WATER RESOURCES STUDY

OF THE

PROVINCE OF NEWFOUNDLAND AND LABRADOR

FOR

ATLANTIC DEVELOPMENT BOARD

VOLUME ONE

GENERAL PRESENTATION AND SUMMARY

THE SHAWINIGAN ENGINEERING COMPANY LIMITED

JAMES F.MacLAREN LIMITED

Report 3591-1-68

September 1968

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Dr. E. P. Weeks
Executive Director
Atlantic Development Board
Sir Guy Carlton Building
161 Laurier Avenue West
Ottawa 4, Ontario

Dear Dr. Weeks,

We are pleased to submit our Report on Stage I of the Water Resources Study of the Province of Newfoundland and Labrador. This report deals with the studies carried out by The Shawinigan Engineering Company Limited and James F. MacLaren Limited over the past eighteen months, to determine the water availability and the present and future conditions of supply and demand in the Province as a basis for more detailed planning studies.

This study has been based on available data obtained from federal, provincial, and municipal agencies, supplemented by data collected from other sources by the study team. Basic assumptions were provided by the Board for the various sectors of the provincial economy, and these were then developed for use in the study in collaboration with the Board's staff. However, it has not been possible to draw specific conclusions on all the aspects investigated under the terms of reference due to the difficulty in obtaining meaningful data on the water demands in the Province and the relatively undeveloped state of many of the areas studied.

As you are aware, this is the first major interdisciplinary study of this type carried out in Canada and, because of its pioneering nature, there were several changes to the emphasis of the terms of reference and the direction of the study as the work progressed. Some of the approaches and techniques developed for the study have also been exploratory. As a result, we believe that the study has produced some useful and original methods of analysis which could have wide application in similar studies for other areas.

We wish to acknowledge the excellent co-operation and guidance that we have received from the Supervisory Committee, and from Mr. Lane and other members of the Board's staff during the course of the work.

We consider it a privilege to have participated in this very important study, and trust that our findings will permit the governments concerned to proceed with establishing priorities for the subsequent comprehensive planning studies of the Province's water resources.

Yours very truly,

R. E. Grout
President

The Shawinigan Engineering Company Limited
James F. MacLaren Limited

VOLUME ONE

GENERAL PRESENTATION AND SUMMARY

The Shawinigan Engineering Company Limited
James F. MacLaren Limited

VOLUME ONE

TABLE OF CONTENTS

OUTLINE OF COMPLETE REPORT

VOLUME ONE - GENERAL PRESENTATION AND SUMMARY

VOLUME TWO A - NATURAL WATER RESOURCES INVENTORY

Part I	Methodology
Part II	Physiographic Characteristics
Part III	Man's Activity Causing Changes in Water Quantity and/or Quality
Part IV	Inland Surface Water - Quantity

VOLUME TWO B - NATURAL WATER RESOURCES INVENTORY

Part V	Inland Surface Water - Quality
Part VI	Estuary and Sea Water - Quality
Part VII	Groundwater - Quantity and Quality
Part VIII	Conclusions on Natural Water Resources

VOLUME THREE A - WITHDRAWAL WATER DEMAND

Part I	Water Demand Methodology
Part II	Economic Considerations and Changes in Specific Demand
Part III	Commodity Producing Sectors - Resource Based

VOLUME THREE B - WITHDRAWAL WATER DEMAND

Part IV	Commodity Producing Sectors - Industry Oriented
Part V	Commodity Producing Sectors - Consumer Oriented and Other Manufacturing
Part VI	Commodity Producing Sectors - Energy and Construction
Part VII	Tertiary Sector and Population Characteristics

VOLUME FOUR - NON-WITHDRAWAL WATER DEMAND

VOLUME FIVE - COMPARISON OF WATER DEMAND AND SUPPLY

Part I	Methodology
Part II	General Appraisal
Part III	Economic Considerations
Part IV	General Conclusions and Recommendations

VOLUME SIX A - RIVER BASINS

Part I	Exploits River Basin and Badger-Botwood Study Area
Part II	Humber River Basin and Corner Brook-Deer Lake Study Area
Part III	South Coast River Basins and Bay D'Espoir Study Area

VOLUME SIX B - RIVER BASINS

Part IV	Terra Nova River Basin
Part V	Gander River Basin and Gander-Glenwood Study Area
Part VI	Cat Arm River Basin
Part VII	Pipers Hole River Basin
Part VIII	Churchill River Basin and Labrador City Study Area

VOLUME SEVEN - STUDY AREAS

Part I	St. John's and Environs Study Area
Part II	Come By Chance and Environs Study Area
Part III	Burin Peninsula Study Area
Part IV	Stephenville and Environs Study Area
Part V	Bonavista Peninsula Study Area

VOLUME EIGHT - APPENDICES

Appendix A	Computer Techniques Applied to the Water Resources Study
Appendix B	Industrial Water Use Study - Selected Industries
Appendic C	Cost Estimating Criteria

PREFACE

This report is one of a series dealing with water demand and supply in the Atlantic Provinces of Canada, and with legal and administrative frameworks relevant to water resource development.

These studies were commissioned and financed by the Atlantic Development Board. A Federal-Provincial Supervisory Committee assisted in the collection of data and the co-ordination of the studies. The Committee included representatives of the Provinces of Newfoundland and Labrador, Nova Scotia, New Brunswick, and Prince Edward Island; and the Canada Departments of Energy, Mines and Resources; Fisheries; Finance; Forestry and Rural Development; and National Health and Welfare. David Ross, Vice President of Hedlin, Menzies & Associates Ltd., acted as a special consultant to the Committee.

The conclusions and recommendations of this report are those of the Consultant, and are not necessarily agreed to by the Atlantic Development Board, the Government of Newfoundland and Labrador, or the Government of Canada.

1 INTRODUCTION

The waters of the Island of Newfoundland and Labrador remind the observer of Wordsworth's rivers and lakes that were "... untouched and unbreathed upon...", for in this vast Province of more than 155,000 square miles, with a little over one-half million residents, much of the water resources have not yet been affected by the activities of man. For centuries, the Newfoundlander confined himself to the rugged, hard, but rewarding life of the sea. However, in recent decades, the progress of the technologically-oriented world has not only created a spectre of economic and geographic isolation for the "livyers" of the seacoasts of Newfoundland, but has also brought an awareness of the necessity for achieving economic and social equality with other regions of North America.

This has led the Newfoundlander to consider the natural wealth of his Province and the opportunity it provides for social and economic progress.

The development of the fresh water resources for hydro-electric power, for water supply, and for fisheries and recreation has played a major role in the overall progress of the land and its people. The recognition by provincial and federal authorities of the importance of the fresh water resources to the future development of the Province led to the implementation of this general inventory and preliminary planning study by the Atlantic Development Board. The results of this study show that the Province's fresh water resources, if properly managed, will continue to contribute significantly to its economic development.

To provide maximum benefit to present and future generations, it is essential that a comprehensive approach be taken to the development of the Province's waters in co-ordination with that of its other resources, and in consideration of economic, administrative, social, and scientific objectives. Emphasis should be placed on planning for long-term development so that problems can be adequately investigated and not met with short-term or ad hoc solutions.

The implementation of the recommendations made in this report will constitute a major advance by the Province towards its goal of economic and social equality. Furthermore, in view of the relatively undeveloped state of the resource, early action will see the Province take a lead in resource management over many more affluent areas of North America which struggle at great cost to regain a resource that has been degraded to a dangerous level in pursuit of short-sighted goals.

During the course of the study, all available data related to the water resources of the Province were brought together. These data are documented and analyzed in detail in Volumes Two to Eight, as follows:

Volume One	-	General Presentation and Summary
Volume Two A Volume Two B	-	Natural Water Resources Inventory
Volume Three A Volume Three B	-	Withdrawal Water Demand
Volume Four	-	Non-withdrawal Water Demand
Volume Five	-	Comparison of Water Demand and Supply
Volume Six A Volume Six B	-	River Basins
Volume Seven	-	Study Areas
Volume Eight	-	Appendices

A System Analysis Techniques Applied to the Water Resources Study
B Industrial Water Use Study - Selected Industries
C Cost Estimating Criteria

This introductory volume presents the highlights, conclusions, and recommendations of the study based on a summary of the data presented in the other volumes and includes a suggested ranking of areas for more detailed investigation. A key reference map of the Province outlining the River Basins and Study Areas is given in Figure 4-1.

2 PURPOSE AND SCOPE

This study was initiated to provide information to assist the provincial and federal governments in planning the future utilization of the water resource. It represents the first stage of a detailed program of water resource development planning and embraces the demand, supply and management of the resource throughout the Province until 1981 or beyond. The purpose of the Study and Report was to identify those areas in the Province that now have or will have major water problems or substantial water possibilities and to rank these in order of priority for detailed development planning.

The study was divided into three major sections concerned with water availability, water demand, and the analysis of supply and demand.

The availability analysis was to be undertaken using data that were available or could be synthesized. From an examination and assessment of the data, only a few watersheds could be categorized as having sufficient information for comprehensive planning. For data deficient basins, techniques were developed to synthesize data required to assess water availability.

The demand phase consisted of an examination of the present day requirements for water in the Province according to quantity, quality, and type of use. These demands have been projected through the forecast period up to 1981, and for a longer period where feasible.

Analyses of supply and demand have been carried out, both on a Province-wide scale and on a selected geographic area basis, to determine:

a) Where the available supply exceeds area requirements and can be further developed for the expansion of economic activity in the Province.

b) Where the available supply is inadequate and must be supplemented to meet the forecast requirements.

c) Where resource conflicts exist or may emerge.

A preliminary ranking of areas for detailed development planning has been presented together with specific recommendations for further action.

The detailed terms of reference for this Study are included at the end of this volume.

3 CONCLUSIONS

3.1 Water Resources Policy and Management

a) In the Province of Newfoundland and Labrador, indiscriminate development of the water resource has been permitted and wastage and misuse of the resource have occurred without proper appreciation of the real cost to the Province and its future generations. Since the water resources of the Province are substantial and of paramount importance to its future, comprehensive water resource planning and positive management should be undertaken now while the demand on the resource is still at a low level and corrective procedures are still possible.

b) In the absence of a policy leading to comprehensive planning for the water resources of the Province, the Federal and Provincial agencies and the private companies with jurisdiction over water have tended to act unilaterally. The resulting lack of co-ordination has contributed to the inefficient use of the resource.

3.2 Water Availability

a) The Province of Newfoundland and Labrador is one of the best endowed areas of Canada insofar as availability of fresh water of good quality is concerned. The average runoff (42 inches per year on the Island) represents one of the highest figures recorded in Canada. The water is generally distributed favourably in relation to development possibilities, so that if properly managed, sufficient water is available over the study period to 1981 to meet the foreseeable requirements for the expansion of industry, recreation, forestry, fisheries, and wildlife, as well as for human comfort and health.

b) Many small basins of the Island have relatively low dependable flows and will require the development of storage reservoirs and/or diversions to satisfy large water demands. However, the potential for storage development is good in most areas of the Province.

c) The lack of underground storage on the Island limits the development of groundwater in most areas to the supply of small demands. Practically anywhere in the Province a supply of groundwater of reasonable quality and in sufficient quantity to service individual houses and municipalities as large as 1000 to 2000 persons can be developed.

d) For most of the smaller communities the cost of water could be decreased if groundwater sources were developed on a more efficient basis than has been done to date. Current practice places too much emphasis on the bedrock as the water source and much more advantage should be taken of the groundwater capabilities of the surficial material. This requires greater skill in well drilling as well as hydrologic advice.

3.3 Water Supply

a) Lack of adequate and safe water supplies for about one-half of the population is a potential hazard to the public health and is one factor contributing to lower and more restricted levels of living than those in other areas of Canada.

b) The provision of water supply and distribution systems for all communities of over 500 persons, including extensions within currently serviced municipalities, represents an estimated capital investment of some $95,000,000.

The unit cost of water supply and waste treatment increases rapidly when the community size falls below 2000 persons. For a community of 500, the estimated cost per gallon for a community water supply is 2 to 2.5 times that for a community of 2000 persons. Population relocation in larger municipalities could therefore result in significant reductions in waterworks and pollution control investment. Further economies could be achieved by combining municipal and industrial schemes to reduce unit costs, or by the development of regional water supply schemes. However, even with these economies, it is apparent that the cost of providing a complete community waterworks system, if borne entirely by the consumer, could result in a charge to him that would exceed the limit of his ability to pay for that service, and some form of subsidy may be required.

c) In many areas such as Topsail-Seal Cove in the St. John's Study Area (Figure 4-11), there are potential hazards to the public health from the contamination of existing individual or private wells, and action in providing improved water supplies is urgently required. For those communities whose size remains at 500 or less, it is obvious that a community water supply system will be difficult to justify financially. However, satisfactory individual well supply systems can be developed and their contamination avoided if the installation of these systems is placed under rigid control and inspection.

d) Based on present economic forecasts and assumptions, the capital investment for water supplies required for planned major industrial development on the Island at Come By Chance and Stephenville and extensions to the Price and Bowaters pulp and paper mills is estimated at $10,200,000. This represents a very low unit cost of water, of as little as three cents per 1000 gallons, with the system fully utilized.

3.4 Water Quality Degradation

a) Water quality degradation by industrial and domestic wastes is widely tolerated and is causing serious conflicts with fisheries, recreation, and tourism in the St. John's area, the Exploits River, the Churchill River, and the Humber Arm. Furthermore, the quality of the supply to existing or potential downstream users is directly affected and, in some instances, is posing a threat to the health of the general public.

b) The permissive attitude to water quality degradation by both Government and citizens alike has resulted in an eventual cost of correction for which there is currently no planned financing. This attitude has permitted resource users, particularly industry, to ignore the need to protect the resource by water re-use and conservation and the control of wastewaters.

Unless action on pollution abatement is taken soon, efficient use of the water resource in many areas will become severely restricted and the cost of effecting adequate pollution control will become excessive.

c) No significant estuarial pollution has yet occurred in the Province with the possible exception of the Humber Arm. However, water quality problems have been identified in a number of harbours such as St. John's and Gaultois. Water quality problems have been encountered by some fish processing plants using sea water for fluming and other purposes.

d) Primary treatment (flocculation and sedimentation) should generally be sufficient to reduce the strength of the industrial and municipal waste discharges to inland waters to a satisfactory level through the study period to 1981. With the exception of certain communities such as St. John's and Botwood, it should be possible to control pollution along the seacoast during this period through efficient diffusion and dispersion of effluent from properly located marine outfalls. Groundwater pollution could

be controlled through improved practices in the installation of wells and septic tanks and the siting of solid waste disposal areas.

e) The total investment to provide municipal wastewater treatment plants for eight communities* where pollution problems appear severe would be $15,000,000. To this must be added the cost of installing or modifying collection sewers.

f) An expenditure of more than $18,500,000 would be required to effect even a minimum level of pollution control for major areas of industrial and mining waste discharge in the Province**.

3.5 Non-withdrawal Use

a) Development for hydro-electric power generation has been accepted as a paramount use of the water resource virtually without regard to other actual or potential users. As a result, the real costs and benefits to the Province for the development of hydro-electric power schemes have not been properly evaluated and conflicts have occurred with other water users. For example, diversions for hydro-electric power have conflicted with fisheries development plans on the Exploits River, and resource conflicts are inherent in the proposed Terra Nova hydro development. Conversely, while conflicts exist with other water uses significant benefits have resulted from improved flow regulation in some areas.

b) Stage II of the Bay D'Espoir development will be completed by 1971 bringing its installed capacity to 450 Mw. During the study period further development of hydro-electric power on the Island will be limited to additional units at Bay D'Espoir and possibly other schemes developed for peaking power. Base load energy will be supplied from either hydro-electric generation in Labrador or from new Island-based thermal generation including the 300 Mw Holyrood plant due for completion in 1971. These developments will change the operation of existing small plants on the Island. Many of the older, smaller hydro-electric plants will probably be closed down during the next few years and storage reservoirs at these plants could then be utilized for water supply or recreation.

* St. John's, Corner Brook, Grand Falls-Windsor, Bishops Falls, Botwood, Buchans, Norris Arm, Dunville.

** Exploits, Humber, Churchill River basins, Burin Peninsula.

c) The Cat Arm River hydro-electric scheme is the most attractive scheme for development of those identified during this study and has a minimum of water resources conflicts. The estimated capital cost of installing 120 Mw at this site is $37,500,000.

d) A few pumped storage sites are available on the Island, particularly in the Great Northern Peninsula, but their development is not considered likely during the study period.

e) In Labrador, hydro-electric power development will continue for export from the Province, for service to the developing local economy, and for transmission to the Island. Apart from the Churchill River, several other Labrador rivers have excellent hydro-electric potential, including the Eagle, the Canairiktok, and the Naskaupi. However, the proposed diversion to the Upper Churchill watershed would significantly reduce the potential of the Naskaupi River.

f) Log driving, although apparently on the decline, has created problems for fisheries and other users due to flow variations and bark deposits, particularly in the basins of the Humber and Exploits rivers. Conversely, log driving capabilities on smaller rivers have been restricted by the river barriers and flow control associated with hydro power developments. In the future log driving will tend to concentrate on the three larger rivers, the Exploits, Humber, and possibly the Churchill, which are, or soon will be, regulated for hydro power.

g) Increased use of natural resources in the Province for recreation and tourism will continue and will have some direct effect on the pattern of the present non-withdrawal uses for hydro-electric power, log driving, and waste disposal. The careful and well-planned development of fisheries for fresh water dependent species and the protection of wildlife are essential to achieve maximum benefit from the development of recreation and tourism for both the residents of the Province and for visitors.

3.6 Planning

a) The existing climatologic, hydrometric, and water quality networks in the Province, particularly in Labrador, are inadequate to define the characteristics of the resource at a level required for detailed water resource planning. Systematic collection of data on groundwater and suspended sediments does not exist and is also required.

b) The examination of selected river basins and study areas for development possibilities and conflicts in water use has identified four regions which immediately require comprehensive planning. The study of the areas is essential to develop solutions to existing conflicts and plans for water resources management in the regions. The regions, in order of priority are:

i) Exploits River Basin
ii) St. John's Study Area
iii) Churchill River Basin
iv) Humber River Basin

c) To establish priorities for detailed planning, it was necessary to rank river basins and study areas. The ranking was made on the basis of the number of resource problems and interactions identified during this study. The complete ranking with a list of significant items which must be considered in detailed development planning is as follows:

River Basins

i) Exploits River (Figure 4-3)

Pollution by industrial and municipal wastes, complicated by diversion.
Contamination of water supplies in small communities.
Fisheries development potential.
Forest operations and log driving.
Possible changes in operating regime of existing hydro-electric plants.
Flooding problems.

ii) Churchill River (Figure 4-10)

Hydro-electric development with planned flooding of large areas.
Pollution in upstream areas due to mining.
Hydro-electric development possibilities for local mining and industrial activity.
Forest operations and log driving potential.
Tourist development potential.

iii) Humber River (Figure 4-4)

Possible estuarial pollution.
Contamination of water supplies in small communities.
Tourist development potential.
Possible changes in hydro-electric plant operation.
Pumped storage development potential.
Fisheries development potential.

iv) Terra Nova River (Figure 4-6)

Hydro-electric development possibilities involving planned flooding.
Tourist development potential.
Fisheries development potential.
Forest operations and log driving.

v) South Coast Basins (Figure 4-5)

Concentration of regulated flows available for industrial development.
Fisheries development potential.
Fisheries problems on diverted rivers.
Tourist development potential.

vi) Gander River (Figure 4-7)

Contamination of water supplies in small communities.
Possibilities of flow regulation to benefit fisheries.
Forest operations and log driving.
Service and transportation industry developments.

vii) Cat Arm River (Figure 4-8)

Hydro-electric development possibilities with concurrent opening up of area for forest exploitation.

viii) Pipers Hole River (Figure 4-9)

Soil erosion problems.

Study Areas

ix) St. John's (Figure 4-11)

Municipal and industrial water supply problems (quantity and quality).
Municipal and industrial wastewater disposal problems.
Population concentration, water supply, and disposal requirements.
Tourist and recreation development potential.
Changes in the use of available storage.

x) Stephenville (Figure 4-14)

Industrial development with relatively large water requirements and wastewater disposal problems.
Fisheries development potential.
Forestry operations.

xi) Come By Chance (Figure 4-12)

Industrial development with relatively large water requirements and wastewater disposal problems.
Limited water availability.
Fisheries development potential.

xii) Burin Peninsula (Figure 4-13)

Mining development potential and wastewater disposal problems.
Population concentration, water supply, and disposal requirements.
Soil erosion and sedimentation problems.
Possible changes in hydro-electric plant operation and use of available storage.

xiii) Bonavista Peninsula (Figure 4-15)

Inadequate individual water supply and waste disposal.
Effect of population relocation.

4 RECOMMENDATIONS

4.1 Policy, Management, and Legislation

4.1.1 Policy and Management

a) The Province should immediately establish a comprehensive policy for the management of its water resources. This policy should recognize the multi-purpose nature of the resource and be designed to achieve maximum benefits for all users.

b) The Provincial policy should be founded on the following major precepts:

i) Ensuring that all uses of the resource are developed in a rational and economic manner.

ii) Ensuring co-operation between governments and avoiding program conflicts in spheres of Federal jurisdiction.

iii) Where its control has been invested in any party other than a provincial agency, reserving the right of the Province to examine all development plans and make recommendations necessary to achieve the overall development of the resource.

iv) Providing safe water supplies to the Province's population.

v) Providing wastewater treatment on a planned and progressive basis but as a secondary consideration to the provision of water supplies.

vi) Ensuring that the management authority is empowered to control the use of the water resource and can finance water supply and wastewater treatment facilities.

vii) Ensuring that all significant systems are licensed and their users are charged for withdrawal and degradation on a realistic but fair and equitable basis.

viii) Ensuring that all works carried out under the direction or approval of the management authority meet acceptable standards.

ix) Gathering data on the resource from federal and provincial sources to provide a sound base for long term planning.

c) The Government of Canada should develop an integrated policy for co-ordination between all federal departments concerned with water resources, in order to centralize assistance to and co-operation with the Province in water resource development.

4.1.2 Legislation

a) The Water Resources and Pollution Control Act 1966-67 of the Province of Newfoundland and Labrador (the Act) gives legislative authority for the development of a comprehensive management plan.

b) The enforcement of a management plan is limited by Section 17(2) of the Act which exempts several major areas of water usage from its jurisdiction. These exemptions concern hydro power rights assigned to the British Newfoundland Corporation Limited and the Newfoundland and Labrador Power Commission, and ore tailings discharges in Labrador. Such specific exemptions should be removed or modified in order to allow management planning to be effectively implemented.

c) Under Section 20(1)(q) provision for licensing withdrawals of water should be clarified to ensure that licensing covers degradation and the return of wastewater to the resource.

d) Under Section 23 the powers to construct, take over, operate, and manage waterworks should be expanded to include wastewater collection and treatment facilities.

4.1.3 Management Instrument

a) The implementation of the water resources management policy of the Province should be the responsibility of the Newfoundland and Labrador Water Authority (the Authority) as established under the Act.

b) The Authority should retain staff to develop and implement its programs as soon as possible, utilizing personnel from existing departments and employing outside services for its non-repetitive programs. Professional staff eventually must include economists, scientists, lawyers, and accountants, as well as engineers.

4.2 Water Availability

For the evaluation of water resource development programs and the granting of licenses for various uses, it is essential that the Province should therefore encourage the collection and analysis of additional data relating to water availability (quantity and quality) throughout the Province by federal agencies now carrying out data collection programs in the Province, including:

a) The expansion of the existing climatologic and hydrometric networks in accordance with the planning guidelines suggested in this report, together with more detailed analysis to evaluate more specifically the future requirements for the networks.

b) The review of hydrologic records to correct for errors due to incorrect interpretation of changes in storage and ice conditions, and a review of the hydrologic studies for the Island on the basis of these corrections.

c) The upgrading of the hydrologic studies for Labrador after additional data has been gathered from the expanded hydrometric network.

d) The eventual expansion of the hydrologic network to lakes and marshes.

e) The measurement of suspended sediments.

f) The establishment of a groundwater hydrometric network, and the re-assessment of the conclusions reached in this study using the data from this network.

g) The substantial expansion of the water quality network including the examination of estuaries and areas of waste disposal to the sea, and the re-assessment of water quality on the basis of results obtained from this network.

4.3 Water Supply

a) The Authority should establish a program of providing central water supply and distribution systems for those municipalities or communities whose populations exceed 500 including those municipal areas where the existing system serves only a portion of the population.

b) To improve operating efficiency and standard of service, the Authority should take over and operate all water supply systems in both incorporated and un-incorporated communities.

c) Where, for public health or other reasons, it is necessary to provide water supplies to communities of less than 500 persons, these should be built and operated by the Authority on behalf of the responsible department.

d) When requested and when considered beneficial because of economies of combined use, the Authority should take over or build and operate water supply systems for industries.

e) The priority of installation of water supply systems should be based on benefit-cost criteria taking due account of intangible factors such as public health.

f) Careful consideration should be given in all water supply systems to the possible development of groundwater as a cheaper alternative to surface water sources.

g) To reduce the investment in water supply and distribution systems, programs should take into account plans for concentrating populations in larger centres, and should be directed to developing groundwater supplies, grouping industries and municipalities in combined and regional supply schemes, re-using water in industrial processes, etc. The use of sea water for cooling, fluming, and fire protection should be given greater consideration in future developments in the Province.

h) Any activity which would endanger the quality of the fresh water resource should be prohibited at the intake areas of potable water supply unless adequate measures are taken to protect the supply. The multiple use of water supply reservoirs should only be permitted if justified by benefit-cost analyses.

i) All chlorination installations in the Province should include standby equipment. This will avoid a deterioration of the water supply in the period between the equipment breakdown and its repair.

j) Precise determination of municipal water demands according to use and for various types and sizes of communities in the Province should be carried out.

4.4 Water Quality Control

a) To provide direction to its pollution control program, the Authority should establish a system of water quality standards in relation to the uses of the Province's fresh and inshore waters. Under its overall resource management policy, it should be possible to determine the priority of spending needed to maintain these standards.

b) Where wastes are discharged which degrade the waters below the required standards, charges should be levied against users to assist in defraying eventual cost of treatment.

c) Industries producing toxic or other objectionable wastes should be encouraged to carry out research into their processing methods in order to minimize pollution of the waters receiving their wastes.

d) The Authority should take over or build and operate all pollution control facilities, both publicly and privately owned.

e) Discharge of municipal and industrial wastewaters to the sea without significant treatment may be permitted provided the point of discharge is carefully selected. The selection should be based on oceanographic studies to ensure that adequate dispersion and diffusion are attained and that other local uses are protected. All systems should be designed so that future treatment can be reasonably incorporated.

f) Highly complicated and automated systems of pollution control should be avoided wherever possible due to the difficulty of readily obtaining parts and service personnel in the widely scattered communities of the Province. Primary treatment or oxidation ponds should be given every consideration as acceptable treatment methods for the short term.

g) The full effects of insecticide spraying on the environment, including the water resource, have not been established. Spraying in connection with forestry or other activities should only be carried out after careful investigation.

4.5 Non-withdrawal Use

The Authority should undertake an investigation in association with the Newfoundland and Labrador Power Commission and the private power companies to resolve existing conflicts in use related to hydro development.

a) All hydro-electric schemes proposed by the Newfoundland and Labrador Power Commission or the private companies with rights to develop power in the Province should be thoroughly examined to identify possible conflicts with other uses such as fisheries, forestry, recreation, and tourism. The assignment of costs and benefits for any modifications to the schemes which would change the basic cost of power should be negotiated between the Authority and the utility concerned.

b) A program should be established in co-operation with the British Newfoundland Corporation Limited (Brinco) to determine the undeveloped hydro-electric potential of Labrador, especially in the southern region. This program would determine the availability of local power sources for future industrial developments and identify potential conflicts with other water users as a basis for comprehensive resource planning.

c) To complete the inventory of hydro power potential for the Island, the Newfoundland and Labrador Power Commission should carry out more detailed investigations to assess the economic viability of the following schemes:

Cat Arm
Upper Humber River
Main River
Star Lake
Hinds Brook
Western Brook Pond (pumped storage)

These investigations should take into account the system requirements, transmission costs, and the requirements of other water users.

d) Consideration should be given to alternative uses of storage at the existing small hydro-electric schemes on the Island (less than 5000 hp) in the light of present power costs and developments.

e) Whenever comparisons are being made by pulp and paper companies between alternatives of log transportation, the deleterious effects of log driving on water quality and the river flow regime should be carefully considered. The transportation by pipeline of pulpwood in the form of chips should be investigated. This method of transportation would exert less demand on the water resource, and should be considered in future construction or modernization programs.

f) Flooding of commercial forest areas by hydro-electric or other storage reservoirs should be subject to prior approval by the Authority, and the possibilities of clear cutting should always be investigated.

g) The development of fisheries, wildlife, tourism, and recreation are closely related and are dependent on the quality and quantity of the water resources. The Authority should recognize the needs of these non-withdrawal activities and incorporate them in its overall planning.

4.6 Regulation and Control

a) For the protection of the resource, the Authority should immediately undertake the licensing of all significant users of shore, surface, or ground waters in the Province in respect of withdrawal, non-withdrawal, and return rights. Users who withdraw less than 2000 gallons per day according to the Authority's best estimate should be excluded from licensing requirements.

b) The Authority should establish, in conjunction with appropriate government departments, regulations under Section 20 of the Act 1966-67. These regulations should govern the following:

i) The application and granting of water use licenses and all related charges.

ii) The design, construction, and operation of private and public water and wastewater facilities, including the provision for the Authority's approval and inspection.

iii) The location, design, and construction of groundwater withdrawal systems, including the related licensing of all well drillers and the inspection and approval of their work by the Authority.

iv) The design and construction of wastewater outfalls into shore waters, including estuaries, harbours, and embayments with provision for their approval and inspection by the Authority.

v) The standards of quality of all water supplies intended for human consumption and the provision for regular quality inspection by the Authority or the Provincial Department of Health.

4.7 Financing

a) In the conclusion of this study, expenditures in excess of $105,000,000 have been forecast as necessary to adequately supply water to that portion of the unserviced population residing in communities of 500 or more, and to potential new industries. An additional expenditure in excess of $33,000,000 would be required to control the more significant effects of wastewater discharges occurring to the water resources of the Province at this time.

The Province must, therefore, determine as soon as feasible the rate of annual spending that can be directed to water supply, wastewater control, and resource management by the Authority, so that a long term implementation program can be developed.

b) The Authority should include, within its policy of licensing, a basis of charging for the effect of use on the quantity and quality of the resource. These degradation charges should be established by determining the effect of each use on the resource through diversion and energy loss, as well as physical, chemical, and biological degradation.

Charges should be established and licensing commenced now to provide funds which will assist the Authority in financing its extensive program. Charges to existing users should be initiated at a portion of the normal charge, increasing annually until the full rate is reached. These charges would be made directly against a municipality, industry, or other major user operating its own system.

c) Where a water supply system is taken over or provided by the Authority, the customers should be required to pay for at least some portion of the cost of the direct service, as well as some portion of the cost of degradation. By the inclusion of the degradation assessment, the Authority should agree to protect the user from any further responsibility for the effects of wastewater discharges.

d) Where the municipality or the industry maintains now, or constructs later, its own water supply system, a bulk charge should be levied for the cost of degradation representative of the cost of wastewater treatment which would eventually be installed by the Authority. The payment of these charges should protect the user from further responsibility in relation to water degradation.

e) The scattered population distribution and relatively low income levels within the Province will require that charges established on a Provincial basis be modified through subsidy for implementation in certain localities.

4.8 Regional Planning

a) As indicated in the Conclusions, the ranking of river basins and study areas has revealed that special attention should be given, in order of priority, to the Exploits River basin, the St. John's Study area, the Churchill River basin, and the Humber River basin in view of their current resource conflicts.

b) The Authority should request the Lieutenant-Governor in Council to appoint in each of these four regions Local Advisory Boards under subsection 5(4) of the Act 1966-67. All jurisdictional levels and types of water users should be represented on these Boards, which would be responsible for giving the Authority assistance in developing comprehensive water resource plans for the regions concerned.

4.8.1 Exploits River Basin (Figure 4-3)

In the Exploits River basin comprehensive planning should include the following major considerations:

a) A critical review of the water quantity and quality requirements of present and potential users and the optimum methods of obtaining them.

b) Investigation of the location, costs and benefits of providing additional storage in the upper portion of the basin to offset the serious water resources conflicts which have been accentuated through recent diversion from the watershed.

c) Optimum methods for waste treatment in respect of pulp and paper effluents and mine tailings.

d) An economic appraisal of the possibilities of further hydro-electric development including the replacement of outdated facilities and their effect on other uses.

e) A general appraisal of the economics of fisheries, tourism, recreation, and wildlife development in the basin through federal and provincial agencies concerned with these This appraisal should recommend action to avoid the loss of anadromous fish in the Exploits River due to rise in pollution levels following the diversion of flow from the Victoria and Lloyds rivers to the White Bear River basin.

4.8.2 St. John's and Environs Study Area (Figure 4-11)

In the St. John's Study area comprehensive planning should consider the following:

a) The eventual provision of adequate municipal water supplies and sewerage systems for all communities in the study area with populations over 500. The construction of these systems could be deferred if the standards of construction and operation of existing privately-owned wells and septic tanks were improved. Regulations to cover this should be instituted as soon as possible along with a technical advisory service.

b) Present discharges of untreated wastes to the fresh water resource should be studied carefully and controls instituted to protect the public health.

c) Pollution of the Waterford River and the Quidi Vidi Lake complex should be reduced to restore the recreational use of these waters.

d) The use of water from Bay Bulls Big Pond as a source of supply for the City of St. John's should be considered as an alternative to the development of a high dam diversion on the Broad Cove River.

e) In conjunction with the installation of residential water meters in St. John's, an investigation should be undertaken to determine the water rate structure that will encourage a reduction in average per capita water demand.

f) A regional water supply system should be established to serve the residential development extending from Topsail to Seal Cove. This recommendation should be given immediate attention in view of the potential health hazards reported in the area.

g) Relatively large quantities of water are stored at the six hydro-electric generating stations in the study area. The use of these waters for industrial purposes should be considered at such times as the generating stations cease to operate, or earlier if satisfactory arrangements can be concluded with the Newfoundland Light and Power Company Limited.

4.8.3 Churchill River Basin (Figure 4-10)

In the Churchill River basin, comprehensive planning should include the following major considerations:

a) A detailed inventory of all natural resources in the basin should be completed. Particular attention should be given to hydro-electric energy, minerals, forestry, fisheries, and wildlife. A complete picture of the development possibilities and problems is essential to planning the harmonious development of these resources.

b) The re-examination of the tailings disposal system by the iron ore industry with a view to reducing pollution of the Churchill River headwaters. The future use of the area for fisheries and recreation and tourism may be seriously affected by this pollution because the toxic characteristics of these wastes may destroy the environment of the resource. Action should be taken before it becomes impossible to protect this environment.

4.8.4 Humber River Basin (Figure 4-4)

In the Humber River basin comprehensive planning should include the following major considerations:

a) A preliminary water quality survey of the Humber Arm to assess the extent of pollution from the pulp and paper mill wastewaters, and means of alleviating it, if necessary.

b) The assessment of long-term plans for forest exploitation and related activities in the area.

c) An analysis of the development possibilities for recreation and tourism and related fisheries and wildlife development.

d) Provision of adequate water supplies for the rural population.

4.8.5 Recommendations concerning water resource problems disclosed in other river basins and study areas are as follows:

a) South Coast River Basins and
Bay D'Espoir Study Area (Figure 4-5)

i) A program for assessing the actual hydrologic conditions in the area affected by the hydro-electric development should be prepared and implemented. River and precipitation gauges should be installed at all diversion points and near the mouths of the White Bear and Grey rivers. These installations will enable calculations of the actual loss of energy at the hydro plants on the Exploits River and the actual compensation flows required for Atlantic salmon in the White Bear and Grey rivers, as well as extending basic hydrologic knowledge of the region required for the implementation of a water resources management plan.

ii) A water resources management plan should be prepared to reduce the conflicts of interest between fisheries, wildlife, and hydro-electric power, and to take maximum advantage of the tourism and fisheries potential in the region.

iii) The potential water supply for industries and the supporting services available in the Bay D'Espoir area should be considered in the selection of locations for new industries requiring significant amounts of water.

iv) Investigations should be carried out to ensure that proper disposal of wastewater in respect to oceanographic conditions can be achieved so as to avoid unnecessary shore pollution.

b) Terra Nova River Basin (Figure 4-6)

i) Industrial development should be discouraged in this basin, and emphasis should be put on forestry, recreation and tourism, wildlife and fisheries development.

ii) The full implications of the proposed hydro-electric scheme, which involves several diversions and reservoirs and will consequently affect the fisheries, forestry, and wildlife resources of several adjacent basins, should be determined. A water resources management review should be carried out, in advance of a decision to proceed with the hydro development, making a careful evaluation of all factors. This will avoid the necessity for ad hoc solutions similar to those required in the Exploits basin.

Full attention should be given to the potential conflicts of interest between log driving and fisheries, should forest exploitation recur in the basin.

iii) Consideration should be given in the water resources management study to the possibility of enlarging the present boundary of the Terra Nova National Park to include the Terra Nova Lake and the area along the main river stem from the lake to the river mouth. This part of the basin could then be included in the recreation and tourism development plans of the National Park. This would bring an Atlantic salmon river into the park boundary, provide a large fresh water lake with sandy beaches in the park area, and enhance development opportunities in the west end of the park. In addition, houses in the Terra Nova village could be acquired to provide additional accommodation for park visitors.

c) Gander River Basin and
Gander-Glenwood Study Area (Figure 4-7)

i) The development of the basin for use by anadromous and fresh water fish should be continued since conflicts of interest with other users are minimal and will continue to be so in the future.

ii) In addition to the development of the basin for fisheries, efforts should be directed towards developing the area for recreation and tourism, taking advantage of the existing transportation network and water resources.

iii) The quality of water for domestic purposes should be monitored throughout the basin to classify all sources of potable water, to identify potential problem areas, and to provide background data for corrective action.

d) Cat Arm River Basin (Figure 4-8)

i) The hydro-electric potential in this basin should be considered for future development and more detailed studies carried out to assess this potential. These studies should be carried out in conjunction with a complete assessment of the other natural resources to permit integrated resources development in the area.

ii) A recording rain gauge should be installed in a representative location in this basin to complement the automatic river gauge recommended earlier in this study and installed by the Canada Department of Energy, Mines and Resources in 1968.

e) Pipers Hole River Basin (Figure 4-9)

i) The Provincial Government in co-operation with interested federal agencies should establish guidelines for forest management and fish and wildlife conservation in the basin.

ii) The effects on the area downstream of the diversion of the upper area of the Pipers Hole River proposed for the Terra Nova hydro power development should be ascertained.

f) Come By Chance and Environs Study Area (Figure 4-12)

i) The study area is served by excellent road and rail facilities and has potential harbour sites on Placentia Bay. Further industrial development in the area should be actively encouraged to complement that already undertaken. Such development, however, cannot be unlimited in view of the relative lack of large quantities of water.

ii) In view of the importance of the Come By Chance River as a source of water to the industrial complex, a recording flow gauge on the river should be installed.

iii) In the region of Placentia and Dunville, surface waters suitable for recreational use should be developed. In addition, surface waters and their drainage areas required for potable water supplies should be delineated and protected to maintain water quality.

iv) Large volumes of industrial and municipal wastewaters are to be discharged to the Bay in this area. Careful oceanographic studies should therefore be carried out to evaluate the adequacy of diffusion and disposal in the sea, or the requirements for treatment of such wastes.

g) Burin Peninsula Study Area (Figure 4-13)

i) This area has limited natural resources and lacks major water supply sources. Because of this, the area should not be assigned a high priority with respect to the establishment of a water resources management plan.

ii) Steps should be taken to preserve Freshwater Pond for recreational use.

h) Stephenville and Environs
Study Area (Figure 4-14)

i) To ensure a satisfactory quality of raw water, further settlement without adequate domestic wastewater treatment in the catchment areas of the water supply serving the town of Stephenville and the former Ernest Harmon USAF base should be prohibited. If this cannot be accomplished, it will be necessary to treat all potable water derived from these drainage areas by filtration as well as chlorination in order to ensure water of acceptable bacteriological quality.

ii) Wastewater from industrial development in the Stephenville area, with the exception of cooling waters and wastewaters containing no organic pollutants or settleable solids, should be discharged to the sea (St. George's Bay) rather than to Stephenville Pond. Wastewaters conveyed to the sea for ultimate disposal should be discharged in such a manner that adequate dispersion and dilution can be achieved.

i) Bonavista Study Area (Figure 4-15)

i) Settlement in the Bonavista study area outside the municipalities of Bonavista, Catalina, and Port Union should be discouraged.

ii) Individual dug wells and septic tank systems in the study area should be brought up to acceptable standards. Construction of new wells and septic tank systems should be regulated to ensure compliance with acceptable standards.

5 SYNOPSIS (VOLUMES TWO TO EIGHT)

This study has dealt with the water resources of the Province of Newfoundland and Labrador at two levels, as required by the Terms of Reference. First, the general conditions of water availability, supply, and demand have been investigated for the Island and for Labrador, as a whole; and second, regional conditions have been examined for important river basins and study areas (Figures 4-1 and 4-3 to 4-15) selected in consultation with the Supervisory Committee to establish a ranking for detailed development planning studies.

While an exhaustive analysis of available information and its further synthesis has enabled valid conclusions to be reached for most water availability problems, the situation was not the same with respect to the water supply and demand conditions and related economic data. For these aspects of the study the available information was either too general, fragmentary, or of dubious quality. A serious effort was made by the Consultant to supplement the available data on water demand by means of questionnaires circulated to the more significant water users followed by personal interviews, and in this way some of the gaps were closed.

Figure 4-2 presents a general picture of the water available under average conditions, of the present water use, and of the increase in demand which may be expected if the economic development follows the forecasts set out in Volume Three.

A general presentation volume by volume of observations in the different phases of the water resources study is given in the following sections.

5.1 Natural Water Resources Inventory (VOLUME TWO)

The quantity and quality of the naturally available water was studied on the basis of existing data from federal and provincial agencies supplemented by a water quality grab sampling program carried out by the Consultant during the fall of 1967.

5.1.1 Surface Water Quantity

Most of the meteorologic and hydrologic data were prepared for storage in computer files and a number of programs were developed for processing these data (Volume Eight, Appendix A). A square grid system was used to divide the Province into computer manageable matrices, and by storing data for each square in the computer, it was

possible to set up programs enabling a large series of physiographic, meteorologic, hydrologic, and other related characteristics to be obtained for any location on the Island and in southern Labrador (south of the 56° 30' parallel). The use of this system permitted an assessment of the general distribution of temperature, precipitation, and evaporation for the Island and southern Labrador.

Furthermore, for the Island, correlations were developed between the average values and standard deviations of the annual, seasonal, and monthly flows, daily maximum and minimum flows, on the one hand and the physiographic characteristics of the basins on the other. These relationships can be used in further studies for a rapid assessment of the hydrologic characteristics for basins in excess of 200 square miles. The relationships can be used only for a tentative approximation for smaller basins, or basins with an average elevation higher than 1300 feet.

Unit hydrographs were also developed, and precipitation and snowmelt characteristics in different areas assessed from which "maximum possible" floods were derived for the rivers studied in more detail. The minimum flows with different probabilities were also computed by means of recession curves and the results compared with the statistical extrapolations.

The analysis of the meteorologic and hydrologic data indicated that the Island has an average annual precipitation of 55 inches. The progressive derivation of the mean annual precipitation distribution by the method described at the beginning of this section is illustrated on Figure 5-1. The Island has an average annual actual evaporation of 13 inches with a corresponding average annual runoff of 42 inches.

The maximum flows are almost invariably the result of combinations of snowmelt and storms, but in some cases maximum levels are caused by ice jams rather than maximum flows.

The Island is covered by a dense network of rivers and lakes, the latter occupying 7.5 percent of its area. Only three rivers, the Exploits, the Humber, and the Gander have drainage basins larger than 2000 square miles, and average flows of all Island rivers are therefore relatively small. For the same reason, and because groundwater supplies to the rivers are not very significant, many rivers have extremely low flows or even dry up during periods of extended drought.

The Island can be divided into four principal regions having hydrologic regimes which are shown with their principal characteristics in the following table:

Hydrologic Region	Avalon and Burin Peninsula	South and East Coast	West Coast and Great Northwest Peninsula	Northeast Coast
Maximum size of drainage (sq. mi)	101	1100	3230**	4400
Average runoff (inches)	40 to 60	35 to 50	35 to 70	25 to 30
Average runoff (cfs/sq. mi)	3.0 to 4.5	2.6 to 3.7	2.6 to 5.2	1.8 to 2.6
Minimum daily runoff 1/20 years (cfs/sq. mi)*	0.0	0.03 to 0.10	0.10 to 0.25	0.05 to 0.10
Maximum daily runoff 1/20 years (cfs/sq. mi)*				
a) for basins of 1 to 200 sq. mi	30 to 60	25 to 50	70 to 150	30 to 50
b) for largest basin in region	-	18	19	17

* Correction for sampling errors not included
** Next largest basin - 390 square miles

Correlations for hydrologic characteristics other than average runoff could not be developed for Labrador because of the scarcity of data. However, from the recorded data at seven existing hydrometric stations, it was possible to obtain a general indication of the variation in flow for this area.

Labrador drainage basins are larger than those on the Island, five rivers have drainage basins of over 4000 square miles including the 31,500 square mile Churchill River basin. The area of lakes in this portion of Labrador is equivalent to 11.2 percent of the total area. Because of late snowmelt and large natural storage, the relative variation of the flow for the larger river basins is smaller than that observed in the Island.

Since more detailed data are not available, Labrador has been divided provisionally into two hydrologic regions, the southern and northern, as shown in the following table:

Hydrologic Region	Southern Labrador	Northern Labrador
Maximum size of drainage basin (sq. mi)	31,500	4806
Average runoff (inches)	20 to 25	15 to 25 (est)
Average runoff (cfs/sq. mi)	1.5 to 1.8	1.1 to 1.8 (est)
Minimum daily runoff 1/20 years (cfs/sq. mi)	0.2 (est)	0.0 (est)

The data for the northern Labrador region were estimated from the general climatologic data available and hydrologic records for rivers in adjacent areas with similar characteristics.

5.1.2 Surface Water Quality

The quality of the surface water was estimated on the basis of the very meagre available data which were correlated to the flow data to obtain an estimate of the quality variation in time. Available data were only sufficient to draw valid conclusions on water quality at a very small number of locations. Therefore, an attempt was made to generally relate physiographic and water quality characteristics for the Island and to use such relationships to estimate the water quality characteristics in rivers for which water quality data were not available. A grab sampling survey was then carried out to check the approximation of the method and to provide additional data.

From the data available and the estimates, including the field checks, it was concluded that the surface water available under natural conditions on the Island can be characterized from the quality viewpoint as follows:

a) The average water temperature ranges from 32 degrees in winter to 60 degrees or more in summer.

b) The turbidity is low, varying mainly between 0 and 5 units, with occasional excessive values being encountered in flood periods, especially in deforested areas.

c) The colour is slightly excessive, varying generally between 10 and 20 units.

d) The dissolved oxygen in rivers in most cases approaches saturation concentration, and in lakes has variable concentration with depth, but generally reflects normal natural conditions.

e) The pH is generally low, being less than 6.5 in most cases, and not exceeding 8.5 in any of the samples.

f) The total hardness is normally low, not exceeding 50 milligrams per litre as $CaCO_3$, except in western regions where the presence of limestone and dolomite increase its value to as high as 120 milligrams per litre.

g) The total dissolved solids content is generally lower than 100 milligrams per litre except in the limited areas where the total hardness is higher than normal.

Some mineralization or eutrophication of certain inland lakes has occurred possibly through the effect of phosphate and nitrate releases from forest fires. Although this situation is not well documented as yet, visible evidence of its occurrence is being encountered more frequently.

5.1.3 Groundwater

The groundwater availability was studied on the basis of geologic information, data on dug and drilled wells, and data obtained from mines. The information is mainly qualitative, since accurate well testing data were practically non-existent, particularly in Labrador. For the Island it was possible to estimate from hydrologic data the relationship between the combined ground and surface storage and the physiographic characteristics.

As a result of the analysis of surficial groundwater possibilities, the Island has been divided into various surficial hydrogeologic units. The delineation of these units is shown in Volume Two, Figures 5-1 and 5-2.

An interpretation of the surficial geologic map in terms of hydrology with units similar to those of the Island was also attempted for Labrador, and the results are shown in Volume Two, Figure 5-3.

The Island has been similarly divided from the viewpoint of bedrock hydrogeology into nine units, as shown in Volume Two, Figure 4-2. The units which present the largest groundwater possibilities together with the major fissures, faults, and fractures are shown in Volume Two, Figure 4-2.

No attempt was made to prepare a bedrock hydrogeologic map of Labrador since most of the bedrock falls within one hydropetrologic unit. Since this unit has a low potential yield, the groundwater possibilities of the area are generally lower than those of the Island.

Data on groundwater quality under natural conditions are available only for the Island. They indicate that the water is generally colourless, with low turbidity, and with a large variation in pH (from 5.2 to 10). The major constituent of dissolved solids is generally calcium, with magnesium predominating in some localities. High salinity which may be related to seawater intrusion was detected in a series of wells near the seacoast and in some cases relatively far inland.

5.2 Withdrawal Water Demand (VOLUME THREE)

In the early stages of this study, it became evident that the amount and quality of data on the present day economy and water demands were insufficient for obtaining a satisfactory view of the prevailing water demand conditions in the Province, thus restricting the ability to forecast future developments and related water demand.

This lack of data was partially remedied by the information obtained from the questionnaires. However, it must be recognized that this did not always result in obtaining useful information simply because many users did not have the required information or, in some cases, because they were reluctant to disclose this information which was considered by them to be confidential.

Relevant economic sector studies carried out by the Royal Commission on the Economic State and Prospects of Newfoundland and Labrador did not become available until the present study was well advanced and because of this it was necessary to gather basic data and to develop much of the data for this study from generalized relationships between different economic factors (gross value of production, net value of production, and salaries and wages in different economic sectors), and water demand. By means of these relationships missing economic and water demand data were estimated, although these are subject to further review.

These relationships were also used for estimating water demands relative to forecasts of future economic and demographic development, which were based on a set of assumptions provided by the Board and checked for consistency by the Consultant in close co-operation with the Board. The assumptions on the economy were purposely biased towards an optimistic forecast to permit examination of the water resources with maximum demands imposed by economic developments.

For planning purposes, it was necessary to include in the study the means to readily assess the consequences of changes in the basic assumptions and/or corrections of inaccurate data. This need is particularly applicable to the Island where alternative locations and characteristics of new developments are more likely to require consideration.

Means to assess the water resources implications related to changes and alternatives were provided by:

a) Generalizing relationships between physiographic and hydrologic characteristics to permit determination of water availability for any significant basin on the Island.

b) Generalizing the relationships between water demand and economic characteristics for the most significant industrial water users whose expansion plans are not completely definite (e. g. pulp and paper, fish processing, oil refining).

c) Setting up a procedure to estimate changes in population distribution, incomes estimate, and corresponding municipal demand, following changes in the forecast regarding location and size of new developments.

The largest withdrawal demand for water on the Island is for the pulp and paper industry, and in Labrador it is for the mining industry. Similarly, wastewaters from the pulp and paper industry are most significant for the Island and those from the mining industry in Labrador. This situation is likely to continue throughout the study period to 1981.

The withdrawal demand indicated in Figure 4-2 represents estimated present and forecast intake water demand, based on the detailed studies described in Volume Three. It should be noted that most of the withdrawal intake demand near the seacoast represents depletion of the source of supply since the corresponding wastewaters are generally disposed of to the ocean. The same pattern will also be maintained generally throughout the study period.

The present industrial water demand estimates are based mainly on data obtained from the questionnaires. The wastewater characteristics and the forecast demand were estimated on the basis of a literature survey described in detail in Volume Eight, Appendix B, and statistical analyses based mainly on data for industries in the Atlantic Provinces and the USA.

Most of the withdrawal demands are small and unevenly distributed across the Province, reflecting the historic development and the character of the resource-oriented economy.

The following comments are pertinent to present and forecast demands:

a) Domestic* and municipal** demand were considered together.

b) The municipal demand includes the commercial and service industry demand related to the smaller industrial establishments normally servicing the local market only.

c) The increase in per capita demand was related to the increase in income which was estimated on the basis of the economic studies and assumptions included in Volume Three.

d) The population projection was estimated from past trends and economic factors corresponding to assumptions developed by the Consultant in collaboration with the Board.

e) It was assumed that there would be no increases in the intake capacity of industries unless major expansions take place. This assumption was based on the fact that specific intake water use of existing Newfoundland industries is relatively high at the present time, and the industries should be able to cope with some increased production by using reserve capacity and by increasing efficiency in water use if necessary.

f) In the case of the fish processing industry, which is one of the most important commodity producing sectors of the provincial economy, it was assumed that production concentration in a number of large plants (100 million pounds input per year or more) will take place in line with the prevailing trends in the industry.

* Water used within the home.
** Consists of residential, commercial, industrial, and public.

g) Possible new industries related either to an existing resource (cellulose-based textiles) or to developing industries (chemical and petrochemical related to oil refining) have been considered from the point of view of their water resources implications.

h) The forecast industrial water demands that have already been established for proposed new industries appear to be high in relation to those normally required by the specific industry types.

5.3 Non-withdrawal Demand (VOLUME FOUR)

The principal non-withdrawal demand in the Province is for hydro-electric power, and the most widespread demand is for fresh water fisheries. The demand for log driving is also significant in the Island and will probably increase in some areas of Labrador in the future. The demand for tourism and recreation, although limited, is increasing rapidly and will probably continue to do so over the study period both in the Island and in Labrador. The water demand for wildlife is limited mainly to habitat preservation, although new developments, especially for hydro-electric power, pose special problems.

5.3.1 Hydro-electric Power

An inventory of existing hydro-electric power plants on the Island has been completed by means of the information obtained from the Newfoundland and Labrador Power Commission and the other power utilities in the Province.

At the present time there are 30 hydro-electric plants having a total of 570 Mw installed capacity on the Island*, and two plants having a total of 286 Mw installed capacity in Labrador. Out of this total, 17 hydro-electric plants, all on the Island, have installed capacities of less than 5 Mw.

Power shortages have been recorded in a few cases in recent years due to drought conditions, the most important being that at the Deer Lake hydro-electric plant in 1966-1967.

The following comments are pertinent to the hydro-electric demand in the Province:

a) A number of existing, planned, and potential hydro-electric developments involve diversions from one basin to another, representing a depletion for the diverted rivers.

* The Bay D'Espoir plant at present has an installed capacity of 300 Mw which will be increased to 450 Mw by 1971.

b) All hydro-electric developments are operated in conjunction with storage, and change the natural regime of the respective rivers. The larger plants are generally operated continuously for production of base energy, thus regulating the flow. The smaller power plants are operated intermittently for peaking and thus increase the natural variability of the flow in most cases.

c) The Island's hydro-electric potential was studied to a level where all sites not previously reported on were identified and preliminary estimates of investment and specific energy costs were prepared for the purpose of ranking the schemes. The Labrador potential was studied at the level of gross river potential only, based on available topographical maps and the hydrologic data developed for this region.

5.3.2 Fisheries for Fresh Water Dependent Species

Fresh water fisheries exert a considerable demand since virtually all the Province's streams are naturally populated by valuable species of fish. An inventory of fresh water and migratory fish facilities has been prepared for this study based on information obtained from the Canada Department of Fisheries and the questionnaires circulated by the Consultant. Most of the facilities identified in this inventory were designed to circumvent natural or man-made obstructions and to assure spawning grounds when they were not adequate because of natural conditions or man-induced changes. Activity in the fresh water fishery sector to date has emphasized research and pilot projects to evaluate the potential of the Province's streams and to ensure a broad base for future development projects.

In this study it was assumed that the minimum monthly flow occurring naturally with a probability of 30 percent represents the minimum demand for fisheries. Relationships were developed for assessing the mean monthly flows and their standard deviations, so that the minimum monthly flows with a probability of 30 percent can be computed for any stream on the Island assuming a normal distribution for the monthly flows. It must be recognized, however, that maintenance of flows near the minimum demand level for long periods due to upstream diversions may adversely affect the fisheries potential of the river. Furthermore, as discussed in Volume Four, it will be necessary to ensure that any flows to meet the fisheries demand have minimum quality conditions above the tolerance limits for fish.

5.3.3 Log Driving

Log driving has been carried out extensively in the past on both small and large rivers on the Island, although this activity is diminishing with the changes in woods operations and the increasing mechanization. Generally the demand for log driving consists in requirements for a certain velocity and water depth; and, since in these conditions the flow is heavily dependent on local conditions, it is not possible to estimate the log driving demand in terms of flow. It may be expected that in the future log driving will concentrate on the larger rivers (Exploits, Humber, and possibly the lower Churchill) which are already or soon will be regulated for hydro power. This will eliminate many log driving dams which have caused conflicts with other water resource uses in the past, particularly fisheries because of abrasion by logs of the spawning grounds, and water quality degradation because of dissolved oxygen reduction through decomposition of bark deposits.

5.3.4 Wildlife, Recreation, and Tourism

In the assessment of water demand in the Province for wildlife, it was assumed that, if water quantity and quality conditions satisfied fresh water fisheries requirements, they would generally satisfy wildlife requirements. There should be no significant water resource problems limiting wildlife conservation and development on the Island during the study period. However, in Labrador, wildlife will be affected by the changes in habitat resulting from the development of major storage reservoirs such as in the Churchill River basin.

At the present time the water demand for recreation and tourism is local in character and is limited to a few areas near St. John's, Corner Brook, Gander, Grand Falls, and to various provincial parks. However, this sector of the economy is receiving considerable impetus from the expansion of highways, and is developing rapidly because of relative decrease in available wilderness areas on the rest of the continent, and to some extent because of increases in population, level of living, and leisure time. Recreation in the Province is strongly related to the fresh water fisheries, and it may be stated that, by satisfying the demand for the latter, the former is generally also satisfied. However, recreation and tourism also benefit from the stability of levels and flows both on rivers and lakes. In the more populated areas such as St. John's, Corner Brook, Gander, Grand Falls, Windsor, and Stephenville, and development areas such as Come By Chance, these level and flow requirements should be considered as part of the demand exerted by recreation and tourism.

5.3.5 Inland Waters Navigation

Water demand for navigation is generally related to requirements for channel depth, width, and maximum velocity, and cannot be expressed in terms of flow requirements. There is no regular commercial inland navigation in the Province, and there is practically no likelihood that this will develop in the future. However, there is some navigation related to log driving and recreation and tourism which is adjusting itself to the conditions created by other uses.

5.3.6 "Negative" Water Demand

There are several undesirable effects of water in developed areas which should be remedied, and these were considered a "negative" demand on the resource.

Flooding due to high river stages is a minor problem in Newfoundland. The only recorded case of flooding with significant economic effect on the Island was at the Grand Falls paper mill on the Exploits River and was caused by ice jams.

A few cases were identified where economic losses have occurred due to intentional flooding of storage reservoirs (e. g. Victoria Lake reservoir). Comprehensive long-term planning would have allowed these to be identified earlier and at least partially avoided.

The drainage of bogs and marshes to improve agricultural and forestry conditions is the major "negative" demand in the Province's conditions and is discussed in Volume Four. Although there are some 3900 acres of bogland which have been drained for agricultural purposes, at the present time there are no known drainage developments for forestry purposes. The extent of further drainage development for either agricultural or forestry purposes is difficult to estimate with the data available, but it is not expected to be significant during the forecast period.

A few cases of concentration of runoff with resulting soil erosion in areas subjected to forest fires, improper road design, and forest cutting were identified during the study. These conditions could be reduced by the improved forest management and reforestation practices now being implemented.

5.4 Comparison of Water Demand and Supply (VOLUME FIVE)

An inventory of municipal and industrial water supply and wastewater disposal systems was compiled using data obtained from the Provincial Department of Municipal Affairs, the questionnaires circulated by the Consultant, and studies by others.

The inventory for municipal systems shows the following (1966 figures):

a) Out of 176 communities with populations of 500 or more, 51 have water supply systems and 49 have sewage collection system.

b) Out of the total 1966 population of some 493,000 in the Province, 238,000 persons live in communities having municipal water supply systems, out of which 200,000 are actually serviced by the water supply systems. In addition, 224,000 persons on the Island and 14,000 in Labrador live in communities with sewage systems.

c) Over 90 percent of the systems use surface water as a source of supply. These are generally gravity systems and, therefore, service pressure is limited in some cases.

d) Supplies from surface water, although generally requiring chlorination, have a better quality than those from ground water. Chlorination equipment in the Province is often improperly operated and inadequately maintained.

e) The charges are generally at a flat rate for residential consumers and metered for industrial and commercial consumers. Expenses exceed revenues by various percentages with the difference increasing for a decrease in community size and system capacity.

f) In small communities, each houseowner normally has developed a dug well for his family's supply. Because of improper well construction and adjacent sewage disposal, many of these wells have water of unsatisfactory quality.

g) All but four inland communities discharge their wastewaters untreated to the nearest receiving body of water and all communities on the seacoast have sewage outfalls directly to the ocean. In many instances wastes from domestic and small commercial and industrial water users which would ordinarily be collected by a municipal sewage system are either discharged to the sea, nearby rivers, or lakes, or to small septic tanks. This results in widespread bacteriological pollution in many settled areas. This situation has been controlled in the newer communities of Labrador by the installation of sewage treatment plants.

The total present water usage by municipalities can be conservatively estimated at 50 million gpd and is probably lower because of low usage in communities without municipal water supply systems. The influence of water withdrawal for municipal uses on the water resources of the Province is, therefore, negligible on the regional scale, but may represent significant water resources problems locally.

The inventory for industrial water supply which covers only those industries having their own water supply system shows the following:

a) The total fresh water intake for industrial uses amounts to about 150 million gpd, excluding the 30,850 gpm used intermittently at the Price (Nfld) Pulp and Paper Limited mill for wood handling.

b) The smaller industrial users are at a disadvantage from the viewpoint of water supply because of the scale effect of costs. This is most pertinent in Newfoundland and Labrador to the fish processing industry.

c) The water quality is generally acceptable for the existing industrial uses, with some exceptions in the fish processing industry caused by bacteriologic pollution.

d) Sea water is normally employed at fish processing plants as a coolant for the refrigeration compressors and in several cases for fluming. The use of sea water in the fish processing industry raises problems related to the contamination of the sea water in the intake area by municipal or industrial wastes, including those from the fish processing plant itself.

e) The disposal of wastes by industry is generally to the nearest receiving water body, or the ocean, without treatment except for the mining industry which generally impounds the wastes (tailings) before disposal.

For the future, the potential water supply on the Island and in Labrador is sufficient to service substantial concentrations of population and industry. However, the minimum flows in many of the Island's rivers are so low as to require storage and/or diversion to support a significant demand.

Fortunately, due to the topography and hydrographic network of the Island, there are numerous possibilities for storage and diversion in most of the basins and these have been studied for the more critical areas of development. Development of storages or diversions should not proceed, however, without considering methods of overcoming the conflicts in use which they may create.

In Labrador, the natural conditions are such that the minimum flows of many of the rivers could sustain significant increases in demand without storage or diversion.

Generally, throughout the Province, the water quality is satisfactory for most uses. Industries and commercial activities whose products are sensitive to the colour of intake water (fine paper, laundries) will require that this constituent be reduced, and in all boiler applications corrosion control as well as the control of total solids will be necessary. Municipal treatment except for chlorination and occasional pH control should not be necessary over the study period (to 1981). Iron and manganese removal through chemical precipitation and filtration may be required in some instances, especially in relation to groundwater.

The opportunity to store fresh water in estuaries to meet large demands for fresh water at the seacoast exists in many areas on the Island and in Labrador. Possibilities of estuarine storage at Come By Chance and Stephenville have been examined in view of the large industrial complexes proposed for these areas. These possibilities did not appear to offer significant cost advantages over the proposed fresh water supplies, and represent a potential problem with respect to water quality.

Although disposal of liquid wastes to the sea can be efficiently carried out through proper diffusion and dispersion, appropriate oceanographic studies should be carried out to devise the optimum scheme considering all local shore uses (including in some areas the potential for the future harvesting of shellfish).

The use of desalinated sea water as a substitute for fresh water cannot be considered as a practical alternative in the Province during the study period in view of its relatively high cost.

Management of the available supply should permit virtually all demands in the Province to be met without undue difficulty and it is not considered that schemes for artificially increasing the available water such as by evaporation control or weather modification would have general application through the study period. However, hydrologic forecasting in relation to water management could be an important consideration in the operation of water resource facilities throughout the Province to permit optimization of the supply.

Cost estimates have been prepared in this study for various water resources schemes whose implementation through the study period should be considered. They represent projects for municipal and industrial water supply, for municipal and industrial wastewater treatment, and for hydro-electric power development. These estimates have generally been developed from the cost indices contained in Appendix C of Volume Eight.

5.5 River Basins and Study Areas (VOLUMES SIX AND SEVEN)

The river basins and study areas selected for more detailed study are outlined on Figure 4-1 and shown individually on Figures 4-3 to 4-15.

A detailed review of the water availability and the present and potential uses of the resource for each of these river basins and study areas with identification of problems and conflicts are given in Volumes Six and Seven. These volumes are divided into the following parts:

Volume Six

Exploits River Basin and Badger-Botwood Study Area
Humber River Basin and Corner Brook-Deer Lake Study Area
South Coast River Basins and Bay D'Espoir Study Area
Churchill River Basin and Labrador City Study Area
Gander River Basin and Gander-Glenwood Study Area
Cat Arm River Basin
Pipers Hole River Basin
Terra Nova River Basin

Volume Seven

St. John's and Environs Study Area
Come By Chance and Environs Study Area
Burin Peninsula Study Area
Stephenville and Environs Study Area
Bonavista Peninsula Study Area

Each of these basins and areas was examined in detail to evaluate the availability of water and the present and forecast demand and supply relationships. Water resource conflicts were assessed where possible and recommendations made for further planning studies for each river basin and study area where this was considered appropriate.

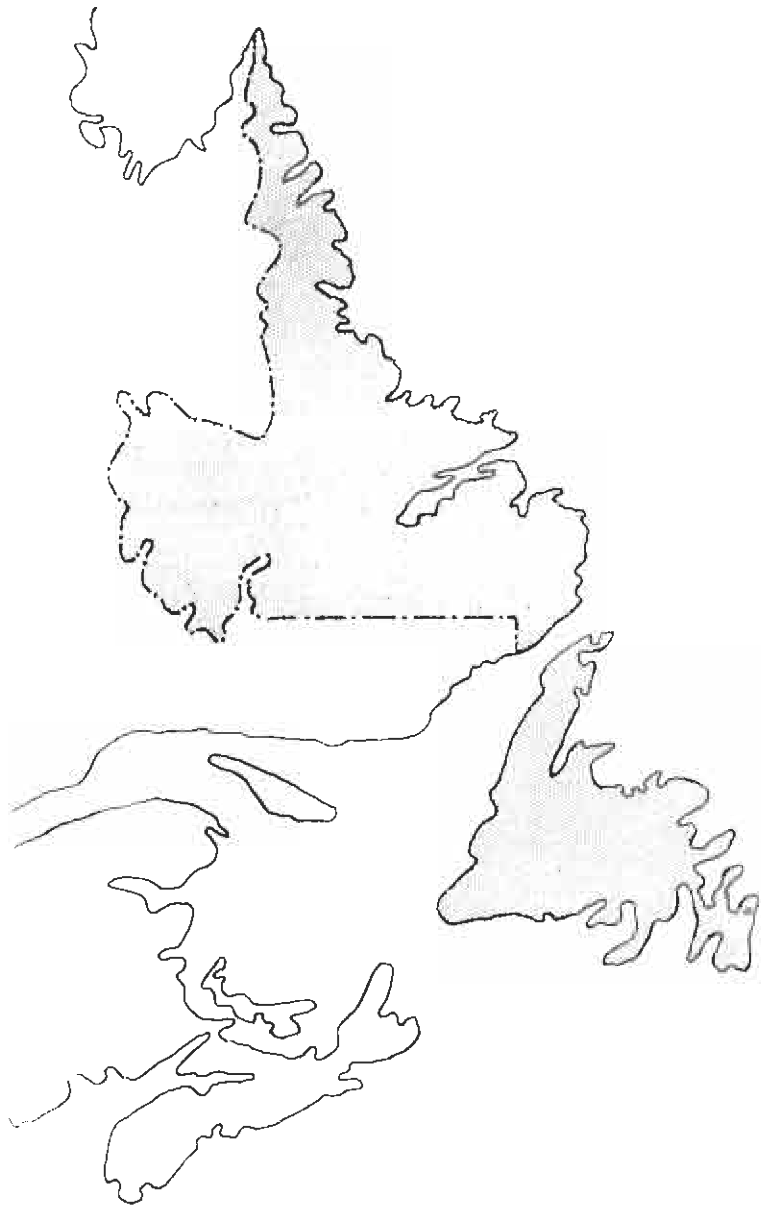
5.6 Appendices (VOLUME EIGHT)

This volume includes three appendices as follows:

Appendix A deals with the system analysis techniques used to store and process the vast quantity of data dealt with during the study.

Appendix B presents a series of water use studies for specific industries which were selected in co-operation with the Supervisory Committee.

Appendix C deals with the cost estimating criteria developed during the study.



6 ORGANIZATION AND METHODOLOGY

6.1 Study Organization

On March 15, 1967, the Atlantic Development Board advised the Consultant of its intention to enter into contractual negotiations for this study with the Consultant.

Detailed planning was therefore commenced jointly with James F. MacLaren Limited of Toronto and the study was authorized by an Agreement signed on June 16, 1967.

As provided for in the Agreement, the following individual consultants knowledgeable in various disciplines associated with a study of this type were retained:

Economics	-	Mr. A. C. Parks, Atlantic Provinces Economic Council
	-	Dr. G. Schramm, University of Manitoba
Reclamation	-	Mr. J. D. Conlon, Amherst, Nova Scotia
Forestry	-	Mr. E. S. Fellows, Fredericton, New Brunswick
Fisheries	-	Dr. A. L. Pritchard, Ottawa, Ontario
Agriculture	-	Dr. P. W. Wright, Guelph, Ontario

The project was organized under a Project Manager, located in Montreal, reporting to a Board of Principals of The Shawinigan Engineering Company Limited and James F. MacLaren Limited. In addition, through the Project Manager, the progress of the study was reported at two-month intervals to the Supervisory Committee, formed by the Atlantic Development Board, made up of representatives of federal and provincial agencies.

As indicated on the accompanying Figure 6-1, the study was then organized under the Project Manager in two separate offices, the head office of the Consultant in Montreal, and a field office located in St. John's, Newfoundland, each under the direction of an Assistant Project Manager.

The field office was established during the month of May 1967 and was retained until June 30, 1968. The office served as a base from which much of the existing data could be conveniently collected, analyzed, and processed to the point of use by the computerized data storage, retrieval, and processing system outlined in Appendix A, Volume Eight of this report. It also served to facilitate contact with the provincial authorities concerned with the study.

During the course of the work on the demand phase, it became evident that a great deal of data were missing on the present day water use by municipalities and by industries as well as for planned installation of new facilities or expansion of existing ones. Although the Agreement stated that the study would be based on existing information, it became clear that the Terms of Reference could not be properly fulfilled without collecting some of this information by site visits whenever possible. For this reason, following approval by the Board and the Supervisory Committee, a data collection program was initiated.

A series of questionnaires was drawn up outlining the information required and sent to the appropriate authorities in municipalities and industries over the signature of Mr. C. W. Powell, Chairman, The Newfoundland and Labrador Water Authority. Four members of the St. John's office staff supplemented by three engineers from the Montreal and Toronto offices were organized into a team to follow up the questionnaires by personal interviews in all parts of the Province. Simultaneously a program of grab sampling was carried out to fill in the more serious gaps in water quality information.

All of the above work was performed between the middle of September and the early part of November 1967. Although a great deal of information was obtained through the co-operation of most agencies, a considerable number of smaller communities and industries proved incapable of providing any useful data on water use.

Work in the Montreal office consisted of the processing of all data obtained to the point of presentation of this report, including the further analysis in the integration of water supply and demand, all computer processing, and economic studies necessary to complete the study, and the writing and editing of the interim and final reports.

An interim report dated January 1968 was prepared at the request of the Supervisory Committee, and covered the work carried out from March 15, 1967, to January 15, 1968. This final report includes all the findings and recommendations of the interim report as well as the work accomplished since January 15, 1968.

6.2 General Methodology

The relationship between the water resources and the economy of an area is generally complex and frequently ill defined. Therefore, the first step in any water resources study is the definition of the basic interrelationships. These definitions may then be used as a guide to the identification of significant water resources development problems.

This report is concerned with the identification of water resources problems and priorities and represents only the first step of a water resources management plan. However, it is considered desirable to review the succession of steps which lead to a comprehensive water resources management plan; retaining for the purpose of this study only those which are relevant.

6.2.1 Water Demand Categories

Basic to the methodology used in this study is the consideration that water demand may be divided into three principal categories:

a) The "non-withdrawal" or "non-consumptive" water demand where no significant change in the quantity and/or quality of water occurs: production of hydro-electric energy, navigation, fisheries, wildlife, tourism, and recreation.

The preliminary analysis of non-withdrawal water demand and the development of related uses is similar to the analysis of any resource development and is considered within the framework of the regional economy. Such an analysis should consider the impact of capital spending and the associated benefit-costs in order to establish development priorities.

b) The "withdrawal" or "public utility" type of water demand which may result in significant changes in the quantity and/or quality of water: water supply for domestic, industrial, and agricultural use, or for the disposal of wastewater.

Analysis of withdrawal water demand should begin with the analysis of the user's requirements in terms of the economy of the industry or municipality and in relation to the general economy. Technologic development can provide substitutes for water and the costs of such substitution must be evaluated against present and future conditions.

c) "Negative" water demand which includes the various harmful actions of water such as floods, ice effects, bank and soil erosion, silting of reservoirs, harbours or estuaries, and the undesirable presence of water (bog, marshes).

An analysis of "negative" water demand should establish the local or regional measures necessary to combat its destructive effects. Furthermore, developments which satisfy other water uses may create, or alleviate, problems of "negative" water demand. Therefore, this aspect of water resources management should always be considered when new developments are proposed.

6. 2. 2 Methodology Outline

Taking into account the water demand categories defined in Section 6. 2. 1, the methodology used for establishing a general development plan for the water resources of a basin or area is shown diagrammatically on Figure 6-2 and comprises the main steps listed below.

It should be noted that the present study is basically concerned with steps 1 to 11 only; the remaining steps will be the object of the next two stages of the investigation.

1 A review of the natural conditions of the basin, including the hydrologic conditions (quantity and quality of available water) and the natural resources.

2 A review of the existing economy and its patterns of water usage. The quantity and quality of available water can be derived from a comparison of these two factors in relation to the natural conditions. (Re-allocation of present uses is not to be excluded if the analysis discussed in step 9 indicates that this could be beneficial.)

3 A forecast of the general development of the area over the study period, based on the analysis of present economic conditions, natural resources, plans for the development of existing and new industries, economic trends, and relations between the different branches of the economy. This forecast must include, in an explicit fashion, the future development of water as a natural resource (energy production, water transportation, fisheries, tourism, and recreation), which should be obtained using the approach outlined in Volume Three, Section 3.

4 An analysis of the specific usage of water by industry and by population (for water supply and discharge of wastewater), and a forecast of possible changes in the specific usage taking into account expected changes in the cost of water, the introduction of new technology, increase in the level of living, etc.

5 An analysis of the probable geographical distribution of proposed developments and parallel detail studies of the hydrologic and hydrogeologic conditions in the development areas.

6 An evaluation of the quantity and quality of the water necessary to fulfill the needs of the population and industry ("public utility" type of demand) in accordance with the forecast development and its geographic distribution, and the results obtained in step 4.

7 An estimation of the "negative" demand as a result of the economic development and its geographical distribution (including effects of development of water as a natural resource).

8 Consideration of the restraints imposed on the development of water resources by the political, administrative, and legal framework*.

9 A study of the interdependence of water availability and demand and possible modifications of the geographic distribution to solve the water resources problems without significantly changing other proposed developments. Included are assessments of required storage volumes, the flows that must be diverted from one basin to another, the water characteristics and flows that must be improved by treatment, the level of this treatment and other necessary measures to meet forecast water demand.

10 A preliminary assessment of the changes in supply conditions due to forecast economic activity (qualitative and quantitative changes due to industrial and municipal uses, including pollution, diversions, changes in forested areas, etc).

*Studies of administrative and legal implications of water resources problems are being prepared by other Consultants to the Board.

11 An analysis of supply (water availability) and demand to indicate:

a) Areas where supply is satisfactory and can be developed to meet the demand without special technologic or economic problems.

b) Areas where supply is difficult and meeting the demand will involve technologic and/or economic problems.

c) Areas where there are conflicts of interest which will require special development adjustments.

d) Areas where changes and re-allocation of present uses should be considered.

e) Areas where the supply conditions indicate that changes in the forecast development and/or its geographic distribution should be immediately considered.

f) A preliminary ranking of areas for detailed development planning studies according to their socio-economic and technical significance.

12 An assessment of problem areas, delineation of economic-hydrologic regions to be considered in water resources management studies and establishment of priorities for detailed studies.

13 An analysis of the integration of the different categories of water demand on a geographic basis together with preliminary schemes for satisfying these demands.

14 An examination of possibilities of satisfying different demands by combined schemes, the effects of structures required by one group of demands on other groups of demands, adjustments for conflicts of interests and loss compensation evaluations, establishment of possible alternative development schemes.

15 An assessment for each alternative of supplementary measures in the basin in order to regulate the runoff, reduce soil erosion, or improve the quality of the water (reforestation, agro-technical measures, snow management, and evaporation control).

16 An evaluation of possible alternatives using common criteria; for example, maximum benefit per dollar invested, or minimum investment for same level of satisfying the total demand.

17 A further evaluation of the economically optimum alternatives and of the two or three closer to the optimum, from the viewpoint of environmental, social and administrative implications, and the selection of the most suitable alternative.

18 An iteration commencing with paragraphs 3 or 5 if, after completing the work indicated in paragraphs 3 to 15, the results obtained necessitate changes in the proposed development (water resources included) or in its geographic distribution. If at the end of the iteration new changes are required, the operation should be repeated until no significant changes appear necessary.

Having identified the location of the main developments, a detailed evaluation of the proposed developments should be carried out. If the evaluation shows that the initial assumptions used on the basis of preliminary information are incorrect the chosen solutions must be modified.

Further methodologic discussion on the different phases of the study is presented in Volume Two, Part I; Volume Three, Part I; and Volume Five, Part I.

6.2.3 Study Period Subdivisions

According to the Terms of Reference, Phase A - General, this report is concerned with the examination of the current use of water and an estimate of future needs through the study period to 1981, with an indication of requirements beyond this point.

As is shown on Figure 6-1, the analysis of future water resources development may be divided into two periods: planned development and forecast development. The paucity of data precluded this distinction in the body of the report.

The planned development period represents the short term for which development plans of existing or new industries or projects have been defined, and only inconsequential changes may occur. The analysis of demand is simpler for this period since technologic changes are more predictable and the preliminary design of projects indicates the water requirements. This is also true for the non-consumptive and "negative" water demand.

The forecast development period follows the planned development period and extends to the end of the study period. For this period government and private industry plans are subject to significant change. In certain areas the development of some existing resources may not have been considered, but the availability of the resource and national or world market trends may indicate that such a development might take place. A reasonable approach to this time period is to generate generalized economic-water demand relationships capable of producing responses, from the water resources viewpoint, to a variable economic input.

The methodology of the different phases of the study was such that, in addition to examining specific areas, specific problems, and specific responses, it established methods and indicated techniques through which other areas or problems could be considered and analyzed by means of generalized relationships and examination of similar cases. Although some of the accuracy involved in applying the results to specific areas and problems might be lost, the advantage of being able to use these techniques for comparing alternatives in a wide variety of possible cases greatly exceeds this loss. When decisions have been made and the problem of feasibility studies and final design is faced, a reconsideration of the specific problems by means of more accurate methods will always be required.

6.3 Ranking of River Basins and Study Areas

The Terms of Reference for this study require a ranking of study areas and river basins for detailed development planning studies on the basis of certain criteria.

The river basins and study areas to be studied were selected in consultation with the Supervisory Committee in the early stages of the study. While this selection was mainly intuitive it proved to include all the areas of the Province where significant water resources problems exist.

All of the criteria given in the Terms of Reference were considered to the extent that data were available, and used as a guide in examining and assessing the important problems and possibilities in each river basin and study area.

However, because of the lack of specific planning data and the resulting difficulty in quantifying benefits in most of the areas considered, emphasis was given in the ranking to the problems and conflicts identified during the study.

A provisional ranking of river basins and study areas was carried out using two basic parameters or "yardsticks",

a) The complexity in the water resources problems.

b) The economic and social significance of the area or basin considered in relation to the Province as a whole.

The complexity of problems or conflicts was analyzed through the use of a matrix table of the input/output type shown in Figure 6-3 which deals specifically with the Exploits River basin. In this table the effects (beneficial, detrimental) that a use or development in one field can produce on other uses or developments in the same or other fields are indicated by symbols in the categories of existing, forecast, or potential uses or developments, with no effect being shown as a neutral symbol. In each basin and study area these uses have been considered separately with respect to their inter-effects.

The relative index of complexity in regard to water resources was then taken as the relative value of the total number of situations where positive effects had been recorded or, in effect, the greatest sum of possibilities and problems set the top priority.

Since this scoring system is empirical and lacks any quantitative input, a considerable amount of judgement was required in using it.

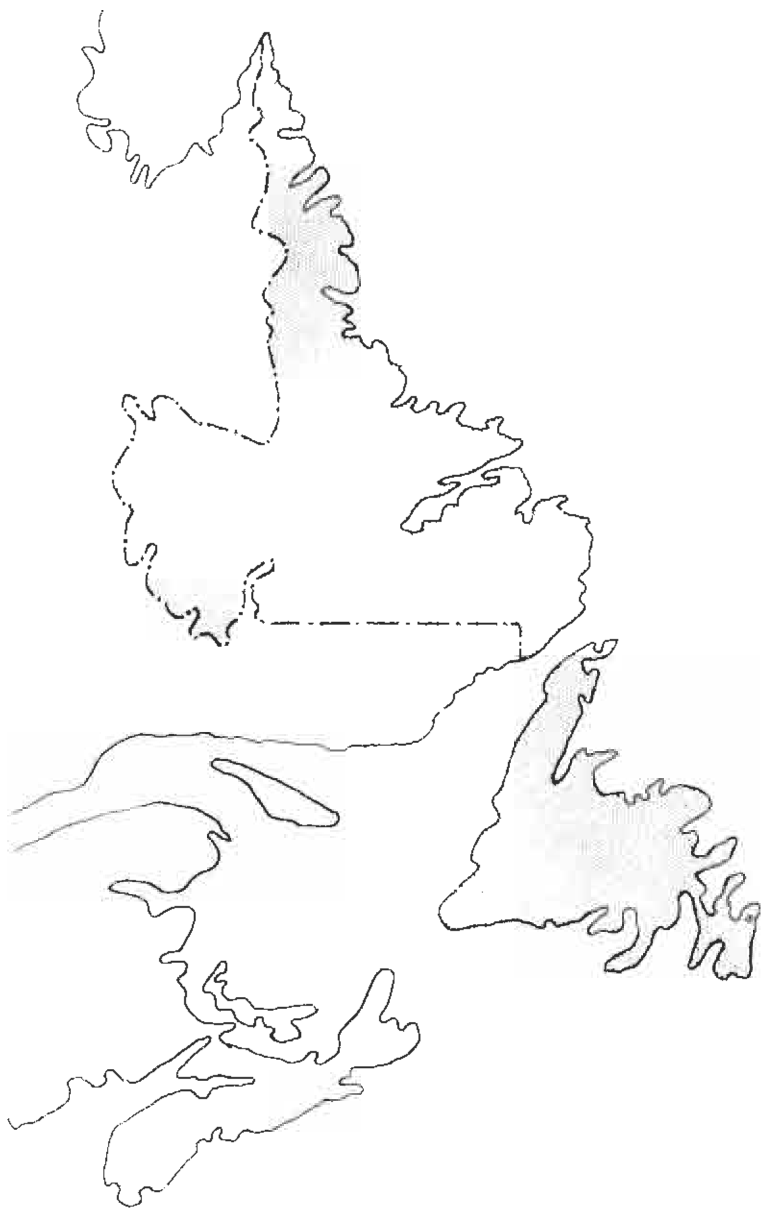
The economic and social importance of an area or basin was assessed according to two basic criteria:

a) The size of population.

b) The estimated capital investment for new developments over the study period.

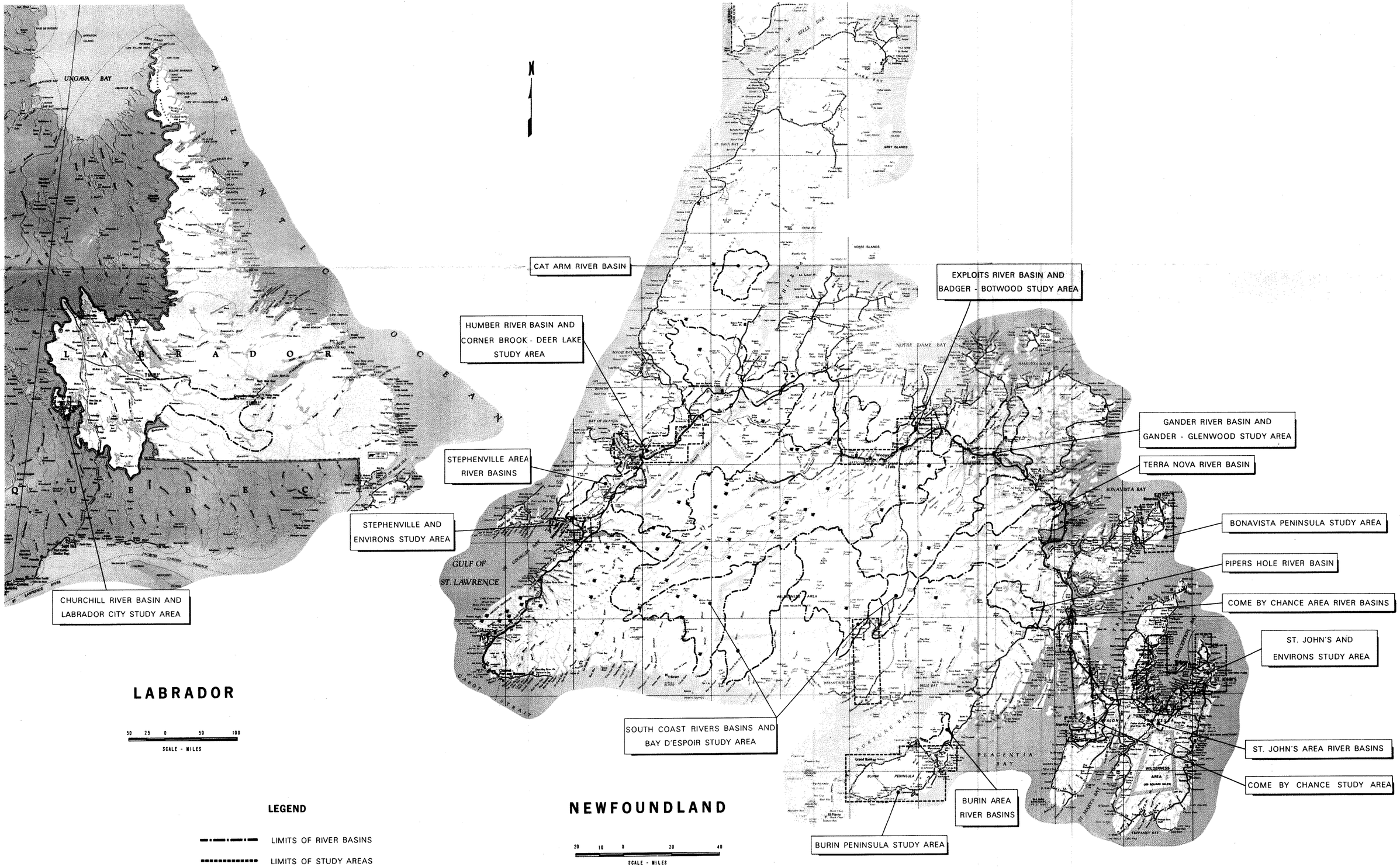
These criteria are such that they could be quantified, but it was not possible to combine them with the index of water resource complexity to obtain an integrated index of priority.

The final ranking was therefore initially set on the basis of the complexity criteria, and re-adjusted using the socio-economic indications in situations where the complexity indices evidenced little or no difference.



VOLUME ONE

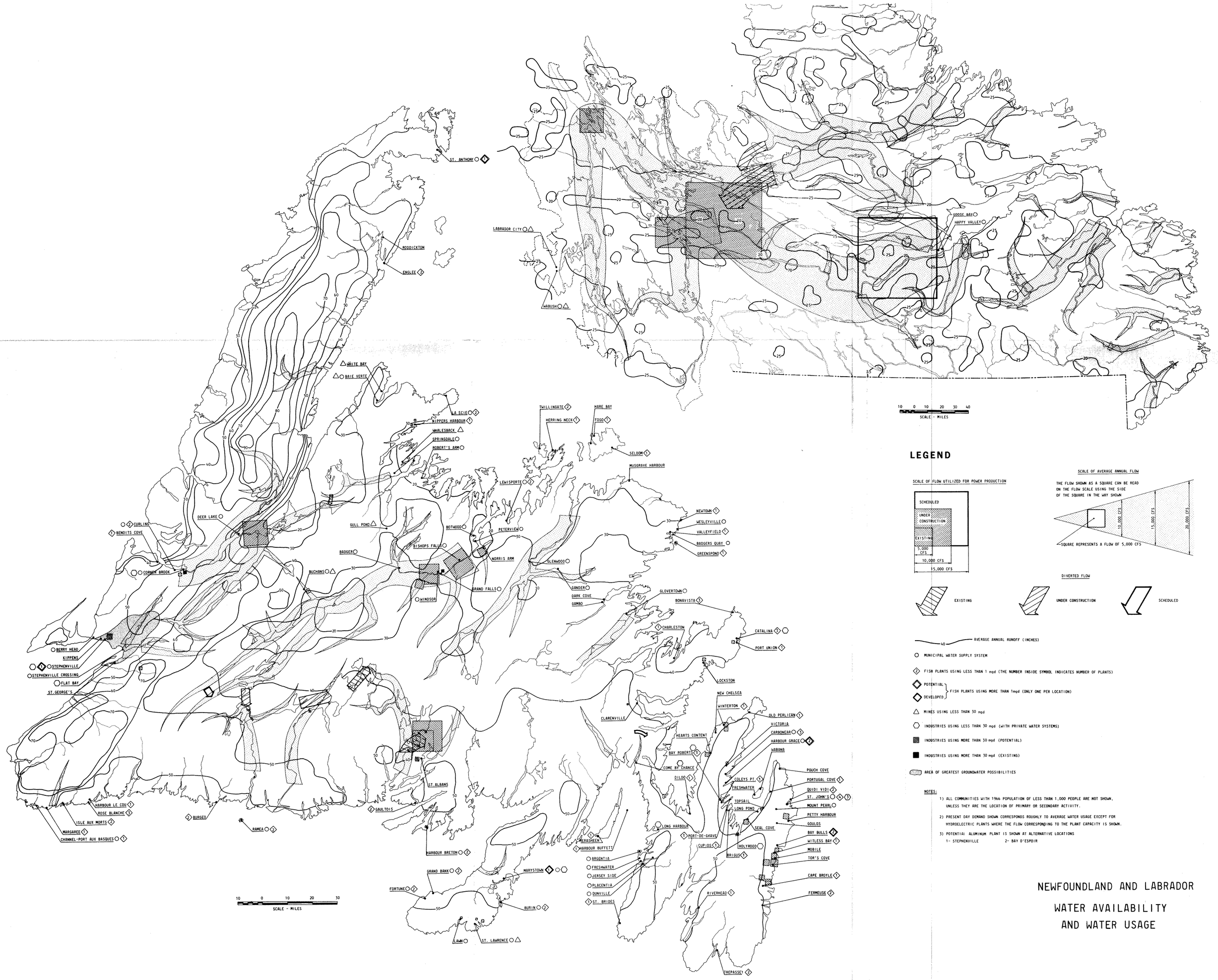
LIST OF FIGURES



NEWFOUNDLAND AND LABRADOR
RIVER BASINS AND
STUDY AREAS

FIGURE 4-1

The Shawinigan Engineering Company Limited
James F. MacLaren Limited



LEGEND

SCALE OF FLOW UTILIZED FOR POWER PRODUCTION

SCALE OF AVERAGE ANNUAL FLOW

THE FLOW SHOWN AS A SQUARE CAN BE READ ON THE FLOW SCALE USING THE SIDE OF THE SQUARE IN THE WAY SHOWN

DIVERTED FLOW

60 AVERAGE ANNUAL RUNOFF (INCHES)

○ MUNICIPAL WATER SUPPLY SYSTEM

◇2 FISH PLANTS USING LESS THAN 1 mgd (THE NUMBER INSIDE SYMBOL INDICATES NUMBER OF PLANTS)

◇ POTENTIAL
◆ DEVELOPED
} FISH PLANTS USING MORE THAN 1mgd (ONLY ONE PER LOCATION)

△ MINES USING LESS THAN 30 mgd

⬡ INDUSTRIES USING LESS THAN 30 mgd (WITH PRIVATE WATER SYSTEMS)

▩ INDUSTRIES USING MORE THAN 30 mgd (POTENTIAL)

■ INDUSTRIES USING MORE THAN 30 mgd (EXISTING)

AREA OF GREATEST GROUNDWATER POSSIBILITIES

NOTES:

1) ALL COMMUNITIES WITH 1966 POPULATION OF LESS THAN 1,000 PEOPLE ARE NOT SHOWN, UNLESS THEY ARE THE LOCATION OF PRIMARY OR SECONDARY ACTIVITY.

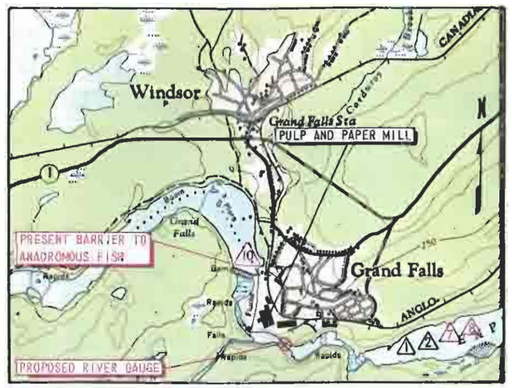
2) PRESENT DAY DEMAND SHOWN CORRESPONDS ROUGHLY TO AVERAGE WATER USAGE EXCEPT FOR HYDROELECTRIC PLANTS WHERE THE FLOW CORRESPONDING TO THE PLANT CAPACITY IS SHOWN.

3) POTENTIAL ALUMINUM PLANT IS SHOWN AT ALTERNATIVE LOCATIONS
1- STEPHENVILLE 2- BAY D'ESPOIR

NEWFOUNDLAND AND LABRADOR
WATER AVAILABILITY AND WATER USAGE

FIGURE 4-2

The Shawinigan Engineering Company Limited
James F. MacLaren Limited



0 0.5 MILE

DETAIL "A"

NOTES:
1. UNTREATED MUNICIPAL WASTEWATERS
2. UNTREATED INDUSTRIAL WASTEWATERS
3. TREATED MINING WASTEWATERS
4. LOG DRIVING
5. COMMERCIAL FISHING AREA
6. STORAGE RESERVOIR
7. TREATED MUNICIPAL WASTEWATERS
8. TREATED INDUSTRIAL WASTEWATERS
9. ATLANTIC SALMON AREA
10. FISH PASSAGE AND COLLECTION FACILITIES
11. RECREATIONAL BOATING

10 0 10 MILES

GENERAL PLAN

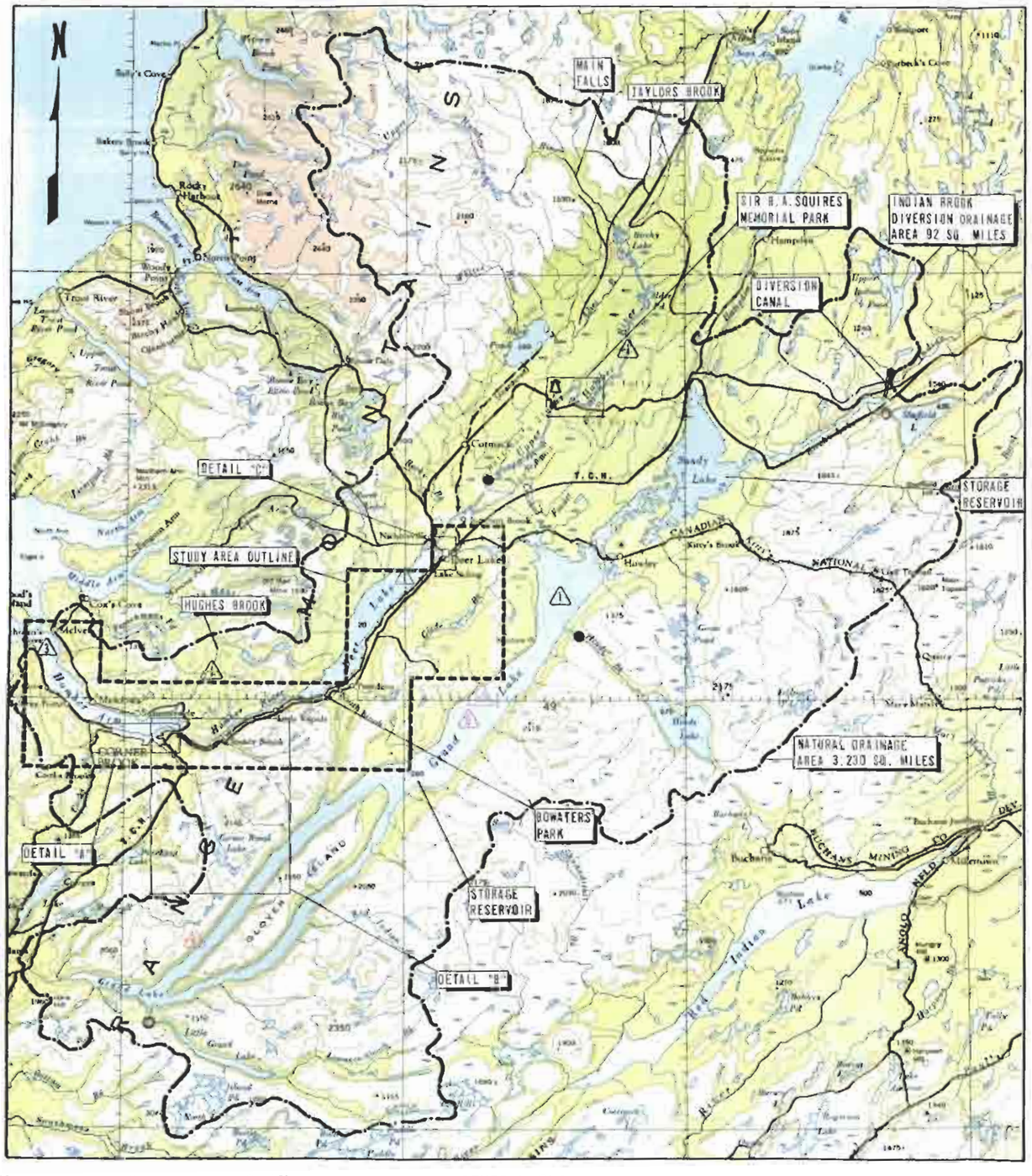
NOTE: POTENTIAL FUTURE DEVELOPMENTS AND PROJECTS UNDER CONSTRUCTION SHOWN IN RED

LEGEND: MINE

NEWFOUNDLAND = KEY PLAN

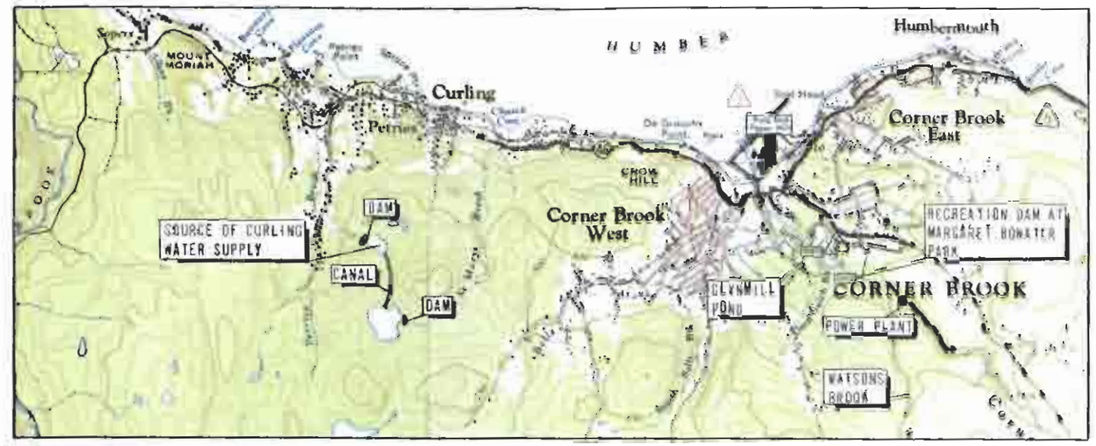
EXPLOITS RIVER BASIN AND THE BADGER-BOTWOOD STUDY AREA

FIGURE 4-3



GENERAL PLAN

LEGEND:
- ● EXISTING RIVER GAUGE
- ◎ ABANDONED RIVER GAUGE



DETAIL "A"

DETAIL "B"

DETAIL "C"

NEWFOUNDLAND - KEY PLAN

NOTES:
- ⚠ LOG DRIVING
- ⚠ SEDIMENTATION PROBLEMS
- ⚠ COMMERCIAL FISHING AREA
- ⚠ SKI CENTRE
- ⚠ LIMESTONE AND SHALE QUARRIES

HUMBER RIVER BASIN
AND THE CORNER BROOK -
DEER LAKE STUDY AREA

FIGURE 4-4

NOTES: POTENTIAL FUTURE DEVELOPMENTS AND PROJECTS UNDER CONSTRUCTION SHOWN IN RED.

1. ATLANTIC SALMON AREA
2. COMMERCIAL FISHING AREA
3. MUNICIPAL WATER SUPPLY AND WASTEWATER DISPOSAL SYSTEM
4. UPPER SALMON HYDROELECTRIC DEVELOPMENT - 80MW
5. COMPENSATION FLOW FOR ATLANTIC SALMON
6. FISHING AREA
7. RECREATIONAL BOATING
8. LOG DRIVING
9. NATIONAL HARBOUR

UPPER GREY RIVER DRAINAGE AREA 375 SQ. MILES

WOODS ROAD

FLOW TO SALMON RIVER BASIN

EBBEGUNBAEG CANAL

WILDERNESS AREA OUTLINE

UPPER SALMON RIVER DRAINAGE AREA 1040 SQ. MILES

LONG POND RESERVOIR OUTLINE 15 BCF STORAGE

CONNE RIVER DRAINAGE AREA 273 SQ. MILES

GREY RIVER RESERVOIR OUTLINE 40 BCF STORAGE

PUDDOPS LAKE DAM

LOWER GREY RIVER DRAINAGE AREA 657 SQ. MILES

LOWER SALMON RIVER DRAINAGE AREA 65 SQ. MILES

BAY D'ESPOIR HYDROELECTRIC PLANT

ROAD TO GRAND FALLS AREA

LOWER WHITE BEAR RIVER DRAINAGE AREA 404 SQ. MILES

SMOKEY FALLS

LABRADOR

QUEBEC

SOUTH COAST RIVER BASINS

STUDY AREA OUTLINE

LEGEND:

- EXISTING RIVER GAUGE
- ABANDONED RIVER GAUGE
- PROPOSED RIVER GAUGE
- BAY D'ESPOIR DEVELOPMENT DIVERTED DRAINAGE AREA OUTLINE
- UNDIVERTED DRAINAGE AREA

0 10 MILES

GENERAL PLAN

NEWFOUNDLAND - KEY PLAN

SOUTH COAST RIVER BASINS AND BAY D'ESPOIR STUDY AREA

FIGURE 4-5

NEWFOUNDLAND - KEY PLAN

NOTE: POTENTIAL FUTURE DEVELOPMENTS SHOWN IN RED.

⚠ ATLANTIC SALMON AREA

NATURAL DRAINAGE AREA
740 SQ. MILES

POSSIBLE FUTURE EXTENSION
TO PARK OUTLINE

ENTRANCE TO MOOSE
MANAGEMENT AREA

WOODS ROAD

TERRA NOVA HYDROELECTRIC DEVELOPMENT
TERRA NOVA DRAINAGE AREA = 612 SQ. MILES

RIVER GAUGE

MOLLYGUAJECK RESERVOIR
OUTLINE FSL 575
LSL 538

FISHWAYS

PARK
OUTLINE

TERRA NOVA

TERRA NOVA LAKE
RESERVOIR OUTLINE

NATIONAL PARK

POWER CANAL

DIVERTED FLOW FROM
LOWER N.W. RIVER

DIVERSION
CANALS

DAMS

CLODE SOUND
POWER DEVELOPMENT
(100 MW)

MOLLYGUAJECK DAM AND
POWER DEVELOPMENT (114 MW)

DIVERTED FLOW
SALMON BROOK

RESERVOIR OUTLINE

DIVERSION CANAL

DAM

DIVERTED FLOW FROM
UPPER PIPER'S HOLE BASIN

N.W. RIVER
RESERVOIR OUTLINE

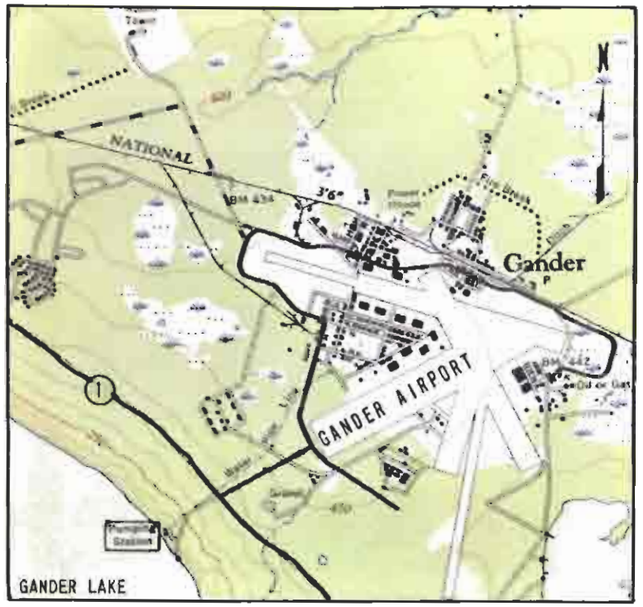
DIVERTED FLOW FROM
EASTERN MEELPAEG

0 5 MILES

GENERAL PLAN

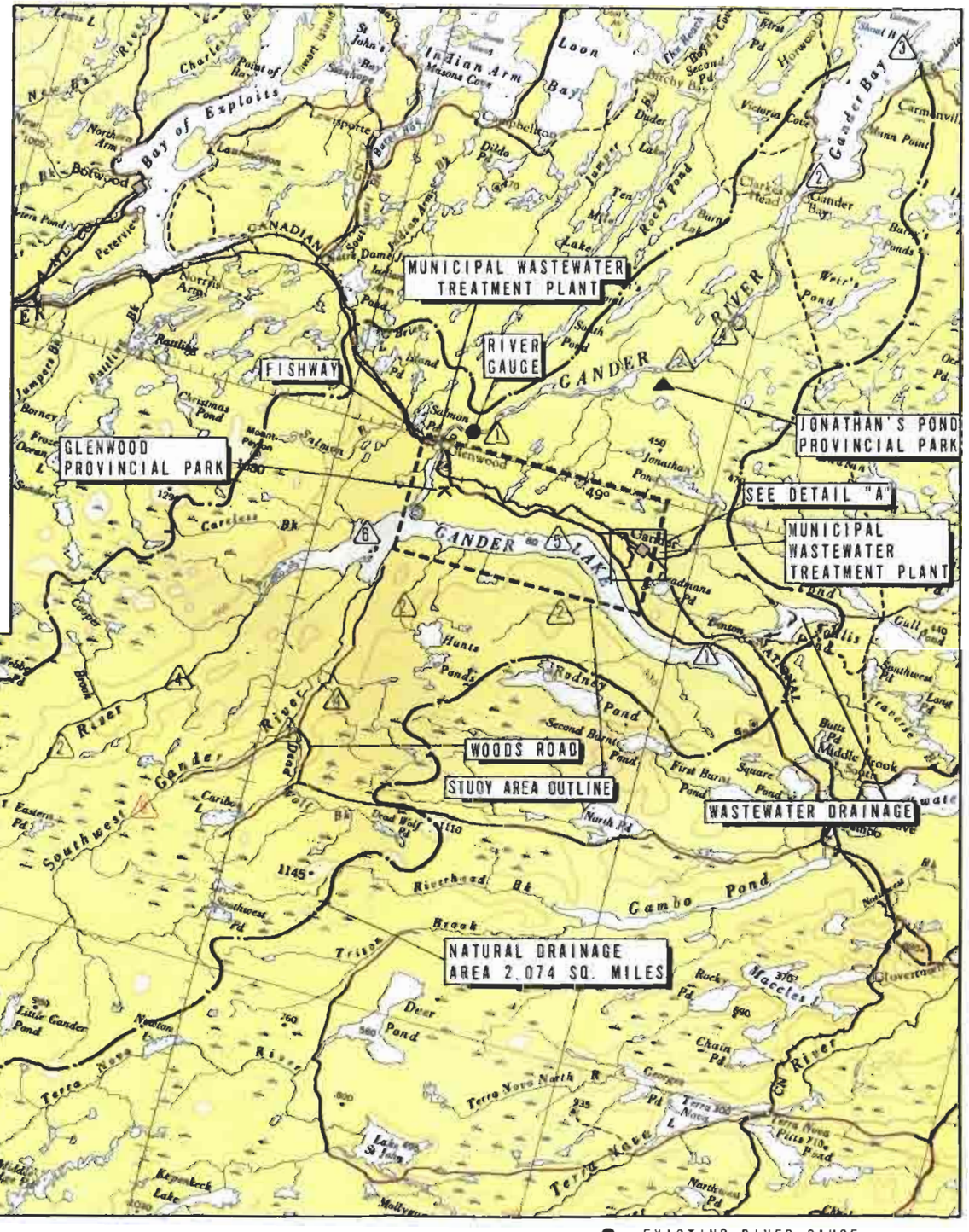
TERRA NOVA RIVER BASIN

FIGURE 4-6



0 0.5 MILE

DETAIL "A"



0 10 MILES

GENERAL PLAN

NEWFOUNDLAND - KEY PLAN

NOTE:

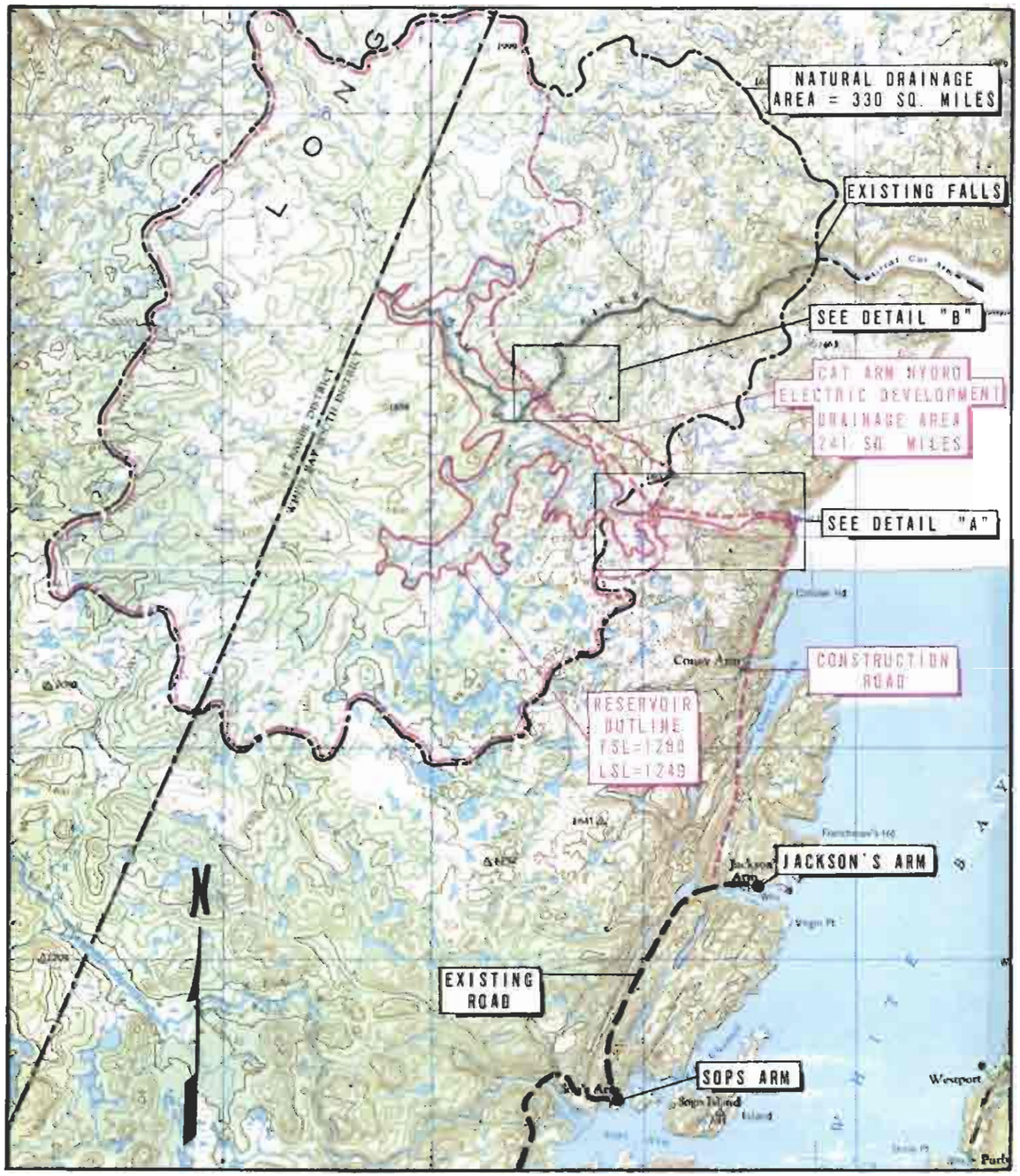
1. TREATED MUNICIPAL WASTEWATERS
2. ATLANTIC SALMON AREA
3. COMMERCIAL FISHING AREA
4. SMALL DRAUGHT NAVIGATION
5. RECREATIONAL BOATING
6. LOG DRIVING

POTENTIAL FUTURE DEVELOPMENTS SHOWN IN RED

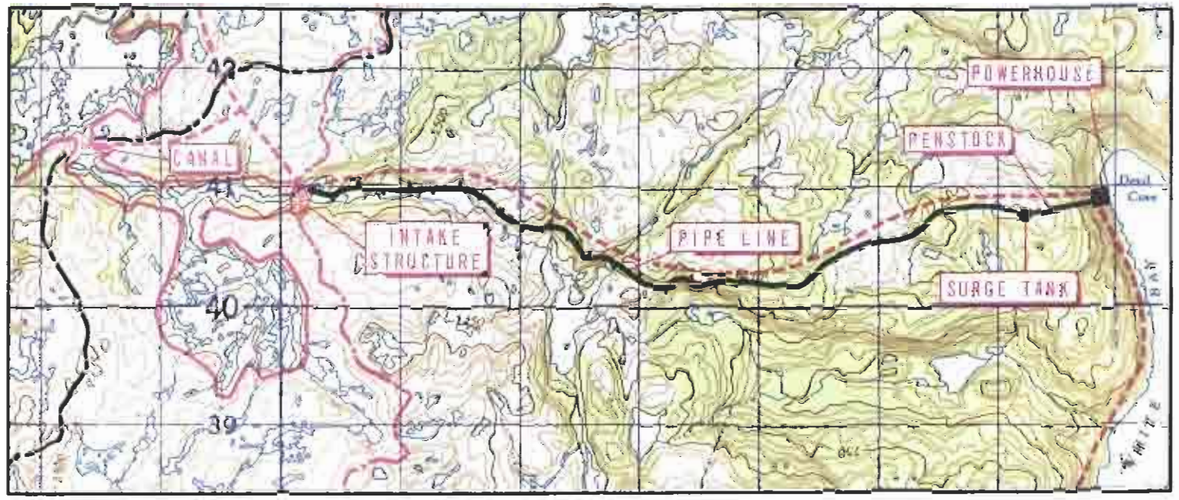
● EXISTING RIVER GAUGE
◎ ABANDONED RIVER GAUGE

GANDER RIVER BASIN AND
GANDER-GLENWOOD STUDY AREA

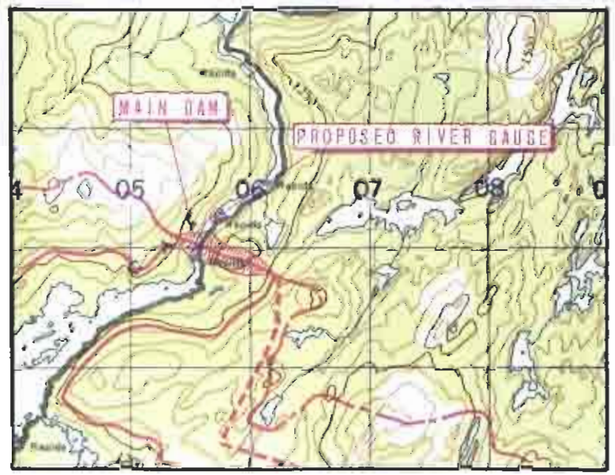
FIGURE 4-7



GENERAL PLAN



DETAIL "A"



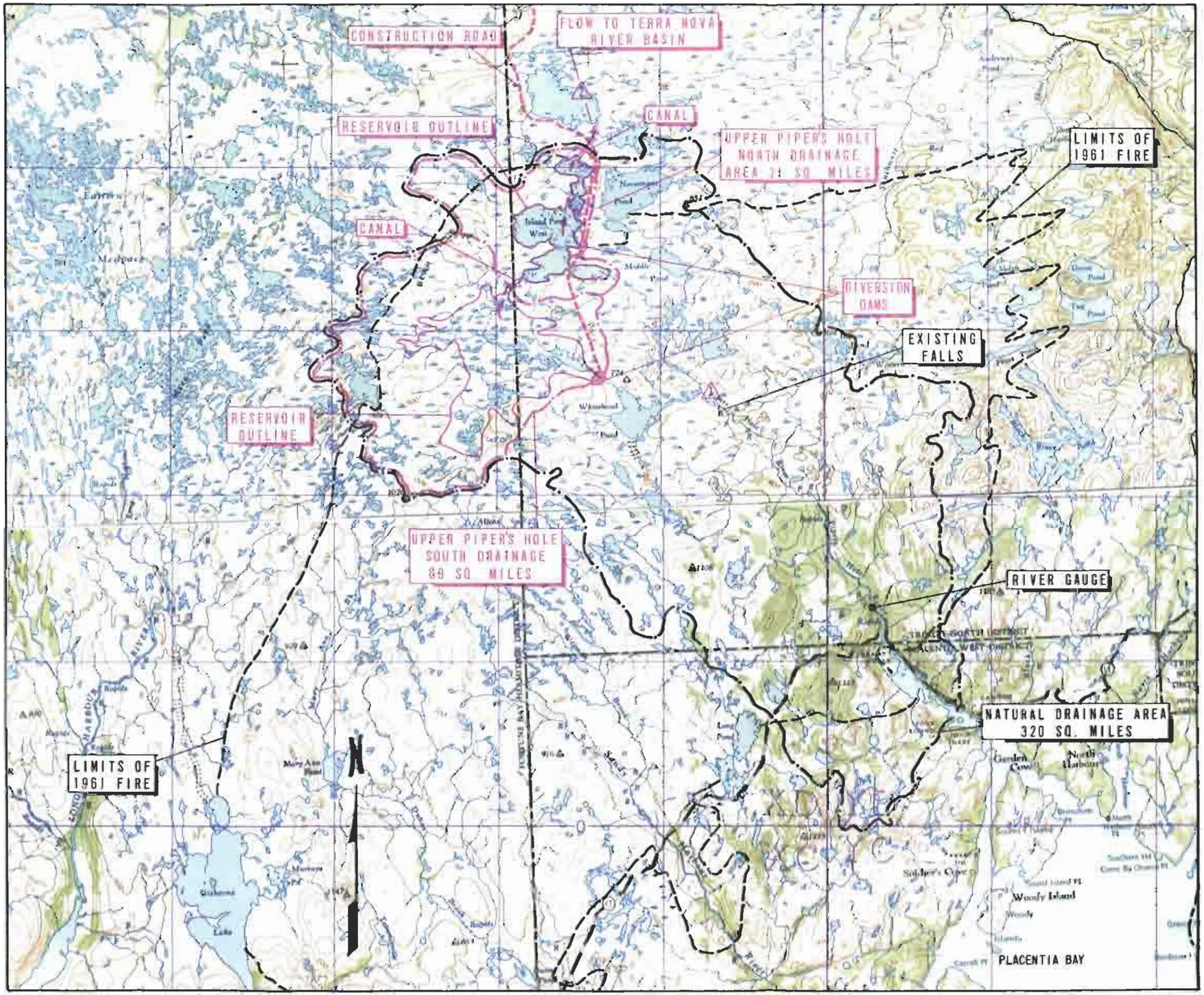
DETAIL "B"

NEWFOUNDLAND – KEY PLAN

CAT ARM RIVER BASIN

NOTE: POTENTIAL FUTURE DEVELOPMENT SHOWN IN RED

FIGURE 4-8



GENERAL PLAN

NEWFOUNDLAND - KEY PLAN

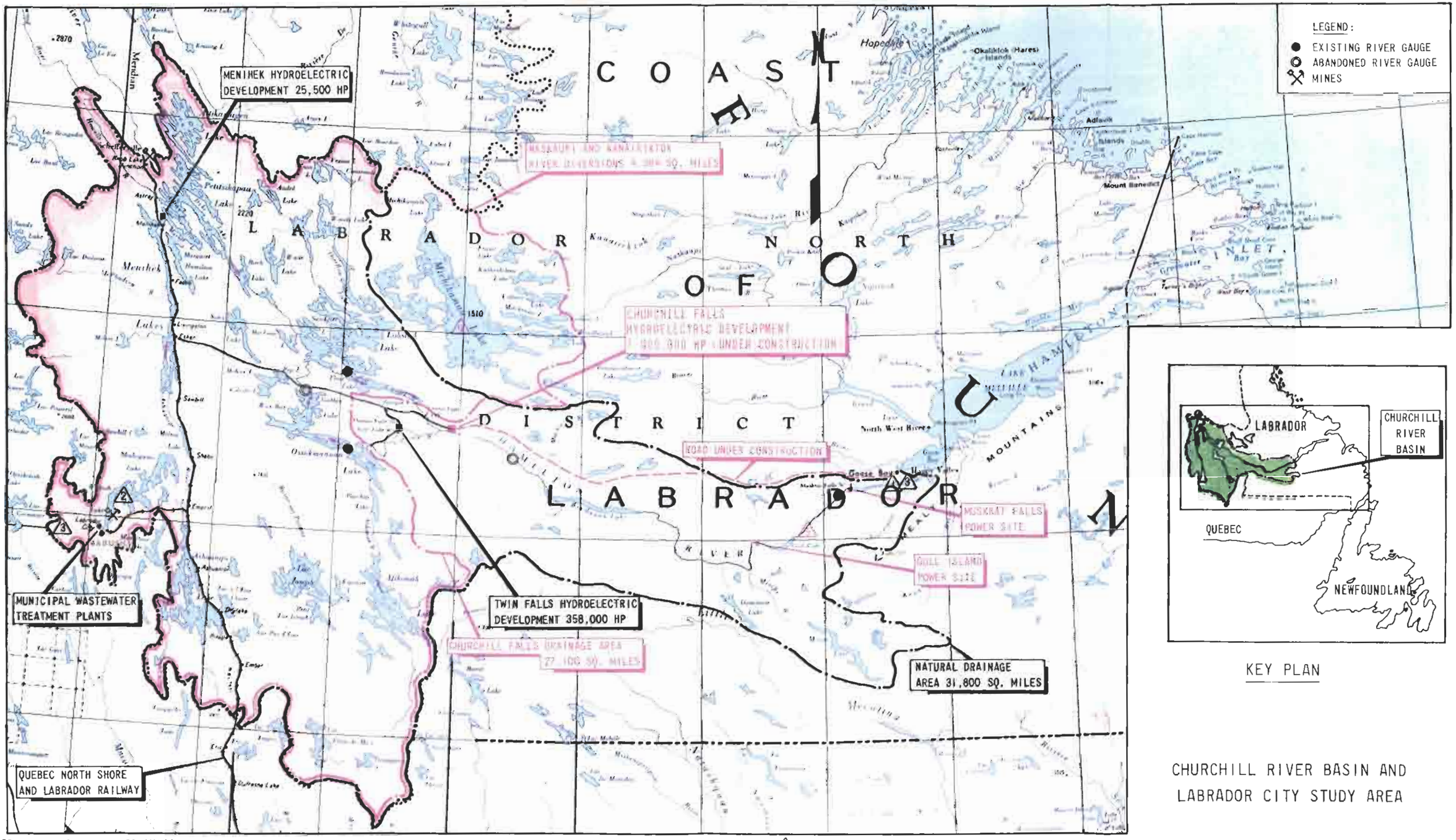
NOTE: POTENTIAL FUTURE DEVELOPMENTS SHOWN IN RED

⚠ ATLANTIC SALMON AREA UPSTREAM OF EXISTING FALLS.

⚠ UPPER AREA DIVERSION TO TERRA NOVA HYDROELECTRIC DEVELOPMENT

PIPER'S HOLE RIVER BASIN

FIGURE 4-9



KEY PLAN

GENERAL PLAN

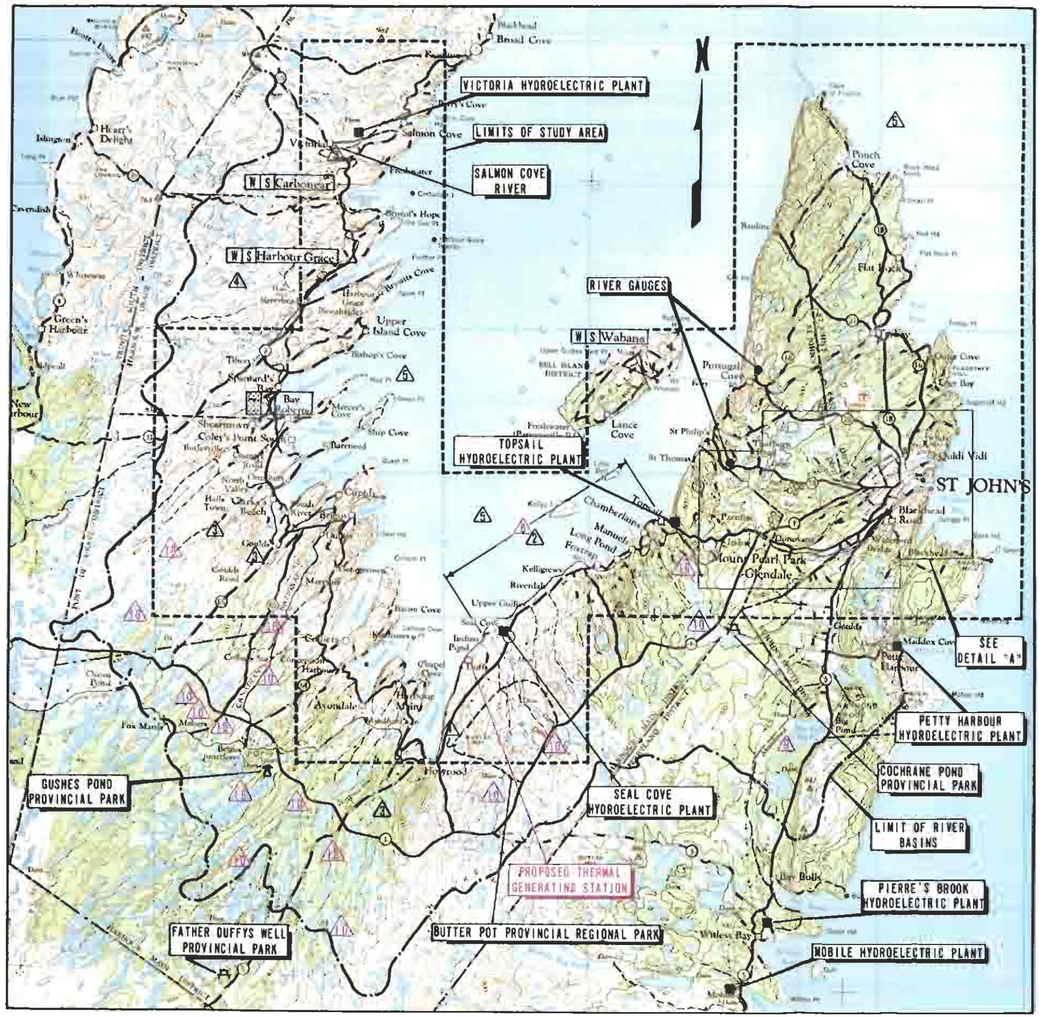
CHURCHILL RIVER BASIN AND LABRADOR CITY STUDY AREA

NOTES: 1) FOR CLARITY OF PRESENTATION FUTURE POWER STRUCTURES AND RESERVOIR OUTLINES NOT SHOWN

2) POTENTIAL FUTURE DEVELOPMENTS AND PROJECTS UNDER CONSTRUCTION SHOWN IN RED

NOTES: ① ATLANTIC SALMON AREA
② MINING POLLUTION
③ MUNICIPAL WATER SUPPLY AND WASTEWATER DISPOSAL SYSTEMS
④ COMMERCIAL FRESH WATER FISHING AREA
⑤ LOG DRIVING

FIGURE 4-10



GENERAL PLAN

NEWFOUNDLAND - KEY PLAN

NOTES: POTENTIAL FUTURE DEVELOPMENTS AND PROJECTS UNDER CONSTRUCTION SHOWN IN RED

1. POLLUTION PROBLEMS AFFECTING RECREATIONAL USE OF WATER
2. POLLUTION PROBLEMS CREATING DIRECT HEALTH HAZARD
3. LICENSED SALMON RIVER
4. WATER SUPPLY STORAGE RESERVOIR
5. COMMERCIAL FISHING AREA
6. WATER METER INSTALLATION PROGRAM
7. SANITARY FLOW DISCHARGE FROM ST. JOHN'S
8. REGIONAL WATER SUPPLY FACILITIES
9. POSSIBLE FUTURE ST. JOHN'S WATER SUPPLY SOURCE
10. STORAGE RESERVOIR SITES

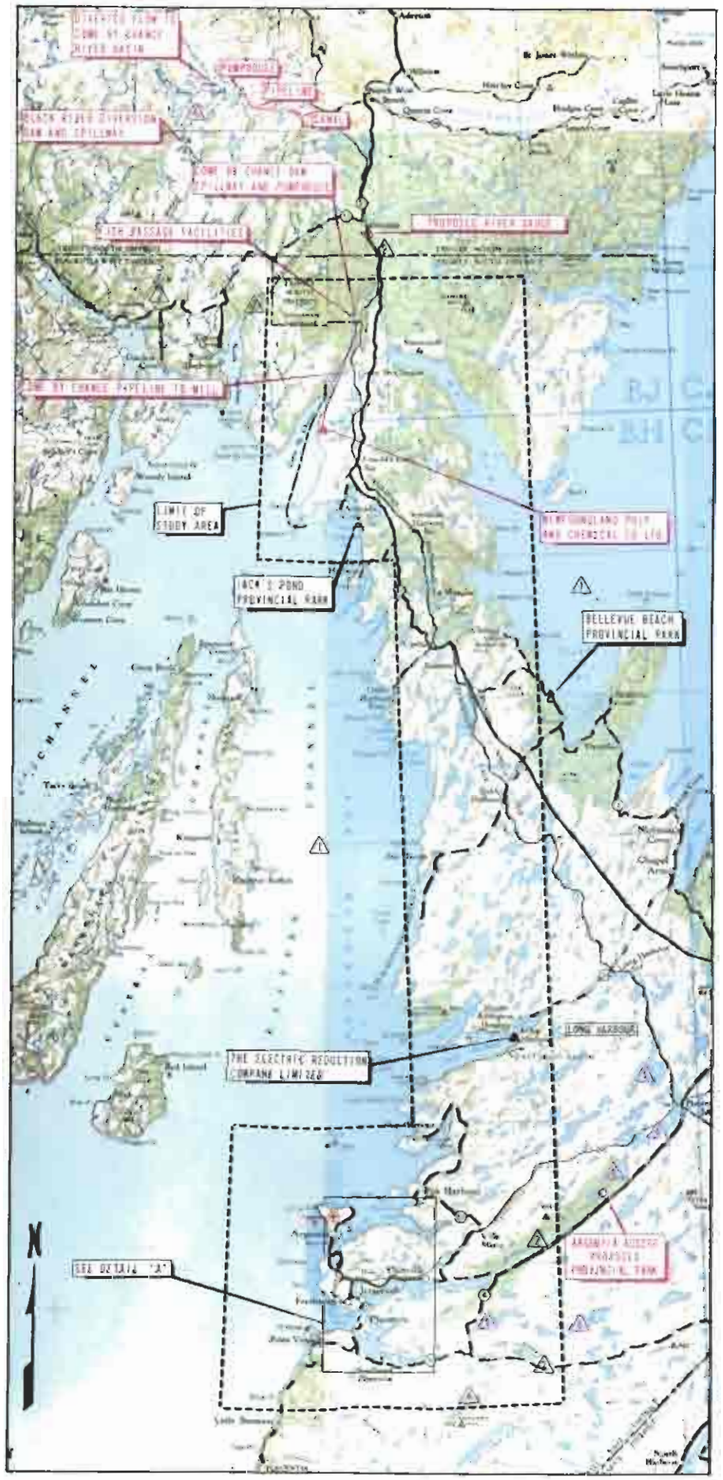
LEGEND:

W S — COMMUNITY WITH WATER SUPPLY AND WASTEWATER DISPOSAL SYSTEMS

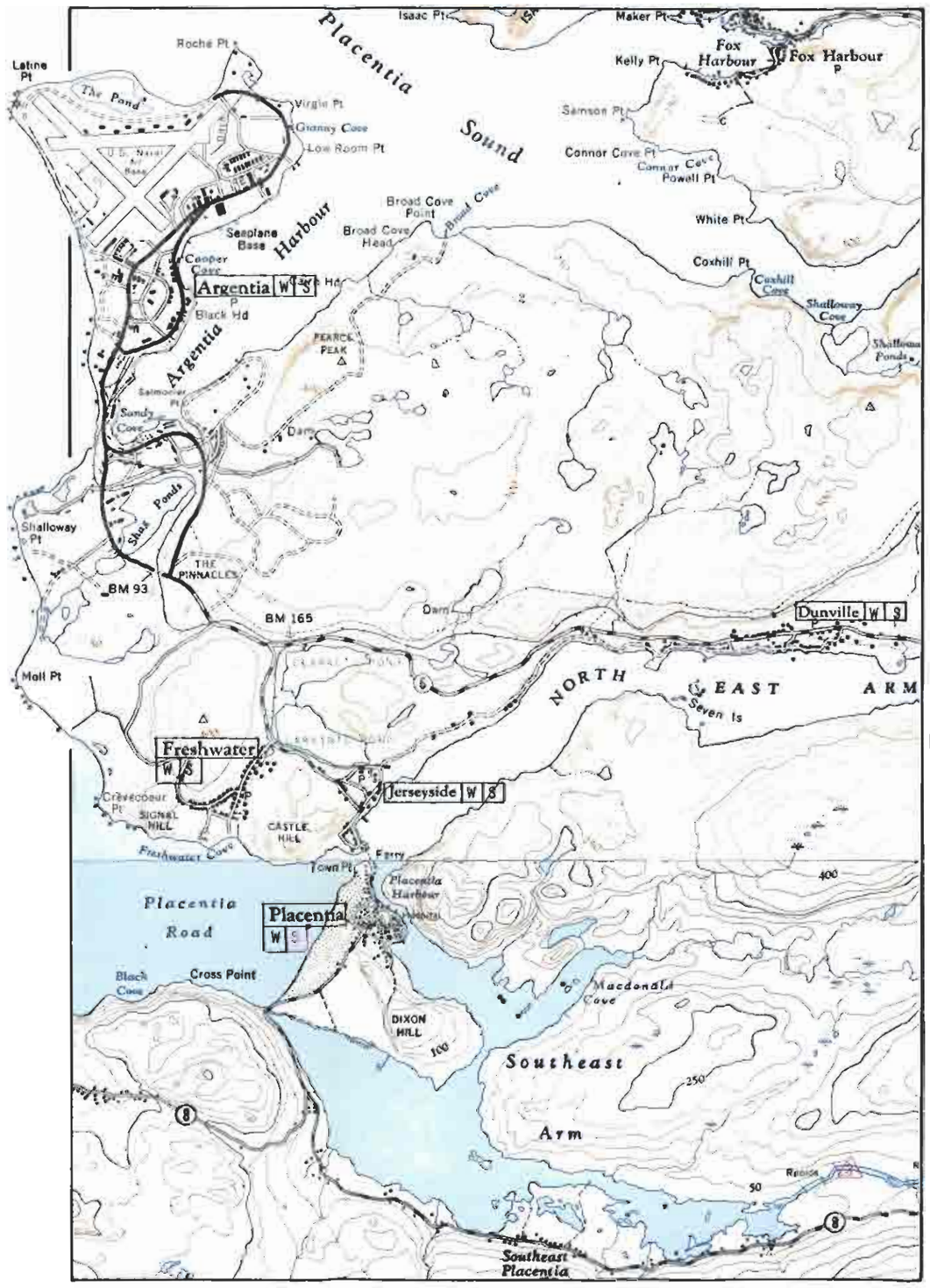
S — COMMUNITY WITH WASTEWATER DISPOSAL SYSTEM ONLY

DETAIL "A"

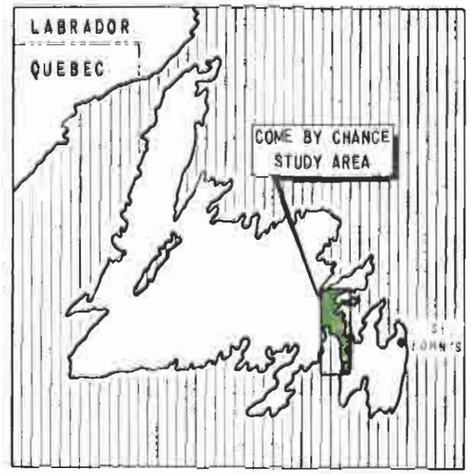
FIGURE 4-11



GENERAL PLAN



DETAIL "A"



NEWFOUNDLAND – KEY PLAN

NOTES: POTENTIAL FUTURE DEVELOPMENTS AND PROJECTS UNDER CONSTRUCTION SHOWN IN RED

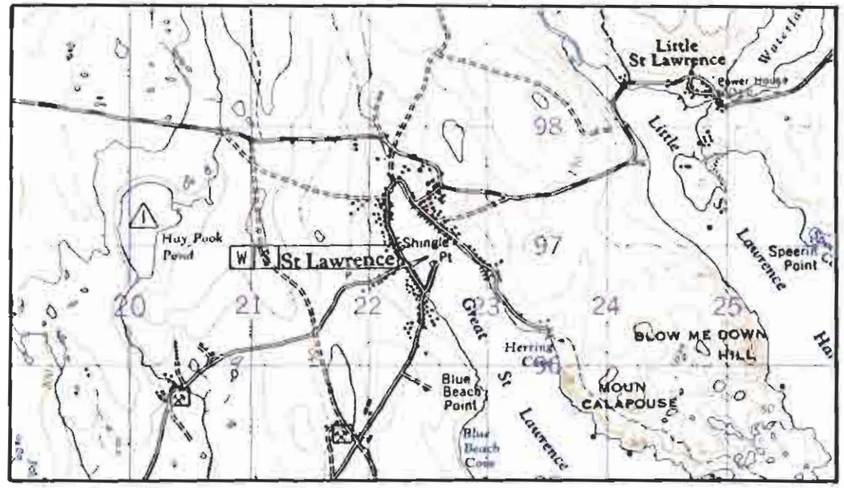
1. COMMERCIAL FISHING AREA
2. ATLANTIC SALMON AREA
3. FUTURE FRESHWATER SOURCE FOR PLACENTIA
4. STORAGE RESERVOIR SITES

LEGEND:

W S COMMUNITY WITH WATER SUPPLY AND WASTEWATER DISPOSAL SYSTEMS

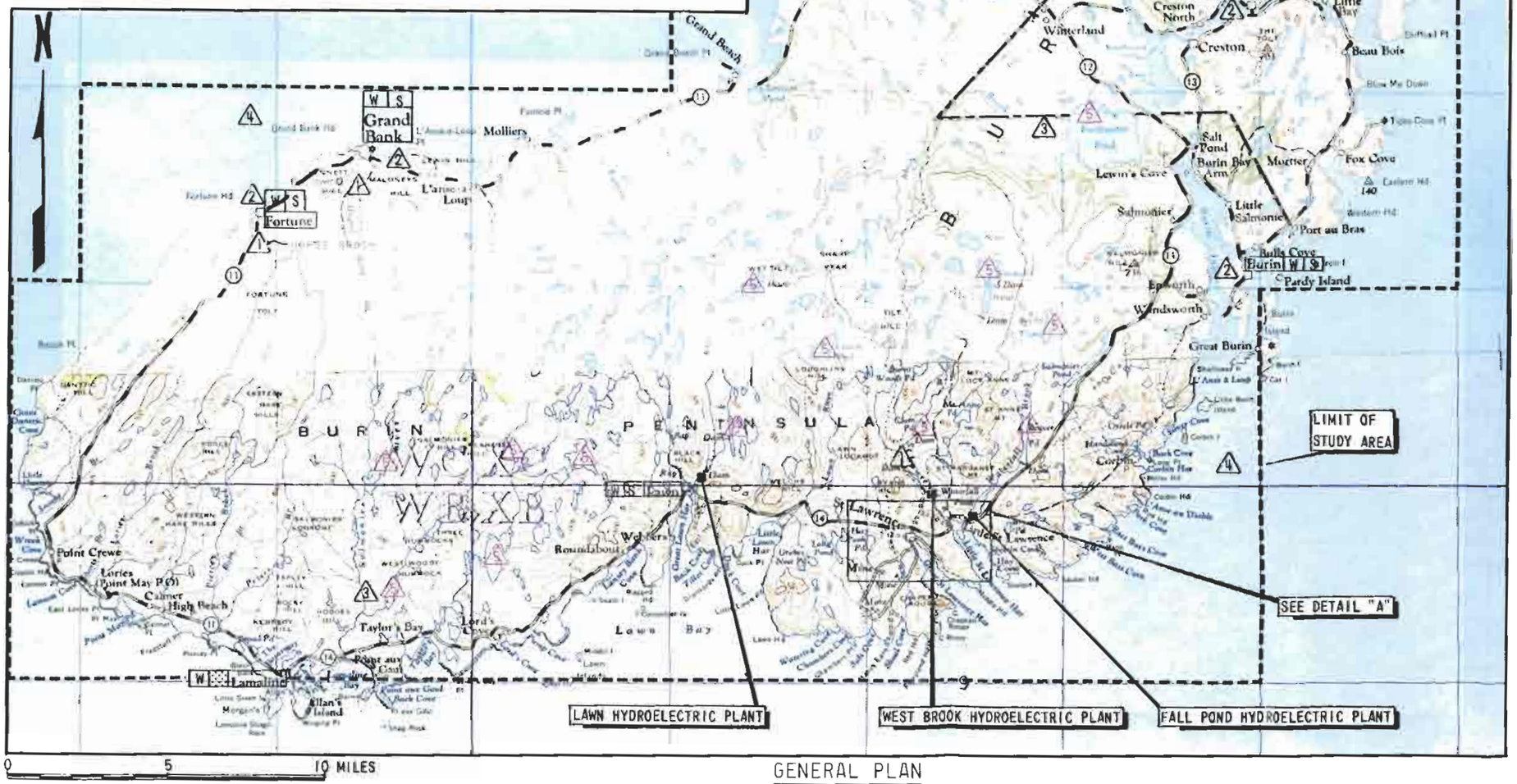
COME BY CHANCE STUDY AREA

FIGURE 4-12



0 ½ 1 MILE

DETAIL "A"



0 5 10 MILES

GENERAL PLAN

NOTES:

POTENTIAL FUTURE DEVELOPMENTS AND PROJECTS UNDER CONSTRUCTION SHOWN IN RED

1. WATER SUPPLY SOURCE
2. FREEZING AND FISH MEAL PLANT
3. ATLANTIC SALMON AREA
4. COMMERCIAL FISHING AREA
5. STORAGE RESERVOIR SITES

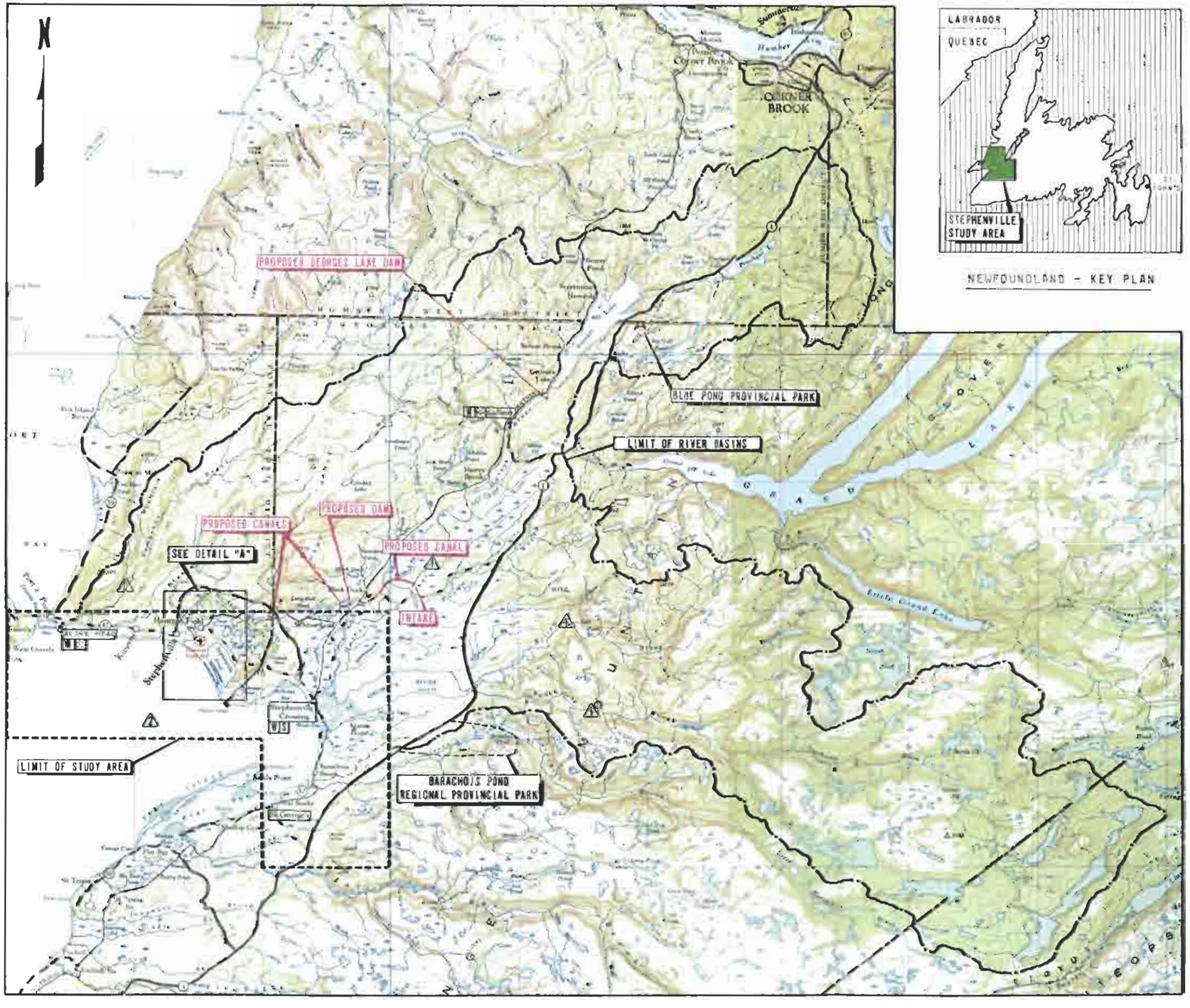
LEGEND:

- MINES
- W S — COMMUNITY WITH WATER SUPPLY AND WASTEWATER DISPOSAL SYSTEMS
- W — COMMUNITY WITH WATER SUPPLY SYSTEM ONLY

NEWFOUNDLAND - KEY PLAN

BURIN PENINSULA STUDY AREA

FIGURE 4-13



GENERAL PLAN

NEWFOUNDLAND - KEY PLAN

DETAIL "A"

NOTES:
ROUTING OF PROPOSED WATER SUPPLY FOR STEPHENVILLE AREA SHOWN IN RED

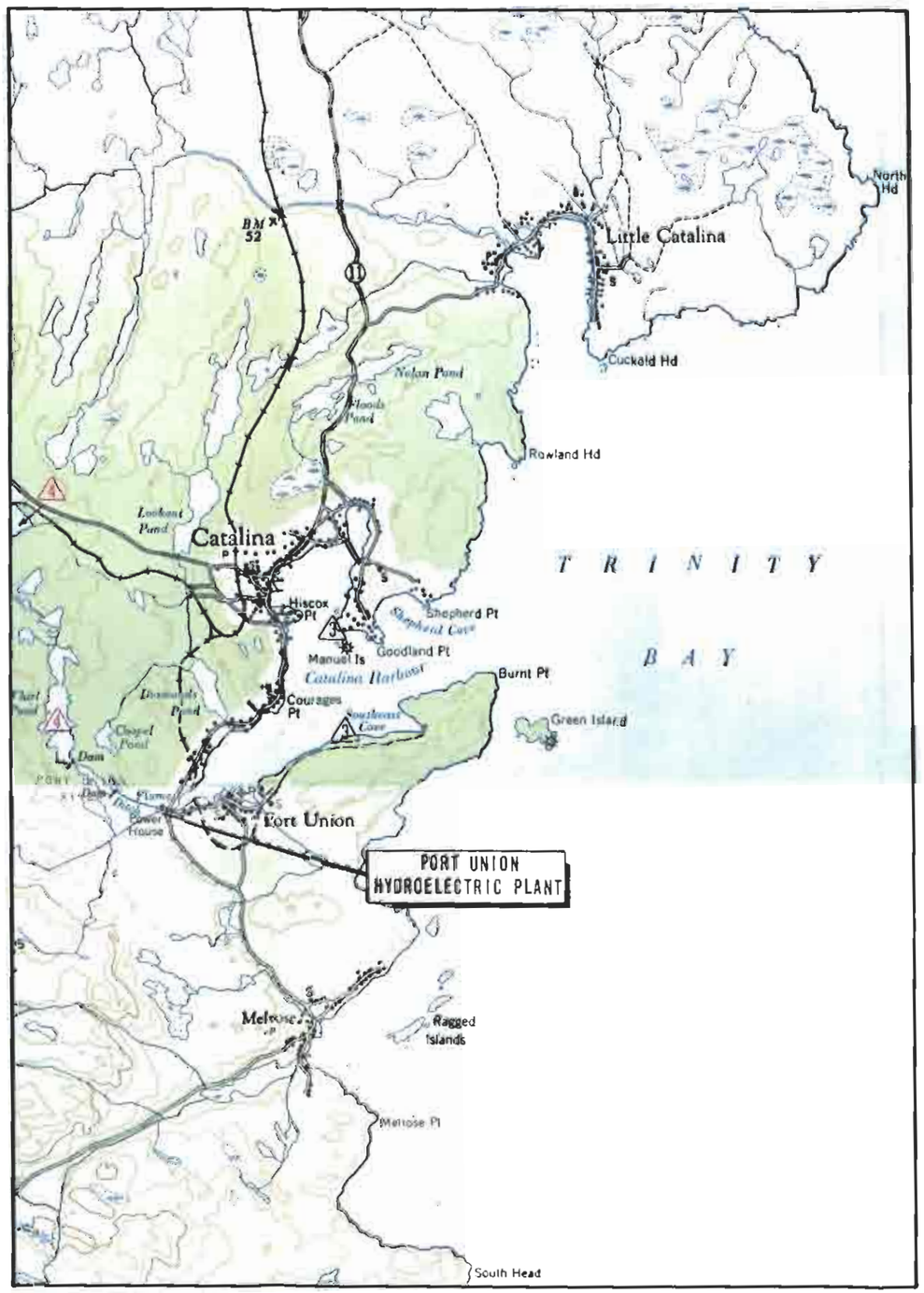
1. ATLANTIC SALMON AREA
2. COMMERCIAL FISHING AREA
3. WATER SUPPLY SOURCE

LEGEND:
- W|S COMMUNITY WITH WATER SUPPLY AND WASTEWATER DISPOSAL SYSTEMS
- W COMMUNITY WITH WATER SUPPLY SYSTEM ONLY

FIGURE 4-14

GENERAL PLAN

0 5 MILES



DETAIL "A"

0 1/2 MILE

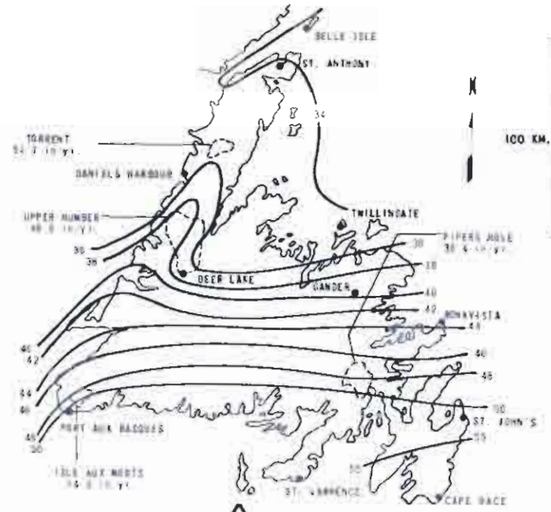
NEWFOUNDLAND - KEY PLAN

NOTES: POTENTIAL FUTURE DEVELOPMENTS SHOWN IN RED

1. ATLANTIC SALMON AREA
2. COMMERCIAL FISHING
3. FISH PROCESSING PLANTS
4. POSSIBLE STORAGE RESERVOIR

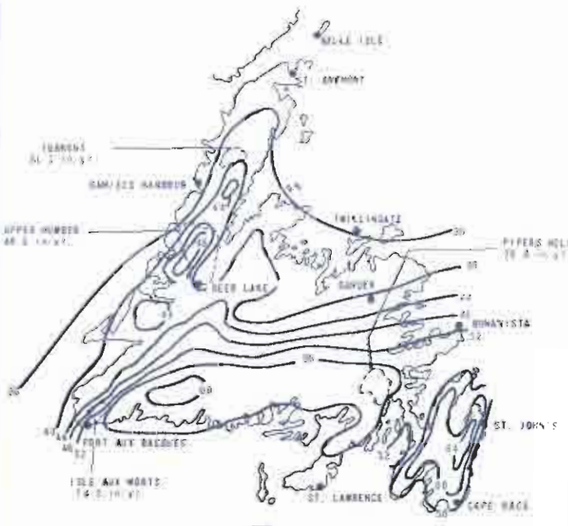
BONAVISTA PENINSULA
STUDY AREA

FIGURE 4-15



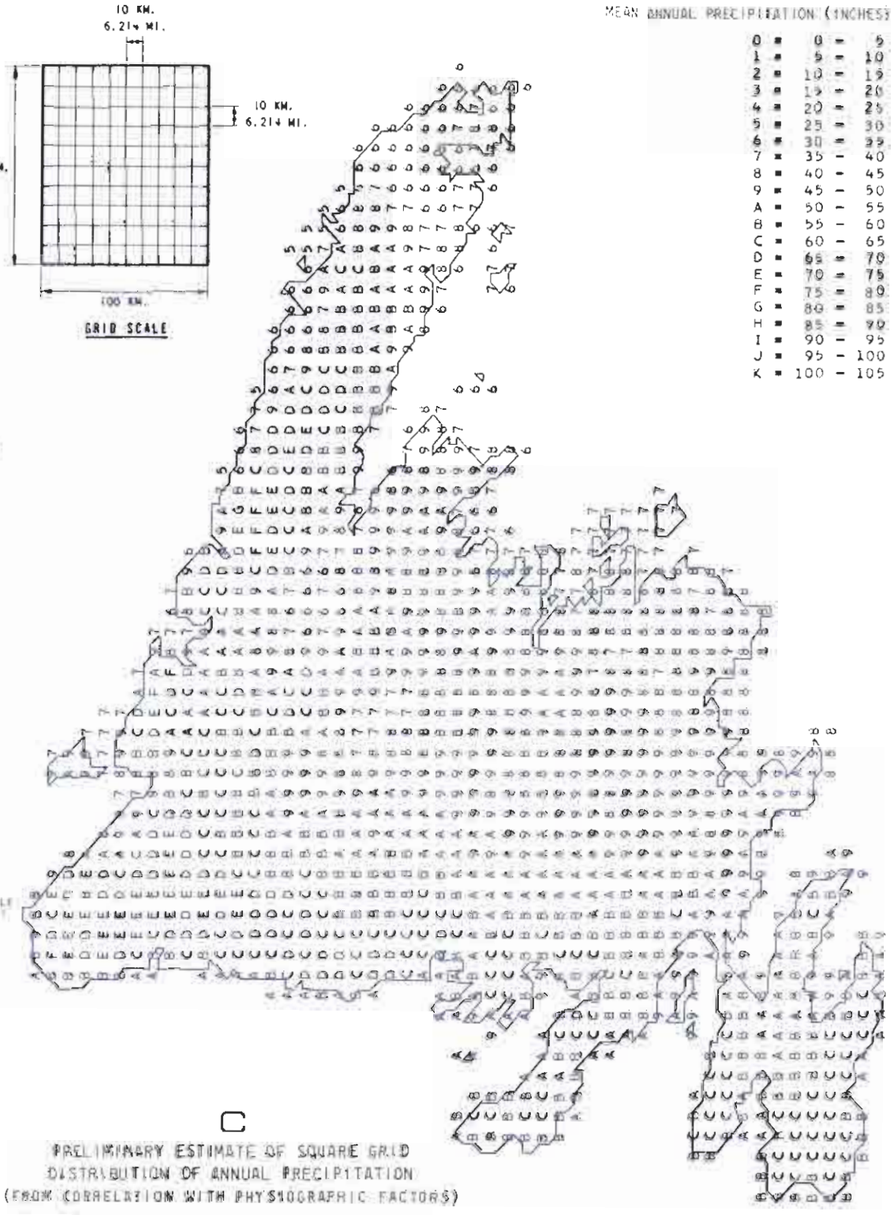
A

ANNUAL PRECIPITATION DISTRIBUTION (INCHES)
ACCORDING TO THE ATLAS OF CANADA
(DEPARTMENT OF MINES AND TECHNICAL SURVEYS, 1957)



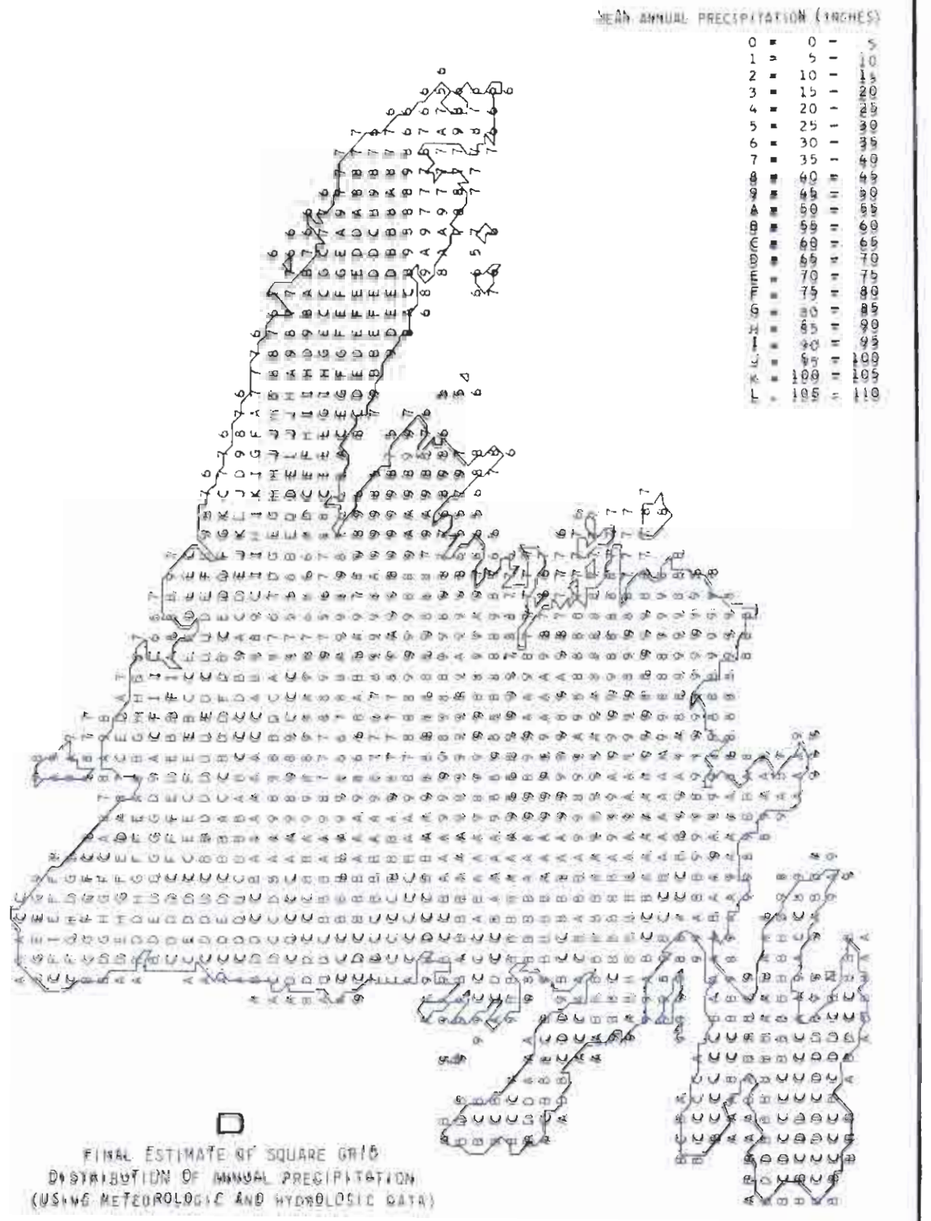
B

REVISED ANNUAL PRECIPITATION DISTRIBUTION (INCHES)
(DEPARTMENT OF TRANSPORT -
METEOROLOGICAL BRANCH WORKING DOCUMENT)



C

PRELIMINARY ESTIMATE OF SQUARE GRID
DISTRIBUTION OF ANNUAL PRECIPITATION
(FROM CORRELATION WITH PHYSIOGRAPHIC FACTORS)



D

FINAL ESTIMATE OF SQUARE GRID
DISTRIBUTION OF ANNUAL PRECIPITATION
(USING METEOROLOGIC AND HYDROLOGIC DATA)

NEWFOUNDLAND

PROGRESSIVE DERIVATION OF
MEAN ANNUAL PRECIPITATION
DISTRIBUTION

FIGURE 5-1

WATER RESOURCES STUDY
ORGANIZATION CHART

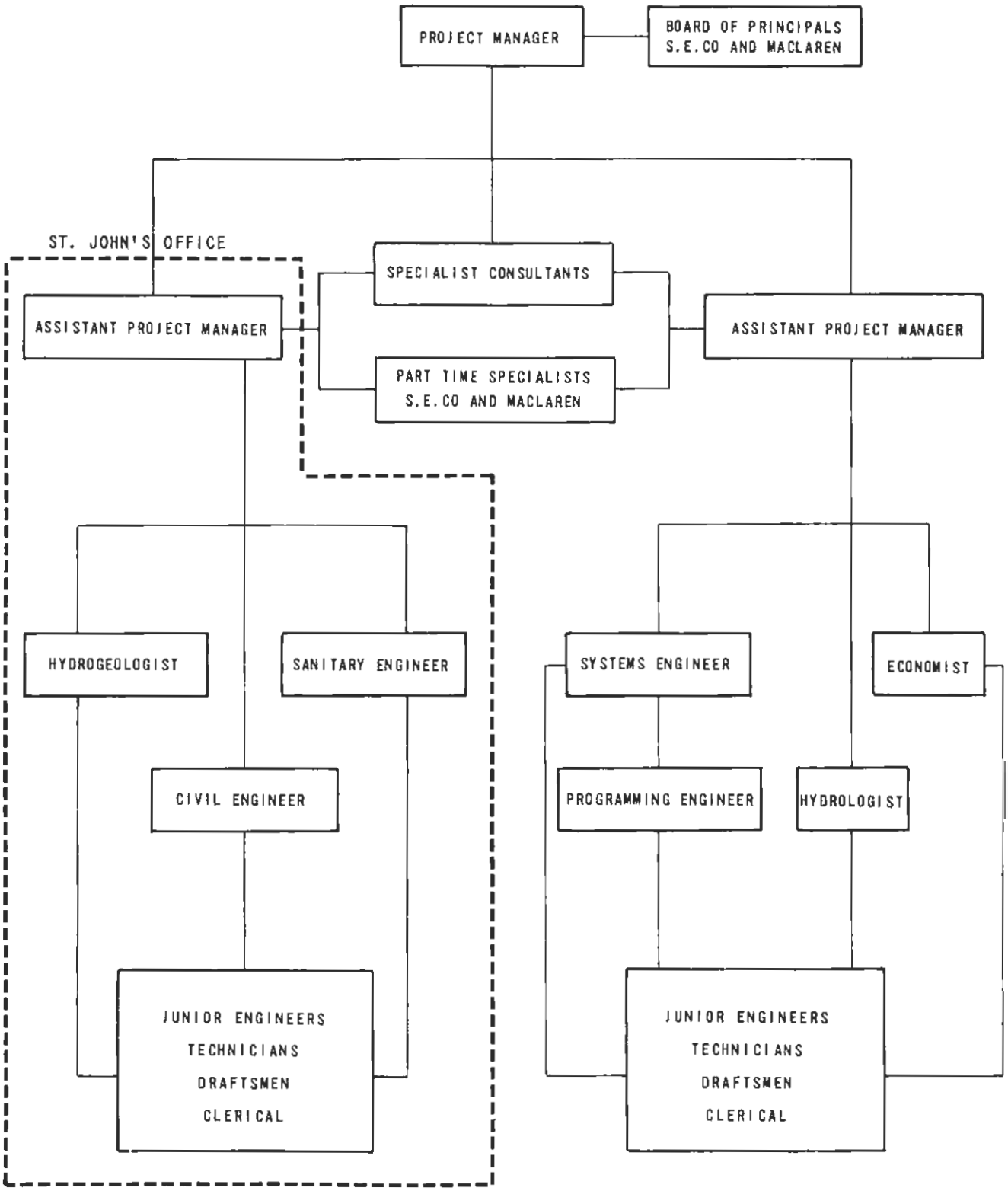
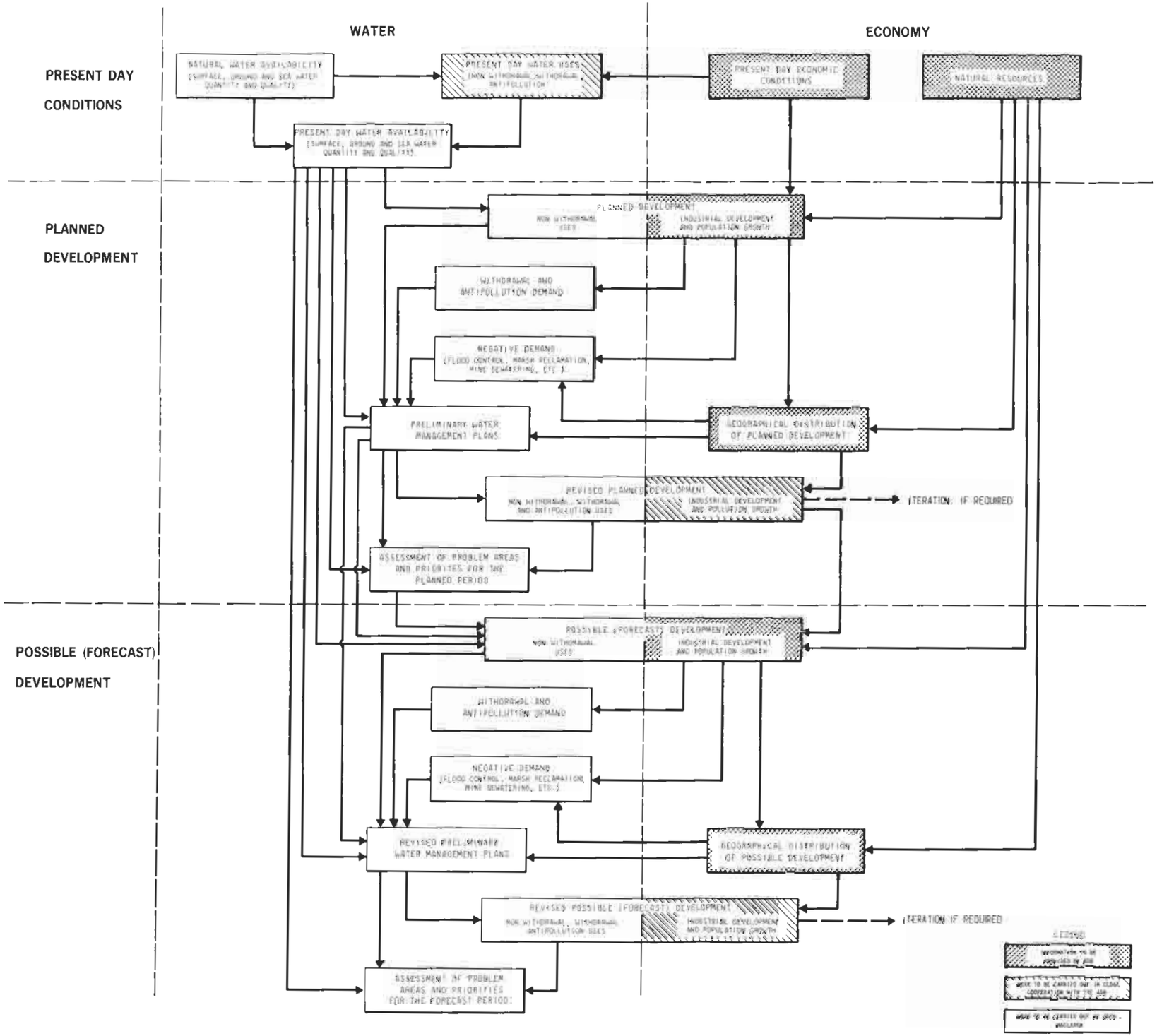


FIGURE 6-1



SIMPLIFIED METHODOLOGIC PRECEDENCE CHART

A DETAILED METHODOLOGIC PRECEDENCE CHART MAY BE OBTAINED FROM THE CONSULTANT UPON REQUEST

FIGURE 6-2

EXPLOITS RIVER BASIN

EFFECT OF USE OR DEVELOPMENT ON / CONSIDERED TYPE OF USE OR DEVELOPMENT		HYDRO ELECTRIC POWER			ANADROMOUS FISHERIES			LAND LOCKED FRESH WATER FISHERIES			SALT WATER FISHERIES			LOG DRIVING			RECREATION AND TOURISM			INLAND WATERS NAVIGATION			SOIL AND BANK EROSION PROBLEMS			FLOODING PROBLEMS			BOG RECLAMATION PROBLEMS			MUNICIPAL WATER SUPPLY			MUNICIPAL WASTE WATER DISPOSAL			INDUSTRIAL WATER SUPPLY			INDUSTRIAL WASTE DISPOSAL			MINE DEWATERING					
		E	S	P	E	S	P	E	S	P	E	S	P	E	S	P	E	S	P	E	S	P	E	S	P	E	S	P	E	S	P	E	S	P	E	S	P	E	S	P	E	S	P	E	S	P	E	S	P
HYDRO-ELECTRIC POWER	E	0	−	−	−		−			±	−		−	±		±	±		±	±		±	±		±	±		±			0	+		+	+		+	+		+	+		+	−		−			
	S	−	0	±	−		−			±	−		−	−		−	±		±	±		±	±		±	±		±			0	−		−	−		−	−		−	−		−	−		−			
	P	−	+	0	−		−			±	−		−	−		−	±		±	±		±	±		±	±		±			0	−		−	−		−	−		−	−		−	−		−			
ANADROMOUS FISHERIES	E	−	−	−	0		+			X	X		X	−		−	+		+	0		0	0		0	0		0			0	0		0	−		−	0		0	−		−	0		0			
	S																																																
	P	−	−	−	+		0			X	X		X	−		−	+		+	0		0	0		0	0		0			0	0		0	−		−	0		0	−		−	0		0			
LAND LOCKED FRESH WATER FISHERIES	E																																											0		0			
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	P	±	±	±	X		X			0	0		0	−		−	+		+	0		0	0		0	0		0			0	0		0	−		−	0		0	−		−	0		0			
SALT WATER FISHERIES	E	0	0	0	−		−			0	0		−	0		0	−		−	0		0	0		0	0		0			0	0		0	0		0	0		0	0		0	0		0			
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	P	0	0	0	−		−			0	−		0	0			−		−	0		0	0		0	0		0			0	0		0	0		0	0		0	0		0	0		0			
LOG DRIVING	E	−	−	−	−		−			−	−		−	0		0	−		−	±		±	−		−	−		−			0	−		−	−		−	−		−	−		−	0		0			
	S																																																
	P	−	−	−	−		−			−	−		−	0		0	−		−	±		±	−		−	−		−			0	−		−	−		−	−		−	−		−	0		0			
RECREATION AND TOURISM	E	−	−	−	−		−			−	−		−	−		−	0		±	+		+	−		−	0		0			0	−		−	−		−	0		0	−		−	0		0			
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	P	−	−	−	−		−			−	−		−	−		−	+		0	+		+	−		−	0		0			0	−		−	−		−	0		0	−		−	0		0			
INLAND WATERS NAVIGATION	E	−	−	−	−		−			−	0		0	±		±	+		+	0		+	0		0	0		0			0	−		−	0		0	0		−	0		0	0		0			
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	P	−	−	−	−		−			−	0		0	±		±	+		+	+		0	0		0	0		0			0	−		−	0		0	−		−	0		0	0		0			
SOIL AND BANK EROSION PROBLEMS	E	−	−	−	−		−			−	−		−	−		−	−		−	0		−	0		0	−		−			0	−		−	−		−	−		−	−		−	0		0			
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	P	−	−	−	−		−			−	−		−	−		−	−		−	−		−	0		0	−		−			0	−		−	−		−	−		−	−		−	0		0			
FLOODING PROBLEMS	E	−	−	−	0		0			X	0		0	0		0	±		±	0		0	−		−	0		±			−	0		0	0		0	0		0	0		0	−		−			
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BOG RECLAMATION PROBLEMS	E																																																
	S																																																
	P	0	0	0	−		−			−	0		0	0		0	X		X	0		0	0		−	0		0			0	−		−	−		−	−		−	−		−	0		0			
MUNICIPAL WATER SUPPLY	E	−	−	−	0		0			0	0		0	−		−	−		−	0		−	0		0	0		0			0	0		0	−		−	0		0	0		−	0		0			
	S																																																
	P	−	−	−	0		0			0	0		0	−		−	−		−	−		−	0		0	0		0			0	0		0	−		−	0		0	−		−	0		0			
MUNICIPAL WASTE WATER DISPOSAL	E	0	0	0	±		±			±	−		−	0		−	0		−	0		0	0		0	0		0			0	−		−	0		−	−		−	0		−	0		0			
	S																																																
	P	0	0	0	±		±			±	−		−	−		−	−		−	0		0	0		0	0		0			0	−		−	−		−	−		−	−		−	0		0			
INDUSTRIAL WATER SUPPLY	E	−	0	−	0		0			0	0		0	−		−	0		0	0		0	0		0	0		0			0	0		0	0		−	0		0	0		−	0		0			
	S																																																
	P	−	0	−	0		0			0	0		0	−		−	0		0	0		0	0		0	0		0			0	0		0	−		−	0		0	−		−	X		X			
INDUSTRIAL WASTE DISPOSAL	E	0	0	0	−		−			−	−		−	0		−	−		−	0		0	0		0	0		0			0	−		−	−		−	−		−	0		−	0		0			
	S																																																
	P	0	0	0	−		−			−	−		−	−		−	−		−	0		0	0		0	0		0			0	−		−	−		−	−		−	−		−	0		0			
MINE DEWATERING	E	0	0	0	−		−			−	−		−	0		0	−		−	0		0	0		0	0		0			X	−		−	−		−	−		−	−		−	0		0			
	S																																																
	P	0	0	0	−		−			−	−		−	0		0	−		−	0		0	0		0	0		0			X	−		−	−		−	−		−	−		−	0		0			
	E																																																
	S																																																
	P																																																

LEGEND

E EXISTING USE OR PROBLEM
S USE OR PROBLEM DURING THE STUDY PERIOD
P POTENTIAL USE OR PROBLEM

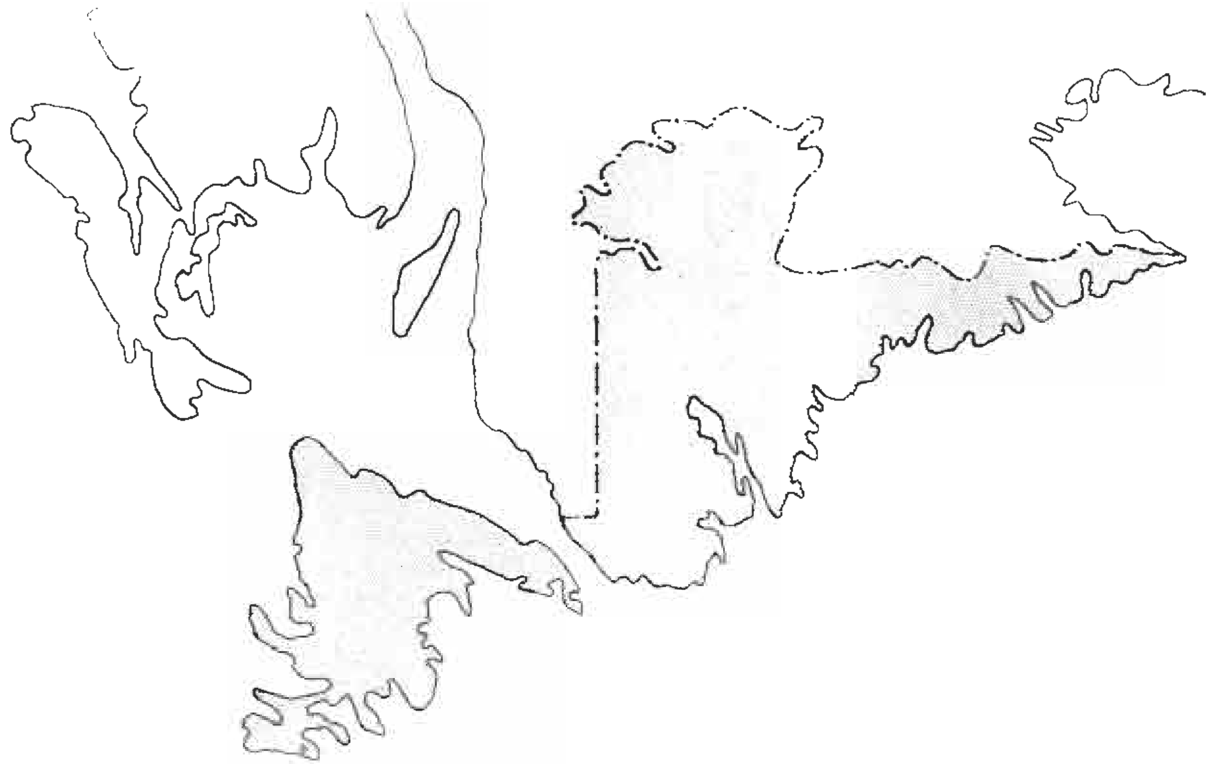
+ POSITIVE EFFECT OR BENEFIT
X POSSIBLE POSITIVE EFFECT OR BENEFIT
− POSSIBLE NEGATIVE EFFECT, LOSS OR RESTRICTION
— NEGATIVE EFFECT, LOSS OR RESTRICTION
0 NEGLIGIBLE EFFECT

NOTE:

INPUTS FROM SINGLE PURPOSE USES OR DEVELOPMENTS AND SINGLE ASPECT PROBLEMS

NEWFOUNDLAND
INTERACTION BETWEEN WATER RESOURCES USES AND PROBLEMS

FIGURE 6-3



TERMS OF REFERENCE

FOR

ATLANTIC PROVINCES WATER RESOURCES STUDY

INTRODUCTION

The work to be done by the Consultant in Stage I of the more comprehensive study, as outlined in the Agreement, may be described more specifically under the following phases:

Phase A: Water demand

Phase B: Water supply

Phase C: Analysis of demand and supply and identification of problems, possibilities and priorities

The data for this study will be compiled and analysed at levels of detail and precision commensurate with the accuracy and detail of the data available and in accordance with the purposes of this study. The study will examine:

1. Study Areas adjacent to selected concentrations of economic activity.

2. River Drainage Basins comprising all the significant river basins.

These study areas and river basins will be selected in consultation with the Supervisory Committee. The criteria for the selection of study areas and river basins will include but will not be limited to:

(a) existing and projected population size and distribution;

(b) existing and projected patterns and levels of economic activity.

With respect to the basic water supply data, it is the intention that in general the entire province or provinces will be covered.

PHASE A: WATER DEMAND

General

This phase of the study will examine the current use of water and estimate future needs through 1981 with an indication of requirements beyond this point. Special attention will be given to the multi-purpose uses of water resources.

The kinds of demand will be classified as follows, taking into consideration both quantity and quality:

(a) Consumptive Use

- i. Domestic
- ii. Municipal
- iii. Primary industry
- iv. Industrial and Commercial

(b) Non-consumptive Use 1/ 2/

- i. Transportation
  - (1) Navigation (Commercial)
  - (2) Log driving

1/ This classification includes certain purposes which may be partially consumptive, e.g., power and effluent disposal.

2/ Where water is diverted from one river basin to another, all such water must be regarded as a consumptive use as far as the original water basin is concerned.

ii. Fish

(1) Habitat preservation and development

(2) Commercial

(3) Sport

iii. Wild-life

(1) Habitat preservation and development

(2) Sport

iv. Recreation

v. Power

vi. Effluent disposal

While the quantitative analysis of use will be made principally on the basis of the consumptive uses, it must be recognized that the non-consumptive uses may be equally or more important. The competitive or complementary requirements of the non-consumptive uses will be examined in relation to the consumptive uses.

Use of water for hydro-electric power production is usually non-consumptive but its use may be competitive or complementary to the consumptive uses of water at a particular location or at a particular time of the year. Plans for projects of this nature will be examined to determine their effect on supplies available for consumptive uses.

Uses such as fish and wild life, recreation and effluent disposal, which often compete with consumptive uses, will be considered where applicable in relation to water supplies for consumptive purposes.

The quality classification will be made by chemical, radiological, bacteriological and thermal characteristics where the data are available.

Consideration will also be given to both annual and peak utilizations.

1. Current Requirements

The Consultant will compile an inventory of the present demand for water in terms of both quantity and quality.

2. Future Requirements

The Consultant will make a forecast of the demand for water through 1981, with an indication of requirements beyond this point, taking into consideration both quantity and quality. The forecasts will be based upon economic studies presently available and the assumptions to be agreed to by the Supervisory Committee.

The forecast will consider:

(a) Population growth and distribution.

(b) The growth and location of the economic development that may take place.

(c) Effects of changes in the level of income in the region and changes in the level of prices paid for water.

(d) Industries with a comparative advantage as far as water supply is concerned.

(e) The infrastructure that represents important factors in the location of economic activity.

(f) Technological changes affecting water use.

i. Re-use of water

ii. Improvement of efficiency of water use

iii. Substitution of salt water for fresh water

In the assessment of water quality, consideration will be given to:

(a) Advances in the technology of treating salt water and fresh water

(b) Technological changes in industry which may make certain industrial processes more or less sensitive to the quality of water.

The Consultant will develop appropriate tables and comments indicating the quantity and quality of water for different kinds of major water users and indicate how these measures change with changes in scale of output and price of water. The list of major water users will be determined in consultation with the Supervisory Committee.

PHASE B: WATER SUPPLY

1. The Compilation and Analysis of Existing Data on Natural Water Resources

This phase of the study will include the compilation, review and analysis of all existing basic data pertaining to the hydrometeorology, surface water, ground water and quality of water. The Consultant will also describe the reliability of the data for the purposes of this study, identify duplication of data collection, redundant data collection, and insufficient co-ordination of data collection 1/ and make recommendations for improving data collection networks.

The Consultant will give attention to man's activities which cause changes in water quantity and quality. The Consultant will also give attention to the physical characteristics of the region as it affects the natural water resource.

The studies to be included under this compilation and analysis are given in more detail as follows:

(a) Hydrometeorology: Preparation of isohyetal maps of mean annual precipitation. Studies of snow accumulation and snowmelt. Studies of rainfall frequency and storm intensity and duration. Studies of evaporation rates and amounts.

1/ (a) Identify those areas where there is a copy of the same data being undertaken or processed by more than one agency.
(b) Identify those areas where data are being obtained which is of no use or at best of marginal use.
(c) Identify those areas where data or parts of the total data required are being gathered but because of jurisdiction, co-ordination, etc., an incomplete picture results.

(b) Surface Water: Preparation of maps showing lines of equal annual runoff. Regional study of co-efficient of variation, co-efficient of skew and frequency of annual runoff. Study of distribution of runoff within the year and preparation of regional typical hydrographs. Study of regional co-efficients for unit hydrographs. Regional frequency analyses of floods and low flows.

(c) Ground Water: Compilation, review and analysis of all available data on presently significant and potentially significant aquifers referring to their quantity and quality of water. Indication in a report with maps those areas which are suitable for ground water prospecting and ground water development. Indication of those areas where management of ground water aquifers is essential owing to the possibilities of over pumping and/or salt water intrusion.

(d) Sea Water: Studies of existing data on the availability of surface or ground salt water in treated or untreated form.

(e) Quality of Water: Evaluation of quality of surface water, ground water and sea water. General identification of their suitability for non-consumptive and consumptive uses, based on existing analyses of chemical, radiological, physical, bacteriological and thermal characteristics. An evaluation of changes in water quality at key points in river basins where water quality may be affected by changes in water use and development as a result of man's activities.

2. The Compilation and Analysis of Existing Data of Existing Water Facilities and Major Structures on Surface Water Resources

An inventory of municipal and industrial intake, well systems, pumping and treatment plants and a survey of water qualities available from such plants. The identification of existing dams and major structures on surface water resources, including fish facilities, that affect the regime or could cause significant constraint on the use of the water.

3. Future Development

A study will be made of the development possibilities of the water resources at a level necessary to meet the purposes of "Phase C, Analysis of Demand and Supply and Identification of Problems, Possibilities and Priorities", including:

(a) The identification of potential dam sites and reservoir areas, including possible pumped-storage sites.

(b) Preliminary appraisals of storage capacity of reservoirs, areas inundated and silt deposition in the reservoirs.

(c) Identification of possible inter-basin diversions, as to locations, feasible diversion quantities, pump lifts and canal capacities plus appraisal of the effect on both original and recipient water-sheds.

(d) Identification of estuaries where possibilities exist for the construction of fresh water storage reservoirs and preliminary appraisals of storage capacity.

(e) Within limits of existing data, assessment of ground water potential based on the natural cycle of re-charge, discharge and storage and considering the possibilities of artificial re-charge.

(f) Planned or feasible extensions to existing facilities to improve water quantity and quality, including supply facilities, structures, fish facilities, storage facilities, pump capacity, treatment facilities.

(g) Commentary on the importance of the existing and future technological applications affecting water supplies, including:

i. Desalinization

ii. Weather modification

iii. Evaporation control

iv. Watershed management

v. Pollution control

vi. Improvement in efficiency of water transport

vii. Improvement in efficiency of weather forecasting

viii. Improvement in efficiency of conservation of water supplies

ix. Improvement in efficiency of water treatment with specific attention to treatment of iron, manganese and organics

x. Factors to be included in an economic evaluation of the use of sea water for cooling purposes

(h) Consideration of deterioration in quantities and qualities of water supplies resulting from increased population and economic activity, e.g., thermal build-up, reductions in oxygen, increased chemical concentrations.

Cost estimates of works of an order-of-magnitude nature will be prepared based upon a degree of detail and level of investigation and cost estimating criteria to be decided in consultation with the Supervisory Committee.

PHASE C: ANALYSIS OF DEMAND AND SUPPLY AND IDENTIFICATION OF PROBLEMS, POSSIBILITIES AND PRIORITIES

This phase of the study will integrate the information obtained in the water demand and water supply phases of the study. The purposes of this phase will be:

1. The identification of areas where supply is sufficient to meet the expected future demand or can be developed at a reasonable cost. Criteria for the cost factors used are to be decided in consultation with the Supervisory Committee.

2. The identification of areas where an abundant water supply exists or can be developed at a reasonable cost and which hold promise for expansion in economic activity but where no known demand for water presently exists.

3. The identification of areas where shortages can be expected to develop on the basis of projected requirements.

4. The identification of areas where conflicts in uses exist or can be anticipated.

5. The identification of areas where water resource management is enhancing or reducing the water supply, including such things as erosion, stream alteration, road building practices, flooding, forestry practices.

This phase will also suggest the ranking of areas according to their priority for detailed development planning studies on the basis of the following criteria:

1. The present and emerging needs for water and their relative importance.

2. The benefits that would accrue expressed in quantitative and/or qualitative terms where feasible in the judgement of the consultant.

3. The natural supply available.

4. The capital investment costs of constructing works.

5. The operating costs of works.

6. The maintenance costs of works.

7. Associated costs.

8. Third party benefits and damages.