WATER RESOURCES STUDY

of the

PROVINCE OF NEWFOUNDLAND AND LABRADOR

for

ATLANTIC DEVELOPMENT BOARD

Volume SIX A

RIVER BASINS

THE SHAWINIGAN ENGINEERING COMPANY LIMITED
JAMES F.MacLAREN LIMITED

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RIVER BASINS

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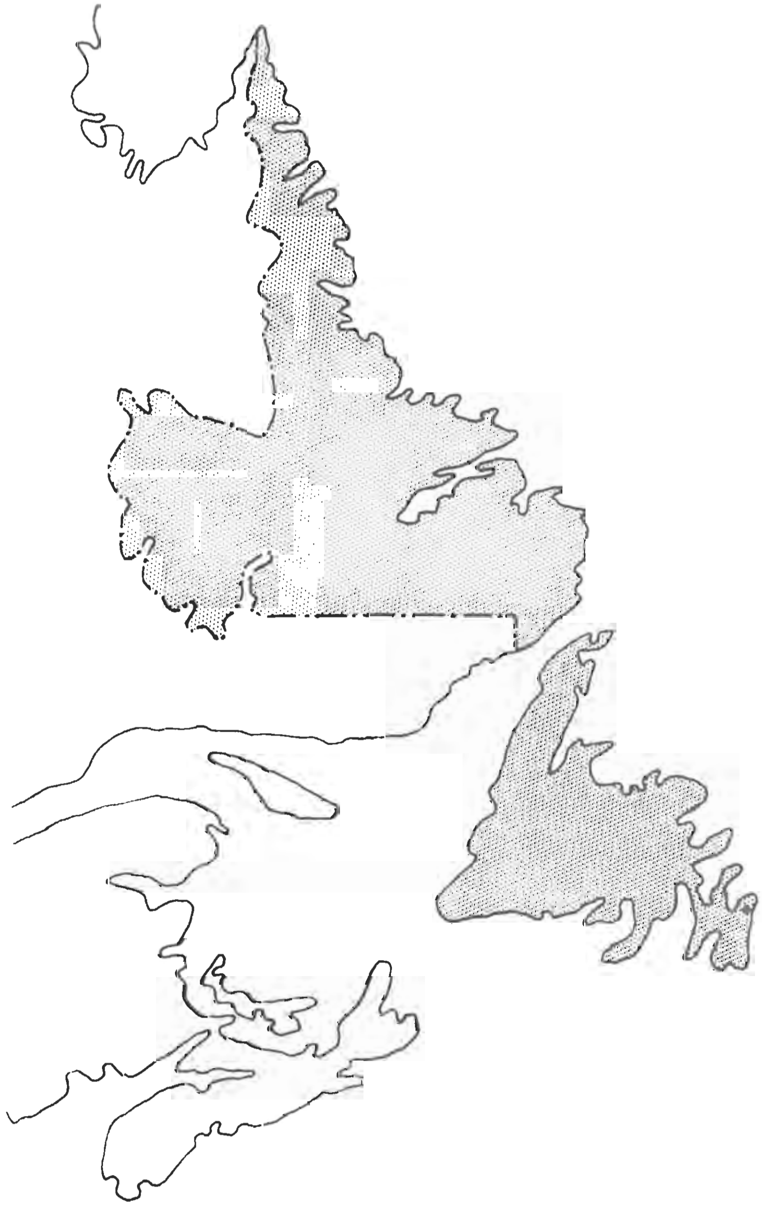

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EXPLOITS RIVER BASIN AND BADGER - BOTWOOD STUDY AREA

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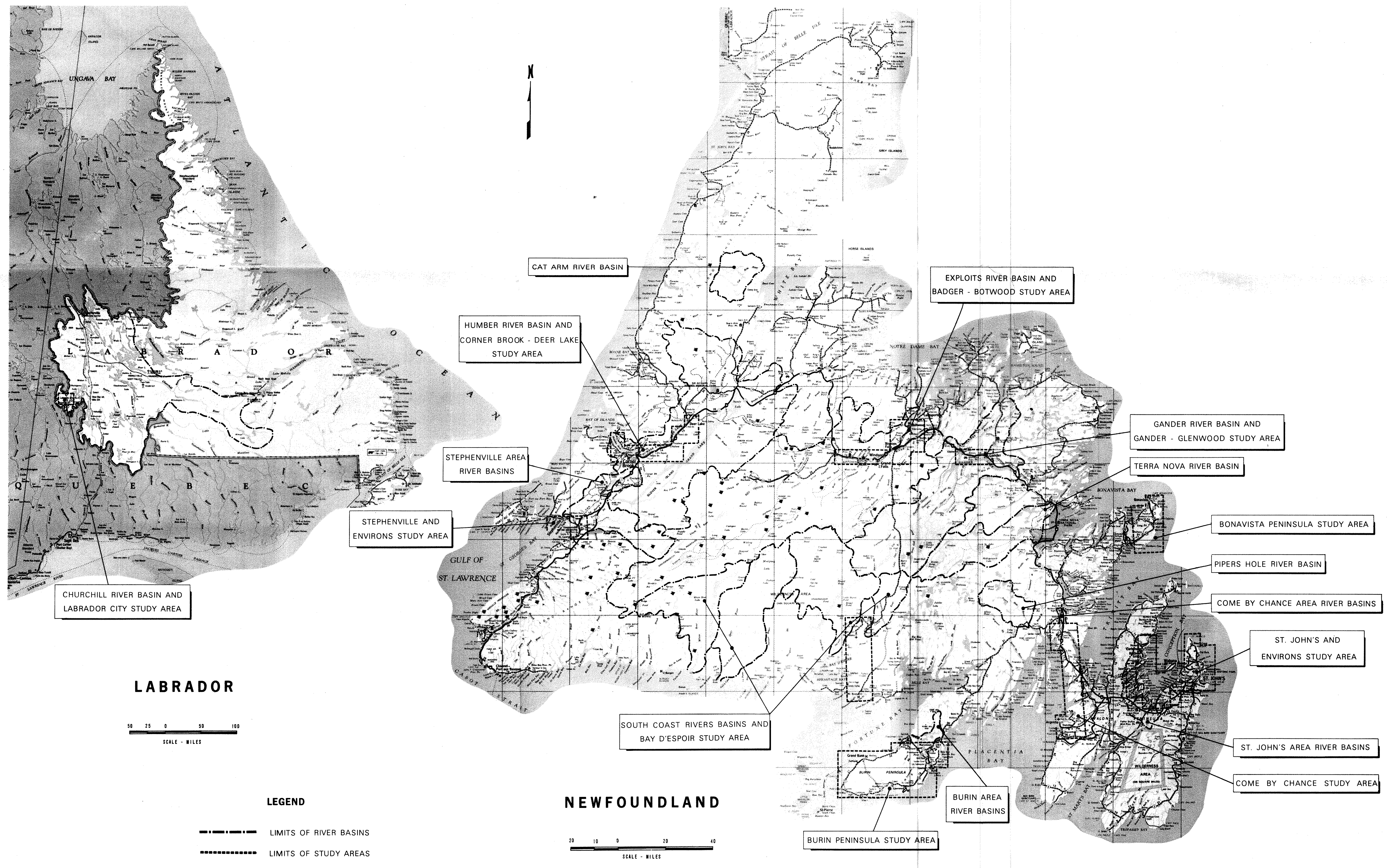

NEWFOUNDLAND AND LABRADOR
RIVER BASINS AND
STUDY AREAS

PART I - EXPLOITS RIVER BASIN AND BADGER-BOTWOOD STUDY AREA

1 NATURAL CONDITIONS

The natural drainage area of the Exploits River above the mouth is over 4,400 square miles, and it is the largest basin on the Island of Newfoundland. The basin can be considered as consisting of two main sections: the upper basin, which is upstream of the Exploits Dam at the Red Indian Lake outlet; and the lower basin, consisting of the area downstream of the Exploits Dam.

The largest tributary which flows into Red Indian Lake is the Victoria River which is in the southern part of the upper basin. The next largest tributary in the upper basin is that of the Lloyds River. The Shanadithit Brook, Star Lake, and Buchans Brook comprise the remainder of the main tributaries of Red Indian Lake. The lake, which is the largest in the Exploits system, has a surface elevation about 500 feet above sea level. The Annieopsquotch Mountains and the Long Range Mountains, located in the upper basin area, have peaks which exceed 2200 feet. The topography, drainage pattern, road system and towns in the basin and details of the Badger-Botwood study area are shown in Figure 1-1.

The Exploits River proper commences at the outlet of Red Indian Lake from where it flows a distance of about 70 miles to the salt water of the Bay of Exploits. On route to the sea several tributaries join the main river stem, the largest of which are Noel Pauls Brook, Sandy Brook, and Great Rattling Brook.

1.1 Physiographic Conditions

The total natural drainage area of the Exploits River is 4945 square miles which includes the drainage into the salt water of Bay of Exploits as shown in Figure 1-1. The drainage area includes 420 square miles of lakes, 809 square miles of bog or marshes, and 638 square miles of barrens. The square grid distribution of lakes, marshes or bogs, and barrens throughout the basin is shown in Figure 1-3.

There are many large lakes in the basin, including Red Indian, Victoria, Long, North Twin, South Twin, Mary Ann, Sandy, Buchans, Star, King George IV, and Lloyds Lakes.

The hypsographic curve of the basin is given in Figure 1-4. The square grid distribution of other physiographic characteristics, elevation, and slope distribution is shown in Figure 1-5. The climate is cool and humid with a mean annual temperature of 37.8 degrees, a mean annual precipitation of 46.5 inches, and a mean annual evaporation of 15.0 inches. The square grid distribution of mean annual temperature, precipitation, and evaporation in the basin is shown in Figure 1-6. Climatic characteristics are summarized in Table 1-4.

The Exploits River basin cuts right across the mobile belt in the centre of the Island. In this region the rocks are sedimentary and volcanic of Ordovician and Silurian age. There are igneous rocks, with granitic and ultra basic rocks to the northwest and ultra basic rocks to the east of Grand Falls. There is also an area of Devonian volcanic rocks to the south of Grand Falls. In the vicinity of Red Indian Lake there is a small area of sedimentary Carboniferous rocks, with Silurian volcanics, and more granitic and ultra basic rocks to the north and west of the lake. The Buchans mining area is situated in the Silurian volcanic rocks near the lake. The basin above Red Indian Lake is situated mainly on highly metamorphosed rocks of Ordovician, Silurian, and Devonian age, with numerous igneous intrusions of varying composition.

The surficial deposits of the Exploits Basin consist largely of ground and ablation moraine, with some areas of ribbed moraine at the southern edge of the basin. The moraine deposits are known to be thick in some parts of the basin, with a maximum thickness of 157 feet recorded at Buchans. Over most of the area, however, the thickness is probably 30 feet or less with areas of exposed rock on high ground and extensive swamps on low ground and on parts of the high plateaux.

1.2 Water Resources and Potential Uses

1.2.1 Surface Water

There are no river gauging stations*, and the hydrologic data in the basin are confined to the information from four flow-recording hydro plants (Grand Falls and Bishops Falls on the Exploits River;

* Except for the gauging station on the Victoria River, which was established recently (October 1966), and where the flows are also affected by changes in storage of Victoria Lake which is used for log driving operations.

Rattling Lake on Rattling Brook; and Sandy Brook on Sandy Brook). The hydrologic data at these stations, especially at Grand Falls and Bishops Falls, are affected by the three types of errors discussed in Volume Two A, Part IV. Therefore, the hydrologic characteristics of the area have been derived from the generalized relationships with physiographic and meteorologic factors and have been checked only for general consistency with the flow recorded at the power plants. The variation of the mean annual runoff in the basin, as derived from these relationships, is indicated in Figure 1-6.

However, since the monthly flow variation at Grand Falls was required in this study for various purposes, the monthly flow at Grand Falls was corrected for changes in storage and increased by 1000 cfs - the finally estimated average error - and as such accepted as a fair estimate of the required flow data. (Table 1-2).

The variation of the mean monthly and annual flows in the lower portion of the basin has been assessed from the flow of the Rattling Brook at Rattling Lake. The missing data at this station were synthesized by correlation with the flows at Grand Falls. Since the correlation is curvilinear, the particularities of the flows in the lower part are reflected in the synthesized flows (Table 1-3). The variation of the flows in the upper portion of the basin has been considered to be similar to that in the neighbouring basin of the Lewaseechjeech Brook at Little Grand Lake. The flows of the Victoria River have been considered consequently proportional to those of the Lewaseechjeech Brook; the proportionality factor being the ratio between the average flows at the two locations. The average flow of the Victoria River was computed by using the relationship between average runoff and physiographic characteristics developed in Volume Two A, Part IV. The hydrologic characteristics are summarized in Table 1-5.

The quality of the surface waters in the Exploits River basin has been affected by man's activities to a far greater extent than any of the other major river basins in the Island. The Exploits River has been utilized as a receiving stream for untreated domestic and industrial wastewaters for many years. Domestic wastewaters originate principally from Windsor, Grand Falls, and Bishops Falls, while industrial wastewaters originate from the base metal mining operations at Buchans and the pulp and paper mills at Grand Falls. In recent years treatment of the mining wastes has reduced the concentration of heavy metals in the Exploits to a level below that harmful to Atlantic Salmon; in addition, treatment of domestic wastewaters has been initiated by the municipality of Badger on the Exploits River thereby reducing bacteriological pollution of the river to some extent.

A review of available chemical and physical analyses in the Exploits River throughout most of its length has indicated that these waters are extremely low in total dissolved solids, having a total equivalent per million of less than 0. 3. The waters are very soft, the hardness expressed as $CaCO_3$ averaging about 10 ppm, with the maximum recorded value being 21 ppm during the period 1955 to 1967. Turbidities are generally less than 3 units; the maximum recorded value since 1955 was 15 ppm, although it is quite likely that values in excess of that have occurred during flood flows.

The surface waters of the Exploits River basin are coloured to the extent of 35 units on the average, the recorded colour during the years 1955 to 1967 ranging from a minimum of 15 units to a maximum of 75 units. The pH of the waters analyzed ranged from 5. 3 to 7. 4 with most values about 6. 8. None of the analyses reviewed indicated excessive concentrations of the minor chemical constituents such as iron, manganese, fluorine, etc., which would limit the suitability of the waters for domestic or industrial purposes.

The only bacteriological data available on the surface waters of the basin was a single grab sample taken from the Exploits River below Bishops Falls; a coliform count of 1000 per 100 ml was detected in the sample. Such a relatively high count is not surprising in view of the quantity of domestic wastewater discharged into the river upstream of the point of sampling.

Water quality extrapolations for various sections of the basin are summarized in Table 1-6.

1.2.2 Groundwater

The groundwater potential of the basin is summarized in Table 1-1. Groundwater provides the main source of supply to small communities in the basin. In most of these communities the supply is derived from the surficial materials. The distribution of surficial materials is shown in Volume Two. There is a cover of surficial material over practically the whole of the basin, the only exceptions occurring in areas of high ground where there may be patches of exposed bedrock. More than 60 percent of the basin is covered with ground and ablation moraine, which varies widely in thickness. The ribbed moraine, which occupies about 38 percent of the area of the basin, will vary rapidly in thickness within a short distance, ranging from about 50 feet thick to 10 feet or less. There are often marshy conditions in the hollows between ridges, but these cannot be indicated on a map to the scale used in Volume Two. There are substantial areas of marsh or bog occupying about 16 percent of the basin; in these areas it is difficult to obtain surficial supplies owing to the poor quality of the water in the bogs. No areas of alluvial material are shown on the map, but there are some minor sand and gravel deposits along the course of the river. The water supply at Bishops Falls is obtained from infiltration wells situated in gravels close to the river.

The groundwater potential of the bedrock is discussed in Volume Two. Only a limited number of wells have been drilled in the bedrock in this area, but the mean depth of wells drilled in the bedrock on the Island in each of the bedrock units represented in the basin is given in Table 1-1. Unit R1 which occupies 32.6 percent of the area is the dominant unit in the basin: most of the area is taken up by granitic rocks, but some basic and ultra basic rocks are included which may give rise to poor quality water. Unit R6, occupying 24.7 percent of the basin, is the next most important followed by unit R5 with 22.6 percent of the area. There may be some poor quality water in the rocks of unit R5 which are of volcanic origin, but no analysis has been made. Unit R4 occupies most of the rest of the basin, and there is one area of rocks belonging to unit R7, carboniferous sediments. Carboniferous sediments in this basin are different from those elsewhere in that they have been relatively unaltered since the time of their original deposition. They consist mainly of sandstones and should be a source of groundwater of good quality and in good quantity.

The limited data available on the quality of the groundwater gave no indication of any widespread problems with respect to the chemical constituents of the groundwater. On the other hand two sources of bacteriological pollution were identified. The first concerned shallow wells where bacteriological pollution had resulted from their proximity to inadequate sewage disposal facilities. The second concerned two municipal wells at Bishops Falls and was caused by the infiltration of river water which supports bacteria resulting from the decaying pulpwood caught along the river banks.

1.2.3 Hydro Power

The gross hydro-electric potential of the main river has been computed by means of the runoff distribution map and the river profiles taken from the 1:250,000 scale maps. The major possible sites are delineated on Figure 1-7.

Schemes involving potential diversions were also considered. The most interesting possible scheme was the one already studied by ShawMont (Report SM-1-66) which concerns the diversion of the Victoria River to the Lloyds River. The development would take advantage of the steep escarpment along the south bank of the Lloyds River (Figure 1-8). The development involves raising the Victoria Lake level to provide storage and facilitate the diversion. The total drainage area would be 440 square miles, the developed head 420 feet, and the installed capacity 80,000 hp at 60 percent capacity factor. In these conditions, the estimates indicate a firm energy cost of 6.6 mills/kwh at the plant for annual fixed charges of 6.73 percent.

Detailed investigations by ShawMont (Report SM-2-67) indicate that the inter-basin diversion of the Victoria River to Bay D'Espoir is much more attractive from the viewpoint of electric energy production (Figure 1-9).

Report SM-2-67 by ShawMont states that the cost of energy made available by the Victoria Lake diversion at the Bay D'Espoir terminal station would be 2.89 mills/kwh for an annual fixed charge of 7.55 percent after losses and compensation allowances for the flow reduction at the Grand Falls and Bishops Falls plants. This cost is increased to approximately 4.2 mills/kwh for an annual fixed charge of 6.73 percent when the additional generating facilities at Bay D'Espoir are included, compared to a cost of 6.6 mills/kwh for the Victoria Lake to Lloyds River diversion scheme.

Construction of a peaking plant to develop the head existing between Victoria Lake and the Lloyds River was also investigated in the ShawMont Report SM-1-66 prior to the investigation of the Victoria River diversion possibilities. A peaking plant at this location may still be feasible after the diversion, discussed in Section 3, since it would probably be competitive with pumped storage sources of peaking power.

1.2.4 Fresh Water and Anadromous Fish

The Exploits River is currently inhabitated by Atlantic salmon, speckled trout, ouananiche, Arctic char, and eels, as well as a few other fish. Because of the barrier formed by the falls and the power dam at Grand Falls, anadromous fish are unable to utilize that portion of the Exploits River and its tributaries upstream of Grand Falls. A natural fishway exists at Bishops Falls which enables salmon to bypass the low power dam located there. It is hard to ascertain what the fish population of the basin would have been without the Grand Falls dam; but, according to the studies completed by the Canada Department of Fisheries, the total annual potential production is very large, amounting to an annual production of 135,000 adult Atlantic salmon as well as some speckled trout. A particular feature of the basin, which is considered of importance by the Canada Department of Fisheries, is the sport fishing area potential. The many miles of rivers and streams in the area above Grand Falls which could be populated by salmon present possibilities for outstanding development. In addition, the existing and potential lakes offer interesting possibilities for species of fish from the mainland which exist under similar environmental conditions but which do not populate the Island's waters because of particular geologic conditions.

In analyzing the fish potential of the basin, attention has to be paid to the quality of water not only from the viewpoint of man-induced conditions, but also, as mentioned earlier, of the presence of heavy metal minerals in the basin.

1.2.5 Navigation and Log Driving

Although the Exploits is the largest river on the Island, because of the presence of falls, navigation potential is limited to small draught logging tugs and pleasure craft. Any significant increase in the size of the boats on the main river stem would require specially designed projects.

The log driving potential of the river and its tributaries is limited under natural conditions to high flow periods, which normally occur during the spring.

1.3 Natural Resources

The present and future development of the basin is strongly related to its natural resources. The fact that the Exploits basin is one of the few inland areas of the Island which was settled more intensively (present day population about 30,000) is due to an advantageous combination of three main resources: water (and related potential), forests, and minerals. In addition, there is the natural wealth of wildlife and land suitable for industrial development and possibly agriculture, especially in the lower portion of the basin.

1.3.1 Forests

At the present time, the forested areas of the Exploits River basin covers 3088 square miles or approximately 63 percent of the basin area, according to the Department of Mines and Technical Surveys 1960, 1:250,000 scale topographical maps. The relative density of the forest area in the basin is indicated in Figure 1-3. The timber limits owned by Price (Nfld) Pulp and Paper Limited are shown in Figure 1-10.

Data on the variation of the forest area over a period of time are not available. However, it may be presumed that the forest area is progressively decreasing due to soil erosion following severe forest fires as in the Miguel Hill area, south of Grand Falls, or occasionally due to over-cutting, as in the area above the north side of Victoria Lake. In addition construction of hydro power dams has resulted in the flooding of some forested areas.

1.3.2 Minerals

The known metallic mineral reserves are listed and shown on Figure 1-2. They include copper, zinc, lead, silver and gold. Possibilities of finding other deposits of commercial size on the companies' chartered lands are excellent.

In 1963, Asarco (Buchans) made an important find in the basin (Tulks Pond - Reid Lot 228) by investigating geochemical anomalies. According to the Department of Mines and Technical Surveys[1] the importance of this find cannot be over-emphasized because the zinc-lead-copper-silver deposit occurs in Ordovician rocks and is geologically similar to the Bathurst, New Brunswick area.

At the present time, only two non-metallic minerals are known to occur in the Exploits River basin - barite and sulphur. Both ore bodies are found in the Buchans area.

1.3.3 Recreation, Tourism, and Wildlife

The natural conditions, especially the extensive network of lakes and rivers with their fishing potential, the existing wildlife, and the general environmental conditions represent an important tourism and recreation potential. However, climatic conditions and the long distance from large population centres somewhat reduce the possibility of full development of the potential.

The drainage area of the Exploits River is the habitat for all species of big game, as well as for many species of small game. Moose and black bear are plentiful, and the Buchans caribou herd which inhabits the area is one of the largest of such herds on the Island.

A number of fur-bearing species inhabit the area adjacent to the Exploits River and they are taken locally for their fur. Among these animals, the more important are beaver, otter, fox, and muskrat.

Some rock ptarmigan are present in the plateau areas near Buchans. Ruffed grouse were successfully introduced into the area of the Exploits River basin near Badger.

1.3.4 Agriculture

The 1955 Royal Commission on Agriculture indicated that there are areas in the interior of the basin sufficiently level and with soil suitable for agricultural use.

Of the fourteen areas recommended for field investigation, five lay in the Exploits Basin:

a) Glaciofluvium and recent alluvium between Badger and Grand Falls

b) Glaciofluvium, south of Badger

c) End moraine, east of the Exploits River and south of Badger

d) Ground moraine, east of the Exploits River and south of Badger

e) Lands adjoining the east and west shores, near the southern tip of Red Indian Lake.

One of the largest areas lies directly south of the junction of the Exploits River and Noel Pauls Brook, starting about five miles south of the Buchans branch of the railway. It is estimated to be about 125 square miles.

In addition, the drainage area downstream from Bishops Falls to the head of the Bay of Exploits is considered one of the areas most suitable to agriculture on the Island[2].

2 PRESENT DAY DEVELOPMENTS

The Exploits River basin has been one of the few areas where the Island's population has ventured towards the interior because of the attraction of its natural resources. Consequently an extensive road network has developed and much of the interior is accessible by road as shown in Figure 1-1. The river itself has contributed to development of the interior as a source of power and transportation of logs.

2.1 Non-Withdrawal Water Demand and Supply

2.1.1 Hydro Power Development

Development of the hydro-power potential of the basin commenced in 1909 with the Grand Falls and Bishops Falls plants, in connection with the pulp and paper mill described in Section 2.2.3. These developments have been the main reason for locating the mill at Grand Falls, and not at tide water, since electric energy transmission over long distances was not developed at the time. Logs were transported to Bishops Falls where they were ground into chips and pumped back a distance of nine miles through a pipeline to Grand Falls for further processing.

Later (1927) a mining company developed a small power plant on the Buchans Brook which is now on standby only. Two more power plants of 17,000 and 8,000 hp were developed on tributaries to the Exploits River in 1958 and 1963 (the Rattling Brook and Sandy Brook).

Table 2-1 gives details of the hydro plants on the Exploits Basin.

The Grand Falls plant has an installed capacity of 43,500 hp electrical plus 22,000 hp hydraulic power connected to grinders. The average annual electric energy production for the years 1954 to 1966 inclusive was 207 million kwh. The main storage reservoir is located at Red Indian Lake. Very little pondage is provided at Grand Falls, and the plant must handle the uncontrolled runoff from the drainage area downstream of the storage dam. This situation results in spilling of the water over the low concrete dam which is 882 feet long and averages 25 feet in height, with wings on either end extending the length a further 500 feet. Adjacent to the forebay is a steel sluice gate 20 feet wide by 19 feet high. The dam was built across the river at the top of the falls.

The Bishops Falls plant, located downstream from Grand Falls, has an installed capacity of 22,300 hp and produced an average of 89 million kwh per year in the period 1954 to 1966 inclusive. The Red Indian Lake storage is also utilized by this plant and the pondage situation is similar to that at Grand Falls, resulting in wastage of water over the dam.

The combined total operation and maintenance costs have risen continuously over the years at these two plants.

The Sandy Brook plant, located upstream of Grand Falls on a tributary of the Exploits basin, has been completed since 1963 and provides additional storage facilities for the two downstream plants. The development prevents the use of Sandy Brook for Atlantic salmon stock unless means of by-passing the hydro facilities are provided.

The installation of the Rattling Brook plant in 1958 prevented use of the area upstream for Atlantic salmon stock. The Department of Fisheries of Canada successfully transferred the run of Atlantic salmon from this area to Great Rattling Brook, a tributary of the Exploits between Grand Falls and Bishops Falls.

2.1.2 Fisheries

From the viewpoint of fisheries the Exploits River basin is divided into three sections by natural and man-made obstructions. The first section is from the river mouth to Grand Falls; the second from Grand Falls to the dam at the outlet of Red Indian Lake comprising one-third of the drainage area; and the third section is the 2,300 square mile area above the dam at the outlet of Red Indian Lake.

The storage dam at Red Indian Lake, known as the Exploits Dam, is a concrete structure 1,421 feet long and from 30 to 40 feet high with abutments. There are 12 steel gates for regulating the discharge, all electrically operated. The spillway structure has 26 openings and a total of 195 feet of spillway. A tramway runs across the dam connecting the village of Millertown to the woods roads of the interior.

A natural fish passage at Bishops Falls enables salmon to by-pass the small dam at that point, but they are unable to use the river above the Grand Falls power dam because of a succession of chutes and violent rapids downstream of the dam which are over a mile in length and have a total drop of about 105 feet.

Although there is no commercial fishing on the Exploits River or its tributaries, the Atlantic salmon reared in these waters contribute to the commercial salmon fishery carried on in the sea adjacent to the Bay of Exploits; of more importance are the benefits derived from the sport fishing in the Exploits River and its tributaries.

From 1952 to 1966 the average number of salmon including grilse caught in the Exploits River and its tributaries each year by anglers was reported by the Fisheries Research Board of Canada to be 577 with a total average annual weight of 2608 pounds. No records are available on the catch of other fish. The Exploits River is a major salmon river, and probably ranks sixth in the number of fish angled each year in the Province, and is exceeded only by the Humber, Gander, Harrys, Salmonier, and Conne Rivers in descending order. The variation in annual anglers' catch from 1953 to 1966 is shown in Figure 2-1. As shown, the anglers catch per rod-day has decreased from about 0.6 in 1953 to 0.2 in 1966. This decrease in success ratio is probably due to a combination of factors including the increase in angling pressure and problems of main stem pollution.

The Canada Department of Fisheries began bio-engineering investigations in the Province a little over ten years ago, and the Provincial Government urged the Department to give high priority to the development of Atlantic salmon stock in the Exploits River. The Department have devoted a major part of the efforts of the Resource Development Branch staff in the Province to this subject.

Departmental biologists have reconnoitered the entire river basin. They have examined in detail the main river and major tributaries from the viewpoint of fisheries potential; they have examined conflicting industrial problems and conducted water quality surveys to seek solutions to potential dangers to fish resources; they have successfully introduced an Atlantic salmon run to a hitherto inaccessible area of a tributary in the first section, Great Rattling Brook; they have introduced salmon to an artificial spawning channel constructed on Noel Pauls Brook, a major tributary above Grand Falls in the second section. The Department have spent a total of $500,000 in investigations and capital works leading to future development.

In addition, Price (Nfld) Pulp and Paper Limited have spent an estimated $25,000 in fisheries remedial works at the request of, or in conjunction with, the Department of Fisheries.

The Department believes that the Exploits has an excellent potential for salmon sport fishing. It has over a thousand miles of water which is accessible or can be made so in numerous tributaries as well as on the main river. With the ability to collect upstream migrating salmon at the proposed fish facility at Grand Falls, adult fish could be transported throughout the watershed, by-passing obstructions, to the most suitable release sites for sport fishing or spawning requirements. A major commercial fishery could be supported at the river mouth to harvest salmon not required to "escape" to satisfy recreational fishing demands and spawning stock needs.

The present fisheries resources of the Exploits River has survived in spite of the many other uses of the river by man which have been steadily increasing since the early part of the century. Fortunately, man's activities have not dealt a lethal blow to the fisheries resources. However, the diversion of the upper drainage area involving a portion of the Victoria and Lloyds River, discussed in Section 3, may aggravate existing pollution to the point of jeopardizing all main stem fisheries resources below Red Indian Lake and all anadromous fish using the Exploits as a migration route. Furthermore, a portion of the watershed environment necessary for future development of a major stock of Atlantic salmon could be lost by such a diversion.

The pollution problems which have developed on the Exploits River over the years, and the activities of the Canada Department of Fisheries in the pollution problems of the Exploits River basin are outlined below. Information on pollution was obtained from various sources 3-5.

The problems are classified according to the source of the pollutant.

a) Wastes from the Mining Industry

Section 2.2.1 describes the characteristics of the mines in the basin, their water demand, and the amount and characteristics of the waste waters. The following discussion is related to the effect of these waste waters in fishery resources:

Wastes from the Buchan's mine are a source of concern as ore tailings discharged from concentrators have physical as well as chemical effects on the fish population. The physical effects are due to turbidity resulting in smothering and gill irritation.

The chemical effects are caused by the tailings which carry lead, copper, and zinc in solution. The solid tailings are a continuous source of supply of copper and zinc ions to the receiving waters. Lead is generally fairly rapidly precipitated and is a lesser problem.

Zinc and copper in solution are toxic to fish life at very low concentrations. Sprague [6] has shown that zinc at 420 ug/l and copper at 32 ug/l in Newfoundland waters are the concentrations at which an organism can no longer survive for an indefinite period - the incipient lethal level (ILL). With this value known, other concentrations of these substances may be expressed as multiples of the ILL. It has been shown that concentrations of dissolved zinc and/or copper equal to 0.4 of their additive ILL are the levels at which Atlantic salmon begin to be adversely affected under natural conditions. Analyses have been carried out by the Canada Department of Fisheries since 1961 on the copper and zinc concentrations in the Exploits River from the disposal of the Buchan's mines wastewater. Results are summarized below:

Exploits River Mine Waste Concentrations

Year	Month	Copper	Zinc
1961	September	20 ug/l to 30 ug/l	140 ug/l to 200 ug/l
1962	August	10 ug/l to 40 ug/l	50 ug/l to 360 ug/l
1963	August and September	4 ug/l to 17 ug/l	39 ug/l to 165 ug/l
1964	August and September	trace to 15 ug/l (1 result at 40 ug/l)	67 ug/l to 260 ug/l
1965	June to October	1.2 ug/l to 52 ug/l (2 results at 85 ug/l)	40 ug/l to 850 ug/l
1966	May to September	trace 77 ug/l (11.2% above 20 ug/l)	35 ug/l to 485 ug/l (10.7% above 250 ug/l)
1967	September	less than 20 ug/l	less than 200 ug/l

The results show that:

i) The 1965 concentrations were generally much higher than in previous years. This may have been due to low precipitation and the consequent release of larger than normal volumes from Red Indian Lake for power production and log driving.

ii) Since Exploits River sampling began in 1961, concentrations of both copper and zinc have been, in the majority of cases up to 1966, 0.4 ILL or higher. Since it has been determined for other rivers that values of 0.4 to 0.5 are sufficient to disturb adult salmon migration and cause fish to return downstream, this is an undesirable situation[7].

iii) The Buchan's mine started to treat their wastes by impoundment early in 1966. The effect of this, combined with the normally high pH in the mine tailings, is to precipitate the heavy metals (copper and zine) as hydroxide and to reduce their concentration. In November 1966, weekly sampling of Buchans Brook, which carries the mine wastes to Red Indian Lake, commenced and was scheduled to continue for at least twelve months.

The apparent reduction in metal concentrations by impoundment is encouraging; however, as there is not yet sufficient evidence to indicate whether or not the bottom deposits in Red Indian Lake mentioned in Section 2.2.1 will be more detrimental than at present. Consequently, more data is required to determine if the apparent reduction in concentrations from Buchans mine would permit a reduction in the minimum flow requirements established by the Department of Fisheries with respect to pollution by heavy metals.

b) Wastes from Pulp and Paper Manufacturers

In Section 2.2.3 the Price (Nfld) Pulp and Paper Limited mill is described together with water demand both in terms of water use and waste water disposal. A survey of the quality of the Exploits River downstream from the Price mill was conducted in 1942[8] and no significant pollution such as would endanger fish population was reported at that time.

Since then, increased production has increased the wastes although this may be offset, to some extent, by the change from a calcium to a sodium base sulphite process. Nevertheless, the Canada Department of Fisheries is concerned about the quality of the river below Grand Falls especially under certain low flow conditions.

The main cause of pollution is sulphite waste liquor (SWL). This SWL exerts two main effects on fish population - a toxic effect on the fish themselves and a reduction of dissolved oxygen in the receiving waters which may make then unsuitable for fish life. These effects are a function of the SWL concentration in water which is in turn related to river flow.

In the area downstream of Grand Falls, the flow is seldom less than 5000 cfs (Figure 3-1) since the powerhouse requirement is of that order and additional water is provided from storage during low flow periods. These low flow periods usually occur during July and August, the time of the Atlantic salmon upstream migration to the spawning grounds. This flow of 5000 cfs is the equivalent of about 112,000,000 gph. The flow of sulphite waste liquor from pulp production is approximately 333 gpm or 20,000 gph.

In evaluating toxicity, it must be borne in mind that, in the experiments to determine critical levels of SWL[9], dissolved oxygen was artificially maintained; whereas in a natural situation the effect of toxicity would be added to that of lower dissolved oxygen. Considering toxicity alone, therefore, probably provides an over optimistic view of the present situation. In addition, the presence of other toxic substances (see wastes from the mining industry) may further complicate the actual conditions.

The SWL experiments[9] were based on a 10 percent total solids content. SWL spilled at Grand Falls has a total solids content of 11 to 14 percent. It is assumed in the following that it is adequately described by the average of this range, namely 12.5 percent total solids.

To compare the effect of SWL at Grand Falls with the experimental data[9] it is necessary to express SWL at Grand Falls in terms of 10 percent total solids. By this method, the hourly SWL discharge becomes about 25,000 gph of 10 percent SWL. Using this figure, the flow of SWL into 112,000,000 gph of river water gives a concentration of about 220 ppm SWL at river flow of 5000 cfs.

The same experiments showed that, at a SWL concentration of 500 ppm, a dangerous situation for young salmon was being approached. In these experiments, as noted earlier, dissolved oxygen level was artificially maintained, whereas in the natural situation it would be lowered by the concomitant oxygen demand of SWL; so that the situation would be less favourable to fish. However, the available experimental data are not sufficient to fully ascertain the detailed implications of SWL in the concentrations on Exploits River salmon and trout population for the following reasons:

i) Atlantic salmon may be slightly more or less susceptible to SWL than the Pacific species tested.

ii) Experiments were conducted on young fish. Adults may be more or less tolerant, but other work does not suggest that this would provide much greater long term resistance.

iii) SWL in the river is not uniformly distributed for several hundred yards below the outfalls. This means that in some areas concentrations are probably lethal, while in others they may be harmless.

iv) Sampling data is not sufficiently precise to accurately chart SWL concentrations in affected areas of the river.

It may be stated with confidence, however, that during the adult migration period which usually occurs during flow period of 5000 cfs (perhaps less at times due to powerhouse operations) there is a genuine cause for concern. During the smolt migration (May - June), river flows are usually well above summer low flow levels; so that SWL concentrations in most years should not reach dangerous levels at this time. Since most smolts originate well below Grand Falls (except those from Stony Brook), it is probable that, for the most of them, the worst zones of SWL pollution do not have to be traversed. There are, however, serious implications for development of the area above Grand Falls for salmon production since both adults and smolts from this area would have to pass through the worst areas of SWL concentrations.[4]

Experiments have also been conducted to determine whether migratory salmon (adult or young) would deliberately avoid areas of SWL pollution if cleaner water were available and thus escape the worst effects of traversing zones of serious SWL pollution. These experiments indicated that, for SWL concentrations from 300 to 1000 ppm, no well-established aversion could be demonstrated.

As noted earlier in addition to its direct toxic effects SWL has a large demand for dissolved oxygen. Obviously, the less water available to satisfy this oxygen demand, the more likely that depletion will occur. It is assumed in the following paragraph that minimum flows in the Exploits River are 5000 cfs, and that salmon require not less than 5 ppm dissolved oxygen to enable them to survive and carry out normal functions.

In the reference quoted earlier, Taylor [9], showed that at a low flow of 5000 cfs below Grand Falls and an average dissolved oxygen level of about 8 ppm about 100 tons of oxygen are available in the area of the outfalls. The oxygen demand of the waste products from one ton of calcium base sulphite pulp production is estimated to be some 600 pounds, though some authors report it to be as high as 700. Based on an average production of some 250 tons of sulphite pulp per day at Grand Falls, there is an approximate oxygen demand of some 150,000 pounds or about 75 tons. Therefore, from the point of view of the oxygen demand of SWL at low flows, it is obvious that a good situation does not exist since these calcium base sulphite pulp wastes require some 75 percent of the dissolved oxygen available. Oxygen determinations have shown some areas of the river to be below 2 ppm at times when the calcium base process was used at the mill. The situation may be alleviated at least partially by the fact that wastes may not be evenly distributed in the river; so that, while some areas may be almost devoid of dissolved oxygen, others may retain a sufficiently high level to enable fish to migrate through. Moreover, the maximum oxygen depletion actually occurs somewhere further downstream of the mill, and the flow may increase slightly before this section is reached.

The above comments refer only to the concentration of SWL and the depletion of dissolved oxygen. It is recognized that other factors are important in the ecology which may influence the river from the standpoint of fish.

In 1966, Price changed from a calcium to a sodium base sulphite process. It is expected that a decrease of up to 10 percent of the BOD of the sulphite waste liquor will result with the sodium base sulphite. However, Price has no immediate plans for the installation of a recovery plant which would have the effect of decreasing the BOD of the SWL even more.

The pollution situation resulting from the mill activities in the Exploits River at Grand Falls has resulted in a request by the Canada Department of Fisheries for the maintenance of a minimum flow of 5000 cfs at Grand Falls which provides a narrow margin of safety for the fish. Under present conditions this requirement is considered reasonable until it can be conclusively demonstrated that a lesser amount is acceptable from the viewpoint of fish tolerance, or measures to reduce pollutants released into the river are undertaken.

c) <u>Domestic Wastes</u>

The total population of the Exploits River basin in 1966 was just over 30,000 with about 27,000 of that number residing in the seven major municipalities of the basin as follows:

Badger	1,192
Bishops Falls	4,127
Botwood	4,277
Buchans	2,159
Grand Falls	7,451
Norris Arm	1,252
Windsor	6,692
Total	27,150

With the exception of Buchans which is located on Buchans Brook, west of Red Indian Lake, these municipalities are located in the lower basin. Bishops Falls is approximately nine miles downstream of Grand Falls and Windsor, and Badger is approximately 18 miles upstream of the Grand Falls-Windsor area. Of these seven major municipalities, only Badger treats its domestic waste waters prior to discharging them into the receiving stream which, with the exception of Buchans and Norris Arm*, is the Exploits River.

Based on the present population of about 27,000 in the major municipalities on the river, the BOD of the domestic waste waters discharged to the river is less than three tons per day. As noted earlier, the oxygen available in the river under natural conditions at a flow of 5000 cfs is about 100 tons per day; consequently the disposal of domestic waste waters - less than 10 percent of which are treated - into the river does not in itself create a significant demand on the available oxygen in the river. For example, the effect of the SWL on the Exploits River is equivalent, from the viewpoint of BOD, to the untreated wastes from a population of one million people, by far exceeding those of all the domestic wastes from the existing 30,000 population. However, discharge of sewage from the Grand Falls-Windsor area is in a section of the river already polluted by SWL and the effect of the nutrient salts in the sewage is such as to accelerate oxidation of SWL thereby worsening an already marginal oxygen condition in the river although there is an opportunity for natural re-aeration in the river downstream of the mill and powerhouse at Grand Falls.

2.1.3 Log Driving

Forest exploitation in the Exploits River basin is carried out almost entirely by Price (Nfld) Pulp and Paper Limited. According to 1966 approximate data, the company harvested wood from an area of 12,900 acres, obtaining 278,000 cords. This represents 60 percent of the area exploited and 73 percent of the wood used by the company in 1966.

The Exploits River itself, as well as all its major tributaries, is used for log driving. Pulpwood from outside the basin, such as the Burnt Berry Brook and other basins in the Hall's Bay and Notre Dame Bay area, is trucked to Badger, dumped in the Exploits River, and driven to Grand Falls.

* However, the waste waters from Buchans finally reach the Exploits River via Red Indian Lake. Wastewaters from Norris Arm discharge into the Bay of Exploits.

The proportion of the total annual deliveries of pulpwood to the Grand Falls mill by way of log driving is declining. However, this was still 64.3 percent in 1966, compared to 84.7 percent in 1961, 86.3 percent in 1956, and 92.9 percent in 1951.

Log driving during the low flow seasons requires flow releases from storage reservoirs to carry the logs. This may affect the spawning ground because of the rapidly changing water levels and flows and possible log jams which have the same, though temporary effect as dams. Effects of log driving on the fisheries resource is outlined in more detail in Section 3.2.2.

There are numerous small storage dams in the basin, and these create obstacles for the migratory fish. However, due to exhaustion of merchantable forest areas, some of these dams are no longer in use, and were partially demolished at the request of the Canada and Provincial Departments of Fisheries. One of the largest logging dams used to be on Victoria Lake which accumulates a live storage volume of 5.6 bcf. Operation of this lake, if the release of water does not occur intermittently, can be of some advantage to all the users downstream by decreasing the spring flows and increasing the summer flows. The flow data at the recently (October 1966) installed gauging station on the Victoria River downstream of the dam, when compared to the flows of the nearby White Bear River, indicate how this logging dam has influenced the natural hydrologic regime of the Victoria River as shown in Volume Four, Figure 3-1.

In addition to the logging done by Price, there are a number of other small logging enterprises in the basin. There are no data on their production, but according to information gathered, their activity is relatively insignificant.

2.1.4 Recreation, Tourism, and Wildlife

There are three provincial parks in the Exploits Basin, all located along the Trans-Canada Highway within 25 miles west of Grand Falls [10].

The Aspen Brook Park located about 10 miles west of Grand Falls, was opened in August 1960. This park of 15.7 acres has been set aside primarily for outdoor recreation and to enhance the travel routes, by providing rest stops in pleasant surroundings. The park includes a small roadside camping and picnic area; a paddling pool for children was provided in 1964.

The Catamaran Brook Park was also established in August of 1960 and is located along the shore of Joe's Lake, about five miles north of Badger. This park is larger than Aspen Brook Park, having an area of 56.6 acres. The primary purpose of the park is to provide for popular outdoor recreation. In 1966 a picnic area was constructed across the lake from the camping site. The lake has an attractive shoreline with excellent swimming potential.

Data on the number of visitors to these two parks are given below:

Park	1964	1965	1966
Aspen Brook	12,428	8,312	15,256
Catamaran Brook	60,384	35,324	35,804

In 1965, for the first time since the inception of the Provincial Park Service, there were fewer visitors than in the previous year. The two parks in the Exploits Basin followed this trend which may be due to several factors including highway construction in the basin area and adverse weather conditions. However, the most important reason for the decrease was probably the introduction of park fees. During 1966, "Come Home Year" in Newfoundland, the number of park visitors increased as shown.

The Rushy Pond Provincial Park is the most recent (1967 - 68) one in the basin. This regional park will contain more extensive facilities than the local highway parks. It is located about two miles west of Grand Falls in the Exploits Valley in the centre of the last known Beothuck Habitants.

The park is adjacent to that part of the Rushy Pond formerly used by residents of Grand Falls as a boating and picnic area. The park contains camping and picnic grounds.

The Atlantic salmon in the basin are attracting sportsmen in increasing numbers. As shown in Figure 2-1 the annual number of rod-days spent on the river by sports fishermen seeking the Atlantic salmon in the lower river and its tributaries has increased from under 1000 in 1953 to over 3000 rod-days in 1966.

Hunting contributed to the tourist expenditures in the basin. Moose, caribou, black bear, and snowshoe hare are harvested by sportsmen in the area. In 1967, 13 hunting camps were in operation, and 357 hunters spent about $91,000. Generally, hunting camps are utilized mainly by non-resident hunters who are required to use the services of guides. Resident hunters use the basin extensively, and it is estimated that over 10,000 hunter days were spent in the basin in 1967.

There are three moose management areas located south of the main river stem in the basin. This system of management prevents a high population build-up in any one area and results in optimum harvests. The extensive road system to the basin interior permits ready access to the management areas.

2.2 Withdrawal Water Demand and Supply

2.2.1 Mining

Mining in the Exploits Basin is dominated by base metal mining carried out by the American Smelting and Refining Company at Buchans, which began production in 1928.

In 1905 the Anglo-Newfoundland Development Company Limited was given a 99 year renewable grant to the mineral rights on approximately 2000 square miles of the Exploits Basin. As a result, a subsidiary, Terra Nova Properties Limited, was incorporated to explore and to acquire the mining rights of base metal occurrence in the Buchans area. The Buchans property and mineral rights within a 30-mile radius of the mine site were leased to ASARCO.

On completion of the Trans-Island Railway, the Reid Newfoundland Company was granted surface, timber, and mineral rights to 148 parcels of land covering an area of 4000 square miles. These areas, known as Reid lots, lie primarily along what is now the CNR right of way. The recently discovered ore body at Tulk's Pond is on such a Reid lot.

The concentrator capacity at Buchans is 1250 tons per day; production in recent years has averaged about 380,000 short tons of ore mined. Gold and silver are also produced as by-products of base metal concentrates. The copper concentrates are shipped to the ASARCO smelters in the United States and Europe. Concentrates are shipped 92 miles by rail to tidewater at Botwood where they are stock-piled, as the shipping season is only about seven months of the year.

The Buchans (ASARCO) mine is using 3,000,000 gpd (5.6 cfs) for different purposes as follows:

1,600,000 gpd in the concentration (flotation) process.

1,000,000 gpd for sandfill.

400,000 gpd for domestic and sanitary uses for the mine and the Buchans Town.

The water used for concentration and sandfill is not treated; the water used for domestic supply is treated by filtration and chlorination. The Provincial Department of Health analyses show that the water is satisfactory after treatment.

In the flotation process, normal lake or river water can be used provided an excess of tannins and pyrogallics is not present.

Some re-cycling is done at Buchans to the extent of approximately 300 gpm for middling thickener overflow for make-up water in the grinding and classification circuit. Also concentrate thickener overflow is used to sluice waste rock from the grinding circuit. Re-cycling must be done with care, as spent water with chemical reagents in solution from one circuit cannot be used in another circuit; re-cycling water is not treated.

The 1,600,000 gpd used in the concentration mill are evacuated with an amount of about 10 percent sediments and with heavy metals in solution. Some losses through evaporation and in the concentrates shipped with some moisture do occur, but these are probably not very significant. Before 1966 the mine waste water was disposed directly in the Buchans Brook with the effect of polluting it heavily, as discussed in Section 2.1.2.

Since 1966 the mine has treated the wastes by impoundment, with results also discussed in Section 2.1.2. In spite of the improvement obtained in this way, there is still a problem related to the previous mining operations which, over a 30-year period, consisted of the discharge of all mine tailings directly into the

Buchans Brook, and the settling of these wastes in the Red Indian Lake. This could provide a source of copper, zinc and lead precipitated at the bottom or linked to the aquatic organisms. There may be a variation in the concentration of metals in different strata and areas of the lake due to complex hydrologic and biologic processes.

Samples of bottom deposits collected since 1962 in Red Indian Lake over an area of approximately ten square miles showed high concentrations of copper, zinc, and lead as follows:

Copper	250 - 1,000 ppm
Zinc	2,000 - 5,000 ppm
Lead	1,200 -10,000 ppm

Analysis of water samples in 1964 from the southern end of Red Indian Lake (presumably unaffected by mine wastes) and from Lloyds Lake, Star Lake, and Victoria Lake (all of which drain into Red Indian Lake and are thus unaffected by mining operations) showed copper ranging from 2.2 ug/l to 16 ug/l and zinc from 7.0 ug/l to 34.6 ug/l. These results seem to indicate that the increase in copper and zinc in the northern end of the Red Indian Lake is due to the mining operations.

2.2.2 Agriculture

Information on commercial agriculture is reported on the basis of census areas. The Exploits Basin is located in three census areas - 3, 5, and 6. It touches upon the northern uninhabited extremity of census area 3 and cuts into the eastern extremity of area 5, but most of the basin is in area 6. However, area 6 is considerably larger than the basin. Because of these factors, it is difficult to analyze the extent of commercial agriculture in the basin. Census area 5 accounts for roughly 8 percent of the Island's commercial agriculture and census area 6 about 4 percent. Considering the location of the basin in these two areas, it would seem safe to assume that certainly no more than 5 percent of the Island's small agricultural activity takes place in the basin.

Regional details on farming activity have not been obtained but, assuming that all activity reported in census area 6 takes place in the Exploits Basin, there are 20 farms of which 9 are considered commercial. The farms are primarily dairy or poultry. Any crops raised in the area are not for commercial sale and therefore are not reported.

2.2.3 Water Uses for Manufacturing

The only major industry which has its own water supply facilities is the mill at Grand Falls. A list of the industries in the basin is shown in Table 1-7. The mill at Grand Falls was established in 1909 by the Anglo-Newfoundland Development Company, a predecessor of Price (Nfld) Pulp and Paper Limited. Initially, three paper machines were installed, but the mill expanded quickly in 1912 with the addition of two new paper machines. A sixth machine was installed in 1925. In 1922 the Bishops Falls groundwood pulp mill was purchased and a nine-mile pipeline to pump the groundwood slush up to the main mill was planned. Over the years, the main mill has shown a continuing expansion.

In 1966 the mill produced 280,000 tons of newsprint and an additional 3900 tons of sulphite pulp for sale with a seasonal variation of production as shown in Table 2-2.

The Price mill uses 33,000,000 gpd for steam production, pulp and paper production, domestic and sanitary uses, and fire protection for the mill and the town.

The source of supply is the Exploits River, upstream of the Grand Falls dam. The drinking water is sand filtered and chlorinated. The water used in paper (newsprint) production is screened on inclined screens to remove coarse floating material. The steam water and the white water are recirculated (17,000,000 gpd), the white water being treated for slime before recirculation. The waste water is returned untreated to the Exploits River downstream of the Grand Falls dam through two sewers.

The slime bacteria, Sphaerotilus natans, usually present in streams receiving waste waters from sulphite pulping mills is evident in the Exploits River, but normally not in sufficient quantity to be objectionable. Increased growth of slime bacteria has been observed in the Exploits River, during periods of low river flow coupled with abnormally high summer temperatures; it would appear therefore that any increase in the concentration of SWL in the river, either through an increase in mill production, or a decrease in river flow, will result in the growth of slime bacteria to such an extent that they will become unsightly and objectionable to users of the river. Such slime growths due to their large floating masses can interfere with sport fishing and through decay can cause taste and odours in the water; in addition, slime growths reduce benthic organisms and thereby adversely influence the biology of the river.

It is possible that growth of slimes has been inhibited in the past by the presence of copper and zinc in the river in sufficient quantities to affect such growth. Reduced levels of these heavy metals now obtaining in the river may result in a substantial growth of these slimes under optimum conditions.

2.2.4 Population, Municipal Water Supply, and Waste Disposal

The population in the Exploits River basin has shown a steady growth over the last four census periods. Details of the growth of the major towns is as follows:

Population of Main Towns - Exploits River Basin

	1951	1956	1961	1966
Badger	872	988	1,036	1,192
Bishops Falls	3,139	3,393	4,099	4,127
Botwood	3,624	4,080	4,467	4,277
Buchans	1,944	2,413	2,463	2,159
Grand Falls	5,064	6,064	6,605	7,451
Norris Arm	1,126	976	1,226	1,252
Windsor	3,674	4,520	5,505	6,692
7 Main Towns	19,443	22,434	25,401	27,180
Balance (Scattered)	2,240	2,390	2,550	3,280
Total Basin Population	21,680	24,826	27,953	30,429

There has been a growth in the population of all the sub-basins although these rates have varied (Figure 2-2).

The discharge of untreated domestic waste waters into the Exploits River pollutes the river from a bacteriological point of view, rendering the river water unsuitable for human consumption without filtration and chlorination.

Studies of the St. Croix River in New Brunswick by the Department of National Health and Welfare have established that coliform bacteria can grow on river bottom fibre deposits from pulp mill wastes during periods of warm weather with subsequent release of these organisms to the river, thereby increasing bacterial pollution. There is no doubt that fibre deposits from the Price (Nfld) Pulp and Paper Limited mill wastes exist on the bottom of the Exploits River below Grand Falls, and it is reasonable to assume that during periods of warm weather these deposits promote the growth and release of bacterial pollution to the river, such pollution originating from the discharge of untreated domestic waste waters into the river. Because of lack of data, the extent of bacterial pollution of the Exploits River is unknown at this time; but this consideration should be kept in mind whenever supply of potable water from the Exploits River is contemplated.

The municipal water supply and sewage disposal in the basin are described below.

Buchans (1966 Population - 2,159)

The water supply for the town is common to the industrial water supply for the ASARCO mine. The water supply for the new subdivision of Buchans (population 1966 - 400) is also connected to the ASARCO mine water supply system (this is covered in the mining section). The town has a sewer system with outfall and the receiving body is the Buchans River.

Badger (1966 population - 1,192)

The water supply system was built in 1966-1967 and 134 domestic and 2 commercial customers are supplied at the present time. The total water supply is drawn from nine wells with an approximate yield of 180,000 gpd and the wells have an average depth of 30 to 35 feet.

The sewage system was built in 1966-1967. At the present time it serves 75 households, and another 125 presently on individual septic tanks and/or cesspools will be added to the system in 1968. The system can support at least 1000 houses.

The wastes are chlorinated and discharged into the Badger River. No information is available on the quantity treated or on the quality of the effluent.

Grand Falls (1966 population - 7,451)

Grand Falls water is obtained from the mill, the intake for the system being one of the penstocks which in turn is fed by the Exploits River from a location above the dam. The river water is treated in the mill by raw screening, pressure filtration, and chlorination. The water is distributed from the mill to the town's domestic and fire protection water system.

Plans were prepared in 1963, and revised in 1964, for a joint water supply and sewage disposal system, with treatment plant, for Grand Falls and Windsor. This project is under further investigation.

Only two significant industrial consumers of water are connected to the municipal distribution system: Brookfield Ice Cream Limited use approximately 20,000 gallons per day in the production of ice cream products; and Browning Harvey Limited use about 20,000 gallons per day in the production of soft drinks.

Windsor (1966 population - 6,692)

The water supply system was built between 1956 and 1961, and in 1966 served 1100 customers with an average demand of 500,000 gpd. The water supply is drawn from the Exploits River above Grand Falls and is considered adequate. There is no treatment plant and the receiving body is the Exploits River. The water supply and distribution system is completely independent of the Grand Falls system.

Bishops Falls (1966 population - 4,127)

The water supply system was installed in 1966 and is owned by the town; it presently serves 448 domestic and 2 industrial customers. The entire water supply is drawn from infiltration wells located on an aquifer 40 feet from the Exploits River. The capacity of the system is 288,000 gpd. The quality of water which may be affected by the Exploits River is being investigated at the present time. The sewage system was installed in 1966, and the receiving body is the Exploits River.

The only industrial consumers of note connected to the municipal system are Gadens (Central) Limited who use approximately 30,000 gallons per day in the production of soft drinks and the Canadian National Railways who use approximately 25,000 gallons per day for miscellaneous purposes.

Botwood (1966 population - 4,277)

Botwood is the port serving central Newfoundland in general and Grand Falls; that is, Price (Nfld) Pulp and Paper Limited, in particular. This municipality has a water distribution system with its source of supply being Peter's Pond. The system was installed in 1940-41 and extended in 1961. Treatment of the water is limited to chlorination. The nearby community of Peterview, with a 1966 population of 836, is supplied with water from the Botwood system. Approximately 60 percent of the municipality of Botwood is served by sanitary sewers discharging untreated waste water to the sea; the unsewered areas of Botwood are in general served by septic tanks.

All of the other communities in the river basin and its associated study area rely upon individually owned water supply systems and means of sewage disposal. In most instances the water supply is a dug well and sewage disposal is by a septic tank system or privy. Norris Arm, with a 1966 population of 1252 persons, is the largest community in the area relying upon individual water supply and waste disposal systems; all other communities in the area are less than 500 in population.

2.3 "Negative" Demand Problems

2.3.1 Flooding

Flooding has occurred several times downstream of the Grand Falls Dam due to ice jams. The most disastrous flood occurred in January 1927 when water backed up through the gorge downstream of the plant tailrace and the grinder room of the mill was flooded to a depth of 22 feet. The openings to the generator room were bulkheaded and sand bagged; and, with the aid of pumps, the three small generators were kept in operation. Sufficient groundwood was pumped from the mill at Bishops Falls to keep some paper machines running. This condition lasted for two or three days.

Figures obtained from Price (Nfld) show that from 1939 to 1963 inclusive, a total of 17,233 net tons of newsprint were lost due to problems with frazil ice conditions at the power intake which cut off the power supply or due to downstream flooding. This amounts to a present-day value of about $150,000 per year. However, with the power now available from Bay D'Espoir, the loss in production due to ice problems will presumably be lessened.

2.4 Present Day Water Resource Problems

Present day problems in the Exploits Basin are mainly due to a conflict in use between fisheries, hydro power, log driving, mining, manufacturing, and municipal water supply interests.

The hydro-electric dam at Grand Falls and the storage dam at Red Indian Lake, known as the Exploits Dam, present barriers to Atlantic salmon stocks. These barriers must be circumvented in order to realize the potential for development of Atlantic salmon stocks in the upstream areas of the basin.

The wastes from the mines at Buchans and the mill at Grand Falls have created a quality problem in the river which is marginal for existing and potential future Atlantic salmon stocks. These mill wastes make the use of the Exploits river water downstream of Grand Falls for municipal water supply difficult.

Even to achieve primary treatment of the Grand Falls mill wastes would require an expenditure in the order of $3,000,000 with an annual operating cost of $200,000. These costs do not allow for the benefits from chemical recovery. Similar control of ASARCO's mine waste would require an investment in the order of $1,700,000 in plant with annual operating costs reaching $35,000 per year. Municipal sewerage and wastewater treatment will require investments in the order of $3,000,000 with annual operating costs of $40,000. These estimated costs were based on criteria outlined in Volume Eight, Appendix C.

The full costs of correcting this degradation has yet to be paid and as losses in the value of other uses, both direct and indirect, approach these amounts, the basic economic justification for the control of pollution in the basin will be more clearly seen.

With these examples, one can readily grasp the immensity of the hidden eventual costs that have been incurred in the Exploits Basin through the degradation of water quality inherent in industrial and municipal demand.

These present day problems will be accentuated by the diversion of the upper Lloyds and Victoria River which is outlined in Section 3.

In addition to the problems of use conflict summarized above, Price (Nfld) Pulp and Paper Company Limited have winter operating problems at their hydro plant at Grand Falls due to ice forming and blocking the intakes as well as creating jams downstream which cause flooding to occur. These problems are accentuated by the small capacity of the reservoir at Grand Falls which prevents effective control of river flows.

3 WATER RESOURCE IMPLICATIONS OF THE DIVERSION OF THE UPPER LLOYDS AND VICTORIA RIVERS

The construction of the Victoria River diversion to the White Bear River basin and further to the Bay D'Espoir Development commenced in April of 1968. The loss of this drainage area will aggravate the conflicts of interest which already exist in the Exploits River basin. An analysis of the effects of the diversion of both the upper Victoria and Lloyds Rivers is included in this section.

According to ShawMont Newfoundland[11], the construction schedules for the diversion of the upper Lloyds and Victoria Rivers are as follows:

Victoria Dam and Spillway	Tender call	August	1, 1967
	Tender close	October	11, 1967
	Contract award	October	27, 1967
	Mobilization	October	30, 1967 to
		March	31, 1968
	Commence construction	April	1, 1968
	Complete construction	December	15, 1969
Lloyds River Diversion*	Tender call	April	1, 1968
	Tender close	May	15, 1968
	Contract award	June	15, 1968
	Mobilization	June	15, 1968 to
		July	31, 1968
	Commence construction	August	1, 1968
	Complete construction	December	15, 1969

Water is to be impounded behind the dam in the Victoria River after August 1, 1968. Should average spring floods occur in 1969, some flow would be passed downstream at this time. All the flow from the upstream area is required for filling the reservoir to meet the load demands of the Newfoundland and Labrador Power Commission.

Provision has been made to by-pass flows downstream during the period of construction of the Lloyds River dam. After construction, only extreme flows will be passed downstream over a reinforced concrete ungated overflow spillway. As indicated by the above, the full effect of the diversion on downstream users may not be felt until after the spring floods of 1969.

* According to recent information, the Lloyds River Diversion has been postponed.

A plan of the diversion of the water of the upper Lloyds River and upper Victoria River areas is shown on Figure 1-9. The diversion by the Newfoundland and Labrador Power Commission will enable the diverted flow to be developed at the existing head of 578 feet at the Bay D'Espoir hydro plant, and an additional potential head of 174 feet at the Upper Salmon plant (undeveloped). The flow from the diversion area is presently used at hydro plants in the Exploits basin, but the head is much smaller, totalling 144 feet.

3.1 Diversion Effect on Present (1968) Uses

The diversion will result in decreased flows especially during dry periods, and will subsequently affect the following present uses of the water resources:

a) Fisheries
b) Log driving
c) Hydro energy production
d) Industrial water supply
e) Domestic water supply
f) Industrial waste disposal
g) Domestic waste disposal
h) Forest production
i) Wildlife
j) Recreation and Tourism

At the same time, the diversion will result in reduced flood peaks and volumes on the Exploits River which will benefit the entire Exploits Valley.

The specific effects of the diversion on present uses of the water resource are outlined below:

a) According to information obtained from the Canada Department of Fisheries, decreased average flows are not likely to create any problems in the use of the water resource for the existing fisheries development or in the future projects for development of Atlantic salmon stock in the lower basin. However, the reduction of low flows during dry periods is expected to have adverse effects on both present conditions and future developments because dilution will be reduced thus increasing the existing level of pollution in the river. Furthermore, potential spawning grounds will be reduced by the diversion scheme in areas above Red Indian Lake on the Victoria and Lloyds Rivers.

b) Extensive use of the water resource has, in previous years, been made for log driving. Flows will generally not be available downstream of the diversion structure on the Victoria River to permit log driving after diversion. Log driving does not presently occur on the upper Lloyds River area. However, the diversion will prevent any future log driving as flows will generally not be provided after the diversion downstream of the diversion structure, except during extreme floods.

c) The water resource is presently used for hydro energy production in the basin. The effects of decreased average flows and reduced dry period flows will create a problem by reducing the average and firm energy production of the Grand Falls and Bishops Falls hydro plant.

d) The supply of water to the various industrial and domestic users in the basin will be adversely affected by the decreased flow conditions created by the diversion. Increase in pollution concentration resulting from the reduced dilution could necessitate additional treatment of the water prior to serving the needs of the various users.

e) Use of the river as a receiver of the industrial and domestic wastes after the diversion may necessitate additional treatment of the wastes. At present, very little is done to treat wastes and dilution is sufficient to keep the pollution from all users of the river at a tolerable level.

f) Forest production will be decreased in the basin as a result of the diversion. The reservoirs created above the diversion dams on the Victoria and Lloyds Rivers will inundate forested areas resulting in a permanent loss of this renewable resource. In addition, there will be a further loss by flooding of a limited amount of access road and several older lumber camps in areas that have been cut.

g) Wildlife will be affected because of the flooding of the forested area above Victoria and Lloyds diversion dams, and possibly by the reduction of low flows of these two rivers.

h) Increased levels of pollution with consequent reduction of fish and possibly wildlife populations can seriously affect the existing tourism and recreation activity and significantly reduce the potential development in this area.

As outlined in the section "Present-day Development", a gradual deterioration of the water quality has occurred in the basin because of man's activities. Generally, the diversion intensifies the interrelated quantity and quality problems already existing in the basin.

3.2 Suggested Solution to Diversion Effects on Present-Day Uses*

During the study of possible solutions of the effects of the diversion, it became apparent that the basin could be considered as two separate problem areas: "A" downstream of the Exploits Dam at the outlet of Red Indian Lake and "B" upstream of this dam. The specific problems created by the diversions are as follows:

Area A - The problem is essentially one of maintaining an acceptable water quality in the river.

Area B - The diversion creates problems concerning water use during low flow periods and inundates existing facilities by the creation of new diversion reservoirs.

The present uses affected by the diversions that occur in both Area A and Area B are fisheries and log driving. Hydro energy, water supply, and disposal uses are affected only in Area A; and forestry production and wildlife is affected by the diversion only in Area B.

* Includes potential uses for fish

3.2.1 Area Downstream of the Exploits Dam

Two possible solutions to the problems resulting from decreased average flows and reduced dry period flows in the area downstream of Red Indian Lake dam are:

a) Regulation of river flow to permit adequate dilution of waste waters; or,

b) Treatment of waste waters to maintain acceptable river quality under all river flow conditions which may be anticipated.

a) One of the major and obvious effects of the diversion is the reduction in energy of the existing power plants on the Exploits River at Grand Falls and Bishops Falls. A compensation for the loss of energy production incurred by Price (Nfld) Pulp and Paper Limited at these plants has been negotiated with the Newfoundland and Labrador Power Commission. However, the disadvantages to other users resulting from decreased flows will not be reduced in any way by such a solution.

One solution which, under present conditions of development in the basin, would satisfy the development plans of the Canada Department of Fisheries with respect to the pollution level during low flows is to maintain the low flow conditions after the diversion equal to those which existed prior to the diversion. This solution would also eliminate the damaging effects of low flows on other users. A means of obtaining this result would be by increasing the available storage on the basin.

The method adopted to measure the effect of the diversion on the water resource users in the basin and the possible alleviating effect of additional storage consisted of:

i) Simulating the operation of the existing storage for a given set of conditions without the diversion to obtain the theoretical flow available for those conditions.

ii) Simulating the operation of the existing and additional storage under conditions existing after the diversion.

iii) By repeating the simulation for different amounts of additional storage, the volume of storage required to produce the same minimum flows that existed prior to diversion can be calculated.

The operation of the existing storage before the diversion was simulated to obtain the maximum average energy production and the maximum firm energy capability of the Grand Falls and Bishops Falls plants combined. It was assumed that the existing storage could be operated to achieve this end.

The simulation of the operation before and after diversion was made using a computer program previously developed by The Shawinigan Engineering Company Limited which calculated the individual plant outputs and reservoir volume changes on a monthly basis to meet a firm energy demand. The program incorporates a rule curve for reservoir operation and allows for head variation due to changes in tailwater level with the variation in river flow. In this simulation it was specified that the reservoir outflows would be regulated so that the Grand Falls plant would operate at full load; that is, at maximum plant discharge, except when this requires drawdown below the rule curve of monthly reservoir levels. When reservoir levels are below the rule curve, the reservoir outflows are regulated so that the combined output of the two plants equals the firm energy demand. The rule curve provided the month-end storage volumes that will allow the required firm energy generation for the remainder of the drawdown sequence. During the flood months, the rule curve specifies levels that will ensure reservoir filling during the dryest conditions on record.

In the study after diversion the program was used to calculate the effect of a range of additional storages on firm energy output, and hence on the low flow conditions. The actual additional storage required to meet the firm flows prior to diversion was then obtained by graphical interpolation. For the purposes of this preliminary study, the additional storage was considered to be available in Red Indian Lake. However, there are several good storage sites on the remaining Exploits basin, and actual site selection would be made on the basis of a detailed cost study which will also consider the hydrologic and water quality conditions, and the most effective locations from the viewpoint of fishery development.

A hydrologic study of the average runoff conditions on the Island outlined in Volume Two indicated that the actual flow at the Grand Falls plant is probably larger than the flow reported by the plant by about 1000 cfs of which 148 cfs is an unrecorded usage for the town and mill. Accordingly, the month-by-month runoff values calculated were increased by this amount. The energy production was, however, maintained at the same level recorded by correcting the efficiency coefficient.

The diverted flow is based on the calculated runoff for the Victoria Lake and upper Lloyds River drainage area as shown in Shawinigan Engineering's Report 3440-2-66. These runoff values have a long term average of 3 cfs per square mile which agrees with the hydrologic computer study outlined in Volume Two.

The river flows before and after diversion were calculated as follows:

Before Diversion

The runoff values at Grand Falls were obtained by correcting the recorded flow past the Grand Falls plant for changes in Red Indian Lake and Victoria Lake storage. In correcting the Grand Falls runoff for the effect of the Victoria Lake storage, it was assumed that the total live storage volume of 5.6 bcf had been fully utilized every year in the past, except when the flow records indicate that there was insufficient inflow into Victoria Lake to fill the reservoir. It was assumed that Victoria Lake was filled in May and June and emptied in July and August. Storage changes that actually occurred in Red Indian Lake were available. For the purpose of this study, 1000 cfs were added to all the monthly figures reported by the Grand Falls hydro-electric plant.

In order to expedite the study the local inflows were assumed to be proportional to the Grand Falls runoff. However in future more detailed studies, the runoff between Grand Falls and Bishops Falls will be correlated to the recorded runoff at the Rattling Brook hydro plant to obtain a closer approximation to the monthly flow variation in this area.

The runoff ratios were developed in the computer study of Volume Two. The flows were distributed as follows

Q = calculated runoff at Grand Falls + 1000 cfs

Q^1 = Q as above but modified to include the effect of Victoria Lake regulation

Inflow to Red Indian Lake reservoir = $0.6758 \times Q^1$

Runoff between Red Indian Lake and Grand Falls = $0.3242 \times Q$

Runoff between Grand Falls and Bishops Falls = $0.1746 \times Q$

After Diversion

The runoff below Red Indian Lake was calculated as above, using the average runoff coefficients applied to the recorded runoff at Grand Falls. In calculating the net inflow into Red Indian Lake, the loss of the diverted area is taken into account as well as the loss of the Victoria Lake Storage. The flows were distributed as follows:

Q = calculated runoff at Grand Falls corrected storage changes + 1000 cfs

Inflow to Red Indian Lake reservoir = $(0.6758 \times Q)$ - (Runoff from Victoria Lake and upper Lloyds River)

Runoff between Red Indian Lake and Grand Falls = $0.3242 \times Q$

Runoff between Grand Falls and Bishops Falls = $0.1746 \times Q$

The maximum plant flow at Grand Falls was estimated as 6460 cfs based on a maximum plant output of 45,400 kw*. At Bishops Falls the maximum turbine flow was established as 6900 cfs, corresponding to a plant output of 13,000 kw.

The monthly energy productions were calculated by first computing an averaged kilowatt per cfs ratio at each plant and correcting it for head variation.

* Includes hydraulic power to operate grinders.

The basic calculated kilowatt per cfs ratios for each plant are obtained as follows:

Grand Falls

Plant capacity	45, 400 kw.
Average head	106. 5 feet
Overall efficiency	78%
Calculated plant flow	6460 cfs
kw/cfs ratio at average head	7. 04 kw/cfs

Bishops Falls

Plant capacity	13, 000 kw.
Maximum flow	6900 cfs
kw/cfs at maximum output	1. 88 kw/cfs

A water utilization factor of 92 percent was used. This figure is a measure of the average annual utilization of the regulated plant flows up to the maximum flow that may be passed through the turbines.

This factor was applied by combining it with the kw/cfs ratios as an efficiency in calculating the monthly energy outputs.

The application of the utilization factor reduces the kw/cfs ratios as follows:

Grand Falls	6. 48 kw/cfs
Bishops Falls	1. 74 kw/cfs

A correlation was developed between the operating head and river flow for each plant. The kw/cfs ratios apply to a specific head and river flow and, therefore, this figure has to be adjusted at different flows. Curves of the ratio of actual kw/cfs versus river flow were developed from the curves of head versus flow, and these curves were used in the computer calculations to obtain the current kw/cfs for any given river flow. The computer study determined the following:

i) Before diversion - the maximum firm and average energy and corresponding regulated flows from the existing storage facilities at Victoria and Red Indian Lakes.

ii) After diversion - the reduced maximum firm and average energy and corresponding flows from the reduced drainage area and the existing storage facilities minus the storage facilities existing on Victoria Lake which are lost due to the diversion.

iii) After diversion - the additional storage required to obtain the same firm energy and flow conditions that existed prior to diversion; the corresponding average energy and the flows available were computed.

Flow duration curves for the three conditions mentioned above are shown on Figure 3-1. Results of the flow conditions existing at Grand Falls for each case are as follows:

	Before Diversion	After Diversion	
		No additional storage	Additional storage
	(i)	(ii)	(iii)
Firm (minimum) flow (cfs)	4685	3804	4685
Average flow (equal to the area under the duration curve) (cfs)	8575	6815	6815

The additional storage required on Red Indian Lake to firm up flow conditions was computed to be 21.5 bcf. This would require the addition of approximately 11 feet to the present full supply level of Red Indian Lake. As mentioned previously, there are several good storage sites within the Exploits basin, and actual site selection would require a detailed study which would consider the effects of the mining operation at Buchans on water quality in Victoria Lake.

Costs for the additional storage facilities may be partially offset by the benefits derived from energy increases at Grand Falls.

Firm and secondary energy available from the additional storage is given below:

	After Diversion	
	No additional storage	Additional storage
	(ii)	(iii)
Firm energy (kw hours/year)	292×10^6	354×10^6
Secondary energy (kw hours/year)	408×10^6	420×10^6

As shown, this preliminary study indicates an additional annual firm energy of 62×10^6 kilowatt hours and an additional secondary energy of 12×10^6 kilowatt hours will be made available by the increase in storage facilities. An increase in energy value of this magnitude will support a cash expenditure in the order of $4.2 million on storage facilities, conservatively assuming a value of 5.0 mills per kilowatt hour for firm energy, 1.3 mills per kilowatt hour for secondary energy, and total annual charges of 7.7 percent.

b) The other solution to the pollution problem imposed on the area downstream of Red Indian Lake dam by the planned diversion is to provide treatment of wastes from the domestic, industrial, and mining activities in the basin. The problems in the basin created by the disposal of wastes resulting from man's activities are outlined in Section 2.4, on "Present Day Developments". As shown in that section, the sulphite waste liquor released by the pulp and paper mill is presently creating the most severe water quality problems in the basin.

The effective treatment of pulp and paper mill wastes normally requires a combination of physical, chemical, and biological treatment processes. For example, sulphite liquors can be treated to yield such by-products as alcohol, vanillin, and yeast; or may be concentrated in multiple effect evaporators and incinerated to recover chemicals. The suspended solids in papermill effluents may be removed physically by such devices as settling basins, lagoons, centrifuges, or flotation towers.

According to the Canada Department of Fisheries, pollution from the mill at Grand Falls reduces the dissolved oxygen in the Exploits below acceptable levels whenever the river flow falls below 5000 cfs. Figure 3-1 indicates that without additional storage, the river flow will be below 5000 cfs 24 percent of the time. This suggests the possibility of storing mill waste waters in a holding reservoir and discharging them at a controlled rate dependent on flow in the river. Preliminary calculations indicate that a storage volume of 1000 acre feet would be required, assuming minimal BOD reduction in the holding reservoir. By introducing various forms of treatment, the size of the holding reservoir could be reduced substantially or could even be eliminated.

Detailed investigations would be required to determine the location and cost of the fresh water storage facilities, the type and location of an impounding lagoon for the sulphite waste liquor, the economics of waste treatment, or the best combination of the various alternatives. Such investigations are outside the scope of the present study.

Future development within the basin with any consequent production of wastes will further pollute the river and severely restrict its use through degradation. It has been amply demonstrated that in a developing economy dilution can only be a temporary or partial solution to water pollution and that it is also necessary to reduce or prevent entirely, pollutants entering water courses. This is established policy in the United States as shown by the following quotation[12]:

> "Among all the research fields receiving attention today in the United States in water quality, there are three which deserve special mention.
>
> "The first is an increasing interest among scientists in stream flow augmentation for the dilution of wastes. The Federal Water Pollution Control Act now provides that in planning any Federal reservoir, this factor must be considered. In no case, however, may this be substituted for adequate control or for treatment of wastes at their source.
>
> "We now generally recognize just what a river basin water quality control program should comprise. It should include provisions for elimination or control of liquid waste at its source; and regulation of stream flow to minimize the effects of residual wastes."

As mentioned in previous sections of the report, it appears that the process change introduced in the pulp and paper mill from a calcium base to a sodium base without recovery facilities, may have reduced the oxygen demand of the wastes by a maximum of 10 percent. This matter requires further investigation. It is recognized that an effective solution to the pollution problem must deal with all wastes from the mill including the sulphite liquor and papermill wastes.

3.2.2 Area Upstream of the Exploits Dam

The following are possible solutions to the problems created by the diversion in the area upstream of Red Indian Lake:

Spawning Grounds

According to the Canada Department of Fisheries, the area upstream of the Exploits dam holds 65 percent of the Exploits River Atlantic salmon natural rearing capacity. The Victoria and Lloyds Rivers account for 35 percent of the total Exploits rearing capacity. Approximately 50 percent of the total drainage areas of these two rivers which drain into Red Indian Lake will be diverted and it is possible that the remaining areas will be less effective in rearing salmon due to the reduced flows.

If the main rearing capacity area of these rivers remains inside the Exploits drainage area, it should be investigated to determine whether storage dams could be provided in the remaining upper reaches of the rivers, and if these are effective in saving the remaining rearing areas. At this stage, it was not possible to investigate this in detail since the location of the rearing areas and the required flows will have to be determined by the Canada Department of Fisheries. Another solution to the loss of natural rearing capacity in the two rivers may be the development of rearing areas on other tributaries or the artificial rearing of salmon smolts. These possibilities will have to be investigated in co-operation with the Federal and Provincial agencies.

Log Driving

Generally, delivery of pulp wood to the mill by log driving has been decreasing in recent years. According to information from Price and the Dominion Bureau of Statistics, the total annual deliveries of pulp wood to the Grand Falls mill from all rivers used for log driving has decreased as indicated in Section 2.1.3.

Log driving by Price is still high relative to Bowaters and other mills in Canada where trucking has almost completely replaced log driving; however, log driving on the Exploits River has remained at a constant level in recent years, averaging about 230,000 cords per year.

As mentioned, the diversion will reduce log driving immediately downstream of the diversion areas. This will be beneficial to the existing and planned development of fish resources since log driving on shallow rivers such as the Victoria and Lloyds Rivers and their tributaries threatens fish resources in the following ways:

> It gouges spawning gravel; diverts water from gravel bars causing deposited spawn to dry out; and diverts flows from potential spawning areas.
>
> It creates log jams which obstruct and hinder the upstream and downstream fish migration.
>
> It deposits bark which stifles bottom-dwelling fish food organisms.

It is difficult to obtain quantitative data on the amount of bark deposition in rivers as a result of log driving. However, some appreciation of the magnitude of bark deposits in the Exploits river is obtained from accounts of bark deposits covering the river bed and bark islands forming in some places in the stretch of river between Grand and Bishops Falls. This situation occurred when the bark was allowed to wash away in the river after being removed at the mill.

However, this does not occur now as the bark is recovered and used for steam production, but the natural barking action which occurs upstream of Grand Falls during the log drives results in large quantities of bark and sunken logs being deposited in the main stem and tributary stream beds.

Future fisheries development programs and log driving activities may be mutually exclusive on the Victoria and Lloyds Rivers. However, should the two uses be compatible, storage dams would be required on the tributaries to facilitate log drives; an activity which will depend on this means of transportation remaining economical.

Forest Production

Productive forest area will be lost by inundation by the diversion reservoirs. The areas to be flooded have been estimated from the 1:50,000 scale maps, as follows:

	Flooded Area (square miles)	Rise in Water Level
Lloyds Diversion	11.7	30 feet
Victoria Diversion	38.0	110 feet

(There is very little open bog in either flooded area)

It should be emphasized that the cost of supplying wood to the mill is mainly for cutting and transportation, since relatively little is expended at this time for forest management. The loss by inundation represents approximately 1.6 percent of the productive forest land within the deeded limits of Price. Considering the possible increase in harvestable wood which could be obtained by careful management, this loss of forested area, though regrettable, is relatively insignificant when compared to the value of the energy produced by the diversion.

On the other hand, decreasing flood magnitudes on the Lloyds and Victoria River will have a beneficial effect on the Exploits valley by reducing future flood damages. These benefits are difficult to assess, however, it might be assumed that they will compensate, at least partially, for the losses due to the flooding of the forest area.

Another benefit which may result from the creation of the large reservoirs would be the possible development of fresh water landlocked fish for commercial use or for sport as a tourist attraction. This benefit may prove significant and deserves further investigation. However, the fact that the new reservoir areas will not be cleared before flooding may create difficulties for such developments.

Wildlife

Management of wildlife by The Department of Mines, Agriculture and Resources has resulted in a steady increase in the annual harvest of big game in the Exploits area, making it one of the better areas in the world for hunting of moose and caribou.

The three most important species from the wildlife conservation viewpoint are the caribou, black bear, and moose.

The creation of reservoirs should have no effect on caribou migration since they are strong swimmers. At the present time, a large portion of the Buchans herd swims Victoria Lake. The width of the lake at the point where the animals presently cross will be increased from 0.6 to 0.9 miles, but this increase should not effect the migration of the caribou.

The black bear has been classified as a big game animal to provide protection and build up the population. It is felt that an abundance of these animals will provide sport and promote non-resident hunting on the Island. Special precautions will be taken during construction of the diversions to prevent a concentration of these animals in the camp area and unnecessary slaughter of these animals. The reservoirs will inundate moose grazing land and these areas will not be able to support as many of these big game animals.

4 PLANNED AND FORECAST DEVELOPMENT

A re-assessment of the planned and forecast water resource developments in the basin has been required due to the direct effect of the diversion of part of the upper Exploits Basin to the Bay D'Espoir development.

4.1 Non-Withdrawal Water Uses

4.1.1 Hydro Power

The original hydro development at Grand Falls, owned by Price (Nfld) Pulp and Paper Limited, is almost 60 years old however, over the years the installation has been expanded and some sections have been replaced. Operating and maintenance costs for this plant have been increasing each year and have averaged over 2 mills per kwh in recent years. The hydro power facilities may have to be replaced before the end of the study period (1981).

Development of the optimum potential of the site (which would include a larger storage reservoir at the site and create a higher head than presently exists) may be economically attractive in the future.

It is unlikely that the existing plant will be utilized in the future for peaking purposes because of the lack of adequate storage at the site. In addition, a peaking operation would conflict with fisheries and recreational interests in the river.

The Star Lake hydro electric site is a possible future power source which is located in the upper basin area. This development is fully described in Volume Four, Part I. As shown in Section 3.2.1, an additional storage volume of 21.5 bcf is required in the basin upstream of Grand Falls to provide minimum flow equal to that which would have occurred prior to the diversions in the upper basin. The Star Lake development has an inherent advantage in that it would provide about 7.8 bcf of additional storage to the system which would benefit downstream users, including fisheries, and it would also increase the energy production of the Price hydro-electric plants.

These inherent advantages should be kept in mind when future hydro sources are considered in the basin. Recommendations concerning the Star Lake development are included in Volume Four.

4.1.2 Fisheries

The Department of Fisheries of Canada plans to spend about $1,000,000 in the next five years on a major fish passage and collection facility at Grand Falls to permit the use of the second section of the river, and in continuing the resource development investigations leading to a major expansion of the Atlantic salmon resource.

These resource development investigations include lake surveys and pollution studies. In addition, future plans include provision for a diversion fence at Noel Pauls Brook and a fish passage at the Exploits Dam.

The Department of Fisheries will use the following guidelines in the conservation, development, and management of fisheries in the Exploits River basin in the period up to 1981:

a) The Department will take action to preserve existing fish populations and the natural environment for potential fisheries development by:

   i) Insisting on abatement of pollution from all present sources and prevention of pollution from all future sources through application of the principles of Section 33 of the Fisheries Act.

   ii) Insisting on control of logging and log driving practices which have a deleterious effect on fisheries through application of the principles of Sections 33 and 20 of the Fisheries Act.

   iii) By negotiating satisfactory flow regimes in connection with the operation of hydro power plants, storage dams, and diversion dams, to provide for migration, spawning, rearing of fish through the application of the principles of Section 20 of the Fisheries Act.

   iv) By managing the exploitation of the fisheries resource by commercial and sport fishermen to maximize economic benefits and ensure perpetuation of fish stocks through regulations provided for by Section 34 of the Fisheries Act.

b) The Department of Fisheries subscribes to the principle of multiple use of water resources and will work with other resource users to devise mutually acceptable plans which will allow, to the greatest extent possible, the coexistence of fisheries resources with other water users.

c) The Department of Fisheries will develop Atlantic salmon resources to the fullest potential of the natural environment of the river and all its tributaries within the economic constraints of demand, benefits, and costs. One should assume that there will be no unsurmountable technological barriers to achieve this objective. The only constraint would be the existence of some other more economically favourable location for such activity.

d) The Department of Fisheries will aim to establish a much closer working relationship with the Province, or other responsible agencies, on future planning for fisheries development and management as it forms part of and concerns the broader field of recreation and tourism planning.

4.1.3 Log Driving

In the upper basin area, future log driving immediately downstream of the diversion dams on the upper Victoria and Lloyds Rivers will be restricted due to lack of sufficient flow. However, log driving may be possible in these rivers in the area between the diversion dams and Red Indian Lake. Future log driving in this area will depend on whether it is economical to construct the necessary storage dams to augment the river flows during log drives and also on whether log driving and fisheries interests are compatible in these rivers. Any comparison must consider Price (Nfld) Pulp and Paper Limited's legal position regarding their right to drive logs on the river. It must be remembered that these rivers account for about 35 percent of the total Exploits River rearing capacity and the river sections which remain after the diversion may prove to be extremely valuable as natural salmon rearing areas.

Use of the other tributaries of Red Indian Lake for future log driving will depend to a large degree on the extent of the merchantable forested areas in these sub-basins and on the potential of these tributaries for the rearing of Atlantic salmon.

In the area downstream of the Exploits Dam, future log driving will be hindered by the reduced average flows available after the diversion. Although the percentage of the total logs delivered to the mill by means of water transport has declined in recent years, log driving in the Exploits River itself has remained relatively constant.

Wood that will be reharvested in areas which will have regrown near the main river will probably be driven by river to the mill as the cost advantages of log driving in these areas are greater than in areas more remote from the main river. In addition, increased use in the combining of trucking of the wood with log driving may occur, with the main river stem being used in the last part of the journey to the mill.

Control of future log driving practices in all parts of the basin will still be required by the Department of Fisheries and co-operation between these two users of the water resource will be essential.

4.1.4 Recreation and Tourism

In addition to the camping, picnic, and natural water resources in the Rushy Pond Provincial Park, an area has been set aside for the future reconstruction of a Beothuck village in natural surroundings adjacent to the lake shore. The Beothuck's were Newfoundland's aboriginal inhabitants and there are plans to incorporate a museum to display Beothuck artifacts, tools, and weapons. This will add to the park's appeal to tourists.

An additional park has been proposed by the Newfoundland Provincial Park Service to be located on the north shore of Red Indian Lake. The park will be near the Badger to Buchans highway and will be named Mary March Provincial Park.

The future increase expected in Atlantic salmon produced from the Exploits River system will draw additional sports fishermen to the basin. The existence of the three moose management areas in the basin will enable optimum harvests in the future. It is expected that hunting pressures in the area will follow the general trend on the Island and increase in the future.

4.2 Withdrawal Water Demand and Supply

4.2.1 Mining

The Fisheries Research Board has recently (May 1968) announced the development of a substance that would virtually eliminate zinc-copper pollution from rivers. The anti-pollutant substance is called NTA - an abbreviation for nitrilotriacetic acid. Detailed studies by the Fisheries Research Board have proved the effectiveness of the substance. However, the Fisheries staff advises that research is needed before the anti-pollutant is ready for use. Fish under study in anti-pollutant areas will be studied for adverse effects and the overall effects of the chemical on other aquatic life is also in the research stage. This recent development could be of great significance to future problems created by the zinc-copper pollution from the Buchans mine.

Future mining activities in the basin will be required to consider the effects of their operations in the fisheries resource and to consider the increasing treatment facilities as part of their operating liabilities.

4.2.2 Water Uses for Manufacturing

The only major water resource user in the basin where the water demand is not included in the total municipal demand is the pulp and paper mill at Grand Falls. The expansion of the mill to provide an increase in capacity of 100 tons per day; that is, from 800 to 900 tons per day, is planned for completion by 1971. No other industrial development is known to be under consideration for this area during, or beyond, the study period.

Future increases in water demand by the mill can be easily met by the present source which is the Exploits River. The quality of the water will be reduced because of the lower flows resulting from the diversion. However, the quality of the river water upstream of the mill is good relative to that downstream of the mill's sewer outlets. Downstream of the mill, it may be necessary to treat river water prior to using it for certain industrial processes.

The expansion of the mill by 1971 will have to take into account the situation existing at that time with regard to water quality suitable to fisheries and other users.

4.2.3 Population, Municipal Water Supply and Waste Disposal

The present-day population of about 30,000 in the basin is expected to increase to about 39,000 by 1981 based upon a projection of population trends in the recent past and making no allowance for new major industrial development in the area. The expected distribution of the population in the basin for the years 1971, 1976, and 1981 is shown in Figure 4-1.

Withdrawal water demand in the river basin study area during the study period will be predominantly domestic with very little industrial consumption from municipal systems. At the present time, Norris Arm is the only major community in the area relying upon individually owned wells and private sewage disposal systems; a central water supply and distribution system for this community, although not specifically planned, is desirable.

In 1964 a joint municipal plan of the towns of Grand Falls and Windsor was prepared. The plan covers these two municipalities and part of the area immediately adjacent to them. The plan recommends the location of areas for various land uses including industrial. In addition, the plan recommends an amalgamation of the two independent water supply and distribution systems as well as the sanitary sewer systems serving the two towns. From an engineering viewpoint amalgamation of these individual town services is desirable; to date no active steps have been taken to implement this recommendation of the plan. Should this amalgamation occur, the source of supply will continue to be the Exploits River above the pulp and paper mill.

The water supply to Bishops Falls is from two recently installed wells adjacent to the Exploits River. Considerable difficulties have arisen with this source which, on the basis of examinations carried out to date, appears to be very high in manganese thereby imparting dark stains to plumbing fixtures. As of this time the problem has not been resolved; if the water from the wells is not amenable to economical treatment, it may be necessary to seek another source should a water with a lower manganese content be desired.

With respect to the other municipalities in the area with water supply systems, no data on contemplated changes are available, although it is unlikely that changes in source are planned.

At the present time Badger is the only municipality in the river basin study area which treats its municipal waste waters prior to discharging them into the adjacent receiving waters. With increased growth in the population of the area coupled with industrial expansion, treatment of municipal waste waters in the area will be necessary before the discharge of such wastes into the river. However, none of the municipalities in the area are currently planning waste water treatment facilities.

5 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

a) The Exploits River basin has undergone significant development in the industrial sector (forestry, mining, and hydro-electric power) due to the abundance of its natural resources. The natural resources also include significant underdeveloped potential for fisheries, wildlife, and related tourism and recreational activities, and in the future, development should continue in all these sectors.

b) In the past, development in this basin has taken place in an unco-ordinated manner and, as a result, a conflict of interests has emerged over the years between the use of water for the disposal of mining and pulp and paper mill wastes and log driving and the use of water for fisheries, tourism, and other interests which require water of good quality.

c) The use of water to develop hydro-electric energy on the main stem at Grand Falls has generally improved the conditions of downstream users because of flow regulation effects, but has created an obstruction for migratory fish, thus precluding development of the major portion of the basin for migratory fish. Similar effects have resulted from hydro plants located on the tributaries of the main river stem.

d) The effects of the Victoria River diversion of the Upper Exploits basin, which commenced in the summer of 1968, has intensified the actual and potential water resources conflicts between the various users in the basin. Depending upon the natural flow conditions in 1969 and the construction schedule of the diversions, significant effects of the diversions on the fisheries resource may be felt as early as the summer of 1969. The effect of increasing pollution and utilization of the tributaries for hydro energy production combined with increased angling pressure may have already begun to affect the fisheries resource as evidenced by the observed trend of reduction in catch per rod-day.

e) A significant alleviation of the deleterious effects of the diversion in the area downstream of the Exploits dam can be obtained by developing additional storage reservoirs in the basin. The additional energy production resulting from these storages would serve to offset most, if not all, of the investment required.

f) The storing and/or treatment of the pulp and paper mill wastes with possible recovery of chemicals or by-products as well as treatment of the mine and domestic wastes would also serve to alleviate the effects of the diversion and should be given consideration in stream improvement.

g) To correct the existing degradation of water quality for the benefit of the river's many users will require even for a minimum treatment level the capital investment in the order of $8,000,000 with annual operating costs of $300,000. The benefits from chemical or by-product recovery might offset these costs and as such merits further investigation.

h) In the area upstream of the Exploits dam, possible loss of the natural rearing areas may be compensated for by the artificial rearing of salmon smolts or the provision of small storage dams for flow augmentation. Log driving in the upper areas may continue if it is compatible with future fisheries development but additional storage dams on tributaries would be required to augment low flows.

i) There is no accurate measurement of the flow in the main stem of the Exploits River and the relationship between quantity and quality of river water is not know. However, during the course of this study, an agreement was reached between interested Federal and Provincial authorities for the installation of a hydrometric gauging station for flow measurement. The station will be located downstream of Grand Falls and include space for monitoring instrumentation to determine the physical and chemical characteristics of the Exploits River water.

j) Additional studies of Stage I I I detail are urgently required in order to evaluate the possible alternative solutions to the conflict of interests that exist in the basin.

5.2 Recommendations

a) Detailed investigations should be carried out as soon as possible to avoid the loss of anadromous fish in the Exploits River due to increased pollution concentrations which will follow the diversion of the Victoria and Lloyds Rivers.

It is considered that the detailed investigations should include:

i) A critical review of the water quantity and quality requirements indicated by present and potential users.

ii) A review of various methods of obtaining the required water quantity and quality along the river.

iii) Field and office investigations of the location, arrangements and costs of additional storage facilities in the upper part of the basin.

iv) A study of the available pulp and paper mill materials recovery systems and alternative methods of treatment of mill waste waters.

v) A further investigation of the method of dealing with mine tailings in relation to the water quality requirements of the river.

b) A local Advisory Board should be set up for this river basin which would include representatives of all jurisdictional levels and water users. Further, a water resource management plan should be developed by the Advisory Board taking into account the specific recommendations resulting from the investigations concerning the possible loss of the fisheries resource outlined above together with the following additional studies:

i) An economic appraisal of the possibilities of further hydro-electric development in the basin including the replacement of outdated hydro-electric facilities and resulting effects on other uses.

ii) A general appraisal of the economics of fishery, tourism, and wildlife resource development in the basin through the Federal and Provincial agencies concerned with these problems.

iii) A further appraisal of the existing municipal water supply and sewage systems and possibilities to provide the required water supply and sewage collection and treatment for the future. The intangible benefits of water pollution control and other water resource developments should also be appraised.

iv) A review of legislative and administrative conditions, including an inventory of water rights in the basin.

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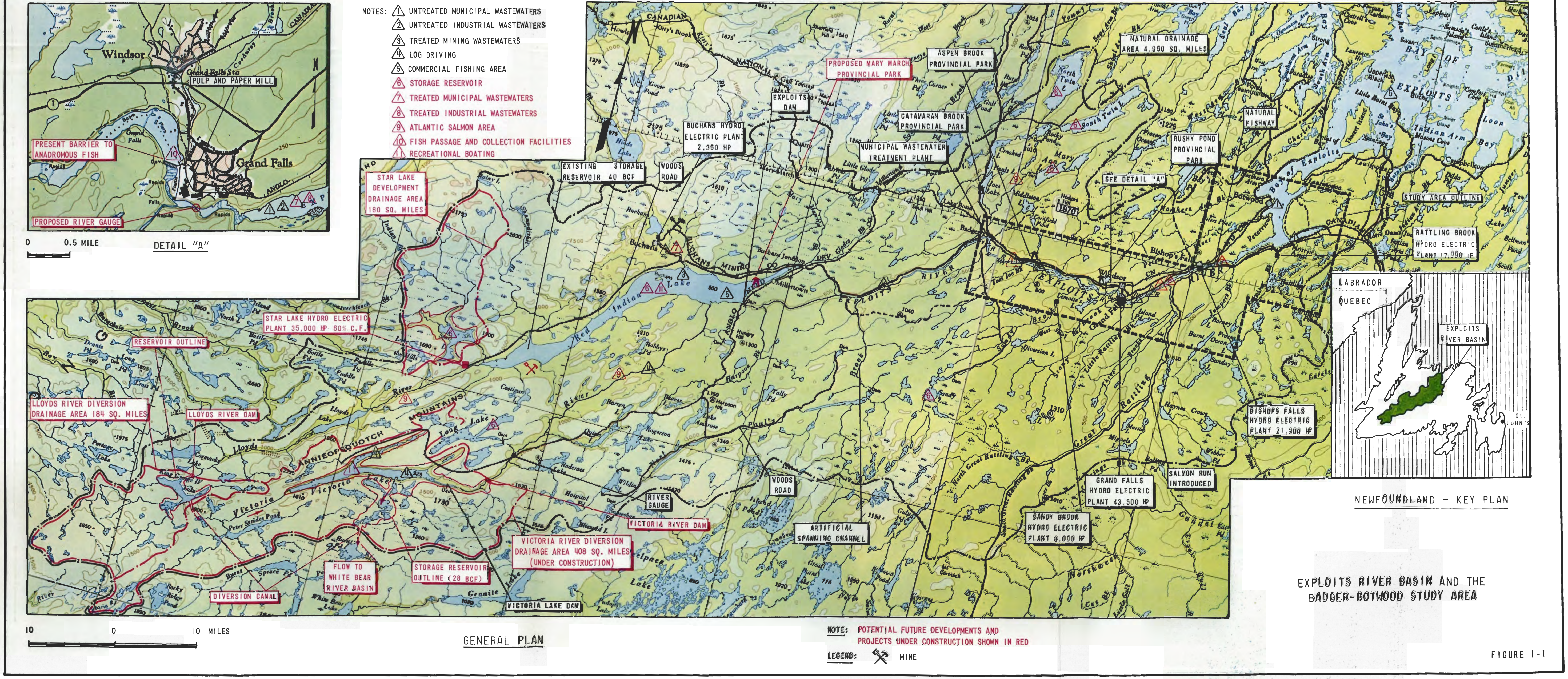
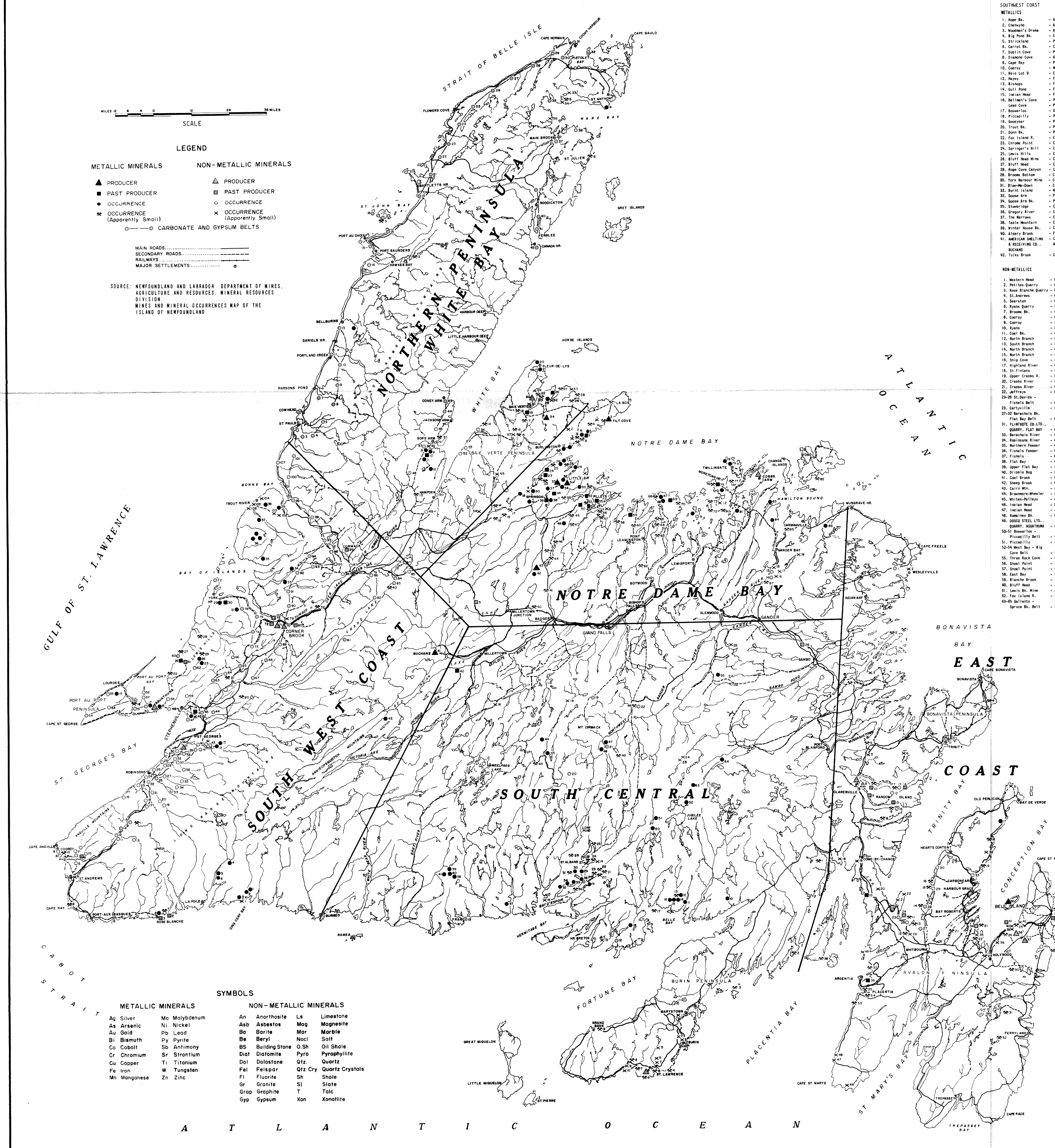
The Shawinigan Engineering Company Limited
James F. MacLaren Limited



EXPLOITS RIVER BASIN AND THE BADGER-BOTWOOD STUDY AREA

FIGURE 1-1



INDEX TO MINES, QUARRIES AND MINERAL OCCURRENCES

SOUTHWEST COAST

METALLICS

1. Hope Bk. - Au
2. Chetwynd - Au,Cu,Fe
3. Woodman's Droke - Au,Ag
4. Big Pond Bk. - Cu,Pb,Zn,Ag
5. Strickland - Pb,Zn,Ag,Cu
6. Carrot Bk. - Cu,Pb,Zn
7. Dublin Cove - Pb,Zn,Ag,Au
8. Diamond Cove - Au,As,Zn,Qtz
9. Cape Ray - Pb
10. Codroy - Mn
11. Reid Lot 9 - Cu
12. Hayes - Fe,Ti
13. Bishops - Fe,Ti
14. Gull Pond - Fe,Ti
15. Indian Head - Fe,Ti
16. Bellman's Cove - Pb,Zn
Lead Cove - Pb,Zn
17. Boswarlos - Sr,Ba
18. Piccadilly - Pb
19. Goodyear - Pb,Zn
20. Trout Bk. - Pb
21. Donn Bk. - Pb,Zn
22. Fox Island R. - Cu
23. Chrome Point - Cr
24. Springer's Hill - Cr
25. Lewis Hills - Cr
26. Bluff Head Mine - Cr
27. Bluff Head - Cr
28. Rope Cove Canyon - Cu,Ni
29. Brooms Bottom - Cu
30. York Harbour Mine - Cu,Zn
31. Blow-Me-Down - Cr
32. Burnt Island - Mo
33. Goose Arm - Pb,Zn
34. Goose Arm Bk. - Pb,Zn
35. Stowbridge - Cr
36. Gregory River - Cu,As
37. The Narrows - Cu,As
38. Table Mountain - Cu
39. Winter House Bk. - Cu,Ni,Asb
40. Aldery Brook - Fe
41. AMERICAN SMELTING & RECEIVING CO., BUCHANS - Cu,Pb,Zn, Au,Ag
42. Tulks Brook - Cu

NON-METALLICS

1. Western Head - Be
2. Petites Quarry - Gr
3. Rose Blanche Quarry - Gr
4. St.Andrews - Coal
5. Searston - Gyp
6. Ryans Quarry - Ls
7. Brooms Bk. - Gyp
8. Codroy - Gyp
9. Codroy - Ls
10. Ryans - Nacl
11. Coal Bk. - Coal
12. North Branch - Gyp
13. South Branch - Ls(Mar)
14. North Branch - Gyp
15. North Branch - Ls
16. Ship Cove - Ls,Gyp
17. Highland River - Gyp,Nacl
18. St.Fintans - Ls
19. Upper Crabbs R. - Nacl
20. Crabbs River - Nacl
21. Crabbs River - Gyp
22. Jeffreys - Nacl
23-26 St.Davids - Fishels Belt - Gyp
23. Cartyville - Ls
27-32 Barachois Bk. Flat Bay Belt - Gyp
31. FLINTKOTE CO.LTD., QUARRY, FLAT BAY - Gyp
33. Barachois River - Coal
34. Robinsons River - Coal
35. Northern Feeder - Coal
36. Fishels Feeder - Nacl
37. Fishels - Nacl
38. Flat Bay - Gas
39. Upper Flat Bay - Peat
40. Dribble Bog - Peat
41. Coal Brook - Gyp
42. Sheep Brook - Gyp
43. Cairn Mtn. - An
44. Brownmore-Wheeler - Peat
45. Whites-Pelleys - Peat
46. Indian Head - Be
47. Indian Head - An
48. Romaines Bk. - Gyp
49. DOSCO STEEL LTD., QUARRY, AGUATHUNA - Ls
50-51 Boswarlos - Piccadilly Belt - Gyp
51. Piccadilly - Ls
52-54 West Bay - Big Cove Belt - Ls
55. Three Rock Cove - Ls
56. Shoal Point - Peat
57. Shoal Point - Oil
58. East Bay - Ls
59. Blanche Brook - Ls
60. Bluff Head - Asb
61. Lewis Bk. Mine - Asb
62. Fox Island R. - Ls
63-65 Gallants - Spruce Bk. Belt - Ls
66. Bonds - Asb
67-70 Georges Lake - Humbermouth Belt - Ls
70. NORTH STAR CEMENT LTD. QUARRY, CORNER BROOK - Ls(Mar)
71. NORTH STAR CEMENT LTD. QUARRY, CORNER BROOK - Sh
72. Curling Quarry - Sh
73-75 Cooks Bk. - Mt. Moriah Belt - Ls
76. Blow-Me-Down - Asb
77. Lark Harbour - Asb
78. Summerside Quarry - Sl
79. Wild Cove - Clay
80. Junction Quarry - Ls
81. Grand Pond Pt. - O.Sh
82. Whetstone Point - O.Sh
83. Coal Bk.(Howley) - Coal
84. Kelvin Brook - Coal
85. Goose Brook - Coal
86. Intake - Gas
87. Deer Lake - O.Sh
88. Nicholsville - Gas
89. Cormack Quarry - Ls
90-101 Hughes Bk. - Deer Lake - Bonne Bay Belt - Ls
102. Table Mtn. - Asb
103. Winter House Bk. - Xon
104. Skinner Cove - Asb
105. Trout River - Asb
106. Trout River - Asb
107. Green Point - Ls

NORTHERN PENINSULA WHITE BAY

METALLICS

1. Leitch Gold Mines Limited - Zn
2. Western Bk. Pd. - Pb
3. St.John Island - Zn,Pb
4. Goose Cove - Cu,Zn,Ni,As
5. Howe Harbour - Ni
6. St.Julien - Cu
7. Schooner Cove - Ag,Pb,Cu
8. West Corner Bk. - Au,Pb,Cu, Ag,Zn
Country Cove - Fe
9. Simms Ridge - Au,Ag,Pb,Cu
10. Brownings Mine - Au,Cu,Pb,Zn
11. Unknown Bk. - Au
12. Freemans - Au,Cu,Pb
13. Gales Brook - Cu
14. Pigeon Island - Ti
15. Flatwater Pd. - Pb,Cu
16. Flatwater Pd. - Cr
17. Six Mile Rd. - Cu
18. Seal Cove Rd. - Pb
19. Terra Nova Mine - Cu,Zn
20. Pigeon Cove - Pb,Zn,Cu
21. Hodder & Travers-town - Cu,Pb,Zn,Ag
Parrell - Mo,Pb,Cu
22. Duck Island - Cu
23. Green Cove - Cu
Penny Cove - Cu
24. CONSOLIDATED RAMBLER MINES LIMITED - Cu,Au
25. Mud Pond - Cu
26. Goldenville Mine - Au
Barry & Cunning-ham - Cu,Fe
27. Mings Tickle - Cu
28. Pacquet - Cu
29. Woodstock - Cu

NON-METALLICS

1. Big Falls - Gas
2. Broom Point - Ls
3. St.Pauls Inlet - Oil
4-5 St.Pauls Belt - Ls
6. Cow Head - Ls
7. Parsons Pond - Oil
8-13 Parsons Pond - Bellburns Belt - Ls
14. Hawke Bay - Ls
15. Point Riche - Ls
16. Eddies Cove - Ls
17. St.John Island - Ls
18. Flat Island - Ls
19-29 St.John Bay - Open Bay Belt - Dol
30-31 Cooks Hr. Belt - Ls
32. Raleigh - Ls
33. Three Brooks Pd. - Asb
34. Howe Harbour - Asb
35. Hare Island - Ls
36. Goose Tickle - Sl
37. Main Brook - Ls
38. Big Spring Inlet - Ls
39-41 Roddickton - Bide Arm Belt - Ls
41. Bide Arm - Mar(Dol)
42. Canada Harbour - Mar(Ls)
43-45 Coney Arm - Jacksons Arm Belt - Mar(Ls)
46. Giles Cove - Asb
47. Sops Arm - Mar(Ls)
48. Taylor Brook - Mar(Ls)
49. Hampden Road - Mar(Ls)
50. Georges Cove Bk. - Mar(Ls)
51. Beaches - Mar(Ls)
52. Publey Cove - Ls
53. Purbeck Cove - Mar(Ls)
54. Upper Indian Pd. - Asb
55. Wild Cove Pd. - Asb
56. Bear Cove - Mar(Ls)
57. Flatwater Pd. - Asb
58. Fleur de Lys - Mar,T
59. Slaughter House Cove Brook - Grap
60. ADVOCATE MINES LIMITED - Asb
61. Baie Verte - Asb
62. Mings Bight - T
63. Hardy Harbour - Fel

NOTRE DAME BAY

METALLICS

1. La Scie - Pb
2. FIRST MARITIMES MINING CORP., TILT COVE - Cu,Au
3. Long Pond - Cu
4. Snooks Arm Pd. - Cu
5. Mount Misery - Cu
6. Betts Cove - Pb,Zn,Ag,Cu
7. Betts Cove Mine - Cu,Zn
8. Burtons Pond - Cu,Zn,Au,Ag
9. Nippers Harbour - Cu
10. Walsh Cove - Cu,Pb
11. Rogues Harbour - Cu,Pb
12. Stocking Harbour - Cu,Pb,Zn
13. Garden Cove - Cu
14. Black Lake Bk. - Cu
15. Silver Brook - Cu
16. White Horn Brook - Cu
17. Indian Pond - Cu
18. Muir Pond - Cu,Pb,Zn
19. Indian Brook - Cu,Pb,Zn,Au
20. Randell Jackman - Cu
21. Wells - Cu,Zn,Au
22. Browns Pond - Cu
23. McNeily Mine - Cu
Colchester Mine - Cu
24. Old English Mine - Cu
25. Swatridge - Cu
26. Silverdale - Cu,Pb,Ag
27. Wheeler - Cu
28. Norris - Cu
29. Little Bay Head - Cu,Zn,As
30. Indian Beach - Cu
Keatons - Cu
31. ATLANTIC COAST COPPER CORP., LITTLE BAY - Cu,Au
32. Hearn - Au,Cu,Pb,Zn,As
33. BRITISH NFLD EXPLORATION LTD. WHALESBACK MINE - Cu
34. Delaney - Cu
35. Bobs Head - Cu
36. Lady Pond - Cu,Fe
37. Mine Pond - Cu
Delgado - Cu
38. Sullivan - Cu
39. Sterling - Cu,Zn
40. Lake Bond - Cu,Zn
41. Skull Hill Lake - Cu
42. Gull Pond - Cu
43. GULLBRIDGE MINES LTD., GULL POND - Cu
44. Burnt Pond - Cu
45. Hand Camp - Au
46. Rocky Pond - Cu
47. Kippens Pond - Cu
48. Rust Pond - Cu
49. Round Pond - Pb,Cu
50. Crescent L. Mine - Cu
51. Sunday Cove Is. - Cu
52. Miles Cove Mine - Cu
53. Roberts Arm - Cu,Pb
54. Roberts Arm - Cu
55. Pilleys Is. Mine - Py,Cu
Freeman - Cu
56. Burton Harbour - Mn
57. Gull Island - Mn
58. Indian Cove - Cu
59. Lockport Mine - Cu
60. South Lake - Cu
61. Long Pd.-Rocky Pond - Cu
62. Rowsells Hill - Cu
63. Saunders Cove - Cu
64. Tea Arm - Cu,Zn
65. Strong Island - Cu
66. Fleury Bight - Fe
67. Fortune Harbour - Cu
68. Fortune Harbour - Mn
69. Fortune Harbour - Fe,Mn
70. Little Northern Harbour - Cu
71. Pond Island - Sb,Bi,Cu
72. Sugarloaf - Ni
73. Tinker Island - Fe
74. Western Head - Cu
75. Moretons Hr. Mine - Sb,As,Au,Pb,Zn
Little Harbour - As
Taylors Room - Au
76. Bridgeport - Cu
77. Trump Island - Cu
78. Sleepy Cove - Cu
79. Wild Cove - Cu,Zn,Pb
80. Farmer Island - Cu
81. Chapel Island - Ni,Cu
82. Cann Island - Cu
83. Dog Bay - Cu
84. Gander Bay - W
85. Mann Point - Ni
86. Shoal Pond - Cr,Cu,Asb
87. Second Pond - Cr,Asb

NON-METALLICS

1. Red Cliff Pd. - T
2. Nippers Harbour - Asb
3. Nippers Harbour - Gr
4. Kings Point - Ls
5. Quarry Station - Gr
6. Little Bay Is. - Ls
7. Lushes Bight - Ls
8. Duck Island - Ls
9. Long Island - Gr
10. Campbellton - Sl
11. Loon Bay Pen. - Gr
12. Cottle Bay - Ls
13. NFLD. LIME MANU-FACTURING CO. LTD., QUARRY, COBBS ARM - Ls
14. Second Pond - Mag
15. First Pond - Mag,Asb,Cr
16. Purseys Hill - Asb
17. Weirs Brook - Asb
18. First Pond - Asb
19. Weirs Pond - Asb

EAST COAST

METALLIC

1. Gooseberry Is. - Au
2. Pitt Sound Is. - Cu
3. Glovertown - Cu
4. Little Catalina - Pb
5. Bloomfield - Pb,Zn,Au,Ag
6. Smith Point - Mn
7. Burgoynes Cove - Mn
8. Northwest Arm - Cu
9. Hatchet Cove - Pb,Zn
10. La Manche Mine - Pb,Zn,Ag,Ba
11. Chapel Arm - Mn
12. Chapel Arm - Mn
13. Spread Eagle Bay - Mn
14. Hopeall - Mn
15. Cavendish - Mn
16. Long Point - Mn
17. Workington Mine - Fe
18. Smooth Cove - Fe
19. Perry's Cove - Pb
20. Snows Pond - Fe
21. Brigus - Mn
22. Colliers Bay - Mn,Cu
23. North Arm - Cu
24. Kelligrews - Mn
25. Manuels - Mn
26. DOSCO INDUSTRIES LTD., WABANA MINES - Fe
27. White Hills - Cu
28. Motion Head - Cu
29. Shoal Bay - Cu
30. Witless Bay Line - Au,Ag,Mo
31. Mt. Carmel Pond - Au
32. Aquaforte - Au
33. Black Point - Pb
34. Verrans Island - Pb
35. Jerseyside - Pb,Ag
36. Silver Cliff Mine - Pb,Zn,Ag
37. Ship Hr. Point - Pb
38. Merasheen Island - Pb,Zn

NON-METALLICS

1. Wesleyville - Be,Diat
2. Wesleyville Area - Gr
3. Fair & False Bay - Grap
4. Keels - Sl
5. Morley's Crossing - Ls
6. Ocean Pond - Ls
7. C & M PELLEY LTD. BRICK PLANT, MILTON
8. C & M PELLEY LTD. QUARRY, RANDOM ISLAND - Sh
9. Elliotts Cove - Clay
10. Snooks Harbour - Clay
11. Smith Point - Sh
12. Petley - Ls
13. Burgoynes Cove - Ls,Sl
14. Burn Point - Sl
15. Hickmans Harbour - Sl
16. Grieves Quarry - Sl
17. North Hr. River - Ls
18. North Harbour - Ls
19. Come by Chance - Ls
20. Rantem Cove - Ba
21. Bellevue - Ba
22. Tickle Hr. Pt. - Ba
23. Long Cove - Ls
24. Colliers Cove - Ba
25. Normans Cove - Ls
26. Chapel Arm - Ls
27. Old Shop - Ls
28-30 Hopeall - Hearts Desire Belt - Ls
31. Grates Cove - Qtz,Cry
32. Adams Cove - Qtz,Cry
33. Victoria - Diat
34. Brigus - Sl
35. Marysvale - Ls
36. Seal Cove - Gr
37. SUNDEW PEAT MOSS, COCHRANE POND - Peat
38. NFLD. MINERALS LTD., MANUELS - Pyro
39. Foxtrap - Ls
40. Manuels - Sh
41. Kellys Island - Bs
42. Topsail - Ls
43. Signal Hill - Bs
44. Southside - Bs
45. Goulds - Peat
46. Point Lance - Ls
47. St.Brides - Ls,Ba
48. Cuslett - Ls,Ba
49. Iona Islands - Fl

SOUTH CENTRAL

METALLICS

1. Hickey's Pond - Fe
2. St.Annes - Cu
3. Oderin Island - Cu,Ba
4. Western Bass Cove - Cu
5. St.Lawrence - Fe
6. Chambers Cove - Pb,Zn,Ag Mo,Fl
7. Mine Cove - Pb,Zn,Ag,Fl
8. Lawn - Mo
9. Grand Bank - Pb,Zn,Cu
10. Anstey Hill - Mo
11. Mal Bay - Pb,Zn,Ag
12. Wylie Hill - Mo
13. Dunphey Brook - Pb,Zn
14. Crow Cliff - Mo
15. Ackley City - Mo
16. Motu - Mo
17. Bell Island - Mo,Cu,Fl,Ba
18. Salmonier Cove Pond - Mo
19. Barasway de Cerf - Pb,Zn,Ag
20. Long Jacks Bight - Pb,Zn,As
21. Whitewood Tickle Brook - Pb
22. Third Basin Little River - Sb,Ag,Au
23. Mine Point - Ni
24. Conne Basin - Pb,Zn
25. Pardy Head - Pb,Zn,Ag,As
26. Woody Hill Pond - Mo
27. Man of War Cove - Au
28. Breccia Brook - Au,Grap
29. Muddy Hole - Pb,Cu,Zn,Ag,Au
30. Grandy Pond - Mo,Bi,Au
31. South Brook - Mo,Pb
32. Roti Bay - Pb,Zn,Ag
33. Buzzard Lake - Pb,Zn,Cu,Ag
34. Northwest Cove - Mo,Cu,Zn,Be
35. Pomley Cove - Mo
36. Bois Island - Pb,Ag
37. Facheux Bay - Pb,Zn,Cu,Ag
38-41 Grey River Area - W
42. Victoria Mine - Cu,Zn
43. Great Burnt Lake - Pb,Zn
44. South Pond - Cu
45. Pipestone Pond - Cr,Cu
46. Great Bend - Cr
47. Burnt Hill - Cr
48. Burnt Hill - Cr
49. Coy Brook - Cu
50. Kim Lake - Pb,Zn,Cu,Ag,Au
51. Kim Lake - Sb
52. Kaegudeck Lake - Cu,Co
53. Lower Rainy Lake - Pb,Zn
54. Kepenkeck Lake - Cu,Pb,Zn,Ag
55. Deer Wolf Bk. - Pb,Zn,Cu,Ag

NON-METALLICS

1. Marystown - Clay
2. Salmonier - Ls
3. Burin Bay - T
4. Burin - Ls
5. Strouds Hill - Pyro
6. St.Lawrence - Fl
7. St.Lawrence - Fl
8. NFLD. FLUORSPAR LIMITED - Fl
9. Webber Cove - T
10. Lawn - Ba,Mn
11. Old Baldy - Fl
12. Wreck Cove - Ls
13. Little Bay West - Ls
14. Conne Basin - Ls,Clay
15. Goblin Head - Ls
16. Tally Pond - Ls
17. Noel Pauls Bk. - Ls
18. Peter Joe River - Ls
19. Great Rattling Brook - Asb
20. Nfld. Dog Pond - Asb
21. Burnt Hill - Mag,Asb
22. Great Bend - Mag
23. Asbestos Bk. - Asb
24. Three Falls Bk. - Asb
25. Hunts Pond - Asb
26. Benton - Gr

NEWFOUNDLAND
MINES AND MINERAL
OCCURRENCES MAP

FIGURE 1-2

EXPLOITS RIVER BASIN AND BADGER-BOTWOOD STUDY AREA
SQUARE GRID DISTRIBUTION OF LAKES, BOGS, BARRENS AND FORESTS

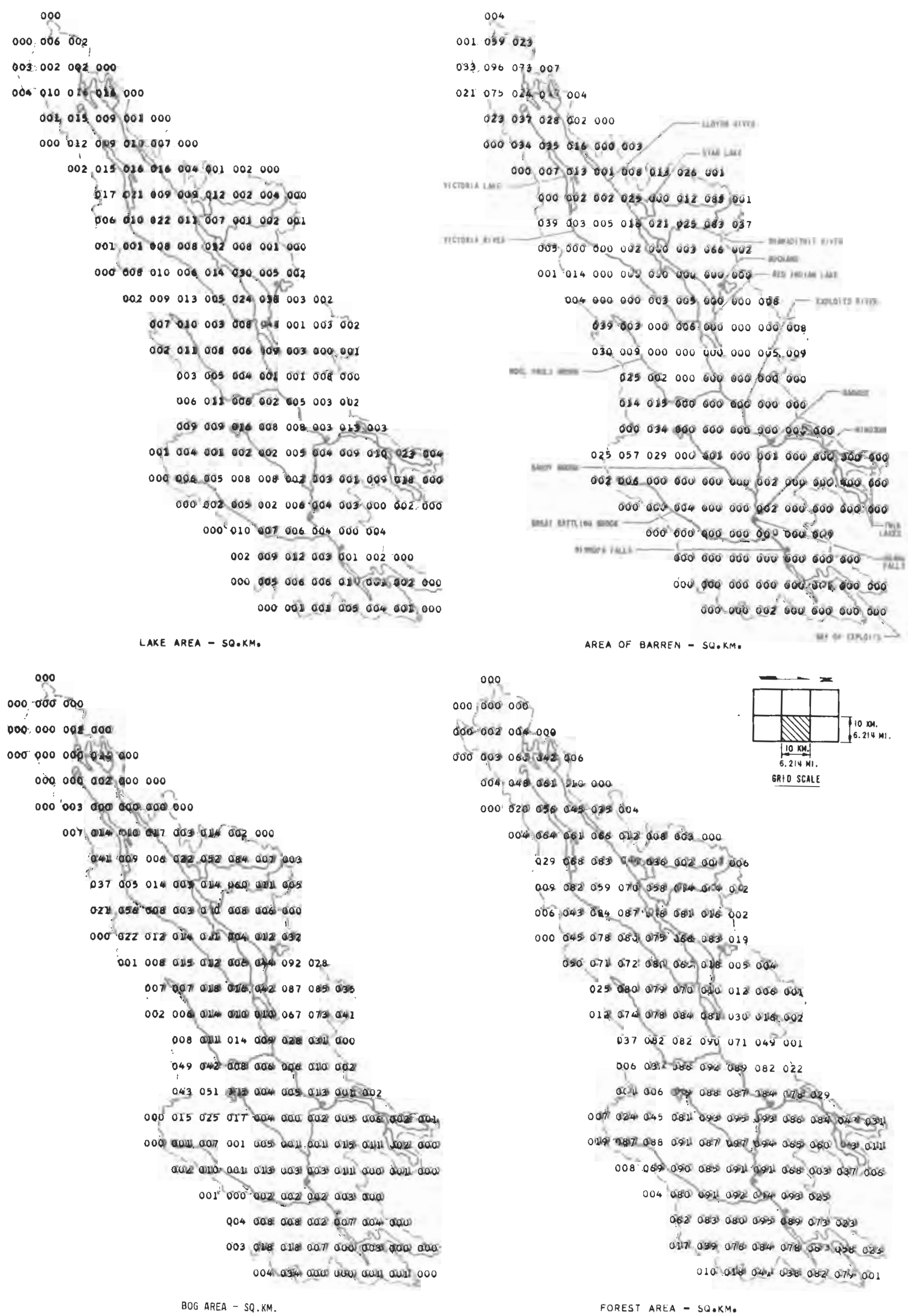


FIGURE 1-3

HYPSOGRAPHIC CURVES
SELECTED RIVER BASINS

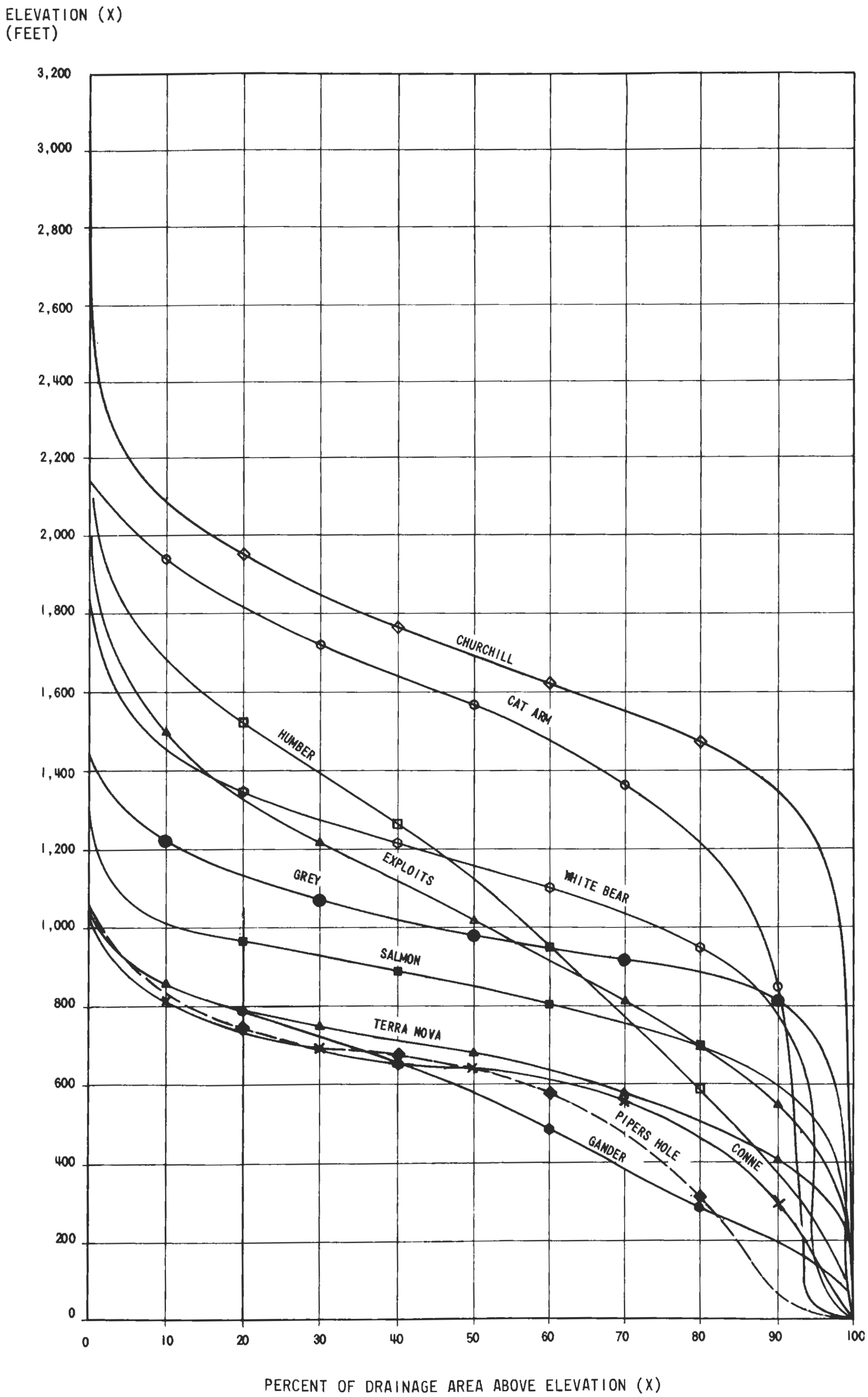


FIGURE 1-4

EXPLOITS RIVER BASIN AND BADGER-BOTWOOD STUDY AREA SQUARE GRID DISTRIBUTION OF LAND SURFACE SLOPE AND ELEVATION

AVERAGE ELEVATION OF SQUARE - TENS OF FEET

SLOPE - TENTHS OF A PERCENT

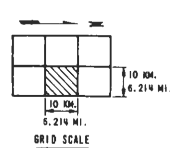
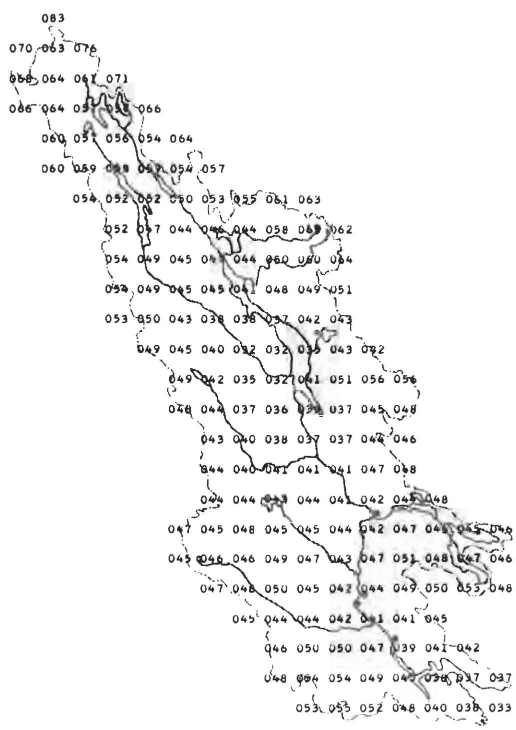


FIGURE 1-5

EXPLOITS RIVER BASIN AND BADGER - BOTWOOD STUDY AREA SQUARE GRID DISTRIBUTION OF MEAN ANNUAL TEMPERATURE, PRECIPITATION, EVAPORATION AND RUNOFF

AVERAGE YEARLY TEMPERATURE -DEGREES FAHRENHEIT

AVERAGE YEARLY EVAPORATION - INCHES OF WATER



AVERAGE YEARLY PRECIPITATION - INCHES OF WATER

AVERAGE YEARLY RUNOFF - INCHES OF WATER

FIGURE 1-6

The Shawinigan Engineering Company Limited
James F. MacLaren Limited

EXPLOITS RIVER BASIN AND BADGER - BOTWOOD STUDY AREA
GROSS HYDRO ELECTRIC POTENTIAL
ON EXPLOITS RIVER

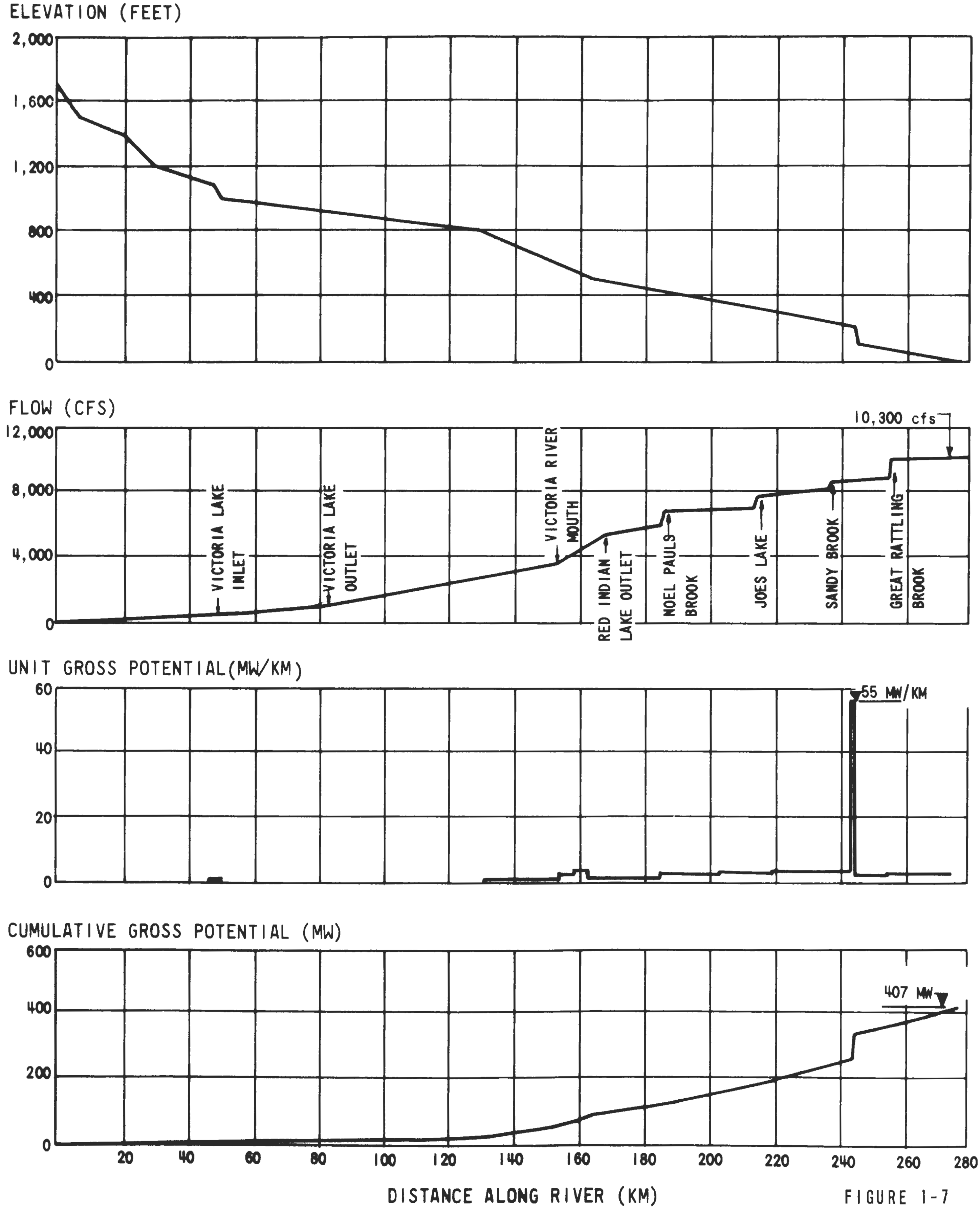
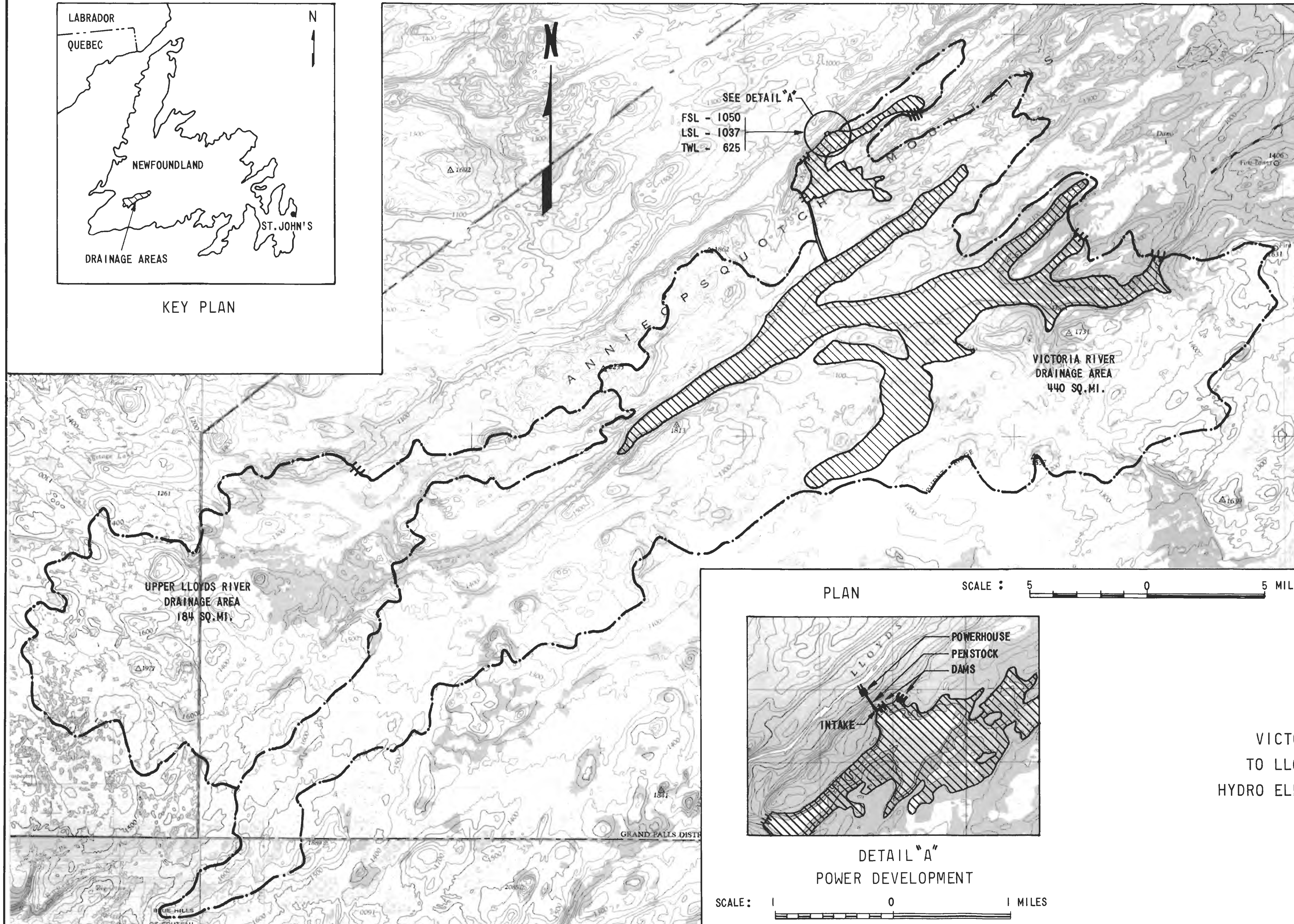


FIGURE 1-7

The Shawinigan Engineering Company Limited
James F. MacLaren Limited



LEGEND

DAM
CANAL OR TAILRACE
CONTROL STRUCTURE
PENSTOCK
POWERHOUSE
FLOODED AREA

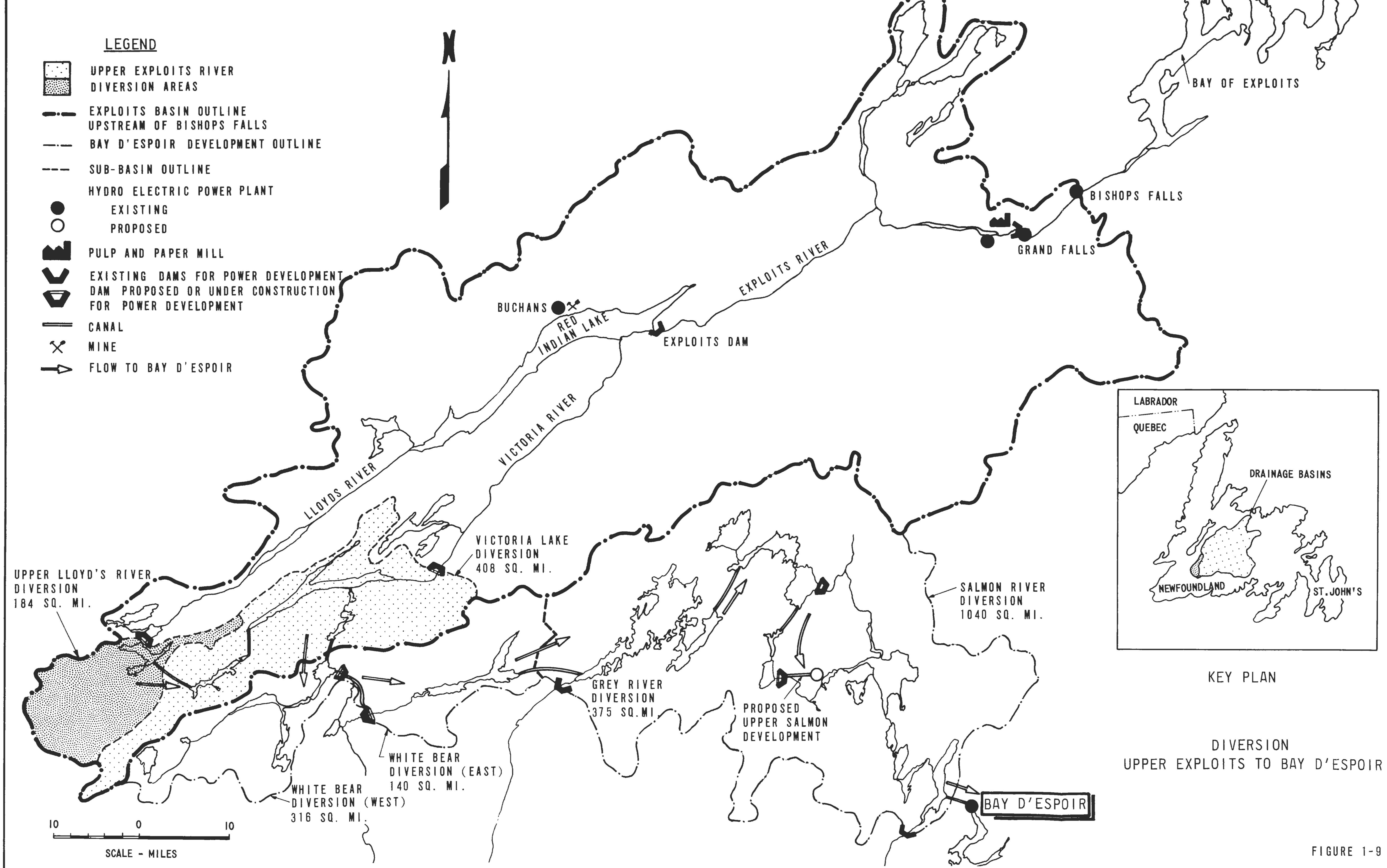
NOTE:

BASIC DATA OBTAINED FROM SHAWMONT REPORT No. SM-1-66

VICTORIA LAKE
TO LLOYDS RIVER
HYDRO ELECTRIC SCHEME

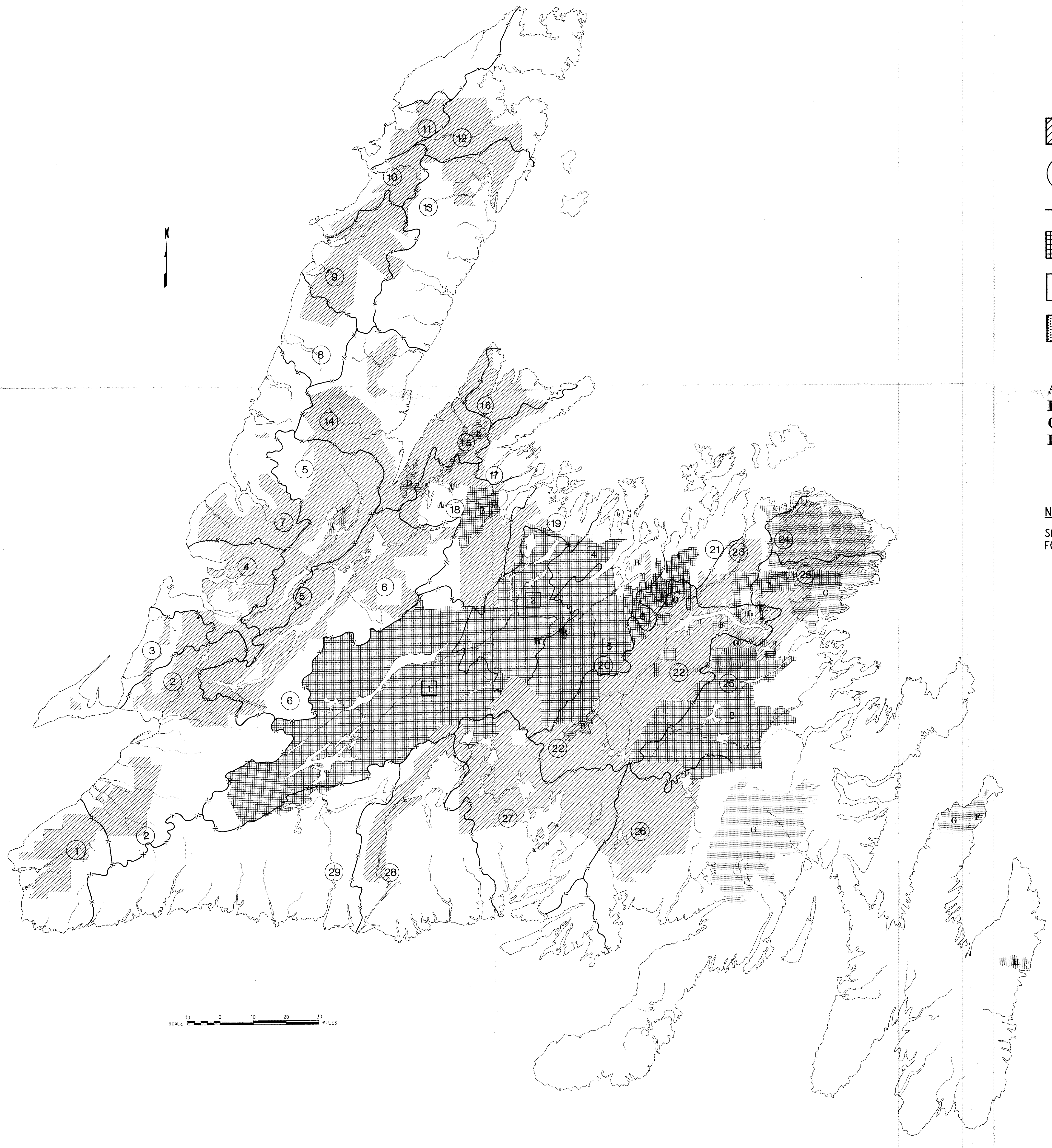
FIGURE 1-8

The Shawinigan Engineering Company Limited
James F. MacLaren Limited



DIVERSION
UPPER EXPLOITS TO BAY D'ESPOIR

FIGURE 1-9



LEGEND

BOWATERS NEWFOUNDLAND LIMITED TIMBER LIMITS

(4) BOWATERS NEWFOUNDLAND LIMITED PRIMARY INVENTORY UNIT NUMBER

—x—x— BOWATERS NEWFOUNDLAND LIMITED PRIMARY INVENTORY UNIT OUTLINE

PRICE (NFLD.) PULP AND PAPER LIMITED TIMBER LIMITS

[3] PRICE (NFLD.) PULP AND PAPER LIMITED INVENTORY NUMBER

A BURNED AREAS

YEAR

A	1949	E	1959
B	1950	F	1960
C	1951	G	1961
D	1952	H	1962

NOTE

SEE TABLE 8-4 AND 8-5 OF VOLUME 3 FOR ACREAGE FIGURES

NEWFOUNDLAND
MAP OF EXISTING TIMBER LIMITS
AND BURNED AREAS

FIGURE 1-10

EXPLOITS RIVER BASIN
ANNUAL ANGLERS CATCH
(SALMON AND GRILSE)

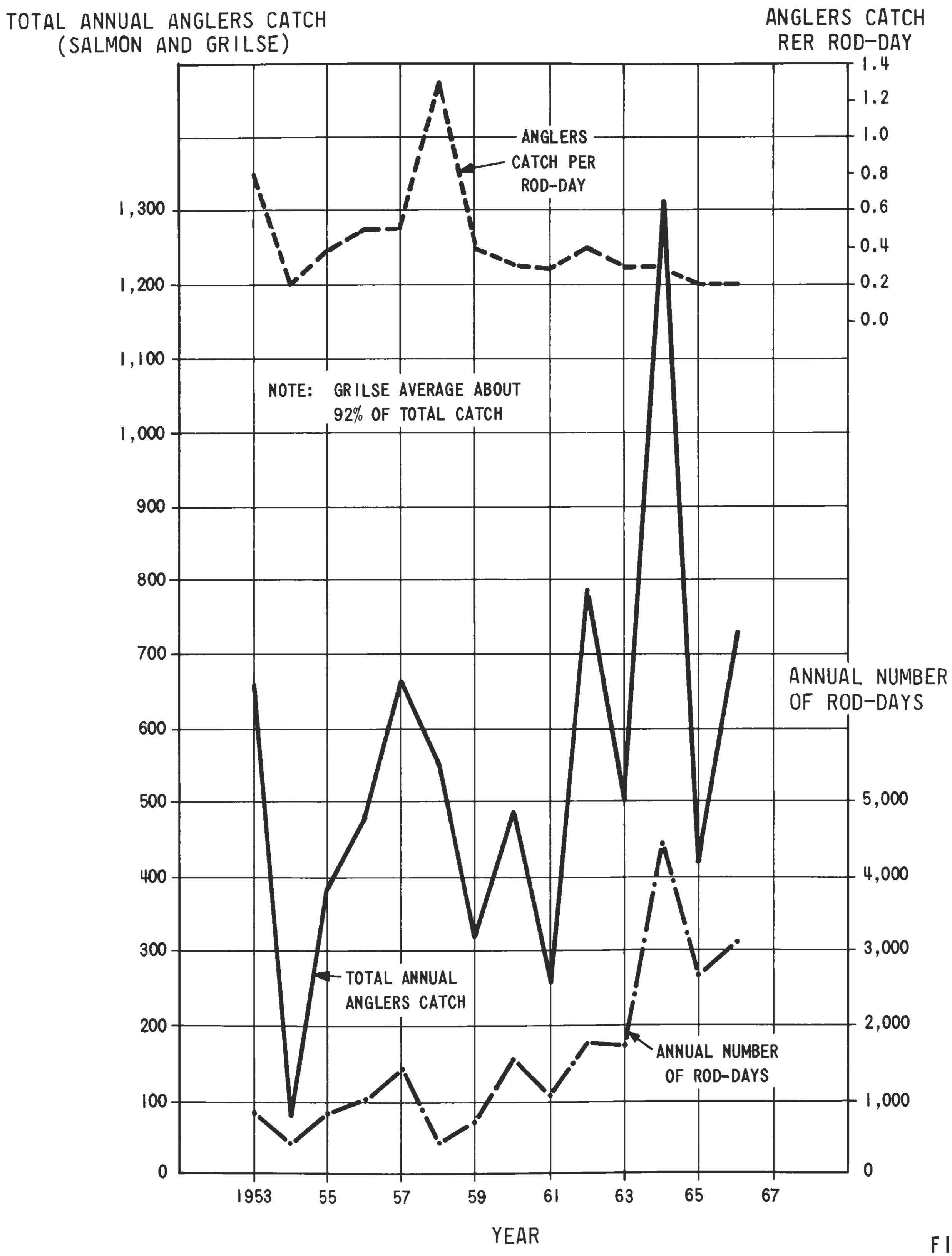
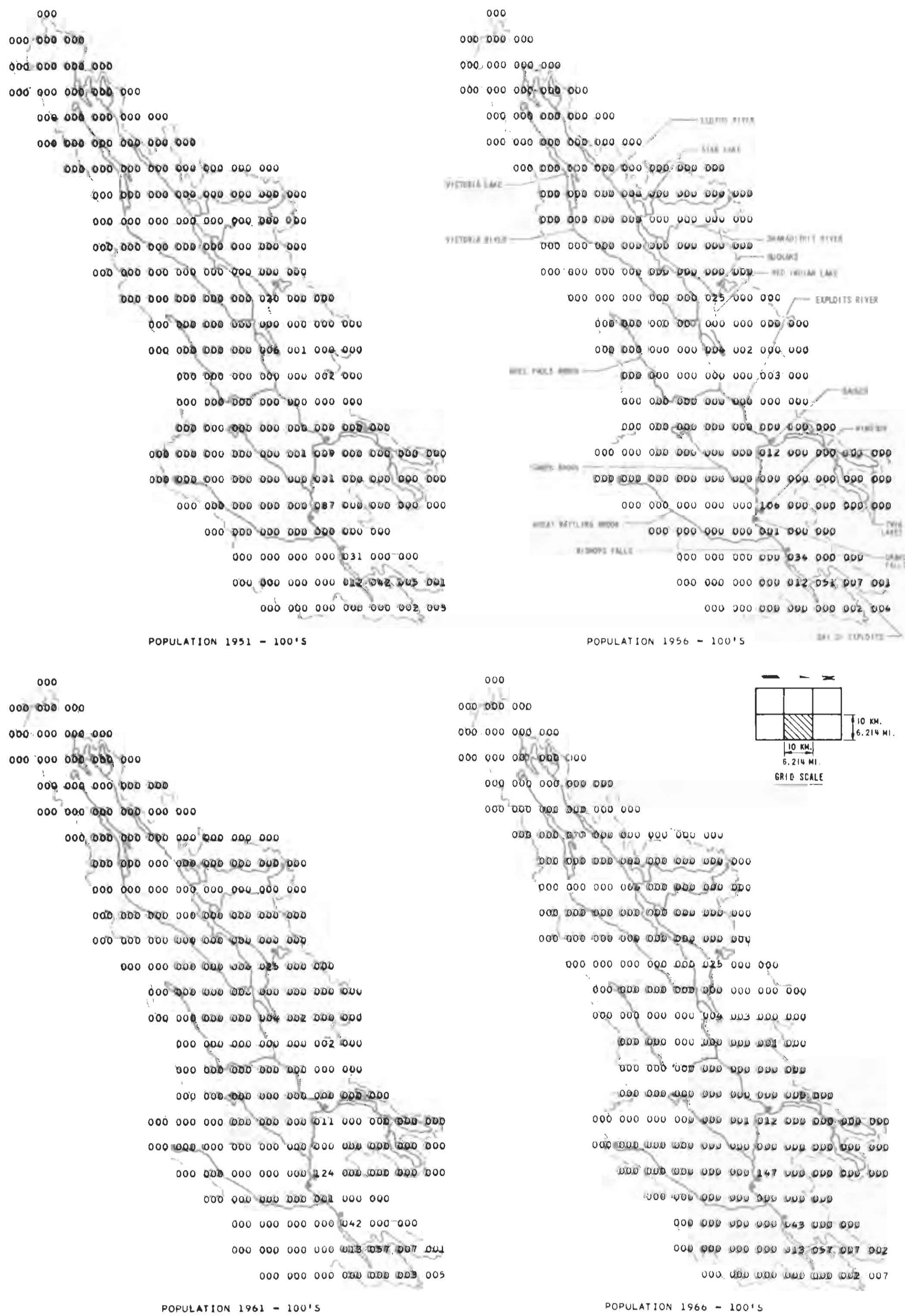


FIGURE 2-1

EXPLOITS RIVER BASIN AND BADGER-BOTWOOD STUDY AREA
SQUARE GRID DISTRIBUTION OF RECORDED POPULATION 1951-1966



POPULATION 1951 - 100'S

POPULATION 1956 - 100'S

POPULATION 1961 - 100'S

POPULATION 1966 - 100'S

FIGURE 2-2

EXPLOITS RIVER BASIN AND BADGER-BOTWOOD STUDY AREA
FLOW DURATION CURVE - EXPLOITS RIVER AT GRAND FALLS

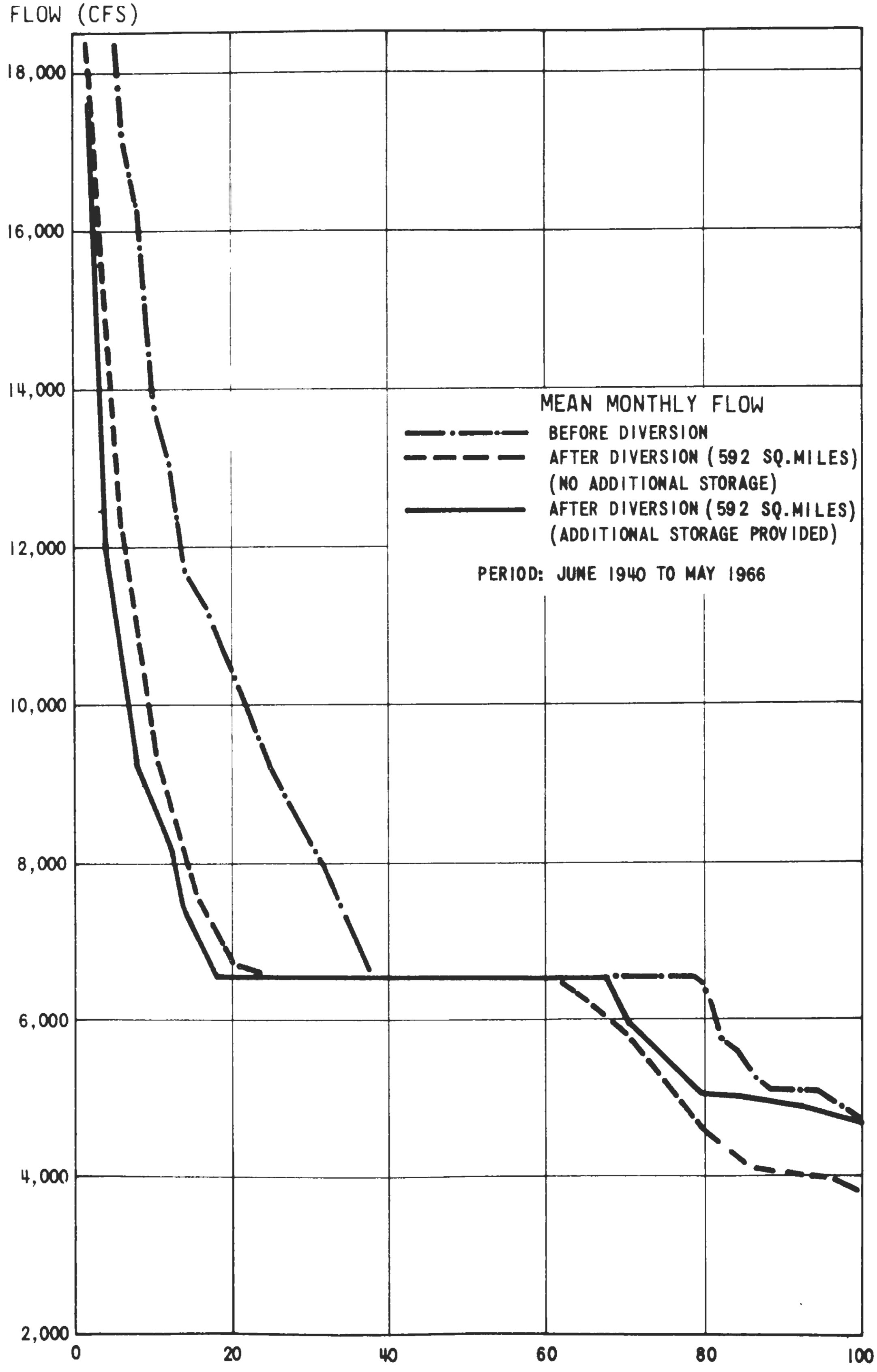
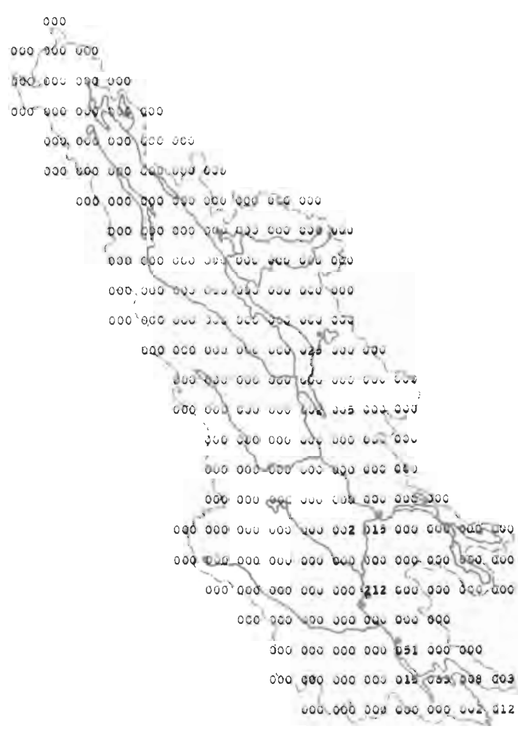


FIGURE 3-1

EXPLOITS RIVER BASIN AND BADGER-BOTWOOD STUDY AREA
SQUARE GRID DISTRIBUTION OF POPULATION FORECAST 1971 - 1981

POPULATION 1971 - 100'S

POPULATION 1976 - 100'S



POPULATION 1981 - 100'S

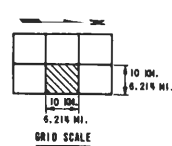


FIGURE 4-1

EXPLOITS RIVER BASIN AND BADGER-BOTWOOD STUDY AREA

GROUNDWATER POTENTIAL

Hydrogeologic Unit	Mean Well Depth (bedrock)	Estimated* Yield Range (gpm)	Percentage of Basin	Area in Basin (sq. mi)	Comments
Bedrock Units:					
R1	159	0 to 40	32.6	1610	Includes some basic and ultra basic rocks which may hold poor quality water.
R4	113	1 to 20	19.6	970	
R5	88	1 to 30	22.6	1120	
R6	127	1 to 200	24.7	1220	
R7	121	1 to 100	0.5	25	These are the only non-indurated sediments on the Island. Unlike other Carboniferous sediments.
Surficial Units:					
S2		10 to 50	62.0	3060	
S3		5 to 50	38.0	1885	
S5			16.0	790	Poor quality water

A detailed discussion of hydrogeology is given in Volume Two.

* 200 feet deep, 6-inch diameter well in bedrock.
12 inch screen and at least 10 feet of water in surficials.

MONTHLY, ANNUAL, AND LONG-TERM AVERAGE DISCHARGE (CFS)

EXPLOITS RIVER AT GRAND FALLS

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	AVERAGE
40	8870.	10350.	9530.	3320.	2580.	3350.	14600.	27800.	8340.	5270.	11800.	5720.	9294.
41	7150.	10340.	6530.	5250.	4750.	3190.	12300.	28000.	8830.	8030.	13800.	7010.	9598.
42	9420.	12700.	5590.	5250.	8300.	6150.	10880.	30600.	5660.	9460.	4920.	4840.	9480.
43	7320.	14500.	3440.	2110.	3020.	4620.	10590.	25100.	6370.	2940.	3670.	9390.	7755.
44	10180.	13700.	4830.	5420.	3980.	5130.	6160.	27500.	17700.	5350.	4960.	12200.	9759.
45	17300.	16300.	6870.	7750.	4150.	4100.	17500.	30000.	10130.	3960.	1514.	4610.	10348.
46	5960.	14900.	11600.	3970.	6500.	7630.	13300.	15800.	3960.	1188.	1997.	2900.	7475.
47	4370.	7350.	4680.	3170.	7630.	5630.	4150.	36800.	14700.	3530.	1557.	1399.	7913.
48	4750.	2560.	2720.	6725.	3760.	3260.	7630.	31900.	8800.	4975.	3650.	11500.	7685.
49	4470.	3235.	5980.	12200.	2710.	15500.	17350.	15600.	7040.	2190.	5110.	6190.	8131.
50	5570.	12800.	10680.	4080.	3090.	2010.	12600.	25800.	5705.	5090.	3450.	1781.	7721.
51	2640.	3960.	7570.	7710.	11700.	8580.	18700.	7650.	4870.	5100.	6700.	4950.	7510.
52	4290.	16500.	7430.	9470.	9570.	5460.	11700.	30000.	9220.	5640.	3040.	1313.	9469.
53	2730.	17100.	6580.	6920.	11700.	3820.	19800.	9070.	8140.	3680.	3410.	4340.	8107.
54	9000.	6530.	9170.	4370.	15300.	13700.	9700.	14500.	6210.	6690.	10090.	2910.	9014.
55	7060.	11800.	18400.	12300.	8000.	5560.	6360.	13500.	7980.	3610.	6590.	5740.	8908.
56	8380.	9730.	4740.	16000.	4000.	3170.	14000.	25100.	12300.	5730.	4430.	3100.	9223.
57	4200.	9860.	7970.	4200.	1610.	3810.	6190.	23300.	8210.	5290.	4940.	8880.	7371.
58	8560.	9470.	13300.	7350.	4850.	7580.	11000.	10760.	7350.	6930.	7410.	11600.	8846.
59	8560.	13800.	6190.	2710.	1350.	1020.	14000.	17100.	7440.	4250.	4110.	4830.	7113.
60	4760.	12600.	12500.	3380.	5650.	3230.	9430.	21300.	5270.	3720.	1970.	2330.	7178.
61	7560.	8020.	5240.	2970.	1000.	2880.	9290.	27900.	7290.	2420.	1226.	1000.	6399.
62	5300.	9610.	7230.	3900.	5290.	5870.	22400.	22500.	10140.	7740.	5170.	2510.	8971.
63	9822.	19798.	6318.	13638.	8295.	4042.	12920.	26263.	7917.	6113.	7502.	8868.	10958.
64	8997.	11327.	11665.	3584.	4807.	2928.	19570.	22706.	10659.	8573.	5284.	4268.	9530.
65	12354.	9388.	5926.	5489.	2790.	17178.	5499.	25246.	15854.	4658.	2551.	1877.	9067.
66	6678.	6662.	6391.	6162.	6266.	6353.	8103.	10997.	7310.	6956.	6751.	7035.	7138.
AVERAGE	7268.	10921.	7743.	6274.	5653.	5768.	12063.	22325.	8644.	5151.	5096.	5299.	8517.

NOTE: ADJUSTED FOR CHANGES IN STORAGE; ONE THOUSAND CFS ADDED TO THE FLOWS REPORTED BY THE PULP AND PAPER MILL.

TABLE 1-2

MONTHLY, ANNUAL, AND LONG-TERM AVERAGE DISCHARGE (CFS) AT GAUGING STATIONS AND FLOW RECORDING HYDRO PLANTS

RATTLING BROOK

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	AVERAGE
40	*335.	410.	375.	110.	80.	115.	635.	1560.	320.	185.	490.	205.	401.
41	270.	410.	245.	185.	160.	100.	510.	1580.	350.	310.	575.	500.	432
42	375.	540.	200.	180.	320.	225.	445.	1845.	205.	370.	175.	170.	420.
43	280.	620.	110.	60.	98.	160.	430.	1330.	240.	95.	120.	375.	336.
44	405.	585.	160.	195.	140.	180.	220.	1545.	800.	190.	175.	505.	425
45	775.	720.	255.	300.	145.	140.	780.	1775.	405.	140.	45.	160.	470.
46	210.	625.	480.	140.	245.	290.	560.	695.	140.	15.	55.	95.	291
47	150.	280.	160.	100.	290.	205.	140.	2570.	640.	115.	45.	35.	394
48	160.	75.	85.	250.	130.	105.	290.	1985.	345.	270.	120.	470.	377.
49	155.	105.	210.	505.	80.	670.	790.	690.	265.	65.	170.	220.	327.
50	200.	540.	435.	140.	100.	55.	520.	1390.	205.	170.	110.	50.	326.
51	80.	140.	290.	295.	475.	340.	845.	295.	170.	170.	250.	175.	293.
52	150.	730.	280.	375.	380.	195.	480.	1775.	360.	205.	98.	35.	421
53	85.	760.	245.	255.	475.	135.	935.	370.	315.	125.	110.	150.	330.
54	355.	245.	355.	150.	680.	585.	390.	625.	225.	250.	400.	90.	362
55	260.	490.	845.	510.	305.	200.	230.	570.	305.	120.	250.	205.	357.
56	320.	390.	160.	700.	135.	105.	595.	1330.	510.	205.	150.	100.	391.
57	145.	395.	305.	145.	35.	135.	220.	1180.	320.	185.	265.	355.	307.
58	340.	370.	560.	270.	170.	290.	445.	435.	270.	260.	280.	480.	347.
59	340.	590.	230.	169.	219.	144.	641.	1050.	234.	85.	34.	110.	320.
60	109.	531.	366.	209.	280.	297.	410.	1640.	229.	92.	19.	15.	349.
61	119.	313.	173.	88.	62.	124.	354.	1440.	234.	37.	5.	3.	248.
62	142.	245.	402.	187.	373.	696.	1200.	1340.	566.	155.	75.	88.	455.
63	488.	561.	297.	1084.	259.	121.	646.	1405.	343.	74.	126.	314.	476.
64	342.	447.	400.	114.	257.	207.	1012.	886.	295.	208.	221.	254.	386.
65	423.	758.	314.	377.	190.	735.	421.	1480.	1110.	112.	0.	0.	492.
66	168.	172.	220.	203.	324.	312.	448.	807.	603.	310.	155.	264.	332.
AVERAGE	265.	446.	302.	270.	237.	254.	540.	1244.	370.	167.	167.	200.	372.

* THE DISCHARGE VALUES FOR THE PERIOD OCTOBER 1939 TO DECEMBER 1958 WERE SYNTHESIZED FROM THE CORRELATION OF THE DISCHARGE BETWEEN RATTLING BROOK AND EXPLOITS RIVER FOR THE PERIOD JANUARY 1959 TO SEPTEMBER 1966.

EXPLOITS RIVER BASIN AND BADGER-BOTWOOD STUDY AREA

SUMMARY OF CLIMATIC CHARACTERISTICS

A ANNUAL MEANS

Precipitation (inches)	Air Temperature (deg F)	Potential Evaporation (inches)	Relative Humidity (percent)
46.3	38.0	18.5	84

B MEAN MONTHLY PRECIPITATION (inches)

Stations	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Buchans	3.31	2.92	2.35	2.10	2.42	2.60	2.94	3.68	3.57	3.33	4.11	3.40	36.73
Grand Falls	2.47	3.02	2.78	1.89	2.06	3.02	2.82	3.34	3.49	4.00	3.95	3.15	35.99
Basin Mean Synthesized	3.9	3.9	3.0	2.6	3.2	3.9	4.0	4.3	4.4	4.2	4.4	4.5	46.3

C MAXIMUM POSSIBLE STORM PRECIPITATION (inches)

Area (sq. mi)	Storm Duration (hours) 6	12	18	24	36	48	72
100	5.55	7.35	9.65	10.60	12.05	12.40	16.10
300	5.45	7.30	9.20	10.40	12.00	12.30	15.60
500	5.40	7.15	8.90	10.15	11.85	12.20	15.20
1000	5.30	6.90	8.55	9.85	11.55	11.90	14.60
4950	2.80	4.30	5.40	5.60	5.90	6.60	9.30

D MAXIMUM POSSIBLE SEASONAL SNOWFALL (inches of water equivalent): 45.0

E CRITICAL SEQUENCES FOR SNOW MELTING (degrees F)

Interval	Date: March 1	March 10	March 20	April 1	April 10	April 20	May 1
4 - day	47.0	47.5	48.5	50.0	51.0	53.0	55.5
8 - day	45.0	45.5	46.5	48.0	49.0	49.5	50.0
16 - day	38.0	38.5	40.0	43.0	47.0	48.5	49.0

F DROUGHT

Return Period	2.33-Year	5-Year	10-Year	20-Year	50-Year	100-Year
Drought Duration	13 days	16 days	19 days	22 days	27 days	30 days

TABLE 1-4

SUMMARY OF HYDROLOGIC CHARACTERISTICS
EXPLOITS RIVER BASIN

I - SYNTHESIZED DATA

A. ANNUAL MEANS FOR THE TOTAL BASIN

FLOW (CFS)	RUNOFF (CFS/SQ.MI)	RUNOFF (INCHES)	ACTUAL EVAP. (INCHES)
11,400	2.3	31.0	15.2

B. MEAN MONTHLY FLOWS (Q) AND STANDARD DEVIATIONS (S) (CFS)

RIVER AND LOCATION		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVGE
EXPLOITS RIVER AT EXPLOITS BAY	Q	8980	7650	8380	17700	36500	11200	6460	6770	6770	8460	14900	11300	11300
	S	5560	4000	4850	7010	11500	5200	2720	4400	4130	4630	6440	4520	1650
EXPLOITS RIVER AT GRAND FALLS	Q	6940	5800	5960	13100	29500	8950	5350	5420	5450	6310	11700	8820	8480
	S	4010	3100	3570	4870	9180	4440	2100	3300	3230	3410	5000	3430	1230
EXPLOITS RIVER AT RED INDIAN LAKE OUTLET	Q	4570	3720	3750	8220	19620	6180	3750	3720	3780	4310	7890	5910	5670
	S	2470	2050	2210	2830	6020	3180	1400	2110	2190	2 240	3340	2230	780

C. MAXIMUM FLOWS (CFS) AND FLOOD VOLUMES (CFS DAY) OBTAINED BY THE MAXIMIZATION PROCEDURE (INSTANTANEOUS PEAKS)

RIVER AND LOCATION	MAXIMIZED RAIN ON SNOW PACK		MAXIMIZED RAIN ONLY		SNOW PACK & AVERAGE RAIN	
	PEAK	VOLUME	PEAK	VOLUME	PEAK	VOLUME
EXPLOITS RIVER AT EXPLOITS BAY	291,000	3,900,000	150,000	1,430,000	169,000	2,810,000

D. MAXIMUM FLOWS OBTAINED BY STATISTICAL ANALYSIS (CFS) (DAILY AVERAGES)

RIVER AND LOCATION	GENERATED BY SNOW MELT & RAIN		GENERATED BY RAIN ONLY	
	1/10000 YEARS	1/1000 YEARS	1/10000 YEARS	1/1000 YEARS
EXPLOITS RIVER AT EXPLOITS BAY	126,000	104,000	61,200	50,600
EXPLOITS RIVER AT GRAND FALLS	96,000	78,000	46,900	39,000
EXPLOITS RIVER AT RED INDIAN LAKE OUTLET	67,500	54,500	35,700	29,900

SUMMARY OF HYDROLOGIC CHARACTERISTICS
EXPLOITS RIVER BASIN

E. MINIMUM FLOWS OBTAINED FROM RECESSION CURVES (CFS)

RIVER AND LOCATION	1/2 YEARS	1/5 YEARS	1/10 YEARS	1/20 YEARS
EXPLOITS AT RED INDIAN OUTLET	1200	780		300
SANDY BROOK AT POWER HOUSE	20	10		2
RATTLING BROOK AT RATTLING BROOK	10	5		1

METHOD NOT APPLICABLE TO DRAINAGE AREAS LARGER THAN 2000 SQ.MI.

F. MINIMUM FLOWS OBTAINED FROM STATISTICAL ANALYSIS (CFS)

RIVER AND LOCATION	1/2 YEARS	1/5 YEARS	1/20 YEARS	1/100 YEARS
EXPLOITS RIVER AT BAY OF EXPLOITS	2780	1720	825	
EXPLOITS RIVER AT GRAND FALLS	2190	1390	700	
EXPLOITS RIVER AT RED INDIAN LAKE OUTLET	1610	1080	630	

G. FULL REGULATION STORAGE

RIVER AND STATION	STORAGE (CUBIC FEET x 10^9)
EXPLOITS RIVER AT BAY OF EXPLOITS	552
EXPLOITS RIVER AT GRAND FALLS	383
EXPLOITS RIVER AT RED INDIAN LAKE OUTLET	258

II - RECORDED DATA

H. MEAN MONTHLY AND ANNUAL FLOWS (CFS)

RIVER AND STATION	YEARS OF RECORD	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVGE
EXPLOITS R. AT GRAND FALLS *	46	5680	5340	5440	11730	20740	7900	4950	4400	4140	6150	8830	7220	7710*
SANDY BROOK AT POWERHOUSE														
RATTLING BROOK AT RATTLING LAKE	-	348	234	332	669	1320	430	109	69	112	271	476	325	388

* A CORRECTION OF ABOUT 800 CFS HAS TO BE ADDED TO THE FLOWS OF THE EXPLOITS RIVER AT GRAND FALLS

I. EXTREMES RECORDED (CFS)

RIVER AND STATION	MAXIMUM FLOWS			MINIMUM FLOWS		
	FLOW	DATE	COMMENTS	FLOW	DATE	COMMENTS
EXPLOITS R. AT GRAND FALLS			DAILY FLOWS AFFECTED BY POWERHOUSE OPERATION			DRAINAGE AREA = 3,650 SQ.MILES
SANDY BROOK AT POWERHOUSE			DAILY FLOWS AFFECTED BY POWERHOUSE OPERATION			DRAINAGE AREA = 196 SQ.MILES
RATTLING BROOK AT RATTLING LAKE			DAILY FLOWS AFFECTED BY POWERHOUSE OPERATION			DRAINAGE AREA = 146 SQ.MILES

EXPLOITS RIVER BASIN
AND
BADGER-BOTWOOD STUDY AREA

SUMMARY OF WATER QUALITY EXTRAPOLATIONS

Location	----- Effects of Characteristics on Use for-----								
	Fish			Pulp & Paper			Domestic and Raw Water		
	P	C	B	P	C	B	P	C	B
Mouth of Lloyds River	+	0	0	+	+	0	+	+	+
Mouth of Star Lake River	+	0	+	+	+	0	+	+	+
Mouth of Shanadithit River	+	+	+	+	+	0	+	+	+
Mouth of Buchans Brook	+	-	0	-	+	0	+	+	+
Outlet of Red Indian Lake	+	0	-	+	+	0	+	+	+
Mouth of Mary March's Brook	+	0	+	0	+	0	+	+	+
Mouth of Noel Pauls Brook	+	0	0	+	+	0	+	+	0
Mouth of Badger Brook	+	0	0	+	+	0	+	+	+
Exploits River I (above Grand Falls)	+	0	-	+	+	0	+	+	-
Mouth of Great Rattling Brook	+	+	+	+	+	0	+	+	+
Exploits River II (below Grand Falls)	+	0	-	+	+	0	+	+	-
Northern Arm Brook	+	0	0	+	+	0	0	+	+
Peters Arm Brook	+	+	0	+	+	0	0	+	+
Mouth of Victoria River	+	0	+	+	+	0	+	+	+

NOTE

P = Physical Characteristics
C = Chemical Characteristics
B = Biological Characteristics
+, 0, - = Comparative Ratings

See Volume Two for description of Water Quality Extrapolations

TABLE 1-6

PRIMARY, SECONDARY, AND TRANSPORTATION INDUSTRIES

IN THE

EXPLOITS RIVER BASIN

GRID	COMPANY	LOCATION	SIC	SA	INDUSTRY DEFINITION
1 KE13	8KING SYDNEY	BISHOPS FA	031	6A	
1 KE13	8ADAMS CONSTR LTD	BISHOPS FA	031	6A	
1 WE30	8OSMOND ERIC J	MILLERTOWN	031		
1 WE31	8JONES ERNEST	BUCHANS JU	031		
1 WE72	8STUCKLESS CYRILL	BADGER	031	6A	
1 WE72	8BADGER LOGGING	BADGER	031	6A	
1 WE92	8KING + KING	WINDSOR	031	6A	
1 WE92	8TUBRETT MICHAEL	WINDSOR	031	6A	
1 WE92	8PRICE /NFLD/ PULP + PAPER	GRAND FALL	031	6A	Logging
1 WE10	8AMERICAN SMELTING + REFIN	BUCHANS	D56		
1 WE10	8AMERICAN SMELTING + REFIN	BUCHANS	D56		Metal mines (silver, lead, zinc)
1 WE10	8SPRAGUE + HENWOOD INC	BUCHANS	D98		Contract drilling
1 WE92	8BROOKFIELD ICE CREAM LTD	GRAND FALL	105	6A	Dairy factory
1 XE13	8GADENS /CENTRAL/ LTD	BISHOPS FA	141	6A	
1 WE92	8BROWNING HARVEY LTD	GRAND FALL	141	6A	Soft drink manufacturers
1 XE23	8LANGDON J C	NORRIS ARM	251	6A	
1 XE23	8OWENS WILLIAM	NORRIS ARM	251	6A	
1 WE10	8BEST CHARLES	BUCHANS	251		
1 WE92	8BEATON ROBERT	GRAND FALL	251	6A	
1 WE92	8EVANS SELBY J	GRAND FALL	251	6A	
1 WE92	8IVANY ROY	WINDSOR	251	6A	
1 WE92	8PURCHASE NORMAN	GRAND FALL	251	6A	Sawmills
1 XE13	8BISHOPS FALLS WOODWORKING	BISHOPS FA	254	6A	Sash and door and planing mill
1 WE92	8PRICE /NFLD/ PULP + PAPER	GRAND FALL	271	6A	
1 WE92	8PRICE /NFLD/ PULP + PAPER	GRAND FALL	271	6A	Pulp and paper mills
1 XE13	8MORGAN WALTER + SONS	BISHOPS FA	286	6A	Commercial printing
1 WE92	8BLACKMORE PRINTING CO LTD	GRAND FALL	289	6A	Printing and publishing
1 XE13	8ARMCO DRAINAGE + METAL PR	BISHOPS FA	304	6A	
1 WE92	8BARTLE BERNARD W LTD	GRAND FALL	304	6A	Metal stamping, pressing, and coating
1 WE92	8HALLETT HERB CONTRACTOR	WINDSOR	404	6A	
1 XE13	8HARRIS BRUCE	BISHOPS FA	404	6A	
1 WE10	8SIMMS H C LTD	BUCHANS	404		
1 WE92	8RALPH WINDSOR CONTRACTORS	WINDSOR	404	6A	
1 WE92	8CLARK E J + SONS LTD	GRAND FALL	404	6A	
1 WE92	8RUST ASSOCIATES LTD	GRAND FALL	404	6A	Building construction
1 WE92	8GOODYEAR CONSTRUCTION CO	GRAND FALL	406	6A	
1 WE92	8GOODYEAR J + SONS LTD	GRAND FALL	406	6A	Highway, bridge, and street construction
1 WE92	8LINCOLN CONSTR LTD	GRAND FALL	409	6A	
1 WE92	8GOULDING W J LTD	GRAND-FALL	421	6A	
1 WE92	8REGIONAL PIERCEY MASONRY	GRAND FALL	421	6A	Special trade contractors
1 WE92	8PRICE SHIPPING LTD	GRAND FALL	504	6A	Water transportation
1 WE92	8GRAND FALLS CENTRAL RAILW	GRAND FALL	506	6A	Railway transportation
1 XE13	8PENTON ALONZO	BISHOPS FA	507	6A	Truck transportation

SIC = Standard Industrial Classification
SA = Study Area

Source: DBS Central Register List of Establishments

TABLE 1-7

Development	Year Commissioned	Owner	Drainage Area above Development (square miles)	Head Developed (feet)	Total Number of Units	Total Unit Capacity (hp)	Type of Units	Storage Reservoir	Storage Capacity (acre-feet)	Location of Plant
Sandy Brook	1963	NLPCL	196	115	1	8,000	Francis	Sandy Lake	30,800	On tributary of Exploits River about five miles upstream of Grand Falls
Rattling Brook	1958	NLPCL	146	307	2	17,000	Francis	Rattling Pond Frozen Ocean Lake Little Xmas Pond	112,000 12,200 3,140	On tributary of Exploits River downstream of Bishops Falls at mouth of Exploits River.
Grand Falls	1909	PNL	3650 (before diversion) 3058 (after diversion)	109	4	43,500	Francis	Red Indian Lake	920,000 (approx)	On Exploits River at Grand Falls
Bishops Falls	1909 1952	PNL	4360 (before diversion) 3768 (after diversion)	35	9	22,300	Francis	Red Indian Lake	920,000 (approx)	On Exploits River at Bishops Falls.
Buchans Brook	1927	ASRC	75	163	1	2,359	---	Buchans Lake	---	On tributary of Red Indian Lake.

Legend:
PNL = Price (Nfld) Pulp and Paper Company Limited.
NLPCL = Newfoundland Light and Power Company Limited.
ASRC = American Smelting and Refining Company Limited.

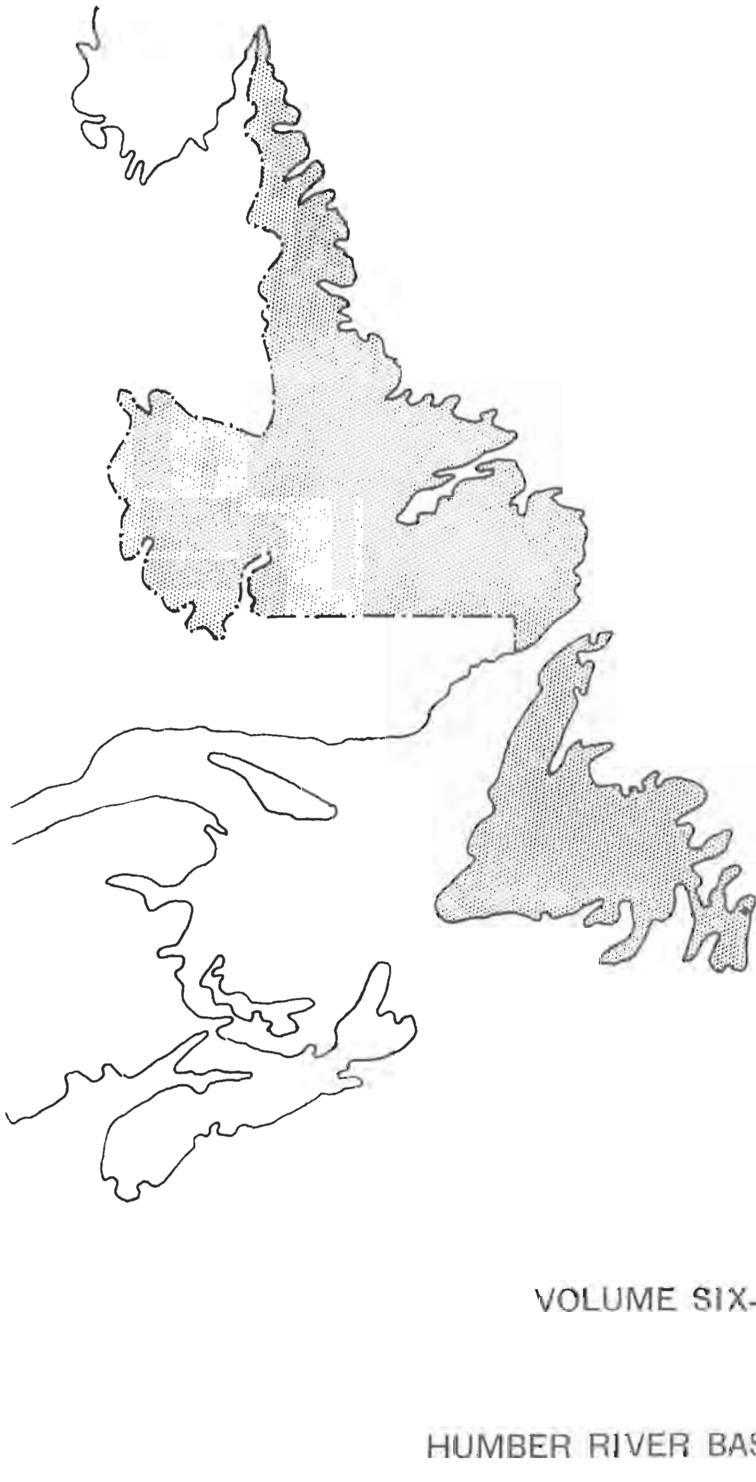
HYDRO POWER DEVELOPMENTS
IN THE
EXPLOITS RIVER BASIN

TABLE 2-1

MONTHLY PRODUCTION
AT THE
PRICE (NFLD) PULP AND PAPER MILL
(Invoice Short Tons)

Month	Newsprint		Dry Baled Sulphite	
	1961	1966	1961	1966
January	20,637	24,681	972	-
February	19,977	22,277	1,008	43
March	17,385	23,768	893	592
April	21,274	24,228	786	781
May	22,858	25,344	997	128
June	22,592	21,165	697	-
July	21,939	23,822	835	660
August	22,954	22,933	847	419
September	20,611	22,705	309	521
October	22,527	24,824	586	747
November	22,633	19,901	663	26
December	20,254	22,609	450	-
Total	255,641	278,257	9,043	3,917

TABLE 2-2



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HUMBER RIVER BASIN AND CORNER BROOK —
DEER LAKE STUDY AREA

PART I I - HUMBER RIVER BASIN AND CORNER BROOK-DEER LAKE AREA

6 NATURAL CONDITIONS

The Humber River is located on the west coast of the Island and is easily accessible by the Trans-Canada Highway and the Canadian National Railway which run parallel to the lower reach of the main river, traversing part of the upper northeastern tributaries (Figure 6-1.) In addition, secondary roads permit access to tributaries in the northern part of the basin.

The lower Humber River basin is one of the most developed areas on the Island. Two natural resources, water and forests, have been the predominant incentives for development to date.

6.1 Physiographic Conditions

The Humber River basin has a total natural drainage area of 3230 square miles which includes that which drains directly into the salt water of Humber Arm. The basin outline and details of the Corner Brook - Deer Lake Study Area are shown in Figure 6-1. The total area can be considered as comprising four sub-areas:

a) 245 square miles which drain directly into the salt water of Humber Arm (excluding the Humber River drainage).

b) 288 square miles upstream of the Humber River mouth to the confluence of the Upper Humber River and Rocky Brook, just upstream of Deer Lake.

c) 847 square miles of the Upper Humber River area.

d) 1850 square miles which is the drainage area of Grand Lake regulated by the Deer Lake hydro plant.

In addition to the natural drainage area of Grand Lake, there is a 92 square mile diversion of the neighbouring Indian Brook into the Grand Lake area.

The total natural drainage area includes 329 square miles of lakes, 240 square miles of marshes or bogs, and 623 square miles of barrens. The proportion of lakes, marshes and barrens in the different sections of the drainage basin is indicated in Figure 6-2.

The topography and the river and lakes network of the basin is shown on Figure 6-1. The largest lake in the basin is Grand Lake which forms the main storage reservoir for the Deer Lake hydro plant. Sandy Lake, and Birchy Lake, which are directly connected to Grand Lake and are about one foot higher in elevation, are also utilized for storage by the development. Other lakes which form part of the Grand Lake drainage area and are connected to the Grand Lake by short tributaries are Little Grand Lake, Hinds Lake, and Sheffield Lake. Another large lake in the basin is Deer Lake, located between Corner Brook and Deer Lake, the two main communities in the basin. The largest lake in the Upper Humber River is Adies Pond.

The hypsographic curve of the basin is shown in Figure 1-4; the land surface slope and elevation distribution are shown in Figure 6-3. These figures indicate a rough topography which is partially responsible for the large runoff. It also limits the agricultural potential and the areas suitable for extensive industrial development and residential settlement.

The variations in mean annual temperature, precipitation and evaporation throughout the basin are shown in Figure 6-4. The climate is cool and humid with a mean annual temperature of 38 deg F, a mean annual precipitation of 56 inches, and a mean annual evaporation of 15 inches. The climate of the Island is discussed in detail in Volume Two, Section 8. The pertinent information on the climate conditions of the basin is summarized in Table 6-1.

There is a wide range of rock types represented in the bedrock on the Upper Humber basin. The northern part of the basin is situated on the Pre-Cambrian metamorphic complex that forms the main ridge of the Northern Peninsula. Along the eastern shore of Grand Lake and in the area to the northwest of the lake, there are Carboniferous sediments which are relatively unaltered. To the south and east of Grand Lake are major igneous intrusions and highly metamorphosed volcanic and sedimentary rocks of Ordovician and Silurian age. The western part of the basin consists of highly metamorphosed rocks of Cambrian or earlier age near Grand Lake, with Cambrian and Ordovician sedimentary rocks, including limestones and dolomites, nearer the sea.

Most of the area has a cover of surficial materials consisting mainly of a moderate thickness of ground and ablation moraines. In the northern part of the basin there are areas of exposed rock, and there are patches of ribbed moraine at the north and south of Grand Lake. At the north of the Humber River and on the shores of Deer Lake are some sand and gravel deposits. In addition, the deposits downstream from Deer Lake have been reworked by the sea and may be capped by marine clays in some areas.

6.2 Water Resources and Potential Uses

6.2.1 Surface Water

Hydrologic data on the basin are available from five river gauging stations: Lewaseechjeech Brook at Little Grand Lake, Sheffield Lake, Hinds Brook near Grand Lake, Diversion Canal Inlet on Indian Brook, and Seal Pond on the Upper Humber River (Figure 6-1). Drainage areas of the stations are 180, 140, 200, 92, and 812 square miles respectively. In addition, there are regulated-flow data records and storage-volume changes in Grand Lake and Sandy Lake available from the hydro plant station at Grand Lake outlet, which has a drainage area of 1942 square miles. The flow records at a small hydro plant near the city of Corner Brook are also available, but these have been disregarded as the records do not take into account the unmeasured Corner Brook city water supply.

The data at the hydro power plants can be used only for the estimation of the mean annual flow. They do not enable the computations of other hydrologic characteristics such as minimum and maximum flows. Therefore, the latter have been derived from the records of the river gauging stations and the generalized relationships with meteorologic and physiographic factors (Volume Two, Part IV). The hydrologic characteristics of the basin are summarized in Table 6-2. These characteristics have been checked for general consistency with the flow recorded at the Deer Lake power plant with satisfactory results. The areal distribution of the mean annual runoff in the basin, as derived from these relationships, is indicated in Figure 6-4. The mean annual runoff for the basin is 40.8 inches or 3.0 cfs per square mile.

The quality of the surface waters in the Humber River basin has been affected by man's activity in only a minor way, undoubtedly because of the relatively sparse population throughout most of the basin and the generally limited access to much of the watershed. The Trans-Canada Highway traverses the basin from a southwesterly to north-easterly direction and by far the greatest portion of the basin's population is located on this highway, thereby affecting to some extent the natural bacteriological quality of the water downstream of this concentration of population.

A review of available analyses of surface waters in the basin shows that these waters are extremely low in total dissolved solids, the total equivalents per million being generally less than 1. The waters are very soft, the total hardness being in the order of 15 ppm as $CaCO_3$ with an observed maximum of 22 ppm during 1955-1967 in one instance on the Upper Humber at Deer Lake. The pH of the rivers sampled ranged from 6.0 to 7.3 with a mean value of approximately 7.0: the wide range shown in pH was undoubtedly caused to some extent by sampling technique (principally delays between sampling and testing which would tend to produce lower than "in place" values).

Turbidities are generally less than 3 units with one value of 20 units observed on the Humber River during 1955-1967. The surface waters of this basin are highly coloured; on the Humber River at Deer Lake the mean colour is about 50 units, ranging from 30 units to 150 units; at the Grand Lake outlet the colour is less intense having a mean value of 20 units, ranging from 15 units to 70 units. For domestic purposes colour of less than 15 units is desirable. Although colour of more than 15 units might be acceptable, users may be inclined to object to it and use water from another source with less colour, which might be bacteriologically unsafe. From an industrial viewpoint these waters are highly coloured and could be classed as unacceptable without treatment by such industries as pulp and paper and textiles.

None of the analyses reviewed showed excessive concentrations of iron, manganese, fluorine, or similar chemical constituents which would affect the suitability of the waters for domestic or industrial purposes. The only bacteriological data available on the surface waters of the basin were those established by the Shawinigan-MacLaren grab sampling program carried out in the fall of 1967; this program noted the presence of coliform at the Grand Lake outlet at the Humber River and on the Upper Humber River at Deer Lake, 3 organisms per 100 ml and 70 organisms per 100 ml, respectively.

Water quality extrapolations for different parts of the basin have been summarized on Table 6-3.

6.2.2 Groundwater

Groundwater is the main source of supply to small communities in the basin. In most of these communities the water is obtained from the surficial materials. The distribution of the surficial materials is discussed and shown in Volume Two A. With the exception of the northern part of the area which is largely uninhabited, the basin has a cover of suitable material for obtaining surficial supplies. In the vicinity of Deer Lake and Humber Arm and at the southern end of Grand Lake there are extensive alluvial, outwash and kame deposits that are capable of producing up to several hundred gallons per minute from properly developed wells. The west side of Deer Lake has a cover of clay in some areas, deposited at a time of higher sea level, and similar deposits occur on the slopes above the Humber Arm.

The groundwater potential of the bedrock within the basin is discussed in Volume Two A. Few bedrock wells have been put down in this area, but the mean depth for the Island for each unit represented in the basin is shown in Volume Two A. The bedrock material occupying the greatest area in the basin in hydropetrologic unit R1, consisting of major igneous intrusions, underlies 48 percent of the basin. Unit R7, Carboniferous sedimentary rocks, underlies 24 percent of the basin, and the rest is underlain by units R2, R5, R6, R8 and R4 in the order of decreasing area.

A summary of the surficial and bedrock units present, the areas they occupy, and the groundwater potential of each unit is given on Table 6-4.

There is very little information available on the quality of groundwater in the basin, but some predictions of the probable trends can be made. Most of the groundwater in the surficial materials will be of good quality, except in the marshy areas. The water in the bedrock can be expected to be of good quality, except in unit R8 where the presence of limestone and dolomite will result in water with a high total hardness; and in unit R7 which includes deposits of gypsum and salt as well as some limestone and can cause a high total dissolved solids content as well as a high total hardness.

6.2.3 Hydro-Power

The gross river hydro-power potential in the basin is described in Volume Four, Part I. The gross potential of the main stem and significant tributaries is shown in Figure 6-5. In addition, the basin has pumped storage sites of significant potential.

6.2.4 Fresh Water and Anadromous Fish

The Humber River with its tributaries is the most productive Atlantic salmon river in Newfoundland. In addition, the river contains landlocked salmon or ouananiche, Arctic char, brook trout (both resident and sea-run), smelt, eels, tomcod, stickleback, and alewife. Part of the river is inaccessible to anadromous fish because of natural or artificial barriers, but it appears feasible to remove or circumvent some of these barriers to expand or develop the populations.

6.2.5 Navigation and Log Driving

The Humber River is one of the largest rivers in the Island, but because of the presence of falls, rapids, dams and shallow sections, it is not extensively used for navigation.

The log driving potential of the river and its tributaries is limited under natural conditions to periods of high flow.

6.3 Natural Resources

In addition to the water resources of the basin, the other resources include forests, minerals, wildlife, and agriculture.

6.3.1 Forests

The forested areas of the Humber River basin cover 2038 square miles or approximately 63 percent of the total basin area according to the Department of Mines and Technical Surveys' 1:250,000 scale topographic maps. The square grid distribution of the forested areas in the basin is shown in Figure 6-2. The timber limits of Bowaters Newfoundland Limited include about 516 square miles of merchantable virgin areas.

6.3.2 Minerals

The known minerals in the basin include marble, iron, limestone, molybdenum, and slate[1]. The location of the occurrences are shown in Figure 1-2.

6.3.3 Wildlife

The drainage area of the Humber River is the habitat for all species of big game found on the Island. Moose are plentiful throughout the basin and caribou inhabit the eastern part. Black bear is also found throughout the basin.

Of the fur-bearing land mammals found in Newfoundland, the Newfoundland muskrat is relatively abundant in the fertile Humber Valley. Beaver, red fox, and otter are also found in the basin. In recent years, ruffed grouse have been introduced into the area with some success.

6.3.4 Recreation

The natural conditions in the basin, especially the extensive network of lakes and streams with their fishing and water sport potential combined with the existing wildlife, scenic beauty, and accessibility, are important assets for the tourist industry. However, the long distance from Island population centres and, to some extent, the climatic conditions may restrict the full development of the tourist potential of the basin.

6.3.5 Agriculture

Although the major part of the basin is suited to wildlife, forestry, and recreation, very little is suitable for cultivation. Moreover, the areas that are suitable for cultivation require intensive development and maintenance treatment with severe to very severe limitations and hazards[2]. In 1966, a total of only 2,000 acres were under cultivation in the river basin.

7 PRESENT DAY DEVELOPMENT

The development of the Humber River basin was based on its hydro power and forest potential. Today the basin contains one of the Island's largest hydro plants as well as one of the two large pulp and paper mills. Facilities for recreation have been provided for fishing, hunting and other available outdoor opportunities. Although other resource based economic activities are limited, the Corner Brook and Deer Lake centres include much of the required service industry for the basin's population and some neighbouring settlements.

7.1 Non-Withdrawal Water Resources Uses

These include hydro-electric power developments, although sport fishing and related recreational activities are gaining in importance.

7.1.1 Hydro-Power Development

The economic development of the basin was originally based on the availability of cheap hydro-electric power concentrated at a hydro plant located between Deer and Grand Lakes.

The first hydro development was installed in 1925 at a plant at Deer Lake to provide power to supply the pulp and paper mill at Corner Brook. The main concrete dam and spillway structure were constructed on Junction Brook which joins the Upper Humber River about five miles upstream of Deer Lake. The main dam, located at the north end of Grand Lake, raised the original lake level about 35 feet to a maximum geodetic elevation of 289 feet. A seven-mile side hill canal connects the storage reservoir to the intake structure. A control structure, located about five miles upstream of the intake structure, limits the highwater level in the power canal. Penstocks about 4,000 feet long connect to the powerhouse which is located on the northeast side of Deer Lake. The difference in elevation between the power canal and Deer Lake is about 250 feet. A log sluice and emergency spillway are located near the forebay at the downstream end of the power canal.

The initial capacity of the plant was 98,000 hp, and the pulp and paper enterprise enlarged and extended its facilities over the years to supply the growing requirements of the industrial, commercial, and domestic loads in the area. Two units of 58,000 hp total capacity were added in 1930, and a 47-mile extension to its transmission system was made to Buchans to serve the mine and townsite.

In 1951 the domestic distribution system in Corner Brook and Deer Lake were taken over by the Newfoundland Light and Power Company. In 1955 the Bowater Power Company was formed, and assumed all the power contracts and assets of the pulp and paper company associated with the generation and transmission of power. Recent improvements to the existing turbines have increased the total plant capacity to 170,000 hp.

In addition, a small hydro plant (12,000 hp) was installed in 1958 by the Bowater Power Company on the Corner Brook River. The powerhouse is located near the mouth of Watson's Brook close to the City of Corner Brook. Extensions to the transmission system were made in 1963 and 1965 to serve the Advocate Mine, Baie Verte townsite, Whalesback Mine, and Springdale townsite. The locations of the hydroelectric power plants are shown on Figure 6-1.

The following table summarizes the characteristics of the two hydro plants in the Humber Basin.

HYDRO POWER DEVELOPMENTS ON THE HUMBER BASIN

Development	Deer Lake	Watson's Brook
Year Commissioned	1925	1958
Owner	The Bowater Power Company	The Bowater Power Company
Total Drainage Area	1,942 square miles	51 square miles
Head Developed	247 feet	559 feet
Total Number of Units	9	2
Total Capacity	170,000 hp	12,000 hp
Type of Turbines	Francis	Francis
Storage Reservoirs	Grand Lake Sandy Lake Birchy Lake	Corner Brook Lake
Storage Capacity	68.8 billion cubic feet	1.1 billion cubic feet
Location of Plant	North end of Deer Lake near town of Deer Lake	Near City of Corner Brook

The Deer Lake plant produced an annual average of 738 x 10^6 kw hours during the period 1954 to 1966. The main storage reservoir has a surface area of approximately 190 square miles. The 68.8 bcf storage corresponds to a normal drawdown of 13 feet. Spilling occurs only about once every four years because the storage is sufficiently large to provide a high degree of regulation with little wastage of water.

The flow downstream from the hydro plant at Watson's Brook is utilized as the water supply for the paper mill at Corner Brook. Thus, energy production at the hydro plant is governed by the water demand of the mill. From 1959 to 1966, the average energy output of the plant was 42.8 x 10^6 kw hours per year.

The water supply to the City of Corner Brook is taken from the same pond used by the hydro plant at Three Mile Dam. The water supply system is described in Section 7.2: "Withdrawal Uses". Operating difficulties have occurred due to silt deposition near the intake structure on Watson's Brook: these problems are described in Section 7.3.

Water regime changes as a result of the hydro developments have occurred in the basin since the reservoirs reduce the natural flow variation in the areas downstream of the control structures.

A comparison of mean monthly regulated plant outflow and synthesized* natural flow (with storage effect removed) is shown in Figure 7-1 for the Deer Lake plant. As shown for the 1962 to 1967 period, the maximum average monthly natural flow was about 18,800 cfs, whereas the plant outflow was about 3,200 cfs for the same month. The minimum average monthly natural flow was 800 cfs, whereas the plant outflow was 4650 cfs for the same month. The natural monthly flow variation was from 800 cfs to 18,800 cfs, whereas the regulated plant outflow variation was only from 2300 cfs to 8800 cfs.

The large storage volume of 68.8 bcf on Grand, Sandy, and Birchy Lakes has resulted in a minimum daily outflow from the Deer Lake hydro plant of about 868 cfs. It was estimated that this flow would normally decrease to about 140 cfs without the regulation of the reservoir.

The effect of reduced daily flood peaks and increased minimum flows on the area downstream of the Deer Lake plant has been impossible to assess from past flow records because of a lack of data on lake levels and river flows prior to the hydro-electric development. However, it is obvious that downstream flooding is reduced and the use of water for fishing, recreation and logging facilitated. This represents benefits which, although difficult to assess, must be recognized.

*The variation of synthesized natural flow is larger than that of the actual natural flow, since the storage removal eliminates both the effect of the artificial storage and part of the storage effect that would naturally occur.

The City of Corner Brook and other water users benefit from the regulation of the Corner Brook River due to the increased storage capacity (1.1 bcf) at Corner Brook Lake which was created to firm up the mill water supply. Although the Corner Brook River has a small watershed, it has been developed for multi-purpose use with hydro power, municipal and industrial water supply, and recreation benefits[4]. However, these developments have eliminated anadromous fish from the river. The total drainage area of the river is 66 square miles of which 26 square miles are controlled by a timber crib dam at the outlet of the main storage reservoir of Corner Brook Lake. About 8 miles downstream and 3.5 miles from the river mouth, a concrete gravity dam called the Three-Mile Dam provides a small pondage for the 51-square mile drainage area and permits the location of the intake structures for the hydro development and city water supply. The hydro plant is located about 2 miles downstream of the control dam where Watson's Brook joins the Corner Brook River. Approximately 1.1 miles from the river mouth a small rock-filled timber crib dam was constructed for recreational purposes. Downstream from this dam is Glynmill Pond, the intake pond for the mill water supply. At tidewater, another small rock-filled timber crib dam provides a constant head supply for the mill's barking operations. In all, there are five small dams located on the river, resulting in changes to the water regime.

All the users downstream of the storage reservoir benefit from the increase of minimum flows made available by the storage facilities on the Corner Brook. The minimum monthly flow recorded by the hydro plant is 66 cfs which might have been below 10 cfs without the storage facilities at Corner Brook Lake. Daily minimum flows would be even lower without the storage effect.

Prior to May 1967, at which date the Newfoundland and Labrador Power Commission's Bay D'Espoir plant became operational, below normal precipitation and runoff occurred in western Newfoundland. The low runoff on the Grand Lake watershed combined with high power usage resulted in attempts by the Bowater Power Company to offset the water shortage by cloud seeding and the release of dead storages contained in lakes drained by the Grand and Sandy reservoirs.

During the period from May to November 1966, a cloud seeding operation with both ground and airborne silver iodide vapourizing units were carried out by Weather Engineering Corporation of Canada Limited. The target area comprised the 2000 square mile Grand Lake watershed area. The effect of the seeding in the basin was estimated by Weather Engineering to increase runoff by 15.4 percent. The evidence produced in the Weather Engineering reports[5] was considered to be insufficient and additional attempts were made during the course of this study to verify the estimated runoff increase. However, due to a lack of adequate data, definite evidence of increased runoff could not be confirmed. This cloud seeding program was the first of its kind to occur on the Island.

The water shortage was partially offset in early 1967 by deepening the outlets of Hinds, Little Grand, and Sheffield Lakes, which are upstream of Grand Lake, as shown in Figure 6-1. Replacement of natural controls in order to raise these lakes to their natural level was required by the Department of Fisheries. Bowaters initiated studies to investigate the possibility of providing regulating structures at the lake outlets to create storage reservoirs and increase the firm energy capability of the Deer Lake hydro plant[6]. Results of these studies indicated that other power sources appeared to be more attractive from Bowater's viewpoint, and the storage schemes were not implemented.

The temporary power shortage created by the low flow, high power usage period cost the Bowater Power Company about $2.6 million during the first six months of 1967 [7].

The hydro development at Deer Lake created a conflict with fisheries because anadromous fish were prevented from proceeding to the river upstream of the powerhouse. In addition, the storage fluctuation of greater than 13 feet hinders the recreation possibilities of Grand Lake. These problems are discussed in Section 7.3, Present-Day Water Resource Problems.

The fish in the Humber River downstream of the Deer Lake hydro plant benefit from the change in the water regime due to the increase in low flow levels and the decrease in the high flow levels resulting from the flow regulation of the hydro plant. Hence, even though the hydro plant may have prevented the use of the major part of the basin by anadromous fish, the section of river downstream receives benefits due to the flow regulation.

7.1.2 Fisheries

7.1.2.1 Sport Fishing

The Humber River with its tributaries constitute the most important Atlantic salmon river in Newfoundland, both in terms of recreational fishery and its contribution to the commercial fishery.

The annual recreational catch for the years 1951 to 1966 averaged 2376 fish (grilse and salmon). From 1961 to 1966, the average angling catch was 4054 fish (Figure 7-2) which reflects the increased demand in this river from about 3000 rod-days in 1961 to about 7000 rod-days in 1966 according to data supplied by the Department of Fisheries.

For comparison, the next highest annual river catch recorded on the Island on the Gander River is about 2000 fish. The Miramichi River in New Brunswick, generally recognized as the greatest single Atlantic salmon river in the world, has an annual recreational catch of about 40,000 fish. Canada's second ranking salmon river, the Restigouche in New Brunswick, yields about 5000 per year to the angler.

The migration of Atlantic salmon in the Humber River occurs from June to October with a distinct late run in mid-September. The angling season is presently from May 24 to September 15. There are several excellent pools or salmon fishing areas in the basin including the lower Humber River below Deer Lake, Big and Little Falls, Adies Stream, Harriman's Steady and the Birchy Basin - Taylors Brook area. Sport fishing does not occur in the Humber Arm.

Other species of fish that have economic importance in the basin are speckled or brook trout (resident and sea run), ouananiche, and eels. All but the latter currently support a local sport fishery but no statistics are available for these species. Brook trout is popular in the Birchy flats area. Upper sections of the river, accessible only by plane, contain large populations of brook trout and ouananiche. Eels could be of economic importance if an efficient means of capture and a ready market were developed.

The development of the anadromous salmon population is the subject of concentrated effort by the Canada Department of Fisheries. Counting fences have been installed at several sites in the basin in order to study the possibilities of obtaining a source of fish for transfer to the Upper Exploits River and to determine the potential escapement to inaccessible reaches in the Humber River basin.

At present Atlantic salmon have access to about 70 miles of the mainstem from the river mouth up to Main Falls, which is on the Upper Humber upstream of Deer Lake, and 130 miles of tributaries. The population is estimated by the Department of Fisheries to provide an annual river escapement of 12,000 to 20,000. Total adult production is estimated to be 24,000 to 40,000 fish.

7.1.2.2 Commercial Fisheries

Commercial fishing does not occur in the Humber River proper but takes place in the Humber Arm. Anadromous fish developed in the Humber River are also taken outside this area. In the period 1952 to 1966, the commercial salmon catch in Humber Arm has averaged 52,000 pounds with a range of 5000 to 126,000 pounds. In 1966, commercial landings for the Humber River estuary were estimated at 9.2 million pounds and valued at $337,000. The principal landings were as follows:

Item	Quantity (lbs)		Value ($)	
	1961	1966	1961	1966
Ground Fish	840,000	493,000	30,000	25,300
Herring	2,500,000	8,093,000	11,500	81,500
Salmon	28,000	94,000	13,500	33,500
Lobster	308,000	301,000	105,000	192,400
Other	324,000	233,000	-	4,000
TOTAL	4,000,000	9,214,000	160,000	336,700

Participation in the more important fisheries in the estuary are indicated below:

Item	Number of Fishermen	
	1962	1967
Cod Fishing	170	139
Lobster Fishing	207	186
Salmon Fishing	94	150
Herring Fishing	234	114
TOTAL*	255	285

The commercial fisheries in the estuary of the Humber River provide partial employment for about 285 fishermen (70 percent fish during less than five months), with a capital investment of $340,000 which provides a gross annual revenue of $337,000. Only about 150 of the 285 fishermen fish for a species which spends part of its life in fresh water (salmon).

7.1.2.3 Water Resource Implications

Significant pollution in the Humber River Basin is restricted to the Humber Arm and is mainly due to paper mill wastes. A survey of the receiving waters for the effluent from the Corner Brook mill was conducted in 1942[8]. The location of the waste outfalls away from the river mouth and the dilution effects of the Humber Arm were at the time able to abate the polluting effects of these wastes on salmon escapements to the Humber River and no significant damaging pollution was reported as a result of the 1942 survey. It should be noted, however, that wastes from the mill have increased since that time as a result of stepped-up production and the area has not been examined in detail since the 1942 survey. Further discussion of the problem is included in Section 7.3.

* Fishermen participate in more than one fishery.

Other present day industrial encroachments which affect fisheries are the numerous logging dams which cause minor holdups during dry years and may decrease spawning and rearing potential. Furthermore, bark deposition resulting from log driving in the basin area may create problems which seriously affect fish populations. An example is the Hughes Brook, draining into Humber Arm, which was used as a dumping site for logging in the area because of its proximity to Bowaters mill at Corner Brook. Although there is very little quantitative information available on the Brook, the Department of Fisheries believe that large concentrations of bark have accumulated on the river bottom changing the pattern of the bottom fauna life and limiting the fish food supply.

Log driving on the tributaries has decreased, thus favouring fisheries development; however, it continues on the main river and contributes to the pollution of the estuary.

7.1.3 Recreation, Tourism, and Wildlife

There have been several parks located in the basin over the years, and these rely heavily on water resources and the natural scenic beauty to attract local and tourist traffic.

The Margaret Bowater Park is a public park provided by Bowaters Newfoundland Limited; it is located in Corner Brook on the Corner Brook River downstream of the hydro plant but upstream of the pulp and paper mill water intake pond. A small rock-fill dam was constructed for recreational development of the stream, and the pond formed by the dam is used as the city swimming pool. The surrounding area has been landscaped where required. In 1962 the park recorded some 74,000 visits[4].

The Bowater Park is a public park provided by Bowaters Newfoundland Limited located just off the Trans-Canada Highway about halfway between the city of Corner Brook and the town of Deer Lake. The park is located on the shore of Deer Lake and has camping facilities. Swimming, boating, and fishing are attractions and the park has a small zoo within its boundaries.

The Sir R. A. Squires Memorial Park is a Regional Provincial Park which was proclaimed in 1954. This Park is located on the Upper Humber River about 21 miles by road from the town of Deer Lake and has an area of 3890 acres. The main attraction is the Big Falls salmon pool which is located in the park. There are camping facilities, and fishing is the main attraction to visitors.

Winter sports are being developed in the basin. The topography of the area and the abundant snowfall averaging over 10 feet combine to produce excellent conditions for skiing. Until recently this potential has been largely untapped, but a ski centre is now being developed about 10 miles from Corner Brook near the Trans-Canada Highway. Due to a relatively small population in the area, the facilities of the centre are on a small scale and are unique on the Island at the present time.

In addition to skiing, the winter sport of snowmobiling has developed in the basin. There is no lack of necessary outlets for pursuers of this pastime, as a plentiful snow cover and unrestricted trails are found virtually everywhere in the basin.

Present day recreational development is hampered in some areas by logging, lake level variation for hydro-electric production (Grand and Sandy Lakes), and the natural and artificial obstructions which restrict the access of game fish in many reaches.

As mentioned in Section 6.3.3, the big game animals which attract hunters to Newfoundland are present in the Humber Basin. Several guides are available in Corner Brook and Pasadena. There are several hunting camps in the basin, four of which did not operate in 1967, but two others attracted a total of 29 hunters who spent about $10,000.

The trapping of the fur-bearing animals existing in the basin is not considered of significance.

The abundance of wildlife in the parks helps to attract tourists to the area. To date, pollution of the water in the basin is not known to have affected the existing wildlife.

7.1.4 Forest Exploitation and Log Driving

In the Humber River basin, forest exploitation is controlled almost entirely by Bowaters (Nfld) Limited. Bowaters have 29 different primary inventory units on the Island on which they have timber limits. Units 4, 5 and 6 are located in the Humber River basin (Figure 1-10). Unit 4 is the drainage area from the Bay of Islands to the Humber River mouth and includes the Humber Arm drainage area. Unit 6 is the area upstream of the Grand Lake power canal and excludes the diverted Indian River area of 92 square miles. Unit 5 is the remaining drainage area of the basin and includes the Upper Humber River drainage area to the Humber River mouth.

An estimate of the merchantable, unmerchantable, developed, and waste (scrub, barren, marsh) areas within the timber limits of Bowaters in the Humber Basin has been made by Bowaters and is shown on Table 7-1.

From the data supplied by Bowaters of the total timber limits in the basin of 1.5 million acres, about 330,000 acres are merchantable virgin timber.

Trucking has gradually replaced log-driving in the Bowaters operations as they are now working further from the rivers. The only major log-driving enterprise within Bowaters' limits is carried out on the main Humber River. As a result, almost all of the logging dams, which are generally small timber crib structures, have been removed at the request of the Department of Fisheries or allowed to decay. Two of the remaining logging dams are located on the Upper Humber River at Adies Lake and Birchy Basin which have a head of about 7 feet. Another four small logging dams are located on brooks flowing into the north side of Humber Arm.

Tree cutting practices which do not consider erosion problems can adversely affect the runoff regime, the reservoir service life, and fisheries developments. For example, the Corner Brook River basin has a total drainage area of about 66 square miles. The forested area is about 33 square miles and 44 percent of the forested area is cut over[4]. The cutover areas may have contributed significantly to soil erosion followed by a marked silting of the reservoirs in the basin, although clearing for new construction in the area may have also contributed significantly to the silting problem. A high silt content of this nature in a river can destroy spawning areas, smother bottom growth, decrease food production and affect the respiratory tissues of fish.

7.1.5 Navigation

Shallow draught vessels are used in the main lakes for log-driving. The main river is navigable by small tugs from Humber Arm to Deer Lake during high flow periods. Small pleasure craft are found throughout the basins. Navigation of ocean going vessels occurs in the Humber Arm and is largely connected with the export of products from the Bowaters (Nfld) Pulp and Paper Company Limited mill in Corner Brook. The harbour facilities at Corner Brook are outdated and under-developed and the harbour is not under the jurisdiction of the National Harbours Board.

7.2 Withdrawal Uses

Withdrawal uses of the water resources in the basin include industrial and domestic water supply. The largest industrial user is the pulp and paper mill located in Corner Brook.

7.2.1 Mining

The only significant mine in the Humber River basin is located near Corner Brook at the three limestone and shale quarries of North Star Cement Limited. The cement plant has recently expanded and will now use approximately 185,000 tons of limestone per year. The peak water demand is estimated to be 300,000 gpd. Although other minerals occur in the basin, none of the deposits is being mined at this time.

The most extensive deposits of good quality sand and gravel on the Island occur in the Humber Valley. Sand and gravel quarrying varies from year to year, depending on the requirements for road building, maintenance, and other construction projects.

The present mining does not affect in any significant way the withdrawal water resources uses; however, it probably increases water turbidity and silting in the areas where the mining and quarrying take place.

7.2.2 Agriculture

Agriculture does not contribute significantly to the economy of the basin. Data indicate that less than one percent of the population is living on farms in the basin[3]. Only about 0.2 percent of the land area is farmland and of this, 20 percent is under crops and about 65 percent is unimproved land. There are fewer than 60 census farms in the basin, of which about 60 percent are classed as non-commercial. Only one farm has had produce sold valued at more than $35,000 annually. Generally, the farms have less than 70 acres; only one has more than 400 acres.

About 40 percent of the farms are classified as commercial farms of which 5 are dairy farms, 9 grow mixed field crops, including hay and potatoes, 5 are poultry farms, and the remainder are mixed. The average value of machinery and equipment of the commercial farms is about $5000.

In all, there are about 500 cattle, 300 cows, 600 pigs, 300 sheep, 33,000 chickens, and 30 turkeys in the basin. The polluting characteristics of the livestock wastes and wastewaters represents an equivalent population of approximately 2000. However, except for localized dissolved oxygen reduction, it might be presumed that livestock does not create a significant pollution problem due to its lack of concentration.

Irrigation is not practiced in the basin and the water supply and disposal systems for the farms are similar to those of the small community dweller; that is, mostly well supplies, and septic tanks provided in some cases. Occasional pollution problems due to faulty arrangement of supply source and waste disposal (man or animal) can be expected to be encountered in some cases.

7.2.3 Water Uses for Manufacturing

The majority of the significant water using industries are concentrated in the City of Corner Brook which is located on the estuary of the Humber Arm. Of these, the Bowaters (Nfld) pulp and paper mill is the largest water user. The main water using industries in the basin are listed in Table 7-2.

The Bowaters' mill is located in the centre of the city near the mouth of the Corner Brook River. The mill has a capacity of 1260 tons per day of newsprint paper produced in average from 80 percent groundwood and 20 percent sulphite pulp. In addition, it sells an average of $5 million worth of sulphite pulp per year. Its capacity increased from about 200,000 tons in 1938 to 460,000 tons per year in 1966, and its production from 130,000 to 350,000 tons per year in the same period. The mill requires an average of 33 million gpd of process water which is gravity fed from Glynmill Pond and delivered to the mill via two 36-inch diameter cast iron pipes. The capacity of the system is 45 million gpd. Chlorine is added at the mill and there are screens at the intake. The water required for wood barking amounts to about 5 million gpd and is taken below the process-water pond at a small dam on the Corner Brook stream near tidewater.

Mill requirements for drinking and make-up water for boilers are about 2 million gpd and are obtained from the municipal water supply system, which is described in Section 7.2.4. The boiler feed water is treated in the mill by a sodium zeolite system. The total cost of the mill water supply system is estimated to be $1.5 million.

There are several sewer outlets from the paper mill and all the untreated mill effluent enters the Humber Arm. Difficulties with the present mill water supply and wastewater disposal systems are discussed in Section 7.3 - Present Day Water Resource Problems.

Lundrigans Limited is the only other major industry in Corner Brook which has its own water supply in addition to the city supply system. The company uses an additional 300,000 gallons per day which is pumped from the mouth of the Humber River and used in the washing plant. The water is primarily used for the washing of concrete aggregate and the production of concrete. The supply scheme, which went into operation in 1967, had a capital cost of $11,000. The water from this source has a salt content which varies according to the tide level in Humber Arm. Problems of disposal of wastewater from the plant are discussed in Section 7.3 - Present Day Water Resource Problems.

The other industries are generally supplied from the municipal system.

7.2.4 Population and Municipal Water Supply and Waste Disposal

In 1966, 96 percent of the population of the Humber River Basin lived in the Corner Brook - Deer Lake study area shown on Figure 6-1. Because there are no communities of significant population concentrations living outside the study area, discussions of population characteristics are confined to study area data.

Over the past four census periods the population increased from 25,150 in 1951 to 32,260 in 1956, and to 35,950 by 1961, and by 1966, 38,970 persons were living in the area. Although these figures represent an absolute increase in population between each census period, the average annual percentage increase has been dropping. Between 1951 and 1956, the average annual increase was 5 percent, the growth to 1961 dropped to 2.3 percent a year and between 1961 and 1966 the annual growth rate had dropped to 1.6 percent.

The census defines an urban area as a community with a population of 1000 or more people. By this definition there were two urban communities in the study area between 1951 and 1966: Corner Brook with a 1966 population of 27,116, and Deer Lake with a 1966 population of 4,289. The degree of urbanization in the study area was 78 percent in 1951, rising to 82 percent by 1956, and level at 81 percent in 1961 and 1966. This is considerably higher than the 1966 provincial average of 54 percent and 7 percentage points higher than the Canadian average of 74 percent.

The 1961 age structure of Corner Brook is used as a benchmark for the study area as a whole. The degree of error between Corner Brook and the total study area or even the river basin will be negligible because of the dominant position of Corner Brook in the total population.

Percentage Distribution of Population

Age Group	Corner Brook	Province	St. John's
0 to 14	44	42	36
15 to 24	16	10	10
25 to 64	37	42	49
65 plus	3	6	5
	100	100	100

Although only two percentage points separate the size of the Corner Brook labour force age group (15 years and over) from that of the Province, significant differences existed in the age structure of the labour force age group itself. The study area appears to have a very large proportion of its population under 24 years of age.

The main surface water supply for the City of Corner Brook is obtained from the 51 square mile area controlled by the hydro-electric development of Watson's Brook. The intake to the main or eastern part of the supply system is located at Three-Mile Dam approximately one mile from the city limits. The rated capacity of the system is 4.5 million gallons per day. Expenditures in 1966 including management, engineering, and debt charges of the water and sewage utility amounted to $580,000.

The pond formed by Three-Mile Dam is at an elevation which permits a gravity supply system to the eastern section of the city. The water supply to this section of the city reduces the flow available to the hydro development.

The western part of the city, Curling, obtains its water supply from a surface source located about one-quarter mile from the city limits. The average daily usage in Curling is about 0.6 million gallons per day. The drainage area controlled by this section of the water supply system is less than one square mile. The water supply from the Curling system has been metered since 1954; that of the eastern or main supply system has been metered since 1967, but no metered usage figures were available.

The water for the system is treated by chlorination and the water usage averages 5 million gallons per day for the 5000 households and for the industries supplied from the municipal system. Approximately 10 percent of the population presently have individual wells for a source of supply.

Problems in water quality for both the town water supply and Bowaters' supply system have occurred during the high flow periods in Corner Brook due to turbidity, as shown in Section 7.3.

The sewage collector system consists of approximately 30 miles of sanitary sewer mains, 6.5 miles of storm sewers, and approximately 3 miles of combined mains. The sewage from the city mains is not treated and is disposed of in 12 separate outfalls which flow into Humber Arm. The untreated effluent of the industries, including that of the mill, also flows into Humber Arm. Pollution problems resulting from this effluent are discussed in Section 7.3 - Present Day Water Resource Problems.

Industrial firms in Corner Brook relying upon the municipal water system and consuming relatively large quantities of water are shown in Table 7-2.

All other industrial firms utilizing the municipal water supply system use considerably less than 5,000 gallons per day each.

The water supply for the town of Deer Lake (1966 population - 4289) is obtained entirely from the drainage area controlled by the hydro development at Deer Lake. The supply system was originally installed in 1929 and is connected to two penstocks of the hydro plant. The 600,000 gallons per day supply services 738 households and the commercial and small industrial needs of the town and is treated by chlorination. The flow is measured by a flowmeter and recorded on a weekly flow chart.

Approximately 630 households are connected to the sanitary sewer system. A comminution installation with a 10 million gallons per day capacity serves 400 households; the remainder are connected to individual septic tanks or cesspools. A separate storm sewer system consists of many small separate networks. All effluent eventually drains into Deer Lake. A report covering a proposed expansion of the water supply and sewage system has recently been prepared for the town.

The twenty communities other than Corner Brook and Deer Lake located in the basin area have a total population of 7,200 and an average population of 360. None of these communities have a population of greater than 850 and they account for 18 percent of the total basin population of 40,500. (1966 census)

Eight of the communities were visited by the Shawinigan-MacLaren team during their 1967 field survey to obtain data on water supply and treatment facilities. Results of the survey are summarized on Table 7-3.

As can be seen from the table, a small community in the basin averages about 64 households. The major source of water supply is individual wells, with only part of one community having a water supply system. The remainder of the households in small communities of the basin obtain their water supply from nearby brooks. None of the communities located along the Humber River where interviews were held utilize the river water as a source of supply. Many of the communities do not have an adequate quantity of water as the wells become dry during low rainfall periods. Also, the quality of water is unsatisfactory for many of the small community users. None of the small communities interviewed has a sewer collector system. About

60 percent of the individual households have their own septic tanks; the remaining households dispose of the wastes in open ditches.

From the above, it is evident that the small communities in the basin generally have inadequate water supply and disposal systems which is typical of rural communities on the Island.

7.3 Present Day Water Resource Problems

As mentioned in Section 7.1.1, the existing hydro-electric developments have experienced supply shortages and the possibility of increasing the present storage in the Grand Lake drainage area was investigated for Bowaters to meet the increasing power demands. At present, there are alternate sources of power which appear more attractive. However, the possibility of developing supplementary storage in this basin may become more attractive under future conditions, especially if multiple uses can be obtained.

Conflicts in water use have occurred between fisheries and hydro developments in the basin. The Fisheries Department have concentrated their efforts for developing areas presently inaccessible to anadromous fish in the Upper Humber River upstream of Main Falls. This area is expected to be able to produce an additional 35,000 adult Atlantic salmon which would significantly increase total adult Atlantic salmon production presently varying from 24,000 to 40,000 fish. The hydro plant at Deer Lake creates a conflict in water use between hydro power and fisheries by making the Grand Lake drainage area inaccessible from the Humber River. The barrier created by the hydro installation is formidable due to the 250-foot head differential between Grand and Deer Lakes. The possibilities of making this area accessible to anadromous fish should be investigated and the potential of the Grand Lake area for producing Atlantic salmon stock assessed. This presently inaccessible drainage area constitutes 60 percent of the total drainage area of the basin.

Disposal of wastewaters by industrial and domestic water users has created a potential conflict with fisheries in the Humber Arm. The Arm is nearly 15 miles long and averages 1.25 miles in width and is surrounded by high steep hills (Figure 6-1). At the head of the Arm there is a bar about 0.75 miles long where the minimum water depth is about 3 feet (Figure 7-3). In the remainder of the Arm, the depth is about 300 feet. The Humber River enters the Arm at the extreme east end and has an average flow of about 10,000 cfs. The tidal variation is about 4 feet in the Arm.

In 1942 a pollution survey was made of the Humber Arm[8] to determine the effects of the Bowaters pulp and paper mill effluent on the fish life in the Arm. The pulp and paper mill is situated at Corner Brook on the south shore of Humber Arm, about 2.5 miles from the head of the Arm. The Arm is about 1.3 miles wide opposite the mill and about 220 feet deep, except for a short distance on either side. The pollution survey of 1942 concluded that the mill effluents did not seriously affect fish life in the Humber Arm.

However, since 1942, the mill production has increased by about 50 percent and the possibility exists of a progressive deterioration of the quality of water in the Arm reaching a point where fish life is endangered. It is during the to-and-fro migration of anadromous fish that pollution in an estuary can cause serious damage and mortality to the fish[9]. A one-week survey of the Humber Arm by the Fisheries Department is planned for the summer of 1968 and may be sufficiently thorough to determine the necessity of a detailed pollution survey.

Recreation has been partly inhibited by hydro developments in the basin. Grand Lake, located in the southeastern part of the Humber Basin, is the largest lake on the Island, is some 60 miles long and averages over 2 miles in width. Rugged shorelines of exceptional beauty rise between 1000 and 2000 feet above the lake surface. The lake serves as a storage reservoir for the Deer Lake hydro plant and the level varies about 13 feet between full and low supply levels. This, together with a lack of salmon sport fishing, deters development of recreational facilities similar to those available on Deer Lake.

Sedimentation has created problems in the industrial and fresh water supply in the Corner Brook area. Corner Brook River, which is utilized for power, recreation, and water supply, has had its shallow intake ponds partially filled with silt over the years. As mentioned previously, the intake for the hydro plant and the town water supply is located at Three-Mile Dam. Each spring the silt content in the water supply becomes a nuisance and creates operating problems. Silting of the small pond (about 4.8 acres surface area) has been accentuated because of the small depth of the pond.

In 1930 the average depth of the pond was only 7 feet. By 1956 the average depth of the pond had decreased to about 3.5 feet. Pafford[4] estimates from sounding data supplied by Bowaters the volume of sediment deposited in the 26-year period to be 27,000 cubic yards. The depth of the pond has been decreasing asymptotically but a complete filling has been prevented because of the high velocities created in the reduced reservoir channel. Consequently, sediment was carried downstream into the hydro and water supply systems. Silt taken into the hydro facilities is passed downstream to the mill intake at Glynmill Pond.

The other water intake on Corner Brook River is located at the Glynmill Pond. This pond serves as a small reservoir for the mill water supply system. The pond has a surface area of about 7.5 acres and in 1966 Bowaters had to remove about 45,000 cubic yards of sediment at a cost of $200,000 to prevent silt from entering their supply system. Due to expanding construction activity in the drainage area, which increases the sediment buildup in the intake ponds, Bowaters believes that additional dredging may be required in the next few years.

The problem of silt entering the mill supply system is accentuated by the relative shallow depth of the Glynmill Pond. Although prior to dredging the water depth at the intake was about 13 feet, a good portion of the pond had a depth of only 3 feet.

The sounding data on silt buildup over the years in the Corner Brook River are one of the few records available in the Island of silt deposits in reservoirs.

The 20 small communities in the basin, which account for about 18 percent of the basin population, generally have fresh water supplies of inadequate quantity and unsatisfactory quality. The waste water disposal systems create a potentially dangerous condition when the disposal system is located near the supply. Generally, the water supply and disposal systems are for individual units and are improperly arranged. Small communities with their own community water supply and disposal systems are an insignificant minority.

8 PLANNED AND FORECAST DEVELOPMENT

8.1 Non-Withdrawal Uses

The main non-withdrawal water use increase is expected to occur in the hydro power field, sport fishery, and recreation and tourism areas.

8.1.1 Hydro Power Development

The potential in the basin was investigated for this report and is described in detail in Volume Four, Part I. Three developments which showed promise have been analysed in more detail. These are located on the Upper Humber River, upstream of Deer Lake. One of these schemes involves the diversion of the Upper Humber River into the Grand Lake drainage area and the development of the potential with increased capacity at the Deer Lake hydro plant. The remaining two schemes involve plants located in the Upper Humber area. According to the accepted power development scheduling none of these developments is scheduled to take place in the next 15 to 20 years.

The hydro potential of Lewaseechjeech Brook and Hinds Brook which drain into Grand Lake were investigated in the late 1950's, on behalf of Bowater Power Company [10, 11]. These studies showed that a total of 68,000 hp could be developed at these sites. This potential has remained undeveloped as the schemes did not fit into the company's plans.

The possibility of pumped storage sites in the Grand Lake area appears promising because of the shoreline topography which reaches elevations of 1000 to 2000 feet a short distance from the lake. As mentioned in Volume Four, Part I, the most promising site investigated for a pumped storage plant was at Western Brook Pond near Bonne Bay. However, some of the Grand Lake sites may prove to be competitive with the Western Brook Pond scheme and their potential should be examined before deciding the scheduling of pumped storage schemes. This problem is outside the scope of the present study since the construction of pumped storage schemes in the basin is considered as a rather remote possibility for the next 15 years. The availability of peak power from pumped storage schemes would remove the difficulty of using the Deer Lake Plant for peaking, and would allow the regulation of plant outflow and upstream levels to be more suitable for other users.

Any additional requirements in the basin in the near future will be obtained from the power grid system on the Island or from Labrador sources.

8.1.2 Fisheries

The commercial fisheries on the Humber River estuary presently provide partial employment for about 285 fishermen (150 of whom fish for salmon), with capital investment in the primary fisheries of about $ 340,000. The gross revenue received by the fisheries amounts to $337,000. Both the number of fishermen and the quantity of landings are not expected to show any strong variation in the next decade, but participation in individual fisheries could fluctuate appreciably.

The policy of the Department of Fisheries in the basin in the future is to:

a) Preserve existing stocks;

b) Develop the river to its maximum salmon potential as soon as resources can be made available;

c) Control present and future pollution in the river and other water areas where it may be deleterious to the salmon run;

d) Control logging activities which have a deleterious effect on fish runs.

Main Falls effectively prevents salmon access to 39 miles of the Upper Humber River plus 249 miles of tributary stream. It is estimated that there are 239 miles of potentially productive river area above the falls which could produce an average unexploited stock of about 35,000 adult Atlantic salmon. The Department of Fisheries estimate that the necessary studies, fishways, and augmentation of the new area with fish culture products would require an expenditure of about $400,000 to $500,000.

In addition to the inaccessible area in the Upper Humber River, the hydro-electric facilities at Deer Lake prevent fish access to 1850 of the total 3230 square miles (excluding the Indian River area) of the drainage basin. The area contains about 100 miles of standing water and over 100 miles of tributaries.

The development of the salmon potential in the Grand Lake area requires studies to ascertain if the scheme deserves priority consideration. These studies would determine the potential of the area for fishery development, whether a fish access facility is feasible, the benefits obtained both to recreational and commercial users, and the costs involved.

Any further hydro-electric developments in the basin will have to consider the inclusion of fish facilities to preserve or expand the fishery potential. If new reservoirs are to be built consideration of reservoir operation to arrange optimum temperature conditions for fish development may be necessary [12].

The assessment of the measures required to preserve existing stocks will have to await the results of the studies on the pollution conditions in the Humber Arm which are due to commence in 1968.

The control of further pollution will be concentrated on industrial pollution sources. The planned and forecast development in the basin does not include industries which could be considered sources of significant pollution. However, industrial development could occur (Section 8.2) and consideration of fisheries implications would be required.

Studies to expand the fish population of the existing lakes and reservoirs by using other than the existing species will be undertaken by the Department of Fisheries.

8.1.3 Recreation, Tourism, and Wildlife

The relatively high population density and high personal income due to the industrial development has already resulted in the establishment of several parks in the basin and of a ski centre near Corner Brook.

As indicated in Figure 7-2, the number of rod-days spent on the Humber River increased seven-fold between 1951 and 1966. This reflects the increase in leisure time enjoyed and the increased tourist traffic to the area.

Figures are available on the number of visits to the Sir R. A. Squires Memorial Park for the 1964 to 1966 period and they show an increase of about 16 percent from 37,502 to 44,377. It is expected that the other parks in the basin would reflect this trend of increasing leisure time activities.

The present day trend indicates that an increase in the use of the recreation facilities can be expected in the coming years as the basin population increases and the tourist traffic from mainland centres, which has shown a marked increase since 1965, continues to grow. The major expansion in this field will probably be related to the expansion of the areas opened for fisheries development. In the more distant future, consideration will probably be given to maintaining less variable levels on the Grand and Sandy Lakes to make them more attractive for recreational activities. This would have to be connected with a general operation plan for electric energy production on the Island and would probably require the introduction of pumped storage hydro-electric developments.

Gradual increase in hunting facilities will probably take place concomitant with organized protection of wildlife in new parks. However, the development of a second Federal park in the Bonne Bay area will probably curtail for the near future any significant expansion of the existing parks or development of new parks in the Humber Basin.

Promotion of big game animals to attract hunters to the area thereby providing additional sources of revenue will increase providing adequate management of the species occurs to insure a high success ratio. Easy access to much of the basin area by automobile or boat, the existence of relatively large communities, and the nearness to Port-aux-Basques help to make the basin attractive to mainland hunters.

Other species of wildlife in the basin are not expected to significantly affect the basin's economy in the future and their population will not be affected by future changes in the water resources.

8.1.4 Log-Driving and Navigation

Although Bowaters attempts to operate on a five-year plan, with a less-defined ten-year plan in mind, it is often found that this is impossible to meet owing to changing conditions in the pulp and paper markets.

It is expected that a high degree of mechanization may help to maintain logging costs at a relatively stable level in the future. Haul distances are expected to increase as the pressure to increase supply grows and areas presently considered inaccessible will be utilized.

Trucking may continue to replace log-driving as the operations continue further from the rivers. Regrowth in timber limits near the rivers might make log driving more attractive, but competition with fisheries and recreation could force trucking to continue to be the most desirable way to bring logs to the mill. In the more distant future, the production of wood chips in different parts of the basin with pipes conveying the chips to the mill might be a partial solution to the problem of log transportation and also provide additional water for withdrawal uses at the mill. Special attention should be paid to the reforestation of the Corner Brook River as it may be effective in reducing silting of the intake ponds.

Small pleasure craft are expected to contribute to increased navigation in the basin. Use of shallow draught tubs in log drives in major lakes and in the main river will probably decrease in the future as emphasis is placed on trucking to transport logs to the mill. Special precautions should be taken with the use of motor boats to prevent pollution by leakage of gas and oil from the motorboats where future use of the water becomes highly competitive among domestic and industrial users, recreation and fisheries.

8.2 Withdrawal Uses

8.2.1 Mining

Water quantity for any future expansion of the present mining activities in the basin or to future mine locations is not expected to be a problem.

Water quality from future mining activities could be a problem to fisheries in the basin because of physical and chemical effects from the mine wastes. Any future mining activity will have to consider protection of the existing salmon run from mine pollution as an operating liability.

8.2.2 Agriculture

There are relatively large areas of tillable land between Deer Lake and Cormack which, if developed, could augment the present agricultural output of the basin. Such development will probably take place gradually and any increase in the present level of agricultural activity in the basin will not be hindered by a lack of water of satisfactory quantity or quality. Attention should be paid to any local pollution which might result from a large concentration of livestock.

8.2.3 Water Uses for Manufacturing

Although the assumptions on future industrial development do not include definite proposals for the basin, it is believed that, due to the existing population concentration, some development may occur in the chemical or aluminum processing sectors and that some of this might take place in Corner Brook. This will depend to some extent on the possibility of expanding the harbour facilities at Corner Brook.

The industrial and domestic water demand is accordingly expected to increase in the future. However, the increased demand will be easily met as the basin has an ample supply of water. Pretreatment may be required depending upon the function for which the water is intended.

The total present water demand of the City of Corner Brook and the Bowaters Mill is about 70 cfs. This is less than half the average flow which is available from the drainage area upstream of Three-Mile Dam on the Corner Brook River. Any large increases in demand can be met by the present supply source provided that additional storage and distribution facilities are installed.

No new industries are known to be planning to locate in this area at the present time. In spite of the present soft world market for newsprint, continued expansion of the capacity of the Bowaters (Nfld) mill is expected. It is known that this company is considering the early changing of its chemical pulping to the sodium sulphite process from the calcium sulphite process, currently in use.* By 1976 the mill's capacity will be increased by 350 tons of newsprint per day, bringing the total capacity of 1550 tons per day. Future plans for the improvement and expansion of the water supply system to the mill include an improved filtration system at the process water intake on Glynmill Pond. A new dam may be required to replace the timber crib section of the present structure at the storage reservoir of Corner Brook Lake, and dredging of the sediment deposits at Glynmill Pond may be required. In the event of an increase in quantity of mill water, a third 36-inch diameter line will be required from the Glynmill intake to the mill. The capital costs of all the improvements are expected to be about $1 million according to information provided by the Bowaters (Nfld) Pulp and Paper Limited.

*This changeover has occurred according to latest information.

Reforestation and intensive forest management in the Corner Brook River basin mentioned in Section 8. 1. 4 should receive special attention as it may significantly reduce the siltation problems. The waste water from the Corner Brook industry and especially the pulp and paper mill accumulates and creates a threat to the water quality of the Humber Arm. It may be in order to investigate possibilities of reducing the mill wastes by recovery of by-products or changes in the technological process which could also be beneficial to the mill. Investigations of this nature should be considered following the results of the pollution surveys in Humber Arm.

8. 2. 3 Population and Municipal Water Supply and Waste Disposal

Based on past trends, the population in the study area is projected to grow steadily over the forecast period. From the 1966 population base of 38, 970 the population was projected to grow to 42, 360 by 1971, to 45, 650 by 1976, and to 48, 960 by 1981. No developments are anticipated to take place in the basin area which lies outside the study area and the size of the total population living in these small communities is expected to remain between 1000 and 2000.

No provision has been made for a net inward movement of population to the river basin because no major expansion in economic activity is anticipated over the forecast period.

The following estimate of the possible size of the labour force was based on the projected study area populations, and the assumptions concerning the size of the labour force age group and the labour force participation rates were provided by the Board (Volume Three A, Section 5).

	Size of the Labour Force Age Group and Labour Force		
	1971	1976	1981
Labour Force Age Group	20, 500	21, 800	23, 000
Labour Force	9, 500	10, 500	11, 500

No major change is anticipated in the pattern of population distribution within the river basin, and the degree of urbanization will remain at the present level.

The only indications of personal income available are estimates for the Census Division. However, because most of the people in the Census Division also live in the river basin, these data were used as an indication of income levels. In 1965 the estimate of per capita disposable income for the Census Division was $1500 compared to a provincial average of $1100. The existing structure of the basin's economy and the fact that no major changes are anticipated over the forecast period form the basis of the estimate of disposable income in 1981. At the end of the forecast period, in terms of 1965 dollars, per capita disposable income is estimated to be $2500.

The intake pond for both the hydro plant at Watson's Brook and the Corner Brook city water supply at Three-Mile Dam will have to be dredged or other remedial measures taken in the near future, as the sediment creates problems in the water supply system during high flow periods. This sediment is probably due to two main sources, forested areas which have been cut or burnt over and new construction clearing. Pafford[4] indicated that about 25 percent of the drainage area of Corner Brook River was cut or burnt over. As mentioned previously, efforts to prevent erosion at its source are required to overcome the sediment problems.

Water quantity is not a future problem for the Town of Deer Lake as the supply is obtained from the Deer Lake hydro plant penstocks which uses Grand Lake as a storage reservoir. The population is expected to reach 5800 in 1981, an increase of about 35 percent from the 1966 figure (Figures 8-1 and 8-2). This may require increases in the present capacity of the supply and disposal systems, for which plans have been filed.

The small communities in the basin generally have inadequate water supplies at the present time and it is expected that community supply systems will be installed as the pressure for a more satisfactory supply system grows, at least in some of the communities which have the required economic base to survive. Unfortunately, because of the small size of the majority of the communities in the basin, which averages 64 households, the unit cost of a water supply system should be high compared to the real estate value, and might generally be increased even more because of the subsurface conditions in many of these communities. However, the availability of an adequate quantity of water from nearby sources required to satisfy a small community demand is generally not a problem.

The majority of the small communities do not have a community sewage collection system at present. Generally, high unit costs as a result of the small number of households in these communities and subsurface conditions will deter future installations. However, when the water supply system is centralized and local wells or sources are not used, septic tanks could provide an acceptable answer to the problem of waste water disposal.

9 CONCLUSIONS AND RECOMMENDATIONS

9.1 Conclusions

a) The Humber River basin has been developed primarily for the pulp and paper industry, and the water resources of the basin have been used by this industry for log driving, hydro power generation, industrial water supply, and wastewater disposal. Some degree of co-ordination between these activities has been implemented by the industry.

b) Because of available natural resources, the geographic position, and the population concentration resulting from the pulp and paper activity, the development of some service industries including tourism has followed the industrial development. Tourism in turn relies on fresh water fisheries and wildlife potential, and imposes certain standards on the lake water levels and quality of water.

c) Between the groups of activities servicing the pulp and paper industry and those related to the service industries, there is a conflict of interest resulting from:

   i) The sealing-off of the entire Grand Lake drainage area at Deer Lake, to anadromous fish due to the hydro-electric development.

   ii) Water quality degradation in the Humber Arm because of pulp and paper mill waste disposal, and in the main river stem and some of the tributaries because of log driving.

   iii) The variation in lake levels due to drawdown for hydro-electric energy production.

d) There is also some community of interest between the two groups consisting of:

   i) The general advantage of having regulated flows downstream of Deer Lake.

   ii) The general interest of avoiding soil erosion and consequent reservoir sedimentation.

e) While the conflicts of interest may develop further as the tourism and related activities increase, there are possibilities of solving these conflicts for the general benefit of the users by co-ordinated measures resulting from water resources management planning.

f) The basin contains interesting potential for pumped storage hydro-electric schemes in the Grand Lake area. Their possible development can have some tourism implications which could possibly be transformed into a community of interests with this activity.

g) Water quality degradation due to industrial and municipal use has incurred a yet-to-be paid cost of improvement. It is estimated that the investment cost of even minimum primary treatment facilities for the pulp and paper mill at Corner Brook would be in the order of $1,500,000 with an annual operating cost of $275,000. This does not consider any offsetting benefits from chemical recovery. Completion of municipal sewage and primary treatment for Deer Lake would require an outlay of about $700,000.

Although the industrial waste does not directly threaten the fresh water resource due to estuarine discharge, it does threaten a valuable non-withdrawal use of the resource - fishing.

9.2 Recommendations

A Local Advisory Board should be established, representing all levels of government having jurisdiction over the water resources and all users. This Advisory Board would be responsible for the preparation of a water resources management plan which would have to be preceded by the following investigations and studies:

i) A preliminary water quality survey of the Humber Arm carried out in enough detail to determine if a comprehensive survey is required. Following an assessment of the results of the pollution survey, it may be necessary to examine the wastewater problems from the pulp and paper mill to ascertain the economic feasibility of chemical recovery from the spent sulphite liquor or other measures leading to the reduction of wastes and related problems.

ii) The assessment of long-term plans for forest exploitation in the area, including log driving activities and forest management and related water quality problems. The problem of soil erosion and sediment in the Corner Brook River, which is presently the most important source of industrial and municipal water supply in the basin, would also be assessed.

iii) The assessment of tourism potential and probable development, related revenue; and, in relation to this, the study of the feasibility of the salmon fishery development and implementation of recreational facilities upstream of the Deer Lake hydro plant.

iv) A more detailed investigation of future industrial and domestic water uses and waste disposal and the related problems.

v) The assessment of the economic feasibility and development possibilities for hydro-electric pumped storage in the basin, with its related water resources implications.

vi) A monitoring of water quality used for domestic purposes throughout the basin to identify all unsatisfactory sources, and the assessment of measures required to gradually improve the water supply of communities which have the greatest problems and which will further develop as population centres.

vii) A review of legislation, administrative conditions, and water rights in the basin.

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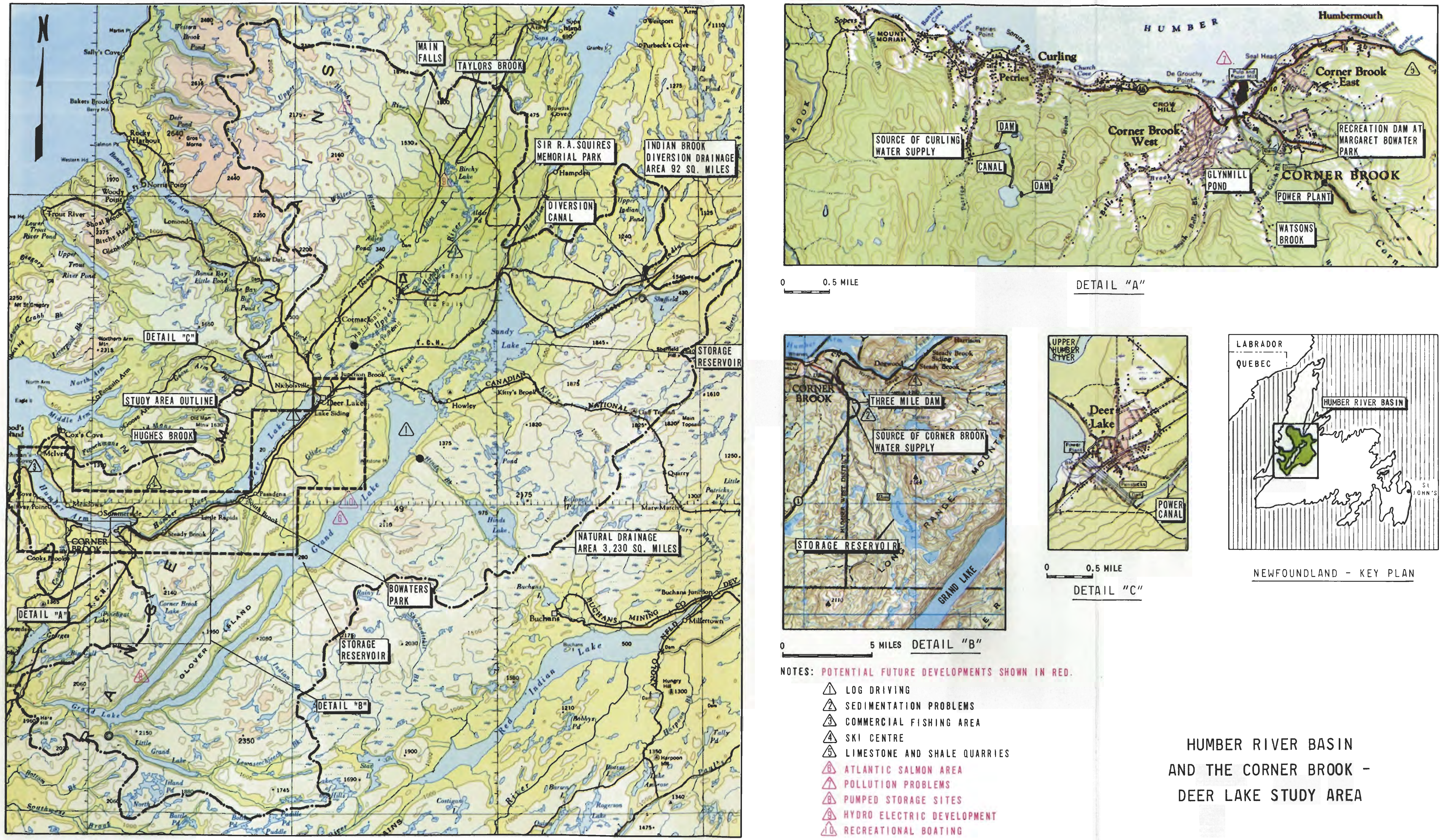


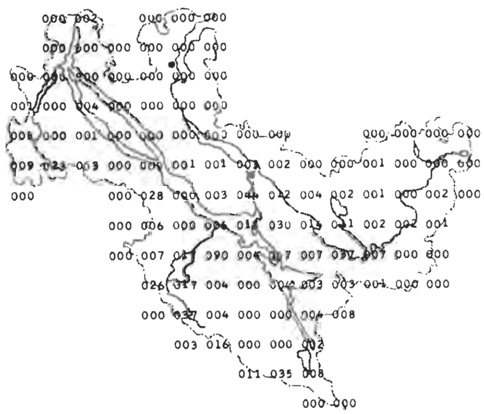
LEGEND:
- ● EXISTING RIVER GAUGE
- ◎ ABANDONED RIVER GAUGE

NOTES: POTENTIAL FUTURE DEVELOPMENTS SHOWN IN RED.
1. LOG DRIVING
2. SEDIMENTATION PROBLEMS
3. COMMERCIAL FISHING AREA
4. SKI CENTRE
5. LIMESTONE AND SHALE QUARRIES
6. ATLANTIC SALMON AREA
7. POLLUTION PROBLEMS
8. PUMPED STORAGE SITES
9. HYDRO ELECTRIC DEVELOPMENT
10. RECREATIONAL BOATING

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

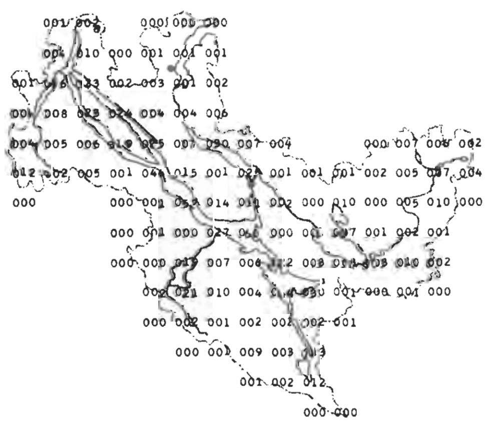
FIGURE 6-1

HUMBER RIVER BASIN AND CORNER BROOK-DEER LAKE STUDY AREA
SQUARE GRID DISTRIBUTION OF LAKES, BOGS, BARRENS AND FORESTS

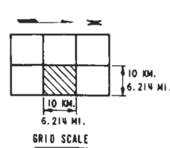


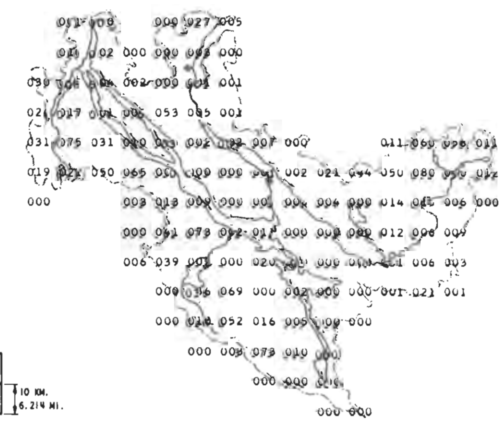
BOG AREA - SQ. KM.

FOREST AREA - SQ.KM.



LAKE AREA - SQ.KM.



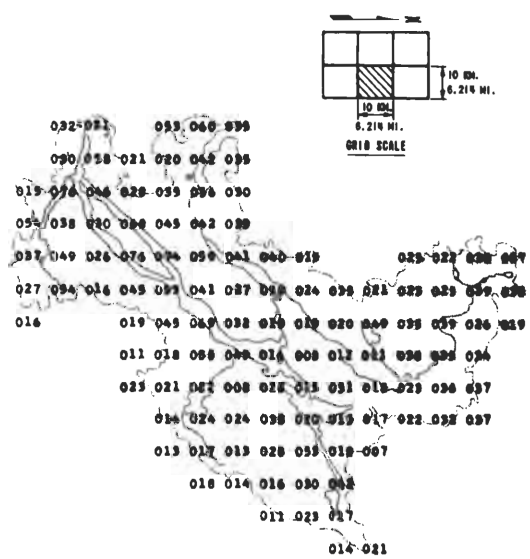


AREA OF BARREN - SQ.KM.

FIGURE 6-2

HUMBER RIVER BASIN AND CORNER BROOK - DEER LAKE STUDY AREA
SQUARE GRID DISTRIBUTION OF LAND SURFACE SLOPE AND ELEVATION

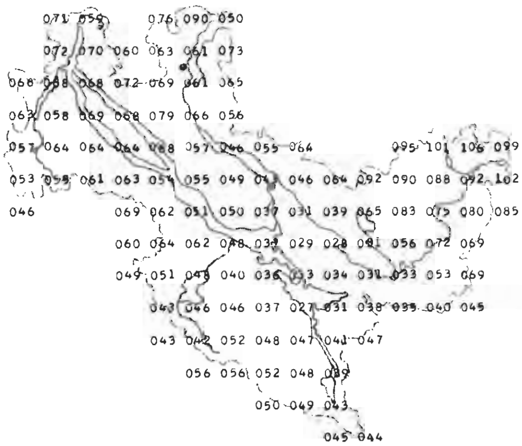
AVERAGE ELEVATION OF SQUARE
TENS OF FEET



SLOPE - TENTHS OF A PERCENT

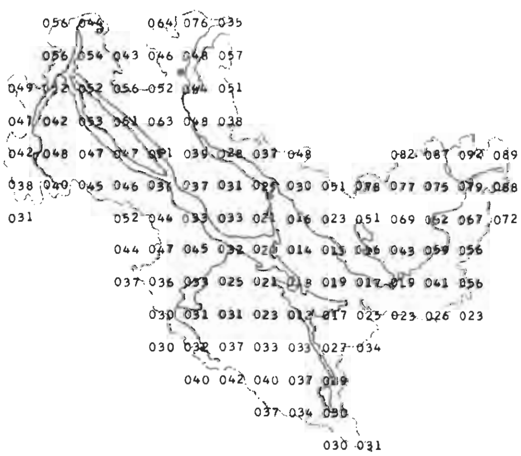
FIGURE 6-3

HUMBER RIVER BASIN AND CORNER BROOK-DEER LAKE STUDY AREA SQUARE GRID DISTRIBUTION OF MEAN ANNUAL TEMPERATURE, PRECIPITATION, EVAPORATION AND RUNOFF

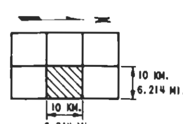


AVERAGE YEARLY PRECIPITATION
- INCHES OF WATER

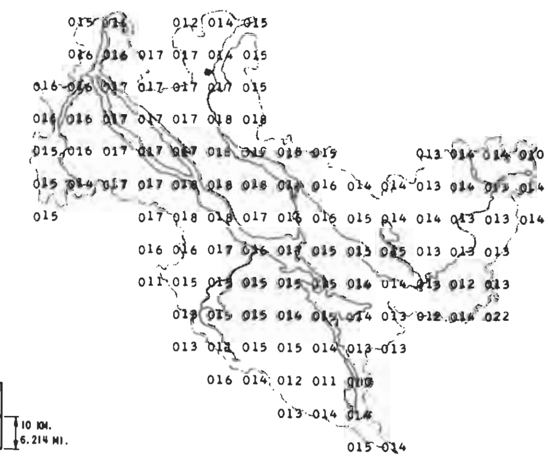
AVERAGE YEARLY TEMPERATURE
-DEGREES FAHRENHEIT



AVERAGE YEARLY RUNOFF
- INCHES OF WATER



GRID SCALE



AVERAGE YEARLY EVAPORATION
- INCHES OF WATER

HUMBER RIVER BASIN AND CORNER BROOK - DEER LAKE STUDY AREA
GROSS HYDRO ELECTRIC POTENTIAL
ON UPPER HUMBER RIVER

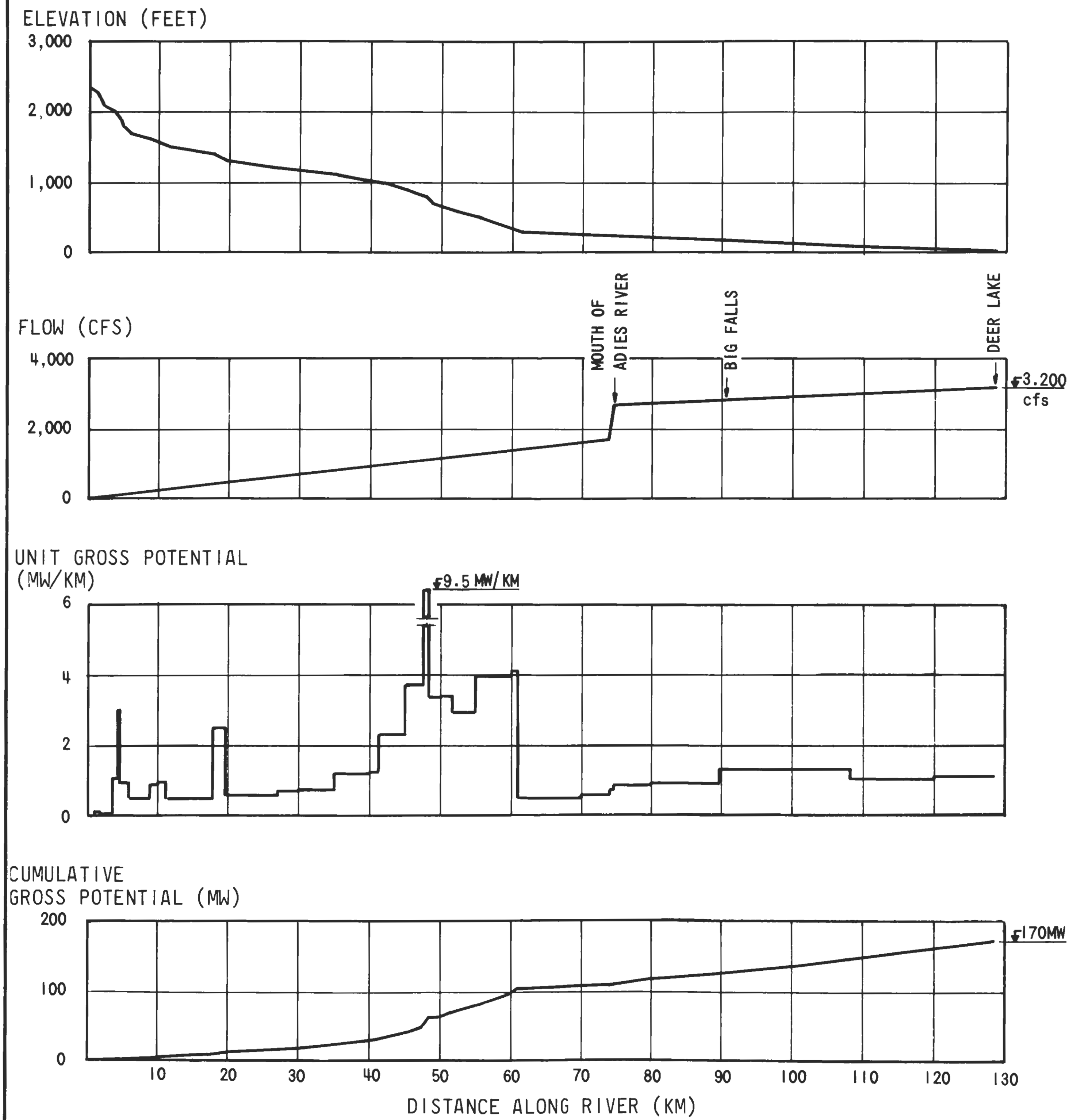


FIGURE 6-5

HUMBER RIVER BASIN AND CORNER BROOK - DEER LAKE STUDY AREA
REGULATED PLANT OUTFLOW VS NATURAL INFLOW
DEER LAKE PLANT

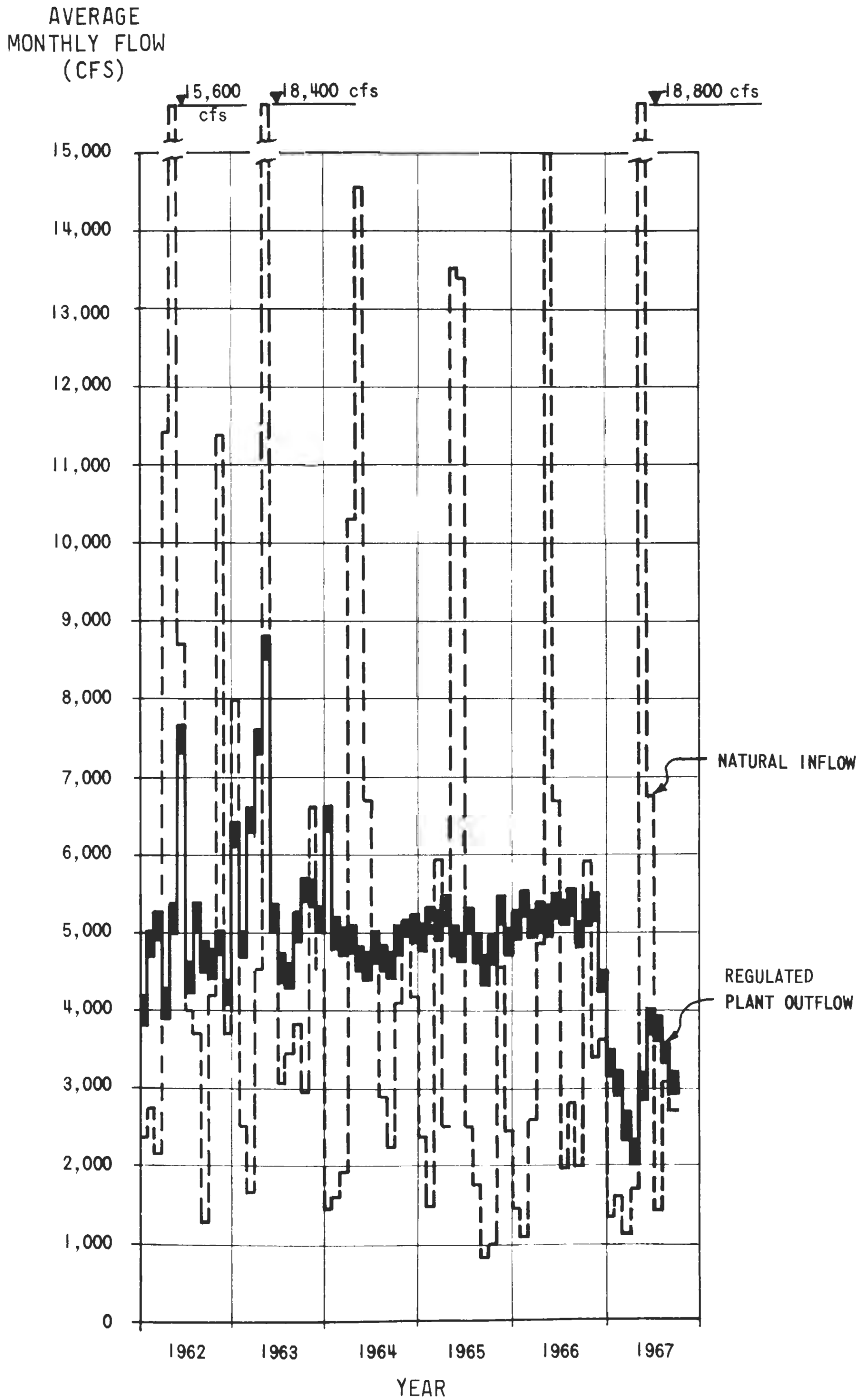


FIGURE 7-1

6

HUMBER RIVER BASIN
ANNUAL ANGLERS CATCH
(SALMON AND GRILSE)

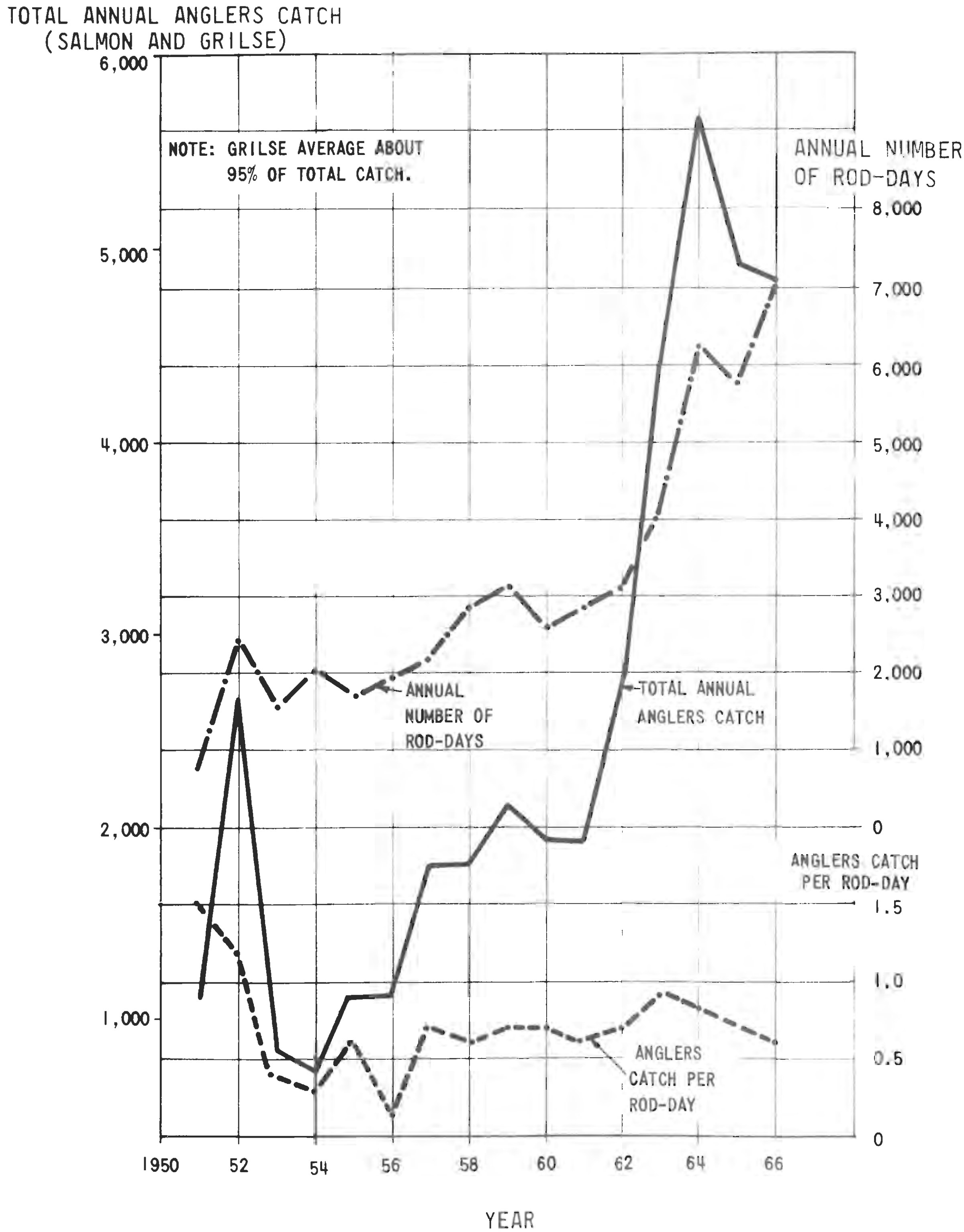
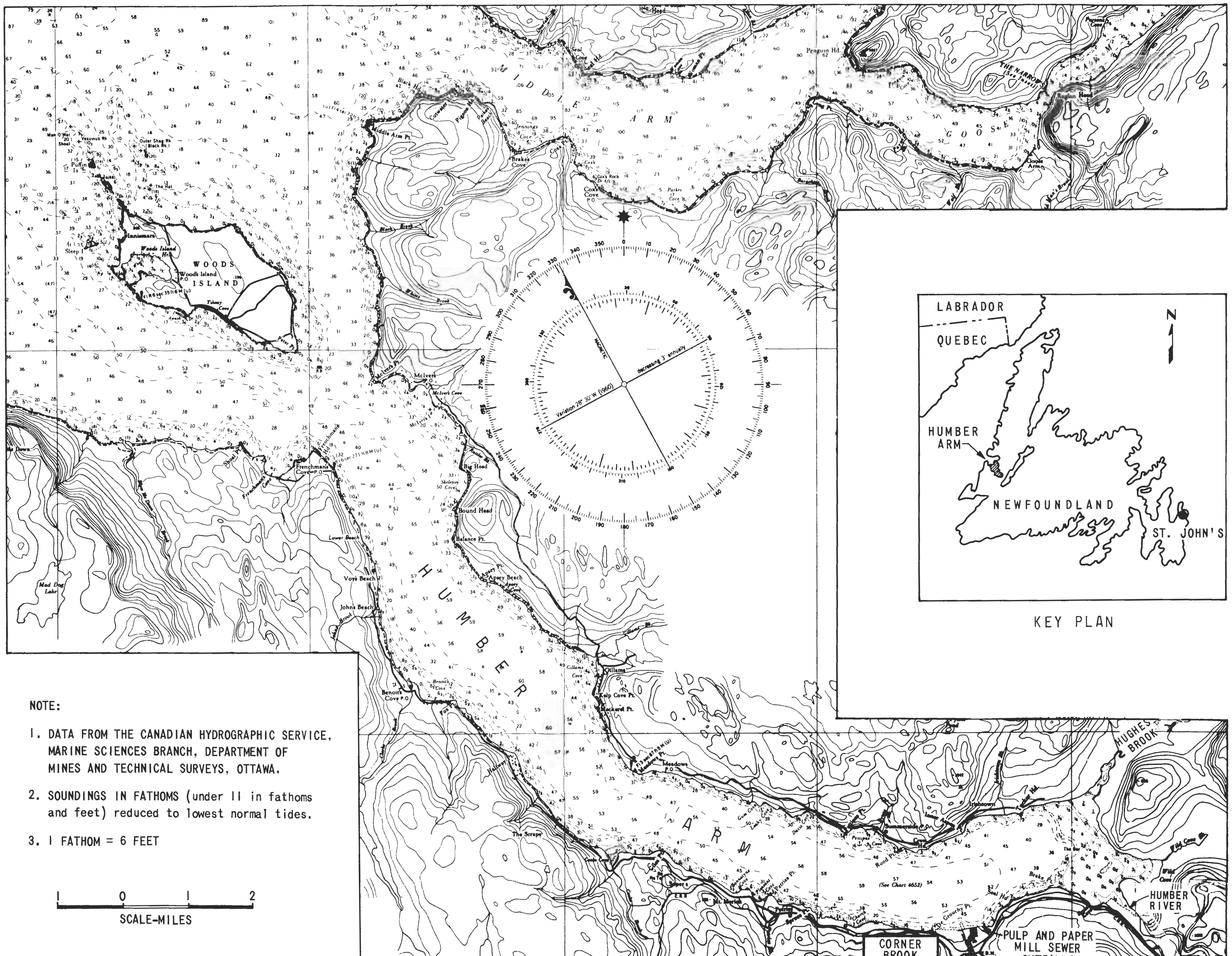


FIGURE 7-2



NOTE:

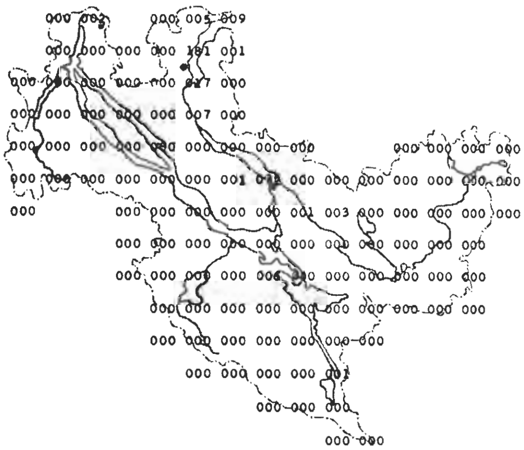
1. DATA FROM THE CANADIAN HYDROGRAPHIC SERVICE, MARINE SCIENCES BRANCH, DEPARTMENT OF MINES AND TECHNICAL SURVEYS, OTTAWA.
2. SOUNDINGS IN FATHOMS (under 11 in fathoms and feet) reduced to lowest normal tides.
3. 1 FATHOM = 6 FEET

HUMBER RIVER BASIN AND
CORNER BROOK-DEER LAKE STUDY AREA

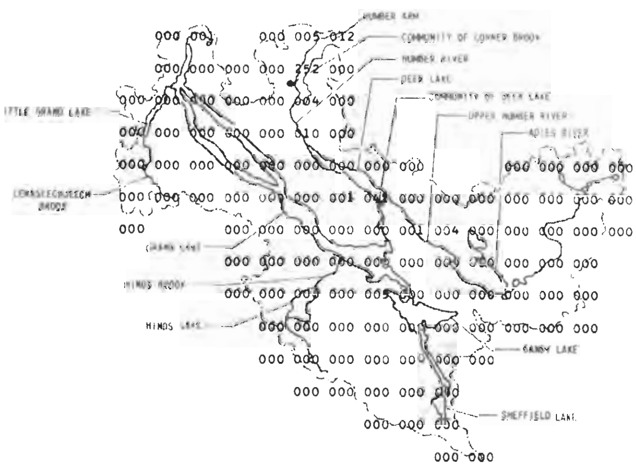
SOUNDINGS IN HUMBER ARM

FIGURE 7-3

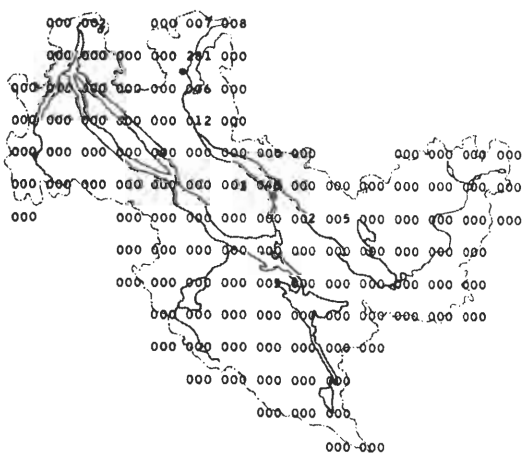
HUMBER RIVER BASIN AND CORNER BROOK-DEER LAKE STUDY AREA
SQUARE GRID DISTRIBUTION OF RECORDED POPULATION 1951-1966



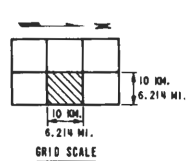
POPULATION 1951 - 100'S

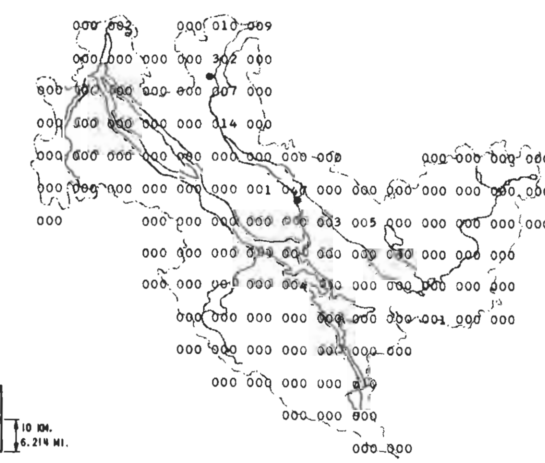


POPULATION 1956 - 100'S



POPULATION 1961 - 100'S

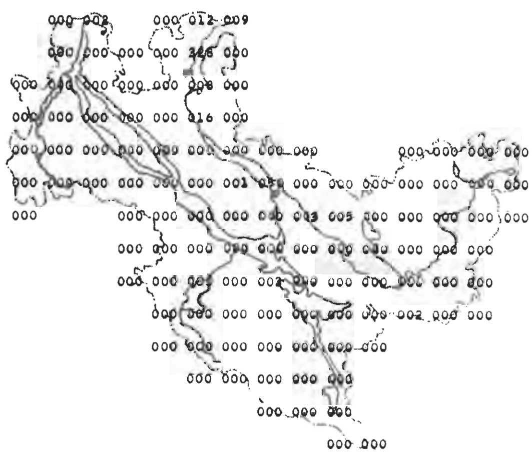




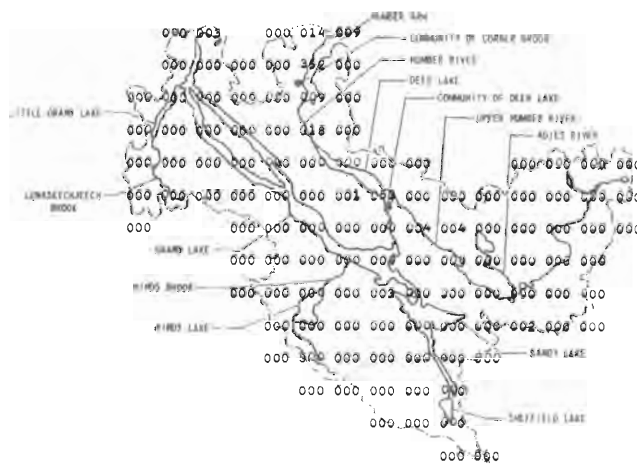
POPULATION 1966 - 100'S

FIGURE 8-1

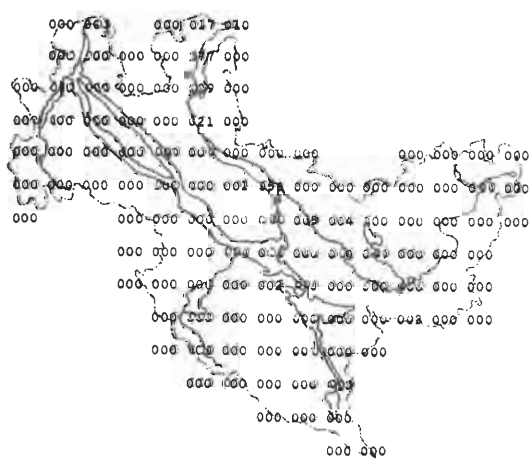
HUMBER RIVER BASIN AND CORNER BROOK-DEER LAKE STUDY AREA
SQUARE GRID DISTRIBUTION OF POPULATION FORECAST 1971 - 1981



POPULATION 1971 - 100'S



POPULATION 1976 - 100'S



POPULATION 1981 - 100'S

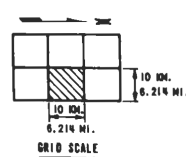


FIGURE 8-2

HUMBER RIVER BASIN AND CORNER BROOK-DEER LAKE STUDY AREA

SUMMARY OF CLIMATIC CHARACTERISTICS

A ANNUAL MEANS

Precipitation (inches)	Air Temperature (deg F)	Potential Evaporation (inches)	Relative Humidity (percent)
56.0	37.7	18.2	85

B MEAN MONTHLY PRECIPITATION (inches)

Station	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Corner Brook	4.93	3.89	3.00	2.56	2.92	3.04	2.87	3.44	3.62	4.09	5.08	4.99	44.43
Deer Lake	2.54	2.59	2.03	2.30	2.95	3.17	3.21	3.71	3.64	3.65	3.67	2.71	36.17
Basin Mean Synthesized	4.8	4.8	3.3	3.3	3.9	4.5	4.8	5.3	5.3	5.2	5.9	5.00	56.0

C MAXIMUM POSSIBLE STORM PRECIPITATION (inches)

Area (sq. mi)	Storm Duration (hours) 6	12	18	24	36	48
100	3.25	4.62	5.85	6.40	7.90	9.30
300	3.00	4.60	5.80	6.30	7.80	9.20
500	3.10	4.50	5.55	6.25	7.70	9.05
1000	2.90	4.35	5.65	6.05	7.55	8.75
3230	2.30	3.80	4.90	5.50	7.05	8.00

D MAXIMUM POSSIBLE SEASONAL SNOWFALL (inches of water equivalent): 41.6

E CRITICAL SEQUENCES FOR SNOW MELTING (degrees F)

Interval	Date: March 1	March 10	March 20	April 1	April 10	April 20	May 1	May 10	May 20
4 - day	48.0	50.0	52.5	55.0	66.5	67.5	69.5	62.5	66.5
8 - day	43.0	45.5	47.5	50.0	51.5	52.5	54.0	56.0	60.5
16 - day	36.0	39.0	41.5	44.5	47.0	49.0	50.5	52.5	55.0

F DROUGHT

Return Period	2.33-Year	5-Year	10-Year	20-Year	50-Year	100-Year
Length of Drought	12 days	14 days	18 days	22 days	25 days	28 days

TABLE 6-1

SUMMARY OF HYDROLOGIC CHARACTERISTICS
HUMBER RIVER BASIN

I - SYNTHESIZED DATA

A. ANNUAL MEANS FOR THE TOTAL BASIN

FLOW (CFS)	RUNOFF (CFS/SQ.MI)	RUNOFF (INCHES)	ACTUAL EVAP. (INCHES)
9,700	3.0	40.8	13.4

B. MEAN MONTHLY FLOWS (Q) AND STANDARD DEVIATIONS (S) (CFS)

RIVER AND LOCATION		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVGE
UPPER HUMBER RIVER AT SEAL POND	Q	1210	1030	1160	2190	11200	6870	1630	1470	1460	2130	2730	1560	2890
	S	830	720	630	1840	3290	2190	1430	1270	1900	1090	1000	1870	435
HUMBER RIVER AT HUMBER ARM	Q	4530	3850	4740	9790	34100	15300	5200	5460	5280	8700	10400	6580	9720
	S	3390	2280	2970	6100	10200	5330	3500	4180	3370	4310	4070	3510	1250
HUMBER RIVER AT GRAND LAKE OUTLET	Q	2670	2210	2640	5520	16600	6380	2730	2820	2820	4350	5660	3780	4940
	S	1840	1300	1670	2770	5150	2770	1460	1920	1740	2110	2320	1720	615

C. MAXIMUM FLOWS (CFS) AND FLOOD VOLUMES (CFS DAY) OBTAINED BY THE MAXIMIZATION PROCEDURE (INSTANTANEOUS PEAKS)

RIVER AND LOCATION	MAXIMIZED RAIN ON SNOW PACK		MAXIMIZED RAIN ONLY		SNOW PACK & AVERAGE RAIN	
	PEAK	VOLUME	PEAK	VOLUME	PEAK	VOLUME
UPPER HUMBER RIVER AT SEAL POND	77,700	580,000	57,500	190,000	31,400	463,000

D. MAXIMUM FLOWS OBTAINED BY STATISTICAL ANALYSIS (CFS) (DAILY AVERAGES)

RIVER AND LOCATION	GENERATED BY SNOW MELT & RAIN		GENERATED BY RAIN ONLY	
	1/10000 YEARS	1/1000 YEARS	1/10000 YEARS	1/1000 YEARS
UPPER HUMBER RIVER AT DEER LAKE	57,400	47,900	40,900	33,400
HUMBER RIVER AT HUMBER ARM	123,000	99,900	75,400	60,400
HUMBER RIVER AT GRAND LAKE OUTLET	61,600	49,600	32,100	25,800

TABLE 6-2

SUMMARY OF HYDROLOGIC CHARACTERISTICS
HUMBER RIVER BASIN

E. MINIMUM FLOWS OBTAINED FROM RECESSION CURVES (CFS)

RIVER AND LOCATION	1/2 YEARS	1/5 YEARS	1/10 YEARS	1/20 YEARS

F. MINIMUM FLOWS OBTAINED FROM STATISTICAL ANALYSIS (CFS)

RIVER AND LOCATION	1/2 YEARS	1/5 YEARS	1/20 YEARS	1/100 YEARS
HUMBER RIVER AT HUMBER ARM	2200	1330	610	
UPPER HUMBER RIVER AT SEAL POND	355	230	130	
HUMBER RIVER AT GRAND LAKE OUTLET	1360	875	460	

G. FULL REGULATION STORAGE

RIVER AND STATION	STORAGE (CUBIC FEET x 10^9)
HUMBER RIVER AT GRAND LAKE OUTLET	176.
UPPER HUMBER RIVER AT SEAL POND	145.
HINDS BROOK NEAR GRAND LAKE	15.

II - RECORDED DATA

H. MEAN MONTHLY AND ANNUAL FLOWS (CFS)

RIVER AND STATION	YEARS OF RECORD	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVGE
HUMBER RIVER AT GRAND LAKE OUTLET	61	3,360	2,950	2,810	6,700	14,600	5,940	3,480	2,890	3,060	4,510	5,940	4,180	5,030
UPPER HUMBER RIVER AT SEAL POND	38	2,730	1,410	1,810	3,680	8,510	5,670	1,860	1,390	1,960	2,900	3,430	2,350	3,140
HINDS BROOK NEAR GRAND LAKE	11	370	205	215	460	1400	925	330	245	290	450	690	590	515

I. EXTREMES RECORDED (CFS)

RIVER AND STATION	MAXIMUM FLOWS			MINIMUM FLOWS		
	FLOW	DATE	COMMENTS	FLOW	DATE	COMMENTS
HUMBER RIVER AT GRAND LAKE OUTLET	-	-	DAILY FLOWS AFFECTED BY POWERHOUSE OPERATION	-	-	-
UPPER HUMBER RIVER AT SEAL POND	28,700 cfs	NOV. 30 1936	DRAINAGE AREA = 812 SQ. MILES	56 cfs	AUG. 31 SEPT. 1 1940	FEB. 1954 TO SEPT. 1966 (CONTINUOUS) PERIOD OF RECORD
SHEFFIELD R. AT SHEFFIELD LAKE	3,300 cfs	MAY 11 1960	DRAINAGE AREA = 140 SQ. MILES	21 cfs	SEPT. 11 1960	PERIOD OF RECORD DEC. 1955 TO SEPT. 1966

HUMBER RIVER BASIN
AND
CORNER BROOK-DEER LAKE STUDY AREA

SUMMARY OF WATER QUALITY EXTRAPOLATIONS

Location	----- Effects of Characteristics on Use for -----								
	Fish			Pulp & Paper			Domestic and Raw Water		
	P	C	B	P	C	B	P	C	B
Mouth of Adies River	+	+	+	+	+	0	+	+	0
Upper Humber River I (upstream of Adies River mouth)	+	+	+	+	+	0	+	+	0
The Main Brook	+	+	-	+	+	0	+	+	+
Grand Lake Power Canal	+	+	-	+	+	0	+	+	+
Upper Humber River II (upstream of Deer Lake)	+	+	0	+	+	0	+	+	0
Mouth of Hinds Brook	+	0	+	+	+	0	+	+	+
Mouth of Lewaseechjeech River	+	0	+	+	+	0	+	+	+
Mouth of Humber River	+	+	0	+	+	0	+	+	0

NOTE

P = Physical Characteristics
C = Chemical Characteristics
B = Biological Characteristics
+, 0, - = Comparative Ratings

See Volume Two for description of Water Quality Extrapolations

TABLE 6-3

HUMBER RIVER BASIN AND CORNER BROOK- DEER LAKE STUDY AREA

GROUNDWATER POTENTIAL

Hydrogeologic Unit	Estimated Yield Range* (gpm)	Percentage of Basin	Area in Basin (sq. mi)	Comments
Bedrock Units:				
R1	0 to 40	48.0	1550	
R2	0.5 to 10	9.0	291	
R4	1 to 20	2.0	65	
R5	1 to 30	9.0	291	
R6	1 to 20	5.0	161	
R7	1 to 30	24.0	775	Quality may be poor
R8	1 to 50	3.0	97	Quality may be poor
Surficial Units: **				
S1 **	0 to 5	18.0	582	
S2	10 to 50	55.5	1790	
S3	5 to 50	5.0	161	
S4	50 to 100	1.5	48	
S5	not relevant	7.0	226	Quality poor
S6	1 to 100	1.0	32	

* 200-foot deep, 6-inch well in bedrock.
12-inch screen and at least 10 feet of water in surficials.

** 12 percent of area is covered by lakes and rivers, therefore total area for surficials is 88 percent.
Bedrock areas include lakes and rivers.

A detailed discussion of hydrogeology is given in Volume Two.

TABLE 6-4

HUMBER RIVER BASIN AND CORNER BROOK-DEER LAKE STUDY AREA

DISTRIBUTION OF FOREST AREA IN BOWATERS TIMBER LIMITS

UNIT NO	DRAINAGE AREA	I - MERCHANTABLE VIRGIN (acres)	BURN (acres)	TOTAL (acres)
4	Bay of Islands	72,790	--	72,790
5	Humber River	101,873	14,355	116,228
6	Grand and Sandy Lakes	154,466	14,056	168,512
		329,129	28,411	357,530

UNIT NO	DRAINAGE AREA	II - UNMERCHANTABLE CUTOVER (acres)	VIRGIN (acres)	BURN (acres)	TOTAL (acres)
4	Bay of Islands	81,636	6,559	4,446	92,641
5	Humber River	205,172	6,080	36,589	247,841
6	Grand and Sandy Lakes	101,720	5,973	20,490	128,183
		388,528	18,612	61,525	468,665

UNIT NO	DRAINAGE AREA	III - WASTE (acres)	IV - DEVELOPED LAND (acres)	*TOTAL I TO IV (acres)
4	Bay of Islands	99,262	1,489	266,182
5	Humber River	247,456	2,952	614,477
6	Grand and Sandy Lakes	304,409	130	601,234
		651,127	4,571	1,481,893

* The timber limits are only a part of the total drainage area.
Source: Bowaters Newfoundland Limited

TABLE 7-1

HUMBER RIVER BASIN AND CORNER BROOK-DEER LAKE STUDY AREA

WATER USING INDUSTRIES

INDUSTRY	LOCATION	NUMBER OF EMPLOYEES	ANNUAL PRODUCTION	APPROXIMATE QUANTITY OF WATER USED (gallons per day)	SOURCE
West Coast Bakery	Curling	26	2.5 million pounds of bread	not metered	Corner Brook City
North Star Cement	Corner Brook	107		275,000	Corner Brook City
Atlantic Gypsum Limited	Corner Brook	141	8695 tons of wallboard and lath	165,000	Corner Brook City
Browning Harvey Limited	Corner Brook	19	395,900 colas and soft drinks		Corner Brook City
Lundrigans Limited	Corner Brook	--	Concrete	200,000 300,000	Corner Brook City Humber River
Bowaters (Nfld) Limited	Corner Brook	1,788*	353,972 tons newsprint 31,079 tons sulphite 24,761 tons specialities 6,282 tons offcuts, etc.	38,000,000 2,000,000	Glynmill Pond Corner Brook City

* excludes wood workers

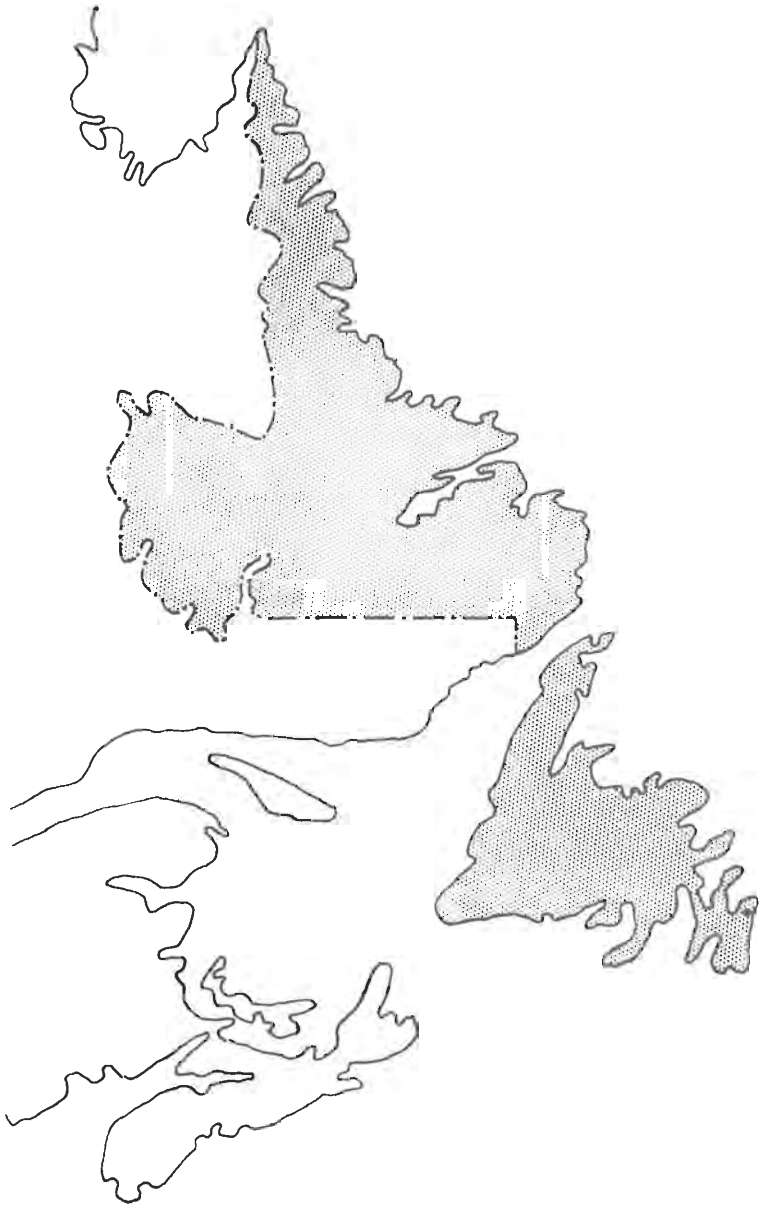
TABLE 7-2

HUMBER RIVER BASIN AND CORNER BROOK-DEER LAKE STUDY AREA

WATER SUPPLY AND DISPOSAL FACILITIES IN SMALL COMMUNITIES

COMMUNITY	MIDLAND-PASADENA	GILLAMS	CORMACK	NICHOLSVILLE	REIDVILLE	STEADY BROOK	LITTLE RAPIDS	HOWLEY
Population	800	225	460	200	220	300	240	500
Number of detached households	125	45	70	30	38	70	40	90
Other water users	1 motel	-	-	-	-	-	1 motel 1 duplex	-
Water Supply System: Percentage using								
Municipal system	0	0	0	0	0	0	0*	66
Individual wells	100	100	85	100	85	100	10	34
Other sources	0	0	15	0	15	0	90	0
Water Disposal: Percentage using -								
Septic tanks	90	20	40	95	30	95	-	50
Municipal system	0	0	0	0	0	0	-	0
Other methods	10	80	60	5	70	5	-	50
Natural water quality	adequate	unsatisfactory	unsatisfactory	adequate	unsatisfactory	unsatisfactory	unsatisfactory	unsatisfactory
Water quantity	adequate	inadequate in dry periods	inadequate in dry periods	adequate	inadequate in dry periods	inadequate in dry periods	adequate	wells inadequate in dry periods

* Plans have been prepared for a water supply system.



PART III

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SOUTH COAST RIVER BASINS AND
BAY D'ESPOIR STUDY AREA

PART III - SOUTH COAST RIVER BASINS AND BAY D'ESPOIR STUDY AREA

INTRODUCTION

The four river basins selected for study on the south coast are the White Bear, Grey, Salmon, and Conne. These basins and the Bay D'Espoir study area have been grouped in this section as a single study region because of their interdependence due to the diversions related to the Bay D'Espoir hydro-electric project. The upper area of the Grey River basin has already been diverted into the Salmon River basin as part of Stage I of the Bay D'Espoir project, and the upper area of the White Bear River basin will be diverted to the upper Grey and thence to the Salmon River basin in the Stage II Development which commenced construction in 1967. Thus, the runoff from part of all three basins will pass through the turbines at the Bay D'Espoir hydro plant.

The Conne River basin was included in this section as it has many features similar to those of the other three basins; its headwaters are adjacent to the Salmon River basin headwaters; and it flows into the sea at Bay D'Espoir as does the flow from the hydro plant. The study area includes the area surrounding Bay D'Espoir, and it contains most of the communities in the study region, including the communities of Harbour Breton and Gaultois which are not presently connected by road with the Bay D'Espoir communities.

10 NATURAL CONDITIONS

In the natural conditions which existed prior to the hydro development in the area, the Salmon, Grey, and White Bear Rivers drained to the south seacoast of the Island. Both the Salmon and Conne Rivers, the latter having remained unaltered in its drainage pattern, drain into Bay D'Espoir.

Figure 10-1 shows the drainage basin and study area outlines. Access roads, lakes, communities, river gauges, and topographic features are also shown on this figure.

The Salmon River is the fourth largest river on the Island and has a natural drainage area of just over 1100 square miles. The Grey River is slightly smaller with an area of just over 1000 square miles. The White Bear River drainage area covers 860 square miles and the Conne River has a much smaller drainage basin of 273 square miles.

Access by road to this area of the south coast from the main population centres on the Island was not possible until 1967, when construction of a gravel highway was completed connecting the existing roads serving the communities in the Bay D'Espoir area to the Trans-Canada Highway near Grand Falls*. The road improved the existing woods roads along the Conne River and provided access to most of the main stem of the river. In addition, the upper reaches of the rivers diverted to the Bay D'Espoir hydro plant are connected to the Red Indian Lake area by a series of Price (Nfld) Pulp and Paper Limited's woods roads and the recently completed Newfoundland and Labrador Power Commission's gravel construction access roads. The major portions of these basins still remain practically inaccessible to all but float equipped air transport, helicopter, or boats. An airstrip capable of handling DC-3 type aircraft was constructed near Long Pond as part of the Bay D'Espoir hydro-electric development.

10.1 Physiographic Conditions

The total natural drainage areas of the White Bear, Grey, Salmon, and Conne Rivers and the areas of lakes, marshes or bogs, forests, and barrens are as follows:

* Approximately one third of the highway was paved in 1968.

		White Bear	Grey	Salmon	Conne
Total Natural Area	(sq. mi)	860	1032	1105	273
Lake Area	(%)	6. 7	11. 4	12. 3	6. 0
	(sq. mi)	58	118	147	16
Bog or Marsh Area	(%)	11. 0	1. 2	2. 3	4. 3
	(sq. mi)	94	13	23	12
Forest Area	(%)	17. 1	12. 5	33. 2	45. 6
	(sq. mi)	147	129	367	125
Barren Area	(%)	65. 2	74. 9	52. 2	44. 1
	(sq. mi)	561	772	568	120

The distribution of lakes, bogs and/or marshes, and barrens in the four basins, according to the 1:250,000 scale maps, is shown on Figure 10-2.

There are several ponds and large lakes in these basins. In the White Bear basin, these include Rocky Ridge, Spruce and Burnt Ponds, White Bear and Granite Lakes. In the Grey basin, Pudops, Meelpaeg, and Ebbegunbaeg are the large lakes. In the Salmon River basin, the large ponds include the Island, Cold Spring, Long, Brazil, and Round ponds, and the lakes include Crooked and Great Burnt lakes. The level of several of these lakes and ponds has been raised in connection with the Bay D'Espoir hydro scheme, which is described in more detail in Section 11. 1. 1. There are no lakes or ponds on the Conne River comparable in size to those mentioned above.

The hypsographic curves of the four basins are shown in Figure 1-4. The curves of the White Bear, Grey, and Salmon basins reflect the steep rise in the topography along the south coast. The hypsographic curve for the Conne River basin is less steep, reflecting the topographic conditions in the area of the river mouth which is located about 20 miles inland from the south coastline. The square grid distribution of land surface slope and elevation in the four basins is shown in Figure 10. 3.

The bedrock of the area consists of Ordovician, Silurian and Devonian sedimentary and metamorphic rock, and some minor areas of volcanic rocks. There are also a number of major igneous intrusions, mainly granitic in composition. Only about a tenth of the area of igneous rocks is occupied by basic and ultrabasic intrusions.

In the coastal areas much of the bedrock is exposed with no significant cover of surficial material. The inland parts of the basin have a cover of ribbed moraine, and there is a zone of ground moraine between the ribbed moraine and the exposed rock at the seacoast. In the basins of the Salmon and Conne Rivers there are some areas of alluvium, and some eskers, also some of the moraines in these two basins have been described as end moraine.

The variation in the mean annual temperature, precipitation, and evaporation in the basins is shown in Figure 10-4. The average basin temperature, precipitation, and evaporation is as follows:

River Basin	Average Temperature (degrees F)	Average Precipitation (inches)	Average Evaporation (inches)
White Bear	37.6	60.6	15.3
Grey	38.0	58.3	14.3
Salmon	38.2	53.5	14.8
Conne	38.6	52.7	14.0

Climatic characteristics of the basins are summarized on Tables 10-1 to 10-4.

10.2 Water Resources and Potential Uses

10.2.1 Surface Water

Four river gauges were established in the basin in previous years. One was located on the White Bear River at White Bear Lake; one on the Grey River at Pudops Lake; and two on the Salmon River at Long Pond and Round Pond. All of these gauges except the one at Round Pond will probably be abandoned due to the Bay D'Espoir project. The Conne River has never been gauged. The hydrologic characteristics of the basins have been derived from these river gauges and the generalized relationships with physiographic and meteorologic factors.

In addition, the river gauge located in the Bay du Nord River at Big Falls was utilized to estimate the hydrologic characteristics of the Conne River basin as the headwaters of these two basins are adjacent. The variations in the mean annual runoff in these four basins are indicated in Figure 10-4. The average annual runoff from the natural drainage areas is listed below for each basin.

River Basin	Runoff	
	cfs/sq. mi	inches
White Bear	3.3	45.2
Grey	3.2	43.9
Salmon	2.9	38.7
Conne	2.9	38.7

Hydrologic characteristics of the basins are summarized in Tables 10-5 to 10-8.

The surface water quality extrapolations to determine the suitability of water on the Island for fisheries, pulp and paper, and raw domestic water supply are discussed in Volume Two. Extrapolations have been made at three locations on the White Bear River, at two locations on the Grey River, at three locations on the Salmon River, and at one location on the Conne River. In addition, three analyses of surface water at Gaultois and one analysis of surface water at Milltown were available. None of these analyses indicated significant variation from the typical Island surface waters; that is high in colour, low in turbidity, low in pH, low in total hardness, and low in total dissolved solids.

Water quality data have been summarized in Table 10-9. As shown at the outlets of the newly-created hydro power storage reservoirs at Long Pond and Meelpaeg Lake, the biological characteristics which affect the use of water for fish are given a "minus" comparative rating. This is because these bodies of standing water will have dissolved oxygen contents of 6ppm or more only in their upper layers. It should be noted that even in their lower layers, these bodies of water will not necessarily be seriously deficient in oxygen and may well be able to support fish life.

10.2.2 Groundwater

The groundwater potential in the basins is summarized on Table 10-10. Most of the communities within the basin are situated along the seacoast which makes it difficult for water supplies to be obtained in shallow wells as there is very little surficial material present. Wells are dug in patches of drift where available, and are excavated into solid rock in other areas. When extended periods of dry weather occur, the supplies from the shallow wells often dry up, and sometimes become contaminated.

The highest yielding surficial unit is S4 (eskers, kames, outwash, beaches, recent alluvium) in the Salmon River basin where it occupies 1 percent of the area, and in Conne River basin and Bay D'Espoir region where it occupies 3.1 percent of the area. More than 50 percent of the total area of the basin is occupied by unit S3 (ribbed moraine) which can provide reasonable supplies as does unit S2 (ground ablation and end moraine) which occupies almost 30 percent of the area. Surficial materials are thin or absent over about 17 percent of the total area. The distribution of the surficial materials on the Island is outlined in Volume Two A.

The areas of the different bedrock hydropetrologic units that occur in these basins are shown in Table 10-10. The unit that occupies the greatest area is R1, major igneous intrusions, which underlies 40 percent of the area. In both the Grey River and Salmon River basins there are intrusions of basic materials which may contain water of poor quality.

The remainder of the area is underlain by Paleozoic rocks of Ordovician to Devonian age, 28 percent of unit R4, 4 percent of R5 and 27 percent of R6. The availability of groundwater should be greatest in unit R5; there is little to choose between the potential of R5 and R6 in this area. No major water quality problems are expected in these units.

10.2.3 Hydro Power

10.2.3.1 White Bear River

As noted earlier, part of the total natural drainage of 860 square miles of the White Bear River is diverted into the Grey River for the Stage II Development of the Bay D'Espoir project, which is to become operational by 1969. This diversion is described in Section 12.1.1.

The area of 456 square miles affected by the diversion is shown in Figure 10-5. The hydro potential remaining in this area after diversion is negligible. Furthermore, the area of 404 square miles, which will continue to drain to the south seacoast, does not appear to have economical hydro potential.

However, there is an undeveloped head of about 120 feet between the Granite Lake diversion canal and the Grey River reservoir. Detailed studies to determine the economics and size of the development have not been carried out by ShawMont Newfoundland Limited. These studies will be influenced by the storage levels finally selected for the Grey Reservoir and the final choice of upstream diverted areas and storages. However, ShawMont has ensured that the location of the structures required to achieve the White Bear to Grey River diversion will not interfere with a future hydro development in this area. Assuming the Lloyds, Victoria, and White Bear Rivers are diverted through the Granite Lake Canal, a continuous horsepower of about 30, 000 will be available at the site.

10. 2. 3. 2 Grey River

The Upper Grey River has already been diverted in connection with Stage I of the Bay D'Espoir project, described in Section 11. 1. 1 and shown in Figure 10-5. There is no residual hydro potential in the 375 square mile area diverted, and hydro development does not appear economically feasible for the remaining 657 square miles which continue to drain to the south seacoast.

10. 2. 3. 3 Salmon River

The Salmon River Basin of 1040 square miles has been almost entirely utilized by the Bay D'Espoir project, and the remaining area of 65 square miles downstream of the diversion is devoid of economic hydro potential. However, in the area upstream of the Long Pond storage reservoir, the hydro potential has been investigated and reported by ShawMont. A description of the remaining hydro potential, concentrated at the Upper Salmon Development, is given in Section 12. 1. 1.

10. 2. 3. 4 Conne River

The Conne River basin, which has not been diverted to the Bay D'Espoir project and which remains in its natural course, does not appear to have economical hydro-electric potential.

The gross hydro power potential along the main stem under natural conditions has been calculated, and the results are shown in Figures 10-6 to 10-9 for the four river basins.

10.2.4 Fresh Water and Anadromous Fish

Information on the fisheries potential of the rivers has been obtained from the Canada Department of Fisheries.

10.2.4.1 White Bear River

The maximum potential of the White Bear River is estimated to be 15,000 to 25,000 Atlantic salmon. Any expansion of the Atlantic salmon resource will depend upon releases of water from upstream storage. The necessary water could come from spill at the diversion dam which is presently under construction (1968) and/or from flow augmentation dams. The problems of low flow created by the diversions are discussed in Section 12.1.2.

10.2.4.2 Grey River

On the Grey River, downstream of the existing Pudops Lake diversion dam, there are about 150 linear miles of river suitable for Atlantic salmon production. It is expected that this drainage below the existing diversion could produce an unexploited stock of 10,000 to 15,000 Atlantic salmon. Any development technique used to increase the Atlantic salmon stock will increase the anadromous brook trout population to a comparable level.

10.2.4.3 Salmon River

The Department of Fisheries has determined that the potential for Atlantic salmon on the Salmon River can be considered negligible. A large percentage of the area upstream of the diversion structures at the outlet of Long Pond on the Salmon River is standing water. The areas upstream of the diversion structures on the Grey and White Bear Rivers also contain similar areas of standing water.

The potential of these areas is not well defined, but some of these lakes and ponds are known to contain large populations of resident brook trout, land locked salmon, and a lesser amount of Arctic char. The Department of Fisheries indicates that improved management for sport fishery is a possibility in these areas and commercial exploitation is another alternative for best use of the fish resources.

10.2.4.4 Conne River

A significant increase in the population of migratory fish in the Conne River is not expected over the present-day escapement of 4000 to 12,000 adult fish as the whole river is presently accessible to the fish. However, if the present stocks are not over-exploited, future populations should increase somewhat beyond present levels due to minor stream improvements by the Department of Fisheries.

10.2.5 Navigation and Log Driving

The navigation potential is limited to small pleasure craft in all the basins and to larger craft in the larger lakes. The log driving potential is a consideration in the Conne River basin because of the presence of suitable forest resources and road access in this basin.

10.3 Natural Resources

Except for the hydro power aspects of the water resources, the resources in the White Bear, Grey, and Salmon River basins have remained undeveloped and today these three basins are virtually unpopulated.

The Conne River has been known for its fishery and forest resources which help to support the population of the study region, concentrated mainly in the Bay D'Espoir area.

10.3.1 Forests

The natural area of forests in the basins, according to the 1:250,000 scale maps, is given in Section 10-1.

Bowaters has timber limits in all the basins except the White Bear. Information from Bowaters indicates there are 237 square miles of merchantable virgin areas within their timber limits in the study region. The timber limits are shown in Figure 1-10.

10.3.2 Minerals

According to the Provincial Department of Mines, Agriculture and Resources[1], there are many occurrences of metallic minerals on the south coast, and several of these are in the study region as shown in Figure 1-2.

In the Bay D'Espoir area, the following metallic occurrences have been recorded:

	Number of Occurrences of Metallic Minerals	
	Significant	Minor
Lead	4	4
Zinc	5	3
Silver	4	3
Copper	3	0
Gold	2	3
Molybdenum	3	1
Bismuth	1	-
Antimony	-	1
Nickel	-	1
Arsenic	-	1

In addition, four significant occurrences of tungsten exist near the mouth of the Grey River. In the interior of the Salmon River basin near Burnt Lake, two significant occurrences of copper and one of chromium are known to exist; and a minor occurrence of lead and zinc is located in this area. In the area north of Round Pond on the Salmon basin, a significant occurrence of the non-metallic mineral asbestos has been recorded.

An occurrence of the non-metallic mineral fluorite is located at Long Harbour near Belle Bay, just east of the south coast study region. The Bay D'Espoir area is considered to be a potential site for a proposed aluminum complex for the Island; however, the value of this occurrence of fluorite, which is used in the aluminum reduction process, is presently undetermined.

10. 3. 3 Wildlife

Moose, caribou, and black bear are found in the region. Fur-bearing land animals common to Newfoundland, such as beaver, red fox, muskrat, otter, and lynx are also known to live in the basins.

10.3.4 Recreation

The potential for recreational development in the study region has been greatly enhanced by the recent road access facilities provided by the development of the hydro resources. The extensive network of lakes and streams which are now interconnected by the diversion structures with their fishing and water sport potential are important assets to the region's future tourist industry.

It should be mentioned that one of the features of the Bay D'Espoir area is its magnificent scenery. A long narrow fjord extends about 30 miles from the coastline to the head of Bay D'Espoir cutting through the rugged forest and rock-covered land which rises steeply out of the water.

10.3.5 Agriculture

At present, there are no farms located in the region, and the potential of the region for agriculture is low since very little of the land is suitable for cultivation.

10.3.6 Industrial Development Sites

Any potential industrial or community development in the Bay D'Espoir area will have to utilize the existing land carefully because of the general scarcity of suitable industrial land in the immediate area. There are only two areas which lend themselves to economical urban development. Reference 2 indicates land areas suitable for residential, commercial, and industrial use.

11 PRESENT DAY DEVELOPMENT

11.1 Non-Withdrawal Water Demand and Supply

The main non-withdrawal use in the study region is for hydro-electric energy production which is presently concentrated at the Bay D'Espoir plant. The other natural resources of the basins in the region have had insignificant development to date, and the major activity has been concentrated in the forest and fishery resources of the Conne River.

11.1.1 Hydro Power Development

The Bay D'Espoir Power Development, Stage I, utilizes the flow of the Salmon and Grey Rivers. A dam across the Salmon River at the southern end of Long Pond and a dam at a low spot on the northern end raised the level of Long Pond by 90 feet to lead the flow to the power canal. A storage reservoir is provided by the raising of Long Pond and the power plant draws water as required through the 8,000-foot power canal to the intakes. Two intakes, each with a control gate, feed the water into two steel pressure conduits, each about 3800 feet long. The conduits are provided with individual surge tanks and bifurcations at the powerhouse to supply the existing three units, and the future fourth unit which is due to be commissioned in late September of 1968.

The 371-foot high surge tanks are the highest of this type built to date. A tailrace channel was excavated in Northwest Brook from the plant to connect to the head of Bay D'Espoir.

In Stage I of the Bay D'Espoir Development, the 1040 square mile drainage area regulated by the control structures in the Salmon Basin was augmented by the diversion of 375 square miles of the Grey River. The diversion structures consist of a dam located at the outlet of Pudops Lake and a diversion canal with a control structure connecting Ebbegunbaeg Lake to the Salmon River basin. The reservoir created raised the levels of Ebbegunbaeg, Pudops, and Meelpaeg Lakes; and will supply a storage volume of at least 40 billion cubic feet. The firm flow from the two areas has been estimated to be 3500 cfs, and the average flow available to be 3785 cfs[3]. Total energy generated will be 1350 x 10^6 kwh/year, and the firm energy will be 1250 x 10^6 kwh/year.

Very little of the standing timber was cleared in the reservoir areas created by the Stage I of the hydro development because of the extra cost. The shoreline along the power canal and an area on the south end of the reservoir were cleared. The latter area was cleared to permit recreational use of the reservoir by the local population.

Construction of Stage I of the Bay D'Espoir Development was completed in 1967. The installation of three units of 100, 000 hp each made the plant the largest on the Island. Stage II of the development, which is under construction, is discussed in Section 12. 1. 1.

Effects of the Bay D'Espoir Development on other resources is discussed in Section 11. 3 under Present Day Water Resource Problems.

11. 1. 2 Fisheries

11. 1. 2. 1 Sports Fisheries

A summary of the available data on the Atlantic salmon catch in the study region supplied by the Resource Development Branch of the Department of Fisheries is given below:

River	Period of Record	Average Annual No. Fish Caught	Average Annual No. Rod-Days	Average Annual Catch/Rod-Day
White Bear	1952-66	59	85	0. 69
Grey	1951-66	152	60	2. 50
Salmon	1965-66	3	19	0. 16
Conne	1952-66	588	568	1. 04

As can be seen, the Conne River is the most popular sport fishing river and records the highest catch of Atlantic salmon of the four rivers in the study region.

The angling statistics for the Salmon River indicate a low level of activity in the river. Counting traps were installed by the Department of Fisheries in 1949 and were operated for three years. An average of 23 fish were counted in a 60-day period of which four were salmon and the remainder grilse.

Due to the insignificant size of the salmon run prior to the Bay D'Espoir diversion, no provisions were made to protect the existing resource. The fifteen to twenty miles of the river downstream from the diversion structures contain only a very small runoff from the 65 square mile drainage area. Consequently, present day salmon activity is even less than before the hydro development.

The White Bear and Grey Rivers have enjoyed a relatively more abundant salmon fishery than the Salmon River and they have not contributed as much of their runoff to the hydro development. A total of 657 square miles of the drainage area and 40 miles of the main stem remain on the Grey River; and 404 square miles of drainage area and over 22 miles of the main stem remain on the White Bear River. Consequently, although the Grey and White Bear are not considered to be good angling rivers, they can still support a salmon fishery.

In the White Bear River, the best fishing pools are found within the first three miles of the river mouth. The present total run size is estimated to be 1000 to 1500 salmon or a total production of 2000 to 3000 fish. The removal of several natural obstacles in the main river and tributary streams could increase the run size. The possibilities of increasing the run and the future problems to the Atlantic salmon run created by the upstream diversions are discussed in Section 12. 1. 2.

In the Grey River, nets were permitted before 1929, and it is thought the river was then overfished. Since that time, the run has reestablished itself, and it is estimated to be about 2000 to 3000 salmon. The best salmon fishing areas are located in the lower reaches of the river within two miles of the river mouth. A very substantial natural obstruction exists at Smokey Falls on the main river which is about 60 feet high and is located 12 miles from the mouth. Because of the diversion dam on the main river for the Bay D'Espoir Stage I development, it is considered unlikely that a by-pass at the falls could be justified. Increasing future low flows in dry periods by releasing water from the reservoir upstream of the diversion dam is discussed in Section 11. 3.

The Conne is known as a good, early run Atlantic salmon river, and is reported to have good fishing areas in the entire watershed. In most years, well over 500 fish are angled before July 1 and the river usually ranks in the top ten on the Island for the total number of fish landed. The present run size is estimated to be 2000 to 6000 salmon.

The Department of Fisheries established concrete baffles in 1963 to remove obstructions to the salmon in a major tributary of the Conne River. In addition, obstructions created by old logging dams on the main river and tributaries were removed. In all, the costs amounted to about $15,000. The Department of Fisheries has also conducted biological and engineering surveys of the river.

The increased activity in the area during the construction years of Stage I of the Bay D'Espoir project resulted in an appreciable increase in the number of anglers using the Conne River. As an example, the long term average number of rod-days per year is 566; but during 1964 to 1966, the figure averaged 1250 rod-days per year. The average anglers' catch is shown in Figure 11-1 for the 1952-66 period.

In addition to Atlantic salmon, all four basins contain a species of American eel, eastern brook trout, and ouananiche. In 1965 two large lakes, Granite Lake and Long Pond, were sampled by the Department of Fisheries using gill nets. In each lake, the number of ouananiche caught outnumbered the resident brook trout by ten to one, and the sampling amounted to well over 1000 fish in each case. Large populations of ouananiche are believed to exist in every pond in the basins; and it is, therefore, thought that the ouananiche populations could sustain more intensive sport fishing in all sections of the study region.

11.1.2.2 Commercial Fisheries

There are no data available on commercial fishing in the estuaries of the four river basins. In the offshore fishing, bounded by Statistic Districts J-36 and J-37, from Burgeo to Pass Island, the following quantitative data are available:

Period	Species	Average Weight (lbs per year)	Average Value ($ per year)
1957-1966	Atlantic salmon	64,620	24,955
1959-1966	Squid	305,918	5,320
1956-1966	Capelin	176,042	1,041
1958-1966	Herring	313,222	6,951
1959-1966	Lobster	12,674	4,470

About 76 percent of the salmon is caught in the area from Francois to Pass Island.

Participation in the more important fisheries in the area is indicated below:

	Number of Fishermen	
Species	1962	1966
Cod	251	215
Lobster	55	98
Salmon	53	86
	267 *	227 *

* more than one species fished.

11.1.3 Log Driving

Log driving is not practiced in the basins at the present time and most of the logging dams which were utilized on the Conne River to supplement low flows have been removed to permit access of anadromous fish to the entire basin.

Access problems have been the main reason that the forest resources of the other basins have not been exploited. Consequently, the White Bear, Grey, and Salmon rivers have not been used for log driving.

11. 1. 4 Recreation, Tourism, and Wildlife

Prior to the completion of construction roads to the basin in the 1966-67 period access was difficult and there was virtually no development for tourism.

Utilization of the basins for recreation is now increasing slowly, but is extremely limited because of the competition from park areas closer to large Island and Mainland population centres.

The White Bear, Grey and Salmon basins are partly included in a "Wilderness Area" (Figure 10-1) which has been established by Provincial authorities to prevent indiscriminate habitat destruction.

Big game hunters are attracted to the study region, and approximately 220 hunters spent a total of about $70,000 in 1967. Data on the number of big game animals killed are not available on a basin distribution. The four basins are included in two of the 1967 caribou hunting areas and two of the moose and bear hunting areas designated by the Wildlife Service of the Provincial Department of Mines, Agriculture and Resources.

11. 2 Withdrawal Water Demand and Supply

11. 2. 1 Population and Municipal Water Supply and Waste Disposal

Present day withdrawal uses are limited to domestic water supply as there is no industry in the study area, except for the freezing and fishmeal plants in Gaultois and Harbour Breton. The population consists of eight small communities centered in the Bay D'Espoir area and the communities of Harbour Breton and Gaultois on the south coast. There is no permanent habitation in the river basins except for the Grey Basin where it is confined to the community of Grey River at the river mouth. The population growth in these communities is outlined as follows:

POPULATIONS

Community	1951	1956	1961	1966
St. Albans	1,079	1,334	1,547	1,715
Milltown	304	349	438	560
Head Bay D'Espoir	259	344	534	519
Conne River	148	151	319	366
St. Joseph's	111	105	138	298
Morrisville	122	166	180	211
St. Veronica's	87	91	121	161
Swanger Cove	-	-	-	55
Total Bay D'Espoir	2,110	2,540	3,277	3,890
Harbour Breton	903	989	1,076	1,442
Gaultois	252	403	497	594
Population Outside Communities	745	788	470	524
Total Study Area	4,010	4,720	5,320	6,650
Grey River	157	167	208	227
Total Region	4,167	4,897	5,528	6,877

Population distribution for the years 1951 to 1966 is shown in Figure 11-2.

In 1966 the degree of urbanization, was approximately 46 percent compared to the Provincial average of 54 percent. An urban area is defined as a community with a population of 1000 people or more.

In 1965 the per capita disposable income was approximately $900 compared to the Provincial average of $1100 . This figure reflects the relatively low level of economic development in the area.

Six of the eight communities in the Bay D'Espoir area were visited by Shawinigan - MacLaren team during the 1967 field survey to obtain data on water supply and disposal facilities. Results of the survey indicate that over 20 percent of the domestic water supply in these communities is obtained from a nearby brook which has been dammed to provide a storage reservoir. A gravity-feed line is connected to the houses in the community. Most of the communities average between 30 and 70 houses, except for St. Albans which is a community of some 300 houses. About 80 percent of the houses in the region, including the entire community of St. Albans, are supplied by dug wells. The water quality varies with season and some sources are inadequate during dry periods. Most of the houses in the Bay D'Espoir area have an individual sewer system with an outfall to the sea, approximately 30 percent have individual septic tanks. This haphazard disposal method has created a minor local problem in the barasway at St. Albans where a bad odour occurs at certain times.

The town of Harbour Breton is an incorporated municipality which had a population of 1442 in 1966. There are about 250 houses in the community, and they are built on land rising steeply from the sea. The town has a fish processing plant operated by B. C. Packers Limited[4]. Electrical power is supplied to the town by a diesel generating plant, and the town has a cottage hospital.

The fish plant uses fresh and salt water in their processing and it is anticipated that, as the harbour water becomes further polluted with sewage wastes, the salt water will not be of sufficient quality to meet the industrial requirements.

The fresh water supply for the town is obtained from the community system which went into operation in 1966. The water supply system was designed for a flow of 2.88 million gallons per day which is adequate for the expected future community and industrial needs. Several sources of water were available to the town and Connaigre Pond was chosen as the initial source, other ponds in the area can be utilized as the demand grows. The water has been chlorinated to ensure adequate quality.

Topographic conditions made provision of a sewer system for the entire town difficult and, as a result, only about 190 houses are connected to the community system, about 60 houses have private outfalls.

The community of Gaultois, incorporated in 1962, had a 1966 population of 594 and is located on Long Island in Hermitage Bay on the south coast (Figure 10-1). There are no roads in the community and consequently no automobiles, tractors, or self-propelled vehicles. There are three other small communities on Long Island, none of which has over 100 inhabitants.

A report on the water supply for the fish processing plant at Gaultois[5] indicates that salt and fresh water is presently used in the processing operations. Salt water is presently pumped from the adjacent Gaultois Harbour, a heavily contaminated source. Fresh water is obtained from a 4 inch gravity supply line from Cluett's Pond which is also contaminated. The chief source of contamination is the half-dozen buildings on the shore of Cluett's Pond. There is no sewage system in the community and sewage reaches the Pond from these buildings. Both salt and fresh water supplies are chlorinated although simple chlorination is considered to be inadequate treatment[5].

The report recommended that Cluett's Pond be selected as the source of supply and that a treatment plant be constructed incorporating coagulation, clarification, filtration and chlorination facilities. In addition, other recommendations included the installation of a water distribution and sewage collection system to serve the buildings on the catchment area and that no further building be permitted in the Cluett's Pond catchment. The total capital cost of the water distribution and sewage collections systems has been estimated at $570,000.

11.2.2 Forestry

The Bowaters Newfoundland Company has timber limits in the region. They are shown in Figure 1-10 and are listed as follows:

Basin	Primary Inventory Units	Total Area of Timber Limits (Acres)	Total Area Merchantable (Acres)
White Bear	29	4,800	Nil
Grey	28	278,000	28,400
Salmon and Conne	27	728,000	123,000

The only basin which has had any significant exploitation of the forest resource is the Conne River basin. Several small sawmills of limited capacity have developed in the Bay D'Espoir area to satisfy local needs. In the past pulpwood was shipped by boat to Corner Brook from this area. Today, the activity in the basin has substantially decreased, and several of the timber crib dams have been demolished to provide access for anadromous fish.

11.3 Present Day Water Resource Problems

The main water resource problems in the region today were created by the recent hydro development as it resulted in a conflict in use of the resource by fisheries. The rivers affected by the Stage I Development are the Salmon, Grey and possibly the Conne. The problems created by the Stage II diversion, which is presently under construction, affect the White Bear River and are discussed in Section 12.1.2.

The increased flow into Bay D'Espoir from the hydro plant may have a detrimental effect upon the existing Atlantic salmon run in the Conne River by attracting its migrants into the head of Bay D'Espoir and thence into the plant tailrace. Observations in 1967 indicate that this did not occur in that year, when the plant outflow was at about 50 percent of its expected future level. This problem will be closely watched by the Department of Fisheries.

An agreement has recently been reached between the Department of Fisheries and the Newfoundland and Labrador Power Commission to provide adequate flow during dry periods in the Grey River to support the existing stocks of Atlantic salmon and brook trout. This agreement is to maintain a flow of at least 600 cfs at the confluence of Salmon Brook, approximately six miles from tidewater, by the release of up to 400 cfs from storage. A gauge station is to be established for flow measurement near the lower end of the river to ensure adherence to the discharge agreement.

The agreement provides for a maintenance of a flow in the river greater than that which would be available under natural conditions. It is important that measurements be taken which will enable a re-creation of the natural dry period flow conditions in the river. Thus, the volume of flow provided above that which would have occurred under natural conditions can be determined and the resulting loss of energy at Bay D'Espoir calculated.

Information provided by ShawMont Newfoundland Limited indicates that average monthly flow may be below 600 cfs at Salmon Brook about one month in every two to three years and below 200 cfs one year in sixteen. The value of spilled water is approximately $60,000 per month at a rate of 400 cfs.

The individual dwellings in small communities in the basin generally have a problem in obtaining fresh water of adequate quantity and quality. As is typical of small Island communities, a potentially hazardous situation exists when the supply source is located near the wastewater disposal system.

A problem facing the region today is that of exploiting the recent developments and the natural resources in order to attract industry. It is probable that the lack of an overland access route to this area has been one of the main factors in keeping the Bay D'Espoir area in an undeveloped state. The new roads to the region will facilitate the development of the mineral, forest, and recreational resources in the area. The area has been designated as a national harbour and it is expected that the National Harbours Board will eventually construct new harbour facilities in the bay.

12 PLANNED AND FORECAST DEVELOPMENT

12. 1 Non-withdrawal Uses

12. 1. 1 Hydro Power Development

As mentioned in Section 10. 2. 3, ShawMont Newfoundland Limited investigated the hydro potential still available in the Salmon basin after the Bay D'Espoir development. The results of the Upper Salmon development were reported by ShawMont[6, 7]. A general plan of the development is shown on Figure 12- 1.

Some of the findings of the report are summarized as follows:

a) When constructed, the Upper Salmon will utilize the flow of four major diversions in addition to the flow of the Upper Salmon watershed. The total drainage area of 1837 square miles is made up as follows:

Upper Salmon River (comprised of North and West Salmon Rivers)	355 sq. mi
Grey River	375
White Bear River	515 *
Victoria Lake	408
Upper Lloyds River	184
	1837 sq. mi

The long-term average flow would be approximately 2. 90 cfs/ square mile or 5330 cfs.

b) The development would divert the North Salmon River into Cold Spring Pond by means of a dam at the outlet of Great Burnt Lake and a canal across the height of land. A spillway is provided at the Great Burnt Lake outlet. The power

* The White Bear diversion has since been reduced by 59 square miles which will reduce the total area of the Upper Salmon Development by approximately 3 percent.

development would consist of a dam on the West Salmon River and a power canal along the north bank of the river leading to a power station on the west shoreline of Godaleich Pond.

c) The maximum gross head of the development would be 181 feet, corresponding to Cold Spring Pond at FSL 817 and Godaleich Pond at elevation 636. The average net head at rated flow (6000 cfs) would be 174 feet. The installed capacity of 80 Mw was selected based on an 80 percent capacity factor.

d) A dominant physical feature of the Upper Salmon Development is the three-mile long power canal, the design of which is governed by winter ice conditions.

e) The total project cost, based on 1966 prices and including transmission lines, was estimated at $32, 670, 000.

f) The cost of energy delivered to the Bay D'Espoir substations was estimated to be 4.9 mills. The total average annual energy at the Bay D'Espoir substation provided by the Upper Salmon Development was estimated to be 544 x 10^6 kwh.

g) The cost of capacity at the Upper Salmon Development is high because of the long power canal and relatively low head.

h) The development would provide a reserve storage of 6 bcf to the Bay D'Espoir system.

i) Construction of the Upper Salmon Development would require a total of three years.

As mentioned in Section 10.2.3, part of the natural drainage area of the White Bear River is diverted into the Grey River as part of the Stage II of the Bay D'Espoir project. The Stage II diversions and power development extensions for the Bay D'Espoir development have been investigated by ShawMont and described in Report No. SM-4-67. A description of the White Bear Diversion is given below.

The location of the structures and map of the drainage area is shown in Figure 10-5. As shown, the headwaters of the White Bear watershed are located south and east of Victoria Lake. The White Bear River is split into two branches: Burnt Pond River which is immediately south of Victoria Lake and flows from Burnt Pond; and Granite Lake Brook, which flows from Granite Lake. Below the confluence of these two streams, the White Bear River flows due south to empty into White

Bear Bay which is about 12 miles west of the mouth of the Grey River and 65 miles west of Bay D'Espoir. The diversion of these two streams will result in the runoff ultimately flowing into the sea at Bay D'Espoir.

The White Bear diversion of 456 square miles serves to direct the headwaters of the White Bear River - Burnt Pond River on the north and Granite Lake Brook on the east - into the Grey Reservoir. In addition, its structures conduct the water from the upstream diversions of Victoria and Lloyds Rivers into the same reservoir. These last two diversions and the power development extensions of the Stage II project are described in Volume Four, Section 1.

To achieve the diversion of the White Bear River, a Sidehill canal will be used to conduct the water southward and eastward to Granite Lake. The Sidehill Canal will consist of three contiguous structures: Burnt Pond dam, the Sidehill Canal dyke and Granite Lake Brook dam. These structures are presently (1968) under construction. From Granite Lake the water will be conducted into the Grey reservoir via a canal cut through the height of land. Spillways will be provided at the Burnt Pond dam and on Granite Lake. Construction is expected to be completed by December 1969.

12. 1. 2 Fisheries

Information of future fisheries developments has been obtained from the Department of Fisheries.

12. 1. 2. 1 White Bear River

The potential total Atlantic salmon population of the White Bear River could be increased by four to six times if several natural obstacles in the main river were removed. However, the diversion of the upper drainage area will probably limit any increase in the present level of the fisheries resource as additional costly storage releases would be required.

The amount and method of providing compensation or make-up water which will permit Atlantic salmon to overcome lower obstacles and reach their customary spawning beds in the tributary streams of the White Bear River has been reported in a study by ShawMont[8]. The study concluded that:

a) Compensation water would be required in 16 years out of 17 years of record.

b) It is possible but expensive to provide compensation water for the Atlantic salmon.

c) The cheapest source of water is a storage dam at the outlet of White Bear Lake.

d) The most practical way of providing water would be through the Burnt Pond spillway (part of Bay D'Espoir - Stage II diversion structures) since no additional capital outlay is required and gate operation may be accomplished by remote control. It should be noted that if the compensation water is provided through the Burnt Pond spillway, it represents a loss of revenue at the Bay D'Espoir hydro plant corresponding to a capital investment of $900, 000.

The calculation for the compensation flow required was based on synthesized flow data from upstream areas which did not take into account the proportionately larger average runoff available from the drainage area downstream of the diversions, as shown on the runoff map prepared for the present study. However, the flows from the downstream area would tend to be equal to the synthesized flows during dry periods and, therefore, the loss of revenue cited can be considered as only slightly conservative.

One of the recommendations of the ShawMont report is that a recording gauge be installed immediately at the mouth of the White Bear River. In view of the loss of revenue if compensation flows are supplied downstream of the diversion area, it is considered that this recommendation should be implemented as soon as possible as it may result in a reduction of the compensation water requirements and the loss of hydro-electric revenue.

12. 1. 2. 2 Grey River

The potential Atlantic salmon population in the Grey River can be increased by two to four times its present 2500 to 5000 population if it is feasible to remedy the situation at Smokey Falls. Such remedial work is improbable as it requires compensation flows greater than that already provided to sustain the present population.

12.1.2.3 Salmon River

The future Atlantic salmon run in the Salmon River will virtually be eliminated for the reasons outlined in Section 11.1.2.

12.1.2.4 Conne River

The trend to increased angling on the Conne River, which started during the construction of the Bay D'Espoir project, is expected to continue because of the new access roads to the basin.

The present Conne River Atlantic salmon run of 2000 to 6000 could be increased slightly if minor remedial work was carried out to remove lesser obstructions, and if the existing run was protected and not adversely affected by the large fresh water flow from Bay D'Espoir.

There are several large lakes or ponds in the White Bear, Grey, and Salmon basins which will be raised in connection with Stages I and II of the Bay D'Espoir scheme. These are listed below:

Basin	Lake or Pond	Approximate Max. Level Rise	Expected Max. Water Level Variation
White Bear**	Burnt Pond	4 feet	1 foot
	Granite Lake	12 feet	10 feet
Grey*	Pudops Lake	33 feet	16 feet
	Meelpaeg Lake	30 feet	16 feet
	Ebbegunbaeg Lake	25 feet	16 feet
Salmon*	Long Pond	90 feet	25 feet
	Brazil Pond	40 feet	25 feet

* Stage I Development (completed in 1967)
** Stage II Development (scheduled to be completed in 1969).

At present these lakes carry substantial populations of desirable angling species including ouananiche or land locked salmon, and speckled trout which are potentially the basis for a significant recreational fishery. It is expected that, with the new access roads in the upper basin areas and the interconnection of these lakes via the diversion canals, the area will receive increased exploitation by sports fishermen. In addition, after the lakes have had a few years to mature biologically, the lakes unit of the Canada Department of Fisheries plans to investigate these waters to determine if additional species, such as lake trout, can be successfully introduced. The development of these large lakes to increase fish production could provide excellent tourist attraction to the area and possibly commercial benefits as well.

12. 1. 3 Log Driving

It is expected that log driving will be confined to the Conne River in the future as the other basins in the study region have a relatively low quality and density of forests and poor access facilities. Due to the expected increase in the Atlantic salmon angler pressure in the Conne River, the Department of Fisheries will be concerned with any plans to re-instate log driving on the river and with erosion problems which may occur should Bowaters reactivate forest operations.

12. 1. 4 Recreation, Tourism, and Wildlife

Recreation and tourism development in the basins will benefit from the access roads required for the construction of the various dams and canals of the Bay D'Espoir hydro development. As shown on Figure 10-5, a series of lakes starting outside the study basins at Victoria Lake will be completely connected in 1969 by diversion canals and natural rivers to the power plant near St. Albans. The total length of interconnected waterways, which join the Victoria, White Bear, Grey, and Salmon river basins, exceeds 120 miles. Access to this new waterway by small pleasure craft will be possible and could provide visitors with excellent fishing and camping areas. A major portage will be required between Granite Lake and Pudops Lake due to the head difference between the two areas which creates high velocities in the diversion canal and turbulence downstream of the canal outlet. In addition, parts of the Salmon basin may require portages in the main river sections.

Parks which are kept uncommercialized and permit small craft access to wilderness areas are becoming increasingly popular in other areas of North America. It is expected that the development of such a park in these wilderness basins, which requires a minimum of facilities, would prove to be an excellent tourist attraction for visitors who wish to enjoy nature in relative privacy.

It must be recognized, however, that development of a significant tourist trade in this area will likely be hindered or at least delayed by competition from other recreation areas located both inside and outside the Province. Many of these have similar attractions for tourists, and are more accessible to large population centres. As an example, on the Island, there are numerous freshwater lakes of varying sizes, some with sand beaches, and all with good fishing resources, located within easy access of the Trans-Canada Highway, and which are presently virtually unused by visiting tourists or local people. In addition, numerous park areas on the mainland, which are competing for the tourist dollar, have more attractive climatic conditions for summer vacationers than the Island can offer. These areas will undoubtedly be developed for tourism first, while the study region develops its tourist trade at a much slower rate because of difficulties of access.

Consequently, the decision to leave most of the timber standing in the reservoirs constructed in 1967, made on the basis of economics with the consideration that uses of the reservoirs for recreation would be rather limited for many years, is difficult to challenge. It must be kept in mind that if recreational pressures are sufficient to warrant the expense, the reservoirs in the Grey and Salmon Rivers could be cleared at low supply levels during winter periods by drawing down the reservoirs specifically for this purpose.

The situation is similar for the White Bear reservoirs in that the economics of future uses will determine whether the reservoirs are to be cleared during the construction period. It seems unlikely that they will be cleared since the areas are more isolated and the clearing costs doubtlessly higher than the Stage I reservoirs. However, the standing timber situation with regard to the White Bear reservoirs is less critical. The existing levels will only be raised by an average of two to six feet for Burnt Pond and Granite Lake respectively and the timber stands are less dense in these areas. The only part of the reservoirs which will contain significant standing timber are the shorelines between the dam sites and the existing lakes. For the Burnt Pond reservoir, this represents a reservoir edge area about 7 miles long, and for Granite Lake, a reservoir edge area about 16 miles long. In both cases, part of the future shoreline area does not have standing timber.

The development of one aspect of the basins' water resources, hydro-electric power, will have a direct influence on the wildlife of the area. The road access to the basin area, resulting from the construction of the hydro and diversion facilities, will enable local hunters who would normally not frequent the area to utilize the big game resource. The total number of big game hunters on the Island has increased from about 8000 to 13,000 in the 1957 to 1967 period. Future increases may be expected, especially in this newly opened-up area. Under proper wildlife management, the new access facilities need not adversely affect the wildlife resource and, with an increase in the number of hunters, overbrowsing the range may be prevented.

12.2 Withdrawal Uses

Future withdrawal uses will depend on the development of the mining and industrial activity in the area.

12.2.1 Mining

The several occurrences of metallic minerals in the study region were outlined in Section 10.3.2. Although there are no producing mines in the study region at present, the location of these significant occurrences are encouraging. Access to many of them has been made available by the recent road construction, which enhances the possibility of exploitation of the mineral resources in the area.

Future mining developments will not be inhibited by a lack of good quality water. However, any future producing mines would have to consider control of pollution as one of their liabilities if fishery stocks are to be protected.

12.2.2 Water Uses for Manufacturing

The regulated flow of over 6000 cfs will pass from the Bay D'Espoir tailrace in the enlarged Northwest Brook channel to the salt water of Bay D'Espoir, a distance of two miles. The combination of a large, good quality fresh water supply, a dependable source of electric energy, an ice-free harbour, and road access presents significant attractions to new industry.

The area was designated as a national harbour, which means that the National Harbours Board may construct new harbour facilities in the Bay if the demand warrants the expenditure. This is presently under investigation and a report is to be prepared shortly. An important climatic factor is that fog occurs about 25 percent of the time, and radar devices would eventually be required in the future harbour[9]. The Bay has the advantage of a sheltered location which results in calm waters. Waves are limited to about 3 feet by the short fetch, and the maximum tidal variation in level is about 8 feet. There are dangerous currents and the Bay has sufficient depth to accommodate ocean ships[9].

12.2.3 Population, Municipal Water Supply, and Waste Disposal

Based on past trends, the population of this study area is projected to grow steadily over the forecast period.

	Population Projections		
	1971	1976	1981
Study Area	7,730	8,890	9,980
Study Region	8,060	9,270	10,410

The estimated age structure of the populations for the forecast years was not available but, by applying Provincial data, an estimation may be made of the size of the labour force age group and the possible size of the labour force.

	1971	1976	1981
Labour Force Age Group	3,790	4,180	4,690
Labour Force	1,740	2,050	2,395

One major development may take place in the basin which would radically change the structure of the regional economy and create a net inflow of population. This is the possible location of an aluminum smelter in the St. Albans area.

For purposes of this report this development would see all employment at the smelter brought from outside the basin. It is also assumed that all indirect employment would come from outside the basin. This inward movement of workers would bring with it an inward movement of households which in this context was assumed to be four people, the worker and three dependents. On the basis of these assumptions the potential net inward movement of population is summarized as follows:

Inward Population Movement Resulting from Aluminum Smelter Located in the Basin

	1971	1976	1981
Direct Employment	975	1, 170	1, 170
Indirect Employment	1, 463	1, 710	2, 340
Total Employment	2, 438	2, 880	3, 510
Net Inward Population Movement	9, 750	11, 520	14, 040

An inward population movement of this size would in effect necessitate the construction of a new town site. An undertaking of this nature, whether private or public, would also involve a transient movement of construction workers.

The level of per capita personal income will remain at a relatively low level if no major development occurs in the basin over the forecast period. In terms of 1965 dollars, per capita disposable income would probably be around $1500 by 1981 compared with the 1965 estimate of $900. However, if the aluminum smelter should locate in the area, per capita disposable income would increase. However, the amount of the increase would be modified by a shift in income structure from transfer payment to wages and salaries. With an aluminum smelter in the area, the per capita disposable income would be about $2200 in terms of 1965 dollars by 1981.

By 1981, the average population of the seven communities in the Bay D'Espoir area, excluding St. Albans, is expected to be about 600 persons if present trends continue and no new industry is attracted to the area. Figure 12-2 indicates the population distribution for the 1971 to 1981 period. Communities of this size will find it difficult to provide community water supply and waste disposal systems because of the high per capita costs; so that it is likely that the water supply and waste disposal systems in existence in these communities will continue to be used.

However, improvements to the present facilities may be feasible to eliminate the water quality and quantity problems which now exist.

The St. Albans local municipal government was created in 1953. Most of the present-day houses are detached one-family homes with individual well supplies and are surrounded by spacious properties, which will make future community supply and disposal systems expensive. However, because of its size, this community has a good possibility of justifying a community supply and disposal system if present population trends continue and if new industry can be attracted to the area.

The town of Harbour Breton has recently installed a community water supply and sewer system that is capable of supplying the expected demand for the next twenty years. Should the supply source of Connaigre Pond prove inadequate for future demands, additional sources are available in the immediate area of Connaigre Pond.

The report on the water supply for the fish processing plant at Gaultois[5] indicates that the future system would require an expenditure of about $570,000.

13 CONCLUSIONS AND RECOMMENDATIONS

13.1 Conclusions

a) The dramatic changes that have occurred in the study region in recent years are a result of the development of the hydro power site near Bay D'Espoir. The construction of the hydro-electric plant has required the provision of improved harbour facilities at Bay D'Espoir, the establishment of an air strip near the plant, and the construction of access roads to the hitherto inaccessible Bay D'Espoir area and the upper basin areas. The diversions created by the hydro development will result in a firm flow of over 6000 cfs being discharged at the plant tailrace making this the highest continuous flow available on the Island, thus providing a source of fresh water supply for large water-using industries. This, together with the transportation system and large power source available, has created opportunities for industrial development in the area.

b) Residual hydro power in the region is confined to the Upper Salmon basin where a base load installation of 80 Mw can be developed at an 80 percent capacity factor. In addition, there is a possibility of developing the head existing between the White Bear and Grey River basins.

c) The Bay D'Espoir development has opened up possibilities for tourism due to the opening of new roads and the creation of canals which might be used for pleasure craft and reservoirs which may be suitable for development of a commercial and sport fresh water indigenous and non-indigenous fishery.

d) The development has considerably reduced the Atlantic salmon potential of the diverted rivers because of the reduction in flow and the creation of barriers to the upper basins.

e) By diverting the headwaters of the Exploits River, the hydro development will significantly increase the existing conflicts of interest between water users in the Exploits basin.

f) Although the hydro development has numerous water resource implications, it was initially conceived as a single purpose project, and various ad hoc measures have been required to resolve the different conflicts of interest (flow release for Atlantic salmon on the Grey River; power and energy compensation for losses at hydro-electric plants on the Exploits River).

g) The hydrometric network established for the gathering of basic hydrologic knowledge in the region will be reduced considerably by the diversion schemes.

h) Degradation of the fresh water resource through municipal demand does not provide a real problem, since disposal of wastewater is to the ocean.

13.2 Recommendations

a) 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 the Grey Rivers. These installations will enable calculations to be made 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. They will also allow for the extension of basic hydrologic knowledge of the region required for the implementation of a water resources management plan.

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

c) The potential water supply for industries and the related infrastructure for industrial development in the Bay D'Espoir area should be considered in the selection of locations for new industries requiring significant amounts of water.

d) Investigations should be carried out to ensure that proper disposal of wastewater in respect to oceanographic conditions is effected: so as to avoid unnecessary shore pollution.

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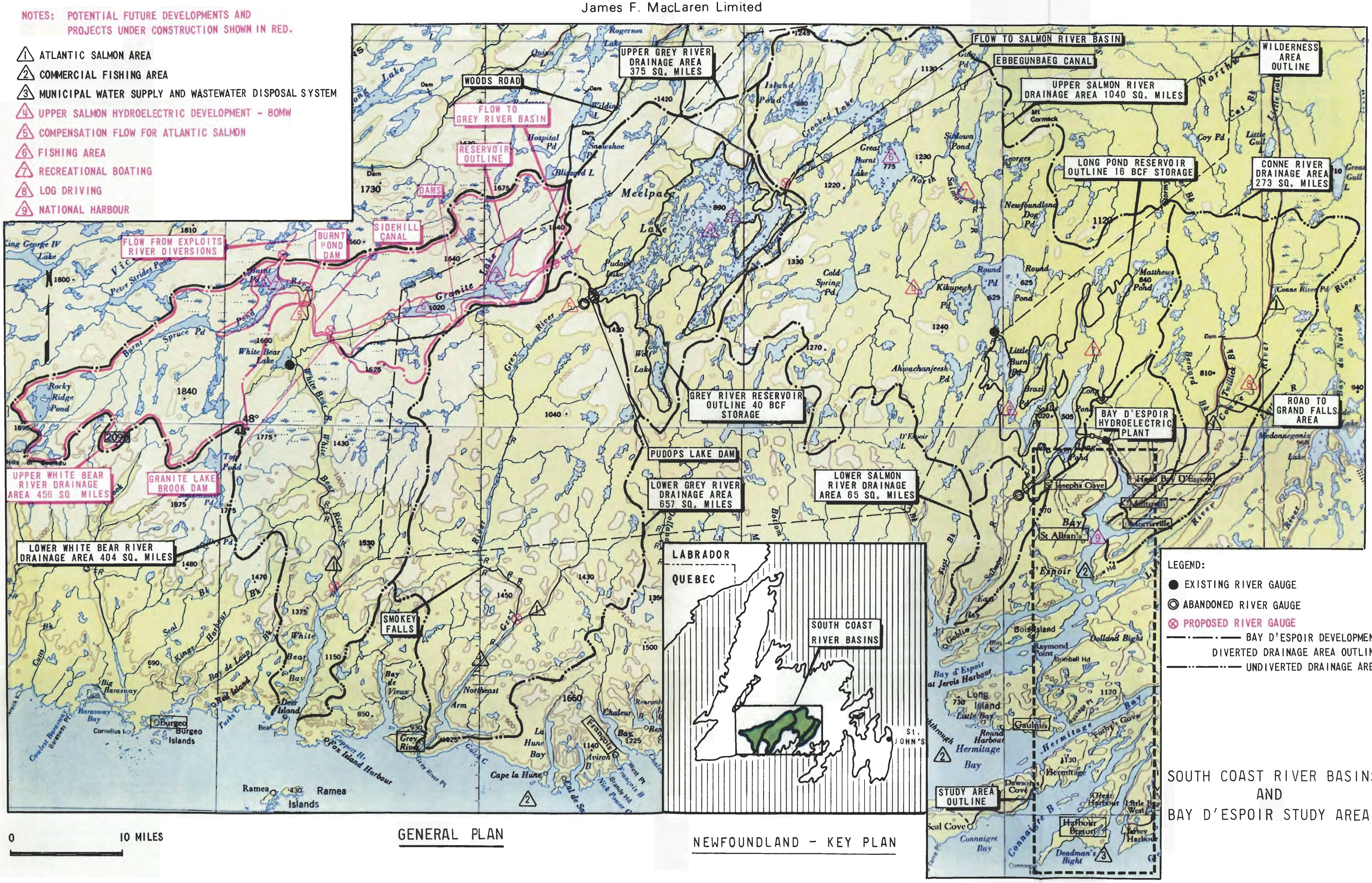
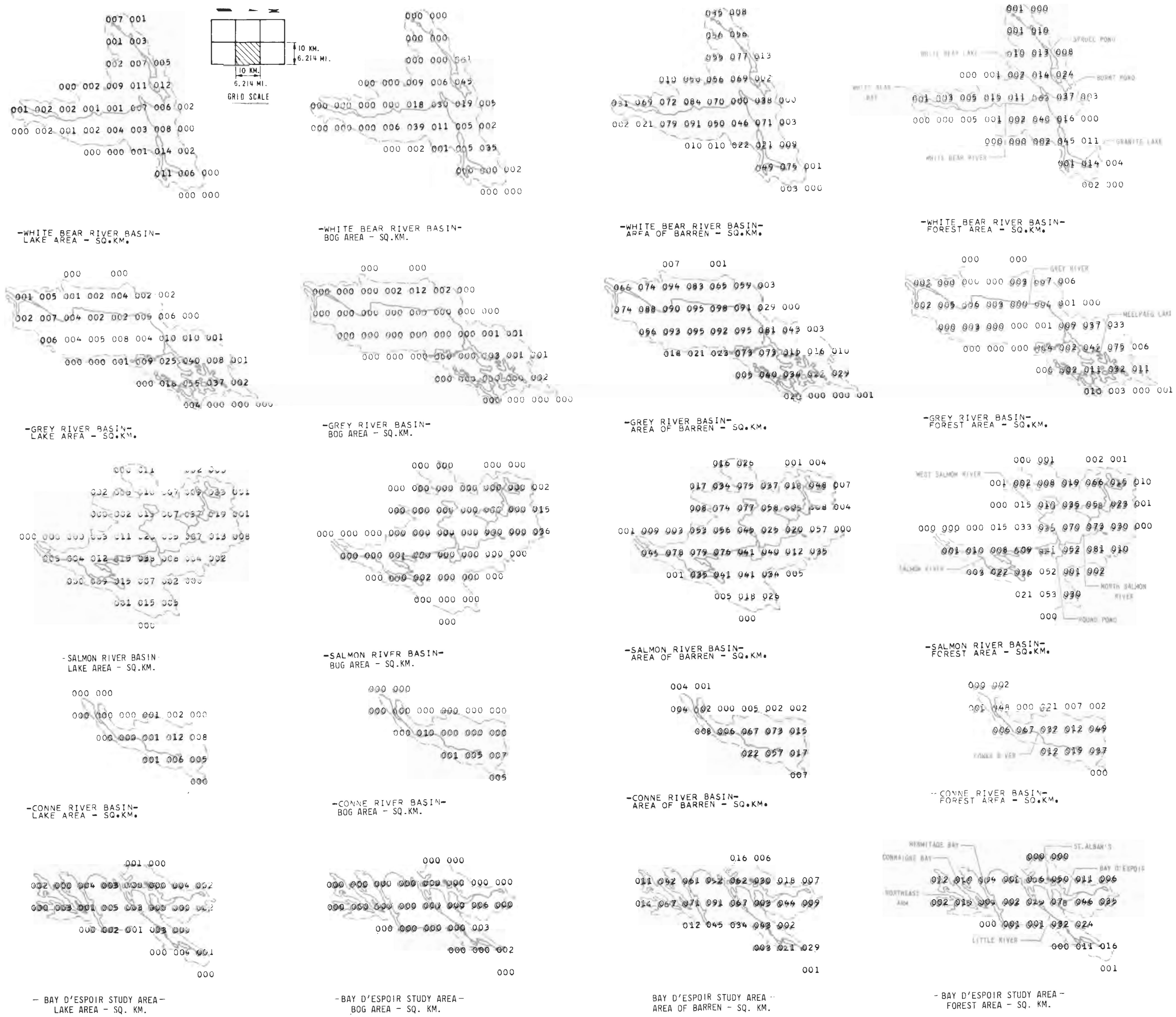


SOUTH COAST RIVER BASINS AND BAY D'ESPOIR STUDY AREA

FIGURE 10-1



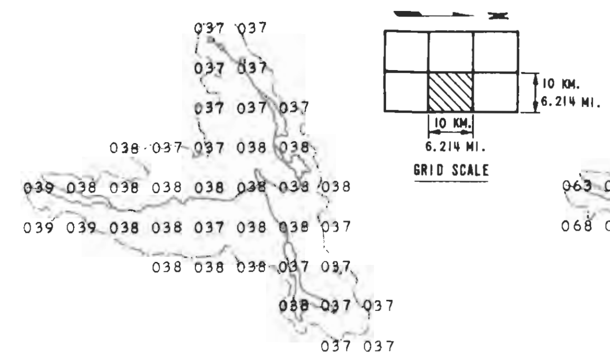
SOUTH COAST RIVER BASINS
AND BAY D'ESPOIR STUDY AREA

SQUARE GRID DISTRIBUTION OF
LAKES, BOGS, BARRENS AND FORESTS

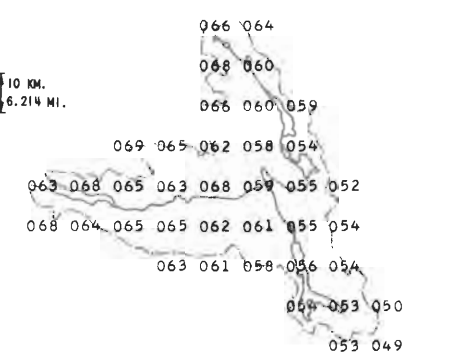
FIGURE 10-2

SOUTH COAST RIVER BASINS AND BAY D'ESPOIR STUDY AREA SQUARE GRID DISTRIBUTION OF LAND SURFACE SLOPE AND ELEVATION

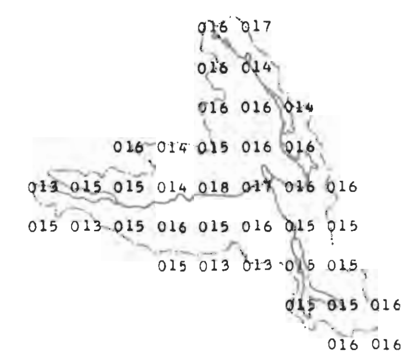
FIGURE 10-3



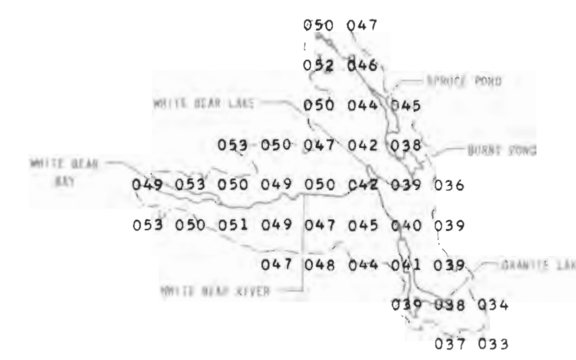
-WHITE BEAR RIVER BASIN-
AVERAGE YEARLY TEMPERATURE - DEGREES FAHRENHEIT



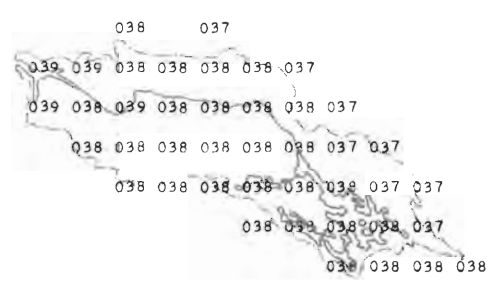
-WHITE BEAR RIVER BASIN-
AVERAGE YEARLY PRECIPITATION - INCHES OF WATER



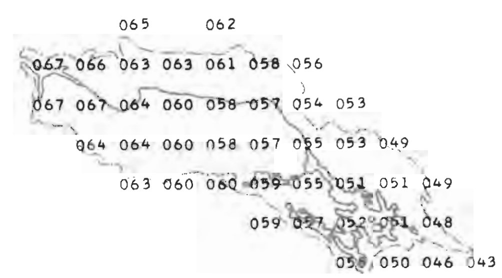
-WHITE BEAR RIVER BASIN-
AVERAGE YEARLY EVAPORATION - INCHES OF WATER



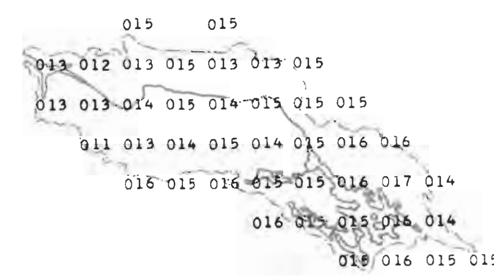
-WHITE BEAR RIVER BASIN-
AVERAGE YEARLY RUNOFF - INCHES OF WATER



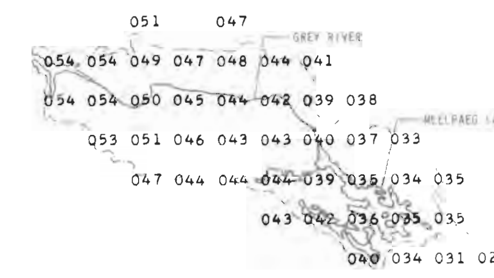
-GREY RIVER BASIN-
AVERAGE YEARLY TEMPERATURE - DEGREES FAHRENHEIT



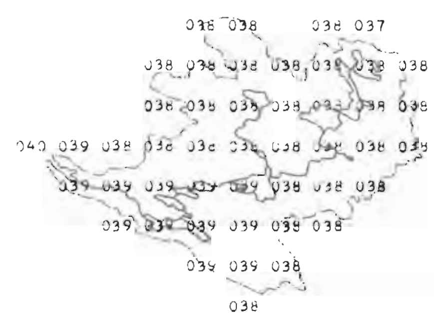
-GREY RIVER BASIN-
AVERAGE YEARLY PRECIPITATION - INCHES OF WATER



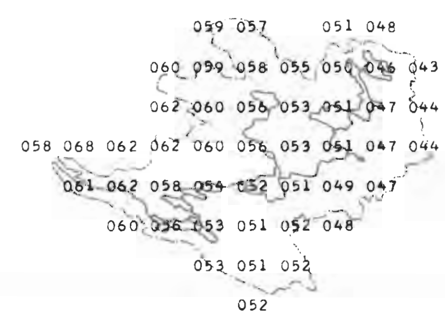
-GREY RIVER BASIN-
AVERAGE YEARLY EVAPORATION - INCHES OF WATER



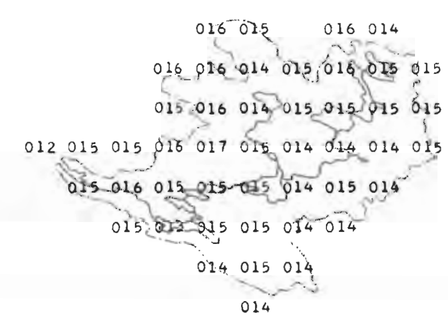
-GREY RIVER BASIN-
AVERAGE YEARLY RUNOFF - INCHES OF WATER



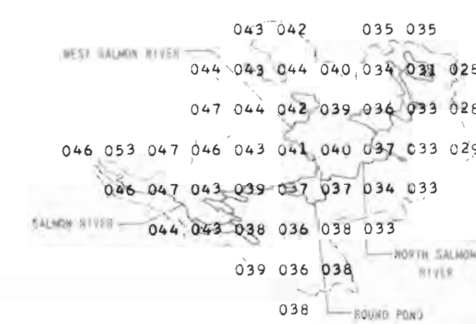
-SALMON RIVER BASIN-
AVERAGE YEARLY TEMPERATURE - DEGREES FAHRENHEIT



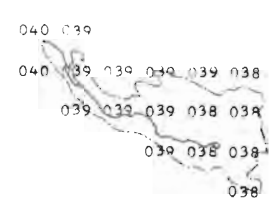
-SALMON RIVER BASIN-
AVERAGE YEARLY PRECIPITATION - INCHES OF WATER



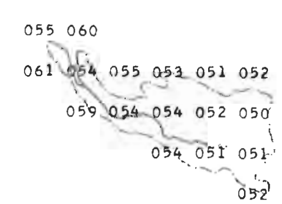
-SALMON RIVER BASIN-
AVERAGE YEARLY EVAPORATION - INCHES OF WATER



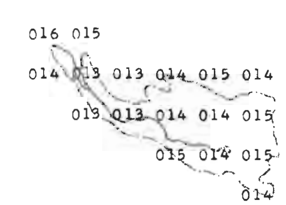
-SALMON RIVER BASIN-
AVERAGE YEARLY RUNOFF - INCHES OF WATER



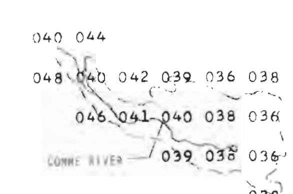
-CONNE RIVER BASIN-
AVERAGE YEARLY TEMPERATURE - DEGREES FAHRENHEIT



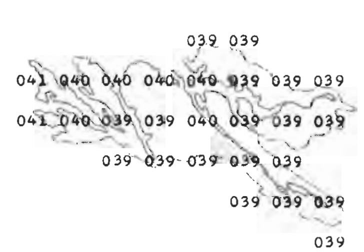
-CONNE RIVER BASIN-
AVERAGE YEARLY PRECIPITATION INCHES OF WATER



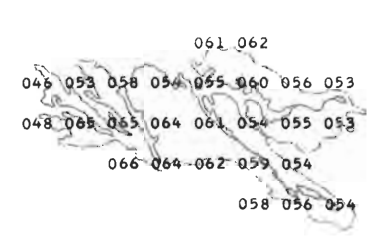
-CONNE RIVER BASIN
AVERAGE YEARLY EVAPORATION - INCHES OF WATER



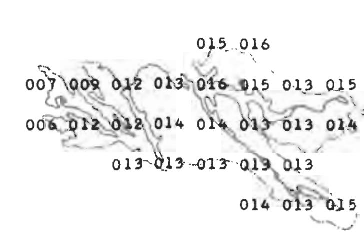
-CONNE RIVER BASIN-
AVERAGE YEARLY RUNOFF - INCHES OF WATER



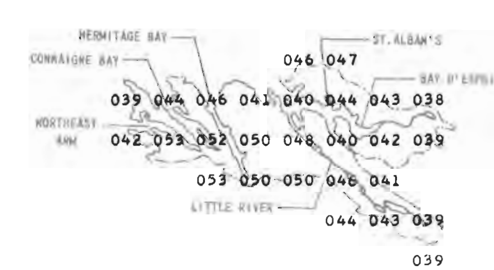
-BAY D'ESPOIR STUDY AREA -
AVERAGE YEARLY TEMPERATURE - DEGREES FAHRENHEIT



-BAY D'ESPOIR STUDY AREA -
AVERAGE YEARLY PRECIPITATION - INCHES OF WATER



-BAY D'ESPOIR STUDY AREA -
AVERAGE YEARLY EVAPORATION - INCHES OF WATER



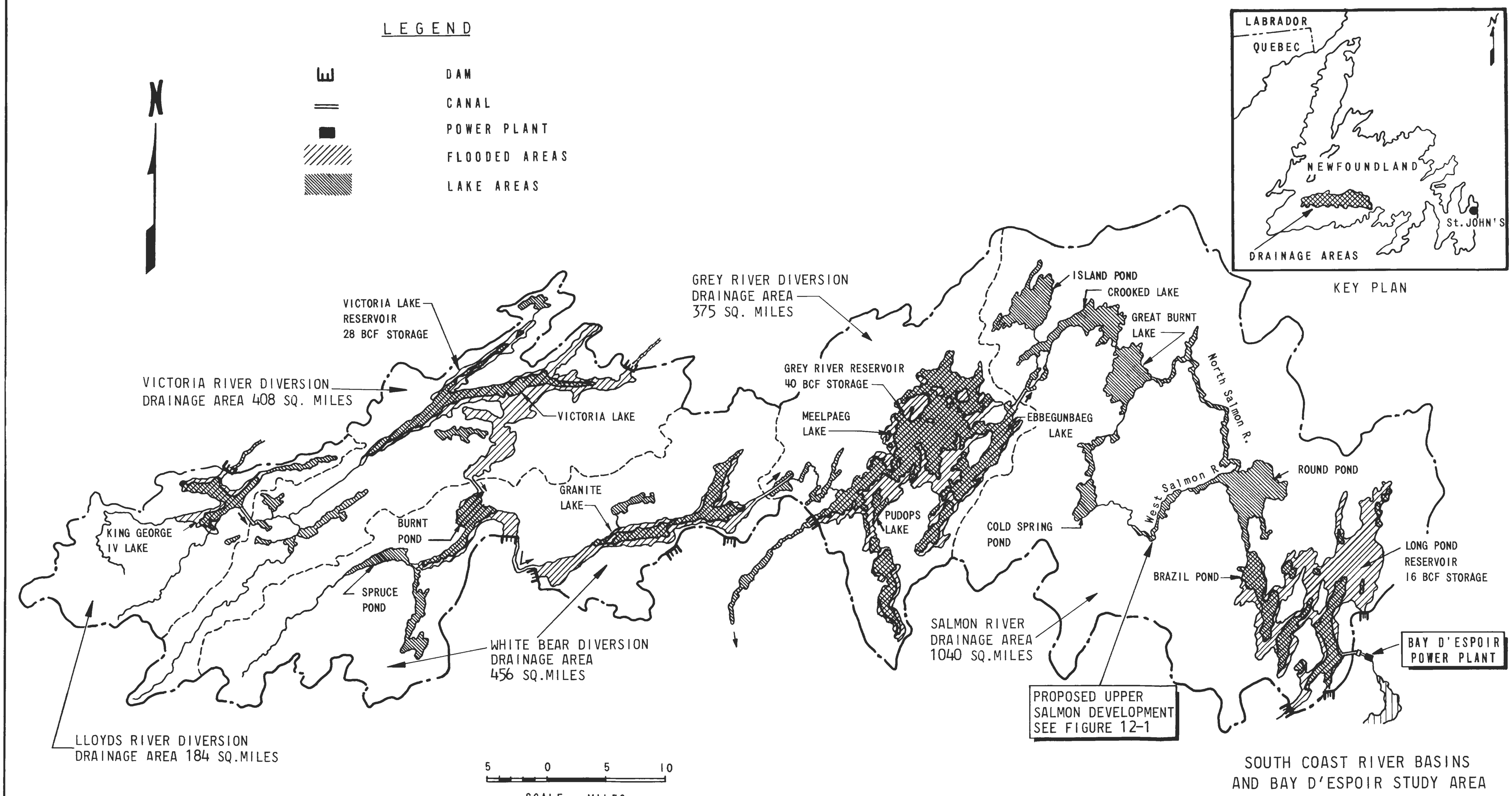
-BAY D'ESPOIR STUDY AREA -
AVERAGE YEARLY RUNOFF - INCHES OF WATER

SOUTH COAST RIVER BASINS
AND BAY D'ESPOIR STUDY AREA

SQUARE GRID DISTRIBUTION
OF MEAN ANNUAL TEMPERATURE,
PRECIPITATION, EVAPORATION AND RUNOFF

FIGURE 10-4

The Shawinigan Engineering Company Limited
James F MacLaren Limited



NOTE:
1) BASIC DATA FROM SHAWMONT NEWFOUNDLAND LIMITED REPORT NO. SM-4-67

SOUTH COAST RIVER BASINS
AND BAY D'ESPOIR STUDY AREA

DRAINAGE AREAS
DIVERTED FOR THE
BAY D'ESPOIR DEVELOPMENT

FIGURE 10-5

The Shawinigan Engineering Company Limited
James F. MacLaren Limited

SOUTH COAST RIVER BASINS AND BAY D'ESPOIR STUDY AREA
GROSS HYDRO ELECTRIC POTENTIAL
ON WHITE BEAR RIVER

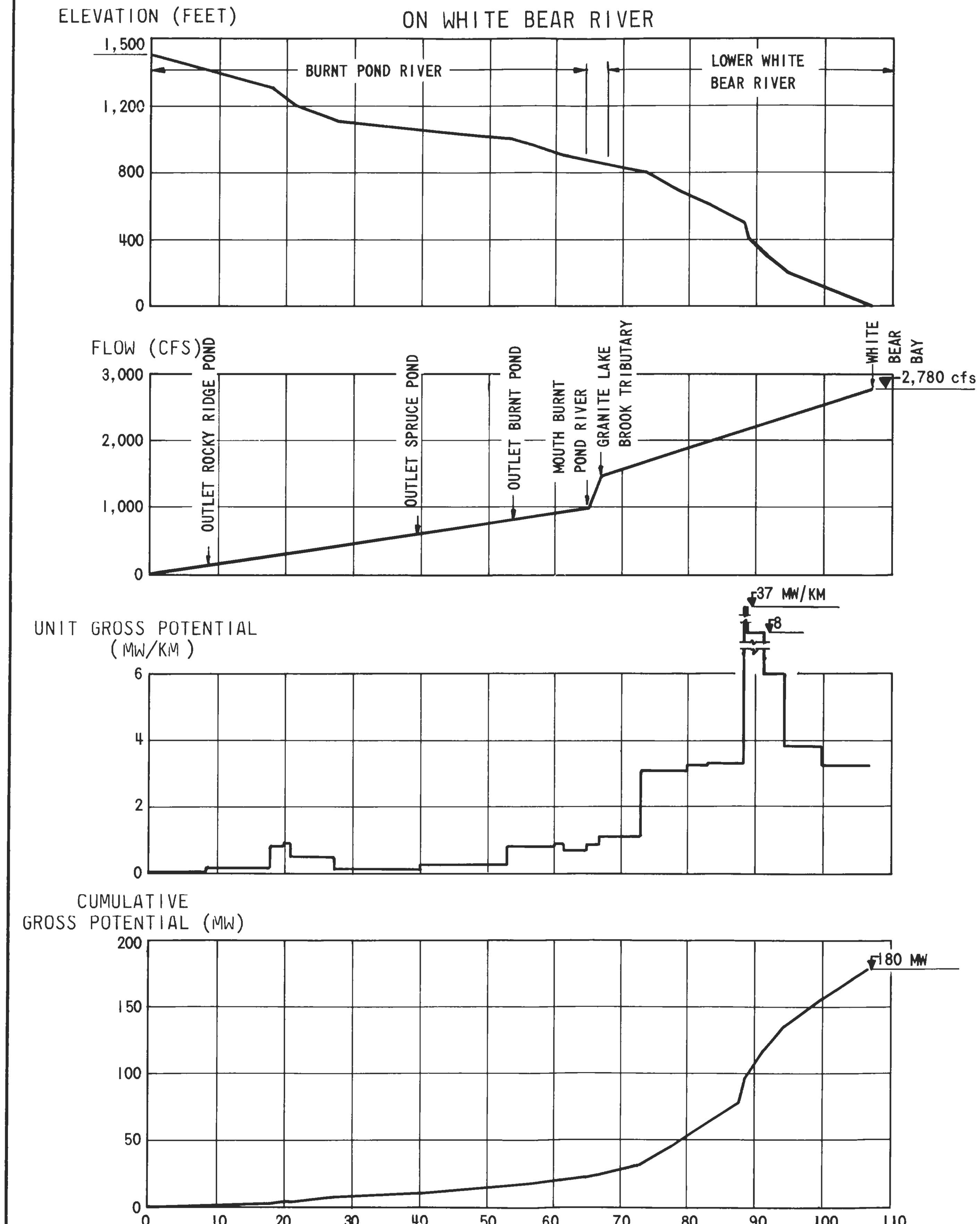


FIGURE 10-6

SOUTH COAST RIVER BASINS AND BAY D'ESPOIR STUDY AREA
GROSS HYDRO ELECTRIC POTENTIAL ON GREY RIVER

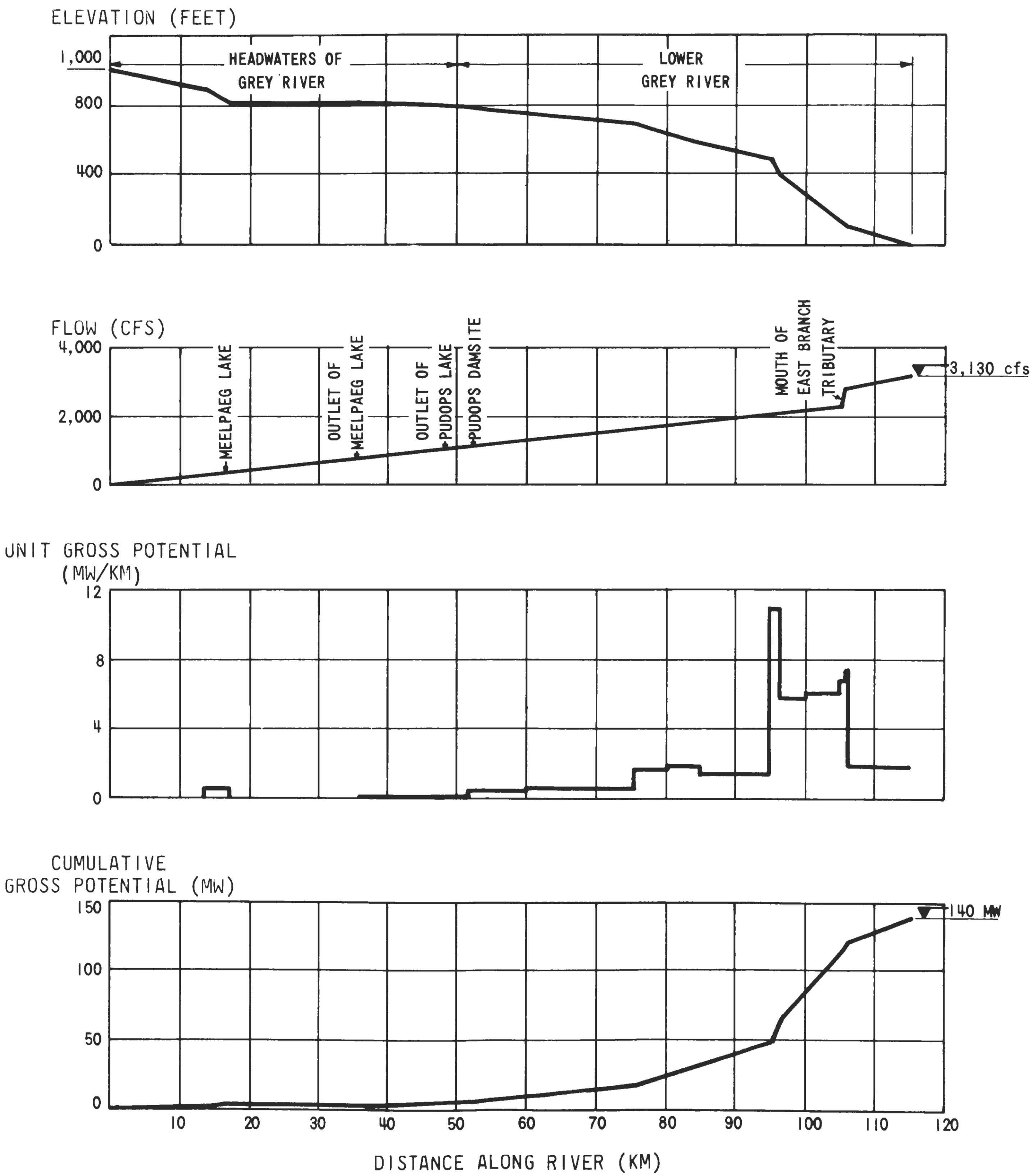


FIGURE 10-7

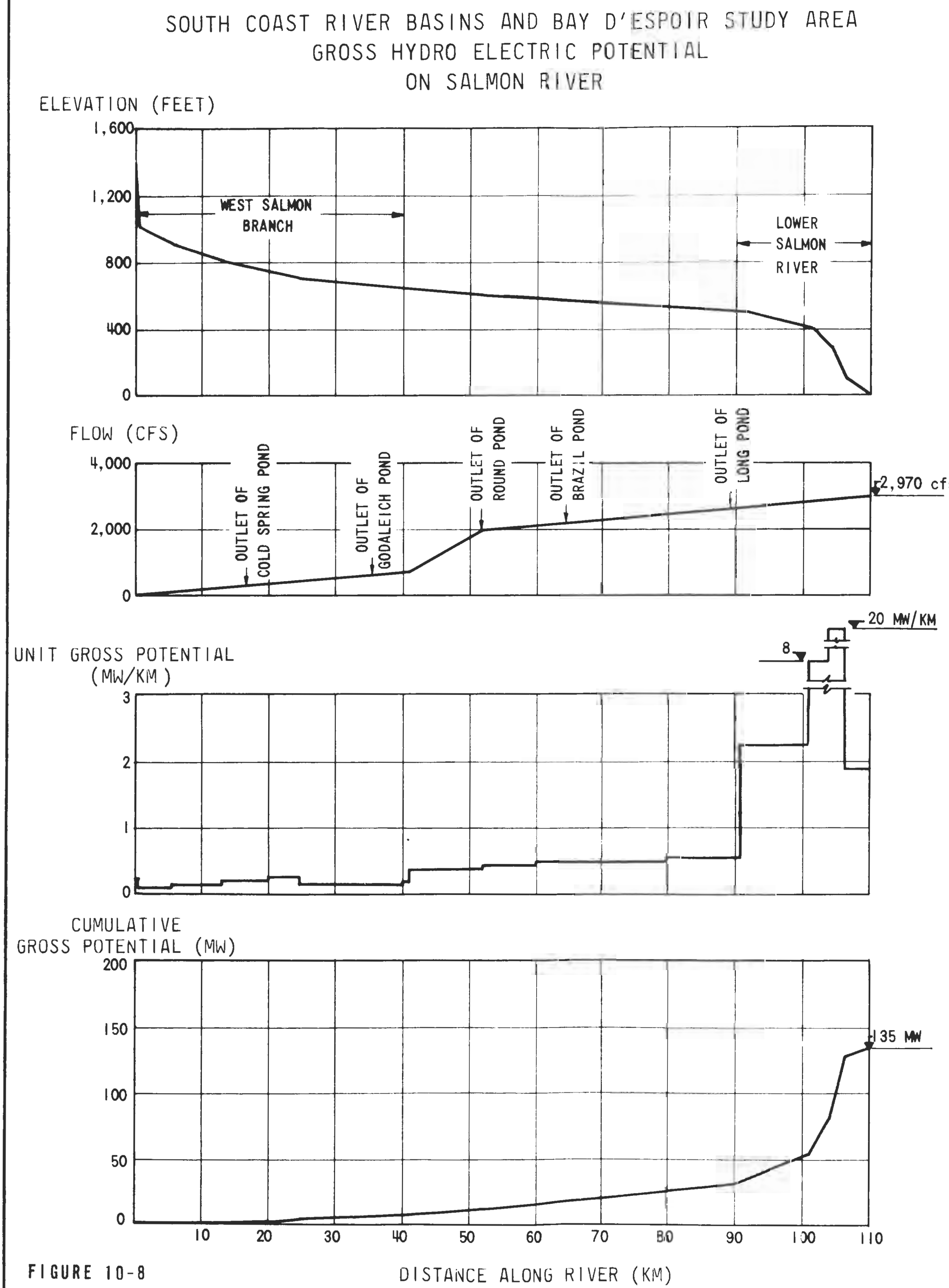

SOUTH COAST RIVER BASINS AND BAY D'ESPOIR STUDY AREA
GROSS HYDRO ELECTRIC POTENTIAL
ON SALMON RIVER
ELEVATION (FEET)
1,600
1,200
800
400
0
WEST SALMON BRANCH
LOWER SALMON RIVER
FLOW (CFS)
4,000
2,000
0
OUTLET OF COLD SPRING POND
OUTLET OF GODALEICH POND
OUTLET OF ROUND POND
OUTLET OF BRAZIL POND
OUTLET OF LONG POND
2,970 cfs
UNIT GROSS POTENTIAL (MW/KM)
3
2
1
0
8
20 MW/KM
CUMULATIVE GROSS POTENTIAL (MW)
200
150
100
50
0
135 MW
10
20
30
40
50
60
70
80
90
100
110
DISTANCE ALONG RIVER (KM)

FIGURE 10-8

SOUTH COAST RIVER BASINS AND BAY D'ESPOIR STUDY AREA
GROSS HYDRO ELECTRIC POTENTIAL
ON CONNE RIVER

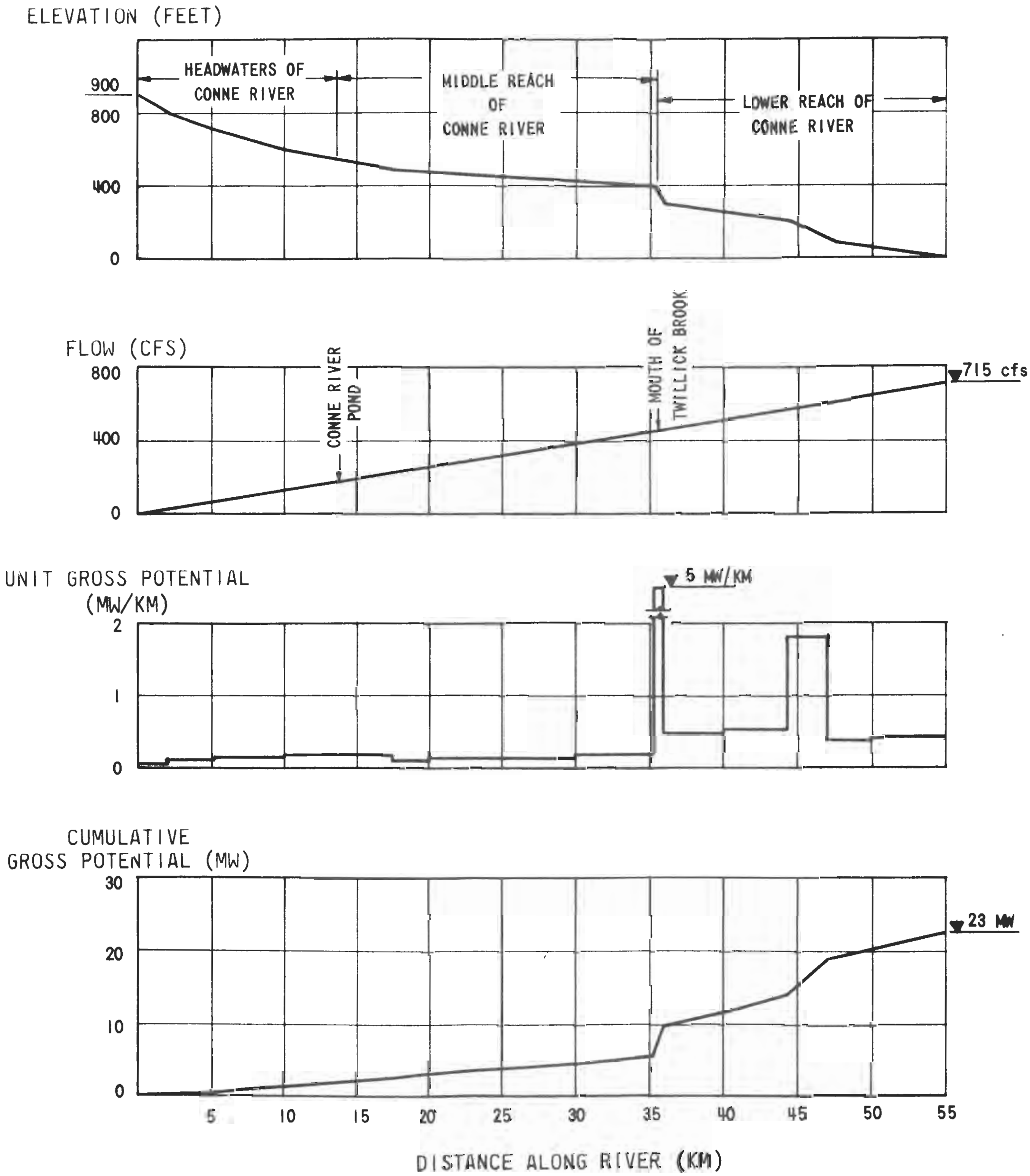


FIGURE 10-9

SOUTH COAST RIVER BASINS AND BAY D'ESPOIR STUDY AREA
CONNE RIVER BASIN
ANNUAL ANGLERS CATCH
(SALMON AND GRILSE)

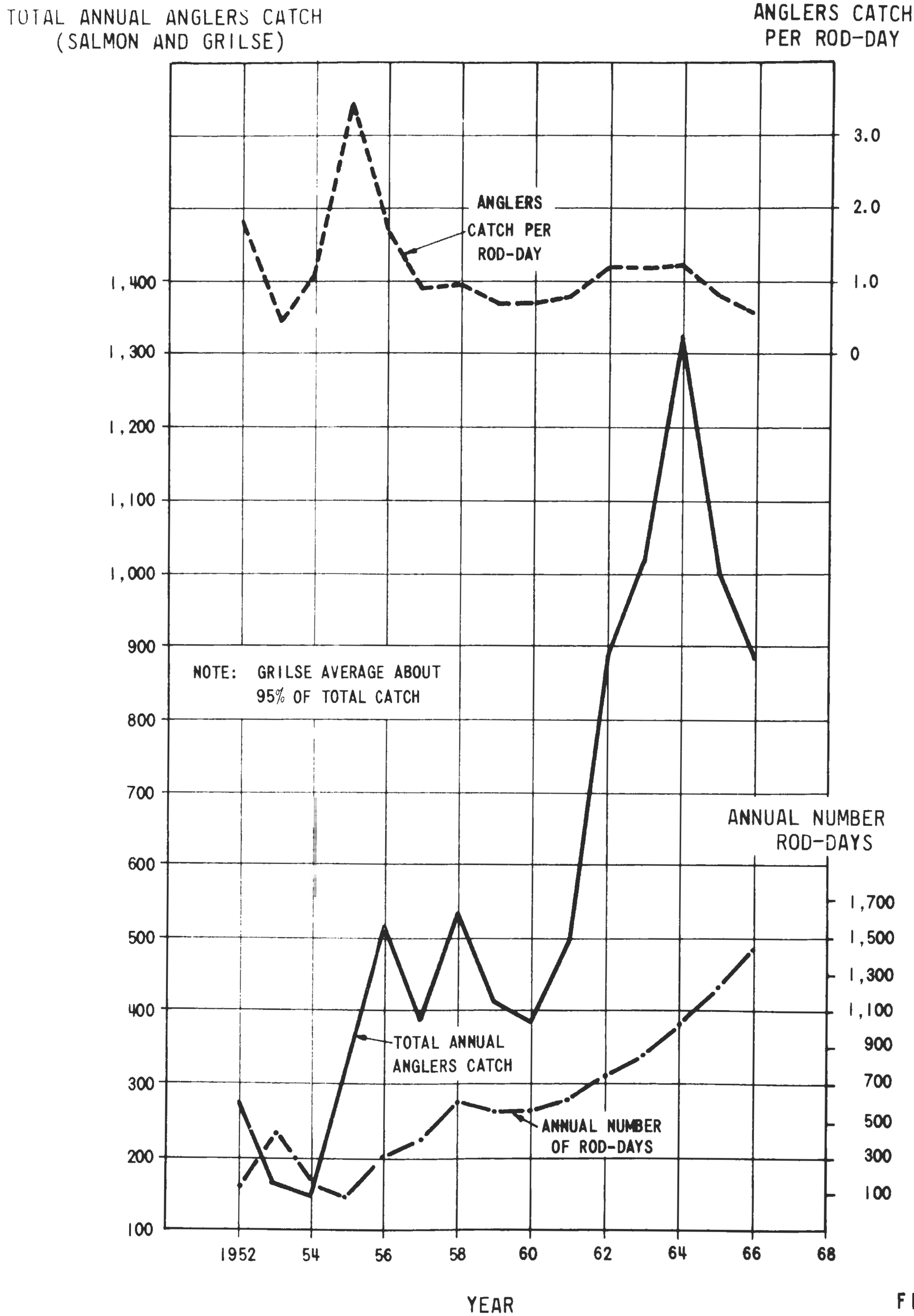
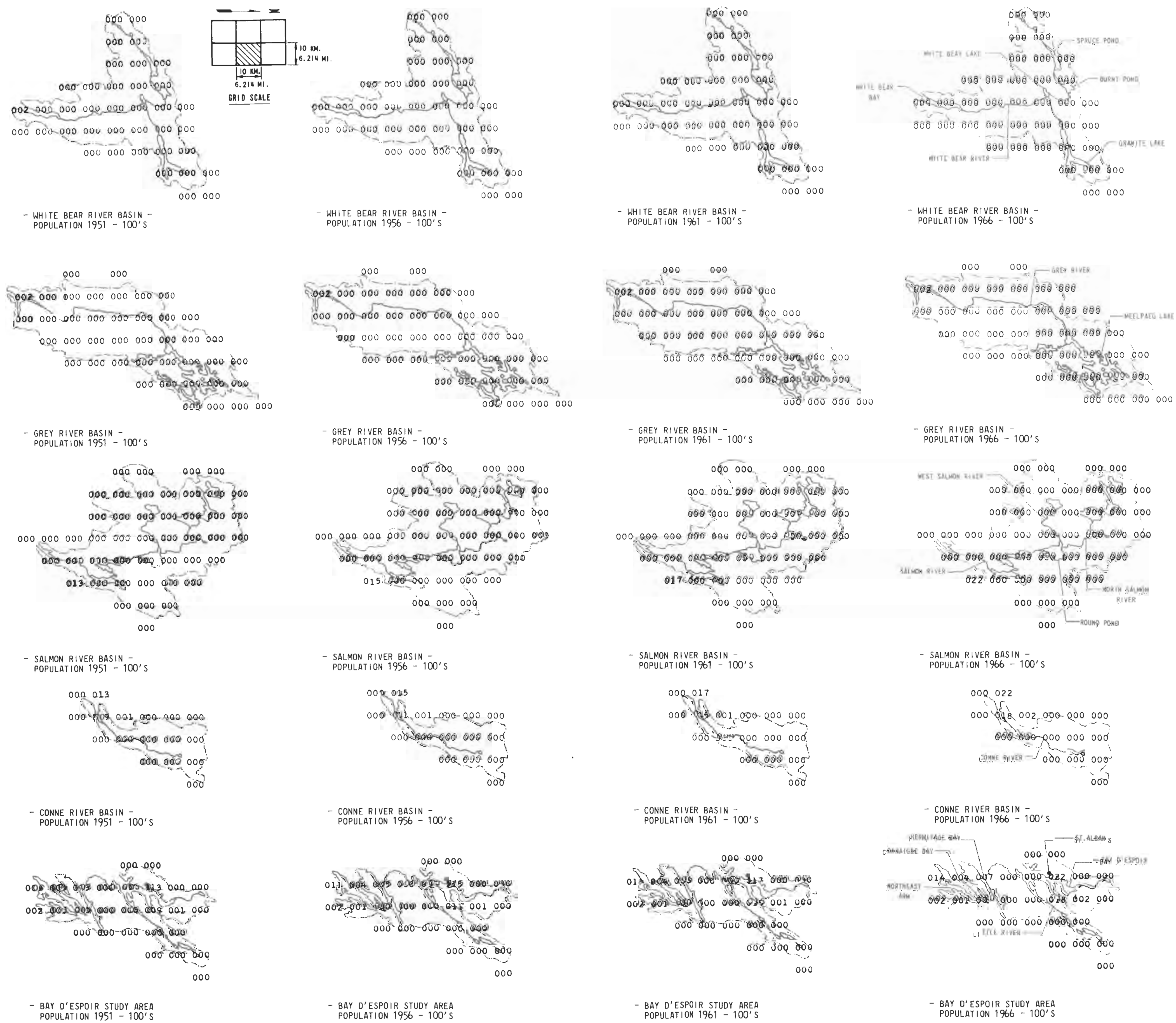


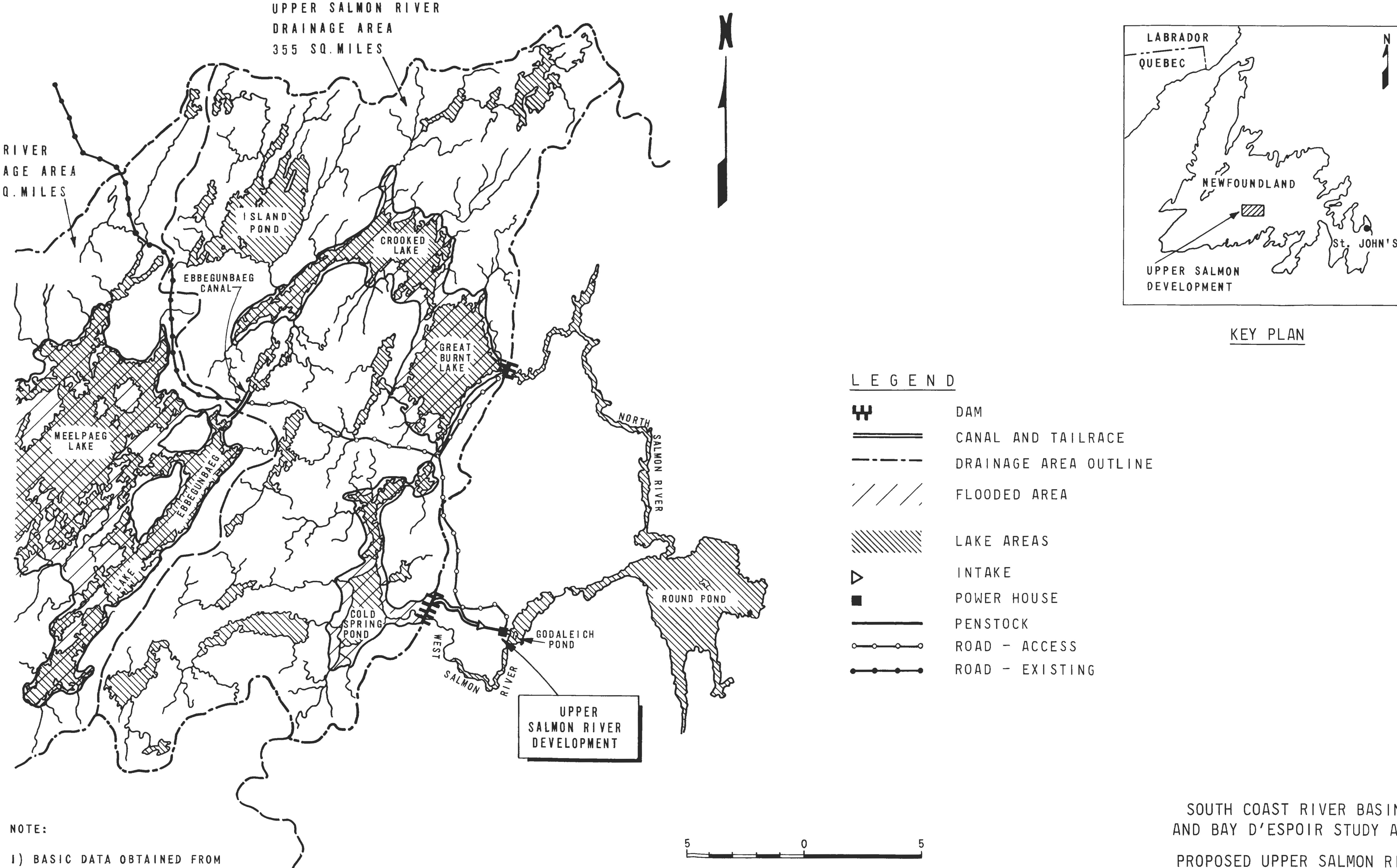
FIGURE 11-1



SOUTH COAST RIVER BASINS
AND BAY D'ESPOIR STUDY AREA

SQUARE GRID DISTRIBUTION OF
RECORDED POPULATION 1951-1966

FIGURE 11-2



NOTE:

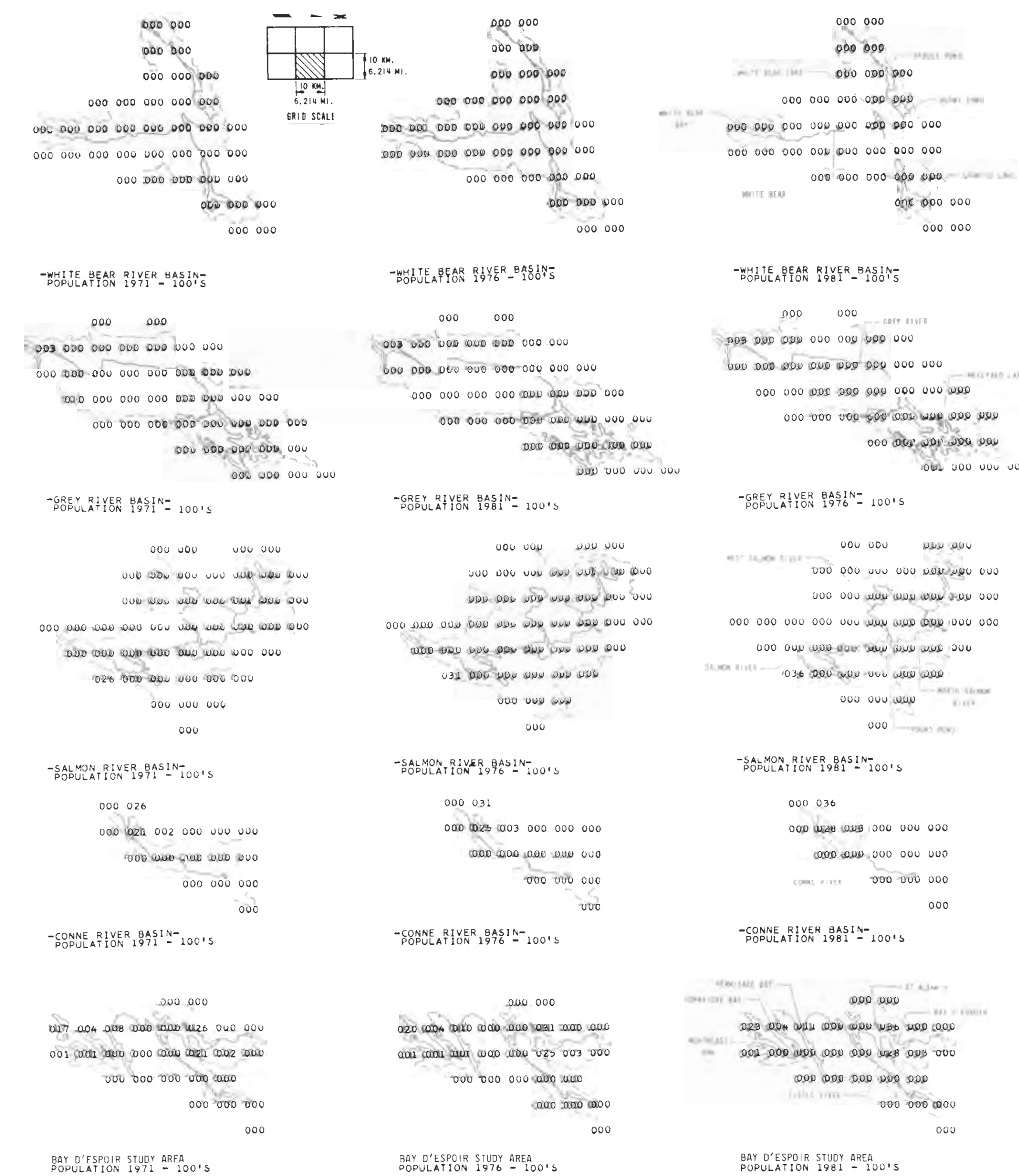
1) BASIC DATA OBTAINED FROM SHAWMONT NEWFOUNDLAND LIMITED REPORT NO. SM-2-67

SOUTH COAST RIVER BASINS AND BAY D'ESPOIR STUDY AREA

PROPOSED UPPER SALMON RIVER DEVELOPMENT

FIGURE 12-1

SOUTH COAST RIVER BASINS AND BAY D'ESPOIR STUDY AREA
SQUARE GRID DISTRIBUTION OF POPULATION FORECAST 1971 - 1981



NOTE: THIS FORECAST CORRESPONDS TO ALTERNATIVE I. FOR ALTERNATIVE 2, WITH ALUMINUM SMELTER, SEE VOLUME SIX PART III, SECTION 12.2.3 AND VOLUME THREE, FIGURES 21-3A, B, C.

FIGURE 12-2

SOUTH COAST RIVER BASINS AND BAY D'ESPOIR STUDY AREA

WHITE BEAR RIVER BASIN

SUMMARY OF CLIMATIC CHARACTERISTICS

A ANNUAL MEANS

Precipitation (inches)	Air Temperature (deg F)	Potential Evaporation (inches)	Relative Humidity (percent)
60.6	37.6	19	83

B MEAN MONTHLY PRECIPITATION (inches)

Stations	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Burgeo	5.21	4.94	3.82	3.91	4.63	4.82	4.77	4.36	5.35	5.35	6.01	5.47	58.62
Basin Mean Synthesized	5.2	5.1	3.9	3.6	4.2	5.2	4.8	5.1	5.5	5.6	6.6	5.7	60.6

C MAXIMUM POSSIBLE STORM PRECIPITATION (inches)

Area (sq. mi)	Storm Duration (hours) 6	12	18	24	36	48	72
100	5.55	7.35	9.65	10.60	12.05	12.40	16.10
300	5.45	7.30	9.20	10.40	12.00	12.30	15.60
500	5.40	7.15	8.90	10.15	11.85	12.20	15.20
860	5.35	7.00	8.60	9.90	11.60	12.00	14.75

D MAXIMUM POSSIBLE SEASONAL SNOWFALL (inches of water equivalent): 45.0

E CRITICAL SEQUENCES FOR SNOW MELTING (degrees F)

Interval	Date: March 1	March 10	March 20	April 1	April 10	April 20	May 1
4 - day	47.0	47.5	48.5	50.0	51.0	53.0	55.0
8 - day	45.0	45.5	46.5	48.0	49.0	49.5	50.0
16 - day	38.0	38.5	40.0	43.0	47.0	48.5	49.0

F DROUGHT

Return Period	2.33-Year	5-Year	10-Year	20-Year	50-Year	100-Year
Length of Drought	13 days	15 days	18 days	22 days	26 days	29 days

TABLE 10-1

SOUTH COAST RIVER BASINS AND BAY D'ESPOIR STUDY AREA

GREY RIVER BASIN

SUMMARY OF CLIMATIC CHARACTERISTICS

A ANNUAL MEANS

Precipitation (inches)	Air Temperature (deg F)	Potential Evaporation (inches)	Relative Humidity (percent)
58.3	38.0	19	83

B MEAN MONTHLY PRECIPITATION (inches)

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Basin Mean Synthesized	4.9	4.9	3.8	3.7	4.1	4.8	4.5	4.9	5.1	5.7	6.4	5.5	58.3

C MAXIMUM POSSIBLE STORM PRECIPITATION (inches)

Area (sq. mi)	Storm Duration (hours) 6	12	18	24	36	48	72
100	5.55	7.35	9.65	10.60	12.05	12.40	16.10
300	5.45	7.30	9.20	10.40	12.00	12.30	15.60
500	5.40	7.15	8.90	10.15	11.85	12.20	15.20
1000	5.30	6.90	8.55	9.85	11.55	11.90	14.60

D MAXIMUM POSSIBLE SEASONAL SNOWFALL (inches of water equivalent): 45.0

E CRITICAL SEQUENCE FOR SNOW MELTING (degrees F)

Interval	Date: March 1	March 10	March 20	April 1	April 10	April 20	May 1
4 - day	47.0	47.5	48.5	50.0	51.0	53.0	55.5
8 - day	45.0	45.5	46.5	48.0	49.0	49.5	50.0
16 - day	38.0	38.5	40.0	43.0	47.0	48.5	49.0

F DROUGHT

Return Period	2.33-Year	5-Year	10-Year	20-Year	50-Year	100-year
Length of Drought	13 days	15 days	18 days	22 days	26 days	29 days

TABLE 10-2

SOUTH COAST RIVER BASINS AND BAY D'ESPOIR STUDY AREA

SALMON RIVER BASIN

SUMMARY OF CLIMATIC CHARACTERISTICS

A ANNUAL MEANS

Precipitation (inches)	Air Temperature (deg F)	Potential Evaporation (inches)	Relative Humidity (percent)
53.5	38.2	19	83

B MEAN MONTHLY PRECIPITATION (inches)

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Basin Mean Synthesized	4.3	4.5	3.5	3.2	3.3	4.3	4.0	4.9	4.6	5.7	6.1	5.1	53.5

C MAXIMUM POSSIBLE STORM PRECIPITATION (inches)

Area	Storm Duration (hours)						
(sq. mi)	6	12	18	24	36	48	72
100	5.55	7.35	9.65	10.60	12.05	12.40	16.10
300	5.45	7.30	9.20	10.40	12.00	12.30	15.60
500	5.40	7.15	8.90	10.15	11.85	12.20	15.20
1000	5.30	6.90	8.55	9.85	11.55	11.90	14.60
1100	5.25	6.85	8.45	9.80	11.50	11.85	14.50

D MAXIMUM POSSIBLE SEASONAL SNOWFALL (inches of water equivalent) : 34.0

E CRITICAL SEQUENCES FOR SNOW MELTING (degrees F)

Interval	Date						
	March			April			May
	1	10	20	1	10	20	1
4 - day	43.5	45.0	46.5	49.5	52.0	55.0	58.5
8 - day	41.5	42.5	44.0	46.5	49.0	51.6	56.0
16 - day	39.0	39.5	41.0	44.0	46.0	49.0	52.5

F DROUGHT

Return Period	2.33-Year	5-Year	10-Year	20-Year	50-Year	100-Year
Length of Drought	13 days	16 days	18 days	24 days	27 days	30 days

TABLE 10-3

SOUTH COAST RIVER BASINS AND BAY D'ESPOIR STUDY AREA

CONNE RIVER BASIN

SUMMARY OF CLIMATIC CHARACTERISTICS

A ANNUAL MEANS

Precipitation (inches)	Air Temperature (deg F)	Potential Evaporation (inches)	Relative Humidity (percent)
52.7	38.6	19	83

B MEAN MONTHLY PRECIPITATION (inches)

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Basin Mean Synthesized	4.6	4.5	3.5	3.4	3.4	4.1	4.0	4.1	4.2	5.5	6.2	5.2	52.7

C MAXIMUM POSSIBLE STORM PRECIPITATION(inches)

Area (sq. mi)	Storm Duration (hours) 6	12	18	24	36	48	72
100	5.55	7.35	9.65	10.60	12.05	12.40	16.10
300	5.45	7.30	9.20	10.40	12.00	12.30	15.60

D MAXIMUM POSSIBLE SEASONAL SNOWFALL (inches of water equivalent): 34.0

E CRITICAL SEQUENCES FOR SNOW MELTING (degrees F)

Interval	Date: March 1	March 10	March 20	April 1	April 10	April 20	May 1
4 - day	43.5	45.0	46.5	49.5	52.0	55.0	58.5
8 - day	41.5	42.5	44.0	46.5	49.0	51.6	56.0
16 - day	39.0	39.5	41.0	44.0	46.0	49.0	52.5

F DROUGHT

Return Period	2.33-Year	5-Year	10-Year	20-Year	50-Year	100-Year
Length of Drought	13 days	16 days	18 days	24 days	27 days	30 days

TABLE 10-4

SUMMARY OF HYDROLOGIC CHARACTERISTICS
WHITE BEAR RIVER BASIN

I - SYNTHESIZED DATA

A. ANNUAL MEANS FOR THE TOTAL BASIN

FLOW (CFS)	RUNOFF (CFS/SQ.MI)	RUNOFF (INCHES)	ACTUAL EVAP. (INCHES)
2,870	3.3	45.2	15.3

B. MEAN MONTHLY FLOWS (Q) AND STANDARD DEVIATIONS (S) (CFS)

RIVER AND LOCATION		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVGE
WHITE BEAR RIVER AT WHITE BEAR BAY	Q	2430	1965	1890	4220	5840	2630	1940	1880	2000	2460	4070	3390	2870
	S	1170	1060	1140	1200	1910	1050	660	860	1070	1060	1470	1050	320
WHITE BEAR RIVER AT WHITE BEAR LAKE	Q	1020	817	710	1430	1900	850	710	660	730	780	1450	1210	995
	S	385	425	400	465	645	390	205	265	370	365	520	375	115
	Q													
	S													

C. MAXIMUM FLOWS (CFS) AND FLOOD VOLUMES (CFS DAY) OBTAINED BY THE MAXIMIZATION PROCEDURE (INSTANTANEOUS PEAKS)

RIVER AND LOCATION	MAXIMIZED RAIN ON SNOW PACK		MAXIMIZED RAIN ONLY		SNOW PACK & AVERAGE RAIN	
	PEAK	VOLUME	PEAK	VOLUME	PEAK	VOLUME
WHITE BEAR RIVER AT WHITE BEAR LAKE	43.000	202.000	32,400	104,000	12,500	114.000

D. MAXIMUM FLOWS OBTAINED BY STATISTICAL ANALYSIS (CFS) (DAILY AVERAGES)

RIVER AND LOCATION	GENERATED BY SNOW MELT & RAIN		GENERATED BY RAIN ONLY	
	1/10000 YEARS	1/1000 YEARS	1/10000 YEARS	1/1000 YEARS
WHITE BEAR RIVER AT WHITE BEAR BAY	43,000	34,700	33,800	28,100
WHITE BEAR RIVER AT WHITE BEAR LAKE	17,000	13,800	11,000	9,050

SUMMARY OF HYDROLOGIC CHARACTERISTICS
WHITE BEAR RIVER BASIN

E. MINIMUM FLOWS OBTAINED FROM RECESSION CURVES (CFS)

RIVER AND LOCATION	1/2 YEARS	1/5 YEARS	1/10 YEARS	1/20 YEARS

F. MINIMUM FLOWS OBTAINED FROM STATISTICAL ANALYSIS (CFS)

RIVER AND LOCATION	1/2 YEARS	1/5 YEARS	1/20 YEARS	1/100 YEARS
WHITE BEAR RIVER AT WHITE BEAR BAY	550	365	210	
WHITE BEAR RIVER AT WHITE BEAR LAKE	215	150	100	

G. FULL REGULATION STORAGE

RIVER AND STATION	STORAGE (CUBIC FEET x 10^9)
WHITE BEAR RIVER AT WHITE BEAR BAY	104
WHITE BEAR RIVER AT WHITE BEAR LAKE	50.6

II - RECORDED DATA

H. MEAN MONTHLY AND ANNUAL FLOWS (CFS)

RIVER AND STATION	YEARS OF RECORD	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVGE

I. EXTREMES RECORDED (CFS)

RIVER AND STATION	MAXIMUM FLOWS			MINIMUM FLOWS		
	FLOW	DATE	COMMENTS	FLOW	DATE	COMMENTS
WHITE BEAR RIVER AT WHITE BEAR LAKE	9,580 cfs	MARCH 4, 1965	DRAINAGE AREA = 308 SQ. MILES	171 cfs	AUG. 22 1965	PERIOD OF RECORD SEPT. 1964 TO OCT. 1966

SUMMARY OF HYDROLOGIC CHARACTERISTICS
GREY RIVER BASIN

I - SYNTHESIZED DATA

A. ANNUAL MEANS FOR THE TOTAL BASIN

FLOW (CFS)	RUNOFF (CFS/SQ.MI)	RUNOFF (INCHES)	ACTUAL EVAP. (INCHES)
3,340	3.2	43.9	14.3

B. MEAN MONTHLY FLOWS (Q) AND STANDARD DEVIATIONS (S) (CFS)

RIVER AND LOCATION		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVGE
GREY RIVER AT SOUTHEAST ARM	Q	2950	2760	2470	5110	7090	3170	2110	2050	2190	2780	4610	3850	3340
	S	1340	1280	1370	1490	2340	1240	810	1070	1120	1190	1450	1220	385
GREY RIVER AT PUDOPS LAKE OUTLET	Q	1133	1060	790	1700	2080	790	625	570	650	708	1390	1260	1015
	S	440	455	445	530	725	400	200	290	335	365	460	395	135
	Q													
	S													

C. MAXIMUM FLOWS (CFS) AND FLOOD VOLUMES (CFS DAY) OBTAINED BY THE MAXIMIZATION PROCEDURE (INSTANTANEOUS PEAKS)

RIVER AND LOCATION	MAXIMIZED RAIN ON SNOW PACK		MAXIMIZED RAIN ONLY		SNOW PACK & AVERAGE RAIN	
	PEAK	VOLUME	PEAK	VOLUME	PEAK	VOLUME
GREY RIVER AT SOUTHEAST ARM	99,600	660,000	65,200	329,000	41,200	385,000

D. MAXIMUM FLOWS OBTAINED BY STATISTICAL ANALYSIS (CFS) (DAILY AVERAGES)

RIVER AND LOCATION	GENERATED BY SNOW MELT & RAIN		GENERATED BY RAIN ONLY	
	1/10000 YEARS	1/1000 YEARS	1/10000 YEARS	1/1000 YEARS
GREY RIVER AT SOUTHEAST ARM	46,400	37,100	37,800	31,000
GREY RIVER AT PUDOPS LAKE OUTLET	14,300	11,300	8,300	6,700

SUMMARY OF HYDROLOGIC CHARACTERISTICS
GREY RIVER BASIN

E. MINIMUM FLOWS OBTAINED FROM RECESSION CURVES (CFS)

RIVER AND LOCATION	1/2 YEARS	1/5 YEARS	1/10 YEARS	1/20 YEARS

F. MINIMUM FLOWS OBTAINED FROM STATISTICAL ANALYSIS (CFS)

RIVER AND LOCATION	1/2 YEARS	1/5 YEARS	1/20 YEARS	1/100 YEARS
GREY RIVER AT SOUTHEAST ARM	730	440		20
GREY RIVER NEAR PUDOPS LAKE	310	210		50

G. FULL REGULATION STORAGE

RIVER AND STATION	STORAGE (CUBIC FEET x 10^9)
GREY RIVER AT SOUTHEAST ARM	102
GREY RIVER AT PUDOPS LAKE	41.8

II - RECORDED DATA

H. MEAN MONTHLY AND ANNUAL FLOWS (CFS)

RIVER AND STATION	YEARS OF RECORD	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVGE
GREY RIVER NEAR PUDOPS LAKE	8	875	650	665	1210	2020	1030	625	485	600	800	1400	1230	965

I. EXTREMES RECORDED (CFS)

RIVER AND STATION	MAXIMUM FLOWS			MINIMUM FLOWS		
	FLOW	DATE	COMMENTS	FLOW	DATE	COMMENTS
GREY RIVER NEAR PUDOPS LAKE	3900 CFS	MAY 17 1961	DRAINAGE AREA = 379 SQ. MILES	76 CFS	OCT.3 1961	PERIOD OF RECORD AUGUST 1958 TO SEPT. 1966

SUMMARY OF HYDROLOGIC CHARACTERISTICS
SALMON RIVER BASIN

I - SYNTHESIZED DATA

A. ANNUAL MEANS FOR THE TOTAL BASIN

FLOW (CFS)	RUNOFF (CFS/SQ.MI)	RUNOFF (INCHES)	ACTUAL EVAP. (INCHES)
3.150	2.9	38.6	14.8

B. MEAN MONTHLY FLOWS (Q) AND STANDARD DEVIATIONS (S) (CFS)

RIVER AND LOCATION		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVGE
SALMON RIVER AT LONG POND	Q	2960	2770	2370	4710	5890	2430	1580	1500	1640	2000	3700	3250	2890
	S	1390	1210	1260	1680	2020	1000	645	900	950	1080	1310	1180	415
WEST SALMON R. AT ROUND POND	Q	845	810	665	1130	1450	665	420	380	435	510	955	835	740
	S	325	340	310	460	510	300	170	215	245	260	315	300	105
	Q													
	S													

C. MAXIMUM FLOWS (CFS) AND FLOOD VOLUMES (CFS DAY) OBTAINED BY THE MAXIMIZATION PROCEDURE (INSTANTANEOUS PEAKS)

RIVER AND LOCATION	MAXIMIZED RAIN ON SNOW PACK		MAXIMIZED RAIN ONLY		SNOW PACK & AVERAGE RAIN	
	PEAK	VOLUME	PEAK	VOLUME	PEAK	VOLUME
SALMON RIVER AT LONG POND	97,300	691,000	61,600	335,000	41,200	399,000

D. MAXIMUM FLOWS OBTAINED BY STATISTICAL ANALYSIS (CFS) (DAILY AVERAGES)

RIVER AND LOCATION	GENERATED BY SNOW MELT & RAIN		GENERATED BY RAIN ONLY	
	1/10000 YEARS	1/1000 YEARS	1/10000 YEARS	1/1000 YEARS
SALMON RIVER AT LONG POND	39,200	31,600	25,700	20,800
WEST SALMON RIVER AT ROUND POND INLET	12,800	10,400	8,760	7,100

SUMMARY OF HYDROLOGIC CHARACTERISTICS
SALMON RIVER BASIN

E. MINIMUM FLOWS OBTAINED FROM RECESSION CURVES (CFS)

RIVER AND LOCATION	1/2 YEARS	1/5 YEARS	1/10 YEARS	1/20 YEARS

F. MINIMUM FLOWS OBTAINED FROM STATISTICAL ANALYSIS (CFS)

RIVER AND LOCATION	1/2 YEARS	1/5 YEARS	1/20 YEARS	1/100 YEARS
SALMON RIVER AT LONG POND	650	400	190	30
NORTH SALMON RIVER AT ROUND POND	455	285	140	30
WEST SALMON RIVER AT ROUND POND INLET	130	80	40	10

G. FULL REGULATION STORAGE

RIVER AND STATION	STORAGE (CUBIC FEET x 10^9)
SALMON RIVER AT LONG POND	110.
SALMON RIVER AT ROUND POND	74.7
WEST SALMON RIVER AT ROUND POND INLET	31.2

II - RECORDED DATA

H. MEAN MONTHLY AND ANNUAL FLOWS (CFS)

RIVER AND STATION	YEARS OF RECORD	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVGE
SALMON RIVER AT LONG POND	16	3090	2780	2300	4130	5530	2610	1420	1260	1210	1710	2160	3700	2650

I. EXTREMES RECORDED (CFS)

RIVER AND STATION	MAXIMUM FLOWS			MINIMUM FLOWS		
	FLOW	DATE	COMMENTS	FLOW	DATE	COMMENTS
SALMON RIVER AT LONG POND	14,200 cfs	DEC. 26 1954	DRAINAGE AREA = 1,020 SQ. MILES	108 cfs	OCT. 2 1961	PERIOD OF RECORD JULY 1949 TO SEPT. 1965

SUMMARY OF HYDROLOGIC CHARACTERISTICS
CONNE RIVER BASIN

I - SYNTHESIZED DATA

A. ANNUAL MEANS FOR THE TOTAL BASIN

FLOW (CFS)	RUNOFF (CFS/SQ.MI)	RUNOFF (INCHES)	ACTUAL EVAP. (INCHES)
800	2.9	38.7	14.0

B. MEAN MONTHLY FLOWS (Q) AND STANDARD DEVIATIONS (S) (CFS)

RIVER AND LOCATION		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVGE
CONNE RIVER AT BAY D'ESPOIR	Q	945	820	635	1420	1220	590	455	420	490	540	1090	990	800
	S	435	380	420	430	460	237	170	215	286	295	400	345	110
	Q													
	S													
	Q													
	S													

C. MAXIMUM FLOWS (CFS) AND FLOOD VOLUMES (CFS DAY) OBTAINED BY THE MAXIMIZATION PROCEDURE (INSTANTANEOUS PEAKS)

RIVER AND LOCATION	MAXIMIZED RAIN ON SNOW PACK		MAXIMIZED RAIN ONLY		SNOW PACK & AVERAGE RAIN	
	PEAK	VOLUME	PEAK	VOLUME	PEAK	VOLUME
CONNE RIVER AT BAY D'ESPOIR	37,800	148,000	28,800	88,500	10,500	73,000

D. MAXIMUM FLOWS OBTAINED BY STATISTICAL ANALYSIS (CFS) (DAILY AVERAGES)

RIVER AND LOCATION	GENERATED BY SNOW MELT & RAIN		GENERATED BY RAIN ONLY	
	1/10000 YEARS	1/1000 YEARS	1/10000 YEARS	1/1000 YEARS
CONNE RIVER AT BAY D'ÉSPOIR	14,300	11,900	9,500	7,770

SUMMARY OF HYDROLOGIC CHARACTERISTICS
CONNE RIVER BASIN

E. MINIMUM FLOWS OBTAINED FROM RECESSION CURVES (CFS)

RIVER AND LOCATION	1/2 YEARS	1/5 YEARS	1/10 YEARS	1/20 YEARS

F. MINIMUM FLOWS OBTAINED FROM STATISTICAL ANALYSIS (CFS)

RIVER AND LOCATION	1/2 YEARS	1/5 YEARS	1/20 YEARS	1/100 YEARS
CONNE RIVER AT BAY D'ESPOIR	75	40	10	0

G. FULL REGULATION STORAGE

RIVER AND STATION	STORAGE (CUBIC FEET x 10^9)
CONNE RIVER AT BAY D'ESPOIR	27.9

II - RECORDED DATA

H. MEAN MONTHLY AND ANNUAL FLOWS (CFS)

RIVER AND STATION	YEARS OF RECORD	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVGE

I. EXTREMES RECORDED (CFS)

RIVER AND STATION	MAXIMUM FLOWS			MINIMUM FLOWS		
	FLOW	DATE	COMMENTS	FLOW	DATE	COMMENTS

SOUTH COAST RIVER BASINS
AND
BAY D'ESPOIR STUDY AREA

SUMMARY OF WATER QUALITY EXTRAPOLATIONS

	----- Effects of Characteristics on Use for -----								
Location	Fish			Pulp & Paper			Domestic and Raw Water		
	P	C	B	P	C	B	P	C	B
Mouth of White Bear River	+	0	+	+	+	0	+	+	+
Mouth of Burnt Pond River	+	0	+	+	+	0	+	+	+
Mouth of Granite Lake Brook	+	0	0	+	+	0	+	+	+
Mouth of Grey River	+	0	+	+	+	0	+	+	+
Ebbegunbaeg Canal Outlet (Meelpaeg Lake)	+	0	-	+	+	0	+	+	+
Mouth of West Salmon River	+	0	0	+	+	0	+	+	+
Mouth of North Salmon River	+	0	+	+	+	0	+	+	+
Bay D'Espoir Power Canal (Salmon River)	+	0	-	+	+	0	+	+	+
Mouth of Conne River	+	0	+	+	+	0	+	+	+

NOTE

P = Physical Characteristics
C = Chemical Characteristics
B = Biological Characteristics
+
0 = Comparative Ratings
-

See Volume Two for description of Water Quality Extrapolations

TABLE 10-9

SOUTH COAST RIVER BASINS AND BAY D'ESPOIR STUDY AREA

GROUNDWATER POTENTIAL

Hydrogeologic Unit	Mean Well Depth (bedrock)	Estimated Yield Range (gpm)	White Bear (Sq. mi)	White Bear (%)	Grey (Sq. mi)	Grey (%)	Salmon (Sq. mi)	Salmon (%)	Conne plus Bay D'Espoir (Sq. mi)	Conne plus Bay D'Espoir (%)	Total (Sq. mi)	Total (%)
			Approximate Areas in Each Basin									
Bedrock Units:												
R1	159	0 to 40	356	41.5	714*	69.1	442*	40.0	137	12.5	1649	40.3
R4	113	1 to 20	376	43.7	223	21.6	360	32.6	195	17.7	1154	28.2
R5	88	1 to 30	13	1.5	8	0.8	24	2.2	130	11.8	175	4.3
R6	127	1 to 20	114	13.3	88	8.5	278	25.2	639	58.0	1119	27.2
Surficial Units:												
S1		0 to 5	46	5.3	155	15.0	24	2.2	402	44.7	717	17.5
S2		10 to 50	242	28.2	215	20.8	423	38.3	344	31.3	1224	29.9
S3		5 to 50	572	66.5	662	64.2	646	58.5	230	20.9	2110	51.5
S4		50 to 1000	0	0	0	0	11	1.0	34	3.1	45	1.1
S5		Poor quality	94	10.9	13	1.2	23	2.1	12	1.1	142	3.5

* Includes basic igneous rocks which may produce poor quality water.

A detailed discussion of hydrogeology is given in Volume Two.

TABLE 10-10