2000	187,700	150,000	356.6	285.0	3629.3	2900.4	1110.0	772.0	768.6	655.6	1509.5	1252.4
2020	246,800	191,000	469.9	362.9	4678.3	3619.9	2160.0	1362.0	1569.2	1256.6	2626.6	2130.5

It is evident that 1971 success rates can only be maintained in headwater lakes if both increased stocking programs are undertaken and fishing is encouraged on all 137 lakes rather than the 57 lakes that are presently utilized. On an individual basis, it is probably that some lakes, especially those with good access, may become over-fished while others will not be utilized to their full potential. In order to make provision for the range of fishing experience demanded by anglers - fly fishing only, no access for power boats, low-density 'wilderness' angling, etc. it may be necessary to establish or extend zoning regulations over the next 10-20 years.

In recognition that some lakes will experience high density angling in the near future, a general shift in the stocking program has been built into the cost estimates. This includes stocking a greater proportion of larger fish (e.g. 50 fry per pound and 10 per pound) in these lakes. The stocking of catchable-sized trout in heavily utilized lakes is a possible management alternative which was not evaluated in this Study because of the lack of immediate requirements for fish larger than 10 per pound.

Benefits and costs associated with an increased stocking program were evaluated. After 1980, the existing hatchery capacity in the Okanagan will not be able to support the Okanagan stocking requirements and also meet commitments in other areas in the interior of the Province. New hatchery facilities would have to be constructed by 1985, resulting in a four-fold increase of annual costs from $53,000 in 1970 to $216,000 by 2020 (in 1970 dollars; not discounted). Net economic benefits (Table 17.4) were valued at $1.73 and $4.90 per resident and visitor angler-day respectively, with social (consumer surplus) benefits valued at $13.50 and $2.50 per resident and visitor angler-day respectively, as obtained from the sport fishermen survey.

The appropriate economic benefits associated with the stocking program involve an estimate of the number of potential angling days that would not occur due to decreasing success rates in absence of increased stocking. There are many problems associated with determining this figure. First, there is little understanding of the relationship between angler participation and success rate. Presumably this would vary among anglers, some persevering longer than others, content with other factors such as low angling densities, aesthetics and lack of power boats. In addition, the 'social value' of an angling day might decline with reduced success rates but this relationship is completely unknown. Second, it is not known how many anglers would simply transfer their participation to the main valley lakes rather than not fish in the basin altogether. A transfer of fishing activity would not incur any net losses to the basin as a whole. Third, it is not certain that angling success rates would fall in a linear manner as noted on Table 17.3. Some type of curvilinear relationship could affect the rate of angler participation foregone.

In the absence of any better data, it was assumed that 10%, 30% and 50% of potential headwater angling effort for 1980, 2000 and 2020 respectively would be foregone if present rates of stocking are not increased. Total benefits and costs are compared in Table 17.4 and indicate that a new hatchery would not be warranted based on net economic benefits only but could be justified if social benefits are included. If resident and non-resident anglers are actually willing to pay all or part of these social benefits in the form of increased licence fees then the costs of constructing and operating a new fish hatchery could be supported. Because of the high potential demand for headwater fishing in both projections, increased investment in stocking programs would appear to be justified regardless of the type of future the Okanagan Valley may experience.

17.5 TRIBUTARY STREAMS

The basic capacities for streams tributary to the Okanagan to produce in-channel trout were estimated by reference to literature and an examination of Trout Creek as an example of Okanagan Basin conditions. Minimal discharge regimes to support the trout fishery were established and adjustments made for regimes that did not maintain such flows. No attempt was made to evaluate disbenefits due to cultural modifications nor to evaluate fish introductions. These factors are not expected to play a major influencing role in this component of the Okanagan fishery resource.

Twenty-one tributary streams support trout fisheries. Fish stocks, maintained entirely by natural reproduction accommodated about 2000 angler-days in 1971. Most of these tributaries are also utilized for reproduction and rearing by salmonids from the main valley lakes.

17.5.1 Harvest Capacities

Two types of harvest capacity estimates which provide an annual sustained harvest were obtained for Okanagan tributary streams;

(1) Primary potential harvest capacity; the estimated number of trout given an 'adequate' discharge regime, consistent with overall average annual discharge volume and present stream habitat.

(2) Present potential harvest capacity; the primary harvest capacity adjusted downward to account for the present discharge regime.

A primary potential harvest capacity of 38,410 trout is available annually if adequate flow discharges are instituted to support fisheries while a present potential harvest capacity of 32,220 trout is available annually. An increase of only 16% is thus possible assuming improved flows.

While stream fishing provides a different form of angling recreation, the size of fish is small, averaging about 0.07 pounds in Trout Creek. There is little potential, aside from expensive management techniques to improve the average fish size in the tributaries.

17.5.2 Management Alternatives (Tributary Streams)

No formal projections have been made for future angling demands in tributary streams. While there is a potential demand for stream fishing which will likely increase, anglers are generally aware of the limited capacity of Okanagan streams.

It is apparent that storage reservoirs on tributary systems expand opportunities to meet residual flow requirements. However, these opportunities have not received much priority in Okanagan reservoir operations. Since only a 16% overall increase in in-channel trout productivity is predicted from minimal acceptable discharge regimes, it may well be that in most creeks, this water would yield greater overall fishery benefits if applied to reservoir level maintenance, or more likely the spawning and rearing needs of salmonids (trout and kokanee) from the main valley lakes.

MAIN VALLEY LAKES

The six main valley lakes presently harbour extensive kokanee fish stocks, but relatively small populations of Rainbow and lake trout. In addition, there are compliment stocks of coarse fish and miscellaneous sport fish which are not extensively utilized and thus not included in this evaluation section.

6.1 Harvest Capacities

Harvest capacities of kokanee and Rainbow trout in the main valley lakes were derived from data on total dissolved solids, mean lake depth and nutrient concentrations which appear to affect fish populations (Chapter 8). Improvements in reproductive environments in tributary streams, where main lake kokanee and Rainbow trout spawn, were also taken into account.

Independent estimates of potential harvest capacities in the main lakes were obtained from present catch data and knowledge of zooplankton standing crop and "competitor or niche group" relationships. Both approaches indicate that all main lakes have far greater capacities to support kokanee and Rainbow trout than the tributary streams are capable of rearing. Thus, even if minimum flows for fish were assured in tributaries, lack of sufficient reproductive habitat would remain the limiting factor of main lake fish populations.

Tables 17.5 and 17.6 present a range of estimates of potential harvest capacities for kokanee and Rainbow trout respectively in all main valley lakes. These estimates are based on (1) present tributary discharge regimes and spawning habitat, (2) modified regimes which would reduce water deficits for sport fish in most creeks and, (3) modified regimes plus improved habitats. It can be seen that provision of water supplies alone would not greatly increase harve

TABLE 17.5

ESTIMATED PRESENT AND POTENTIAL SUSTAINABLE KOKANEE HARVEST CAPACITIES IN MAIN VALLEY LAKES, 1970 LEVEL OF DEVELOPMENT

TRIBUTARY STREAMS		NUMBER OF KOKANEE HARVESTABLE ANNUALLY X 1000						
DISCHARGE REGIME	REPRODUCTIVE HABITAT	WOOD	KALAMALKA	OKANAGAN	SKAHA	VASEUX	OSOYOOS	TOTAL
Present	Present	7.1	25.7	1128.7	95.8	0.5	25.5	1283.3
Modified	Present	8.6	37.3	1207.7	132.2	0.8	40.7	1426.8
Modified	Enhanced	13.2	37.3	2347.7	209.8	0.8	40.2	2649.0
		POUNDS OF KOKANEE HARVESTABLE PER ACRE						
Present	Present	0.49	0.75	3.65	10.12	0.23	1.79	
Modified	Present	0.60	1.09	3.90	13.97	0.34	2.83	
Modified	Enhanced	0.91	1.09	7.59	22.17	0.34	2.83	

TABLE 17.6

ESTIMATED PRESENT AND POTENTIAL ANNUAL SUSTAINABLE HARVEST OF RAINBOW TROUT, OKANAGAN MAIN VALLEY LAKES, 1970 LEVEL OF DEVELOPMENT

TRIBUTARY STREAMS		NUMBER OF TROUT HARVESTABLE X 1000						
DISCHARGE REGIME	REPRODUCTIVE HABITAT	WOOD	KALAMALKA	OKANAGAN	SKAHA	VASEUX	OSOYOOS	TOTAL
Present	Present	0.15	2.79	17.86	1.45	0.05	0.23	22.53
Modified	Present	0.35	6.50	31.97	1.52	0.05	0.24	40.63
Modified	Enhanced	1.40	6.50	197.00	2.35	0.05	0.24	207.54
		POUNDS OF RAINBOW TROUT HARVESTABLE PER ACRE						
Present	Present	0.09	0.60	0.26	0.20	0.05	0.10	
Modified	Present	0.21	1.40	0.46	0.21	0.05	0.11	
Modified	Enhanced	0.84	1.40	2.86	0.33	0.05	0.11	

capacities for kokanee but in combination with improvements to reproductive habitat, total harvest could be doubled. Harvest potential for Rainbow trout could be significantly increased with modified discharge and greatly increased (almost ten-fold) by enhanced habitat and modified regime (Table 17.6).

Modified operation of headwater storage reservoirs would not have a major impact on increasing sport fishery populations in some creeks, because in certain critical months, zero or near zero flows would continue to prevail. However, changes in the pattern of storage releases could significantly reduce the amount of additional water required to maintain minimum flows in all months. Such assured flows are absolutely essential in at least average and wet years before any investment in restoring reproductive habitat in tributary creeks is worthwhile.

17.6.2 Management Alternatives (Main Valley Lakes)

Due to lack of data and time, detailed evaluation of fishery management alternatives to satisfy projected angling demands in the main valley lakes were restricted to Okanagan and Skaha Lakes. Observations pertinent to fishery management in Wood, Kalamalka, Vaseux and Osoyoos Lakes are as follows:

(a) Wood Lake

According to limnological evaluations detailed in Section 8, Wood Lake water quality may slowly improve as nutrient loadings are reduced. Under these circumstances, Wood Lake might return to its 1930 condition when it harboured an important kokanee and trout fishery.

The re-establishment of Wood Lake as a productive sport fishery is dependent upon such a chain of variables that it is difficult to make any firm projections of sport fishery potential at this time. It is simply worth noting that there is considerable potential should water quality conditions improve.

(b) Kalamalka Lake

Lake trout, introduced in 1967, contributed the largest proportion by weight of all angled species in 1971. Although this species will likely have considerable impact on the population dynamics of other sport fisheries in Kalamalka Lake in the future, such changes cannot be predicted without improved data. Provision of additional reproductive habitat is expected to enhance the kokanee population of this lake.

(c) Vaseux Lake

This lake is highly eutrophic and completely dependent on Skaha Lake and Okanagan River water quality. It is not presently a significant producer of desirable sport fish, a condition which is expected to continue over the next 50 years.

(d) Osoyoos Lake

Due to high surface water temperatures, low summer oxygen concentrations in the bottom waters of the lake, and abundance of predatory species, this lake is far from ideal as rainbow trout habitat. Enhancement of kokanee stock would probably result from improvements in reproductive habitats, notably Okanagan River discharge regimes. Recommendations concerning the bass fishery are not possible with presently available data.

17.6.3 Management Alternatives (Okanagan Lake)

Okanagan Lake supports over 80% of all main lake angling and this proportion is expected to be maintained or possibly increased over the next 50 years. Consequently, present (1971) demands of 70,350 angling days may be expected to increase between two and four-fold depending on the growth of tourist and resident populations and the extent of the counter-attraction of headwater lakes.

Assuming that no additional action is taken to manage the resource over the next 50 years, sport fishery populations in the lake may be expected to decline due to increased water consumptive use requirements in tributary creeks, although these withdrawals would be partially compensated by an increased storage in headwater reservoirs. Projected angling day demands would not over-fish the present (1971) harvest potential of the lake, but success ratios would be expected to drop significantly below present levels for both angling day projections resulting in declines in angler satisfaction and potential participation (Table 17.7).

TABLE 17.7

CHANGE IN ANGLING SUCCESS RATES FOR KOKANEE AND RAINBOW TROUT IN OKANAGAN LAKE ASSUMING NO FISHERY ENHANCEMENT

YEAR	POTENTIAL HARVEST	PROJECTED ANGLING DAY DEMANDS		KOKANEE AVAILABLE PER ANG. DAY		CATCH PER UNIT EFFORT NO.PER HOUR	
	No.X 1000	HIGH	LOW	HIGH	LOW	HIGH	LOW
(a) Kokanee							
1970	1128.7	70,300	70,300	15.46	15.46	1.264	1.264
1980	1365.1	95,000	93,200	14.37	14.65	1.164	1.198
2000	1212.4	158,000	128,900	7.67	9.40	0.627	0.769
2020	1054.1	281,000	281,000	3.75	6.34	0.307	0.518
(b) Trout							
1970	17.86	70,300	70,300	0.245	0.245	0.022	0.022
1980	17.95	95,000	93,200	0.189	0.193	0.017	0.017
2000	17.90	158,000	128,900	0.113	0.139	0.010	0.012
2020	17.82	281,000	166,300	0.063	0.107	0.006	0.010

A number of alternatives were examined to maintain current success rates for kokanee and to improve success rates for Rainbow trout, in view of the preferences of the latter fishery. These included:

(a) Tributary Management and Enhancement of Spawning Areas in Selected Streams.

(b) Artificial Reproductive Habitat.

(c) Enhancement of Shore Spawning Kokanee Habitat.

(a) Tributary Management and Enhancement of Spawning Areas in Selected Streams

As discussed in Chapter 14, tributary streams are presently managed primarily for the purpose of providing water for irrigation and domestic purposes. Consequently, fishery flows are met only incidentally and not at all in Trout, Peachland and Powers Creeks during dry years (Table 17.8). Even under average run-off conditions, minimum flow requirements in the later summer months may not be met resulting in considerable loss of fishery potential in all six creeks for which discharge data are available.

TABLE 17.8

DISCHARGE DEFICIENCIES FOR KOKANEE AND RAINBOW TROUT IN SIX STREAMS TRIBUTARY TO OKANAGAN LAKE FOR 1971 LEVEL OF DEVELOPMENT

STREAM	WATER MGT.	HYDROLOGICAL TYPE YEAR	MOST LIMITING MONTHLY DISCHARGE DEFICIENCY(%)		AVERAGE MOST LIMITING DISCHARGE DEFICIENCY (%)	
			KOKANEE	TROUT	KOKANEE	TROUT
Trout	historic	dry avg.	91 6	100 50	49	75
	modified	dry avg.	55 0	60 0	28	30
Peachland	historic	dry avg.	75 46	100 50	61	75
	modified	dry avg.	0 0	0 0	0	0
Powers	historic	dry avg.	68 14	100 50	41	75
	modified	dry avg.	79 0	63 0	40	32
Equesis	historic	dry avg.	49 20	27 9	35	17
	modified	dry avg.	0 0	0 0	0	0
Vernon (Lower)	historic	dry avg.	50 10	50 10	30	30
	modified	dry avg.	0 0	0 0	0	0
Mission	historic	dry avg.	82 64	78 46	73	62
	modified	dry avg.	80 66	43 24	73	33

Because the tributaries are generally managed for irrigation, in most years residual storage is reserved in headwater reservoirs to protect licenced water users against possible shortages in the following year should runoff be small. Under modified operation of these streams, it was assumed that some of this residual storage could be released during kokanee spawning and incubation to meet minimum desirable fishery flows. Table 17.8 shows that such an alternative would considerably reduce water deficiencies in all six tributaries for fisheries, effectively eliminating deficiencies in Vernon, Peachland and Equesis Creeks.

This alternative has a number of potential drawbacks. First, in all but Mission and Kelowna Creeks, carry-over storage is necessary to ensure adequate irrigation supplies from year to year and this storage will become more important as consumptive water requirements increase in tributary streams in the future. Second, winter drawdowns of headwater reservoirs may have a detrimental effect on headwater fisheries creating winter-kill conditions through lack of water, or oxygen under the ice. Third, due to freezing conditions throughout the winter at higher elevations, it may not be possible to provide fishery flows at the mouths of creeks as the water might freeze enroute.

The harvest potential of both kokanee andRainbow trout from tributary creek spawning, assuming adequate flows, is shown in Table 17.9 and 17.10. Under assured flows for fisheries, Mission Creek could increase its annual harvest capacity from 84,000 to almost 400,000 kokanee, accounting for over 90% of all tributary stream spawning potential under present development of reproductive habitat. The only other creek exhibiting a significant increase in harvest potential under assured flows is Equesis, which could deliver 54,000 harvestable kokanee. A similar pattern holds for Rainbow trout. Mission Creek has a potential harvest capacity of 26,000 trout under assured flows compared to 9,000 at present.

Once minimum flow requirements have been met either through modified flows or increased storage, it would then be feasible to improve spawning habitats in the lower reaches of selected tributaries. This action would not be justified at present due to the high frequency of flow deficits during the summer months. Tables 17.9 and 17.10 show that habitat improvement would generally increase potential harvest capacities for both trout and kokanee in Mission, Trepanier and Equesis Creeks. Indeed, these three creeks would account for almost all potential harvest available from tributary spawning kokanee and trout.

The potential harvests discussed above are based on maximum harvests allowable to maintain a sustained fishery population. Fisheries evaluations for Okanagan (and Skaha) Lake were actually done on a two level frequency. Firstly, the ability of the lakes to produce at a maximum sustained yield was evaluated. While this is a biologically feasible alternative, it would mean a greater harvest from the same fish population, and thus a lower rate of angler success

TABLE 17.9

KOKANEE HARVESTS IN OKANAGAN LAKE 1970-2020 UNDER VARIOUS FISHERY MANAGEMENT ALTERNATIVES

CREEK	PRESENT HARVEST 1970 STORAGE HISTORIC DISCHARGE	ABILITY OF LAKES TO PRODUCE AT A MAXIMUM SUSTAINED YIELD		HARVEST POTENTIAL - 2020 MAINTAINING 1970 ANGLER SUCCESS RATES			
		1970 LEVEL POTENTIAL HARVEST AVAILABLE ASSURED FLOWS NO ENHANCED HABITAT	1970 MAXIMUM POTENTIAL HARVEST FULL ENHANCEMENT OF REPRODUCTIVE HABITAT & ASSURED FLOWS	HISTORIC OPERATION INCREASED STORAGE NO ENHANCEMENT		MODIFIED OPERATION INCREASED STORAGE NO ENHANCEMENT	
				HIGH IRRIGATION DEVELOPMENT	LOW IRRIGATION DEVELOPMENT	HIGH IRRIGATION DEVELOPMENT	LOW IRRIGATION DEVELOPMENT
COLUMN	X 1000 (1)	X 1000 (2)	X 1000 (3)	X 1000 (4)	X 1000 (5)	X 1000 (6)	X 1000 (7)
Mission	84.3	399.4	953.5	90.75	108.8	163	326.7
Trepanier	2.8	19.8	394.4		No Hydrological Data		
Trout	0.1	0.8	4.5	0	0.1	0.1	0.14
Vernon (lower)	.3	1.8	39.8	1.8	1.8	1.8	1.8
Equesis	7.5	54.0	205.8	6.1	6.9	7.0	11.40
Whiteman	0.2	1.2	2.4		No Hydrological Data		
B-X Creek	0	0.8	1.4		No Hydrological Data		
Powers	2.0	9.6	14.5	.91	1.8	1.75	2.1
Peachland	1.3	6.0	18.3	1.02	1.07	2.4	3.3
Lambly	5.1	0.8	1.8		No Hydrological Projections		

TABLE 17.10

RAINBOW TROUT HARVESTS IN OKANAGAN LAKE 1970-2020 UNDER VARIOUS FISHERY MANAGEMENT ALTERNATIVES

CREEK	PRESENT HARVEST 1970 STORAGE HISTORIC DISCHARGE	ABILITY OF LAKES TO PRODUCE AT A MAXIMUM SUSTAINED YIELD		HARVEST POTENTIAL - 2020 MAINTAINING 1970 ANGLER SUCCESS RATES			
		1970 LEVEL POTENTIAL HARVEST AVAILABLE ASSURED FLOWS NO ENHANCED HABITAT	1970 MAXIMUM POTENTIAL HARVEST ASSURED FLOWS FULL ENHANCEMENT	HISTORIC OPERATION INCREASED STORAGE NO ENHANCEMENT		MODIFIED OPERATION INCREASED STORAGE NO ENHANCEMENT	
				HIGH IRRIGATION DEVELOPMENT	LOW IRRIGATION DEVELOPMENT	HIGH IRRIGATION DEVELOPMENT	LOW IRRIGATION DEVELOPMENT
COLUMN	X 1000 (1)	X 1000 (2)	X 1000 (3)	X 1000 (4)	X 1000 (5)	X 1000 (6)	X 1000 (7)
Mission	9.2	26.44	157.56	3.27	6.98	34.2	41.19
Trepanier	0.31	1.17	2.05	-	No Hydrological Data		-
Trout	0.02	0.05	0.28	0.0	0.01	0.05	0.07
Vernon (Lower)	0.03	0.04	0.95	0.04	0.04	0.04	0.04
Equesis	0.81	1.60	6.12	0.55	0.62	0.78	0.98
Whiteman	0.02	0.05	0.10	-	No Hydrological Data		-
B-X Creek	0.02	0.05	0.07	-	No Hydrological Data		-
Powers	0.21	0.97	1.44	0.14	0.36	0.63	0.71
Peachland	0.14	0.92	2.05	0.08	0.17	0.48	0.56
Lambly	0.02	0.05	0.09	-	No Hydrological Data		-

(number of fish caught per angler per hour). It was decided that maintenance of angler success levels at present or improved catch rates is also a desired criteria. Therefore, in the latter part of the evaluation, the economic and social costs and benefits of maintaining 1970 levels of angler success rates are evaluated to the year 2020. Tables 17.9 and 17.10 show the projected harvests for kokanee and Rainbow trout under varying fishery management alternatives.

Mission, Trepanier and Equesis Creeks continue to provide most of the fishery potential. In view of the potential importance of these creeks, detailed evaluations of water management alternatives required to assure minimum flows were assessed.

(i) Mission Creek

By 2020, if the present operation and storage capacities in Mission Creek watershed remain unchanged, only about 10% and 4% of potential harvests of kokanee and trout respectively would be available. Modified operation of existing storages, would significantly decrease water deficiencies for fisheries from 11,100 acre feet to 8,000 acre feet in dry years (Table 17.11). By itself, this management alternative would not improve kokanee harvest capacities as zero flows would still occur in September during dry and average runoff years. Trout harvest capacities would be increased by about 25% by this modified operation.

TABLE 17.11

WATER DEFICITS FOR FISHERIES IN MISSION CREEK BY 2020 ASSUMING EXISTING STORAGE AND ALTERNATIVE OPERATING RULES

OPERATING RULE	HIGH LEVEL OF IRRIGATION DEVELOPMENT		LOW LEVEL OF IRRIGATION DEVELOPMENT	
	DRY YEAR DEFICITS	AVERAGE YEAR (acre feet)	DRY YEAR DEFICITS	AVERAGE YEAR (acre feet)
Present Operation	14,800	9,800	11,100	5,700
Modified Operation	11,300	5,400	8,000	500
Reduction in Deficits	3,500	4,400	3,100	5,200

To improve kokanee and trout harvest capacities to desirable levels in Mission Creek an additional 3,000 to 4,000 acre feet of storage would be required over and above that available under the modified operation of existing storages. This would assure full fishery flows in approximately 8 years out of 10. Preliminary hydrologic investigations indicate that approximately 3,600 acre feet of additional storage are available for development in the upper reaches of Mission Creek. Development of this storage would cost approximately $900,000 and would support an additional 78,700 and 28,100 harvestable kokanee and trout respectively (Table 17.12).

TABLE 17.12

OKANAGAN SPORT FISHERY MANAGEMENT EVALUATION MATRIX
IN MISSION, TREPANIER AND EQUESIS CREEKS

ALTERNATIVE	POTENTIAL KOKANEE HARVEST		POTENTIAL TROUT HARVEST		COSTS		CAPITALIZED BENEFITS	
	INCREMENTAL HARVEST	TOTAL HARVEST	INCREMENTAL HARVEST	TOTAL HARVEST	CAPITAL $1000	ANNUAL $1000	ECONOMIC $1000	SOCIAL $1000
	NO. X 1000		NO. X 1000					
Mission Creek								
1. modified discharge	-	1212.7	6.9	24.8	-	-		
2. increased storage	78.7	1291.4	28.1	52.9	$ 900.0	$ 99.0		
3. streambed improvement	120.8	1412.2	89.0	141.0	440.0	44.4		
TOTAL	199.5		114.0		$1,340.0	$143.4	$1191.9	$1991.7
Equesis Creek								
1. increased storage	43.0	1418.1	6.0	141.5	$ 175.0	$ 18.0		
2. streambed improvement					28.5	2.5		
TOTAL	43.0		6.0		$ 202.5	$ 20.5	$ 254.0	$ 423.8
Trepanier Creek								
1. pumping	83.5	1499.6	4.7	145.2	$ 173.0	$ 55.0		
2. streambed improvement					100.0	10.5		
TOTAL	83.5		4.7		$ 273.0	$ 65.5	$ 508.2	$ 850.1
TOTALS	326.0		131.7		$1,816.5	$240.5	$1,954.1	$3,265.6

When minimum flows can be assured in all but drought years, rehabilitation of the spawning beds, costing approximately $440,000 would support an additional 120,800 harvestable kokanee and 89,000 harvestable trout. Total costs of these fishery enhancement measures on Mission Creek are estimated at $1,340,000, but would be justified by total net economic benefits of $1,192,000 and social benefits of $1,992,000 over the next 50 years.

(ii) Equesis Creek

Due to limited developed headwater storage in Equesis Creek, modified operation of this storage would not be feasible without significantly reducing carry over storage in drought years. Present water deficits to support fisheries in average-dry runoff conditions total 700 acre feet. Preliminary hydrologic studies indicate that 550 acre feet of storage could be developed on Pinaus Lake. The additional 150 acre feet required to support the fishery might be obtained from some modification of headwater storage operation, or, if necessary, some water could be bought from the irrigation district. Total costs of developing or purchasing water rights for 700 acre feet are estimated at $175,000. Since the above would deplete headwater storage opportunities, no expansion of existing agricultural acreage, based on headwater storages, is recommended for this tributary basin. Total benefits associated with the enhanced fishery are estimated at $254,000 in economic terms and $423,000 in social terms over the next 50 years (Table 17.12).

(iii) Trepanier Creek

As no storage sites were identified on the headwaters of Trepanier Creek, the current fishery deficit of 2200 acre feet would have to be pumped from Okanagan Lake. This alternative is relatively inexpensive as the spawning beds lie within one mile of the Creek mouth. Total costs (1970 dollars) are estimated at $173,000 with annual costs (amortization, operation and maintenance) of $55,000. Improvement to natural reproductive habitat would also be required to realize maximum harvest potential, at a cost of approximately $100,000. These measures would support an additional 83,500 harvestable kokanee and 4,700 harvestable trout annually worth a total of $508,000 and $850,000 in economic and social benefits respectively.

(iv) Summary

The estimated costs of enhancement of natural reproductive habitat for kokanee and Rainbow trout in Mission, Equesis and Trepanier Creeks are compared in Table 17.12. It is anticipated that management of these three basins towards the goal of realizing their maximum potential harvest capacities, together with protection and enhancement of shore spawning habitats, could satisfy potential angling demands to about the year 2000 under the high growth projection and to 2020 under the low growth projection. Harvest potentials may be expected to

TABLE 17.13

SPORT FISHERY MANAGEMENT PROGRAM FOR KOKANEE AND RAINBOW TROUT IN OKANAGAN LAKE, 1970-2020

IMPROVEMENT	DATE	POTENTIAL INCREASED HARVEST KOKANEE NO. X 1000	TROUT	ANNUAL COSTS $1000	ANNUAL COST PER HARVESTABLE FISH
1. Implement Okanagan Lake operation improvements	1974	47.2	0	nil	nil
2. Initiate modified operations on Mission Creek	1975	0	6.9	nil	nil
3. Development of Storage on Mission Creek	1976	78.7	28.1	99.0	0.93
4. Pumping and Streambed improvement on Trepanier	1980	83.5	4.7	65.0	$0.74
5. Incubation Channel in Trout Creek	1980	25.4	4.8	17.2	$0.57
6. Rehabilitate Mission Creek spawning area	1990	120.8	89.0	44.4	$0.21
7. Rehabilitation and Storage on Equesis Creek	1990	43.0	6.0	20.5	$0.42
8. Enhancement of shore-spawning kokanee habitats	2000+		To be determined		
9. Establishment of incubation boxes as required	2000+		To be determined		

TABLE 17.14

CHANGE IN ANGLER SUCCESS RATES FOR KOKANEE AND RAINBOW TROUT IN SKAHA LAKE-NO FISHERY ENHANCEMENT

YEAR	POTENTIAL[1] HARVEST	PROJECTED ANGLING DAY DEMANDS		KOKANEE AVAILABLE PER ANG. DAY		CATCH PER UNIT EFFORT NO. PER HOUR	
	NO.X 1000	HIGH	LOW	HIGH	LOW	HIGH	LOW
(a) Kokanee							
1970	95.8	6,650	6,650	14.4	14.4	0.048	0.048
1980	78.1	9,000	8,800	8.7	9.8	0.029	0.032
2000	76.4	14,900	12,200	5.1	6.3	0.017	0.021
2020	82.2	26,500	15,700	3.1	5.9	0.010	0.019
(b) Rainbow Trout							
1970	1.45	6,650	6,650	0.22	0.22	0.022	0.022
1980	1.98	9,000	8,800	0.22	0.22	0.022	0.022
2000	1.81	14,900	12,200	0.12	0.15	0.012	0.015
2020	1.73	26,500	15,700	0.06	0.11	0.006	0.011

1 Assumes present water quality is maintained or improved.

significantly if no fishery enhancement program is undertaken (Table 17.14).

Due to limited natural stream spawning habitat around Skaha Lake, any significant increase in kokanee and Rainbow Trout harvest capacities will be dependent on artificial propagation. Since Rainbow trout and kokanee are subject to excessive predation in the lake, the natural or artificial stocking of fry at 2500 fry per pound would not result in any significant increase in harvest capacities. This predation problem could be overcome by stocking trout and kokanee at sizes of 50 and 10 fry per pound.

Costs and benefits of a proposed fish hatchery for Skaha Lake are presented in Table 17.15. It was assumed that prior to hatchery construction, certain other less costly improvements would be undertaken including enhancement of the natural spawning habitat in Okanagan River. The stocking program would likely increase angling success rates substantially, particularly for Rainbow Trout, but would cost some $228,000 annually by 2020.

TABLE 17.15

APPROXIMATE COSTS AND BENEFITS OF HATCHERY RAISED KOKANEE AND RAINBOW TROUT FOR THE SATISFACTION OF ANGLING DEMAND IN SKAHA LAKE, 1980 TO 2020

YEAR	ADDITIONAL HARVEST REQ'D NUMBER X 1000	CORRESPONDING NUMBER X 1000 @ 2500/lb.	CORRESPONDING NUMBERS X 1000 AT WEIGHTS INDICATED 50/lb	10/lb	ANNUAL COST, TOTAL X$1000	PER HARVESTABLE FISH, $	ANNUAL BENEFITS $1000 ECONOMIC	SOCIAL
KOKANEE								
1980	23	393	43.5	12.6	29.4	1.28		
2000	55	[illegible]	104.2	33.0	70.4	1.28		
2020	178	2,967	337.2	97.5	227.9	1.28	19.0	58.4
							27.2	84.5
RAINBOW TROUT							48.4	169.1
1980	0	0	0	0	0			
2000	0.48	8.0	0.91	0.26	0.61	1.28		
2020	2.60	43.3	4.92	1.42	3.33	1.28		

Annual benefits associated with the enhancement of Skaha Lake sport fishery were estimated on the basis that 65% of the projected angling day demands (high estimate) above the 1970 level would be due to improved Rainbow trout fishing. This assumption is based on the finding that 65% of main valley lake fishermen preferred catching trout to kokanee.

Under this assumption, anticipated increases in net expenditures by non-resident anglers would not pay for full hatchery program. However, stocking of Skaha Lake would certainly enhance the Rainbow trout fishery and could be provided from the hatchery recommended to support the headwater lake fishery. Consequently, Skaha Lake should be considered when establishing the stocking capability of the new hatchery for the Okanagan Basin.

17.7 OKANAGAN RIVER FISHERY MANAGEMENT

The Okanagan River system serves the Okanagan primarily as a flood control and water conservation channel and it produces only a limited number of sport fishes. The sport fish capability is heavily dependent on movement of fishes from the main valley lakes and is most realistically evaluated on this basis. In-channel sport fishes could not be shown to be particularly sensitive to the discharge alternatives considered. The "unimproved" section of the river, (S.O. L.I.D. dam to just north of Oliver) serves as a spawning bed for the major Columbia River sockeye salmon run which is extremely sensitive to river discharges.

17.7.1 Sport Fishes

About 4,900 days were spent in 1971 angling for Rainbow trout and Whitefish in the Okanagan River resulting in a harvest of 700 pounds of preferred sport fishes. However, no angler demand projections for the river were made, because Okanagan River is not considered to be of major importance to Okanagan anglers.

The availability of fish in the river is dependent to such a large degree on the fish populations of the main valley lakes, particularly Skaha and Osoyoos, that the future fisheries potentials are inexorably linked to management of these lakes. The detailed projections in the main valley lakes section can therefore be used as a basis for estimating the harvest potential of the Okanagan River sport fishery.

17.7.2 Sockeye Salmon

Of an annual average escapement of 85,000 Sockeye salmon to the Columbia River 19,000 spawn in the Okanagan River. The annual Sockeye catch at the mouth of the Columbia River for the period of 1961 to 1971 was 21,600 fish, of which 15,120 (70%) originate in the Okanagan River. An additional 3,100 fish are taken by the Indian fishery.

This catch to escapement ratio is considered as extremely low due to below average environmental conditions, and because the results were recorded during a period when fishery managers were attempting to re-build the run. Based on average environmental conditions and the maintenance of existing spawning habitat the future annual catch may be in the order of 40,000 sockeye per year.

Alternatives for protecting the salmon run over the next 50 years were described in Chapter 14 and will only be summarized here. Continuation of present operating rules for releasing water into Okanagan River could threaten the viability of the run by 2000 as withdrawals for consumptive uses increase. The water conservation alternative involving lowering intakes along Okanagan River to reduce minimum flows to 100 cfs at Oliver during the irrigation season would guarantee fishery requirements in all but a period of consecutive drought years when fishery flows would have to be reduced. The amount of reduction would depend on the size of the salmon run and the magnitude of drought. Implementation of this water conservation alternative would at least maintain the salmon run at current levels over the next 50 years.

Construction of an artificial spawning channel adjacent to Okanagan River to maintain the present run would cost over $500,000 with an annual cost, including amortizated capital, operation and maintenance of $54,500. Such a facility could conserve about 30,000 acre feet in a drought year assuming minimum flow requirements for fisheries were met at all times. These costs could not be justified on the basis of any economic or social benefits that might occur to the Okanagan Basin itself.

17.8 SUMMARY

It appears that an increase of over three times the current stocking program in the headwater lakes will be required over the next 50 years to maintain existing success rates. Due to the high economic and social values placed on headwater angling, such a program could be justified for both of the growth projections considered.

In addition, management measures on Mission, Equesis and Trepanier Creeks which are tributary to Okanagan Lake, plus protection of shore-spawning habitats will be necessary to maintain an adequate stock of kokanee and trout to meet potential angling demands. Preliminary evaluations indicate that the economic benefits resulting from these improvements would exceed implementation costs.

Enhancement of Kokanee and Rainbow trout in Skaha lake is dependent on artificial propagation. This may not be economically justified alone, but could be if programmed in conjunction with headwater fishery management.

Total costs of the entire sport fishery management program for the Okanagan could exceed 3 million dollars over the next 50 years. In the past, the costs of such fishery enhancement programs have been borne by the Province and recovered in part from annual licence fees paid by anglers. Alternatively, as the benefit is expressed by angler's satisfaction gained through sport fishing and from exenditures of non-resident anglers appear to exceed costs of enhancement, part or all of these costs could be borne by anglers within the Okanagan. Both these management approaches have implications that can only be discussed briefly in this report.

If the costs are borne by the entire Province, then the program described above should be evaluated in a provincial perspective. The Okanagan basin is only one sport fishery management area in British Columbia and thus the benefits of a 3 million dollar investment may be better obtained by allocating some or all of this amount to other regions. Such decisions will depend upon knowledge of fishery resource capability and potential angling demands in all major fishery areas in the Province.

If the costs are borne by resident and non-resident anglers in the Okanagan, then a system of user charges would have to be instituted. From an administrative point of view, such charges would be best levied on annual licences, though in theory, they should be applied to each angling day. Higher costs of angling in the Okanagan, either through increased licence fees or daily charges would have policy implications in the Province and could also upset the estimation of future demands. If licences cost more in the Okanagan than in neighbouring regions, some anglers might avoid the Okanagan completely, thus reducing potential demands and the subsequent costs of fishery enhancement.

Any financial arrangement for managing the sport-fishery program will have to be carefully evaluated before recommendations can be made. Such evaluations have not been undertaken within the scope of this draft report.

CHAPTER 18

Wildlife Evaluations

18.1 REVIEW OF WILDLIFE VALUES AND POTENTIAL

The water dependent wildlife resources of the Okanagan Valley are limited. Productivity generally is low. Some resident waterfowl exist in the north arm of Okanagan Lake and the north arm is also an important resting and holding area for migrating and wintering waterfowl.

The Okanagan River system has a low wildlife productivity with the possible exception of some of the larger "oxbow" areas of the old river bed removed from the channel during flood control "improvements" of the late 1950's, and the delta area marshes at the north end of Osoyoos Lake. A limited number of muskrats and beaver reside in the Okanagan River and are occasionally taken by trapping.

Vaseux Lake is approximately on a par with the north arm of Okanagan Lake with reference to waterfowl breeding and migratory capabilities. Canada geese are the primary waterfowl users of Vaseux Lake. The area has been declared a waterfowl sanctuary, primarily due to its reproduction capability for Canada geese.

Numbers of waterfowl using the system has declined since the turn of the century, primarily due to altered shoreline, influxes of humans and introduction of carp. The exception to this are Canada geese, whose numbers have increased in recent years. Stabilized water levels in Vaseux Lake and habitat improvements are in part accountable for the increase.

18.2 EVALUATION

18.2.1 Water Quantity

Alteration of lake levels at critical times of the year, primarily during the spring nesting and incubation, would adversely effect brood success in the north arm of Okanagan Lake and Vaseux Lake. A major elevation increase would result in nesting flooding, while a major lowering would make reed and bulrush areas unavailable to young. Major water level changes at other periods of the year will effect availability of food sources, i.e. rooted and semi-attached aquatic plants.

The oxbow areas of the Okanagan River are generally dependent on the maintenance of river levels to maintain water in the oxbows. These oxbows are now either directly charged from the river to service irrigation intakes, or controlled by seepage if no direct charging takes place. From observation, it appears that river flows below 250 cfs severely limit wildlife capabilities of the oxbows. Charged oxbows become essentially useless to wildlife once the irrigation season ends and the water flow is shut off.

Table 18.1 indicates the "scores" various water quantity alternatives were rated at, with respect to their effect on wildlife. Generally, little effect is to be expected from implementing any of these alternatives. A slight decrease in wildlife populations are expected if alternatives 1(b) and 2(b) are implemented, otherwise an improvement of wildlife populations will result.

TABLE 18.1

EFFECT OF VARIOUS MAINSTEM OPERATING ALTERNATIVES ON WATER DEPENDENT WILDLIFE IN THE OKANAGAN BASIN, BASED ON PRESENT CONDITIONS, EVALUATED AT ZERO ON A +10 TO -10 RANGE

ALTERNATIVE		SCORE -RANGE- (+10 to -10)	
		1970	2020
1(a)	Historic Conditions (Fisheries Incidental)	0	0
1(b)	Historic Conditions (Fisheries Met)	-2	-
2(a)	Flood Control & Water Conservation (Fisheries Incidental)	+5	-
2(b)	Flood Control & Water Conservation (Fisheries Met)	+2	-2
3(a)	Water Importation (Fisheries Incidental)	+4	+1
3(b)	Water Importation (Fisheries Met)	+2	-

* A zero score indicates no change from 1970 conditions.

18.2.2 Water Quality

Waterfowl thrive in marsh-like, heavily eutrophic aquatic areas. The generally oligotrophic-mesotrophic nature of the main valley lakes coupled with the lack of muddy organic bottom sediments is one of the major factors limiting waterfowl production in the area. Limited eutrophic areas, i.e. north arm, Okanagan Lake, north end, Osoyoos Lake and Vaseux Lake where other requirements for aquatic plant production exist, are exceptions to this. Heavy aquatic growths at outlets of nutrient rich effluents would be expected to attract waterfowl.

Addition of nutrients to most of the lakes would be expected to slightly increase water bird usage of the immediate area.

Water quality is expected to have a negligible effect on the wildlife potential of the Okanagan River.

18.2.3 General Comment and Summary

The Okanagan lakes have a limited water dependent wildlife potential. The north arm of Okanagan Lake, Vaseux Lake and some of the larger oxbows adjacent to the southern portion of Okanagan River have some wildlife production capabilities. Mainstem operating alternatives are not expected to effect wildlife to a major degree. With two exceptions, mainstem quantity alternatives will be beneficial to nesting and migrant waterfowl.

PART V

DEVELOPMENT OF COMPREHENSIVE PLAN

CHAPTER 19

Framework Plan and Recommendations

19.1 INTRODUCTION

The purpose of this chapter is to describe the comprehensive framework plan for the development and management of the water resources in the Okanagan. This plan represents an integration of the best alternatives described and evaluated in the preceeding chapters for managing water quantity, water quality, shoreline recreation and fishery resources, to provide the future lifestyle preferred by the residents of the Okanagan Basin as expressed through the Public Involvement Program (P.I.P.) Task Forces. These task forces unanimously supported Projection III involving a lower pace of growth, protection of agricultural lands and maintenance of a high quality environment as stated in their primary recommendation (Appendix C) that:

> *"Future planning in the Okanagan should place primary emphasis on environmental protection, giving due emphasis to maintaining the economic viability of the valley."*

19.2 THE PLANNING PROCESS

Consensus on the development of the framework plan was gained incrementally during the four year planning study. This agreement was achieved through repetition of the sequence of steps comprising the planning process as described in Chapter 12.

1) Establish Objectives
2) Assess resource capability
3) Project future demands
4) Identify alternatives
5) Evaluate alternatives
6) Select Plan

The first step in any planning study is to gain a clear understanding of the nature of the problem. At the start of this study, a number of water management problems had been generally defined, but many required further clarification. First, there was some concern that future water requirements for irrigation, municipal and recreational uses could not be met by the water resources within the basin, and that a large scale water importation might be required at an early date. This concern was based primarily on the assumption that there would be a large increase in the land irrigated which assumption has not been supported by subsequent detailed economic growth projections. Second, it was known that excessive nutrient inputs from human activity in the basin were contributing to the eutrophication of the main valley lakes and the control mechanisms were not known. Third, there were growing conflicts between water for fisheries and agriculture in some tributary watersheds, but as no means of assessing the potential values of these conflicting uses had been devised, no rational allocation procedures were available.

Solutions to these problems required new approaches to planning, new techniques of evaluation and integration of a wide range of technical information from many different disciplines. Because many of these concepts were untested, the Consultative Board and Study Committee agreed to tackle the planning process incrementally, thereby gradually becoming more familiar with both the nature of the water management problems and more competent at evaluating them in a comprehensive manner.

The major steps in the study prior to the signing of the Canada-British Columbia Okanagan Basin Agreement up to its termination on March 31, 1973 are shown in Figure 19.1.

The first complete run at the planning process involved the evaluation of water quantity management in the Okanagan mainstem system, undertaken during the summer of 1971. As the Okanagan Basin Agreement specified that a comprehensive impact assessment of any large scale diversion from the Shuswap or other watershed would be required, it was necessary - early in the Study - to check the need of such a diversion so that a complete evaluation could be undertaken if this alternative was required to meet the stated water quantity objectives.

For the first time in the Okanagan Study, all the major disciplines were integrated into an evaluation team to complete this preliminary assessment. This comprised of fishery biologists, hydrologists, economists, system engineers, recreation geographers, and wildlife ecologists. Preliminary projections of economic growth and associated water requirements to 2020 were made and a number of alternatives including diversion were assessed. As mentioned in Chapter 14, large scale diversion could not be justified based on these evaluations and so more attention could be focussed on solving other major water management problems in the Okanagan.

The next step in development of a framework plan involved the full evaluation of all water and related resource management alternatives to 1980. The short time horizon was selected for two reasons:

1) Economists argued that projections of economic development and population could only be reasonably accurate to 1980. Thereafter, such projections become little more than educated guesses.

2) A full 'dress rehearsal' of planning and evaluation procedures was

MAJOR PHASES IN THE PLANNING PROCESS - OKANAGAN BASIN STUDY

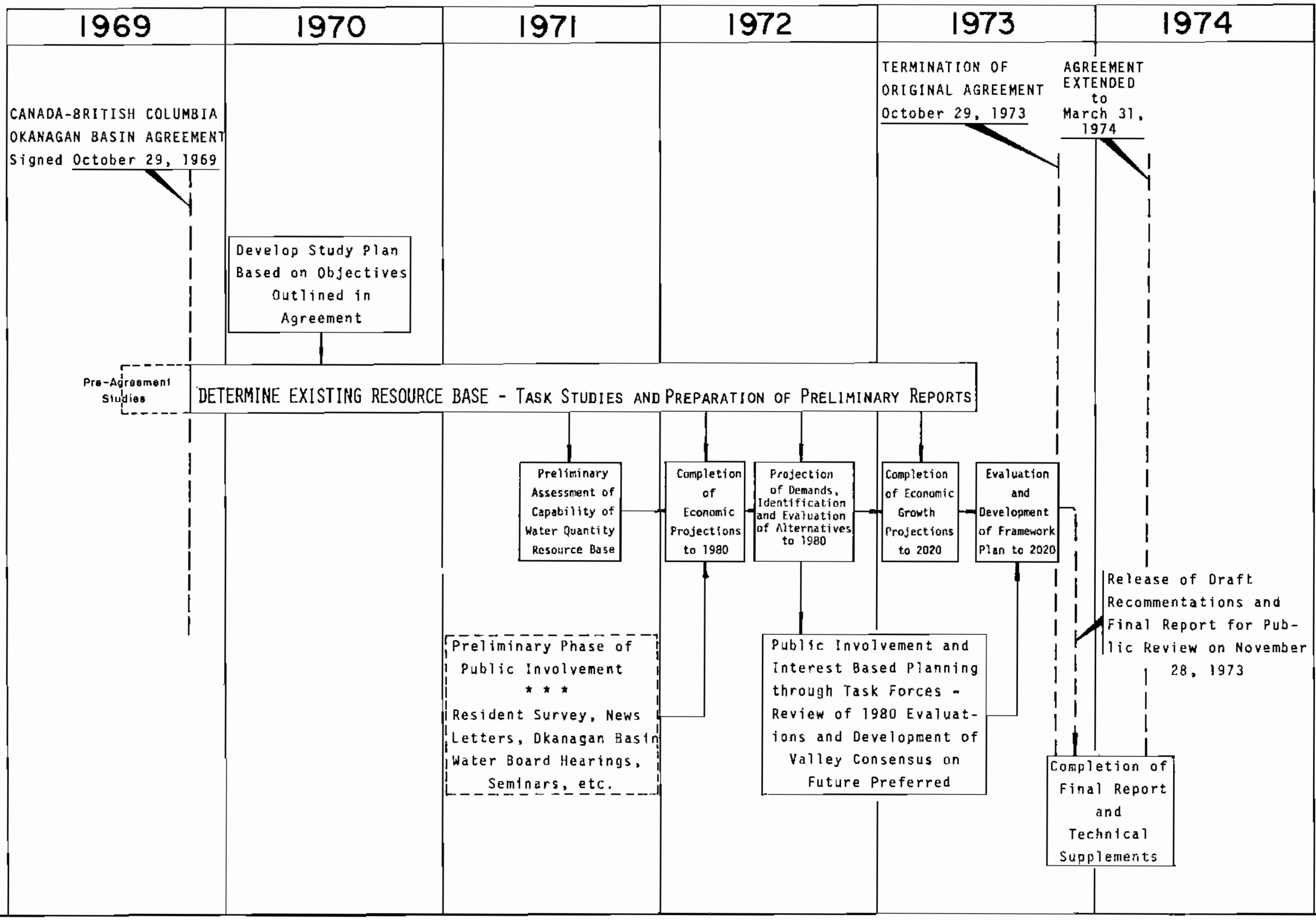


Figure 19.1

desireable before launching into the major step of evaluating a range of economic growth projections to the year 2020.

During the spring and summer of 1972, the evaluation team analysed a number of water resource management alternatives, for the mainstem system and selected tributaries. At the same time, the public involvement program was gaining momentum, educating the community on the scope of water resource problems and receiving comments on public reaction to water management alternatives. Six PIP "task forces", established in the fall of 1972 examined the first draft of the 1980 evaluations on water management during the winter of 1972-73.

At this point in the planning process, the Study personnel and the task forces began to formulate a plan to the year 2020. The task forces took the information on the projections available for 1980 and other data prepared by the Study Committee, to arrive at the type of future development they would like to see in the valley. This philosophy stressed environmental and social goals at the expense, but not neglect of economic growth.

The Study personnel developed three projections of economic growth, as described in Chapter 13, to test the capability of the water and related resource base to satisfy a wide range of resource demands and to provide a more flexible plan for the future. Analysis of these projections indicated that the same basic water management plan was required for all three growth projections.

The PIP task forces favoured Projection III, which emphasizes environmental quality and agricultural development at the expense of a somewhat slower pace of economic growth. The final stage in the planning process involved the integration of the basic principles enunciated by the Task Forces with the technical details of the water resource management alternatives. This important step was undertaken by the evaluation team and Task Force Seven during the spring and summer of 1973. Members of the evaluation team attended all Task Force Seven meetings and two seminars were held in June and September 1973 to which Study personnel and task force members were invited. In addition, the Consultative Board and Study Committee met with Task Force Seven in July, 1973. As a result of these meeting a general consensus on the make-up of the framework plan to 2020 was obtained.

19.3 THE COMPREHENSIVE FRAMEWORK PLAN

The framework plan maps out a sequence of water and related resource management decisions over the next fifty years, based on the economic growth projections prepared by the Study (Figure 19.2). One of the major findings of this study, however, is that the same basic plan applies to all three growth projections, and that the same mix of water management decisions will be required over the next thirty years at least, whichever economic future the Okanagan pursues.

CONCEPT OF THE FRAMEWORK PLAN

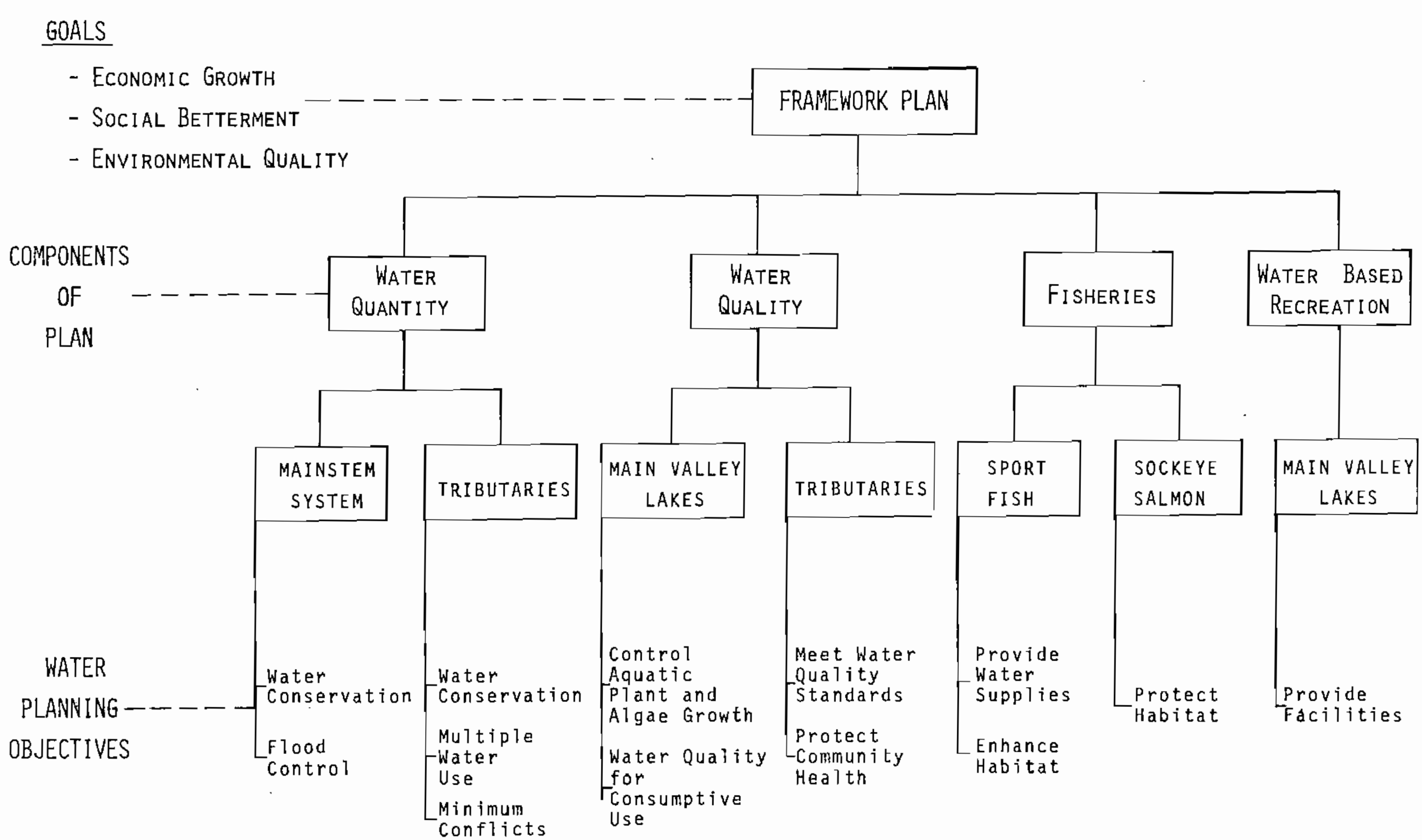


Figure 19.2

Although the framework plan has been developed to encompass the next fifty years, because of the many uncertainties in the factors controlling the plan, it is probably only reliable for the next ten years or so. After that time, projections of future demands for water and related land resources may vary from those forecast in this report, or the water resource may respond differently to water and waste management measures than as predicted, or indeed, the residents of the valley may place different weights on environmental and social factors affecting water management. All these uncertainties combine to make it necessary to monitor regularly the response of water and related resources to the set of management measures implemented over the next ten years and to undertake a full review of the entire plan in the year 1980. Appropriate adjustments may then be made so that the plan continues to meet the goals of economic growth and social betterment of valley residents.

One of the major challenges in any planning study is to make recommendations on specific actions when the outcomes of these actions cannot be fully predicted. It is usually too expensive in both time and costs to attempt to remove all the uncertainties associated with planning decisions, and therefore, once a reasonable amount of information is available on the economic, social and environmental consequences of alternatives, decision-makers must act. Consequently there must be no doubt that the framework plan described below should be implemented and then carefully monitored.

As mentioned in Chapter 12, the framework plan represents a mix of water quantity, water quality, sport-fishing and shoreline recreation resource management measures, which together provide a satisfactory balance for meeting the economic, social and environmental goals of the basin community. The plan itself must be firmly established on the social philosophy for future development in the basin as developed by consensus of valley interest group representatives at the task force meetings. Within this basic framework, the components of the plan (namely specific water quantity, waste management and water-based recreation planning alternatives) are designed to meet the set of planning objectives outlined in Chapter 12. It may be impossible to achieve all of these planning objectives due to inherent resource conflicts, lack of funds and uncertainty in the behaviour of the water resource system in the Okanagan. Consequently, the recommended plan comprises a mix of alternatives which together will ensure good water resource management and resolve most of the major conflicts in water use at minimum costs.

In view of the uncertainty surrounding water management measures on the longer term horizon, the plan exhibits one additional characteristic - flexibility. With the likelihood of improved techniques of waste management in the future, the plan only recommends measures required in the immediate future to ensure high water quality in the main lakes. This initial action is strongly recommended however, because the major threat that must be avoided at all costs is the over-enrichment of Okanagan Lake.

This event would not only be almost irreversible due to the long residence time of water in the lake, but would also create eutrophic conditions in Skaha, Vaseux and Osoyoos Lake, which could not be corrected by existing waste management practices within our lifetime. Other than this feature, it appears that the Okanagan has some flexibility in the path selected for water and related resources management, and the framework plan described below represents the optimum approach at the present time.

19.3.1 Socio-Economic Goals of the Valley Community

The valley consensus emphasized as a basic concept that the unique environment in this valley is the key to maintaining the presently desirable life-style. Future planning in the Okanagan must place primary emphasis on environmental protections, though giving due attention to maintaining the economic viability of the basin. Projection III was thus preferred over the other two growth projections, incorporating careful economic planning with population stabilizing around 275,000 to 300,000 by 2020. In addition, there was an appreciation for regional differences in economic opportunity with preference for the main thrust of future growth to remain in the Central Okanagan rather than in the agricultural north and south.

Task Force Seven stated that agriculture, especially the tree fruit industry is an integral component in the Okanagan life-style, and thus favoured the development of agricultural lands consistent with Projection III. Apart from the need to provide food, the development of agriculture was supported because of its aesthetic appeal, and the social value of the small farm to Okanagan residents.

Because of the uncertain economic future of the agricultural industry in the Okanagan, a large expansion of irrigated acreage will require more than the availability of relatively cheap water supplies. Strict controls on landuse to preserve good agricultural lands must continue, together with economic incentives to farmers to remain in production, but these aspects lie outside the terms of reference of the Okanagan Study. However, the Study has indicated that should economic and social conditions conspire to help the agricultural industry, water supplies can be developed to meet projected developments, calling for up to an additional 25% more land than that presently irrigated.

The broad approach to water management in each of the major components of the framework plan described in the following sections has been developed by the Consultative Board based on input from the Study Committee and consultation with the Public Involvement Task Forces. The recommendations prepared by the task forces themselves are summarized in Appendix C of this report.

19.3.2 Water Quantity

The basic water quantity objective of meeting all consumptive and non consumptive water requirements at all times is not feasible because of limited water supplies during prolonged drought periods. However, the frequency of these is such that no large scale importation of water is justified to meet water requirements along the mainstem system, provided that Okanagan Lake can be drawn down below its normal low water elevation, and improved water management is practised. Priorities for water use may also be required, particularly in the tributary sub-basins where storage reserves are limited. Shortages in tributary basins may be expected to occur in the second year of a consecutive drought cycle. When such deficits are forecast, the task forces have recommended that human consumptive needs be given first priority on available supplies, followed immediately by agriculture. Thus, in extreme and prolonged droughts, the Okanagan water resource would be managed so that consumptive uses are met at all times if possible, foregoing some fishery requirements in tributary streams and in the Okanagan River as necessary, provided the viability of the sport fishery resource is maintained in the long run. Okanagan Lake would be operated over an increased range (up to 9 feet between extreme drought and flood conditions) assuming appropriate adjustments are made to water intakes to ensure continuous water supplies to all users.

Because the water levels of Osoyoos Lake are controlled by the Zosel dam in the United States under normal or low flow conditions, and by the Similkameen River in the United States under flood conditions, any long term solutions to the problem of fluctuating water levels on this lake must be resolved through the International Joint Commission. The only short term solution that can be implemented in the Canadian portion of Osoyoos Lake to minimize the impact of extreme floods is flood plain zoning.

In tributary basins, it was recognized that there is a need for multiple purpose water management on some creeks where there is demonstrated fishery potential. Thus, the potential of developing increased headwater storages for irrigation and domestic uses should be investigated on all tributaries. On Mission and Equesis Creeks, new storage and operational procedures for releasing existing water from headwater storages, should be examined to meet the multiple needs of fisheries, irrigation and domestic uses.

The detailed recommendations developed by the Board to meet the water quantity objectives of the framework plan are outlined below. The rationale for each of the recommendations has been set out in Chapter 14. (See also Basic Recommendations 1 to 11 at the front of this report).

Normal Operating Conditions Okanagan Lake

12. *"That Okanagan Lake be regulated within its normal four foot range (elevation 1119.8 to 1123.8 feet) in all but anticipated extreme flood years (net inflows to Okanagan Lake exceeding 500,000 acre-feet), and successive drought years (net inflows less than 200,000 acre-feet per year)."*

13. (i) "Okanagan Lake should be drawn down below its normal low water elevation of 1119.8 feet prior to freshet, in an anticipated flood year, by up to one foot."

(ii) "That flood plain zoning be implemented and enforced by a regional water management authority up to 1127.5 feet elevation around Okanagan Lake. Further development on this flood plain should be limited to recreation, parks and agricultural activities (see also Recommendation 5)."

Lake Operation Under Flood Conditions

(iii) "That the gates on Okanagan and Skaha Lakes be improved to avoid icing during the winter and erosion and bank protection works be built around some drop structures and along Okanagan River."

(iv) "That flood plain zoning around Osoyoos Lake be implemented by the Regional authority to 921 feet as soon as possible (see also Recommendation 5)."

(v) "That emergency protection measures and flood warning systems be further developed for Osoyoos Lake as soon as possible by the British Columbia Water Resources Service. These measures should be described in an information booklet and made available to all residents around the lake."

14. (i) "That the level of Okanagan Lake be maintained at as high an elevation as possible during drought years, recognizing that in single drought years, all consumptive and non-consumptive water requirements should be met. Under prolonged drought conditions, the lake level may reach a low of 1116.8 feet."

(ii) "That irrigation and domestic intakes along Okanagan River channel be lowered or altered so that they are fully operative under a base flow of 100 cubic feet per second (c.f.s.) in drought years."

Lake Operation Under Drought Conditions

(iii) "That once the intakes have been lowered or altered, water requirements for sockeye salmon in Okanagan River should be met in all years except consecutive drought years as follows:

	FLOWS MEASURED AT OLIVER HYDROMETRIC STATION
August 1 - September 15	300 - 400 c.f.s.
September 26 - October 31	350 - 550 c.f.s.
November 1 - April 30	275 c.f.s.

In two or more consecutive drought years, these flows may have to be reduced."

(iv) "That all irrigation and domestic intakes around Okanagan Lake be adjusted as required to be operable at a minimum lake elevation of 1116.8 feet."

Structural Requirements RE Lake Levels

15. *"That all future intakes, wharves, boat ramps and other structures around Okanagan Lake be built to operate with a lake elevation range of 1116.8 to 1125.5 feet. Similar structures around Osoyoos Lake must operate with a lake elevation range of 909 to 919 feet with possible revisions resulting from the proposed I.J.C. review."*

Kelowna Floating Bridge

16. *"That contingency plans and costs be prepared by the Province of British Columbia for possible adjustments to the Kelowna Floating Bridge, so that the bridge can function within an operating range of 1116.8 to 1125.5 feet on Okanagan Lake."*

Tugulnuit Lake

17. *"That the existing improved channel way used to maintain Tugulnuit Lake be supplemented by the addition of a pumping unit."*

Monitoring To Improve Inflow Forecasts

18. *"That the stream monitoring program in the tributary streams to Okanagan Lake and the mainstem should be continued to improve inflow forecasts to Okanagan Lake and the major tributaries."*

Multiple Water Use in Tributaries

19. *"That multiple purpose water management be practiced in selected tributary basins to meet present and future consumptive and non-consumptive uses."*

Pumped Diversion To Vernon Creek

20. *"That the pumped diversion from Okanagan Lake to Vernon Creek be continued."*

19.3.3 Water Quality

Maintenance of high water quality standards for consumptive and non-consumptive uses was of critical importance in the framework plan. The primary goal was to retard the process of eutrophication in the main valley lakes. The concept of exporting wastes outside the basin was rejected in favour of development of a comprehensive waste management program to reduce discharges of controllable sources of nutrients to the surface waters. Water quality standards for all main valley lakes have been established, based on their capacities to assimilate nutrients without promoting algal or rooted aquatic plant growth, and annual phosphorus loadings must be within or below these criteria by 1977. No firm recommendations on waste management can be made beyond 1985 until more information on the response of the lakes to immediate reductions in nutrient loadings is available.

With the uncertainty associated with the water quality management component of the framework plan, a complete program of removing all controllable nutrient sources from the surface water may be more expensive than that required to maintain good water quality conditions. Moreover such action may not always be advantageous. Therefore the framework plan recommends an interim approach to water quality management for the main valley lakes in which phosphorus loadings will be reduced within the established criteria in the immediate future, while maintaining a long term flexibility to take advantage of possible improvements in waste management practices and to reduce the uncertainty in water quality management through careful monitoring of the response of the lakes to decreased nutrient loadings.

In addition to high phosphorus and other nutrient concentrations in some main valley lakes, there are also high coliform levels, oxygen deficiencies, turbidity and high concentrations of iron, manganese and phosphorus in some tributary creeks. Because tributaries have very limited capacities to assimilate wastes, the framework plan recommends complete removal of all direct industrial and municipal waste discharges containing pollutants to the creeks by 1980 and strict regulations on drainage from cattle feedlots and other livestock operations near creeks to prevent surface runoff reaching the stream. In addition because of siltation problems in creeks due to erosion, the framework plan recommends that greenbelts of a suitable width be reserved along the entire lengths of creeks where logging or cultivation is practised.

The detailed recommendations developed by the Board to meet the water quality objectives of the framework plan are outlined below.

Municipal & Industrial Discharges To Tributaries

21. *"That all municipal and industrial waste discharges causing pollution be prevented from entering tributary streams."*

Erosion Management

22. *"That forest management and agricultural practices be reviewed by the B.C. Forest Service and the B.C. Department of Agriculture, and greenbelts established where necessary to reduce nutrient loadings from erosion."*

Drainage Waters From Livestock Operations

23. *"That regulations controlling surface drainage from cattle feed lots, and other livestock operations be established and enforced by British Columbia Water Resources Service by 1975."*

Fertilizers and Sprays

24. *"That future regulations controlling fertilizers and sprays be reviewed by the B.C. Department of Agriculture based on the impending report of the Royal Commission presently studying the matter."*

Wood Lake

25. *"That a sewage collection treatment system at the urban center of Winfield, with facilities for 80% phosphorus removal, be installed by 1977."*

Kalamalka Lake

26. *"That sewage collection for the urban center of Coldstream with a trunk transport line to the treatment plant at Vernon be installed by 1977. This would effect 100% phosphorus removal in serviced areas and reduce local phosphorus loadings to the Kalamalka Beach area."*

Okanagan Lake

27. *(i) "That the City of Vernon remove all sanitary and industrial wastes causing pollution from Vernon Creek by implementing one of the two wastewater management options detailed below:*

OPTION A - Removal of 80% of phosphorus by 1977 with discharge of treated effluent into Vernon Creek.

This option assumes a discharge effluent which is free of pollutants. Should continued monitoring of Vernon Creek indicate this discharge to contain pollutants which affect the quality of the Vernon Creek and the North Arm of Okanagan Lake, an outfall sewer between the Vernon Sewage Treatment Plant and the main body of Okanagan Lake may be required.

OPTION B - Spray irrigation of secondary treated effluent by 1977. This measure would achieve over 90% phosphorus removal."

(ii) "That sewage collection and treatment with 80% phosphorus removal for the urban center of Okanagan Landing be started by 1977 to reduce loadings to the Vernon Arm of the lake. The option of constructing a trunk line to the central plant at Vernon should be investigated."

(iii) "That 80% phosphorus removal from City of Kelowna waste effluents be implemented by 1977 to reduce loadings within acceptable criteria beyond the year 1980 under a low economic

growth rate. The inclusion of Rutland and new areas in the City of Kelowna sewer system should be undertaken immediately. Increased phosphorus removal may be required by the year 2000."

(iv) "That phosphorus removal at Westbank, Armstrong, Naramata, Summerland, Peachland and other urban shoreline developments be implemented as required by the B. C. Water Resources Service to improve water quality in local shoreline areas of Okanagan Lake."

28\. *(i) "That 80% phosphorus removal at the City of Penticton Sewage Treatment Plant be achieved and/or maintained."*

Skaha Lake

(ii) "That treatment and phosphorus removal at Okanagan Falls and other urban shoreline developments be implemented as required by the B. C. Water Resources Service to improve local shoreline areas, based on the results of monitoring programs."

29\. *(i) "That 80% phosphorus removal at Oliver is required by 1980 to reduce loadings to Osoyoos Lake."*

Osoyoos Lake

(ii) "That 80% phosphorus removal at Osoyoos is required by 1977. Urban areas in Osoyoos adjacent to Osoyoos Lake and serviced by septic tanks should be sewered and included in the Osoyoos waste treatment program by 1980."

Regional Waste Management

30\. *"That the Regional District be given the responsibiltiy for the construction, operation, maintenance and financing of all solid waste and sewage treatment plants in the basin, subject to permits issued by the Government of British Columbia."*

Septic Tanks

31\. *"That all new septic tank installations be constructed to standards that ensure 80% phosphorus removal where soil conditions are such that special measures are required to control nutrients from this source."*

19.3.4 Water Based Recreation and Fisheries

Water-based recreation and fishing are important contributors to the economic and social life-style of valley residents and tourists. Thus, the framework plan sets out to manage this facet of the water resource system by improving and increasing the quantity and quality of water-based recreation opportunities with primary emphasis on the needs of residents.

The program of waste management outlined above is expected to control aquatic plant and algal growth in the lakes to levels that permit maximum recreational and aesthetic benefits to be attained. To provide adequate land to meet projected resident and visitor beach day demands, it is recommended that all land alienation of public or crown lands with any recreation potential be prohibited. Development of such areas for shoreline recreation should satisfy future demands without the need to expropriate private shoreline properties.

If current angling success rates are to be maintained over the next 50 years, existing stocks of sport fishes will have to be increased three to four times present levels. Consequently, not only must adequate water supplies for fisheries be assured in all but drought years in selected tributaries and in the Okanagan River, but natural and artificial spawning habitats must be protected and enhanced.

The Boards' recommendations on fisheries and water based recreation to meet the objectives of these components of the framework plan are as follows:

Fishery Management

32. *"That the fishery resource continue to be managed on a valley-wide basis by the British Columbia Department of Recreation and Conservation but a number of alternative means of financing this program should be investigated by this agency in cooperation with the Regional District."*

Trout Stocking

33. *"That the Rainbow trout stocking program should be increased from 1.7 million fry annually at present (1971) to 2.1 million fry by 1980 using existing hatchery facilities."*

Fish Hatchery

34. *"That studies be undertaken by the British Columbia Department of Recreation and Conservation by 1975 for locating and designing a new fish hatchery in the Southern Interior of the Province."*

Boating Regulations

35. *"That federal boating regulations in headwater lakes be extended and enforced by the British Columbia Department of Recreation and Conservation in cooperation with the Regional District."*

Modified Operation of Existing Storage

36. *(i) "That a modified operation of headwater storage releases on Mission Creek be established by 1975 by the British Columbia Water Resources Service in cooperation with the irrigation districts."*

New Storage Mission Creek

(ii) "That 3,600 acre-feet of headwater storage on Mission Creek be licenced and developed for fisheries by 1980."

(iii) That rehabilitation of the streambed spawning habitat on Mission Creek be undertaken after assuredwater supplies are available."

New Storage on Equesis Creek

37. "That an additional 700 acre-feet of storage be made available to support the fishery in Equesis Creek."

Pumped water - Trepanier Creek

38. "That 2200 acre-feet of water be pumped from Okanagan Lake to the lower reaches of Trepanier Creek by 1985."

Incubation Channel

39. "That further consideration should be given to the development of an incubation channel in one of the tributary creeks to South Okanagan Lake."

Shore Spawning

40. "That due consideration be given to shore spawning kokanee when regulating Okanagan Lake water levels over the winter months."

Coordination of Water-Based Recreation Facilities

41. "That the Regional District be responsible for coordinating the various responsible agencies at the Provincial and Municipal levels in the implementation of recommendations involving shoreline recreation management in the framework plan. Specifically, the Regional District should perform the following duties by 1975:

(i) Preparation of detailed shoreline recreation landuse plans for all main valley lakes.

(ii) Collect recreation data such as the number of summer holiday visitors, number of beach days enjoyed by residents and visitors annually, preferences and attitudes of beach users for shoreline landuse management and other pertinent data.

(iii) Manage recreation use conflicts through implementation of boating regulations on main valley and headwater lakes.

(iv) Undertake a full review of water-based recreation management needs as part of the re-assessment of the Okanagan Study in 1980."

Water Quality for Recreation

42. "That water quality objectives for water-based recreation be met at all public and private beaches in all the main valley lakes, based on the following criteria:

(i) Total mean coliform counts not to exceed a most probable number (M.P.N.) of 240 organisms per 100 milliliters, based on a minimum of 10 samples per beach.

(ii) Fecal mean coliform count not to exceed a most probable number (M.P.N.) of 100 organisms per 100 milliliters, based on a minimum of 10 samples per beach

(iii) Dissolved oxygen not be less than 5 parts per million.

(iv) The water be free from floating debris, scum, weeds, oil slicks, and other objectionable material that detract from its quality and appearance."

Protection of Shoreline for Recreation

43. *"That further alienation of public or crown owned shorelines with moderate or high capability be prohibited. These areas which will be required to support future recreation demands are illustrated on the landuse plans accompanying the final report"*

Public Access

44. *"That all existing public access points to the main valley lakes be inspected, maintained and clearly marked. This should be undertaken by 1975, by the responsible agencies at the provincial and local levels of government."*

Boat Launching Facilities

45. *"That additional boat launching facilities be built near Kelowna and Osoyoos by 1975, and others built as indicated in Table 16.4. All such facilities on Okanagan Lake should be constructed to accommodate a 9-foot lake level fluctuation from 1116.8 to 1125.5 feet, and on Osoyoos Lake a 9-foot fluctuation from 909 to 918 feet."*

19.3.5 Management Considerations

The Consultative Board believes that only through careful planning on a valley-wide basis can the present desirable balance between economic growth and high environmental quality be maintained. A rapid growth of population and industrial development is predicted in the near future for all economic policy options and the natural environment can only be protected if this growth is carefully planned throughout the basin. There is also a need for more effective coordination at the regional level of government to ensure that the basic tenets of the comprehensive plan described above are consistently held throughout the basin.

Consequently, the Consultative Board recommends that the boundaries of the present Regional Districts of North Okanagan, Central Okanagan and Okanagan-Similkameen be redrawn to create a single Okanagan Basin Regional District. The letters patent of this new Regional District would make it responsible for implementing those water resource management functions that are valley-wide in scope, notably waste water treatment, the orderly development of shoreline recreational facilities and flood plain zoning.

Because all parts of the Okanagan are linked by the flowing nature of water, it is important to avoid actions in one part of the basin that may adversely affect the environment or economic viability in another area. This concept particularly applies to the upgrading of waste treatment facilities, where lack of action in one area can seriously affect water quality in another area, even though appropriate waste treatment measures have been implemented by the latter. Furthermore, as benefits of improved lake water quality are valley-wide, it appears to be unequitable to ask individual communities to pay the major costs of waste treatment which benefit the basin as a whole.

It also appears to be the consensus of the majority of the Okanagan Community that a single authority be established to coordinate the implementation of the framework plan. As much use as possible should be made of existing institutions, for neither the public nor the senior governments desire the creation of a new intervening level of government. The success of the task forces during this Study in bringing together people from all parts of the basin verifies that valley-wide consensus on water management problems is possible.

Provincial legislation is available to establish a regional district for the watershed. While the process of setting up such an authority normally provides for the assignment of a number of functions, it is felt that certain characteristics and functions essential to the success of this new body should be identified in the documents establishing it, for example, in the letters patent. These are:

1) That all residents within the watershed are required to share in the burden of costs, or to undertake necessary common actions, that clearly affect the valley as a whole, for example - upgrading of the main lakes.

2) That standards set by governments for such things as water quality be considered as minimum standards for the Basin and may need upgrading to provide a superior quality of the environment in specific areas.

3) That the Regional District should be supported by a technical resource advisory committee representing the resource agencies concerned. The establishment of such a group is now provided for in provincial legislation.

4) That continuing public participation, which has been a principal feature of this study, be imbedded in the future planning process and be built into the institutional arrangements proposed herein.

Because of local concern that a major reorganization of local government is premature and would create very difficult administrative problems, two alternatives to a single regional district for the basin,either of which could achieve the same objectives, are also outlined in the plan. The first of these provides for the inclusion of areas outside of the basin boundaries within the proposed Regional District Boundaries. The second alternative provides for a reconstruction of the Okanagan Basin Water Board with appropriate amendments to its "Letters Patent" to give this Board authority to carry out the basin-wide water resource management functions outlined in this report. The success of this latter alternative would depend upon the willingness of the three Regional Districts involved to delegate the necessary powers to the Water Board to achieve the objectives of the comprehensive plan. In presenting these two alternatives however, it is important to keep in mind the four characteristics listed above.

19.3.6 Implementation

In view of several conflicts in water management, it is important that the major requirements of the comprehensive plan are implemented as quickly as possible. Many components of the plan such as flood plain zoning, shoreline recreation and fishery management measures are clearly the responsibility of the proposed Okanagan Basin Regional District or the Provincial government and should be carried out without delay. Other aspects of the plan, such as adjustments to the Okanagan Flood Control Works, require joint agreement on cost-sharing by the senior levels of government, before they can be implemented. In the case of waste treatment, although implementation responsibility rests with the Regional District, there are provisions for cost-sharing established under existing programs.

To ensure continuity from planning to implementation of those measures that require joint agreement between governments, the Consultative Board recommends that an implementation task force be established on or before March 31, 1974. This task force would consist of Federal, Provincial and local government representatives and would prepare a draft implementation agreement to the senior governments by June 30, 1974. This agreement will contain details of equitable cost-sharing as developed by the senior governments.

Nothing in this recommendation should inhibit ongoing programs presently in progress, and the implementation of recommendations where responsibilities are clear.

19.3.7 Institutional and Legal Considerations

In examining the legal and institutional aspects of water resource management in the Okanagan, it is apparent that certain deficiencies have hindered effective planning and utilization in the past. These weaknesses are summarized below.

1) No single agency has regulatory controls over all pollutants from sanitary waste discharges to the ground of less than 5,000 gallons per day.

2) No one agency is empowered to enforce waste management, flood plain zoning and green belt measures recommended under the framework plan on all Indian Lands in the Okanagan.

3) There is a lag in the enforcement of legislation, regulations and guidelines affecting water resource management.

4) Prior to this study, the public has had no opportunity for participation in the planning process.

The common thread in these weaknesses is the lack of a basin-wide approach to managing water and water related resources at the local level. The Board believes that a regional authority could, with the benefit of direct experience gained over time, solve most of the problems. It could, for example, develop plans for the orderly use or phase-out of septic tanks that have both health hazard and nutrient loading problems; it could work directly with the Indian bands to solve their problems in a harmonious way; it could identify deficiencies in enforcement programs; and, it could be the focal point for continuing public participation. Specific answers to these problems are not proposed here. Indeed, it is the Boards' view that a single regional authority will in time become more capable of providing effective and acceptable solutions. This is the heart of the Boards' conclusions; namely, that the future of the Valley rests primarily in the hands of local residents, with the support and assistance of senior governments.

CHAPTER 20

Monitoring The Framework Plan

20.1 INTRODUCTION

The comprehensive framework plan presented in Chapter 19 provides for the logical development and management of water and water related resources in the Okanagan Basin over the next fifty years, in keeping with the expressed desires of the public for a particular life style. The monitoring of these resources to determine how they respond to the various management measures implemented, and where necessary to make suitable adjustments to ensure that the plan continues to meet the social and economic goals of the valley community, is considered to be an integral part of the framework plan.

This chapter outlines the overall monitoring objectives that should be met based on knowledge and experience gained by the Board during the tenure of the Okanagan Basin Study. These objectives apply particularly to the immediate future and the full review to be undertaken by 1980. The actual development of a monitoring program to meet these objectives, including consultation with appropriate technical groups, is considered to be a function of the 'Implementation Task Force.'

20.2 MONITORING OBJECTIVES

The planning objectives of the four management components comprising the comprehensive plan were outlined in Chapter 12, Section 12.5. Data obtained during the study and used as a basis for developing alternatives to meet these objectives, represents the best information presently available. However, as new records are obtained, new floods and droughts experienced and new or improved waste management programs implemented, the data base prepared under this study will become obsolete.

To ensure that an up-to-date data base is available on which management can found both short and long term decisions regarding the plan, the following objectives are set out for the establishment of a suitable monitoring program. Examples of monitoring requirements to meet various planning objectives are also shown in Table 20.1.

1. To provide current data for the day to day management of water and water related resources on such aspects as reservoir storage levels, runoff potential, diversions, water quality for consumptive use and water-based recreation, etc.

TABLE 20.1

EXAMPLES OF MONITORING REQUIREMENTS TO MEET PLANNING OBJECTIVES

PLANNING OBJECTIVE	EXAMPLES OF MONITORING REQUIREMENTS
(a) Water Quantity Management	
(i) to supply water for all consumptive water requirements for agriculture, residential, commercial and industrial purposes	1. Current data on reservoir storage levels, diversions, water demands, etc. 2. Continuous monitoring of selected tributaries to improve estimates of firm water supplies and runoff forecasts.
(ii) to supply water for all non-consumptive water requirements for fisheries, wildlife, recreation and aesthetic resources.	1. Same as for (i) above 2. Short term study on effects of reduced flows on fisheries down Okanagan River during drought cycles. 3. Short term study on effect of storage and modified operation on flows for fisheries (Mission, Equesis and Trepanier Creeks).
(iii) to minimize conflicts between existing and potential uses of water.	1. Same as for (ii) above
(b) Water Quality Management	
(i) to protect the health of Okanagan residents	1. Current data on water quality for consumptive use, water based recreation and waste treatment effluents
(ii) to provide water quality compatible with agriculture, municipal, domestic and industrial use.	1. Same as for (i) above
(iii) to provide a water quality compatible with recreation, sport fisheries and other non-consumptive uses of water.	1. Short term monitoring of lake water quality at periodic intervals (limnological). 2. Current data on water quality for beach oriented recreation.
(c) Fishery Management	
(i) to preserve, enhance and manage environments suitable for sport fishery development	1. Current data on fish stocks, spawning escapements, and angler participation, with emphasis on Mission, Equesis and Trepanier Creeks for Okanagan Lake
(ii) to maintain and protect the environment for Sockeye salmon stocks in the Okanagan River.	1. Current data on spawning escapement of Sockeye salmon.
(d) Water Based Recreation Management	
(i) to provide opportunities for a full range of water based recreation opportunities.	1. Current data on use and demand of existing facilities.
(ii) to protect and enhance the aesthetic qualities of the Okanagan Valley	1. Current data on land use planning and development.

2. To provide continuous records of a sufficient time base for the long term improvement of water management in the Basin - e.g. to establish the extent of firm water supplies in the Basin for water licencing purposes, particularly in the tributary streams; to improve runoff forecasts in drought and flood years, etc.

3. To provide a measure of the response of water and water related resources to specific measures implemented under the plan - e.g. the response of the lakes to new or improved waste management programs, the effect of improved spawning facilities on fishery potentials, the effect of increased drawdowns on Okanagan Lake in drought periods on recreation and fisheries, etc.

Some of the above objectives require continuous monitoring while others may best be achieved through concentrated short term programs at periodic intervals. In many cases monitoring programs already exist that will meet the requirements of the first two objectives. These should however, be coordinated into an overall program along with any additional monitoring required to meet the third objective. It should also be recognized that many of the monitoring needs of individual components of the plan may be similar, and therefore close liason will be required between different disciplines and agencies during the development of this program.

One additional component not included in the above objectives is that of economic growth. The economic projections provided in this report should be compared to actual growth rates following the next federal census in 1981. This is required to orient the plan in time with respect to actual growth, water demands, waste loadings, etc; to compare the data obtained from the 1980 review with actual growth conditions; and to modify the plan as required based on improved forecasts over the next decade.

ACKNOWLEDGEMENTS

The Consultative Board wishes to acknowledge the contribution of the many individuals and agencies involved in the investigations, evaluations and report preparation carried out under the Canada-British Columbia Okanagan Basin Agreement. A complete list of these participants is included as Appendix D.

The Board is particularly appreciative of the major contributions made by the Study Committee, Study Director and Program Coordinators, who were deeply involved in all phases of the Study, including the preparation of the comprehensive plan, final report and technical supplements (Table 1, pp xii).

The input of the public involvement task force members represents a new concept in basin planning, and this group is to be commended for their interest, time and effort in synthesizing and compiling the report "To Our Children's Children", which represents the consensus of Valley opinion regarding the community's desires for the future development and management of the water resource in the Okanagan Basin.

Finally, the Board wishes to acknowledge the major contributions of the following agencies which carried out the task assignments and prepared the technical supplements to the main report.

1. British Columbia Water Resources Service.
2. Inland Waters Directorate, Environment Canada.
3. Atmospheric Environment Service, Environment Canada.
4. Fisheries and Marine Service, Environment Canada.
5. Soils Branch, B.C. Department of Agriculture.
6. B.C. Department of Health Laboratory
7. Civil Engineering Department, University of British Columbia
8. B.C. Department of Industrial Development, Trade and Commerce.
9. Fish and Wildlife Branch, B.C. Department of Recreation and Conservation.

REFERENCES

REFERENCES

(1) Dept. of National Health and Welfare, "Canadian Drinking Water Standards and Objectives", 1968.

(2) Anon, "Drinking Water Standards", Title 47, Public Health Chapter 1, Public Health Service, Dept. of Health, Education and Welfare, Part 72, Interstate Quarantine Federal Register 2157 (March 6, 1962).

(3) National Swedish Nature Conservatory Council, "Report on Water Quality Criteria for Swedish Surface Waters", Summary, 1969 1E.

(4) McKee and Wolf, "Water Quality Criteria", Publication 3-A, 1971 California.

(5) B.C. Research, "The Disposal of Mining and Milling Wastes with Particular Reference to Underwater Disposal", Provincial Water Resources Service, 1970.

(6) W.H.O. International, 1958 and W.H.O. European, 1961, "Drinking Water Standards".

(7) Lloyd, R. and Herbert, D.W.M., "The Effect of the Environment on the Toxicity of Poisons to Fish", J. Inst. Public Health Eng. July, pp. 132-145, 1962.

(8) U.S. Department of the Interior, "Water Quality Criteria", Federal Water Pollution Control Administration, 1968.

(9) "Recommended Water Quality Standards", Division of Public Health Engineers, Health Branch, Province of British Columbia, 1969.

(10) "Federal Water Pollution Control Administration, Report of the Committee on Water Quality Criteria", Federal Water Pollution Control Administration, Washington, D.C., April, 1968.

(11) Moore, B., "The Detection of Paratyphoid Carriers in Towns by Means of Sewage Examination," Monthly Bulletin of Minister of Public Health, Laboratory Services, 1948, Vol. 5, No. 7, Pg. 241-248.

(12) Geldreich, E.E., "Applying Bateriological Parameters to Recreation Water Quality", Journal of American Water Works Association, February, 1970.

(13) Eliassen R., and Tchobanoglous, G., "Removal of Nitrogen and Phosphorus from Waste Water," Environmental Science and Technology, 3, 6, 536 (June, 1969).

(14) Black and Veatch. Process Design Manual for Phosphorus Removal, U.S. Environmental Protection Agency Technology Transfer, October, 1971.

(15) Clemens, W.A., D.S. Rawson and J.L. McHugh. 1939. A biological survey of Okanagan Lake, British Columbia. Fish. Res. Bd. Canada, Bull. 56: 70 p.

(16) Flint, R.F. 1935a. Glacial Features of the Southern Okanagan: Geol.Soc., Amer. Bull., Vol. 46, pp. 169-193.

1935b. "White Silt: Deposits in the Okanagan Valley, B.C.: Roy. Soc. Canada, Trans., Series 3, Vol. 29, Sec. 4.

(17) Fulton, R.J. 1965. Silt Deposition in Late-Glacial Lakes of southern British Columbia: Am. J. Sci., v. 263, 553-570

(18) Stein J.R., and Coulthard T.L., 1971, A Report on the Okanagan Water Investigation. Prepared for the Water Investigations Branch, British Columbia Water Resources Service.

(19) Armstrong, F.A.J. and D.W. Schindler. 1971 Preliminary chemical characterization of waters in the Experimental Lakes Area, northwestern Ontario. J. Fish. Res. Bd. Canada 28: 171-187.

REFERENCES (CONT'D)

(20) Livingstone, D.A. 1963. Chemical composition of rivers and lakes. Data of geochemistry, 6th ed. Chap. G. Geological survey professional paper 440-G. U.S. Govt. Printing Office, Washington 25, D.C. 61 p.

(21) Ferguson, R.G. 1949. The interrelations among the fish populations of Skaha Lake, B.C. and their significance in the production of Kamloops trout (Salmon gairdnerii kamloops Jordan). B.A. thesis, Dept. Zool., Univ. Brit. Coll 84 p + 6 appendices.

(22) Vollenweider, R.A. 1969. Moglichkeiten und Grenzen elementarer Modelle der Stoffbilanz von Seen. Arch. Hydrobiol. 66, 1:1-36.

(23) Ryder, R.A. 1965. A method for Estimating the Potential Fish Production of North-Temperate Lakes. Trans. Am. Fish. Soc. 94:214-218.

(24) Report to the International Joint Commission, United States and Canada, "Water Resources of the Columbia River Basin - Okanagan-Similkameen Basin," International Columbia River Engineering Board, Appendix IV, 1955.

APPENDICES

APPENDIX A

THE CANADA-BRITISH COLUMBIA OKANAGAN BASIN AGREEMENT

CANADA-BRITISH COLUMBIA OKANAGAN BASIN AGREEMENT

THIS AGREEMENT made as of the 29th day of October, 1969

BETWEEN: THE GOVERNMENT OF CANADA
represented herein by the Minister of Energy, Mines and Resources (hereinafter called "Canada")

OF THE FIRST PART

AND THE GOVERNMENT OF THE PROVINCE OF BRITISH COLUMBIA
represented herein by the Minister of Lands, Forests and Water Resources (hereinafter called "British Columbia")

OF THE SECOND PART

WHEREAS the Governments of Canada and British Columbia recognize the growing need to plan water resources development on a comprehensive basis; and

WHEREAS the economy of the Okanagan Basin is heavily dependent on the quantity and quality of its limited water resource for agricultural production, recreation and tourism, as well as for domestic, municipal and industrial water supply and for the assimilation of wastes; and

WHEREAS the water supply problems in the Basin may involve the re-use of municipal waste water in irrigation systems, increased efficiencies in the use of water for irrigation, and the augmentation of water supply from groundwater and from diversion; and

WHEREAS the Shuswap-Thompson Rivers and the Okanagan River are important habitats for valuable stocks of Pacific Salmon; and

WHEREAS the Shuswap-Thompson system is a potential diversion source for the Okanagan Basin; and

WHEREAS these problems and possible solutions may have not only municipal, regional, provincial, and national significance, but potential implications outside Canada; and

WHEREAS His Excellency, the Governor-in-Council by Order-in-Council, P.C. 1969-7/2051 has authorized the Minister of Energy, Mines and Resources to execute this Agreement on behalf of Canada; and

WHEREAS His Honour, the Lieutenant Governor-in-Council by Order-in-Council No. 2423/1969 has authorized the Minister of Lands, Forests and Water Resources to execute this Agreement on behalf of British Columbia.

NOW THEREFORE THIS AGREEMENT WITNESSETH THAT in consideration of the premises, covenants and agreements herein contained the parties covenant and agree with each other as follows:

1. OBJECTIVE

The purpose of this Agreement is to develop a comprehensive framework plan for the development and management of water resources for the social betterment and economic growth in the Okanagan Basin.

2. SCOPE

The Okanagan Basin is of major significance to the Province of British Columbia. Due to increasing demands likely to be placed on the water resources of this Basin for municipal, industrial, agricultural and recreational uses and for fish and wildlife management and in view of the deterioration of water quality, disturbance of ecological balances, and diminution of water quantity in the Basin, the study will focus on identification and analysis of these problems and the evaluation of economic, engineering, ecological, financial and organizational alternatives for water resource utilization in the solutions to these problems. The planning horizon of the study will be to the year 2020 A.D.

The study will also embrace any areas likely to be affected by the adoption of various alternative solutions including, but not limited to, the possibility of diverting water from the Shuswap-Thompson Basin.

The study may also include the expansion of the present hydrologic and water quality data collection systems and an implementation phase in the form of pilot advance treatment plants and an experimental program of effluent disposal including spray irrigation and other techniques.

3. TERMS OF REFERENCE

The studies leading to the formulation of a comprehensive framework plan for the Okanagan Basin are to be sufficiently broad in scope as to examine possible alternatives for the efficient utilization and provision of an adequate quantity and quality of water in the Basin and in those areas likely to be affected by a diversion. Consequently, the program will include:

(a) ECONOMIC GROWTH STUDIES - as required, to provide a regional, national and internationl market perspective in which to view the emerging patterns of water demand for the Basin. The studies will focus on the regional resource base and on the economic viability of new and existing kinds of industry and agriculture, including tourism and water-based recreations, upon which water demand predictions can be based.

(b) WATER DEMAND STUDIES - as required, to provide an estimate of current demands and a forecast of future water demands by sector - municipal, industrial, agricultural, transportation, fisheries, recreational - to the year 2020 A.D.

(c) WATER SUPPLY STUDIES

(i) Water Quality Studies - as required, to determine present sources and levels of pollution, the relationships between inputs and outputs of nutrients and other chemical parameters in the waters of the Basin; to devise mathematical models to express the nutrient balances and pollution effects; and to determine the extent and range of possible future sources and levels of pollution.

(ii) Water Quantity Studies - As required, to evaluate the existing hydrologic regime of the Basin, including studies of runoff, lake levels, flows, groundwater and geological structure; climatology and meteorology; to evaluate means of regulating flows through storage and diversion; and to evaluate means of augmenting water supplies within the Okanagan Basin.

(d) ECOLOGICAL AND AESTHETIC STUDIES - as required, to determine the effects of water resources development and utilization on the fish and wildlife, and on the aesthetic values of the Basin.

(e) WATER RE-USE AND PILOT PROJECTS FOR ADVANCED TREATMENT OF WASTE WATER - as part of the water quality studies to determine practicability of augmenting water required for irrigation with the waste waters and to develop pilot plants for the control of nutrient discharges through the treatment of municipal and industrial wastes.

(f) STUDIES OF FINANCIAL AND ORGANIZATIONAL STRUCTURES - as required, to broaden the scope of the planning process to include all practical alternatives for the subsequent efficient utilization of the water resources of the Okanagan Basin.

(g) PUBLIC INVOLVEMENT - as required, to enable a comprehensive plan to be truly responsive to the wishes of the people for which it is designed while reflecting the characteristics of the people in the Okanagan Valley and surrounding regions.

4. FINANCING

(a) Canada and British Columbia shall equally share the entire cost of the study, including, but not limited to, the cost of collection of data, field surveys and the cost of consultants engaged as part of the program as well as an equitable share of the items described in (d) hereunder. Salaries of federal and provincial civil servants engaged in the program shall not be paid from funds approved under this Agreement excepting staff specifically assigned to and engaged in studies under this Agreement.

(b) Subject to the terms and conditions of this Agreement and subject to the funds being voted by Parliament, the aggregate sum to which Canada shall be liable in respect of the Agreement is not to exceed $1,000,000 of which not more than $250,000 will be available for financial assistance provided by Canada for the items described under (d) below.

(c) Subject to the terms and conditions of this Agreement and subject to the funds being voted by the Legislative Assembly, the aggregate sum to which British Columbia shall be liable in respect of the Agreement is not to exceed $1,000,000 of which not more than $250,000 will be available for the items described under (d) below.

(d) From time to time during the life of this Agreement, and as part of the Program, Canada and British Columbia may approve and provide financial assistance to local communities and organizations for:

(i) an experimental program of waste water reclamation by irrigation; and

(ii) a pilot advanced treatment installation.

Any project thus approved and constructed shall be operated and maintained by the municipality or local authority. Access shall be provided at all times for personnel authorized to work on the Program.

(e) This Agreement shall take effect on the date that the parties have executed this Agreement. No costs incurred prior to March 25, 1969 shall be eligible or considered for payment under this Agreement. This Agreement shall terminate four years from the date of signing.

(f) Canada and British Columbia shall keep complete records of all expenditures made severally pursuant to the Agreement and shall support such expenditures with proper documentation. Canada and British Columbia upon request shall make these records and documents available to auditors appointed by the other.

(g) British Columbia shall keep complete financial records of all costs incurred under this Agreement. Upon request, British Columbia will make these records available to auditors appointed by Canada.

(h) Subject to the cost-sharing provisions of this Agreement, Canada shall pay to British Columbia, Canada's share of expenditures made by British Columbia pursuant to this Agreement upon the submission of a claim in a mutually agreed manner and form by British Columbia, certified by a senior official of British Columbia, and bearing a British Columbia audit certificate

(i) Subject to the cost-sharing provisions of this Agreement, British Columbia shall credit Canada for expenditures made directly by Canada pursuant to this Agreement, upon the submission by Canada of a claim in a mutually agreed manner and form.

(j) Each party shall provide the staff including any field staff and administrative facilities necessary to implement any portion of the program assigned to the respective parties.

5. LEGAL IMPLICATIONS

Any studies undertaken under the provisions of this Agreement shall take into account in an appropriate fashion any legal implications necessarily incidental thereto.

6. ADMINISTRATIVE FRAMEWORK OF THE STUDY

Canada and British Columbia shall participate in a process of joint planning. To facilitate this, the following shall be established:

(a) A CANADA-BRITISH COLUMBIA CONSULTATIVE BOARD consisting of six members at a senior level in the public service, three of whom will be appointed by Canada and three by British Columbia. This Board shall be responsible for undertaking the program described herein; shall supervise the Okanagan Study Committee; shall meet at least once each year; and shall report to the Minister of Energy, Mines and Resources of Canada and to the Minister of Lands, Forests and Water Resources of British Columbia on progress of the Program and on the results of the investigation.

(b) AN OKANAGAN STUDY COMMITTEE, reporting to the Canada-British Columbia Consultative Board, will consist of three members appointed by Canada and three members appointed by British Columbia. With the approval of the Board, the Committee may appoint a study director, various sub-committees and other staff to carry out specific portions of the Program. All staff appointments shall be through the Provincial Civil Service Commission on the advice and consent of the Consultative Board. A party hereto may, upon the recommendation of the Board, employ the services of private consulting individuals and firms as required for data collection, planning and implementation.

(c) The Okanagan Study Committee under the supervision of the Board, shall carry out the joint planning studies and pilot projects in accordance with the terms of reference. In addition, the Committee shall involve the public in the planning process.

7. FINAL REPORT

The comprehensive plan resulting from this Agreement shall be accompanied by a final report including a full benefit-cost analysis of the alternative solutions and recommendations for further courses of actions.

8. GENERAL

(a) British Columbia and Canada shall exchange copies of all reports and related available information from prior and current studies for use in the Program.

(b) This Agreement shall not be construed as to vest in Canada any proprietary interest in projects constructed hereunder.

(c) The Agreement may from time to time be reviewed by the parties hereto and with the approval of the Governor-in-Council and the Lieutenant Governor-in-Council, may be revised.

(d) No Member of the Parliament of Canada or Member of the Legislative Assembly of British Columbia shall hold, enjoy or be admitted to any share or part of any contract, agreement, commission or benefit arising out of this agreement.

(e) The Okanagan Study Committee will submit annual reports to the Consultative Board on its findings as well as a final report on or before the expiration date of this Agreement, and other reports as required by the Board.

(f) The Board may make recommendations to both parties regarding further participation in detailed studies beyond the terms of this Agreement and regarding the implementation of the comprehensive plan.

IN WITNESS WHEREOF the Honourable J.J. Greene, Minister of Energy, Mines and Resources, has hereunto set his hand on behalf of Canada and the Honourable Ray Williston, Minister of Lands, Forests and Water Resources, for the Province of British Columbia.

In the Presence of	Signed on behalf of the Government of Canada
"A.T. Davidson"	"J.J. GREENE" Oct. 29, 1969
In the Presence of	Signed on behalf of the Province of British Columbia
"V. Raudsepp"	"Ray Williston" Oct. 29, 1969

APPENDIX B

SUMMARY STATEMENT
O.B.W.B. HEARINGS
MARCH 1972

SUMMARY STATEMENT ON BRIEFS SUBMITTED AT OKANAGAN BASIN WATER BOARD HEARINGS MAY 26 TO NOV. 23, 1971

(PREPARED BY O.B.W.B. MARCH, 1972)

DESCRIPTION

During the period, May 26, 1971 to November 23, 1971, the Okanagan Basin Water Board sponsored a series of six public meetings to hear the views of local residents relating to water management. Meetings were held in Vernon, Penticton, Princeton, Kelowna, Osoyoos, and Enderby. Total attendance for these meetings was 590 persons.

One hundred and ten written and verbal presentations were made by a variety of organizations and individuals.

Since briefs submitted on behalf of organizations represent the views of many individuals within the group, it is likely that opinions expressed during the meetings represent a much larger population than merely the number of briefs presented or the number of persons attending. The large number of individuals who prepared briefs to express their own views without the guidance of a group are to be commended.

The views expressed during these public meetings were unprompted, and therefore a wide variety of statements relating to water resource management were received. This technique provides for a liberal expression of public opinion; but on the otherhand, does not lend itself to statistical analysis as does a planned questionnaire based on random sampling techniques. The results of public meetings will. therefore, be analyzed and provide good complimentary information to statistical data gathered through a resident survey undertaken by the Okanagan Basin Study.

Key phrases or statements indicating various viewpoints have been placed under appropriate headings, such as - water quality, water quantity, etc., on the following pages. Each brief presented was reviewed, and the number of briefs expressing views similar to each of the key statements were tabulated.

The number of briefs expressing a given view should provide an indication of the relative public concern related to each statement.

SUMMARY STATEMENTS:	NO. SUPPORTING STATEMENT
WATER QUALITY	
1 - Water quality is a local problem	23
2 - Stricter controls for waste should be researched and enforced. Waste discharge to streams and lakes should be stopped.	31

SUMMARY STATEMENTS:	NO. SUPPORTING STATEMENT
WATER QUALITY (cont'd.)	
3 - A high level of water quality should be maintained	20
4 - Water quality is important for local industries, tourism and domestic use.	1
5 - Water standards must be maintained to meet health requirements	3
6 - There are water quality problems in upper domestic reservoirs due to recreation, development and other activities which should be controlled, e.g. logging, mining, grazing, etc.	8
7 - Do not feel there is any water pollution in the Valley at present.	-
8 - Water pollution is restricted to relatively small areas at present	-
WATER QUANTITY	
1 - Increasing water demand is a local water resource problem	10
2 - The water resource is of prime importance.	4
3 - Domestic drinking water supply is a local resource problem.	4
4 - Population has outgrown available water supply.	1
5 - Water quantity should be managed more carefully.	24
6 - Water should not be diverted simply to aid developers.	1
7 - Opposed to diversion from the Shuswap.	5
8 - Wish to have more flood control.	4
9 - Water should be diverted from watersheds where it is in excess	1
QUALITY OF ENVIRONMENT	
1 - The Okanagan is a good place to live. Climate, rural atmosphere, scenery, lakes and fruit growing, etc., add to the attractiveness and uniqueness of the Valley.	15
2 - The Okanagan has environmental problems.	2
3 - The present environment of the Okanagan should be maintained or improved.	15
4 - Preserving the environment is more important than achieving higher incomes, economic growth, or more employment in the Valley.	2
5 - Economic growth and preservation of the environment are equally important.	1

SUMMARY STATEMENTS:	NO. SUPPORTING STATEMENT
QUALITY OF ENVIRONMENT (cont'd.)	
6 - Protecting the environment is of secondary importance.	-
7 - A change in human attitude and life style is required to correct environmental problems.	6
TOURISM	
1 - Tourism should be encouraged.	6
2 - Tourism should be restricted. Too many tourists are causing crowding and are adding to local problems	5
AGRICULTURE	
1 - Express concern regarding loss of agricultural land.	3
2 - Wish to see agricultural land retained in agricultural use.	17
3 - Subdivision and development should be planned to protect agricultural land.	14
4 - Agriculture should be assisted to maintain agricultural land use.	11
5 - There is no need to control subdivision of agricultural land, at least in the near future.	-
6 - It would be wrong to support agriculture with public funds or by controlling subdivision.	-
7 - Agriculturists should have the priveledge of sub-dividing.	3
8 - Agriculture is becoming less economic.	4
9 - Fresh fruit and irrigated landscapes are unique features and contribute to tourism.	5
10 - Agriculture contributes greatly to the economy.	5
11 - Large quantities of easily available water are required for a viable agricultural industry.	2
12 - Studies should be done on land use.	1
INDUSTRY AND URBAN DEVELOPMENT	
1 - More industry should not be encouraged in the Valley.	4
2 - Only light, clean industry should be allowed in the Valley.	15
3 - Large industry is permissible if sewage is properly treated.	1

SUMMARY STATEMENTS:	NO. SUPPORTING STATEMENTS
INDUSTRY AND URBAN DEVELOPMENT (con'td.)	
4 - Industrial growth and/or urban development should be slowed down and planned or it will destroy the Valley.	19
5 - The average person does not gain by the increased industrialization and development. Only developers gain.	1
6 - Industrial growth is necessary, but should be planned.	7
7 - Service and recreational industries should be encouraged.	4
8 - By curtailing industry other values will be attained, i.e.. increased tourism, higher property values, culture, etc.	2
9 - There should not be any controls on Industrial Development.	-
POPULATION	
1 - Population growth should be controlled.	10
2 - Population increases should be confined to urban areas.	2
3 - Population should be stopped until there is planned growth with proper sewage treatment.	3
4 - There are already plenty of people in the Okanagan. Population should not be allowed to increase.	-
5 - There is no need to regulate population growth presently, but it should be regulated in the future.	-
6 - There is no need to regulate population in the Valley at any time.	-
WILDLIFE	
1 - Animal and bird habitats are threatened. More public effort and management should be directed to protecting fish and wildlife.	10
2 - Wildlife should be protected if it doesn't cost too much.	-
3 - No more protection of wildlife is needed.	-
PARKS, MINING, GRAZING AND FORESTRY	
1 - Logging practices, road construction, and/or mining, have resulted in damage to watersheds.	4
2 - Logging and/or mining practices should be more closely controlled.	7

SUMMARY STATEMENTS:	NO. SUPPORTING STATEMENT
PARKS, MINING, GRAZING AND FORESTRY (cont'd.)	
3 - Areas of unique and natural beauty should be conserved (ecological reserves).	8
4 - Recreational areas and parks should be planned and maintained.	17
5 - Watershed management is important to preserve water quality and quantity.	6
6 - Sustained yield and coordinated forest management meets the objectives of best land use and water management.	1
SOCIO-ECONOMIC	
1 - Education and culture should be encouraged.	3
2 - The public should be informed and consulted regarding water management.	3
INSTITUTIONAL	
1 - A local water management authority is required.	1
2 - The Okanagan Basin Water Board should become a local water management authority.	5
3 - There should be a better way of financing water systems.	2
4 - A valley-wide planning organization is needed.	1
5 - A form of authoritative Water Board is required to carry on after the Okanagan Basin Study is complete.	2

APPENDIX C

P.I.P. TASK FORCE SEVEN RECOMMENDATIONS

RECOMMENDED PLAN AS PRESENTED BY THE PUBLIC THROUGH "PIP" TASK FORCE SEVEN

(FROM PRELIMINARY REPORT NO. 1 "TO OUR CHILDREN'S CHILDREN")

A major assignment of Task Force Seven was to synthesize all the work of the previous six PIP Task Forces and to develop a type of framework plan for the future development and management of the Okanagan's water resource. In carrying out their responsibilities in this regard, the Task Force gave consideration to all recorded inputs received through the "info in" aspect of the Public Involvement Program. The framework plan developed by Task Force Seven is primarily a series of recommendations plus a time chart and maps (the unabridged version is to be found in Preliminary Report #1 and Technical Supplement XII). In providing a condensed version of it now a brief preamble introduces the recommendations:

"Since a unique environment is the key to the very desirable life-style of the Okanagan, we, who live here, should attempt to exert control over social and economic planning so as to prevent deterioration of that physical environment. Any such deterioration would inevitably lead to the deterioration of our unique social and economic environments as well. All planning decisions, at any level of government, should be made only after full assessment of the effect of such decisions on the quality of life in this area, not only for our own sake, but also for the sake of future generations.

We recognize that the Okanagan is not yet in imminent danger of environmental collapse but concern is growing that already there has been too much deterioration. While we recognize that it is necessary to maintain the economic viability of the valley, we do not believe that a rapid growth policy is necessary particularly when such policies have adverse effects on the environment.

We are convinced that the water resource is critical to the maintenance of our environment which in turn preserves the desired life-style. Therefore, it is imperative that sufficient supplies of water be made available, when . necessary, for those priorities decided upon through a valley consensus. It is recognized that there are two major categories in water use: consumptive (water not returned to the system, i.e. drinking, orchards, cattle, certain industrial uses, etc.) and non-consumptive (water used but either left in the system or else returned to the system shortly after use, i.e. fishing, swimming, boating, sewage treatment systems, industrial and domestic cooling systems, etc.). In future Okanagan planning both consumptive and non-consumptive uses must be taken into consideration. However, priorities need to be established for guidance in those years in which the amount of inflow is less than the required diversions. The knowledge of such a system of priorities would greatly influence the decisions concerning future expansion of any segment of the economy.

Results from preliminary study investigations, including hydrological information, economic projections, and computer simulation lead us to the opinion that there is enough water in the mainstem system to provide for all consumptive and non-consumptive uses during most years. In all years there is enough water for consumptive uses if the management process is altered and improved. We further recognize that the present water system also depends on tributary storage. Available preliminary data indicates there could be quantity problems in certain tributaries in drought years. Consideration should therefore be given to increasing tributary storage where possible, pumping from the lake where feasible, and curtailing of population expansion in critical areas.

We are also seriously concerned about the quality of water. Preliminary research by the Study has shown that water quality is declining in varying degrees and in various places throughout the Okanagan system. It is of prime importance that such decline be arrested and when and where possible, reversed. Water quality is critical for consumption, recreation, aesthetics, fish and wildlife.

While the Okanagan Basin Study was established to examine specifically water resources, we have found that activities on land both have an effect on, and are affected by, water quality and quantity and therefore should be taken into account in comprehensive planning. If we wish to plan the development of the Okanagan Valley towards the achievement of the optimum life-style, those activities should be promoted which will enhance the environment, or at least have a minimal negative effect. In assessing the nature of the Okanagan we feel that agriculture, and especially the fruit industry, is an integral component of the quality of life. The second major aspect of Okanagan life that should be protected and enhanced is the recreational potential.

Before outlining our recommendations however, we also believe that it is important to recognize that the Okanagan Basin Study has made people aware of other deficiencies in planning exercises. Throughout the deliberations of the various Task Forces and especially through the work of the PIP staff, it became obvious that there is a major problem of communication between the public and their governments. Often people don't realize what is happening within the operations of their government, or why. Yet democracy demands an enlightened electorate. In this age of rapidly advancing technology and resource utilization, it is critical that society as a whole continually be aware of the operations and interconnectedness of the components of their physical, social and economic environment. As well, it is increasingly important that people be guided towards maintaining those practices which will enhance the physical, social and economic environment of the valley by legal as well as by educational means. There are too many regulations overlooked intentionally or unintentionally which, if adhered to, would significantly improve the water resource.

Furthermore, a major Task Force concern has been post-study activity and the fear exists that the results of this Study will be shelved and forgotten. As this Study is a unique pilot project in inter-jurisdictional planning, we hope that there will be some type of continuance into an implementation phase, with ongoing public involvement. We feel that the public involvement sector of this Study has been too valuable a factor to abandon, and there should be continuing opportunities for residents to give their views on the future of their valley."

It is from the above beliefs and rationale that Task Force Seven presents the following recommendations based on the earlier work of Task Forces #1 - #6 representing a cross-section of the Okanagan community, towards the planning of an improved Okanagan River Basin:

1. Therefore, we recommend that: *Future planning in the Okanagan should place primary emphasis on environmental protection, giving due emphasis to maintaining the economic viability of the valley.*

2. Therefore, we recommend that: *For purposes of water quantity the Okanagan water system be planned so that all consumptive and non-consumptive uses be met in all but the most severe drought conditions (historically, one in fifty years).*

   We also recommend that: *Provincial legislation concerning strict floodplain zoning be enacted and enforced, the responsibility of implementation be given to the regional district.*

3. Therefore, we recommend that: *Water quality standards be developed for the Okanagan which will be directed towards the improvement of present water quality and that all practices affecting water quality be made to conform with such standards.*

4. Therefore, we recommend that:

   1) The agricultural industry be the first priority in the management of water after the personal consumptive needs of the present population have been met.

   2) Agriculture be given more attention by senior levels of government so that it becomes a viable industry in the economy of the nation.

   Because:

   i. B. C. has such a small proportion of arable land, that it should be conserved for food production.

   ii. Support payments for an industry which maintains the desired environment (such as agriculture) may prove to be cheaper than cleaning up the pollution of some other industries.

iii. *Agriculture assists in the preservation of green spaces between the urban centres.*

iv. *The small family farm is an important social component in the Okanagan life-style.*

v. *Agriculture provides a great deal of the aesthetic value of the Okanagan.*

vi. *Agriculture provides opportunities for re-cycling human waste.*

Though we are suggesting that agriculture be given this priority in water use, we realize that this is a simplification of the question of the overall direction of planning and we therefore would further recommend the following ideas which are compatible with such a priority:

a) *Each area should be encouraged to develop its own capabilities but any such development should not affect negatively the environment of other areas.*

b) *Future development should be geared towards low, but stable growth policies, such as a projected population in 2020 A.D. of 275,000 to 290,000 people, with the main increase going to the urban central portion, rather than the agricultural north and south.*

c) *In the future, because we desire a high standard of environmental quality, we should no longer actively promote residential growth, industries with waste problems and tourism, because these sectors will likely increase anyway, due to the momentum already built into the Okanagan economy.*

d) *Future growth policies should emphasize the expansion of existing industries, that are compatible with the new standards desired above, rather than seeking to bring in new ones.*

5. Therefore, we recommend that: *Considering the trends towards increased leisure time, and considering the unique recreational possibilities of the Okanagan Valley, the second priority in the management of the water resource should be improving and increasing the quality and quantity of water-based recreational opportunities, with primary emphasis on the needs of the residents. The costs of future developments, including pollution control facilities should be shared by all users, whether resident or tourist.*

6. Therefore, we recommend that: *In the development and management of water resources within the Okanagan Valley, there should be a strong and continuing commitment to the enhancement of sport fisheries, with the planning focus on the needs of the residents.*

7. Therefore, we recommend that: *Strict pollution control standards be instituted and rigorously enforced for industries locating in the Okanagan.*

8. Therefore, we recommend that: *A comprehensive program of education towards proper water resource management and planning be developed for both the "public-at-large" and the "student-in-the-classroom".*

   That this program, utilizing as wide a variety of media as possible including booklets, video-tapes, pamphlets, tv, radio the press , films etc. would explain and discuss at least the following:

   - *The process of operating Lake Okanagan as a reservoir.*
   - *Drought possibility and consequences plus elementary steps to alleviate drought problems including basic practical steps reducing water consumption around the home.*
   - *The life-process (especially spawning) of the Columbia sockeye salmon, including on-site tours of the spawning run in the Okanagan River in the fall of the year.*

- *The present institutional and social frameworks for the management of water resources in the Okanagan.*
- *The present operational process of various departments of governments involved in water management.*
- *The possible effects of agricultural practices (cattle, fertilizers, etc.) on water quality, plus plausible management alternatives to alleviate such problems.*

9. Therefore, we recommend that: *All legislation, regulations and guidelines whioh have been established for the purpose of improved water management should be policed more consistently and more extensively than at present in order to attain and maintain a better environment and that public involvement and participation in this process be encouraged through education.*

10. Therefore, we recommend that: *Upon conclusion of the Canada-British Columbia Okanagan Basin Agreement an Okanagan Basin authority be established by the Provincial and Federal Governments with the responsibility for management of water and other resources in the valley.*

    a) *That such an authority be given real powers in the field of water management and the responsibilities arising therefrom. These responsibilities to include implementation of the recommendations of the Okanagan Water Basin Study and the recommendations of the Public Involvement Program.*

    b) *That such an authority be responsible for the development and co-ordination of a totally comprehensive plan for the future orderly development of the Okanagan Water Basin.*

    c) *That provision be made for continuing public participation so that changing attitudes, perceptions and goals of valley residents would continually be taken into consideration in the planning process.*

In addition to the general recommendations which outline the objectives and the philosophy of Task Force Seven, there are numerous recommendations and suggestions that the Task Force members believe must be acted upon over the next few years in an effort to ensure not only the preservation of the Okanagan Valley but to aid in the improvement and management of the water resource and evolve from an "indepth" consideration of the results of the various research tasks ubdertaken by the Okanagan Basin Study.

11. Therefore we recommend that: *All municipalities undertake programs to ensure that as a minimum standard, no more than 20% of the phosphorus from its sewage waste effluent reach either surface of ground water systems; and in order to achieve the major goal of effectively retarding eutrophication of the lakes in the Okanagan, all municipalities must strive to severely limit the input of all nutrients and other deleterious substances from seage waste effluent to surface and ground water systems.*

    All built-up municipalities and unorganized urban areas must be utilizing some form of sewage collection and treatment by the year 1985 in accordance with the above standards and the timetable accompanying these recommendations - Appendix A (because different communities have begun various treatment systems at various times completion dates are set non only according to the size of the community but also to the degree to which their facilities are currently achieving some measure of phosphorus removal). (Consideration should be given by all governments to continuing studies regarding the feasibility of marketing or otherwise disposing of sewage sludge as a soil conditioner or fertilizer.)

    All industrial plants must adhere to the above standards by 1985 in accordance with the accompanying timetable.

We also recommend that: *In an effort to control all inputs of nutrients (in addition to phosphorus) all positive waste discharges should be removed from the major valley lakes and tributary streams by the year 2000 A.D. Municipal governments should note that when developing new waste treatment systems that may be necessary following the implementation of the recommendation noted previously, overall it may be more economical to initially develop facilities that do not require discharging effluent to receiving waters. Moreover, as will be noted in the aforementioned timetable (Appendix A), it is evisaged that in the near future the minimum standard for phosphorus removal, with expanding population will have to be 90% to achieve the same effect as 80% with today's population.*

There are several possible alternatives to discharging effluent to mainstem lakes and streams:

(i) *Spray irrigation of effluent should be utilized as a method of waste disposal wherever feasible throughout the valley.*

(ii) *Waste stabilization ponds with exfiltration facilities utilizing spray irrigation during the summer might be acceptable for smaller centres provided the overall effect is the removal of 80% phosphorus.*

(iii) *Consideration should be given to the development of methane gas production facilities utilizing sewage in combination with other municipal and industrial wastes.*

(iv) *Wherever geologically or geographically impractical to implement (i) or (ii) above, consideration might be given to advanced forms of tertiary treatment.*

We also recommend that: *In some areas the possibility exists that individual septic tanks may be an acceptable alternative providing that their efficiency is such as to keep 80% of the phosphorus from entering the water system. A study should be done to establish definite guidelines as to where these would be permitted using such parameters as soil type, residential density, proximity to water table and water courses.*

Until those areas with septic tanks are able to achieve 80% phosphorus removal, regular pump-outs should be instituted on at least a three year rotation; such effluent could be further treated by aeration or through distribution to proper agricultural lands by approved methods.

Consideration should be given to the approval and installation of other biological treatment systems (including the Clivus, etc.) in such areas where septic tanks are unacceptable and regional treatment systems are uneconomical.

12. Therefore, we recommend that: *Specialized agricultural practices (i.e. feedlots, etc.) should be managed so that there are no adverse effects on the water quality.*

13. Therefore, we recommend that: *There be a greater attempt to control and plan for future tourist expansion and that the facilities be developed with regard to consideration for improving the quality of the environment and also diversifying the recreational experience. It is realized that there is also going to be a need to provide additional funding for such programs in order that proper quality control and clean-up be maintained. (Such funds might come, in part, from present allotments used for the promotion of summer tourism: as summer tourism has not been shown to be dependent on advertising - only 2% come as a result of advertising - such funds could be a good investment in helping to educate*

people themselves to maintain the environment for all to continue to enjoy).

There must be an increase in the availability of waste collection facilities for the traveller including:

- *increased number of pump-out stations for mobile trailers, campers, motorhomes, boats, etc.*
- *improved accessibility of the above mentioned pump-out stations*

There must be an alleviation of the crowded beach conditions, including:

- *an increase in the number and diversity of other outdoor recreational opportunities (e.g. hiking, scenic drives, etc.)*
- *more encouragement to industries and orchards to conduct tours and otherwise provide non "water-based attractions"*
- *consideration in certain locations to restricting the number of power craft on a lake at any one time*

We also recommend that: *As the Okanagan is a natural recreational attraction, the enhancement of water-based recreation should enjoy a broader base for financial support than that of local taxes. Studies should be conducted as to the feasibility of establishing methods whereby the tourist may fully participate financially in the development and enhancement of water-based recreational opportunities.*

One possible method would be to assess an annual licence fee for boats which would support a fund for lake management (such a fund, being federal, would be dispersed throughout the nation including the Okanagan).

We also recommend that: *There should be an expansion of facilities to relieve congestion for the local resident (it may be necessary to create certain spots with limited access and limited promotions in order that only residents and very keen visitors would find the place).*

We also recommend that: *It is imperative that provision for improved water-based recreation include the immediate initiation of continuing programs aimed at establishing and maintaining more and better lake access points, and that such points be made more visible to the public. Policies should be developed and implemented to ensure public access and therefore should be maintained for public use.*

In the future all private commercial developments on crown land should be prevented within 660 feet of the lakeshore in an effort to increase the amount of land for public recreational use.

Continuing programs be immediately initiated to establish and maintain more government campsites, and stricter supervision of private campsites, all conforming to new standards of environmental and social quality (i.e. less crowding). Should the achieving of such standards prove to be more expensive than present operations the per-night fee should be raised accordingly - in other words, permit the consumer to contribute!

Lake access points should be posted and the public informed of their rights to beach usage. Such postings should be reasonably noticeable to the public.

In developing future plans regarding the expansion of water-based recreational opportunities, a major criteria should be the capability of a particular area to support a given number of people: When designated capabilities are reached, further development would be prevented; whenever individual capacities *are reached, additional tourists would have to go elsewhere.*

14. Therefore, we recommend that: *Certain high potential spawning gravel beds fronting the shoreline be designated and protected in order that natural spawning in the mainstem lakes will be significantly enhanced; moreover, in certain high potential streams, storage reservoirs should be developed to provide water to keep certain areas of the stream bed available for maintenance of fish stock.*

    We also recommend that: *The costs of enhancing the sport fisheries of the Okanagan should not be assessed against local taxes*

15. Therefore, we recommend that: *Regarding possible internal measures that might be taken within a lake system to improve the water quality in the Okanagan Valley, weed harvesting is a reasonable practical method, but it should be used only in the short run to clean up a problem while simultaneously the source of food for the weed problem is also being cleared up. This process would usually be utilized in areas where weeds are deemed objectionable. Should the weeds have an aesthetic value or supply a natural habitat for waterfowl and wildlife, they should not be removed. It is also possible in the case of Wood Lake that some forms of chemical treatment may be effective (but again the provisions mentioned for weed harvesting are applicable).*

16. Therefore, we recommend that: *As a management tool, zoning be implemented in the lake systems with consideration being given to the following activities: Fishing, boating, water-skiing, sailing, canoeing, etc. Such zoning would be necessary in any lake where these activities, in having to compete at large, might seriously override other people's particular pleasure, be seriously jeopardized by other people's activities, or jeopardize the fish stock and/or wildlife and domestic water.*

    In the consideration of zoning particular parts of the lake system for particular uses, any restriction that might be considered should be both discussed with and made known to the public in order that people do not invest in particular modes of water-based recreation only to have noticeable restrictions placed on them shortly thereafter.

17. Therefore, we recommend that: *Policies should be initiated to permit the following:*

    a) *The acquisition and retention of shoreline for potential use as beach land or other forms of water-based recreation and related activities.*

    b) *The restriction of certain lake areas for particular uses, for example:*

       - *Vaseux Lake region - wintering ground for Bighorn Sheep*
       - *Head of Osoyoos Lake - fowl habitat*
       - *Headwaters of Inkaneep Creek - waterfowl habitat*
       - *Cousins Bay at Coldstream - environmental park*
       - *etc.*

       (i) *It is further suggested that there be more provision for mapped recreational reserves around the various lakes.*

    c) *The allocation of certain "set-back footage" around selected major lakes and streams for the purpose of activities such as hiking, riding, cycling, walking, etc.*

       (i) *Moreover, some shoreline on all lakes should be protected now for multiple public use.*

18. Therefore, we recommend that: *Greater protection of the littoral zones in various areas of the lakes be provided and that bulldozing in of the lakeshore should be severely limited. There should be no alteration of the natural conditions of the lakeshore, except where it can be shown that it is for the benefit of the public.*

    An investigation should be carried out regarding the private use of shoreline; moreover, it should be determined who is legally permitted to have leases for wharfs, etc. Any individual without legal right should be required to remove any obstruction. Furthermore, in the future, no such leases should be given out in prime shoreline areas.

19. Therefore, we recommend that: *Flood-plain zones should be defined and mapped and further building on these areas be prohibited. In the future, consideration might be given to buying out present structures already built in the more flood prone areas. (These zones would include at least to the 918 foot elevation on Osoyoos Lake and 1127 foot elevation on Okanagan Lake.) Flood-plain zones could provide a variety of alternate uses: Agriculture, recreation, wildlife habitat, etc.*

20. Therefore, we recommend that: *A rationalization of the water supply and water demand situation be undertaken such that wherever domestic, agricultural and industrial demands exceed the supply available from the tributaries, alterations would be implemented which would require those areas adjacent to the lakes, not already doing so, to draw water from the major lakes themselves. Such alterations would not be at the expense of the present licence holders (especially those holding licences for agricultural purposes) but rather would be paid for by the new developments, through compensation or other fiscal levy.*

21. Therefore, as was mentioned earlier, and is now reiterated for further emphasis, we recommend that: *In an effort to control all nutrient inputs that cause weed problems along lakeshores, all discharges from sewage treatment facilities should be removed from the mainstem lakes by the year 2000 A.D.*

22. Therefore, we recommend that: *In an effort to increase the ability of the river channel to handle its capacity flow, several changes should be made to the structures along its course.*

    Improvements on the Oliver Highway #97 Bridge and in the drainage of Tugulnuit Lake should be undertaken to increase the ability during high flow periods to release more water from Okanagan Lake: In the case of Tugulnuit such improvements would also provide benefits of a recreational nature by keeping it cleaner for both people and fish. In the case of the Oliver Bridge, it should be replaced in that it poses a potentially serious threat to motorists both in its approaches and in its width; since #97 is a major vehicular route, such problems should be corrected in the very near future and when this is done, the water flow constraints could also be overcome.

23. Therefore, we recommend that: *A definite commitment should be made to provide sufficient water for desirable fish species in the Okanagan River during the spawning and incubation periods; this commitment being consistent with higher priorities.*

    The sockeye salmon fishery in the lower Okanagan River must be protected for the native people's fishing rights and for the educational value to school children and the public in the area. Moreover, in this latter regard, some effort should be made to make the spawning areas more accessible to the public; the salmon, however, being very delicate and especially vulnerable at certain times of the year, must be very carefully protected from possible *menace from this public.*

Studies should continue on the feasibility and desirability of construction of a spawning channel in the Okanagan River; Such studies should have built-in communication and participation links with the American community in the Columbia - Okanagan Basin!

24. Therefore, we recommend that: *Extended green-belt policies should be implemented along the Okanagan River.*

    In keeping with the previously mentioned flood-plain zoning and the suggested "set-backs" from all water courses buffer zones are recommended. Dyking is more effective if set back somewhat from the river bank. In doing this, we could alleviate the severe stress put on the banks during flood as well as providing space for green-belt strips between the banks and the dykes.

    Furthermore, it is suggested that consideration be given to the restriction of certain areas for particular uses such as:

    - *spawning areas for sockeye salmon*
    - *wildlife habitat (ox bows)*
    - *environmental park (natural part of channel at McIntyre's Bluff)*

25. Therefore, we recommend that: *Greater co-ordination among all authorities involved should be developed in an effort to schedule instream flows in a manner that would meet not only human demands but also certain critical fish needs (especially downstream).*

    We also recommend that: *In three tributaries: Mission, Equesis and Trepanier fisheries, requirements including in-stream flows for spawning be guaranteed for fish enhancement.*

    We also recommend that: *In seven other tributaries: Vernon, Whiteman, Powers, Coldstream, Trout, Peachland and Shingle, consideration should be given to facilitating many non-consumptive uses including fish preservation in all but very severe drought years.*

    (It is suggested that consideration be given to restriction of certain areas for particular uses. For example:

    - *Brent Mountain - Environmental Park*
    - *Lambly Creek - multiple-use recreational area*
    - *Headwaters of Inkaneep Creek - waterfowl habitat*

    We also recommend that: *Consideration should be given to increased multiple-use of certain selected reservoirs for improved natural reproduction of fish and fish enhancement. This requires joint co-operation between Irrigation Districts and Fish & Wildlife people.*

    We also recommend that: *An additional number of lakes be opened as is deemed feasible and beneficial to accommodate increase in fishing demand; moreover, a reasonable number of lakes should retain limited access only. Some other lakes with good access could be zoned for a variety of different fishing experiences (e.g. speciality fishing - fly, trophy, etc.) and some might even be allotted to recreational uses in general wherein the fisherman would compete for space with the canoeist, etc. Such lake zoning should be* *developed under the leadership of the Fish & Wildlife Department (Provincial Government).*

We also recommend that: *Fish management practices be given due priority in water management so that optimum efficiency and production is gained from each fishing lake in the system.*

26. Therefore, we recommend that: *More multiple-use, non developed areas be designated to provide more opportunity for outdoor recreational activity; with the increasing amounts of leisure time becoming available to each of us it will be imperative the facilities be available.*

We also recommend that: *Regulations be developed to permit the acquisition and retention of shoreline on tributary lakes for potential use in various forms of recreational activities.*

> *Moreover, we should make sure that we have other recreational opportunities besides those which are water-based in order to meet a diversity of interests and also to relieve some of the pressure on the prime water-based sports themselves. An inventory of all recreationary potential, including sites, should be developed for the valley as a basis to longer range planning.*

27. Therefore, we redommend that: *Extended green-belt or buffer zone policies be implemented along all significant water courses. The usual benefits to be gained from green-belting, are the provision of open areas both for the recreational use and aesthetic pleasure of residents around these areas as well as in many instances restricting urban sprawl. In addition, control could be established on activities along and adjacent to all water courses for the ultimate protection of the water quantity and quality as well as safeguarding wildlife along these water courses.*

28. Therefore, we recommend that: *Included in an education program there be provision for acquainting the public with the use of sewage sludge as a soil conditioner.*

We also recommend that: *Further publicity should be given to the economic benefits that are possible via agriculture in growing of forage crops with assistance from land spray irrigation sewage disposal.*

29. Therefore, we recommend that: *Consideration must be given to better water management leading to improved water utilization:*

> *Some consideration should be given in all major municipalities and in any new residential developments to the installation and utilization of water meters or water-use control valves.*
>
> *Greater re-cycling of water should be encouraged and more studies should be conducted into the potential viability of double water systems for municipalities as well as the feasibility of some of the new home toilet and wast water systems now being studied (e.g. Clivus, etc.).*
>
> *Due to the tentative state of the art regarding present levels of development of trickle irrigation, this procedure should not at present be considered a prime method for reducing agricultural water consumption or withdrawl: This does not rule out future potentials due to potential refinements in the process.*
>
> *Further study be conducted as to the necessary collaboration between members of the forest harvesting industries and the Resource Departments of the Provincial and Federal Governments to effect a system of forest management more consistent with the needs of our water resources and the wishes of the residents of the Okanagan.*

30. Therefore, we recommend that: *Greater emphasis be given to attempting to spread the tourist demand more evenly throughout the entire calendar year; such things as hiking and other non water-based activities, varied fishing seasons, skiing and other winter sports in controlled areas might help to alleviate some of the summer stress and strain and also provide a more economically viable situation for those valley residents more directly affected by the tourist.*

    A fund should be provided to support an educational program for the tourist not only to inform them of the varieties of campsites, etc., that would be available, but also helping to communicate to them the need for proper environmental management while on their vacation.

31. Due to the deteriorating condition of Wood Lake, it is imperative that major efforts be undertaken to eventually retard the rapid process of eutrophication: However, the delicate condition of this lake requires that any activities being undertaken must receive exhaustive study prior to implementation. In this regard, Task Force Seven believes that two alternatives to improving water quality in the Central Okanagan should receive serious consideration and further study. It is possible that some of the nutrient loads in Wood Lake can be reduced by a massive irrigation program which would take Wood Lake water up to the agricultural land and the bench lands beyond, thus depositing most of the nutrients in the soils before water returns to Wood Lake via ground water, etc. In this same geographic area, the recommended removal of sewage outfall from the main lakes system has brought in an effort to provide a suitable winter storage area for the Kelowna and Winfield treated sewage effluent. It may be possible to utilize Duck Lake (Ellison Lake) as a nutrient sink, providing, of course, that Vernon Creek was re-directed to by-pass Ellison Lake. In both of these instances, however, significant questions remain in terms of the implications of the proposals and therefore, we suggest that before any positive action be taken:

    1. *Further studies be conducted into the long term advantageous and potentials of utilizing a form of hypo-limnetic irrigation to attempt to arrest the eutrophication process presently going on in Wood Lake.*

    2. *Further studies be conducted into the possibility of utilizing Duck Lake (Ellison Lake) as a potential winter reservoir for treated effluent from Kelowna, Rutland, and Winfield. (It might be possible to use this lake as a natural lagoon and nutrient sink; by short-circuiting Vernon Creek so that it does not enter the lake at all, the lake could then be used as a reservoir in the winter and, in the summer, could be pumped out and up onto the east side agricultural lands along with the regular sewage effluent: The study would also investigate various measures to reduce any possible noxious side effects for the local area.)*

32. Therefore, we recommend that: *In all future river basin planning studies, full consideration be given to the effects of land-use, forest management and any other significantly related resource in the development and management of a comprehensive water resource plan.*

    Furthermore, we recommend that: *In all river basin planning studies, public involvement be an integral part of such a venture from the outset in order that the social, economic, and environmental goals of the community will be a major influence and continuing component in the development and management of a comprehensive water resource plan.*

APPENDIX D

STUDY PARTICIPANTS

ALPHABETICAL LISTING OF OKANAGAN BASIN STUDY PARTICIPANTS

NAME	AFFILIATION AT START OF STUDY INVOLVEMENT	INVOLVEMENT	
		Field	Task
1. ANDERSON, Dr. T.W.	C.C.I.W.,I.W.D., Environment Canada, Burlington, Ont.	Limnology	121
2. ATKINS, Lynn	Okanagan Basin Agreement, Penticton, B.C.	Public Involvement	170
3. ANDRES, J.E.	F.W.I., F.R.B., Environment Canada, Penticton, B.C.	Fisheries	66
4. BANCROFT, C.G.	B.C.W.I.B., W.R.S., Lands, Forests and Water Resources Victoria, B.C.	Water Quantity	22
5. BAXTER, W.	F.W.I., F.R.B., Environment Canada, Penticton, B.C.	Fisheries	66
6. BENNER, G.B.	B.C.W.I.B., W.R.S., Lands, Forests and Water Resources Victoria, B.C.	Water Quantity	21
7. BERNHARDT, R.	F.W.I., F.R.B., Environment Canada, Penticton, B.C.	Fisheries	66
8. BERZINS, A.	Dayton and Knight Consultants, Vancouver, B.C.	Waste Treatment	113,141
9. BJONBACK, R.D.	W.P.& M., I.W.D., Environment Canada, Vancouver, B.C.	Socio-Economics	205,206
10. BLANTON, Dr. J.O.	C.C.I.W., I.W.D., Environment Canada, Burlington, Ont.	Limnology	120
11. BODNARUK, L.	B.C.P.C.B., W.R.S., Lands, Forests and Water Resources Victoria, B.C.	Water Quality and Waste Treatment	102B, 103 T.S. IV, VI
12. BOWMER, Dr. E.J.	Division of Laboratories, Health Branch, Department of Health and Welfare, Vancouver, B.C.	Water Quality	135
13. BOYD, Forbes C.	F.M.S., Environment Canada, Vancouver, B.C.	Member-Study Committee	1971-74
14. BROOKS, A.C.	Consulting Biologist, Summerland, B.C.	Wildlife Studies	160
15. BROWN, L.	F.W.I., F.R.B., Environment Canada, Penticton, B.C.	Fisheries	66
16. BROWNLEE, C.H.	Soils Division, B.C. Department of Agriculture, Kelowna, B.C.	Waste Treatment Task Force	139
17. BUCHANAN, Dr. R.J.	B.C.W.I.B., W.R.S., Lands, Forests and Water Resources Victoria, B.C.	Interim Coordinator	1969-70
18. BUNGE, J.	B.C.W.I.B., W.R.S., Lands, Forests and Water Resources Victoria, B.C.	Secretary-Consultative Board	1970-71
19. CHMELAUSKAS, A.J.	B.C.P.C.S., W.R.S., Lands, Forests and Water Resources Victoria, B.C.	Water Quality Task Force	
20. CLOUGH, B. Ms.	Summer Student, Penticton, B.C.	Socio-Economics	200
21. COLLINS, M.	S.P.& M., I.W.D., Environment Canada, Vancouver, B.C.	Socio-Economics	200, 10, T.S. VIII

Continued . . .

ALPHABETICAL LISTING OF OKANAGAN BASIN STUDY PARTICIPANTS

NAME	AFFILIATION AT START OF STUDY INVOLVEMENT	INVOLVEMENT	
		Field	Task
22. CONNORS, Dr. M.	Consulting Sociologist, Ottawa, Canada	Socio Economics	170
23 CORRIGAN, D.	B.C.P.C.B., W.R.S., Lands, Forests and Water Resources Victoria, B.C.	Coordinator-Water Quality and Waste Treatment - 1972	113, 141, 142, 147
24 CRAWFORD, I.	W.P.& M., I.W.D., Environment Canada, Penticton, B.C.	Public Involvement and Socio-Economics	170
25 DABROWSKI, R.S.	B.C.W.I.B., W.R.S., Lands, Forests and Water Resources Victoria, B.C.	Water Quantity Tasks Technical Assistant	
26. DAVIDSON, H.	G.W. Sinclair and Associates, Penticton, B.C.	Public Involvement	171
27. DE BECK, H.	Water Rights Branch. W.R.S., Dept. Lands, Forests and Water Resources, Victoria, B.C.	Member-Consultative Board	
28. DEW-JONES, J.E.	B.C.P.C.B., W.R.S., Lands, Forests and Water Resources Victoria, B.C.	Waste Treatment Task Force	
29 DRUCE, E.	W.R.S., Lands, Forests & Water Resources, Victoria, B.C	Socio-Economics	201, 202
30 EDGEWORTH, L. *1	Fisheries Service, Pacific Region, Vancouver, B.C.	Member-Study Committee	1970-71
31 FAST, L. Ms.	Okanagan Basin Agreement, Penticton, B.C.	Socio-Economics	119
32 FEDDES, J.	B.C.P.C.B., W.R.S., Lands, Forests and Water Resources Victoria, B.C.	Water Quality and Waste Treatment	102, 103, T.S. IV, VI
33. FEE, P.	W.Q.L., I.W.D., Environment Canada, Calgary Alberta	Water Quality Analysis	131, 117, 118
34. FERGUSON, H.L.	A.E.S., Environment Canada, Downsview, Ontario	Water Quantity	35, T.S. I
35. FIDLER, M. Ms.	Okanagan Basin Agreement, Penticton, B.C.	Public Involvement	171
36. FINDLAY, D.	F.W.I., F.R.B., Environment Canada, Penticton, B.C.	Limnology	66
37. FOWERAKER, Dr. J.C.	B.C.W.I.B., W.R.S., Lands, Forests and Water Resources Victoria, B.C.	Water Quantity Task Force	47
38. FRASER, A.	B.C.W.I.B., W.R.S., Lands, Forests and Water Resources Victoria, B.C.	Draftsman, Water Quantity	
39. FUMALLE, M.	W.P.& M., I.W.D., Environment Canada, Penticton, B.C.	Socio-Economics	200, 21
40. GARTNER, Dr. G.	Planning Branch, Dept. of Regional Economic Expansion Canada, Victoria, B.C.	Socio-Economic Task	
41. GERMAN, G.R.	F.W.I., F.R.B., Environment Canada, Penticton, B.C.	Limnology	119
42. GILES, G.	B.C.P.C.B., W.R.S., Lands, Forests and Water Resources Victoria, B.C.	Water Quality Evaluator	102, T.S. IV, VI

ALPHABETICAL LISTING OF OKANAGAN BASIN STUDY PARTICIPANTS

Continued . . .

NAME	AFFILIATION AT START OF STUDY INVOLVEMENT	INVOLVEMENT Field	INVOLVEMENT Task
43. GLOVER, M.H.A.	Economic Research, Industrial Development, Trade and Commerce, Victoria, B.C.	Socio-Economic Task Force	201
44. GREGG, B.	Summer Student	Socio-Economics	112
45. GULLIVER, J.	Lundberg Seismic Consultants Limited, Calgary Alberta	Water Quantity	39
46. HALL, G.D.	W.R.S., Lands, Forests and Water Resources, Victoria, B.C.	Socio-Economics	202, 54
47. HALL, P.L.	B.C.W.I.B., W.R.S., Lands, Forests and Water Resources Victoria, B.C.	Water Quantity	28, 41, T.S. I
48. HALLIDAY, L. Ms.	W.R.S., Lands, Forests and Water Resources, Victoria, B.C.	Socio-Economics	112
49. HALSTEAD, E.C.	H.S.D., I.W.D., Environment Canada, Vancouver, B.C.	Hydrology Task Force	38, T.S.I
50. HALSEY, G.	Fish and Wildlife, Department of Recreation and Conservation, Victoria, B.C.	Fisheries	115, 66
51. HAMILTON, Dr. A.L.	F.W.I., F.R.B., Environment Canada, Winnipeg, Manitoba	Limnology	104
52. HAMMERTON, B. Ms.	G.W. Sinclair and Associates, Penticton, B.C.	Public Involvement	171
53. HAUGHTON, E.	B.C.P.C.B., W.R.S., Lands, Forests and Water Resources Victoria, B.C.	Coordinator-Water Quantity and Waste Treatment-1973-74	102, 103, 105, T.S. IV, VI.
54. HAYLEY, B.P.	G.W. Sinclair and Associates, Penticton, B.C.	Public Involvement	171
55. HENDREN, M.K.	Department of Civil Engineering, University of British Columbia, Vancouver, B.C.	Waste Treatment	133, 139, 147
56. HENDERSON, H.A.	B.C.P.C.B., W.R.S., Lands, Forests and Water Resources Victoria, B.C.	Waste Treatment	130
57. HILL, Dr. H.	University of Waterloo, Waterloo, Ontario	Planning & Evaluation	21
58. HINTON, B.R.	Fisheries Consultant, Vancouver, B.C.	Fisheries	163
59. HODGES, R.C.*1	Planning Division, Energy, Mines and Resources, Canada	Co-Chairman, Study Committee - 1970-71	
60. HORSWILL, W.	Okanagan Basin Agreement, Penticton, B.C.	Public Participation (1972).	171
61. HUNTER, H.D.C.	Barrister and Solicitor, Vancouver, B.C.	Socio-Economics	201
62. HUNTER, H.I.	B.C.W.I.B., W.R.S., Lands, Forests and Water Resources Victoria, B.C.	Water Quantity Task Force	60, 180, 101, T.S. I

ALPHABETICAL LISTING OF OKANAGAN BASIN STUDY PARTICIPANTS

Continued . . .

NAME	AFFILIATION AT START OF STUDY INVOLVEMENT	INVOLVEMENT	
		Field	Task
63. JACKSON, K.W.	F.M.S., Environment Canada, Vancouver, B.C.	Water Quality Task Force	
64. JACKSON, L.W. Ms.	Okanagan Basin Agreement, Penticton, B.C.	Secretary - Okanagan Basin Study Office	
65. KASTELEN, W.A.	B.C.P.C.B., W.R.S., Lands, Forests and Water Resources Vernon, B.C.	Water Quality	130, 102
66. KENNEDY, G.F.	Canada-Bio-Research Consultants, Cloverdale, B.C.	Water Quality	139
67. KERR, A. Ms.	G.W. Sinclair and Associates, Penticton, B.C.	Public Involvement	171
68. KIDD, G.J.A.	Underwood, McLellan and Associates, Vancouver, B.C.	Executive Secretary to Consultative Board	
69. KIRBY, A.R.	C.C.I.W., I.W.D., Environment Canada, Burlington, Ont.	Public Involvement	171
70 KOSHINSKY, G.D.	F.W.I., F.R.B., Environment Canada, Penticton, B.C.	Coordinator-Fisheries	66 T.S. IX
71. LANE, Dr. R.K.	C.C.I.W., I.W.D., Environment Canada, Burlington, Ontario	Limnology Task Force	
72. LEACH, T.A.J.	B.C.W.I.B., W.R.S., Lands, Forests and Water Resources Victoria, B.C.	Water Quantity Co-chairman, Study Committee: Coordinator-Water Quantity Studies	T.S. I, III
73. LE BRETON, G.	B.C.W.I.B., I.W.B., Lands, Forests and Water Resources Victoria, B.C.	Water Quantity	38, 39, 40, 47, 41, T.S.I
74. LENNOX, D.H.	Groundwater Sub-Division, I.W.D., Environment Canada, Ottawa	Groundwater Review Board	
75. LERMAN, Dr. A.	C.C.I.W., I.W.D., Environment Canada, Burlington, Ont.	Limnology	117
76. LEWIS, D.	Associated Engineering Services Ltd., Vancouver, B.C.	Waste Treatment	113, 141
77. LIVINGSTON, Dr. E.	Consulting Geologist, Vancouver, B.C.	Groundwater Studies	40
78. LOWE, L.V. Ms.	Okanagan Basin Agreement, Penticton, B.C.	Clerk, Study Office	
79. LUCAS, K.C.*1	Resource Development Service, Department of Fisheries and Forestry, Ottawa, Canada.	Member-Consultative Board - 1970-72	
80. LUNDBERG, R.M.	Lundberg Seismic Consultants Limited, Calgary, Alberta	Groundwater Studies	39
81. LYNCH, A.J.*2	Health Laboratories, B.C. Department of Health Services, Victoria, B.C.	Water Quality Laboratory, Analysis	135-130

ALPHABETICAL LISTING OF OKANAGAN BASIN STUDY PARTICIPANTS

Continued . . .

NAME	AFFILIATION AT START OF STUDY INVOLVEMENT	INVOLVEMENT Field	INVOLVEMENT Task
82. MARR, B.E.	B.C.W.I.B., W.R.S., Lands, Forests and Water Resources Victoria, B.C.	Co-Chairman, Consultative Board.	
83. MASON, Dr. J.L.	Summerland Research Station, Agriculture Canada, Summerland, B.C.	Member-Study Committee	
84. MAWHINNEY, M.R.	C.C.I.W., I.W.D., Environment Canada, Burlington, Ont.	Limnology	117, 118, 120
85. MC DONALD, S.J.	F. & W., B.C. Dept. of Recreation and Conservation, Penticton, B.C.	Fisheries and Socio-Economics	66, 161
86. MC KENZIE, G.	Okanagan Basin Agreement, Penticton, B.C.	Draftsman, Study Office	
87. MC LAREN, R.E.	E.P.S., Environment Canada, Vancouver, B.C.	Member-Consultative Board - 1973-74	
88. MC LEAN, M.P.	F.W.I., F.R.B., Environment Canada, Winnipeg, Manitoba	Limnology	120
89. MC NEIL, R.Y.	Department of Civil Engineering, University of British Columbia, Vancouver, B.C.	Water Quantity - Evaluator	29, 34, 101 T.S. II
90. MEREDITH, J.R.	Bureau of Economics, Dept. of Industrial Development, Trade and Commerce, Victoria, B.C.	Socio-Economics	201
91. MICHNOWSKY, E.	W.Q.L., I.W.D., Environment Canada, Kelowna, B.C.	Water Quality, Okanagan Field Laboratory	
92. MINERS, K.	C.C.I.W., I.W.D., Environment Canada, Burlington, Ont.	Limnology	120
93. MOOIJ, H.	B.C.P.C.B., W.R.S., Lands, Forests and Water Resources Victoria, B.C.	Water Quality	102
94. MORTON, R. Ms.	Okanagan Basin Agreement, Penticton, B.C.	Secretary - Okanagan Basin Study Office	
95. NEILSON, C.L.	Department of Agriculture, Victoria, B.C.	Water Quality Task Force	126
96. NG, H.Y.F.	C.C.I.W., I.W.D., Environment Canada, Burlington, Ont.	Limnology	120
97. NORTHCOTE, Dr. T.G.	F.& W., B.C. Department of Recreation and Conservation University of British Columbia, Vancouver, B.C.	Limnology Task Force	115
98. OBEDKOFF, W.	B.C.W.I.B., W.R.S., Lands, Forests and Water Resources Victoria, B.C.	Water Quantity	36, 53
99. OLDHAM, Dr. W.	Department of Civil Engineering, University of British Columbia, Vancouver, B.C.	Waste Treatment	147, 133, 139
100. OLIVER, D.W.	W.P.& M., I.W.D., Environment Canada, Penticton, B.C.	Socio-Economics	200

ALPHABETICAL LISTING OF OKANAGAN BASIN STUDY PARTICIPANTS

Continued . . .

NAME	AFFILIATION AT START OF STUDY INVOLVEMENT	INVOLVEMENT	
		Field	Task
101. O'RIORDAN, Dr. J.*1	P.& P., Energy, Mines and Resources, Canada, Vancouver, B.C.	Federal Coordinator Socio-Economic Studies; Co-chairman, Study Committee	T.S. VII, Main Report
102. OSTOFOROV, J.E.	Okanagan Basin Agreement, Penticton, B.C.	Draftsman, Study Office	
103. PARSONS, D.	B.C.P.C.B., W.R.S., Lands, Forests and Water Resources Victoria, B.C.	Waste Treatment	139
104. PATALAS, K.	F.W.I., F.R.B., Environment Canada, Winnipeg, Manitoba	Limnology	123
105. PINSENT, M.	F.& W., Dept. of Recreation and Conservation, Victoria, B.C.	Fisheries	T.S. V, IX
106. POMEROY, M.	F.W.I., F.R.B., Environment Canada, Penticton, B.C.	Limnology	119
107. PRINCE, Dr. A.T. *1	I.W.B., Energy, Mines and Resources, Canada, Ottawa	Co-chairman, Consultative Board	
108. PROCTOR, C.	Stanley Associates Engineering Limited, Vancouver, B.C.	Waste Treatment	113, 141
109. RAMSDEN, H.T.	W.S.C., I.W.D., Environment Canada, Vancouver, B.C.	Water Quantity Task Force	
110. REEDER, S.W.	W.Q.L., I.W.D., Environment Canada, Calgary, Alberta	Water Quality Task Force	
111. REINSTRA, Dr. J.M.	Ward and Associates, Vancouver, B.C.	Socio-Economics	205
112. REKSTON, D.E.	B.C.W.I.B., W.R.S., Lands, Forests and Water Resources Victoria, B.C.	Water Quantity	53
113. RICKETTS, K.M. Ms.	Okanagan Basin Agreement, Penticton, B.C.	Typist, Study Office	
114. ROBARTS, R.D.	F.W.I., F.R.B., Environment Canada, Penticton, B.C.	Limnology	119
115. ROBERTS, J.E.	B.C. Research Council, University of British Columbia, Vancouver, B.C.	Water Quality	128, 129
116. ROBERTSON, A.R.D.	B.C.W.I.B., W.R.S., Lands, Forests and Water Resources Victoria, B.C.	Water Quantity	5, 111 T.S. I, III, VII
117. ROSENBERG, H.B.*1	P.& P., Energy, Mines and Resources, Ottawa, Canada	Federal Coordinator for Study	
118. RUNDBERG, H.	F. & W., B.C. Department of Recreation and Conservation Victoria, B.C.	Limnology	115

ALPHABETICAL LISTING OF OKANAGAN BASIN STUDY PARTICIPANTS

Continued . . .

NAME	AFFILIATION AT START OF STUDY INVOLVEMENT	INVOLVEMENT	
		Field	Task
119. RUSSELL, Dr. S.O.	Department of Civil Engineering, University of British Columbia, Vancouver, B.C.	Water Quantity	29, 34
120. SAETHER, O.A.	F.W.I., F.R.B., Environment Canada, Winnipeg, Manitoba	Limnology	122
121. SALKI, A.	F.W.I., F.R.B., Environment Canada, Winnipeg, Manitoba	Limnology	123
122. SCOTT, G.R.	Okanagan Basin Agreement, Victoria, B.C.	Socio-Economics	209
123. SINCLAIR, G.W.	G.W. Sinclair and Associates, Penticton, B.C.	Coordinator-Public Involvement	171 172
124. SLEZAK, M.W.	B.C.P.C.B., W.R.S., Dept. Lands, Forests and Water Resources, Victoria, B.C.	Member-Study Committee; Coordinator-Water Quality and Waste Treatment (1970-1972).	
125. SMITH, H.	Okanagan Basin Agreement, Penticton, B.C.	Public Involvement Socio-Economics	170 15
126. SMYTH, W.W.K.	B.C.W.I.B., W.R.S., Lands, Forests and Water Resources Victoria, B.C.	Water Quantity	5, 111, T.S. 1, III
127. ST. JOHN, Dr. B.	C.C.I.W., I.W.D., Environment Canada, Burlington, Ont.	Limnogeology	121
128. STAPLE, G.R.	W.P.M., I.W.D., Environment Canada, Vancouver, B.C.	Socio-Economics	205, 206
129. STEVENSON, Dr. D.W.	Summerland Research Station, Agriculture Canada, Summerland, B.C.	Waste Treatment Task Force	139
130. STOCKNER, Dr. J.G.	F.W.I., F.R.B., Environment Canada, Winnipeg, Manitoba	Limnology Coordinator (1970-1973)	T.S.V
131. STRACHAN, Dr. C.C.	Summerland Research Station, Agriculture Canada,	Member-Study Committee, 1970-1971	
132. TAIT, J. Ms.	W.P.M., I.W.B., Environment Canada, Penticton, B.C.	Socio-Economics	15, 200
133. THOMAS, C.H.	W.R.S., Lands, Forests and Water Resources, Victoria B.C.	Provincial Coordinator, Socio-Economics	T.S.VII
134. THOMSON, A.M.	Okanagan Basin Agreement, Penticton, B.C.	Study Director	
135. TINNEY, Dr. E.R.*1	P.& P., Energy, Mines and Resources, Ottawa, Canada	Member-Consultative Board	
136. TOFTE, G.	W.S.C., I.W.D., Environment Canada, Vancouver, B.C.	Water Quantity	52
137. TOWNSHEND, A.R.	C.C.I.W., I.W.D., Environment Canada, Burlington, Ont.	Waste Treatment Task Force	

ALPHABETICAL LISTING OF OKANAGAN BASIN STUDY PARTICIPANTS

Continued . . .

NAME	AFFILIATION AT START OF STUDY INVOLVEMENT	INVOLVEMENT	
		Field	Task
138. VALLENTYNE, Dr. J.R.	F.W.I., Fisheries Research Board of Canada, Winnipeg, Manitoba	Limnology Task Force	
139. VENABLES, W.N.	B.C.P.C.B., W.R.S., Lands, Forests and Water Resources Victoria, B.C.	Member-Consultative Board	
140. VERNON, E.H.	F.& W., Department of Recreation and Conservation, Victoria, B.C.	Member-Study Committee	
141. WALDEN, C.C.	B.C. Research Council, University of British Columbia Vancouver, B.C.	Limnology	117
142. WALLACE, T.J.	W.S.C., I.W.D., Environment Canada, Vancouver, B.C.	Water Quantity	43, 52
143. WIGGINS, M.	W.P.& M., Environment Canada, Vancouver, B.C.	Member-Study Committee (1974) Replaced Dr. J. O'Riordan	
144. WILLCOCKS, T.J.	F.W.I., F.R.B., Environment Canada, Vancouver, B.C.	Fisheries	66, 163
145. WILLIAMS, D.J.	C.C.I.W., I.W.D., Environment Canada, Burlington, Ont.	Limnology	117, 118, 120, 124
146. WILLINGTON, Dr. R.P.	Faculty of Forestry, University of British Columbia Vancouver, B.C.	Water Quantity	180
147. WILSON, S.C. Ms.	Okanagan Basin Agreement, Penticton, B.C.	Typist, Study Office	
148. WREGGITT, R.	Okanagan Basin Agreement, Penticton, B.C.	Socio-Economics	203
149. WRIGHT, J.B.	Atmospheric Environment Service, I.W.D., Environment Canada, Vancouver, B.C.	Water Quantity	44, 52
150. ZALANFY, J.G.	B.C.W.I.B., W.R.S., Lands, Forests and Water Resources Victoria, B.C.	Water Quantity	36, 60

NOTES:

A. *1 - Federal members associated with the Department of Energy, Mines and Resources at the initiation of the Study, were transferred to the Department of the Environment following its formation in June, 1971.

B. *2 Provincial members associated with the Public Health Chemistry Section of the Division of Laboratories, Health Branch, B.C. Department of Health and Welfare at the initiation of the Study were transferred to Chemistry Laboratory, B.C. Water Resources Service in 1971.

C. Most of the federal study participants shown did not commence their affiliation with the Study until after the change shown in *1 had occurred. Their affiliation is therefore shown as being with the Department of the Environment.

KEY TO ABBREVIATIONS

A.E.S.	Atmospheric Environment Service	F.W.I.	Freshwater Institute
B.C.P.C.B.	British Columbia Pollution Control Branch	H.S.D.	Hydrologic Service Division
B.C.W.I.B.	British Columbia Water Investigations Branch	I.W.D.	Inland Waters Directorate
C.C.I.W.	Canada Center for Inland Waters	W.P.M.	Water Planning and Management Branch
E.P.S.	Environmental Protection Service	W.Q.L.	Water Quality Laboratory
F.M.S.	Fisheries and Marine Service	W.R.S.	Water Resources Service
F.R.B.	Fisheries Research Board	W.S.C.	Water Survey of Canada
F.& W.	Fish and Wildlife Branch		

APPENDIX E

PUBLIC INVOLVEMENT TASK FORCE MEMBERS

ALPHABETICAL LISTING OF OKANAGAN BASIN PUBLIC INVOLVEMENT TASK FORCE MEMBERS

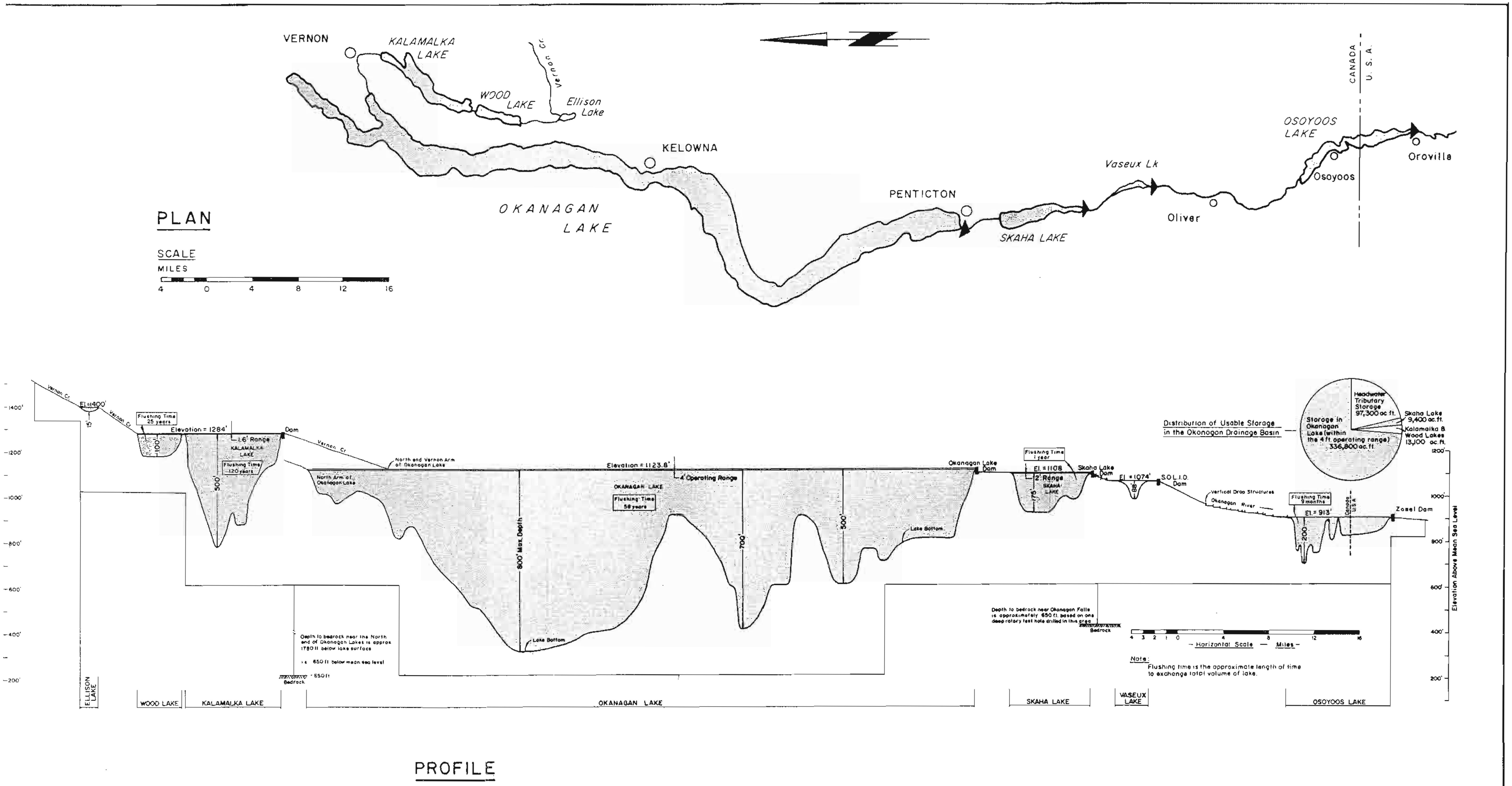
	NAME	PROFESSION OR AFFILIATION	ADDRESS	TASK FORCE
1.	A. Allan	Professional-Agronomist	c/o B.C.D.A., Courthouse Vernon	6
2.	E. Anthony	District Engineer, B.C. Water Resources Professional	1420 Water Street, Kelowna	2 & 7
3.	D. Barcham	Planner	C.O.R.D., 540 Groves Avenue Kelowna	2 & 7 Alt.
4.	Mayor B. Barkwill	Political	District of Summerland, P.O. Box 159, Summerland	1 & 7 Alt.
5.	L. Bawtree,	Logger-Rancher (Past Chairman)	Okanagan Basin Water Board 540 Groves Avenue, Kelowna	1 & 7
6.	F. Becker (Deceased)	Former Mayor	3205 - 20th Street, Vernon	6
7.	Ralph Belamy	Trade Unionist	Klinger Road, Okanagan Landing	6 & 7
8.	J. Belsham	Agricultural Researcher	Dept. of Agriculture 3103 - 32nd Avenue, Vernon	6
9.	Mrs. S. Black	Housewife	Crawford Road, Oyama	6 & 7 Alt.
10.	Hans Blattner	Alderman	R.R.#3, Hayes Road, Armstrong	6 & 7
11.	H. Bohn	Business proprietor/Conservationist	Okanagan Falls	3 & 7
12.	Mike Booth	Industrial Chemist	c/o Hiram Walker & Sons Winfield	5 & 7 Alt.
13.	Dwight Brown	Industrial Chemist	Casabello Wines, Penticton	7
14.	Jim Browne	Alderman	c/o City Hall, Penticton	4 & 7 Alt.
15.	D. Burtch	Jaycee	R.R.#1, Glenmore Drive, Kelowna	5
16.	Reverend Campbell	Theologian	3702 - 17th Avenue, Vernon	6
17.	T. Connelly	Planner	North Okanagan Regional Dist. 3109 - 31st Avenue, Vernon	2 & 7
18.	W. Cook	Realtor	Osoyoos	3
19.	D. Corbishley	Rotarian	R.R.#1, Oliver	3
20.	Sid Cornock	City Assessor	Penticton	4
21.	M. Covert	Vegetable Producer	Island Road, Oliver	3
22	G. Creighton	Retired Professional Engineer	Box 251, Okanagan Falls	3 & 7
23.	Bill Kane	Alderman	City Hall, Kelowna	5
24.	I. Cumming	Theologian	Naramata Centre, Naramata	4 & 7
25.	F. Van Duzee	Sec'ty Flood Control Committee	Osoyoos	3

26.	Dave Evans	Farmer/Sportsman	So. Okanagan Sportsmen's Association, Oliver	3 & 7
27.	P. Farmer,	Chairman-RDOS	Regional District, Okanagan-Similkameen	1
28.	S. Fleming	Mayor	City Hall, 3400 - 30th Street, Vernon	1
29.	S. Forrest	Fish & Game enthusiast	1190 Penticton Avenue, Penticton	4
30.	O. Foster	Agriculturist	Lansdowne, R.R.#2, Armstrong	6
31.	Doug Fraser	Orchardist	Osoyoos	3 & 7
32.	H. Fritz	Jaycee	1630 Duncan Ave., Penticton	4
33.	J.E. Fry	Ecologist	Pritchard Drive, R.R.#1, Westbank	5 & 7
34.	Bob Graham	Municipal Clerk	Dist. of Spallumcheen Box 100, Armstrong	2 & 7
35.	B. Harvey	Professional Engineer	c/o Vernon Irrigation 2904 - 29th Avenue, Vernon	6 & 7
36.	Rev. Ian Hind	Theologian	1488 Aspen Court, Kelowna	5 Alt.
37.	Mrs. Ken Hornby	Housewife	Naramata	4 & 7 Alt.
38.	B. Hume	Chairman	Assoc. of B.C. Irrigation Districts, 1481 Water St. Kelowna	2
39.	Dave Hurn	Wildlife & Conservation Officer Professional	Dept. Recreation and Conservation, 152 Main St. Penticton	2 & 7
40.	Bill Kane	Former Alderman	Kelowna	5
31	H. "Butch" Kaneda	Industrialist	c/o Noca Dairy, 3204 - 27th Avenue, Vernon	6 & 7 Alt.
42.	W. Kastelen	Professional	B.C.P.C.B., Vernon	2
43.	K. King	Orchardist	3940 Lakeshore Drive, Penticton	4
44.	John M. Kosty	Alderman	R.R.#2, Westside, Vernon	6
45.	F. Laird	Mayor	152 Main Street, Penticton	1
46.	E. Lane	Land Surveyor/Professional	Box 166, Kelowna	5 & 7 Alt.
47.	W.L. Lawrence	Alderman	Box 161, Peachland	1 & 7 Alt.
48.	H. Lever	Business Proprietor	Apex Janitor Service, R.R.#1, Peachland	5
49.	O. Litke	Regional District Director	R.R.#3, Vernon	6 & 7 Alt.
50.	Ian Loomer	Logger	1321 King St. Penticton	4 & 7 Alt.
51.	D. Lovedahl	Technician	Water Resources Service Water Rights Branch 1420 Water Street, Kelowna	2

52.	D. MacKay	Professional	City Engineer, City Hall Vernon	2
53.	J. McCoubrey	Regional District Director	R.R.#1, Winfield	5
54.	Dr. D. McMullen	Agricultural Scientist	c/o Entomology Dept. Summerland Research Station Summerland	4
55.	G. Meldrum	Alderman	Beach Avenue, Peachland	5
56.	S. Mepam	Agriculturist	Osoyoos	3 Alt.
57.	Frank Metcalf	Technician	Okanagan Flood Control Office Court House, Penticton	2
58.	Judge C.W. Morrow	Judge	#209-3618-30th Avenue, Vernon	6
59.	Frank Oakes	Alderman	West Bench, Penticton	7
60.	Bill Parchomchuk	Professional/Okanagan Basin Water Bd.	540 Groves Avenue, Kelowna	2 & 7
61	J. Passmore	Business Proprietor	c/o Alpine Distributors Box 159, Vernon	6
62.	A. Pitt	Tourist Resort Operator	c/o Belvedere Resort, Winfield	5 & 7 Alt.
63.	Dave Porteous	Alderman	Crestview Heights, Osoyoos	3 & 7
64.	R. Postill	Mayor	Dist. of Coldstream R.R.#2, Vernon	1
65.	Hilbert Roth	Mayor	1435 Water Street, Kelowna	1
66.	B. Rouw	Finance Manager	1472 St. Paul St.,Kelowna	5
67.	J. Sawicki	Teacher	2204 - 34th Street, Vernon	6
68.	Ruth Schiller	Fruit Stand Operator	Osoyoos	3 & 7 Alt.
69.	B. Scott	Irrigation District Secretary	R.R.#1, Okanagan Falls	3 & 7
70.	Warren Seabrook	Industrialist	c/o Noca Dairy, 3204 - 27th Avenue, Vernon	6 & 7
71	Jack Shaw	Mayor	Village Office, Box 301 Osoyoos	1 & 7 Alt.
72.	G. Sidney	Mayor	Dist. of Spallumcheen, Box 100, Armstrong	1
73.	Elmer Siemens	Tourist Facility Operator	2784 Skaha Lake Road, Sun Valley Motel, Penticton	4
74	C. Sladen,	Irrigation District Manager	1481 Water Street, Kelowna	5
75.	Norman Slingsby		R.R.#2, Vernon	6
76.	Dr. M.R. Smart	Professional(Director-Health Unit)	North Okanagan Health Unit 3300 - 37th Avenue, Vernon	2 & 7
77.	J. Smith	Mayor	City Hall, Box 40, Armstrong	1
78.	Wally Smith	Orchardist/Press Commentator	R.R.#2, Oliver	2
79.	F. Snowsell	Retired Teacher	63 Sioux Square, Hiawatha Park Lakeshore Drive, Kelowna	5 & 7
80.	Father Stephens	Theologian	St. Anne's Church, Osoyoos	3

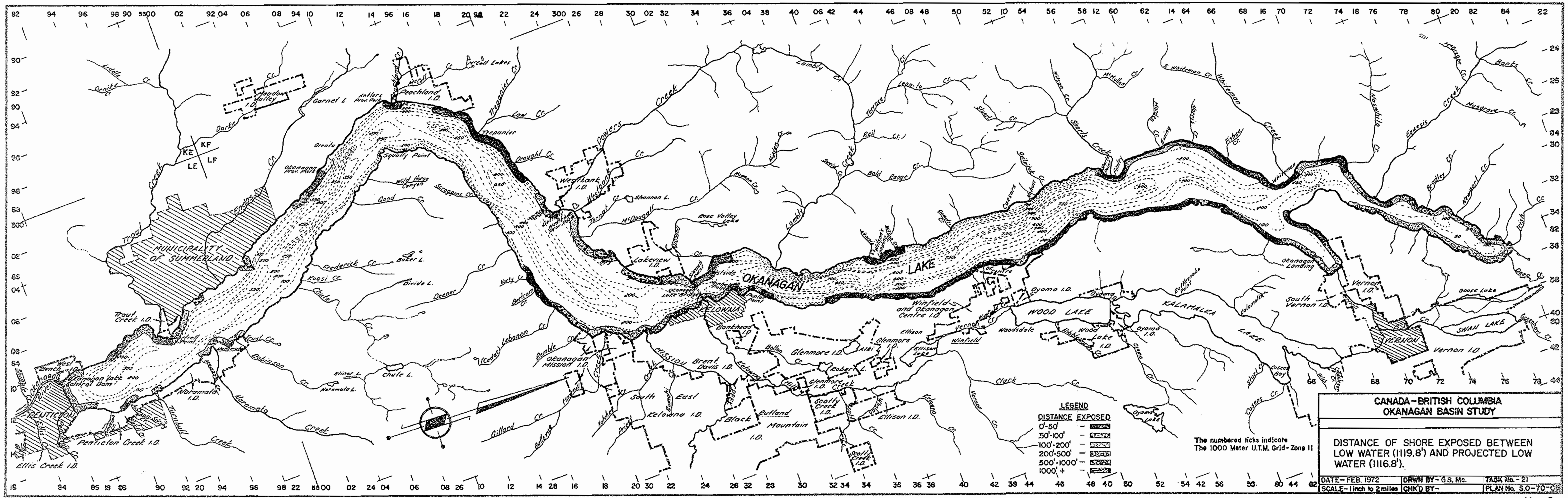
81.	Dr. D. Stevenson	Professional/Agricultural Scientist	Dept. of Agriculture Summerland Research Station	2 & 7
82.	J.H. Stuart	Agriculturalist/Alderman	Regional Director, Central Okanagan Regional District R.R.#3, Kelowna	1 & 7
83.	Roy Sturgess	Alderman	1st Avenue, Oliver	3
84.	Bill Sullivan	Realtor	Kelowna	7
85.	Jack Tait	Sales Representative	R.R.#1, Oliver	3
86.	H. Thompson	Alderman	P.O. Box 631, Oliver	3
87.	H. Thompson	Planner	Planning Director, R.D.O.S. 1101 Main Street, Penticton	2 & 7 Alt.
88.	G. Thomson	Agriculturist	4193 Paret Road, Kelowna	5
89.	Harold Thwaite	Mayor	Dist. of Peachland P.O. Box 390, Peachland	1
90.	R. Topping	Mayor	Village Office, Box 638 Oliver	1
91.	S.J. Truscott	Biologist	B.C.P.C.B., Vernon	2
92.	H.G. Wilson	Professional Engineer	c/o Stewart Morgan AR & Co. 3003 - 34th Street, Vernon	6 & 7 Alt.
93.	Rev. John Wollenberg	Theologian	1421 Richmond, Kelowna	5
94.	Olive Woodley	Environmentalist	Box 129, Vernon	6 & 7
95.	Gavin Young	Professional/Agricultural Researcher	Dept. of Agriculture, Spall Road, Kelowna	5 & 7
96.	Lorna Young	Housewife	R.R.#4, Kelowna	5 & 7

MAP SECTION

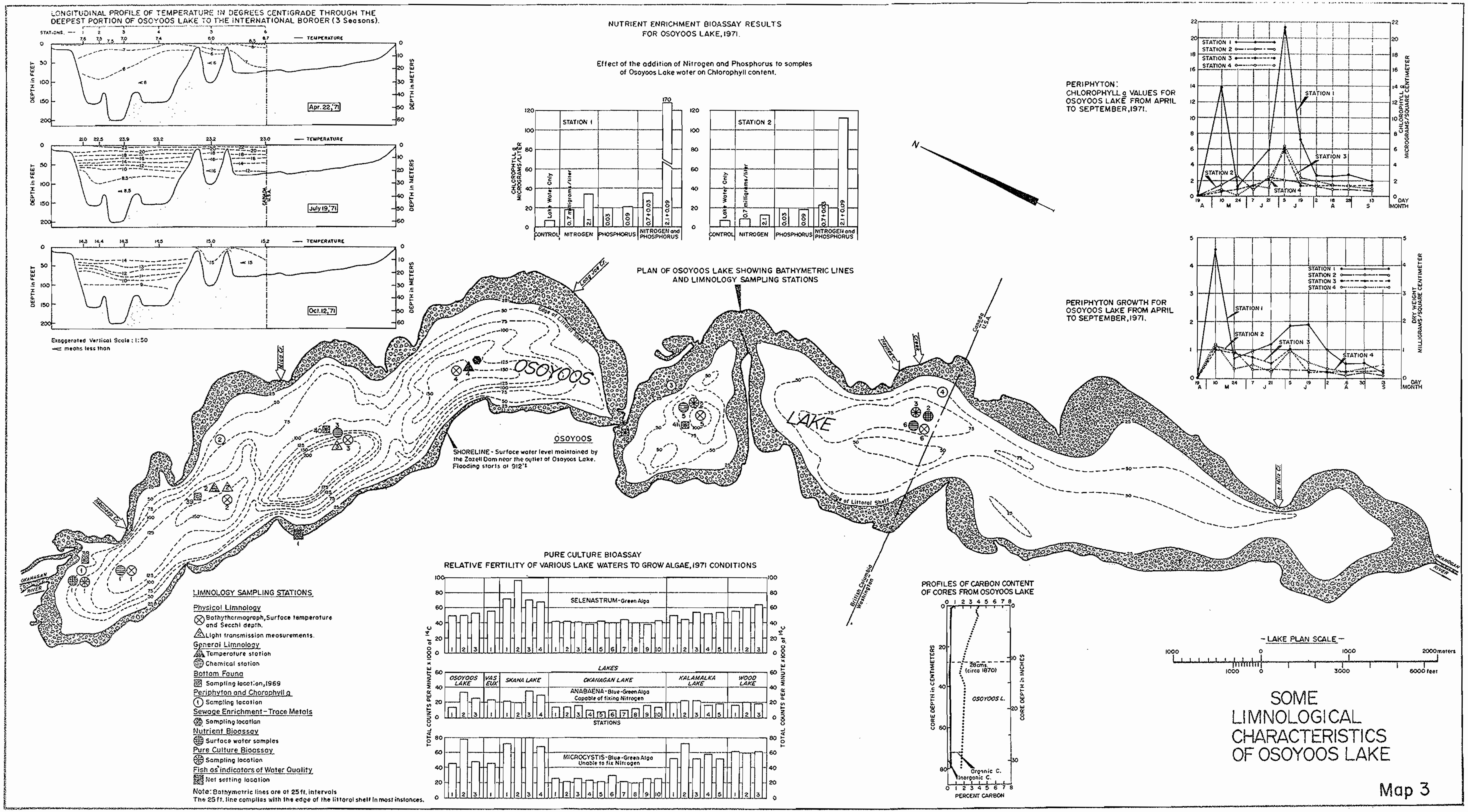


PLAN AND PROFILE of OKANAGAN MAIN VALLEY LAKES

Map 1

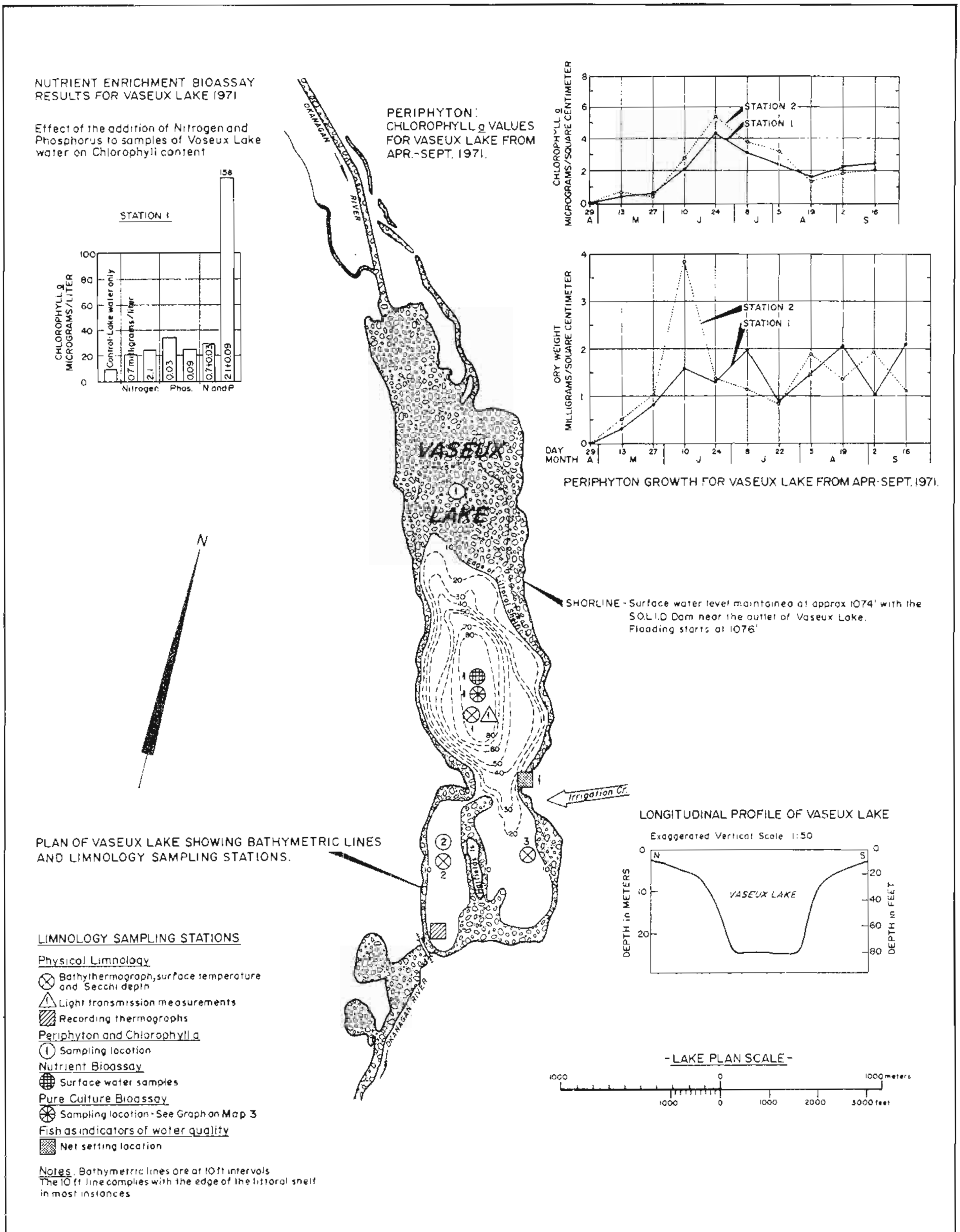

CANADA-BRITISH COLUMBIA
OKANAGAN BASIN STUDY
DISTANCE OF SHORE EXPOSED BETWEEN LOW WATER (1119.8') AND PROJECTED LOW WATER (1116.8').
DATE - FEB. 1972
DRWN BY - G.S. Mc.
TASK No. - 21
SCALE - 1 inch to 2 miles
CHK'D BY -
PLAN No. S.0-70-08
LEGEND
DISTANCE EXPOSED
0'-50'
50'-100'
100'-200'
200'-500'
500'-1000'
1000' +
The numbered ticks indicate
The 1000 Meter U.T.M. Grid-Zone 11
OKANAGAN LAKE
MUNICIPALITY OF SUMMERLAND
PENTICTON
KELOWNA
VERNON
WOOD LAKE
KALAMALKA LAKE
SWAN LAKE
Peachland I.D.
Westbank I.D.
Lakeview I.D.
Glenmore I.D.
Winfield and Okanagan Centre I.D.
Oyama I.D.
South East Kelowna I.D.
Black Mountain I.D.
Rutland
Naramata I.D.
Penticton Creek I.D.
Ellis Creek I.D.
Trout Creek I.D.
Okanagan Mission I.D.
Vernon I.D.
South Vernon I.D.
Meadow Valley I.D.
Squally Point
Trepanier Cr.
Powers Creek
Whiteman Creek
Mission Creek
Naramata Creek
Chute Cr.
Lambly Cr.
Shorts Creek
Clark Cr.
Oyama Lake
Okanagan Landing
Goose Lake

Map 2



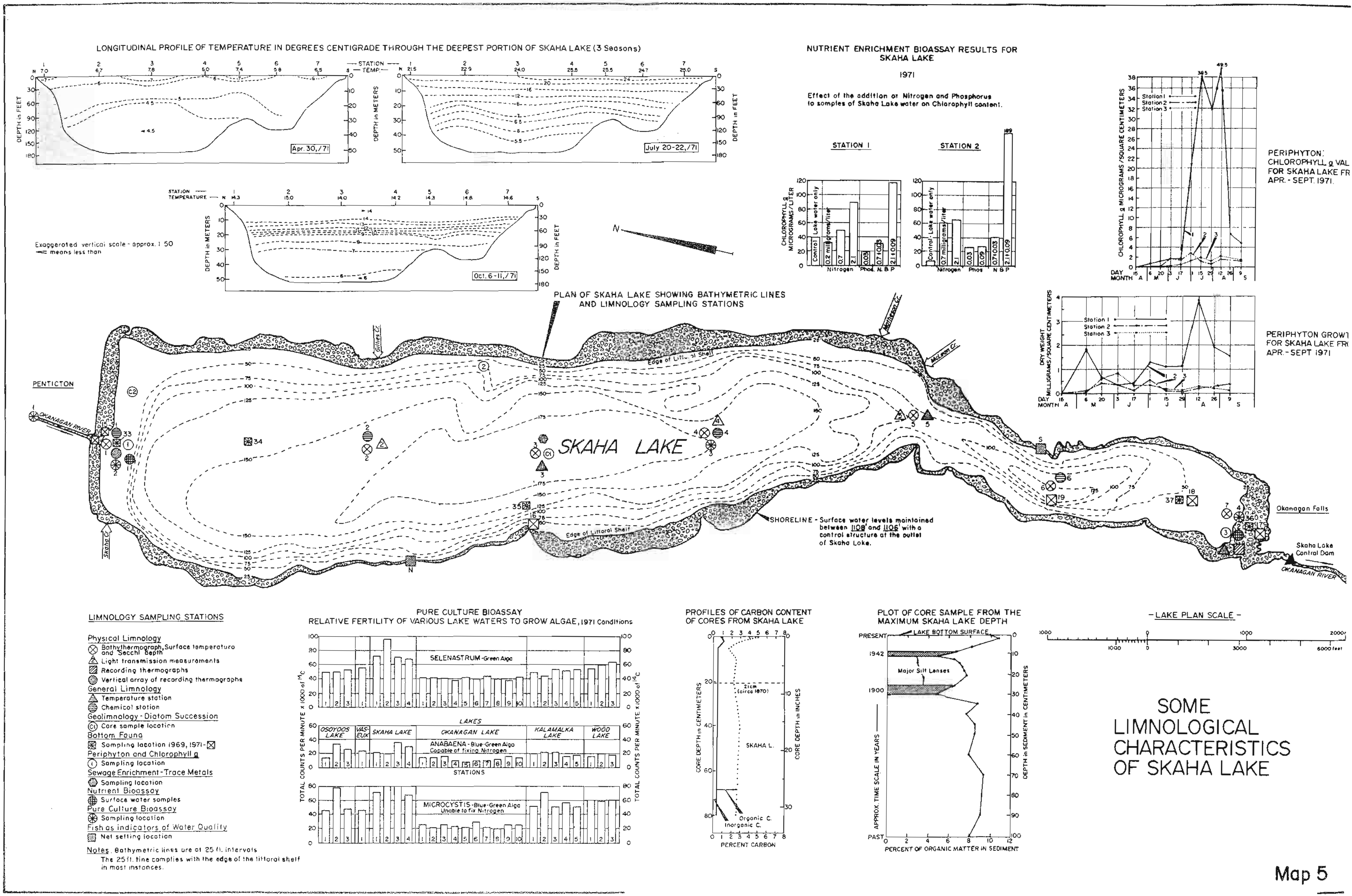
SOME LIMNOLOGICAL CHARACTERISTICS OF OSOYOOS LAKE

Map 3



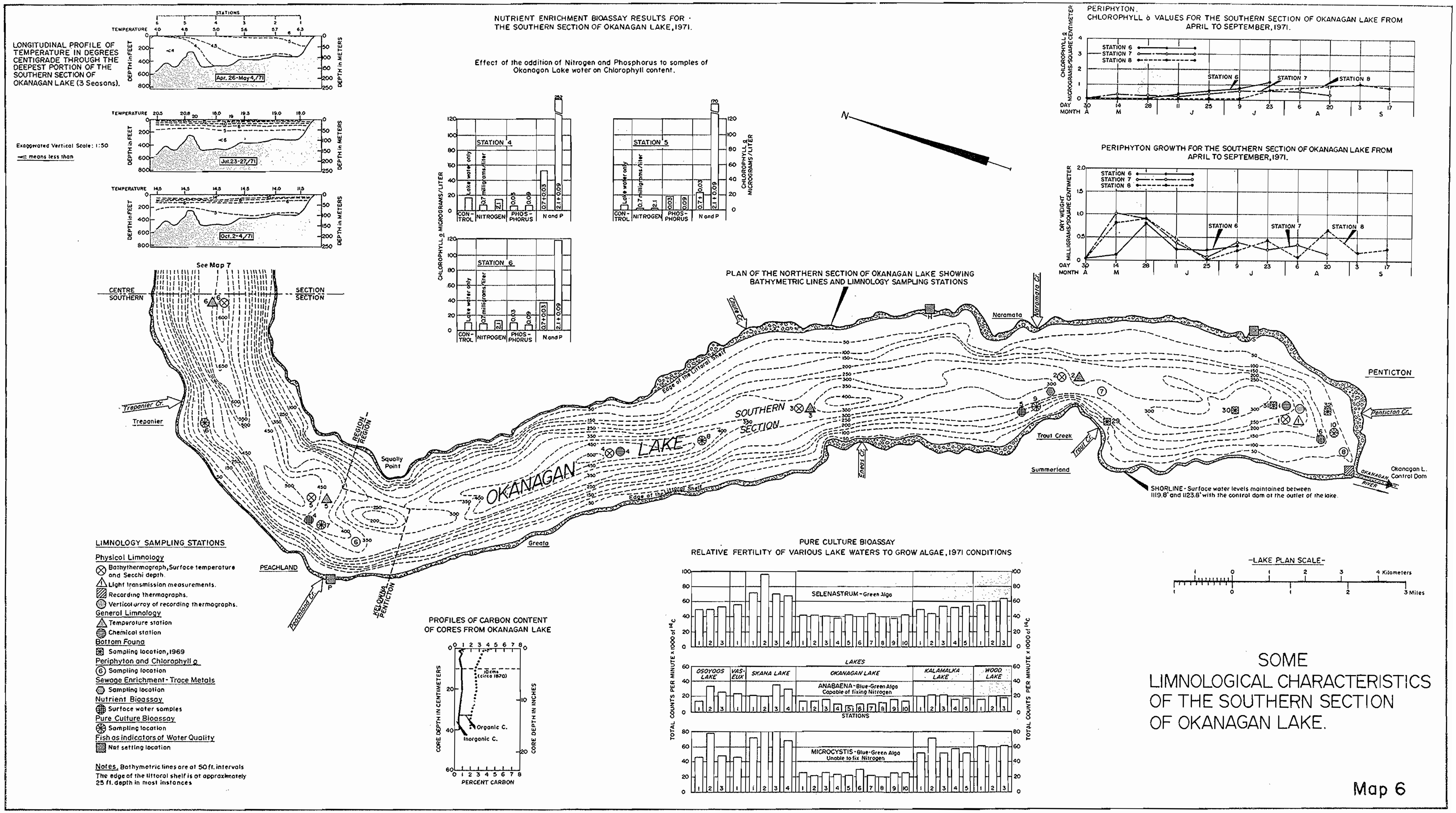
SOME LIMNOLOGICAL CHARACTERISTICS OF VASEUX LAKE

Map 4



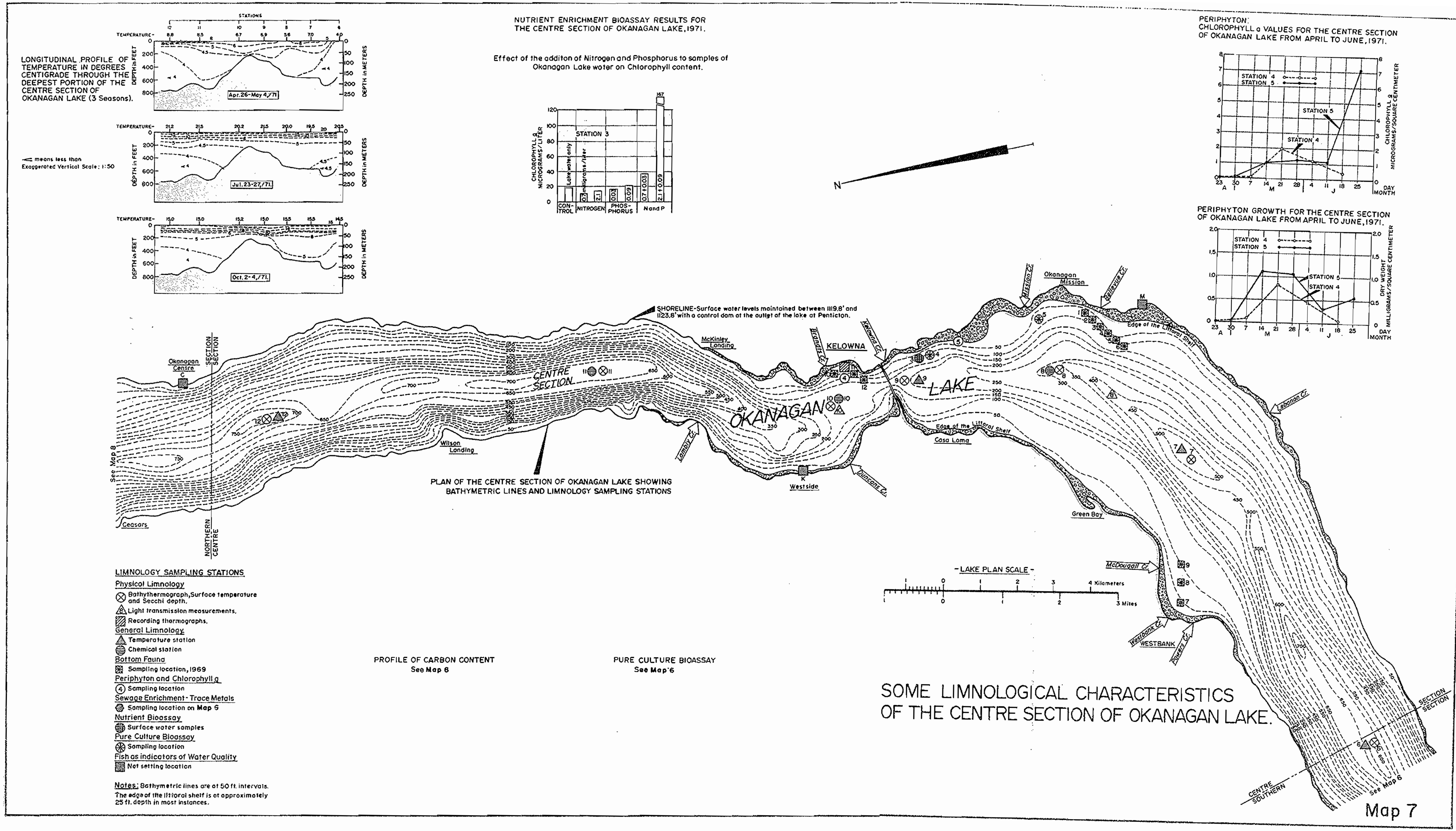
SOME LIMNOLOGICAL CHARACTERISTICS OF SKAHA LAKE

Map 5

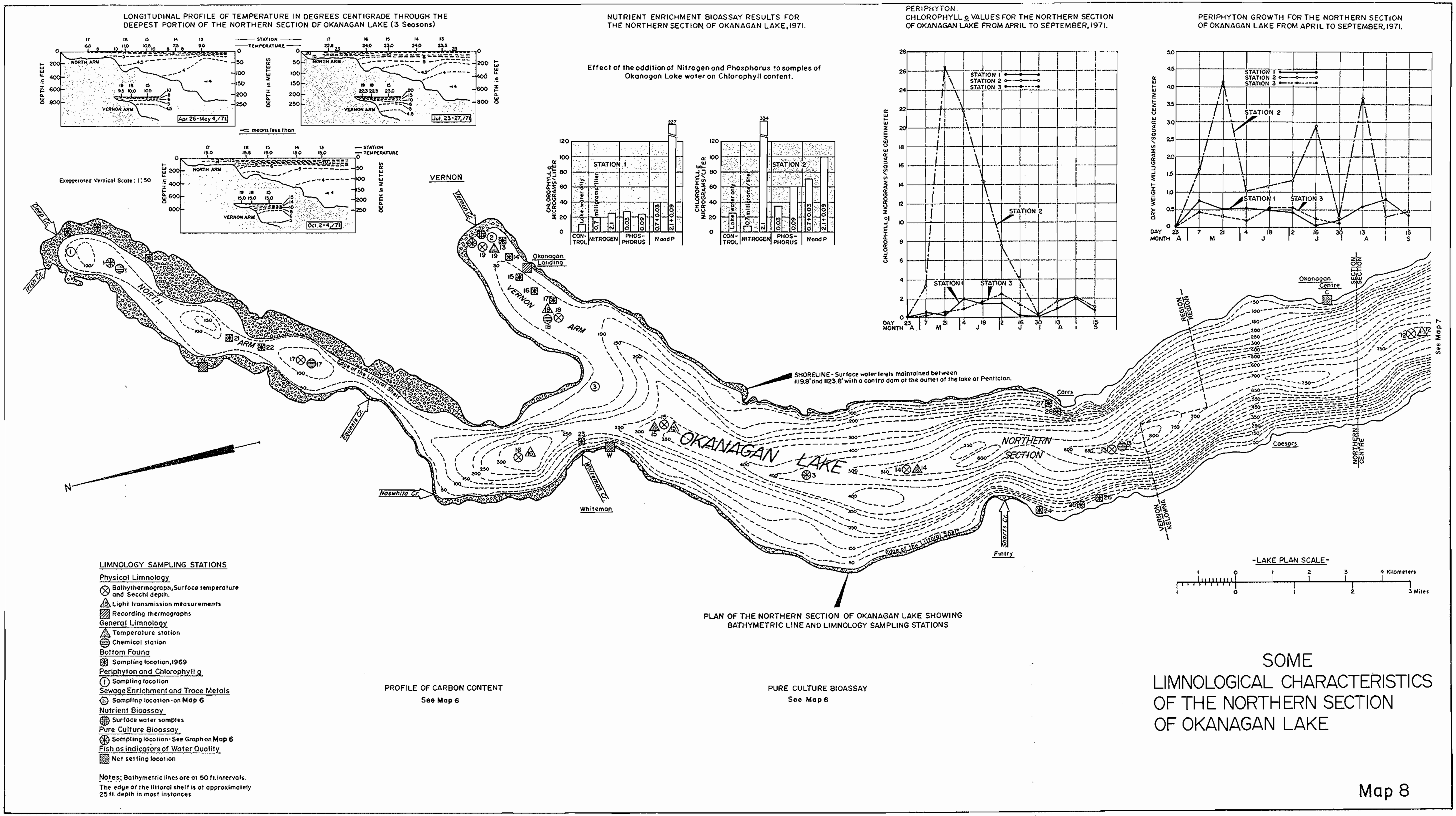


SOME LIMNOLOGICAL CHARACTERISTICS OF THE SOUTHERN SECTION OF OKANAGAN LAKE.

Map 6

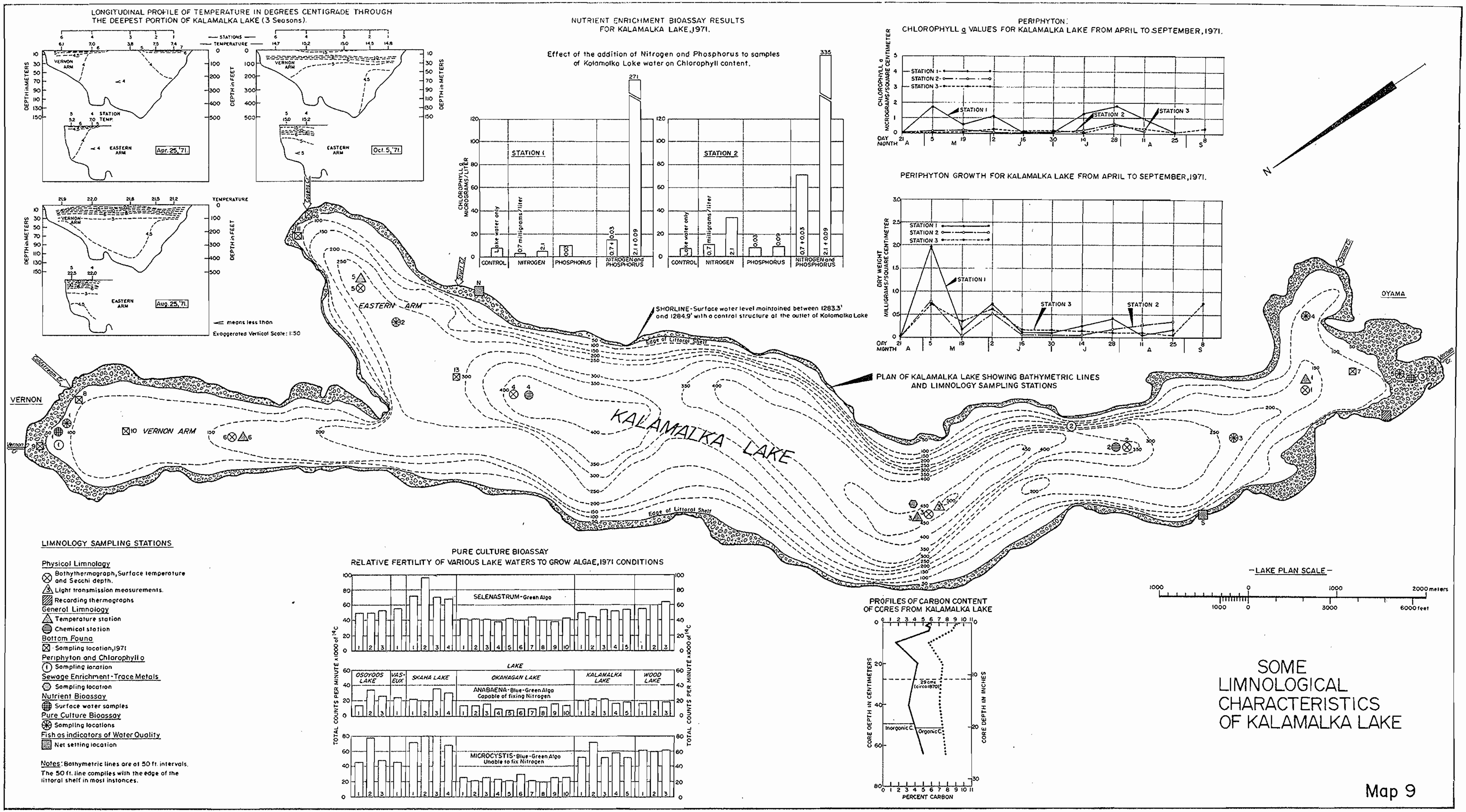


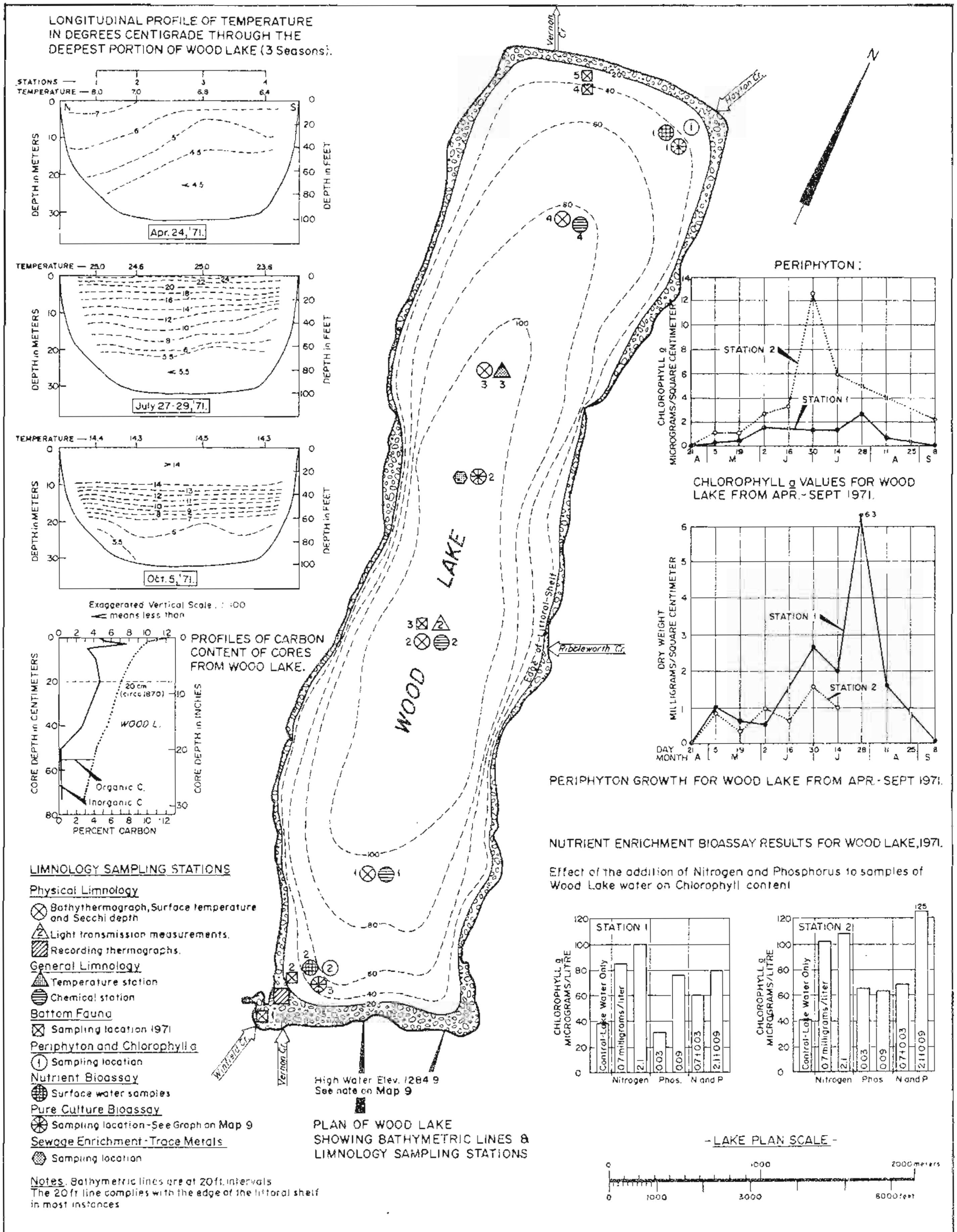
LONGITUDINAL PROFILE OF TEMPERATURE IN DEGREES CENTIGRADE THROUGH THE DEEPEST PORTION OF THE CENTRE SECTION OF OKANAGAN LAKE (3 Seasons).
STATIONS
TEMPERATURE
DEPTH in FEET
DEPTH in METERS
Apr. 26-May 4,/71.
Jul. 23-27,/71.
Oct. 2-4,/71.
means less than
Exaggerated Vertical Scale: 1:50
NUTRIENT ENRICHMENT BIOASSAY RESULTS FOR THE CENTRE SECTION OF OKANAGAN LAKE, 1971.
Effect of the additon of Nitrogen and Phosphorus to samples of Okanagan Lake water on Chlorophyll content.
CHLOROPHYLL a MICROGRAMS/LITER
STATION 3
Lake water only
milligrams/liter
CONTROL
NITROGEN
PHOSPHORUS
N and P
N
PERIPHYTON: CHLOROPHYLL a VALUES FOR THE CENTRE SECTION OF OKANAGAN LAKE FROM APRIL TO JUNE, 1971.
STATION 4
STATION 5
CHLOROPHYLL a MICROGRAMS/SQUARE CENTIMETER
DAY
MONTH
PERIPHYTON GROWTH FOR THE CENTRE SECTION OF OKANAGAN LAKE FROM APRIL TO JUNE, 1971.
DRY WEIGHT MILLIGRAMS/SQUARE CENTIMETER
SHORELINE-Surface water levels maintained between 1119.8' and 1123.8' with a control dam at the outlet of the lake at Penticton.
Okanagan Centre
SECTION SECTION
NORTHERN CENTRE
CENTRE SECTION
OKANAGAN
LAKE
McKinley Landing
Brandts Cr.
KELOWNA
Kelowna Cr.
Mission Cr.
Okanagan Mission
Bellevue Cr.
Edge of the Littoral Shelf
Lebanon Cr.
Wilson Landing
Lambly Cr.
Westside
Duncans Cr.
Casa Loma
Green Bay
McDougall Cr.
Westbank Cr.
WESTBANK
Powers Cr.
Ceasars
See Map 8
See Map 6
CENTRE SOUTHERN
PLAN OF THE CENTRE SECTION OF OKANAGAN LAKE SHOWING BATHYMETRIC LINES AND LIMNOLOGY SAMPLING STATIONS
-LAKE PLAN SCALE-
4 Kilometers
3 Miles
LIMNOLOGY SAMPLING STATIONS
Physical Limnology
Bathythermograph, Surface temperature and Secchi depth.
Light transmission measurements.
Recording thermographs.
General Limnology
Temperature station
Chemical station
Bottom Fauna
Sampling location, 1969
Periphyton and Chlorophyll a
Sampling location
Sewage Enrichment-Trace Metals
Sampling location on Map 6
Nutrient Bioassay
Surface water samples
Pure Culture Bioassay
Sampling location
Fish as indicators of Water Quality
Net setting location
Notes: Bathymetric lines are at 50 ft. intervals.
The edge of the littoral shelf is at approximately 25 ft. depth in most instances.
PROFILE OF CARBON CONTENT
See Map 6
PURE CULTURE BIOASSAY
See Map 6
SOME LIMNOLOGICAL CHARACTERISTICS OF THE CENTRE SECTION OF OKANAGAN LAKE.
Map 7



SOME LIMNOLOGICAL CHARACTERISTICS OF THE NORTHERN SECTION OF OKANAGAN LAKE

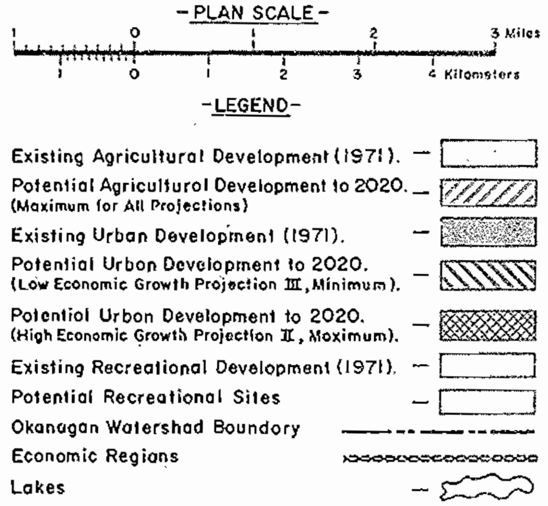
Map 8

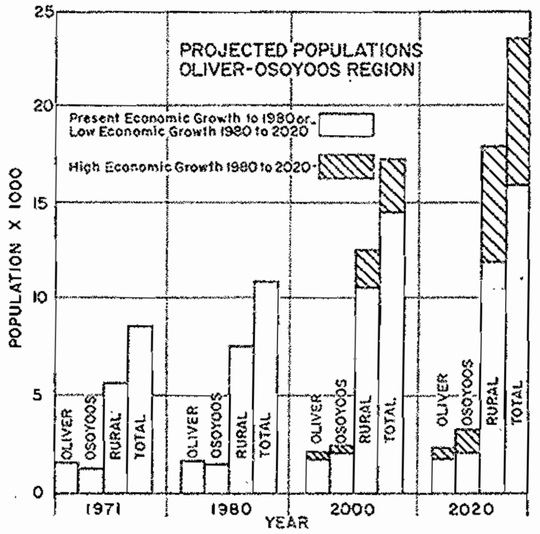

LONGITUDINAL PROFILE OF TEMPERATURE IN DEGREES CENTIGRADE THROUGH THE DEEPEST PORTION OF KALAMALKA LAKE (3 Seasons).
STATIONS
TEMPERATURE
DEPTH in METERS
DEPTH in FEET
VERNON ARM
EASTERN ARM
Apr. 25,'71.
Oct. 5,'71.
Aug. 25,'71.
means less than
Exaggerated Vertical Scale: 1:50
NUTRIENT ENRICHMENT BIOASSAY RESULTS FOR KALAMALKA LAKE, 1971.
Effect of the addition of Nitrogen and Phosphorus to samples of Kalamalka Lake water on Chlorophyll content.
CHLOROPHYLL a MICROGRAMS/LITER
STATION 1
STATION 2
CONTROL
NITROGEN
PHOSPHORUS
NITROGEN and PHOSPHORUS
Lake water only
0.7 milligrams/liter
PERIPHYTON: CHLOROPHYLL a VALUES FOR KALAMALKA LAKE FROM APRIL TO SEPTEMBER, 1971.
CHLOROPHYLL a MICROGRAMS/SQUARE CENTIMETER
STATION 1
STATION 2
STATION 3
DAY MONTH
PERIPHYTON GROWTH FOR KALAMALKA LAKE FROM APRIL TO SEPTEMBER, 1971.
DRY WEIGHT MILLIGRAMS/SQUARE CENTIMETER
N
SHORLINE - Surface water level maintained between 1283.3' and 1284.9' with a control structure at the outlet of Kalamalka Lake
Edge of Littoral Shelf
PLAN OF KALAMALKA LAKE SHOWING BATHYMETRIC LINES AND LIMNOLOGY SAMPLING STATIONS
KALAMALKA LAKE
VERNON
VERNON ARM
EASTERN ARM
OYAMA
Vernon Cr.
Oyama Cr.
LIMNOLOGY SAMPLING STATIONS
Physical Limnology
Bathythermograph, Surface temperature and Secchi depth.
Light transmission measurements.
Recording thermographs
General Limnology
Temperature station
Chemical station
Bottom Fauna
Sampling location, 1971
Periphyton and Chlorophyll a
Sampling location
Sewage Enrichment - Trace Metals
Sampling location
Nutrient Bioassay
Surface water samples
Pure Culture Bioassay
Sampling locations
Fish as indicators of Water Quality
Net setting location
Notes: Bathymetric lines are at 50 ft. intervals. The 50 ft. line complies with the edge of the littoral shelf in most instances.
PURE CULTURE BIOASSAY
RELATIVE FERTILITY OF VARIOUS LAKE WATERS TO GROW ALGAE, 1971 CONDITIONS
TOTAL COUNTS PER MINUTE x1000 of 14C
SELENASTRUM - Green Alga
LAKE
OSOYOOS LAKE
VASEUX
SKAHA LAKE
OKANAGAN LAKE
KALAMALKA LAKE
WOOD LAKE
ANABAENA - Blue-Green Alga Capable of fixing Nitrogen
MICROCYSTIS - Blue-Green Alga Unable to fix Nitrogen
PROFILES OF CARBON CONTENT OF CORES FROM KALAMALKA LAKE
CORE DEPTH IN CENTIMETERS
CORE DEPTH IN INCHES
29 cms (circa 1870)
Inorganic C.
Organic C.
PERCENT CARBON
-LAKE PLAN SCALE-
meters
feet
SOME LIMNOLOGICAL CHARACTERISTICS OF KALAMALKA LAKE
Map 9

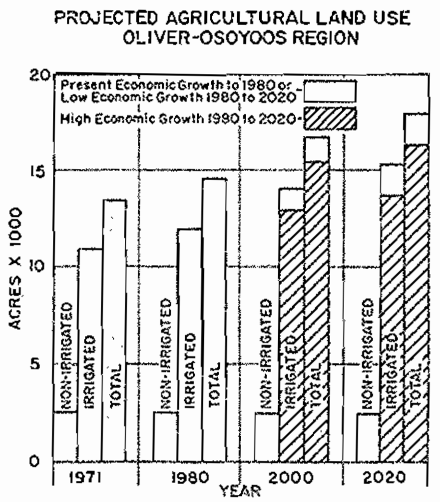


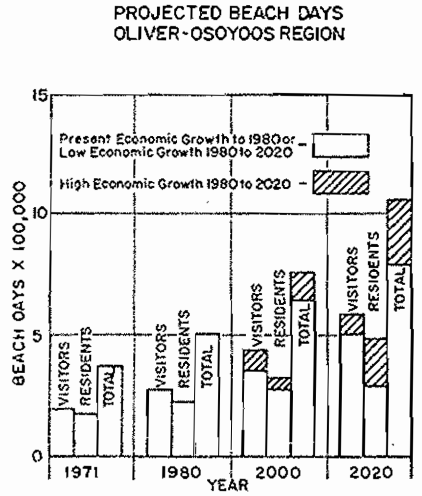
SOME LIMNOLOGICAL CHARACTERISTICS OF WOOD LAKE

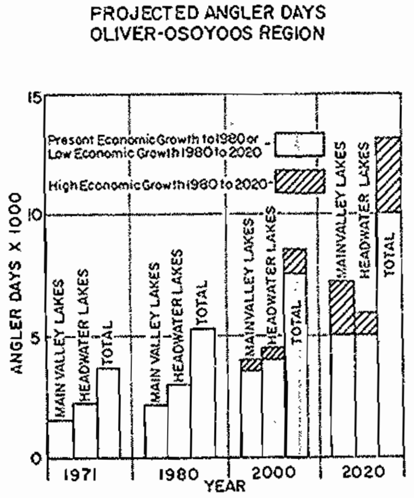
Map 10

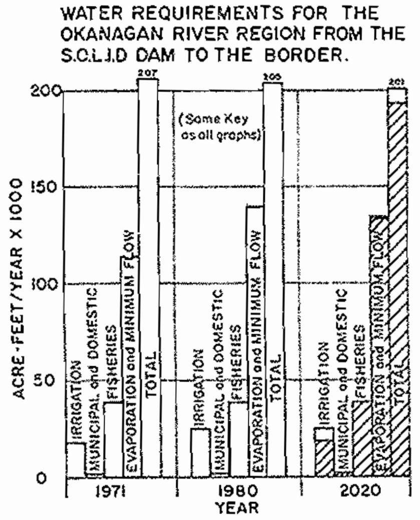






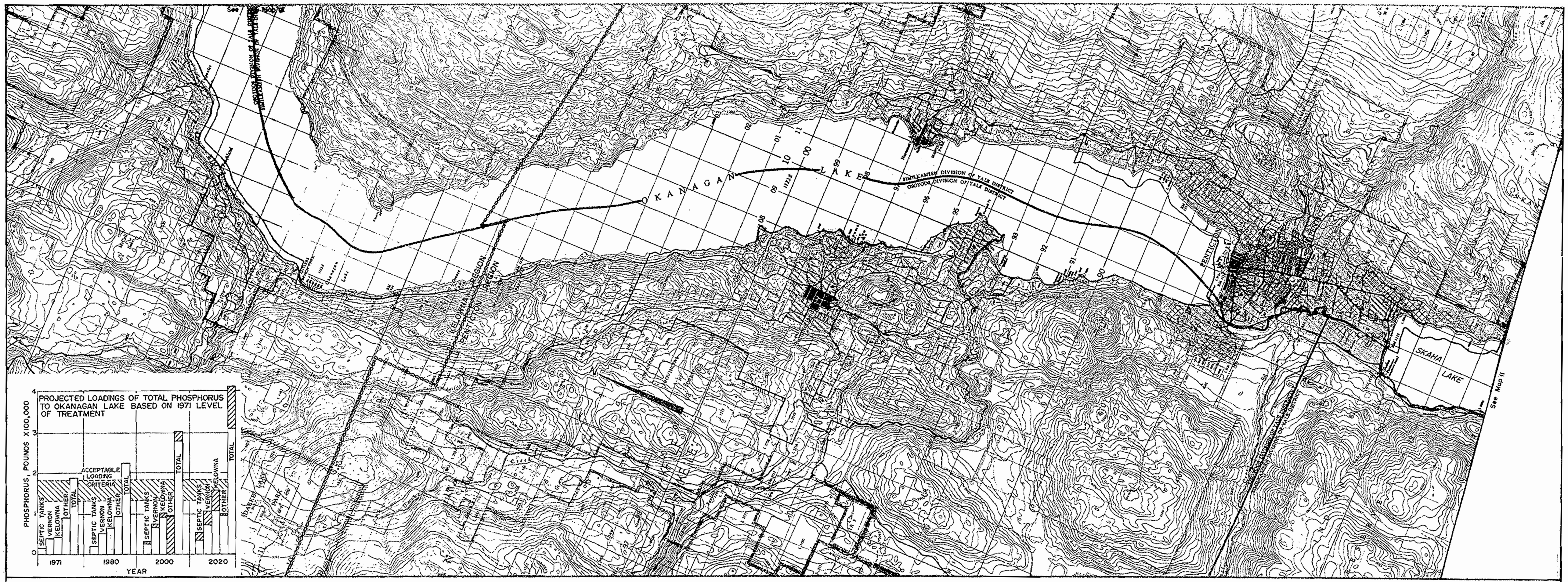


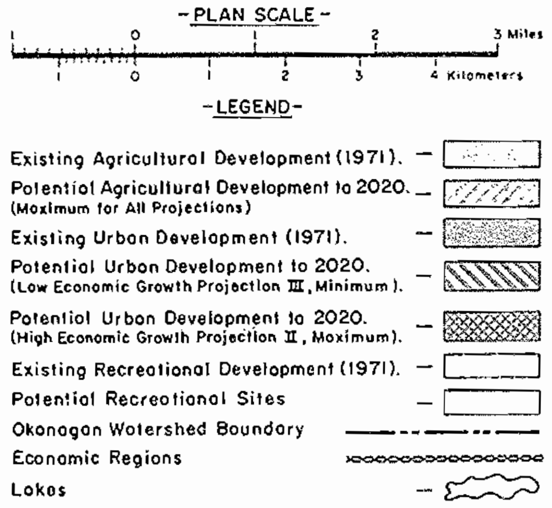


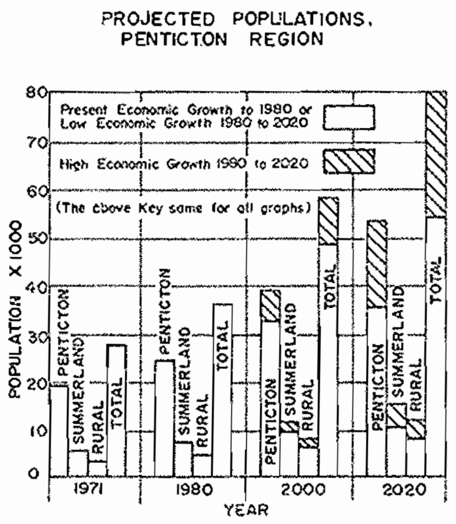


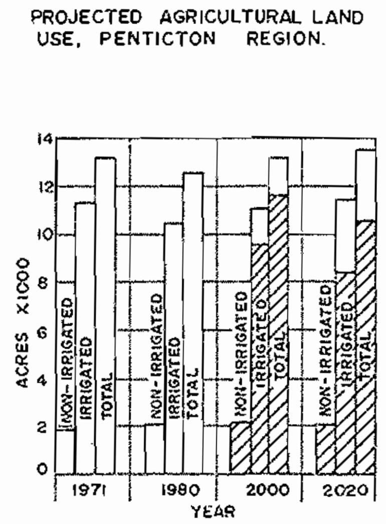
EFFECT OF PROJECTED GROWTH ON WATER AND WATER RELATED RESOURES IN THE OLIVER-OSOYOOS REGION, 1971 to 2020.

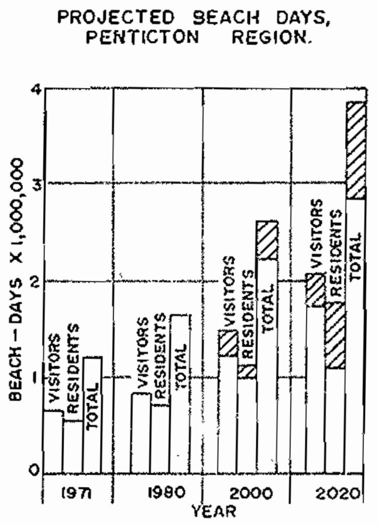
Map 11

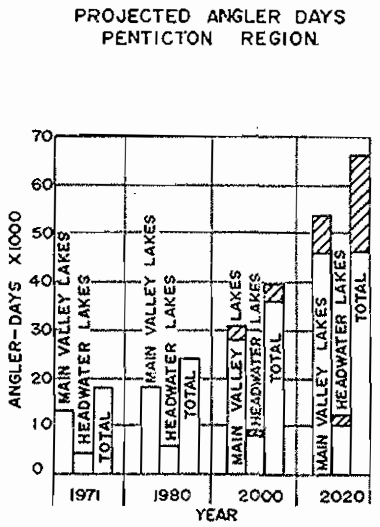


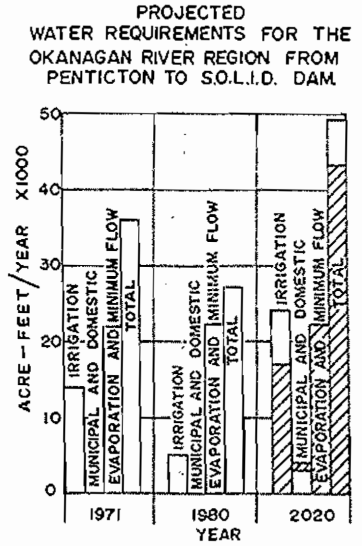


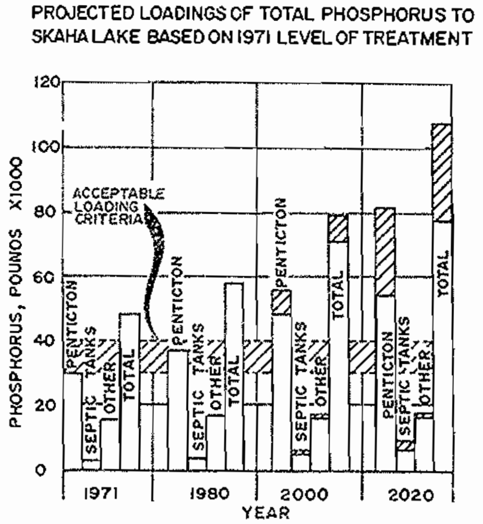






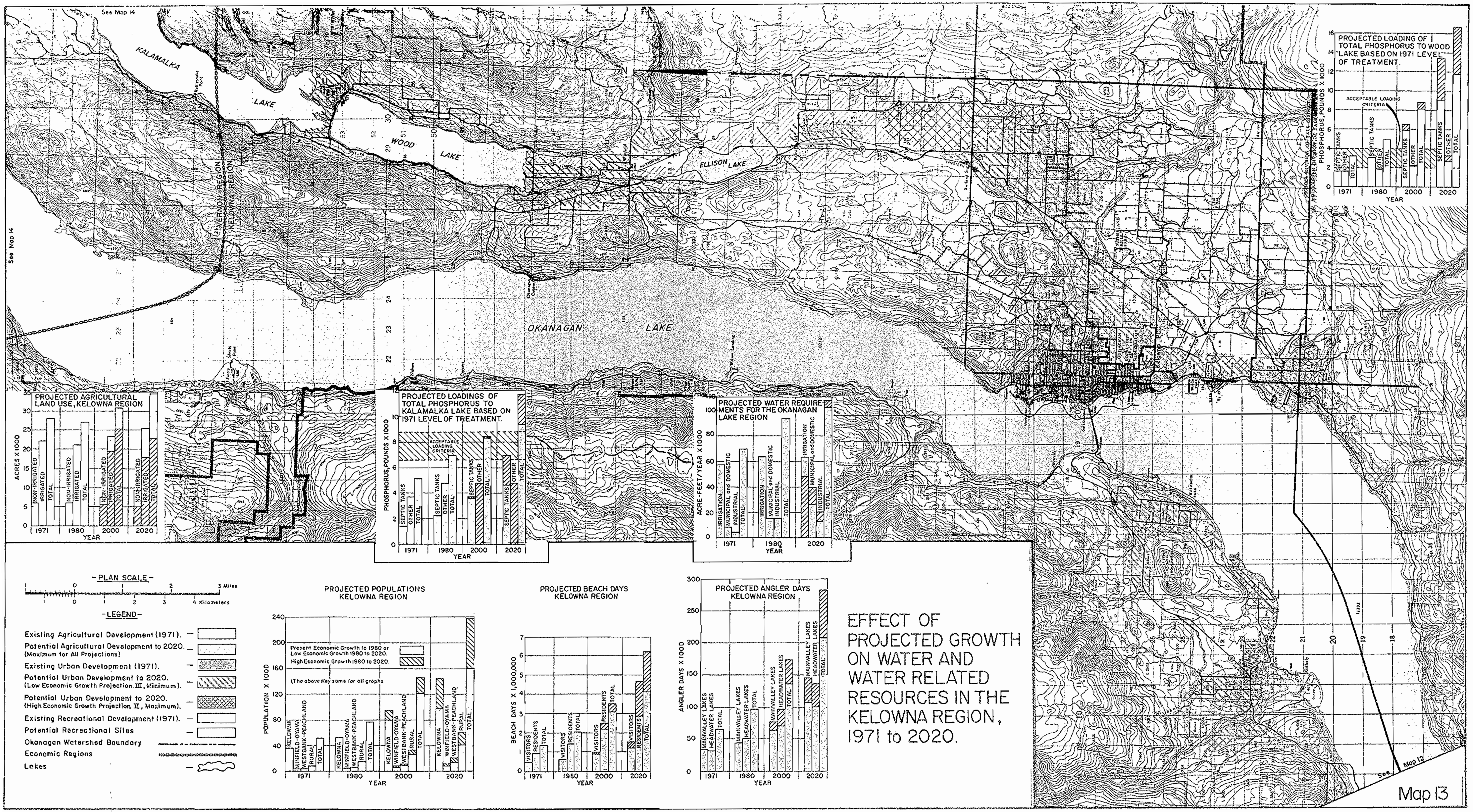


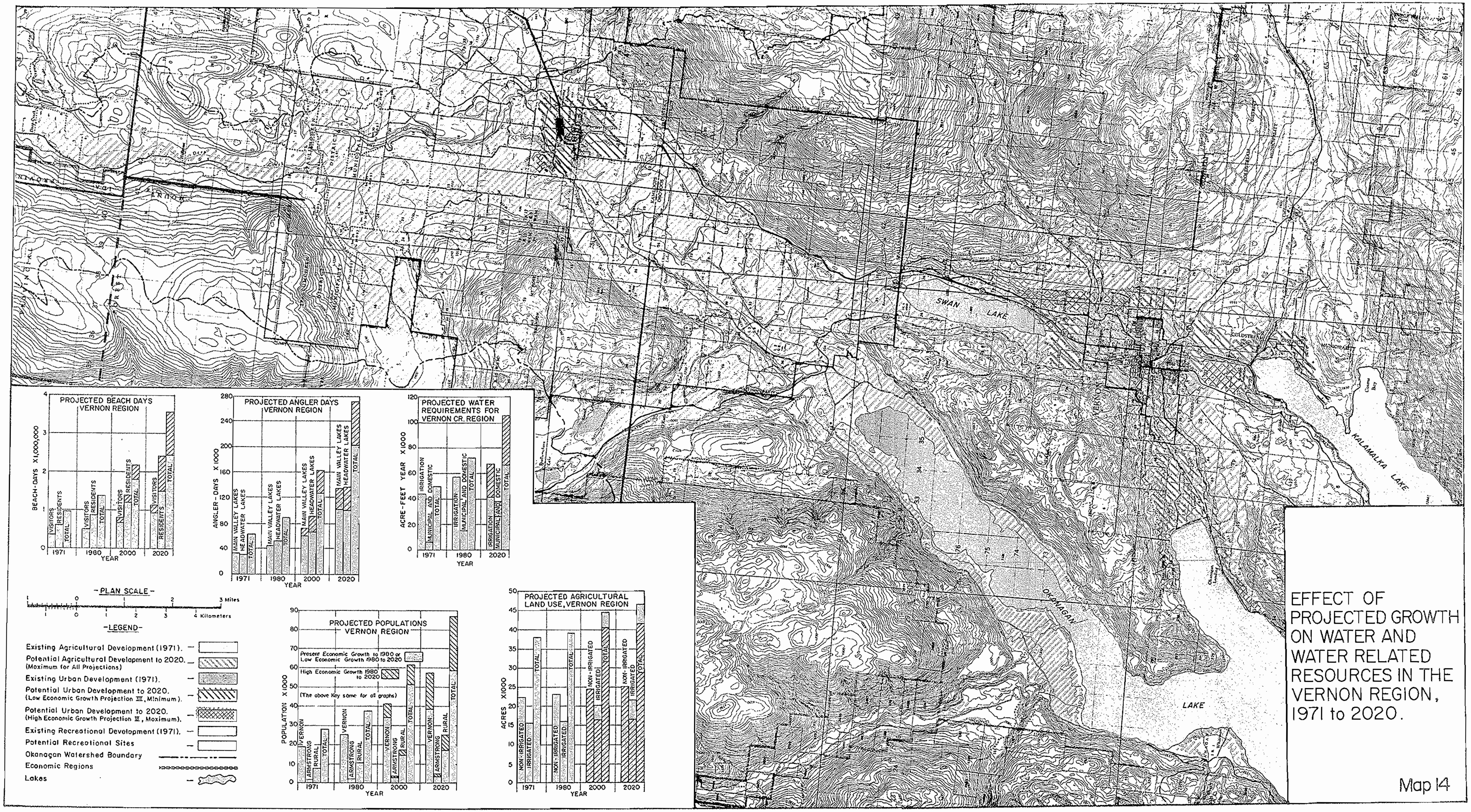




EFFECT OF PROJECTED GROWTH ON WATER AND WATER RELATED RESOURCES IN THE PENTICTON REGION, 1971 to 2020.

Map 12


See Map 14
KALAMALKA LAKE
WOOD LAKE
ELLISON LAKE
OKANAGAN LAKE
VERNON REGION
KELOWNA REGION
PROJECTED LOADING OF TOTAL PHOSPHORUS TO WOOD LAKE BASED ON 1971 LEVEL OF TREATMENT.
PHOSPHORUS, POUNDS X 1000
ACCEPTABLE LOADING CRITERIA
SEPTIC TANKS
OTHER
TOTAL
YEAR
PROJECTED AGRICULTURAL LAND USE, KELOWNA REGION
ACRES X 1000
NON-IRRIGATED
IRRIGATED
TOTAL
PROJECTED LOADINGS OF TOTAL PHOSPHORUS TO KALAMALKA LAKE BASED ON 1971 LEVEL OF TREATMENT.
PHOSPHORUS, POUNDS X 1000
PROJECTED WATER REQUIREMENTS FOR THE OKANAGAN LAKE REGION
ACRE-FEET/YEAR X 1000
IRRIGATION
MUNICIPAL and DOMESTIC
INDUSTRIAL
-PLAN SCALE-
Miles
Kilometers
-LEGEND-
Existing Agricultural Development (1971).
Potential Agricultural Development to 2020. (Maximum for All Projections)
Existing Urban Development (1971).
Potential Urban Development to 2020. (Low Economic Growth Projection III, Minimum).
Potential Urban Development to 2020. (High Economic Growth Projection II, Maximum).
Existing Recreational Development (1971).
Potential Recreational Sites
Okanagan Watershed Boundary
Economic Regions
Lakes
PROJECTED POPULATIONS KELOWNA REGION
Present Economic Growth to 1980 or Low Economic Growth 1980 to 2020.
High Economic Growth 1980 to 2020.
(The above Key same for all graphs)
POPULATION X 1000
KELOWNA
WINFIELD-OYAMA
WESTBANK-PEACHLAND
RURAL
TOTAL
PROJECTED BEACH DAYS KELOWNA REGION
BEACH DAYS X 1,000,000
VISITORS
RESIDENTS
PROJECTED ANGLER DAYS KELOWNA REGION
ANGLER DAYS X 1000
MAINVALLEY LAKES
HEADWATER LAKES
EFFECT OF PROJECTED GROWTH ON WATER AND WATER RELATED RESOURCES IN THE KELOWNA REGION, 1971 to 2020.
See Map 12
Map 13



EFFECT OF PROJECTED GROWTH ON WATER AND WATER RELATED RESOURCES IN THE VERNON REGION, 1971 to 2020.
Map 14
PROJECTED BEACH DAYS VERNON REGION
BEACH-DAYS X1,000,000
PROJECTED ANGLER DAYS VERNON REGION
ANGLER-DAYS X1000
PROJECTED WATER REQUIREMENTS FOR VERNON CR. REGION
ACRE-FEET YEAR X1000
PROJECTED POPULATIONS VERNON REGION
Present Economic Growth to 1980 or Low Economic Growth 1980 to 2020
High Economic Growth 1980 to 2020
(The above Key same for all graphs)
POPULATION X1000
PROJECTED AGRICULTURAL LAND USE, VERNON REGION
ACRES X1000
YEAR
-PLAN SCALE-
3 Miles
4 Kilometers
-LEGEND-
Existing Agricultural Development (1971).
Potential Agricultural Development to 2020. (Maximum for All Projections)
Existing Urban Development (1971).
Potential Urban Development to 2020. (Low Economic Growth Projection III, Minimum).
Potential Urban Development to 2020. (High Economic Growth Projection II, Maximum).
Existing Recreational Development (1971).
Potential Recreational Sites
Okanagan Watershed Boundary
Economic Regions
Lakes
SWAN LAKE
KALAMALKA LAKE
OKANAGAN LAKE
VERNON