WATER RESOURCES STUDY

of the

PROVINCE OF NEWFOUNDLAND AND LABRADOR

for

ATLANTIC DEVELOPMENT BOARD

Volume FOUR

NON-WITHDRAWAL WATER DEMAND

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THE SHAWINIGAN ENGINEERING COMPANY LIMITED
JAMES F.MacLAREN LIMITED

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VOLUME FOUR

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Water Resources Study - Newfoundland and Labrador

VOLUME FOUR

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1 HYDRO POWER

Hydro power is, from the economic viewpoint, the most important non-withdrawal water use and will continue to be so over the study period. Recent development has involved diversions representing a consumptive use for the diverted rivers and this has created and intensified a series of water resources problems. Although the economically feasible hydro-electric potential of the Island is almost exhausted, a few large scale possibilities still remain and may be developed in the study period. Changes in the operating regime of existing plants can be expected. The integration of the existing and new hydro-electric developments in the general management of the water resource is, and will remain, one of the most important water resources problems of the Province.

1.1 Hydro Power Potential - General Appraisal

This section presents a general appraisal of potential developments additional to those included in the Planned and Forecast Developments outlined in Section 1.4. The appraisal covers sites which are presently undeveloped and have not previously been investigated by others. Detailed investigations were restricted to the Island of Newfoundland and potential developments generally greater than 30,000 hp, preferably at a single site which would utilize a major proportion of the available head and stream flow. Possibilities of pumped storage power sites have also been investigated in a preliminary way.

Generally, smaller developments which could take advantage of favourable but small head concentrations were not investigated. Recent development of the Island-wide transmission grid system and the overall cost advantages of large-scale power plants will make the majority of small-scale developments relatively uneconomical. Nonetheless, the analyses of gross surface potential and of river gross potential, which were carried out by computer and which are discussed in Section 1.2, can be used for the selection of areas where possibilities for small hydro development exist.

During the course of the investigation, meetings were held with members of the staff of the Newfoundland and Labrador Power Commission to inform them of, and receive guidance on, the general nature of the investigations.

1.1.1 Scope of Work

The investigation covered all areas on the Island of Newfoundland and of Labrador from the viewpoint of surface gross potential using the 1:250,000 scale maps. In addition, an investigation of river gross potential was carried out. The results of these gross potential studies are reported in Section 1.2.

The more detailed investigations were carried out for possible sites on the Island and consisted of office studies of the 1:50,000 scale, 50-foot contour National Topographic Series maps of the areas under consideration to ascertain maximum usable drainage areas and effective head, possible storage sites, best apparent structure layouts for various alternate schemes of development, and an appraisal of their feasibility.

Air photo interpretation was used for schemes that warranted further investigation. However, in keeping with the Terms of Reference of the study, field investigations necessary to enable a detailed study of the more promising schemes were not carried out.

During the course of the work, frequent reference was made to the following reports prepared by ShawMont Newfoundland Limited:

Report No. SM-4-65, May 1965
Report on the Bay D'Espoir Development

Report No. SM-1-66, January 1966
Report on Studies of Hydro-Electric Potential in Central Newfoundland - Part I - General Appraisal

Report No. SM-3-66, June 1966
Interim Report on the Terra Nova Development

Report No. SM-2-67, February 1967
Interim Report on the Upper Salmon Development, Victoria Lake Diversion, Lloyds River Diversion

Report No. SM-4-67, November 1967
Report on Stage II Diversions and Power Development Extensions for Bay D'Espoir Development

1.1.2 Description of Developments Studied

At the beginning of the investigations, an inventory was taken of the existing hydro developments on the Island and of the plans of the Newfoundland and Labrador Power Commission for further expansion. In addition, reports by others on the feasibility of various potential hydro schemes were reviewed to avoid duplication of investigation[3, 4, 5].

The rivers which have their headwaters on the Great Northern Peninsula on the northwest part of the Island were initially investigated as generally these basins had not been investigated by others. Only those sites which showed relative promise of economic development possibilities were investigated in greater detail to obtain "order of magnitude" costs.

The study was then broadened to investigate all other rivers of the Island which have undeveloped sites and which have not previously been reported.

The development data, estimated generation, and order of magnitude costs of the developments are presented in Table 1-1 which presents a comparison of the various developments investigated. In general each development has been designed for a capacity factor of 50 percent as a basis for comparison. However, those developments that showed promise were investigated at various capacity factors, including 60 percent, in order to permit a comparison with the studies covered in ShawMont Report No. SM-1-66. Transmission costs were not included in the comparisons because they will depend on future load and system configurations and because they were not considered essential to these preliminary comparisons.

The general hydrologic studies required for the determination of regulated flows, storage requirements, and flood flows for the various hydro schemes investigated are outlined in Volume Two A of this report.

The economic evaluation of the developments was carried out on the basis of available firm energy. However, the Newfoundland power system will contain some thermal power capacity in the future, and the secondary energy benefits which can accrue from hydro developments could therefore be significant.

1.1.2.1 Upper Humber River
Development No I, Table 1-1

The development envisioned requires a dam located at approximately 49° 36' 00" latitude and 57° 18' 30" longitude on the

Upper Humber River (drainage area 188 square miles) to divert the natural flow and form a reservoir at about elevation 1100. A forebay dyke is located on the same drainage area about five miles to the southeast of the dam. An 11-foot diameter continuous-stave wood pipeline 13,500 feet long connects the forebay intake to the upstream end of a 15,700-foot long steel penstock leading to the powerhouse located near the northwest shore of Birchy Lake with tailwater elevation at about elevation 250. A surge tank is provided for turbine regulation.

Despite the large head developed, the relatively large cost of dams and conduit system and the small drainage area developed combine to produce a 9.7 mill firm energy cost which is not competitive with other sources of energy. Nevertheless, more detailed investigations are recommended because the scheme has considerable peaking potential which, combined with the secondary energy production, could make the scheme more economically attractive.

1.1.2.2 Upper Humber River
Development No. II, Table 1-1

This scheme develops a drainage area of 724 square miles, and requires a main dam located just upstream on the bridge on Highway 1A which crosses the Upper Humber River three miles downstream from Big Falls. Small dykes are required about one mile south of the main dam to contain the full supply level of elevation 250. A relatively short pipeline and penstock system connect the intake to the powerhouse located about 2500 feet downstream of the main dam.

Although this scheme would develop a relatively large drainage area compared to Development No I, the small head available results in a firm energy cost estimated at 9.3 miles at the plant bus bar.

Attempts to increase the head by raising the dam crest were not investigated because of the difficulty in reliably interpreting the topography. However, it is expected that studies based on more detailed topography would indicate a decreased benefit/cost ratio with increased head. Furthermore, this preliminary appraisal ignored the fisheries problems inherent in a hydro scheme on this section of the river, the solution of which would increase the costs. Consequently, the development is not considered competitive at this time, and is not recommended for further investigation.

1.1.2.3 Upper Humber River
Development No. III, Table 1-1

This development involves the diversion of the Upper Humber River into Grand Lake to develop the 250-foot head which exists between Grand Lake and Deer Lake. The scheme envisaged requires a long, low dam across the Humber River just upstream of the bridge which crosses the river near Little Falls on Highway 1A. A side hill canal, which consists of a low homogeneous earthfill dyke, retains water on the uphill side and extends from the east side of the main dam, a distance of about nine miles, along the hillside to Mary Ann Brook which drains into Grand Lake. A spillway is located at the main damsite upstream of the canal. A control structure is located at the canal entrance to regulate the flow from the 734 square mile area into Grand Lake. The cost estimates include an allowance for two additional units at the existing Deer Lake plant with a total additional capacity of 65,000 hp.

Firm energy costs for this development are about 7.6 mills per kwh at a 75 percent capacity factor. At a 50 percent capacity factor, as used in Developments Nos. I and II, the costs would be over 9 mills per kwh.

The disadvantages of this scheme are the problems created by flooding the existing recreational facilities at Sir Richard Squires Memorial Provincial Park and the fisheries problems inherent in a hydro scheme on this section of the river. Furthermore, costs of the development may increase as they did not take into account an allowance for increasing the size of the existing 7-mile-long sidehill power canal which connects the present plant at Deer Lake to Grand Lake reservoir. It is quite possible that modifications to this existing canal would be required but detailed topographic and subsurface data are needed to ascertain if remedial work is required and, if so, the costs of such additional work. Because of the major disadvantages, this scheme is not recommended for further study at this time.

1.1.2.4 River of Ponds
Development No. IV, Table 1-1

This development which takes advantage of existing topographic conditions requires a dam located at 50° 27' 30" latitude and 57° 14' 00" west longitude on the River of Ponds to create a reservoir at elevation 240. Runoff from the 262 square mile drainage area would be diverted from the main river to a point about one mile west of the dam where a 4,000-foot long power canal would lead to an intake dyke. A relatively short penstock would connect to the powerhouse on Pond Lake which has a surface elevation at 40.

The main factor which adversely affects the costs of this development is the relatively high cost of the dam for a scheme of this magnitude. The 10.6 mill cost of firm energy at the plant bus bar is not competitive at this time, and further investigations are not recommended.

1.1.2.5 Southwest Brook
<u>Development No. V, Table 1-1</u>

This development is located on Southwest Brook which has its headwaters in the Long Range Mountains of southwest Newfoundland. The brook drains westward into St. Georges River upstream of Stephenville Crossing.

The scheme envisioned involves the diversion of Southwest Brook into Bottom Brook by the construction of a dam located at 48° 30' 24" north latitude and 58° 12' 00" west longitude, which creates a reservoir with a full supply elevation of 318. A canal, excavated through a height of land separating the drainage areas, is located one mile east of the dam and diverts the flow two miles to the north to a forebay dyke located in the Bottom Brook drainage area.

A short penstock connects the forebay dyke to the powerhouse located on the east bank of Bottom Brook. A tailrace channel is excavated to connect with the main channel of Bottom Brook.

This scheme, developing the flow from 225 square miles, has several advantages tending to reduce costs such as minimum road construction and a relatively inexpensive water conduit system. However, the high cost of the dam required to take advantage of the increased head available from the diversion scheme outweighs the advantages, and results in a 11.9 mill firm energy cost at the plant bus bar. Further investigation of the scheme is not recommended due to high cost and low installed capacity.

1.1.2.6 Great Rattling Brook
<u>Development No. VI, Table 1-1</u>

Great Rattling Brook flows in a northerly direction and joins the Exploits River between Grand Falls and Bishops Falls.

The scheme investigated requires a dam located about two miles upstream of the junction with the Exploits River and a pipeline and penstock leading from the dam to the powerhouse located near the Exploits River. Lack of sufficient head and economical storage facilities makes the development of the 563 square mile drainage area totally uneconomical.

1.1.2.7 Main River
Development No. VII, Table 1-1

The Main River has its headwaters on the east side of the Long Range Mountains of the Great Northern Peninsula. Various schemes of development along the Main River were studied, and the total available head of about 2,000 feet could be partially developed at various locations along the 35-mile length of the river.

The scheme considered to be the most economical requires a dam located on the river to create the required storage for flow regulation as shown on Figures 1-1 and 1-2. A forebay dyke would be located about one mile west of the main dam, and two spillway structures would be situated in the area north and east of the forebay dyke. From the forebay dyke a combination of pipeline and penstocks would lead the water a distance of some five miles to the powerhouse located about two miles from the river mouth. The topography along the selected conduit route was not suitable for the location of a surge tank of reasonable size; consequently a bypass valve was provided for turbine regulation in this preliminary appraisal. However, a surge tank could be located on another conduit route if power system conditions indicated that the resulting improved turbine speed regulation was worth the added cost.

The cost of firm energy of 7.7 mills at the plant bus bar is higher than the cost of energy from competitive sources. However, if a large block of secondary energy is available in an average year, the cost of total energy of the scheme might prove to be competitive with alternative sources. Consequently, the Main River development may be economically feasible under system and market conditions which would allow more of the energy available to be considered as firm. Thus, it should be noted that the scheme might well become attractive at some future date and then warrant more detailed investigations.

1.1.2.8 Star Lake
Development No. VIII, Table 1-1

The development of the Star Lake drainage area for hydro purposes was previously investigated by ShawMont (Report SM-1-66). The scheme was re-evaluated because the recent road construction, which connects the community of Buchans to the Star Lake area, permits a significant reduction in the road costs originally charged to the scheme. To enable comparison with the previous calculations by ShawMont, the scheme was costed at a 60 percent capacity factor using updated cost figures.

The scheme presently investigated would develop a head of about 450 feet between Star Lake and the Lloyds River upstream of Red Indian Lake as shown in Figures 1-3 and 1-4. The small drainage area of Lake of the Hills is diverted into the Star Lake area as an attractive addition to the scheme. All the structures required for the development are of modest size.

Results of the reappraisal indicate a reduction of the firm energy costs by about 10 percent from 7.2 mills to 6.5 mills at the plant bus bar. This scheme is recommended for further studies as it may be economically feasible under market and system conditions which would allow more of the energy to be considered as firm. In addition, the storage of about 7.8 bcf provided by this scheme would result in an increase in the low flows occurring downstream. Consequently, the problems created as a result of the Upper Exploits River diversion to Bay D'Espoir would be significantly reduced. The diversion of the Upper Exploits River is discussed in detail in Volume Six A, Part I.

1.1.2.9 Shanadithit Brook
Development No. IX, Table 1-1

Diversion of the Shanadithit Brook to the Star Lake drainage areas was considered but appeared impractical in ShawMont Report No. SM-1-66. After re-investigating the Star Lake scheme, the possibility of diverting the Star Lake and Lake of the Hills drainage areas to the Shanadithit Brook area was investigated and costed at a 60 percent capacity factor.

The scheme would use a total drainage area of 301 square miles, but the developed head is less than the Star Lake scheme.

Storage facilities would be provided on Star Lake. The structures required for the development are modest in size. The cost of firm energy at the plant bus bar came to 7.4 mills making the scheme less attractive from this viewpoint than the Star Lake scheme.

1.1.2.10 Cat Arm River
Developments No. XA and XB-1 to XB-5, Table 1-1

The Cat Arm River with a total natural drainage area of 324 square miles is located on the east side of the Long Range Mountains in the Great Northern Peninsula. The upper reaches of the drainage area exceed 2000 feet in elevation, and the total area has one of the highest average drainage area elevations on the Island.

The river profile is steeper than that of any river in the vicinity, about 175 feet per mile on the first four miles upstream from the river mouth. In the next seven miles the slope lessens to about 65 feet per mile. At eleven miles from the mouth, the river profile levels out to about twenty feet per mile for a distance of five miles. This section provides the most economical storage site on the entire river length of 26 miles. At mile 16, the slope of the main river profile increases to about 70 feet per mile until the height of land of more than 2000 feet is reached 26 miles from the river mouth.

The Cat Arm River has a natural water fall located near the mouth which presents a barrier to anadromous fish. This barrier precludes a conflict of interest between hydro and fisheries developments.

Several development opportunities exist along the river which had to be investigated in order to select the optimum scheme. In particular, a scheme was investigaged which required a dam to be located on the main river approximately 3.5 miles from the river mouth. A large proportion of the total available drainage area would be controlled, and various combinations of forebay and tailrace elevations are possible. The optimum solution resulted in Development No. XA, Table 1-1. However, less head would be developed and upstream storage facilities would be expensive compared to Development No. XB.

The most attractive scheme investigated on the Cat Arm River - Development No. XB - was initially estimated at a

50 percent capacity factor (Development No. XB-1). Results of the order of magnitude cost appraisal indicated a relatively attractive firm energy cost of 5.4 mills at the plant bus bar. The scheme was then appraised at a 60 percent capacity factor (Development No. XB-2) to permit comparison with schemes reported in ShawMont Report No. SM-1-66. (It is interesting to note that Development No. XB has the lowest cost of firm energy of all schemes considered in this report and in ShawMont Report No. SM-1-66.) The cost effects of increased storage were calculated in Development No. XB-3 to compare with Development No. XB-2. Subsequent calculations (Developments Nos. XB-4 and XB-5) were carried out for lower capacity factors to investigate the effects of varied capacity factors on energy and capital costs per installed horsepower.

Development No. XB requires a storage dam located on the main river as shown in Figure 1-5. The dam, a rock-fill type with a maximum height of approximately 170 feet, would create a reservoir with a full supply level of 1280 feet. A low supply level of 1249 would provide a storage volume of 257,000 acre feet which is required to regulate the flow from the 241 square mile drainage area to a 725 cfs minimum plant outflow.

A short diversion canal, located at the southeast end of the main storage reservoir, would be required to connect the reservoir to a low forebay dyke located at the headwaters of a small stream draining into the salt water of White Bay. From the forebay dyke the regulated flow would pass through a high-level low-pressure conduit of continuous-stave wood pipe for a distance of about 3 miles, thence through a steel penstock for a distance of 1.3 miles to the powerhouse located at tidewater near Devil Cove on White Bay. One surge tank would be provided about 2300 feet from the powerhouse. Preliminary studies indicate that the surge tank required would be large, approaching the size of one of the Bay D'Espoir surge tanks. The average gross head developed would be 1265 feet, more than twice that developed at the existing Bay D'Espoir plant.

The selection of a regulated flow of 725 cfs is conservative, and increased regulated flow could possibly be obtained with the storage contemplated in the estimates or by increasing this storage. Volume Six B, Part VI, dealing with the Cat Arm River basin indicates that the average annual flow is expected to be about 5.4 cfs per square mile or 1300 cfs. Consequently, a regulated flow of greater than 4.0 cfs per square mile or 965 cfs is quite possible with increases in the energy, capacity, and benefit/cost ratio.

The effect on the costs of increasing the storage was investigated. The storage provided in Development XB, 257,000 acre feet (excluding XB-3), supplies a minimum flow of 725 cfs. Development No. XB-3 was estimated in order to determine the cost effect of increasing the storage to 430,000 acre feet. This was considered a severe but possible storage requirement in the initial stages of the study. As shown in Table 1-1, the increase in firm energy cost is from 5.0 to 5.2 mills, or 4 percent between the comparable Developments Nos XB-2 and XB-3. This reflects the fact that the site enjoys storage facilities which could economically regulate the natural flow from the 241 square mile drainage area. Several of the alternative schemes considered did not enjoy this topographic feature.

The effect on the costs of decreasing the capacity factor is investigated in Developments Nos XB-4 and XB-5. The high head to drainage area ratio of the Cat Arm development overcomes the cost disadvantages inherent in the long conduit system, and produces an attractive peaking site from the cost viewpoint relative to other sites on the Island. For example, a Victoria Lake scheme in Report No. SM-1-66 was considered a feasible peaking site, and was estimated at $153 per installed horsepower with a 9.8 mill firm energy cost at a 20 percent capacity factor. Development XB-5 was estimated at $151 per installed horsepower, and had a 6.7 mill firm energy cost at a 30 percent capacity factor. For a comparable 20 percent capacity factor, it is estimated that the cost per horsepower would be reduced to about $137, and the mill cost increased to about 7.5.

The Cat Arm development appears to offer a very attractive alternative to the Terra Nova development already studied in detail by the Newfoundland and Labrador Power Commission. From a comparison with the Terra Nova Development it can be concluded that:

a) The 160,000 hp Cat Arm River development offers a firm energy cost at the plant bus bar of 5.0 mills per kwh compared to 5.4 mills per kwh for the 195,000 hp Terra Nova development. In fact, the firm energy costs of the Cat Arm Scheme are lower than any of the comparable schemes investigated in Reports SM-1-66 and SM-3-66.

b) Lower capital expenditure is required for the Cat Arm River development, \$233/hp vs \$263/hp for the Terra Nova development.

c) The Terra Nova development requires the diversion of rivers which will present barriers to anadromous fish unless expensive remedial works and downstream flows are provided; these were not included in cost estimates. The rivers diverted are the Terra Nova River upstream of Terra Nova village, Northwest River upstream of Northwest Pond, Salmon Brook, the upper reach of the Long Harbour River (Eastern Meelpaeg) and the Upper Pipers Hole River. In contrast, the Cat Arm River development does not involve major river diversions nor does it involve a fisheries conflict as a natural barrier at the river mouth has precluded an anadromous fishery.

d) The Terra Nova development lies partly within a National Park and is located in an area which is valuable for recreational purposes. There is a distinct possibility of conflicts in use of the water resource with recreation and forestry as well as fisheries and water sport activities. The Cat Arm River is located in virgin territory which is uninhabited, and problems of conflict in use of water resources are not foreseen.

The above comparison indicates that the Cat Arm River scheme, on the basis of the present appraisal using existing data, is worthy of a more detailed study to determine its potential as it compares favourably in many respects with hydro schemes undeveloped on the Island.

1.1.3 Pumped Storage

The possible direct current infeed to the Island from the Churchill Falls plant in Labrador or the extensive use of thermal energy at a high load factor will create a need for sources of peaking power on the Island. Consequently, the possibility of pumped storage hydro-electric power as a source of peaking power was investigated, although it is recognized that a pumped storage peaking source will not be practical for the Island in the near future.

The map of gross surface potential (Section 1. 2. 1) of the Island was used as a preliminary indication of the pumped storage potential. The 1:50, 000 scale topographic maps were then scrutinized to locate suitable sites in the areas of high gross surface potential. Several possible sites have been located where suitable upper and lower reservoirs could be developed. Further discussion is limited to what appears to be the most attractive site which is approximately 55 road miles from Deer Lake, just north of Bonne Bay on the Great Northern Peninsula as shown in Figure 1-6.

The lower reservoir, Western Brook Pond, has a surface area of 8. 8 square miles at elevation 80 (Figure 1-7). The upper reservoir is an unnamed lake which drains into the northeast end of Western Brook Pond. This reservoir has a natural surface area of 0. 3 square miles, a drainage area of 3. 4 square miles, and is at elevation 1, 575. The gross head is approximately 1, 500 feet and the scheme envisaged would require a penstock approximately 4, 300 feet in length. With the large head available, approximately 300, 000 hp can be developed without creating severe drawdown conditions on the upper reservoir, depending on the capacity factor chosen.

Further investigation would be necessary to ascertain the cost of development of the sites.

1. 1. 4 Development Cost and Benefit Assumptions

The cost estimates shown in Table 1-1 are based on 1967 prices, and do not take into account transmission lines or losses. Thus, the cost of power presented is the cost at the plant bus bar.

It is emphasized that the costs are "order of magnitude" only, and may undergo appreciable changes when the developments are studied in more detail. However, care has been taken to ensure that similar unit costs, basic parameters, and concepts were used throughout, making the data presented adequate for comparative purposes. The basic parameters and concepts used throughout the study were kept identical to those used by ShawMont in Report No. SM-1-66; consequently, comparison of the results of the two studies is possible.

Generally, all the schemes in this study were estimated at a 50 percent capacity factor. Schemes that were attractive enough to offer economical alternatives to those in Report No. SM-1-66 were appraised at 60 percent capacity factor to allow direct comparison of the schemes.

Annual fixed charges of 6.73 percent were assumed for this study in order to afford comparison with the ShawMont studies, although it is recognized that the charges are about 0.5 percent higher at the present time. This increase in the annual fixed charges has the effect of increasing the firm energy costs by about 6 percent.

It is stressed that the costs of energy shown in Table 1 - 1 are firm energy only. Secondary energy benefits, which may amount to as much as 20 percent of the firm energy, have not been calculated for the schemes investigated. Hence, the cost of total energy will be reduced below the firm energy costs shown in Table 1 - 1.

The estimates do not include the cost of clearing flooded areas, or those costs related to other uses of the water resources. For example, facilities and storage releases required for migrating fish and logging operations are not included in the costs of the schemes investigated.

Generally, all schemes investigated could be partially or fully commissioned within two years from the start of construction. However, because of the relative inaccessibility of the Cat Arm scheme, completion of the main construction in a two-year period would probably require the completion of the major portion of the access roads prior to the start of the main construction. Due to the large dam volumes required for the Main River development No. VII, a three-year construction period was considered necesaary and the interest costs during construction were increased accordingly.

The location of the schemes listed in Table 1 - 1 are shown in Figure 1 - 8.

1.2 Gross Hydro Power Potential

1.2.1 Gross Surface Hydro Power Potential

As mentioned in Section 1.1, the gross surface hydro power potential was calculated using the computer for each square in the grid system for the entire Island of Newfoundland and for that part of Labrador lying south of 56°-30' north latitude.

The gross surface hydro power potential is the mean gross annual capacity that could be theoretically installed from the total of the mean annual runoff and the mean gross head available in each square grid. This evaluation assumes complete regulation of the natural surface runoff, complete utilization of the mean gross head, 100 percent efficiency, as well as 100 percent utilization of the plant.

The formula derived for the calculations is as follows:

$$P_i = (S_i \times L \times R_i \times A_i) \Big/ \left[2 \times F(Az_i)\right]$$

where P_i = gross surface potential in each square

S_i = slope of square

R_i = runoff in each square

A_i = area of land in each square = (area of square - area of sea)

L = length of side of square

$F(Az_i)$ = function of azimuth of square depending on octant of azimuth

Figures 1-9 and 1-10 indicate the square grid distribution of gross surface potential for the Island and for part of Labrador respectively. As shown in Figure 1-9, the highest surface potential on the Island lies in areas where high precipitation and steep surface slopes combine to produce advantageous conditions for hydro-electric development such as the west coast area, the Grand Lake area, and part of the south coast. These areas are possible sites for pumped storage or small scale hydro-electric developments. Investigation of the 1:50,000 scale maps indicated favourable topographic conditions which may enable the economical development of pumped storage sites in several of the high gross surface potential areas including the Western Brook Pond area and the Grand Lake area.

Figure 1-10 indicates that the highest gross surface potential areas are located in the north, central, and eastern parts of Labrador. The flat plateau upstream of the Churchill Falls has, as would be expected, poor surface potential.

1.2.2 Gross River Hydro Power Potential

The gross hydro power potential along the main river stem was calculated for the selected river basins on the Island and for all river basins of greater than 500 square miles in Labrador which are located south of the Harp Lake drainage area. The Harp Lake basin and those basins further to the north of Labrador which have areas of greater than 500 square miles were not assessed for a gross potential due to a lack of suitable topographic maps.

The unit gross potential is the mean gross capacity that could be theoretically installed from the total of the mean annual runoff and the mean gross head available between two given adjacent points on a river profile. This evaluation assumes complete regulation of the natural surface runoff, complete utilization of the mean gross head, 100 percent efficiency as well as 100 percent utilization of the plant. The gross river hydro power potential is an accumulation of the unit gross potential for the entire main river stem. It should be noted that the gross river hydro power potential refers to that available from the head and flow on the main river stem in question and does not include the potential available from the head existing on tributaries to the main stem or the potential available from flow that could be diverted from outside the natural basin area. For example, as shown in Table 1 - 3, the cumulative gross potential along the main stem of the Churchill River is 4400 Mw. Also included in the table is the gross potential along the main stem of several large tributaries to the Churchill River, that is, the Fig, Munipi, and Metchin Rivers. The gross river potential of the Churchill basin would include the sum of the potential along the main stems of the Churchill, Fig, Munipi, Metchin, and all the other main stem tributaries.

The formulas used to calculate the river potential are as follows:

a) $$S = \frac{H_1 - H_2}{L_1 - L_2}$$

b) $$P = \int_0^L S \times Q \times dL$$

where $H_1 - H_2$ = difference in elevation of two given adjacent plants along river

$L_1 - L_2$ = distance between two points

S = slope of river between points

Q = discharge at given points along river

L = length of river

P = hydro-electric gross potential

Results of the gross river hydrc-electric potential for the selected Island river basins are given in Volume Six which describes the selected river basins. The 1:250,000 scale maps were utilized in the gross river potential studies.

Table 1-2 summarizes the gross river potential studies for the rivers in the Island.

As shown on the table, the Exploits River has the largest hydro potential on the Island followed by White Bear, Upper Humber, and Cat Arm Rivers. The Terra Nova River has a relatively low potential along its main stem. However, detailed studies by ShawMont have shown that the optimum utilization of the available sites in the Terra Nova basin depends on the diversion of several adjacent rivers. In a similar manner, detailed studies have shown the advantages of combining the flow of the upper Exploits, White Bear, Grey, and Salmon Rivers to utilize the head available near the mouth of the Salmon River. The gross river potential studies indicate that the Gander, Pipers Hole, and Conne Rivers have a low potential along their main stems, and detailed studies by ShawMont and others have confirmed the fact that diversions into these river basins are not economical as attractive development sites do not exist in these basins.

However, diversion of part of the flow out of the Pipers Hole basin forms part of the proposed Terra Nova development.

Detailed studies in other than the Churchill River basin to determine economically exploitable potential of rivers in Labrador were not available. Consequently, the gross river hydro-electric potential studies carried out for Labrador rivers represent an attempt to appraise the size of the undeveloped hydro-electric potential in Labrador.

There are uncertainties incorporated in the Labrador studies due to lack of flow and topographic data. For example, several of the rivers for which gross river hydro-electric studies were completed have not been gauged and flow data used was that obtained in the average annual runoff studies outlined in Volume Two. Maps of 1:50,000 scale with 50-foot contour intervals are generally not available except in the Churchill basin area. In addition, even the 1:250,000 scale coverage of Labrador is incomplete and some of the maps of this scale have contour intervals of 200 feet instead of the usual 100-foot intervals. Consequently, these gross river hydro-electric potential studies should be considered as a first approach only. More detailed surveys are required to determine the optimum economically exploitable sites and the possibilities resulting from inter-basin diversions.

Table 1 - 3 summarizes the cumulative gross potential of the Labrador rivers studied. As indicated, the four rivers with the largest natural potential are the Churchill, Naskaupi, Eagle, and Canairiktok. Figure 1 - 11 indicates the unit gross potential along the main river stem of the Churchill River. As shown, the Churchill Falls site has the highest unit gross potential along the river. The diverted flows from the neighbouring Naskaupi and Canairiktok Rivers are not included in these studies as mentioned previously. In addition, the inter-basin diversion of the Julian and Atikonak (Unknown) Rivers to the Churchill Falls site are not reflected in the unit gross potential at the Falls, as these rivers do not flow over the Falls. However, using the data available from the studies, the additional gross potential available from these diversions at sites along the main stem of the Churchill River can be calculated. Figures 1 - 12 to 1 - 14 indicate the unit gross potential available on the main stems of the Naskaupi, Eagle, and Canairiktok Rivers respectively.

Tables 1 - 4 to 1 - 7 indicate the flow variation, unit gross potential, cumulative gross potential, and the river profile of the other Labrador rivers studied.

1.3 Present Day Development

1.3.1 Island of Newfoundland

Electricity was first generated on a large scale early in the century by two large pulp and paper companies for their own consumption at a high annual load factor. These facilities were extended over the years to supply the commercial and industrial loads in their immediate vicinities[1, 2].

The first of the two companies, a predecessor of Price (Nfld) Pulp and Paper Limited, built a hydro plant at Grand Falls on the Exploits River. This plant developed the flow from a drainage area of 3650 square miles; this is the largest area developed for a hydro plant on the Island (Table 1 - 8). The available head and flow on this river were not fully utilized, presumably because of the incremental stages by which the plant capacity was increased to meet the load growth.

The principal storage reservoir was developed at Red Indian Lake 50 miles upstream of the main plant. Lack of adequate pondage exists at the plant and this causes wastage of water due to the variation in natural flow between the storage and plant site.

In addition to the hydro-electric station at Grand Falls, hydraulic turbines directly connected to grinders were initially installed at Bishop's Falls near the mouth of the Exploits River. Pulp was ground and transported up to Grand Falls by pipeline. In 1953 this plant was converted to a generating plant by the installation of generators on the existing turbines.

The second company, a predecessor of Bowaters Newfoundland Limited, constructed a hydro plant in 1925 at Deer Lake on the Humber River. The plant effectively used the available head and the flow from a drainage area of 1942 square miles and ultimately reached a capacity of 170,000 horsepower. The main storage reservoir of Grand Lake is connected to the intake by a seven-mile power canal, and is sufficiently large to provide a high degree of regulation with little wastage of water.

The pulp and paper mill was built at Corner Brook, 35 miles from the hydro station.

At the end of 1964 these two companies accounted for 60 percent of the Island's generating capacity.

Generation for domestic loads outside of the area of the large industries took place near the larger centres of population, and electricity was retailed by small companies servicing their immediate areas. The inability of these small companies to secure the capital required for expansion and development led to their acquisition by larger companies - the Newfoundland Light and Power Company Limited, United Towns Electric Company Limited, and their wholly owned subsidiary, West Coast Power Company, and the Union Electric Light and Power Company. These larger companies were amalgamated in 1966 into one company known as the Newfoundland Light and Power Company Limited. The domestic distribution systems of the large industries were acquired in the 1950's by the Newfoundland Light and Power Company Limited.

The growth of power generation and transmission on the Island was not co-ordinated on a Provincial scale until recently. In most cases, local blocks of power were developed near the load centres and sized accordingly. Table 1-8 shows that, except for the pulp and paper companies, the plants serving domestic loads are extremely small - averaging about 5,000 horsepower capacity and developing drainage areas generally less than 50 square miles. As late as 1966 there were no major interconnections between the widely separated load areas and transmission lines were relatively short.

The western and central sections of the Island became the largest industrial users. Two 50 cycle frequency areas resulted from British interests in the initial paper mill developments at Corner Brook and Grand Falls. The balance of the Island's system was at 60 cycles, centered mainly on the Avalon Peninsula with five other independent areas operating on this frequency. These are:

Bonavista Peninsula
Grand Falls - Gander - Bonavista North Area
Burin Peninsula
Stephenville - Port-au-Port Area
Port aux Basques Area

The Newfoundland Power Commission was originally established by an Act of the Provincial Legislature in 1954 (The Newfoundland Power Commission Act), and was replaced in 1965 by new legislation covering the Newfoundland and Labrador Power Commission (Newfoundland and Labrador Power Commission Act No. 20). The Commission is charged with the responsibility and obligation of developing the power resources of the Island.

By 1964 several of the major power companies on the Island were operating above their firm energy capability. The several systems, which then operated independently of each other, were actually overextended, and the Island faced a power shortage. In addition, the Provincial authorities were attracting new industries to raise the level of economic activity which, prior to Confederation, had required only a small amount of electric power. The Power Commission was thus confronted with the necessity of meeting the exceptionally large load increases, and two major projects requiring a total capital expenditure of $87,000,000 were undertaken.

One project was the construction in 1965 - 67 of an Island-wide transmission grid which basically consists of a 230 kv "backbone" running west to east with 138 kv extensions. The grid permits the interconnection of all the existing generating sources and enables reserve power and energy to be shared. The establishment of the network was complicated because approximately 60 percent of the existing generation was at the European frequency of 50 cycles. The 50 cycle system has been reduced and progressive conversion to the standard North American 60 cycle frequency has been implemented. All future expansion on the Island will be at 60 cycles.

The other project was the construction of a large hydro-electric development known as Bay D'Espoir Stage I which utilizes part of the drainage areas of the Salmon and Grey Rivers in the south-central part of the Island. The unique topography of the area permits a concentration of close to 600 feet of head to be developed. Abundant rainfall and low evapotranspiration losses permit an average runoff of about 3.0 cfs per square mile. Despite these natural advantages, the scheme requires diversions to develop its maximum potential since its natural drainage area is too small to support a large hydro development. This condition is typical of rivers on the Island.

By the middle of 1967, a capacity of 300,000 horsepower with firm energy of approximately 1.3 billion kilowatt hours a year was installed at this plant. This development represented an immediate increase of 70 percent in the available power and energy, and was tied in with the Island's high voltage grid.

Construction on the next major project began in the summer of 1967, and is an extension of the Bay D'Espoir development to include the diversion of the headwaters of the White Bear, Lloyds, and Victoria Rivers. (The diversion of the Lloyds and Victoria Rivers which are the headwaters of the Exploits River adversely affects the hydro plants of Price (Nfld) Pulp and Paper Limited at Grand Falls and Bishop's Falls, and the reduced minimum flows create problems for the anadromous fish in the Exploits River. These and other problems caused by the diversion are discussed in Volume Six A, Part I, dealing specifically with the Exploits River basin.) The project will increase the capacity of the plant to 600,000 horsepower; it is expected to require an expenditure of about $80,000,000, and to be completed by 1969. In addition to the second stage of Bay D'Espoir, the Power Commission is continuing the extension of the transmission line grid.

Hydro power is now being generated by the following groups:

a) The Newfoundland and Labrador Power Commission (NLPC) operates the Bay D'Espoir development which is expected to have an ultimate capacity of at least 600,000 horsepower.

b) The Bowater Power Company Limited (BPCL) operates two hydro plants with a total capacity of 182,000 horsepower.

c) The Newfoundland Light and Power Company Limited (NLPCL) operates 22 small plants with an average capacity of approximately 5100 horsepower and a total capacity of 112,000 horsepower.

d) Price (Nfld) Pulp and Paper Limited (PNL) operates two hydro plants on the Exploits River which have an installed capacity of 65,800 horsepower, Hydraulic power to operate grinders accounts for another 22,000 horsepower.

e) Two mining companies operate three small hydro plants with a total capacity of 3600 horsepower*. In June 1968 these plants were purchased by the Newfoundland and Labrador Power Commission who now operate them. They are the American Smelting and Refining Company Limited (ASARCo) and the First Maritime Mining Corporation Limited (FMMCL), and have operated the plants over the years for their own use. The plants are not connected to the Provincial grid.

Table 1 - 8 outlines the features of the existing hydro-electric developments on the Island and Figure 1 - 8 shows their locations.

1.3.2 Labrador

In contrast to the Island, hydro power has only recently been developed in Labrador. Only two hydro sites have been established and they are for the use of mining companies that commenced production

* In June 1968 these plants were purchased by the Newfoundland and Labrador Power Commission who now operate them.

in the mid-1950's. Hydro power is now being generated by the following groups:

a) The Iron Ore Company of Canada (IOCo) has operated the Menihek hydro plant since 1954. The total capacity of the plant is 25,000 horsepower.

b) The Twin Falls Power Corporation Limited (TFPCo) operates a hydro plant which was expanded in October, 1968, to give a peak output of approximately 358,000 horsepower. The current installation of a fifth unit is required for the construction of the Churchill Falls development. After completion of the Churchill Falls development, the Twin Falls development will be used for standby purposes only.

Construction has commenced on the Churchill Falls project which has an immense hydro potential of about 7,000,000 horsepower. The plant is expected to commence operation by 1972.

Table 1 - 9 outlines the features of the hydro developments in Labrador and Figure 1 - 15 shows their locations.

1.4 Planned and Forecast Developments

This sub-section summarizes hydro-electric developments which are under construction and assumptions with respect to power load and power supply provided by the Board.

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.

The Bay D'Espoir Stage II development, which is under construction, is aimed at adding energy and capacity to the system in stages so as to help meet the demand estimates for electric power up to January 1, 1972. Energy generation at the plant high voltage bus by the Stage II development is expected to total 1082×10^6 kwh. Three 100,000 hp units are being installed in the Stage II power extensions.

The diversions involved in the development - the Lloyds River, Victoria River, and White Bear River - are situated southwest of the geographical centre of the Island of Newfoundland. A general plan showing the drainage area locations is shown in Volume Six A, Figure 10 - 5.

The Lloyds and Victoria Rivers are situated in the headwaters of the Exploits River which flows in a northeast direction to reach the north sea coast of the Island. By completing the diversion of the Lloyds and Victoria Rivers, the runoff will ultimately flow into the sea on the south coast at Bay D'Espoir.

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 immediately south of Victoria Lake which 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 the two streams will result in the runoff ultimately flowing into the sea at Bay D'Espoir.

The Lloyds River diversion is the farthest upstream diversion and lies immediately to the west of the Victoria River basin and at the south end of the Annieopsquotch Mountain Range. It will divert the flow of 184 square miles of drainage area which lies upstream of the outlet of King George IV Lake.

The diversion will be a simple uncontrolled scheme without provision for water storage. Consequently, the associated structures are limited to a dam, spillway, and diversion canal cut through the height of land to conduct the water into the Victoria River basin.

Construction of this diversion was scheduled to commence in the summer of 1968, but according to recent advice from the Newfoundland and Labrador Power Commission has been postponed. However, this diversion is very attractive from a hydro-electric cost viewpoint, and downstream facilities have been sized to accommodate flow from this area and it is likely that construction will eventually proceed.

The Victoria River diversion will divert the flow from the Victoria River watershed from a site near the present outlet of Victoria Lake, amounting to an area of 408 square miles, into the White Bear drainage basin. The water diverted from the Lloyds River diversion will also be conducted through the Victoria River diversion. In addition, the water flow through Victoria Lake will be regulated by the effect of the storage reservoir provided in this diversion.

As with the upstream diversion, this diversion will be accomplished by a dam to raise the water level in the existing lake, a canal through the height of land, and a spillway structure. The one difference is in the gated concrete control structure which will be built in the canal to regulate the outflow.

The White Bear diversion of 456 square miles serves to divert the headwaters of the White Bear River which are the 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 into the same reservoir.

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. 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 in the Burnt Pond Dam and on Granite Lake.

Construction of the White Bear and Victoria River diversions is expected to be completed by December 1969.

In addition to Stage II of the Bay D'Espoir project, two 150 Mw oil-fired thermal units will be located at Holyrood to meet the demand estimated for electric power up to January 1972.

Although detailed studies of power developments in Labrador were outside the scope of this report, it is likely that the lower Churchill river sites offer competitive potential sites if large blocks of power and firm energy are required in the Province. On the other hand, it is probable that peaking capacity for the Island can be obtained more economically from undeveloped sites on the Island by pumped storage schemes or by increasing the capacity of existing developments. It is considered that the existing Bay D'Espoir development is a possible site for competitive capacity increase, although changes in the operation of other existing hydro plants which operate as base plants may be feasible. Due to high operating and maintenance costs of older plants on the Island, some of the existing smaller plants may be abandoned and redevelopment of the Grand Falls power plant is a possibility during the study period.

In view of the above considerations, the following assumptions on the future development of the electric energy potential of the Province were indicated by the Board:

May 1972	- First Churchill power block	- 360 Mw
September 1974	- Second Churchill power block	- 360 Mw
November 1976	- Third Churchill power block	- 360 Mw
November 1979	- Units 7 and 8 at Bay D'Espoir	- 225 Mw
November 1981	- Fourth Churchill power block	- 360 Mw
November 1984	- Units 9 and 10 at Bay D'Espoir	- 225 Mw
November 1987	- Fifth Churchill power block	- 360 Mw
November 1991	- Sixth Churchill power block	- 360 Mw
November 1992	- First 500 Mw nuclear unit located at Come By Chance	
November 1994	- 300 Mw peaking capacity from undeveloped local hydro or gas turbines	
November 1996	- Second 500 Mw nuclear unit located at Come By Chance	
November 1998	- 300 Mw peaking capacity from undeveloped local hydro or gas turbines	
November 1999	- Third 500 Mw nuclear unit located at Grand Falls	

These assumptions indicate that no major new hydro-electric development is likely to occur on the Island over the study period except for that already under construction. However, under these assumptions, the undeveloped hydro sites on the Island may be used for peaking plants. Consequently, the pumped storage and high head schemes investigated in Section 1.1 may provide economic development alternatives.

REFERENCES

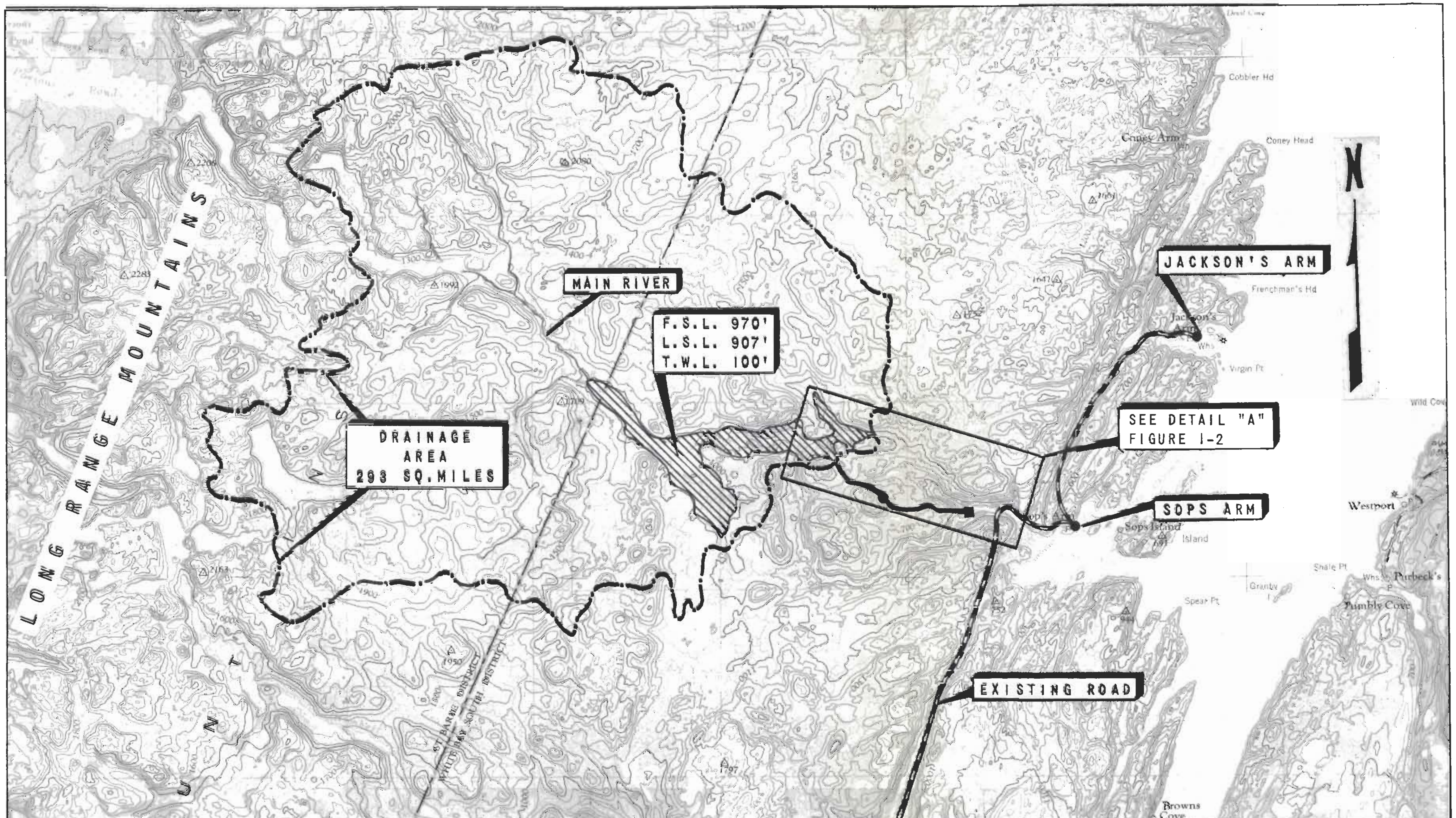
1 Presentation to The Royal Commission on Electrical Power and Energy by Newfoundland and Labrador Power Commission, St. John's, Newfoundland, July, 1965.

2 Report of The Royal Commission on Electrical Energy, Government of Newfoundland and Labrador, February, 1966.

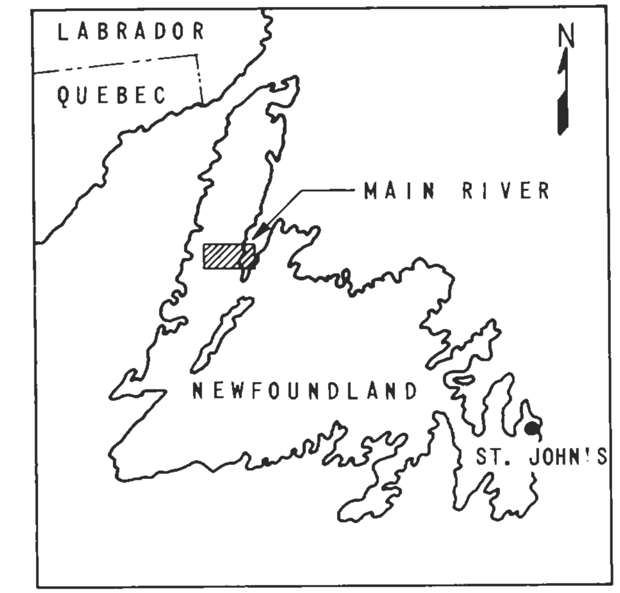
3 The Shawinigan Engineering Company Limited. Report on Proposed Power Development at Hinds Lake for The Bowater Power Company Limited, 1957.

4 The Shawinigan Engineering Company Limited. Report on Proposed Power Development of the Corner Brook River for The Bowater Power Company Limited, 1955.

5 The Shawinigan Engineering Company Limited. Report on Proposed Power Development at Little Grand Lake for The Bowater Power Company Limited, 1959.



GENERAL PLAN



KEY PLAN

LEGEND

DRAINAGE AREA OUTLINE

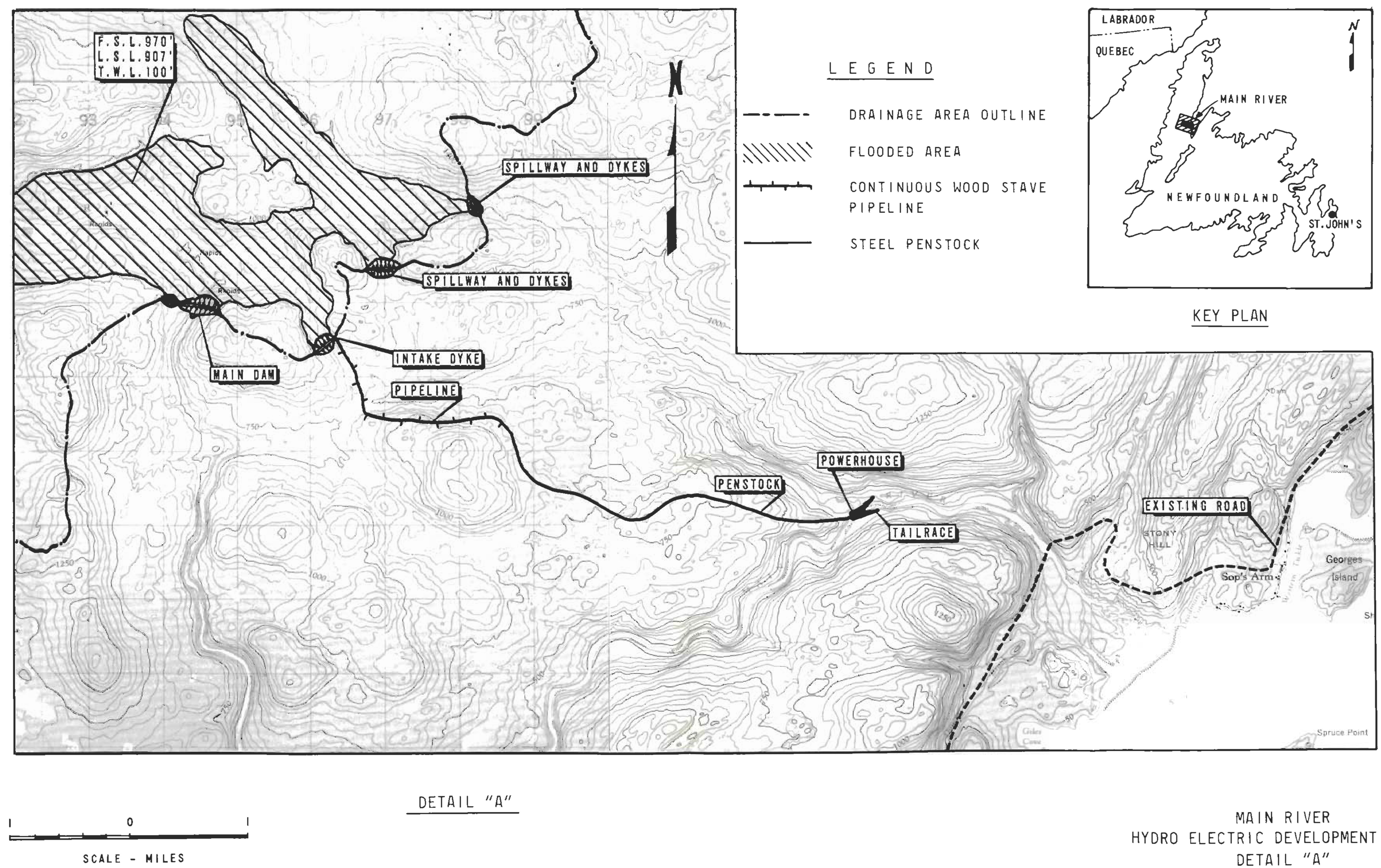
FLOODED AREA

5 0 5
SCALE - MILES

MAIN RIVER
HYDRO ELECTRIC DEVELOPMENT NO.VII
GENERAL PLAN

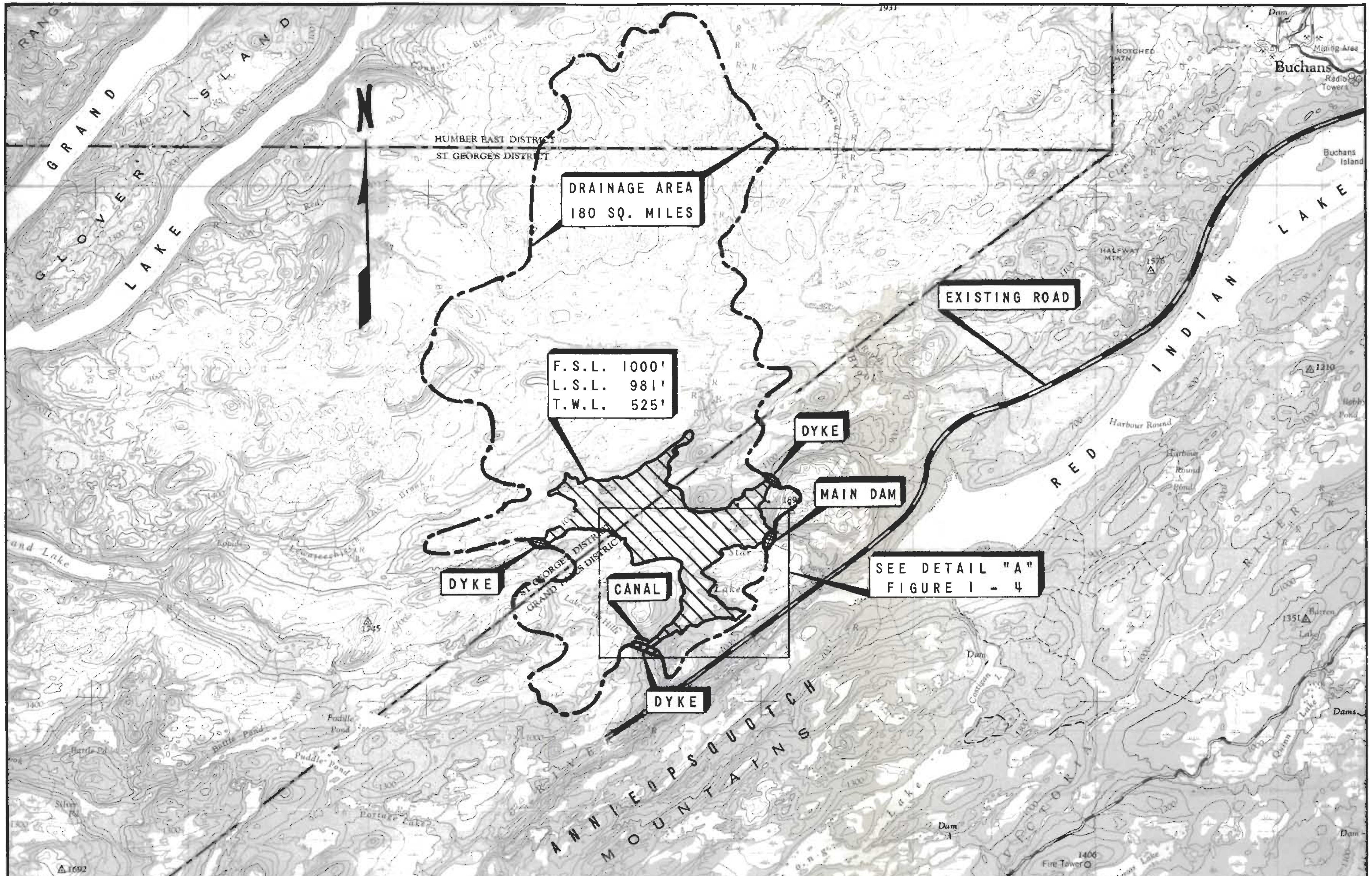
FIGURE 1-1

The Shawinigan Engineering Company Limited
James F. MacLaren Limited



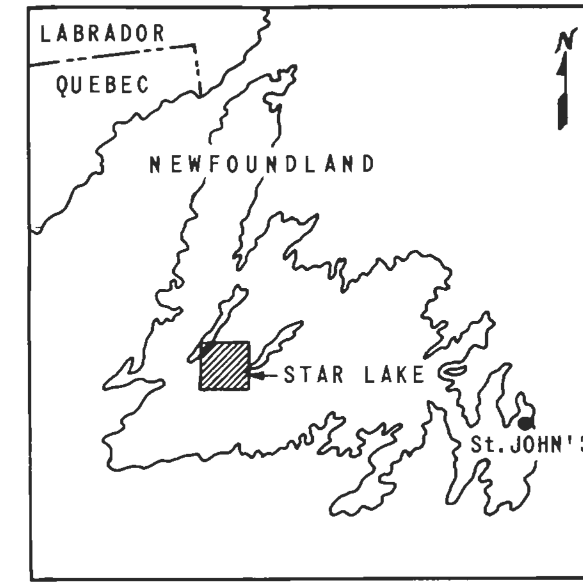
MAIN RIVER
HYDRO ELECTRIC DEVELOPMENT NO. VII
DETAIL "A"

FIGURE 1-2



GENERAL PLAN

5 0 5
SCALE - MILES



KEY PLAN

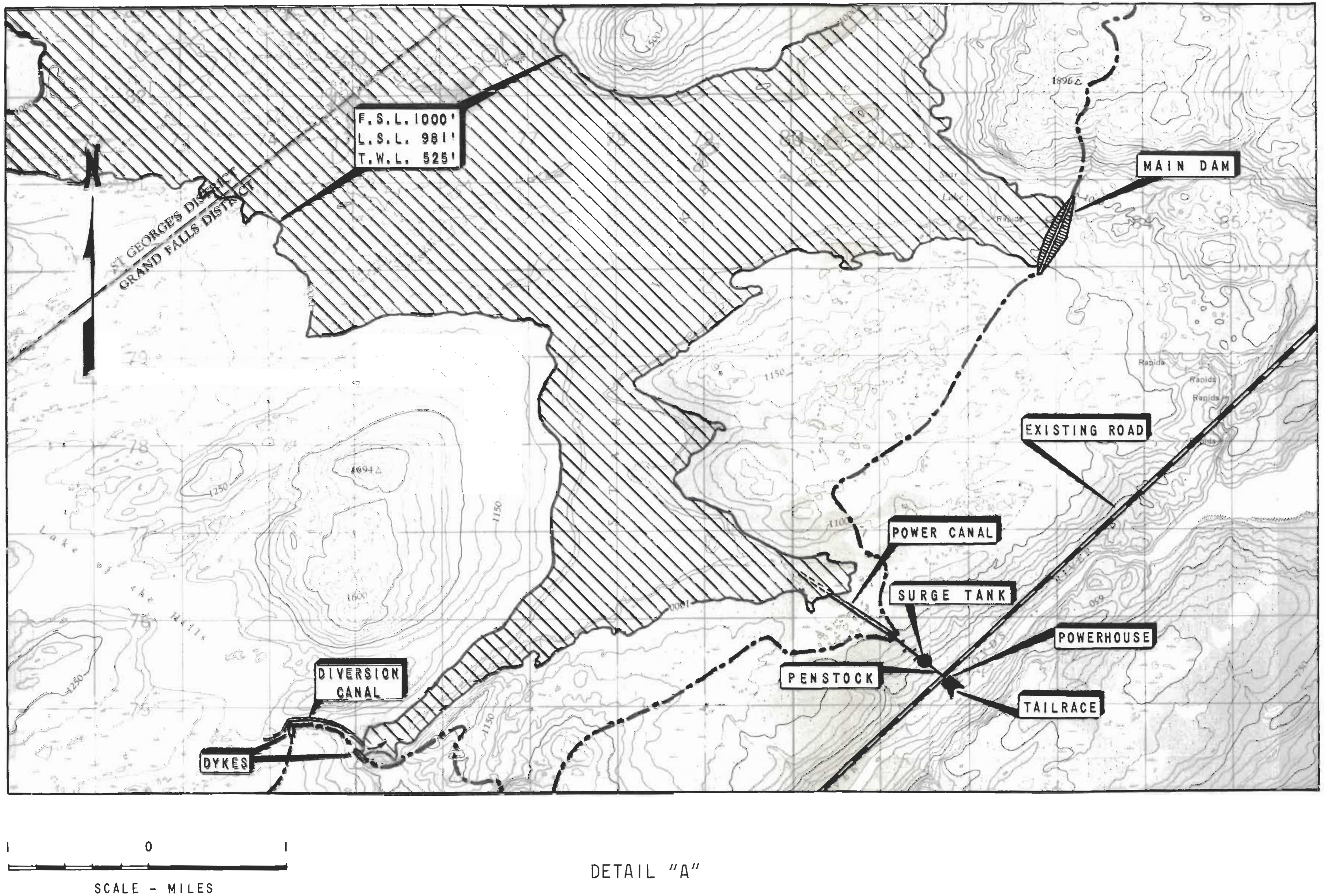
LEGEND

DRAINAGE AREA OUTLINE

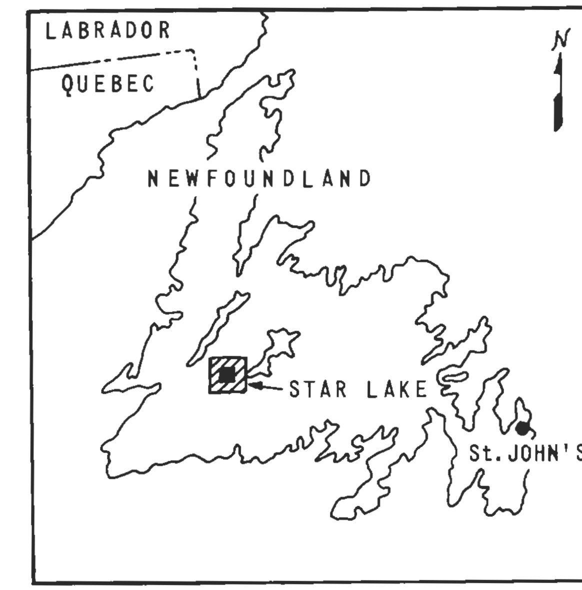
FLOODED AREA

STAR LAKE
HYDRO ELECTRIC DEVELOPMENT NO. VIII
GENERAL PLAN

FIGURE 1-3



DETAIL "A"



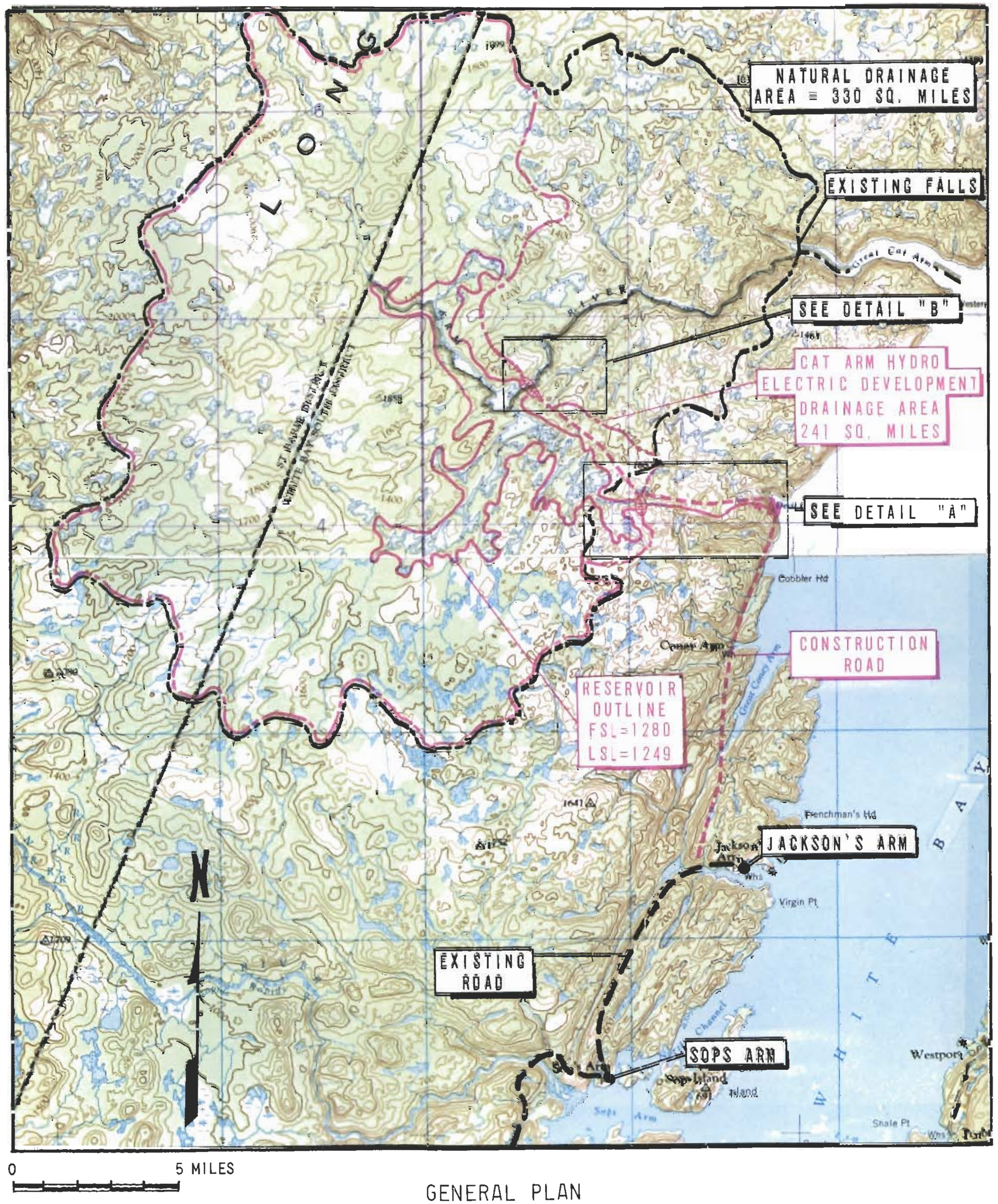
KEY PLAN

LEGEND

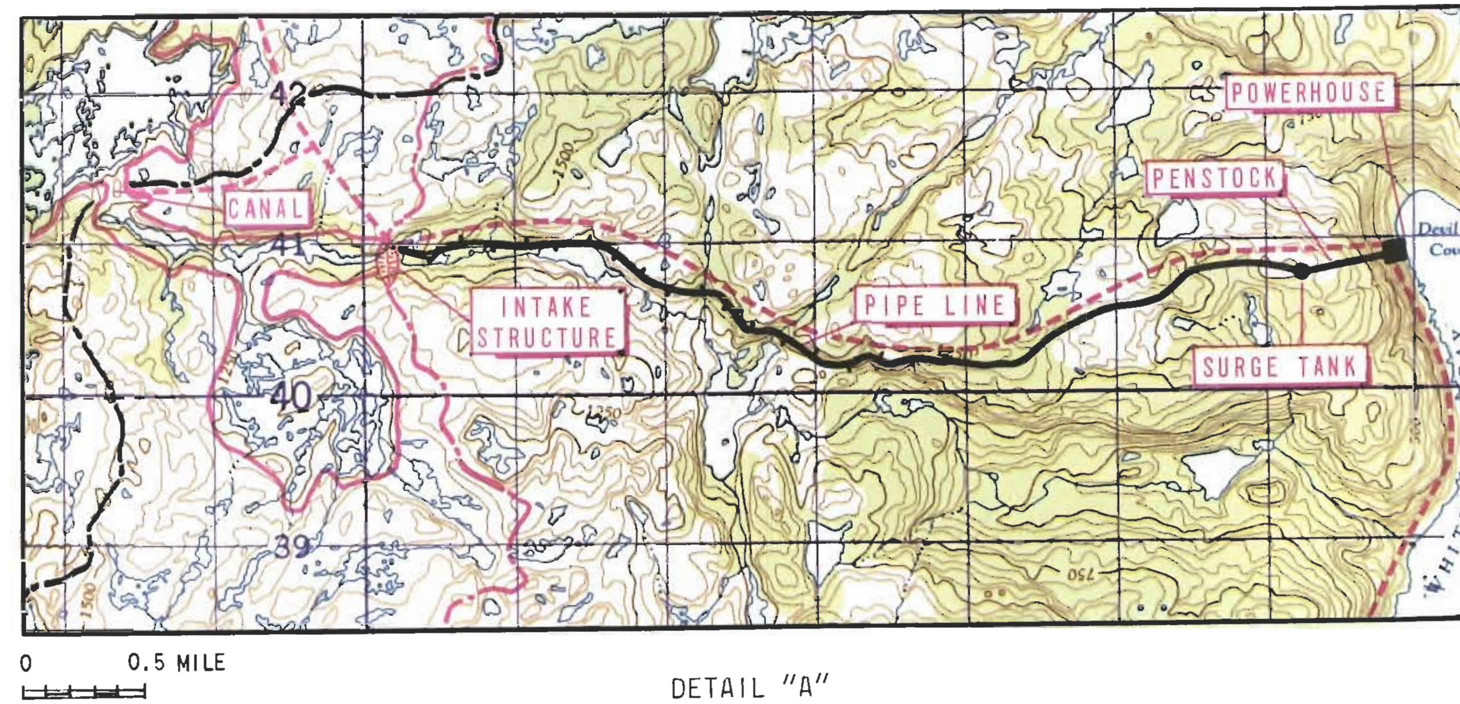
- DRAINAGE AREA OUTLINE
- FLOODED AREA
- CONTINUOUS WOOD STAVE PIPELINE
- STEEL PENSTOCK

STAR LAKE
HYDRO ELECTRIC DEVELOPMENT NO. VIII
DETAIL "A"

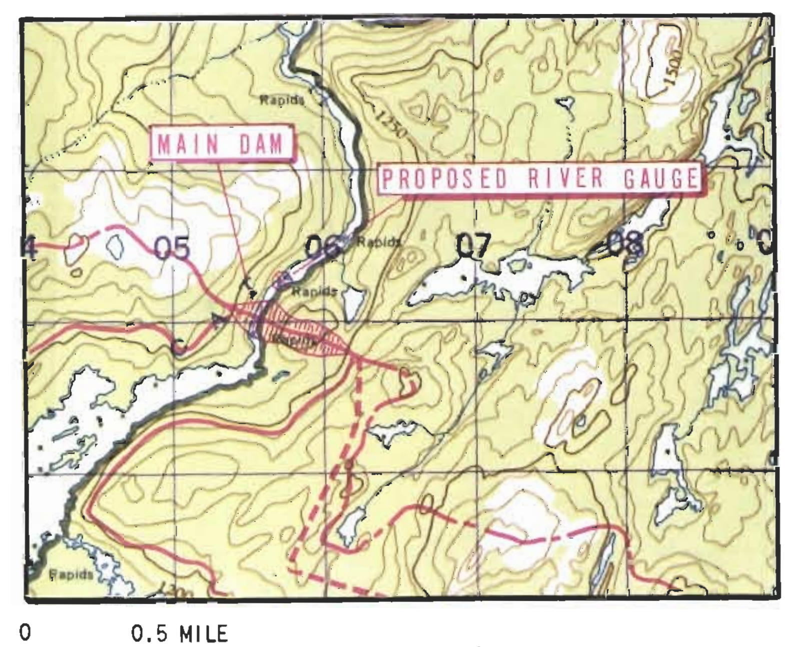
FIGURE 1-4



GENERAL PLAN



DETAIL "A"



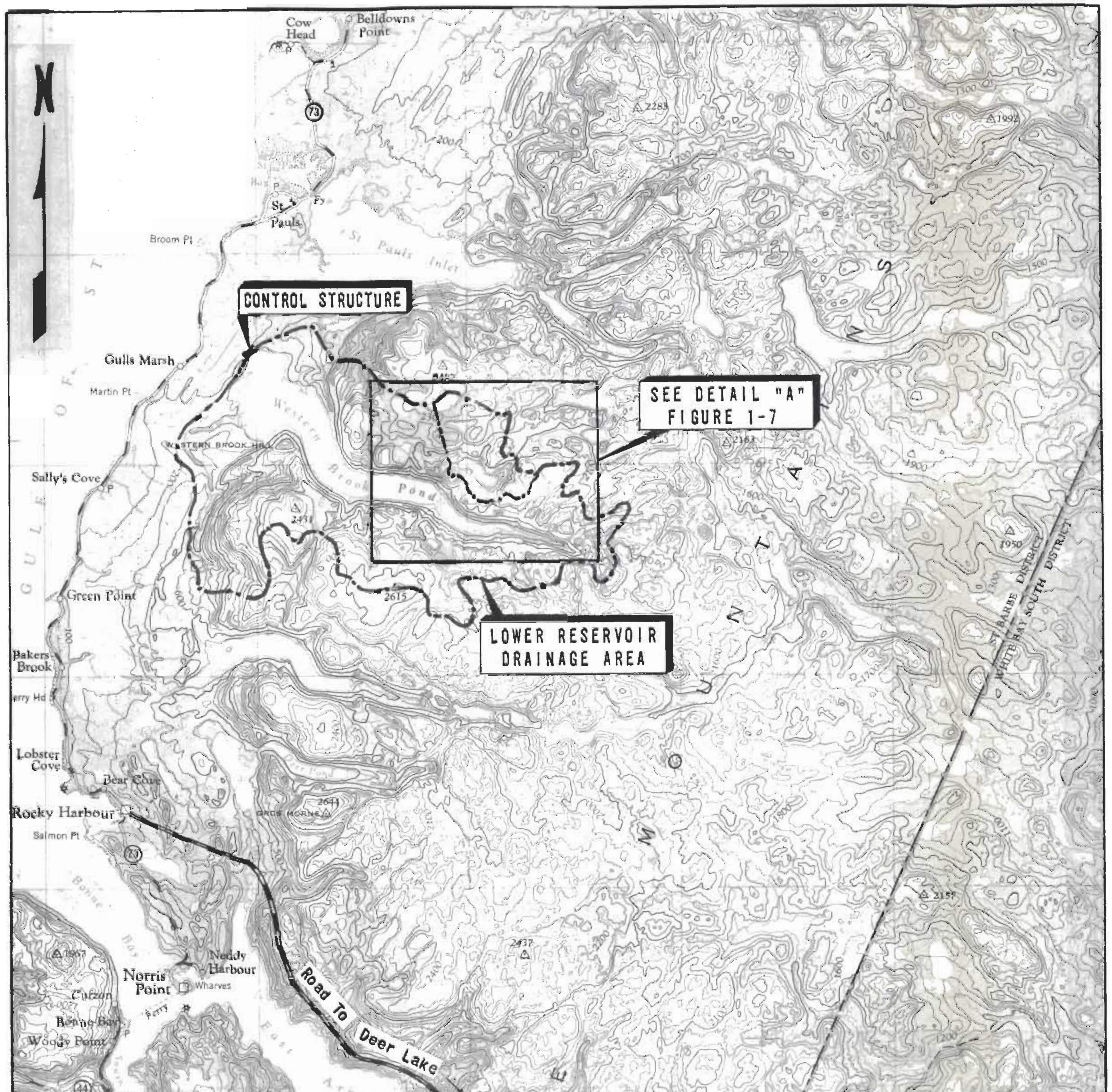
DETAIL "B"

NEWFOUNDLAND - KEY PLAN

CAT ARM RIVER BASIN

NOTE: POTENTIAL FUTURE DEVELOPMENT SHOWN IN RED

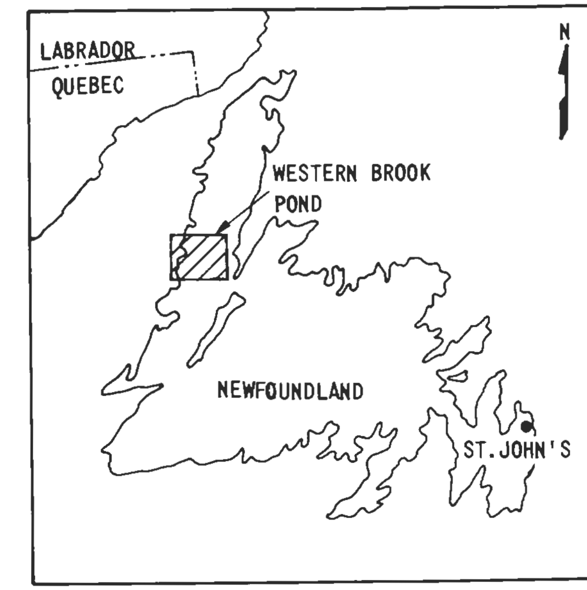
FIGURE 1-5



5 0 5

SCALE - MILES

GENERAL PLAN



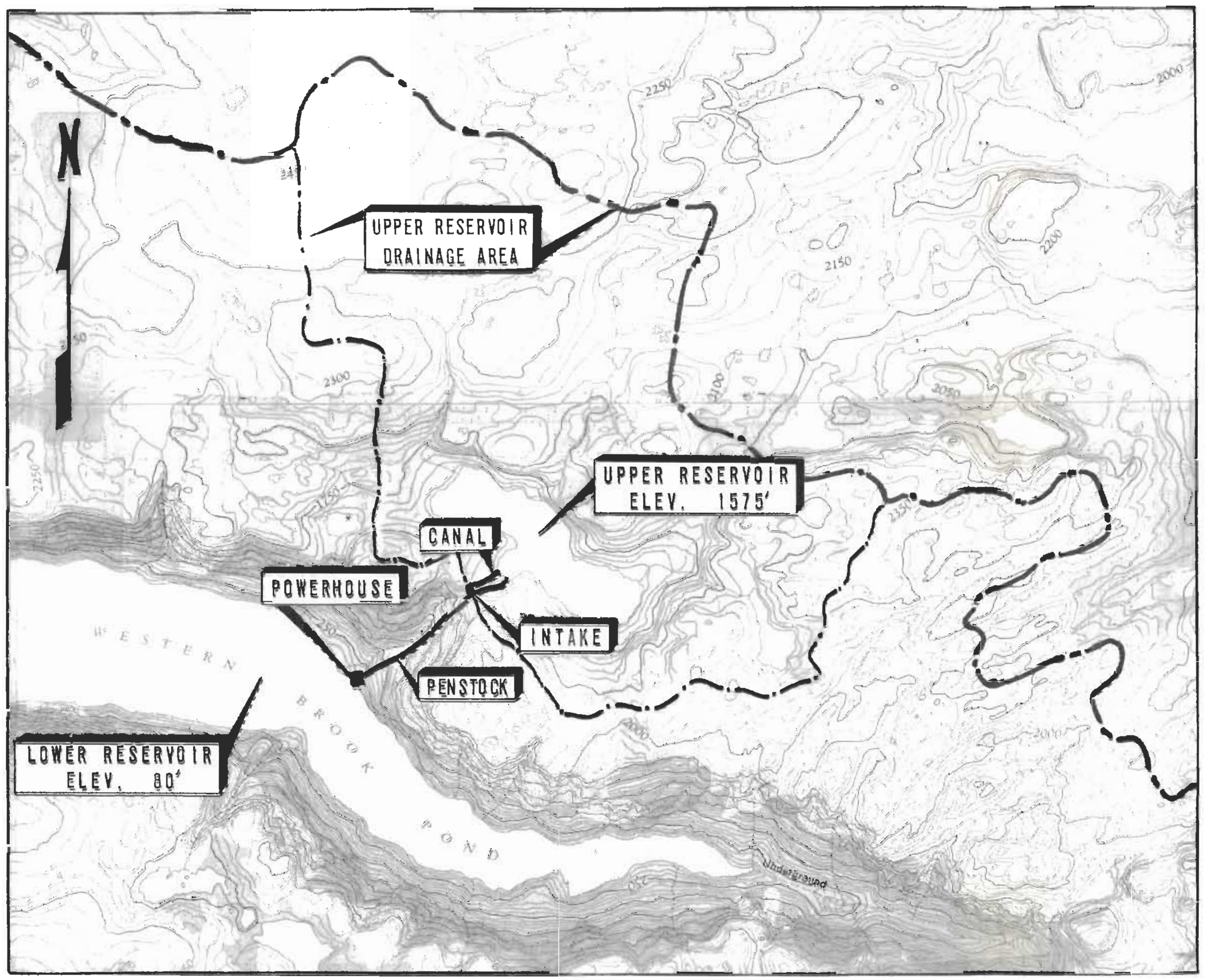
KEY PLAN

LEGEND

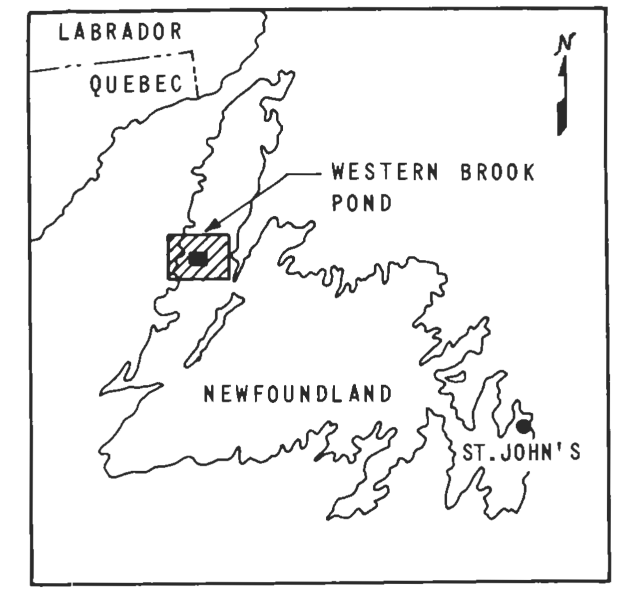
—·—·— DRAINAGE AREA OUTLINE

WESTERN BROOK POND
PUMPED STORAGE DEVELOPMENT
GENERAL PLAN

FIGURE 1-6



DETAIL "A"

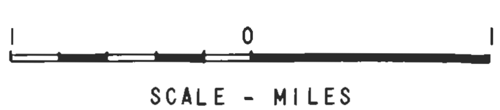


KEY PLAN

LEGEND

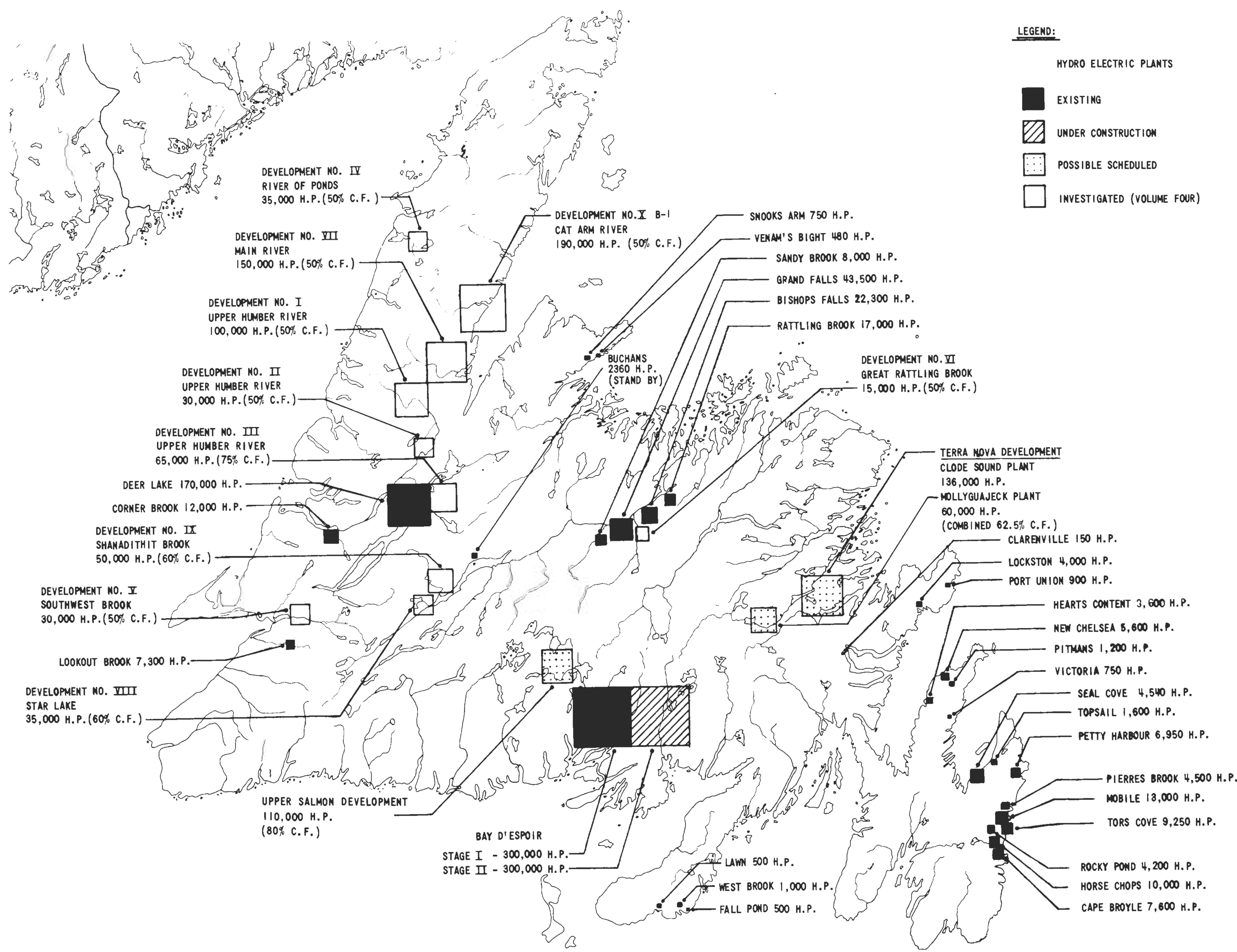
—·—·— DRAINAGE AREA OUTLINE

——— STEEL PENSTOCK



WESTERN BROOK POND
PUMPED STORAGE DEVELOPMENT
DETAIL "A"

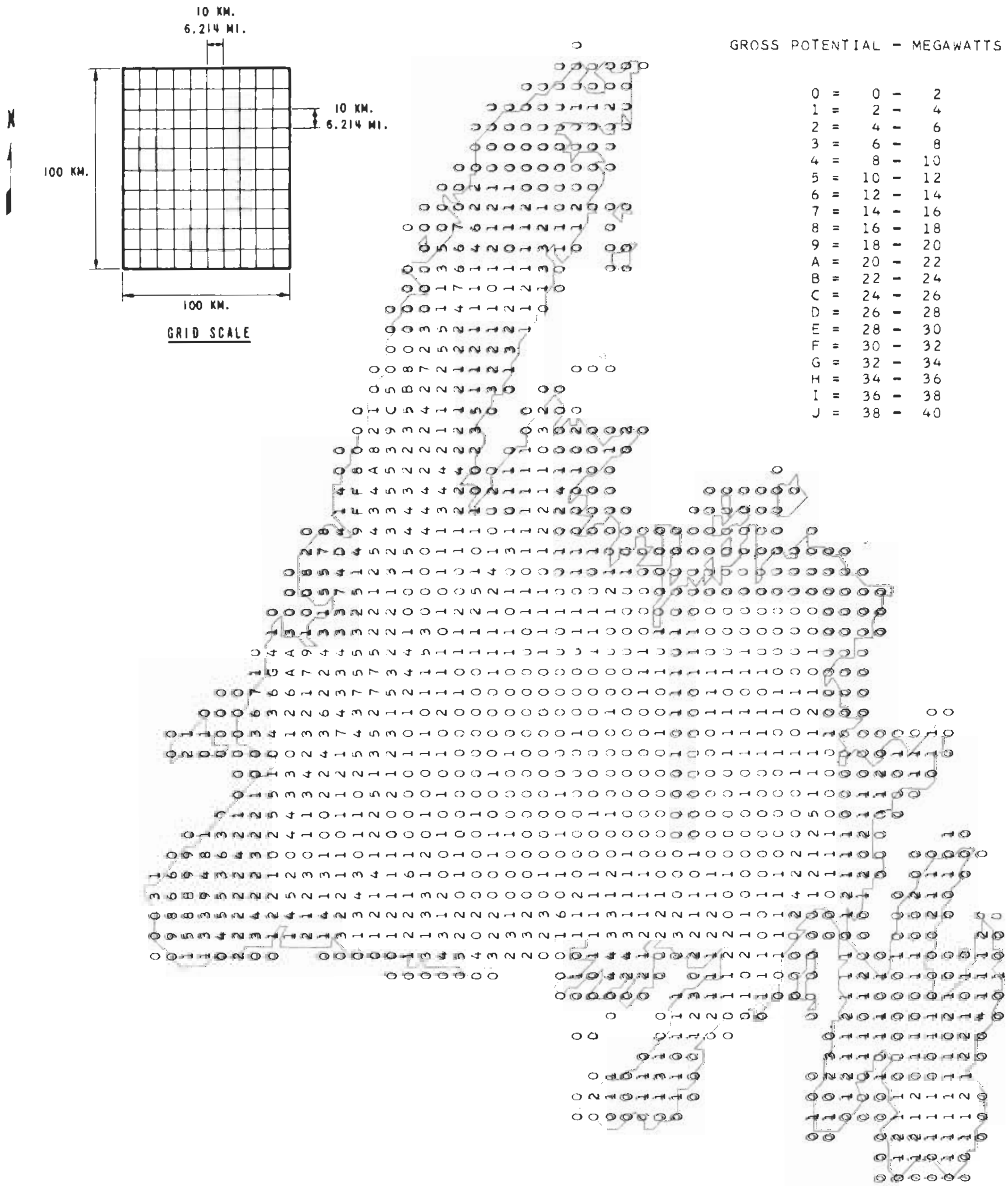
FIGURE 1-7



NEWFOUNDLAND
EXISTING HYDRO ELECTRIC PLANTS AND
UNDEVELOPED HYDRO ELECTRIC SITES

FIGURE 1-8

NEWFOUNDLAND
SQUARE GRID DISTRIBUTION OF GROSS SURFACE HYDRO ELECTRIC POTENTIAL



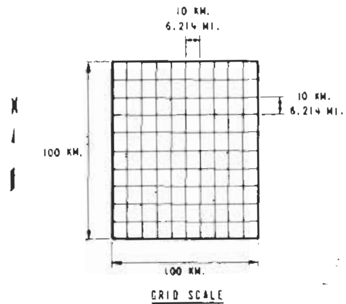
GRID SCALE

GROSS POTENTIAL - MEGAWATTS

0 =	0 -	2
1 =	2 -	4
2 =	4 -	6
3 =	6 -	8
4 =	8 -	10
5 =	10 -	12
6 =	12 -	14
7 =	14 -	16
8 =	16 -	18
9 =	18 -	20
A =	20 -	22
B =	22 -	24
C =	24 -	26
D =	26 -	28
E =	28 -	30
F =	30 -	32
G =	32 -	34
H =	34 -	36
I =	36 -	38
J =	38 -	40

FIGURE 1-9

LABRADOR
SQUARE GRID DISTRIBUTION OF GROSS SURFACE HYDRO ELECTRIC POTENTIAL



SURFACE GROSS POTENTIAL – KWATTS –

0 =	0	–	499
1 =	500	–	999
2 =	1000	–	1499
3 =	1500	–	1999
4 =	2000	–	2499
5 =	2500	–	2999
6 =	3000	–	3499
7 =	3500	–	3999
8 =	4000	–	4499
9 =	4500	–	4999
A =	5000	–	5499
B =	5500	–	5999
C =	6000	–	6499
D =	6500	–	6999
E =	7000	–	7499
F =	7500	–	7999
G =	8000	–	8499
H =	8500	–	8999
I =	9000	–	9499
J =	9500	–	9999
K =	10000	–	10499
L =	10500	–	10999
M =	11000	–	11499
N =	11500	–	11999
O =	12000	–	12499
P =	12500	–	12999
Q =	13000	–	13499
R =	13500	–	13999
S =	14000	–	14499
T =	14500	–	14999
U =	15000	–	15499
V =	15500	–	15999
W =	16000	–	16499
X =	16500	–	16999
Y =	17000	–	17499
Z =	17500	–	17999

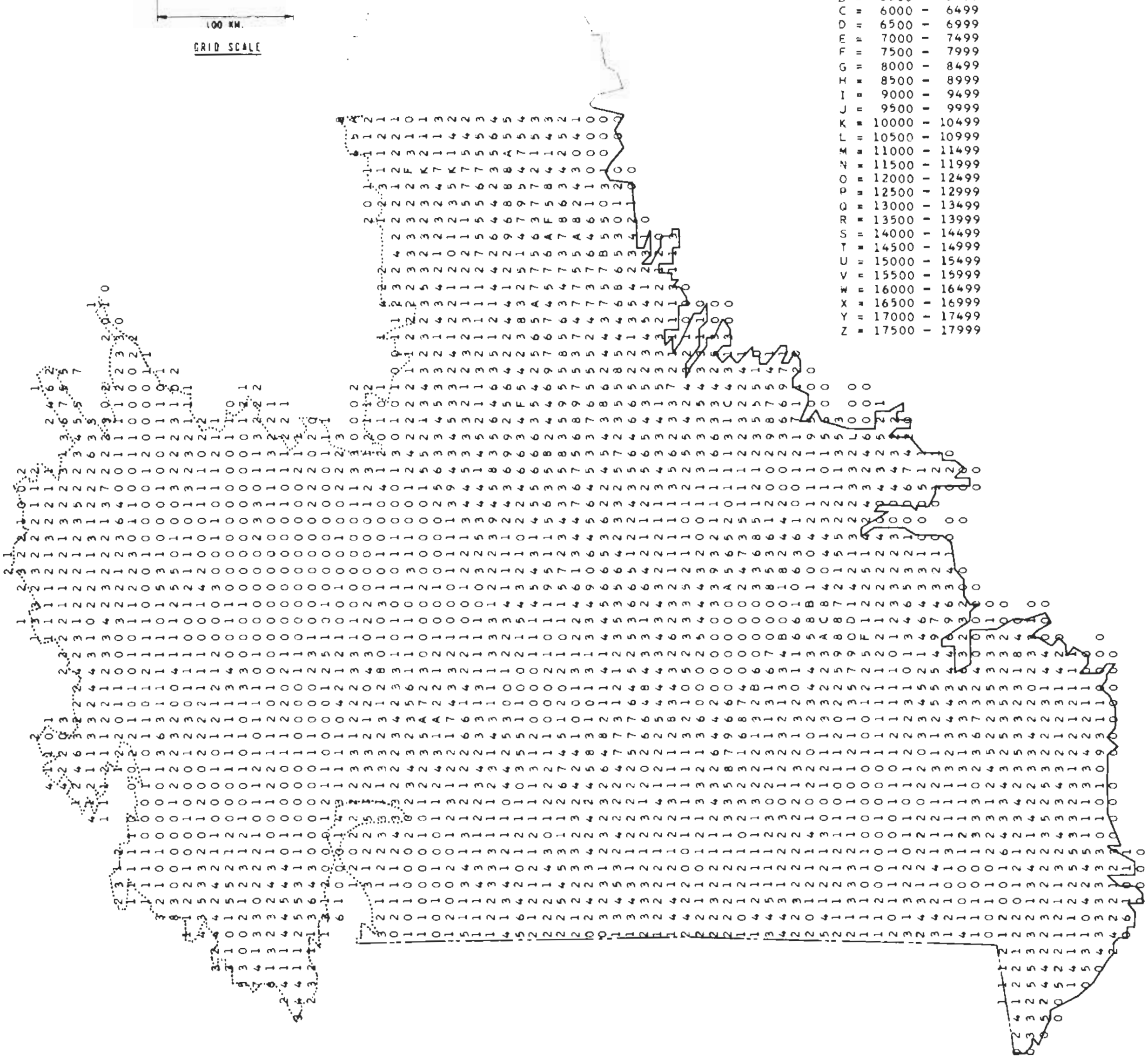


FIGURE 1-10

GROSS HYDRO-ELECTRIC POTENTIAL ON MAIN STEM OF CHURCHILL RIVER

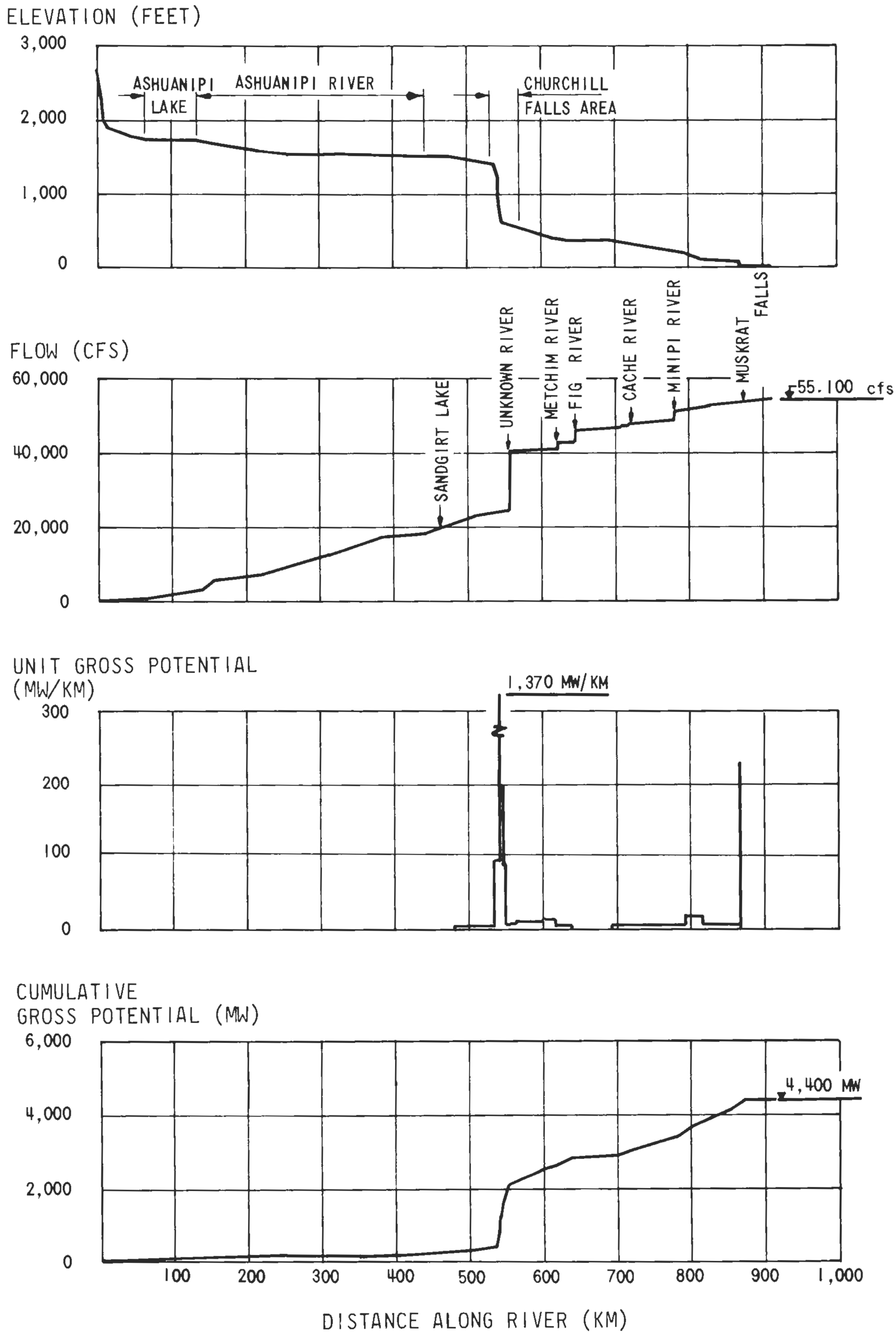


FIGURE 1-11

GROSS HYDRO ELECTRIC POTENTIAL ON NASKAUPI RIVER

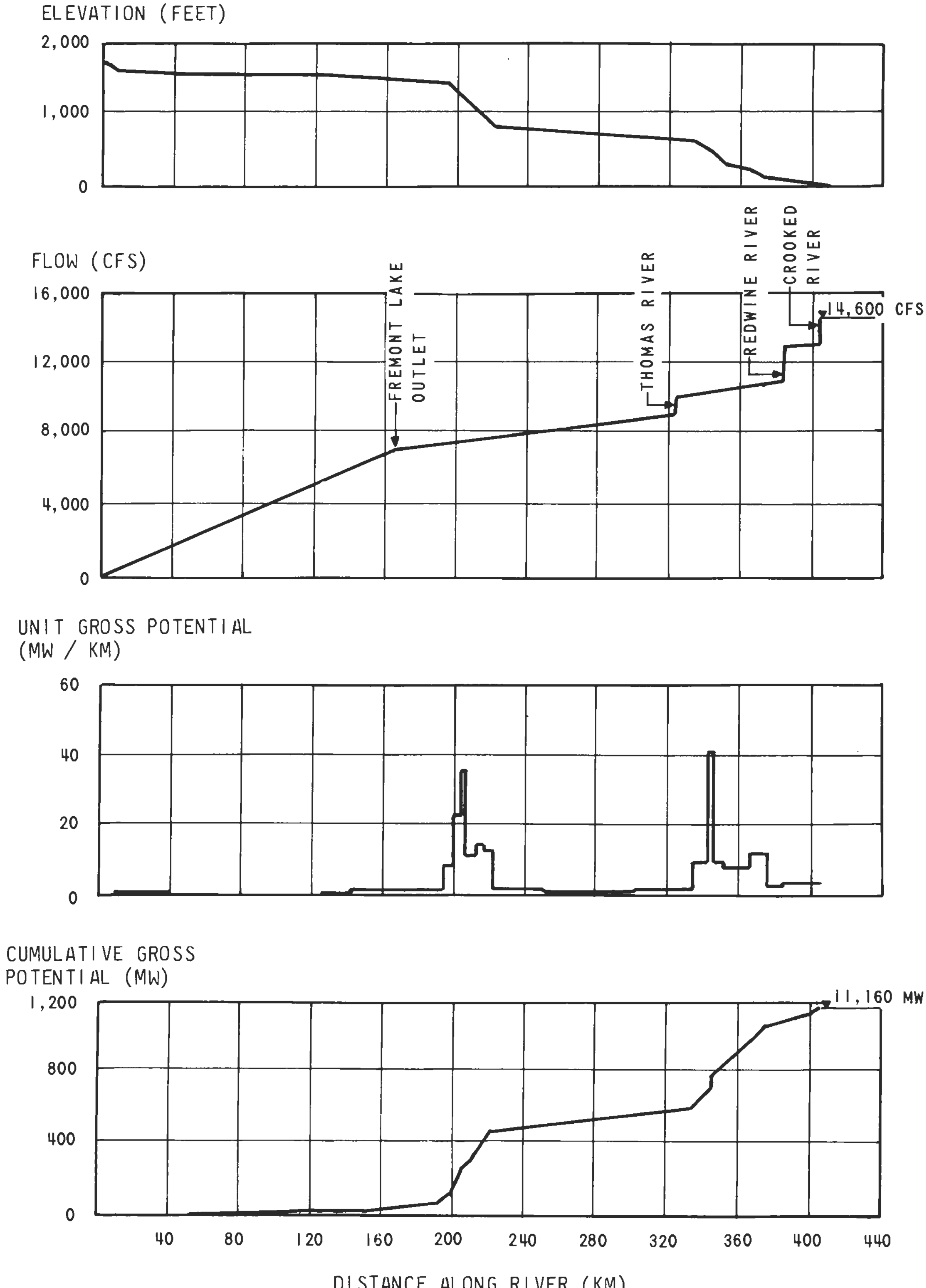


FIGURE 1-12

GROSS HYDRO ELECTRIC POTENTIAL ON EAGLE RIVER

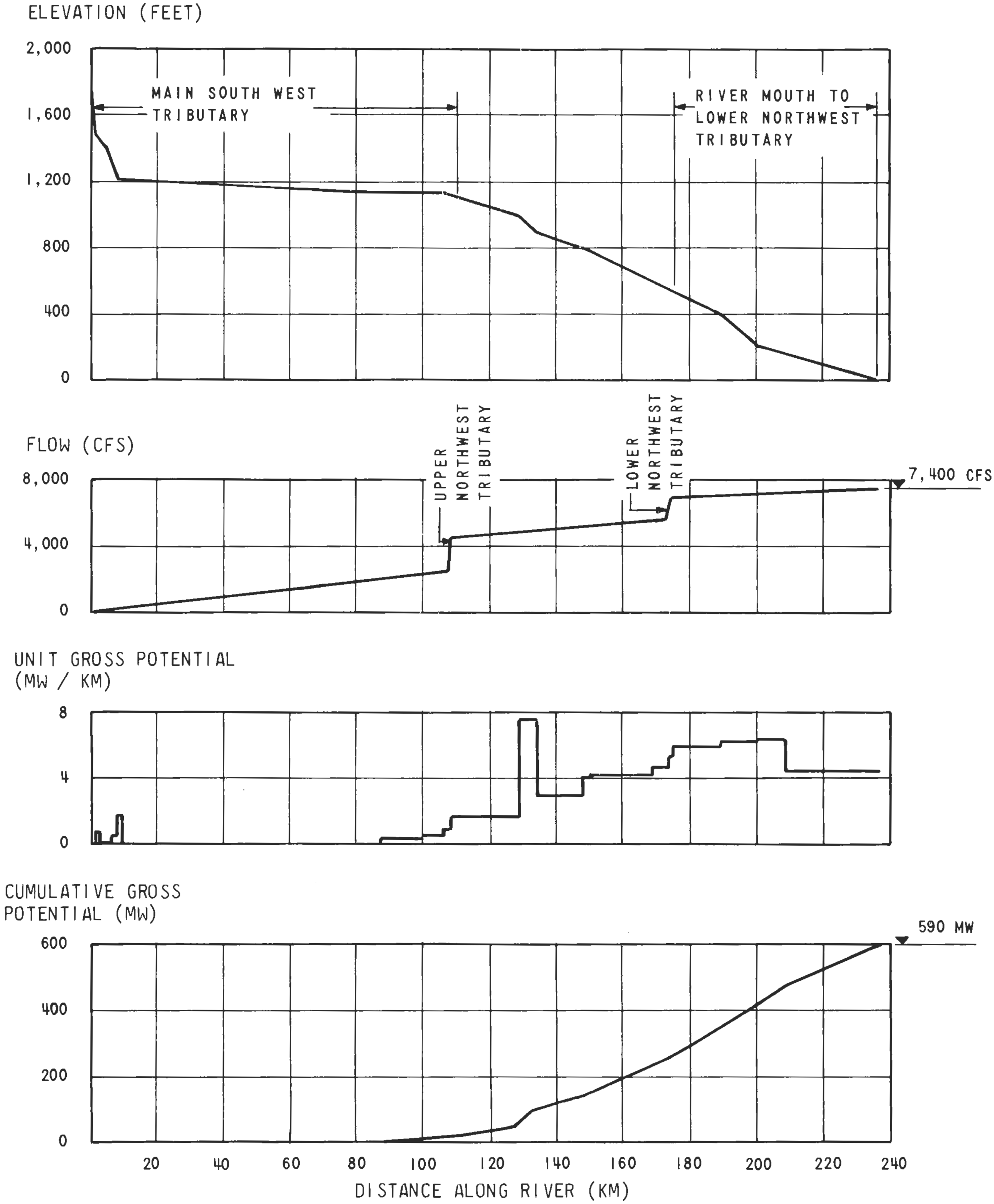


FIGURE 1-13

The Shawinigan Engineering Company Limited
James F. MacLaren Limited

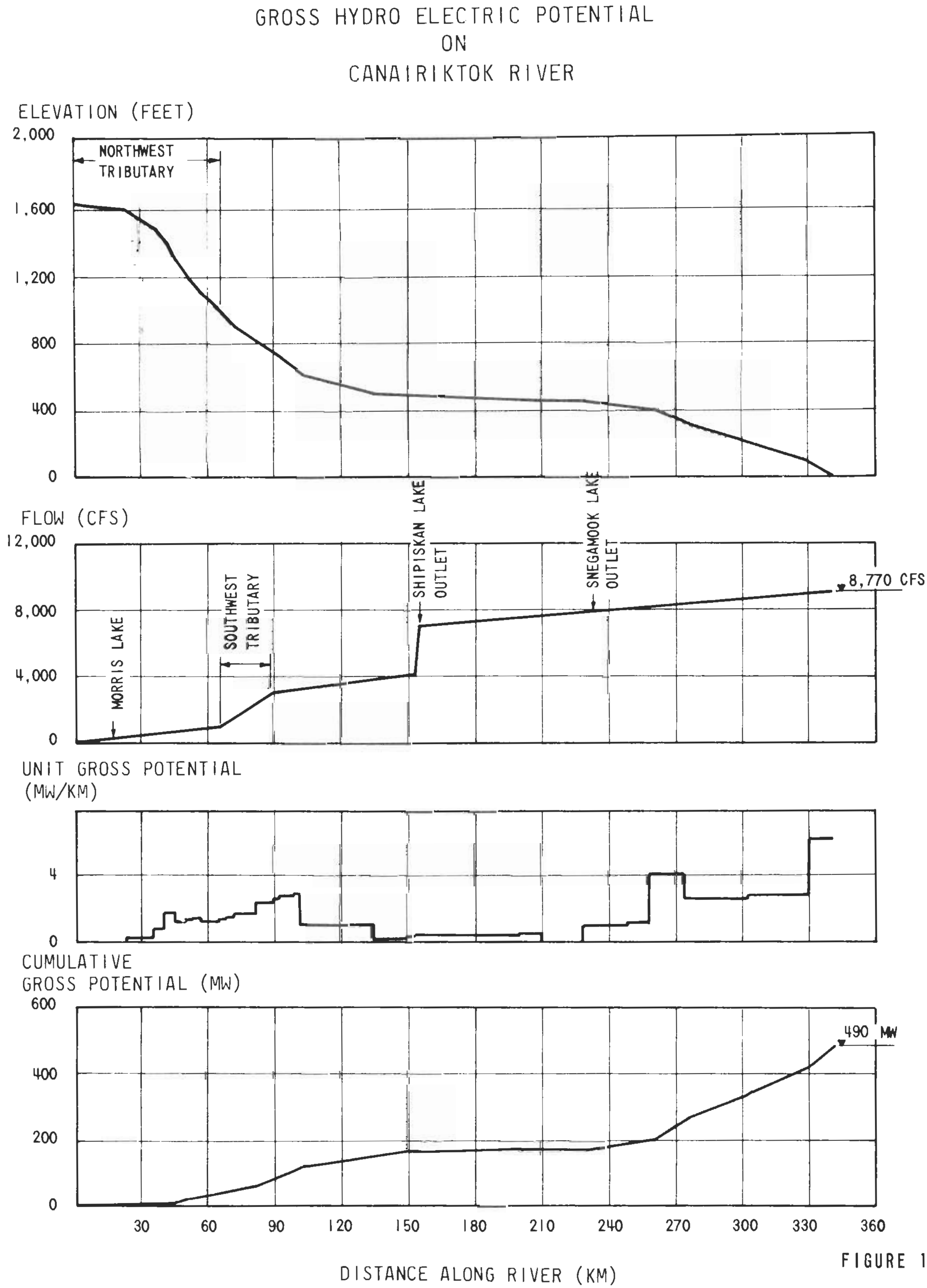


FIGURE 1-14

LABRADOR
EXISTING HYDRO ELECTRIC PLANTS AND UNDEVELOPED HYDRO ELECTRIC SITES

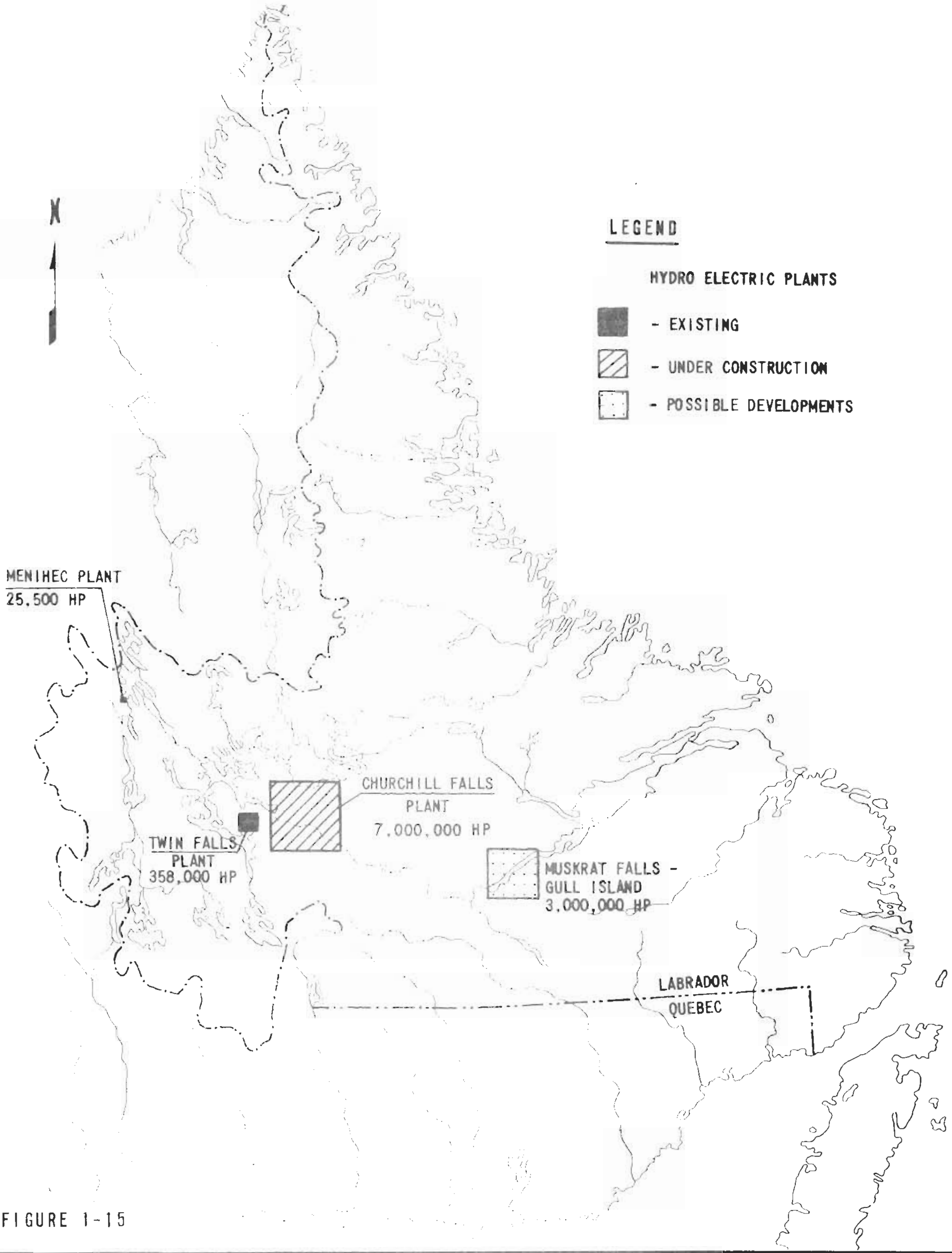


FIGURE 1-15

		DEVELOPMENT		UPPER HUMBER RIVER			RIVER OF PONDS	SOUTH WEST BROOK	GREAT RATTLING BROOK	MAIN RIVER
		DEVELOPMENT NO.		I (50% C.F.)	II (50% C.F.)	III (75% C.F.)	IV (50% C.F.)	V (50% C.F.)	VI (50% C.F.)	VII (50% C.F.)
DEVELOPMENT DATA										
1				UPPER AREA	UPPER AREA	UPPER AREA	RIVER OF PONDS	SOUTH WEST BROOK	GREAT RATTLING BROOK	UPPER MAIN
2					MIDDLE AREA	MIDDLE AREA				
3										
4		DRAINAGE AREAS DEVELOPED								
5										
6										
7										
8		TOTAL DRAINAGE AREA	SQ.MILE	188	724	734	262	225	563	293
9		TOTAL REGULATED FLOW	CFS.	564	1,450	1,835	786	562	619	880
10		FULL SUPPLY LEVEL	FT.	1,118	250	280	240	318	230	970
11		DRAW DOWN	FT.	53	18	0 (B)	16	53	45	63
12		LOW SUPPLY LEVEL	FT.	1,066	232	280	224	265	185	907
13		TAIL WATER LEVEL	FT.	250	140	15	40	40	90	100
14		AVERAGE GROSS HEAD	FT.	841	101	265	202	253	118	839
15		AVERAGE NET HEAD AT REGULATED FLOW	FT.	815	93	247	198	245	115	814
16		CONTINUOUS H.P. AVAILABLE	H.P.	50,000	15,000	48,000	16,500	15,000	7,500	75,000
17		ANNUAL FIRM ENERGY	KWH	287×10^6	88×10^6	283×10^6	87×10^6	86×10^6	43×10^6	448×10^6
18		INSTALLED CAPACITY	H.P.	100,000 (2 UNITS)	30,000 (1 UNIT)	65,000 (3 UNITS)	35,000 (1 UNIT)	30,000 (1 UNIT)	15,000 (1 UNIT)	150,000 (3 UNITS)
ESTIMATED COSTS - $ x 1,000	ACCOUNT									
19	1	LAND PURCHASE		-	-	85	-	-	-	-
20	2	LAND CLEARING		30	6	50	20	61	14	75
21	3	ROADS AND BRIDGES		875	400	1,000	650	100	300	475
22	4	RAILWAYS, DIVERSION OF POWER LINES		-	-	-	-	-	-	-
23	5	DAMS, SPILLWAYS AND RESERVOIRS		7,732	2,940	9,081	4,632	6,432	5,830	9,853
24	6	HEADWORKS, WATER CONDUITS, TAILRACE		11,843	1,515	5,581	1,762	540	422	14,765
25	7	POWER HOUSE AND P.H. EQUIPMENT		4,500	3,350	4,000	1,995	1,875	1,650	4,380
26	8	SUBSTATION INCLUDING TRANSFORMERS		700	300	450	300	300	170	1,100
27	19	CONSTRUCTION INDIRECT COSTS		3,243	924	2,567	1,175	1,183	1,066	3,852
28	20	PROJECT MANAGEMENT AND ENGINEERING		2,892	833	2,281	1,053	1,047	945	3,460
29		CONTINGENCY		4,339	1,250	3,432	1,580	1,571	1,418	5,190
30		SUBTOTAL		36,154	10,418	28,517	13,162	13,089	11,815	43,250
31		OWNER'S COST		362	104	285	132	131	118	432
32		INTEREST DURING CONSTRUCTION		2,350	677	1,853	856	851	768	4,108
33		TOTAL PROJECT COST (IN THOUSANDS OF DOLLARS)		38,866	11,199	30,655	14,155	14,071	12,701	47,790
34		ANNUAL FIXED CHARGES AT 6.73		2,616	754	2,063	953	947	855	3,220
35		ANNUAL OPERATING AND MAINTENANCE COST		165	75	88	84	75	36	217
36		TOTAL ANNUAL CHARGES (IN THOUSANDS OF DOLLARS)		2,781	829	2,151	1,037	1,022	891	3,437
37		CAPITAL COST PER INSTALLED H.P.	$/H.P.	$ 389	$ 373	$ 439	$ 405	$ 469	$ 847	$ 319
38		COST OF FIRM ENERGY (AT PLANT BUSBAR)	MILLS PER KWH	9.7	9.3	7.6	10.7	11.9	19.8	7.7

		DEVELOPMENT		STAR LAKE	SHANADITHIT BROOK	CAT ARM RIVER					
		DEVELOPMENT NO.		VIII (60% C.F.)	IX (60% C.F.)	X A (50% C.F.)	X 3-1 (50% C.F.)	X B-2 (60% C.F.)	X B-3 (60% C.F.)	X B-4 (40% C.F.)	X B-5 (30% C.F.)
DEVELOPMENT DATA											
1				STAR LAKE	STAR LAKE	UPPER CAT ARM	UPPER CAT ARM	UPPER CAT ARM	UPPER CAT ARM	UPPER CAT ARM	UPPER CAT ARM
2				LAKE OF THE HILLS	LAKE OF THE HILLS	MIDDLE CAT ARM					
3					SHANADITHIT BROOK						
4		DRAINAGE AREAS DEVELOPED									
5											
6											
7											
8		TOTAL DRAINAGE AREA	SQ.MILE	180	301	296	241	241	241	241	241
9		TOTAL REGULATED FLOW	CFS.	450	787	770	725	725	725	725	725
10		FULL SUPPLY LEVEL	FT.	1,000	850	742	1,280	1,280	1,292 (A)	1,280	1,280
11		DRAW DOWN	FT.	19	5	5	31	31	52	31	31
12		LOW SUPPLY LEVEL	FT.	981	845	737	1,249	1,249	1,240	1,249	1,249
13		TAIL WATER LEVEL	FT.	525	495	100	0	0	0	0	0
14		AVERAGE GROSS HEAD	FT.	465	352	640	1,265	1,265	1,262	1,265	1,265
15		AVERAGE NET HEAD AT REGULATED FLOW	FT.	451	342	620	1,227	1,227	1,234	1,227	1,227
16		CONTINUOUS H.P. AVAILABLE	H.P.	21,000	28,000	50,000	94,000	94,000	97,000	94,000	94,000
17		ANNUAL FIRM ENERGY	KWH	127×10^6	167×10^6	299×10^6	554×10^6	554×10^6	560×10^6	554×10^6	554×10^6
18		INSTALLED CAPACITY	H.P.	35,000 (1 UNIT)	50,000 (1 UNIT)	100,000 (2 UNITS)	190,000 (3 UNITS)	160,000 (3 UNITS)	160,000 (3 UNITS)	250,000 (3 UNITS)	325,000 (3 UNITS)
ESTIMATED COSTS - $ x 1,000	ACCOUNT										
19	1	LAND PURCHASE		-	-	-	-	-	-	-	-
20	2	LAND CLEARING		12	8	20	46	46	46	46	46
21	3	ROADS AND BRIDGES		700	905	1,600	1,425	1,425	1,425	1,425	1,425
22	4	RAILWAYS, DIVERSION OF POWER LINES		-	-	-	-	-	-	-	-
23	5	DAMS, SPILLWAYS AND RESERVOIRS		2,316	3,195	7,102	6,952	6,952	8,612	6,952	6,952
24	6	HEADWORKS, WATER CONDUITS, TAILRACE		2,322	4,275	6,663	11,076	9,775	9,775	12,501	14,274
25	7	POWER HOUSE AND P.H. EQUIPMENT		1,730	2,190	4,300	5,960	5,420	5,420	6,650	7,220
26	8	SUBSTATION INCLUDING TRANSFORMERS		450	500	620	1,450	1,200	1,200	2,000	2,700
27	19	CONSTRUCTION INDIRECT COSTS		894	1,370	2,556	3,304	3,064	3,280	3,579	3,883
28	20	PROJECT MANAGEMENT AND ENGINEERING		822	1,245	2,286	3,021	2,788	2,976	3,315	3,650
29		CONTINGENCY		1,233	1,867	3,429	4,532	4,182	4,464	4,973	5,475
30		SUBTOTAL		10,279	15,555	28,576	37,766	34,852	37,198	41,441	45,625
31		OWNER'S COST		103	155	286	377	348	372	414	456
32		INTEREST DURING CONSTRUCTION		668	1,010	1,857	2,455	2,265	2,418	2,694	2,966
33		TOTAL PROJECT COST (IN THOUSANDS OF DOLLARS)		11,050	16,720	30,719	40,598	37,465	39,988	44,549	49,047
34		ANNUAL FIXED CHARGES AT 6.73		745	1,128	2,067	2,732	2,522	2,691	2,998	3,300
35		ANNUAL OPERATING AND MAINTENANCE COST		84	108	164	265	224	224	313	407
36		TOTAL ANNUAL CHARGES (IN THOUSANDS OF DOLLARS)		829	1,236	2,231	2,997	2,746	2,915	3,311	3,707
37		CAPITAL COST PER INSTALLED H.P.	$/H.P.	$ 316	$ 334	$ 307	$ 214	$ 234	$ 250	$ 178	$ 151
38		COST OF FIRM ENERGY (AT PLANT BUSBAR)	MILLS PER KWH	6.5	7.4	7.5	5.4	5.0	5.2	6.0	6.7

(B) STORAGE RESERVOIR LOCATED UPSTREAM OF PLANT INTAKE.

(A) INDICATES EFFECTS OF INCREASING STORAGE DEMAND FROM 257,000 (SCHEME XB-2) TO 430,000 ACRE - FEET.

SUMMARY OF ESTIMATED COSTS
AND DEVELOPMENT DATA

- POTENTIAL HYDRO DEVELOPMENTS

TABLE 1-1

ISLAND OF NEWFOUNDLAND

SUMMARY OF GROSS RIVER HYDRO-ELECTRIC POTENTIAL*

SELECTED RIVER BASINS

River	Average Annual Flow at River Mouth		Total Head	Length	Cumulative Gross Potential
	cfs	cfs/sq. mi	(ft)	(Km)	(Mw)
Exploits	10,300	2.3	1,700	270	407
White Bear	2,780	3.3	1,500	107	180
Upper Humber	3,210	3.6	2,350	129	170
Cat Arm	1,580	5.0	2,000	44	155
Salmon	2,970	2.9	1,330	110	135
Grey	3,130	3.2	1,000	115	140
Gander	4,960	2.4	1,000	174	75
Terra Nova	1,970	2.7	700	140	70
Pipers Hole	875	3.2	700	43	27
Conne	715	2.9	900	55	23

* Refers to potential available on main river stem only.

TABLE 1-2

LABRADOR

SUMMARY OF GROSS RIVER HYDRO-ELECTRIC POTENTIAL*

River	Average Annual Flow cfs	Average Annual Flow cfs/sq. mi	Total Head (ft)	Length (Km)	Cumulative Gross Potential (Mw)
Churchill	55,100	1.75	2,700	908	4,400
Naskaupi	14,600	1.85	1,700	405	1,160
Eagle	7,400	1.80	1,800	237	590
Canairiktok	8,770	1.90	1,650	341	490
Kenamu	2,970	1.75	1,700	190	188
Paradise	3,690	1.60	1,600	182	175
Red Wine	1,950	1.80	1,850	140	153
Goose	2,200	1.65	1,800	200	148
Fig	2,990	1.75	1,700	82	140
Big	2,160	1.85	1,100	105	137
Minipi	2,000	1.75	1,400	111	130
St. Lewis	1,580	1.70	1,700	139	120
Metchin	1,650	1.70	2,000	68	107
North	1,570	1.80	3,000	154	96
Crooked	1,500	1.75	1,300	103	92
Alexis	2,340	1.80	1,700	110	86
Beaver	1,160	1.60	2,200	111	76
Pinware	1,410	1.45	1,300	99	72
Hawke Brook	1,130	1.65	1,300	90	27
Kaipokok	1,900	1.70	1,300	101	18

* Refers to potential available on main river stem only.

TABLE 1-3

GROSS RIVER HYDRO-ELECTRIC POTENTIAL

Kenamu River, Paradise River, Red Wine River, and Goose River

- KENAMU RIVER - GROSS POTENTIAL STUDY -

DISTANCE KM.	ELEVATION FEET
0.0	1700.
0.6	1600.
2.4	1500.
16.4	1400.
37.5	1300.
48.5	1200.
61.9	1100.
70.4	1000.
74.5	900.
91.5	800.
107.3	700.
113.7	600.
127.8	500.
132.3	400.
139.5	200.
190.0	0.

DISTANCE KM.	DISCHARGE CFS
0.0	0.
190.0	2968.

DISTANCE ALONG RIVER KM.	UNIT GROSS POTENTIAL MEGAWATTS/KM	CUMULATIVE GROSS POTENTIAL MEGAWATTS
0.0		0.00
	0.06	
0.6		0.03
	0.11	
2.4		0.23
	0.08	
16.4		1.48
	0.11	
20.0		1.89
	0.18	
37.5		5.04
	0.46	
40.0		6.20
	0.53	
48.5		10.72
	0.53	
60.0		16.88
	0.60	
61.9		18.02
	1.02	
70.4		26.77
	2.33	
74.5		36.35
	0.60	
80.0		39.65
	0.66	
91.5		47.32
	0.80	
100.0		54.13
	0.86	
107.3		60.46
	2.28	
113.7		75.07
	1.09	
120.0		81.97
	1.16	
127.8		91.03
	3.82	
132.3		108.23
	4.99	
139.5		144.16
	0.73	
140.0		144.53
	0.78	
160.0		160.23
	0.89	
180.0		178.04
	0.96	
190.0		187.72

- GOOSE RIVER - GROSS POTENTIAL STUDY -

DISTANCE KM.	ELEVATION FEET
0.0	1800.
20.5	1600.
60.0	1400.
71.5	1300.
73.8	1200.
77.6	1100.
82.2	1000.
88.5	900.
93.2	800.
94.6	700.
98.2	600.
103.0	500.
119.3	400.
140.0	300.
150.0	200.
160.8	100.
200.0	0.

DISTANCE KM.	DISCHARGE CFS
0.0	0.
200.0	2215.

DISTANCE ALONG RIVER KM.	UNIT GROSS POTENTIAL MEGAWATTS/KM	CUMULATIVE GROSS POTENTIAL MEGAWATTS
0.0		0.00
	0.09	
20.0		1.82
	0.18	
20.5		1.92
	0.14	
40.0		4.72
	0.23	
60.0		9.46
	0.53	
71.5		15.62
	2.96	
73.8		22.43
	1.86	
77.6		29.53
	1.60	
80.0		33.38
	1.65	
82.2		37.02
	1.26	
88.5		45.02
	1.81	
93.2		53.53
	6.28	
94.6		62.34
	2.50	
98.2		71.37
	1.93	
100.0		74.86
	1.98	
103.0		80.80
	0.63	
119.3		91.22
	0.54	
120.0		91.60
	0.58	
140.0		103.37
	1.35	
150.0		116.96
	1.34	
160.0		130.42
	1.39	
160.8		131.53
	0.40	
180.0		139.35
	0.45	
200.0		148.44

- PARADISE RIVER - GROSS POTENTIAL STUDY -

DISTANCE KM.	ELEVATION FEET
0.0	1600.
1.2	1500.
5.2	1400.
18.3	1300.
33.6	1200.
63.2	1000.
69.5	900.
78.0	800.
85.5	700.
97.7	600.
122.5	400.
133.5	200.
182.5	0.

DISTANCE KM.	DISCHARGE CFS
0.0	0.
115.0	1565.
115.5	2162.
182.5	3689.

DISTANCE ALONG RIVER KM.	UNIT GROSS POTENTIAL MEGAWATTS/KM	CUMULATIVE GROSS POTENTIAL MEGAWATTS
0.0		0.00
	0.05	
1.2		0.06
	0.09	
5.2		0.43
	0.10	
18.3		1.79
	0.14	
20.0		2.03
	0.20	
33.6		4.77
	0.28	
40.0		6.61
	0.38	
60.0		14.39
	0.47	
63.2		15.92
	1.21	
69.5		23.57
	0.99	
78.0		32.06
	1.21	
80.0		34.49
	1.27	
85.5		41.48
	0.86	
97.7		52.03
	0.91	
100.0		54.14
	0.99	
115.0		69.11
	1.27	
115.5		69.75
	1.51	
120.0		76.55
	1.56	
122.5		80.46
	3.76	
133.5		121.88
	0.91	
140.0		127.82
	1.01	
160.0		148.19
	1.17	
180.0		171.71
	1.26	
182.5		174.87

- RED WINE RIVER - GROSS POTENTIAL STUDY -

DISTANCE KM.	ELEVATION FEET
0.0	1850.
1.8	1800.
21.3	1700.
22.1	1600.
26.8	1500.
54.0	1400.
61.1	1300.
64.4	1200.
66.3	1100.
73.0	1000.
75.3	900.
84.4	800.
92.4	700.
98.3	600.
100.0	500.
105.0	400.
108.5	300.
115.1	200.
125.0	100.
140.0	50.

DISTANCE KM.	DISCHARGE CFS
0.0	0.
140.0	1949.

DISTANCE ALONG RIVER KM.	UNIT GROSS POTENTIAL MEGAWATTS/KM	CUMULATIVE GROSS POTENTIAL MEGAWATTS
0.0		0.00
	0.02	
1.8		0.05
	0.06	
20.0		1.25
	0.12	
21.3		1.41
	3.19	
22.1		3.97
	0.61	
26.8		6.85
	0.14	
40.0		8.76
	0.20	
54.0		11.61
	0.94	
60.0		17.28
	1.00	
61.1		18.39
	2.24	
64.4		25.78
	4.05	
66.3		33.48
	1.22	
73.0		41.69
	3.79	
75.3		50.42
	1.00	
80.0		55.15
	1.06	
84.4		59.83
	1.30	
92.4		70.25
	1.90	
98.3		81.48
	6.87	
100.0		93.16
	2.41	
105.0		105.24
	3.59	
108.5		117.82
	1.99	
115.1		130.99
	1.39	
120.0		137.84
	1.45	
125.0		145.13
	0.52	
140.0		152.94

TABLE 1-4

GROSS RIVER HYDRO-ELECTRIC POTENTIAL

Fig River, Big River, Minipi River, and St. Lewis River

- FIG RIVER - GROSS POTENTIAL STUDY -

DISTANCE KM.	ELEVATION FEET
0.0	1700.
4.6	1600.
14.0	1500.
31.5	1400.
47.3	1300.
60.8	1200.
69.6	1000.
71.0	800.
73.1	600.
82.5	400.

DISTANCE KM.	DISCHARGE CFS
0.0	0.
70.5	746.
71.0	2866.
82.5	2990.

DISTANCE ALONG RIVER KM.	UNIT GROSS POTENTIAL MEGAWATTS/KM	CUMULATIVE GROSS POTENTIAL MEGAWATTS
0.0		0.00
	0.04	
4.6		0.20
	0.08	
14.0		1.03
	0.08	
20.0		1.56
	0.13	
31.5		3.07
	0.20	
40.0		4.79
	0.24	
47.3		6.60
	0.35	
60.0		11.12
	0.40	
60.8		11.44
	1.32	
69.6		23.12
	8.96	
70.5		31.18
	21.83	
71.0		42.10
	23.10	
73.1		90.81
	5.26	
80.0		127.16
	5.35	
82.5		140.56

- BIG RIVER - GROSS POTENTIAL STUDY -

DISCHARGE CFS	ELEVATION FEET
0.0	1100.
15.7	1000.
41.5	900.
55.3	800.
59.4	700.
65.5	600.
66.5	500.
67.6	400.
69.3	300.
74.6	200.
81.8	100.
105.0	0.

DISTANCE KM.	DISCHARGE CFS
0.0	0.
47.0	548.
47.5	1595.
105.0	2157.

DISTANCE ALONG RIVER KM.	UNIT GROSS POTENTIAL MEGAWATTS/KM	CUMULATIVE GROSS POTENTIAL MEGAWATTS
0.0		0.00
	0.04	
15.7		0.77
	0.06	
20.0		1.06
	0.11	
40.0		3.36
	0.15	
41.5		3.59
	0.31	
47.0		5.33
	0.65	
47.5		5.66
	1.00	
55.3		13.47
	3.49	
59.4		27.79
	2.37	
60.0		29.21
	2.41	
65.5		42.52
	15.02	
66.5		57.55
	13.74	
67.6		72.67
	8.96	
69.3		87.90
	2.92	
74.6		103.42
	2.21	
80.0		115.40
	2.25	
81.8		119.46
	0.73	
100.0		132.87
	0.77	
105.0		136.76

- MINIPI RIVER - GROSS POTENTIAL STUDY -

DISTANCE KM.	ELEVATION FEET
0.0	1400.
0.5	1300.
3.5	1200.
5.0	1145.
59.0	1145.
60.0	1100.
65.0	1000.
85.2	900.
89.0	800.
98.7	700.
99.4	600.
103.3	500.
103.5	400.
108.0	300.
111.5	250.

DISTANCE KM.	DISCHARGE CFS
0.0	0.
63.0	1334.
111.5	1999.

DISTANCE ALONG RIVER KM.	UNIT GROSS POTENTIAL MEGAWATTS/KM	CUMULATIVE GROSS POTENTIAL MEGAWATTS
0.0		0.00
	0.08	
0.5		0.04
	0.11	
3.5		0.40
	0.27	
5.0		0.82
	0.00	
20.0		0.82
	0.00	
40.0		0.82
	0.00	
59.0		0.82
	4.79	
60.0		5.62
	2.20	
63.0		12.23
	2.28	
65.0		16.79
	0.61	
80.0		25.99
	0.67	
85.2		29.48
	3.70	
89.0		43.57
	1.53	
98.7		58.44
	22.10	
99.4		73.92
	3.98	
100.0		76.31
	4.04	
103.3		89.66
	79.88	
103.5		105.63
	3.61	
108.0		121.89
	2.38	
111.5		130.24

- ST LEWIS RIVER - GROSS POTENTIAL STUDY -

DISTANCE KM.	ELEVATION FEET
0.0	1700.
0.5	1500.
3.5	1400.
7.8	1300.
40.0	1250.
46.5	1250.
54.5	1200.
63.5	1100.
73.7	1000.
81.0	900.
85.5	800.
90.0	700.
102.7	600.
112.5	500.
113.8	400.
121.3	300.
129.1	200.
131.0	100.
139.0	0.

DISTANCE KM	DISCHARGE CFS
0.0	0.
139.0	1585.

DISTANCE ALONG RIVER KM.	UNIT GROSS POTENTIAL MEGAWATTS/KM	CUMULATIVE GROSS POTENTIAL MEGAWATTS
0.0		0.00
	0.09	
0.5		0.04
	0.06	
3.5		0.24
	0.12	
7.8		0.78
	0.02	
20.0		1.04
	0.04	
40.0		1.93
	0.00	
46.5		1.93
	0.30	
54.5		4.37
	0.61	
60.0		7.75
	0.66	
63.5		10.07
	0.64	
73.7		16.69
	1.01	
80.0		23.09
	1.06	
81.0		24.15
	1.78	
85.5		32.18
	1.88	
90.0		40.65
	0.72	
100.0		47.87
	0.77	
102.7		49.95
	1.05	
112.5		60.34
	8.39	
113.8		71.26
	1.50	
120.0		80.58
	1.55	
121.3		82.60
	1.54	
129.1		94.68
	6.60	
131.0		107.23
	1.62	
139.0		120.26

TABLE 1-5

GROSS RIVER HYDRO-ELECTRIC POTENTIAL
Metchin River, Norm River, Crooked River, and Alexis River

- METCHIN RIVER - GROSS POTENTIAL STUDY -

DISTANCE KM.	ELEVATION FEET
0.0	2000.
1.0	1800.
5.0	1600.
38.0	1400.
47.0	1200.
52.5	1000.
58.8	800.
65.0	600.
68.0	400.

DISTANCE KM.	DISCHARGE CFS
0.0	0.
51.0	560.
51.5	1307.
53.0	1591.
68.0	1655.

DISTANCE ALONG RIVER KM.	UNIT GROSS POTENTIAL MEGAWATTS/KM	CUMULATIVE GROSS POTENTIAL MEGAWATTS
0.0		0.00
	0.09	
1.0		0.09
	0.13	
5.0		0.65
	0.07	
20.0		1.70
	0.16	
38.0		4.64
	0.80	
40.0		6.25
	0.89	
47.0		12.54
	1.65	
51.0		19.16
	2.87	
51.5		20.60
	4.31	
52.5		24.91
	4.14	
53.0		26.99
	4.30	
58.8		51.97
	4.41	
60.0		57.28
	4.45	
65.0		79.55
	9.30	
68.0		107.45

- NORTH RIVER - GROSS POTENTIAL STUDY -

DISTANCE KM.	ELEVATION FEET
0.0	3000.
3.5	1800.
13.0	1600.
24.9	1400.
32.4	1200.
55.2	1000.
65.0	800.
74.0	600.
91.5	400.
108.3	200.
154.0	0.

DISTANCE KM.	DISCHARGE CFS
0.0	0.
154.0	1572.

DISTANCE ALONG RIVER KM.	UNIT GROSS POTENTIAL MEGAWATTS/KM	CUMULATIVE GROSS POTENTIAL MEGAWATTS
0.0		0.00
	0.51	
3.5		1.81
	0.15	
13.0		3.23
	0.23	
20.0		4.91
	0.32	
24.9		6.51
	0.66	
32.4		11.46
	0.27	
40.0		13.54
	0.36	
55.2		19.03
	1.01	
60.0		23.90
	1.10	
65.0		29.41
	1.33	
74.0		41.42
	0.76	
80.0		45.98
	0.84	
91.5		55.72
	0.98	
100.0		64.09
	1.07	
108.3		72.98
	0.43	
120.0		78.03
	0.49	
140.0		87.86
	0.55	
154.0		95.64

- CROOKED RIVER - GROSS POTENTIAL STUDY -

DISTANCE KM.	ELEVATION FEET
0.0	1300.
10.4	1200.
19.7	1100.
24.5	1000.
28.8	900.
31.8	835.
53.2	835.
59.3	800.
69.8	700.
70.4	600.
75.0	500.
80.6	400.
82.0	300.
83.5	200.
92.4	100.
103.0	0.

DISTANCE KM.	DISCHARGE CFS
0.0	0.
103.0	1504.

DISTANCE ALONG RIVER KM.	UNIT GROSS POTENTIAL MEGAWATTS/KM	CUMULATIVE GROSS POTENTIAL MEGAWATTS
0.0		0.00
	0.06	
10.4		0.64
	0.19	
19.7		2.50
	0.51	
20.0		2.65
	0.57	
24.5		5.23
	0.76	
28.8		8.52
	0.81	
31.8		10.96
	0.00	
40.0		10.96
	0.00	
53.2		10.96
	0.39	
59.3		13.39
	0.70	
60.0		13.88
	0.76	
69.8		21.37
	14.43	
70.4		30.03
	1.95	
75.0		39.01
	1.71	
80.0		47.57
	1.77	
80.6		48.63
	7.17	
82.0		58.68
	6.81	
83.5		68.90
	1.22	
92.4		79.77
	1.12	
100.0		88.29
	1.18	
103.0		91.84

- ALEXIS RIVER - GROSS POTENTIAL STUDY -

DISTANCE KM.	ELEVATION FEET
0.0	1740.
0.6	1600.
1.1	1500.
4.1	1400.
17.5	1300.
27.5	1200.
31.2	1100.
32.2	1000.
35.0	900.
39.1	800.
44.9	700.
50.0	600.
51.5	500.
53.8	400.
60.0	300.
68.0	200.
75.4	100.
110.5	0.

DISTANCE KM.	DISCHARGE CFS
0.0	0.
73.0	1079.
73.5	1491.
110.0	2195.
110.5	2339.

DISTANCE ALONG RIVER KM.	UNIT GROSS POTENTIAL MEGAWATTS/KM	CUMULATIVE GROSS POTENTIAL MEGAWATTS
0.0		0.00
	0.08	
0.6		0.05
	0.21	
1.1		0.15
	0.10	
4.1		0.48
	0.10	
17.5		1.83
	0.23	
20.0		2.42
	0.29	
27.5		4.64
	0.99	
31.2		8.32
	3.96	
32.2		12.28
	1.50	
35.0		16.49
	1.13	
39.1		21.12
	0.85	
40.0		21.89
	0.91	
44.9		26.37
	1.16	
50.0		32.31
	4.23	
51.5		38.66
	2.86	
53.8		45.24
	1.14	
60.0		52.36
	1.00	
68.0		60.37
	1.19	
73.0		66.33
	1.46	
73.5		67.06
	1.72	
75.4		70.34
	0.37	
80.0		72.09
	0.43	
100.0		80.81
	0.50	
110.0		85.87
	0.54	
110.5		86.14

TABLE 1-6

GROSS RIVER HYDRO-ELECTRIC POTENTIAL
Beaver River, Pinware River, Kaipokok River, and Hawke Brook

- KAIPOKOK RIVER - GROSS POTENTIAL STUDY -

DISTANCE KM.	ELEVATION FEET
0.0	1100.
0.5	1000.
0.6	900.
0.7	800.
10.7	700.
12.2	600.
16.1	500.
31.1	400.
34.0	300.
47.0	200.
51.3	100.
101.0	0.

DISTANCE KM.	DISCHARGE CFS
0.0	0.
57.0	423.
57.5	1212.
67.0	267.
101.0	1905.

DISTANCE ALONG RIVER KM.	UNIT GROSS POTENTIAL MEGAWATTS/KM	CUMULATIVE GROSS POTENTIAL MEGAWATTS
0.0		0.00
	0.03	
0.5		0.01
	0.34	
0.6		0.05
	0.40	
0.7		0.09
	0.03	
10.7		0.44
	0.47	
12.2		1.16
	0.22	
16.1		2.05
	0.07	
20.0		2.35
	0.10	
31.1		3.53
	0.70	
34.0		5.58
	0.17	
40.0		6.65
	0.21	
47.0		8.12
	0.71	
51.3		11.21
	0.06	
57.0		11.60
	0.13	
57.5		11.67
	0.18	
60.0		12.13
	0.10	
67.0		12.87
	0.09	
80.0		14.15
	0.23	
100.0		18.83
	0.32	
101.0		19.15

- PINWARE RIVER - GROSS POTENTIAL STUDY -

DISTANCE KM.	ELEVATION FEET
0.0	1300.
0.4	1200.
5.8	1100.
8.7	1000.
15.3	900.
29.5	800.
41.3	700.
48.9	600.
62.6	500.
69.2	400.
87.0	300.
89.2	200.
92.2	100.
99.0	0.

DISTANCE KM.	DISCHARGE CFS
0.0	0.
53.0	535.
53.5	977.
99.0	1411.

DISTANCE ALONG RIVER KM.	UNIT GROSS POTENTIAL MEGAWATTS/KM	CUMULATIVE GROSS POTENTIAL MEGAWATTS
0.0		0.00
	0.04	
0.4		0.01
	0.04	
5.8		0.28
	0.21	
8.7		0.90
	0.15	
15.3		1.92
	0.10	
20.0		2.42
	0.14	
29.5		3.84
	0.25	
40.0		6.48
	0.29	
41.3		6.86
	0.50	
48.9		10.71
	0.31	
53.0		12.02
	0.46	
53.5		12.25
	0.62	
60.0		16.30
	0.64	
62.6		17.98
	1.40	
69.2		27.25
	0.56	
80.0		33.31
	0.60	
87.0		37.51
	5.02	
89.2		48.57
	3.75	
92.2		59.84
	1.71	
99.0		71.51

- BEAVER RIVER - GROSS POTENTIAL STUDY -

DISTANCE KM.	ELEVATION FEET
0.0	2200.
1.0	2000.
4.7	1800.
38.5	1600.
47.0	1500.
56.2	1400.
59.4	1300.
62.1	1200.
65.3	1100.
68.6	1000.
71.0	900.
73.7	800.
76.6	700.
78.8	600.
82.2	500.
84.0	400.
86.0	300.
89.2	200.
93.3	100.
111.0	0.

DISTANCE KM.	DISCHARGE CFS
0.0	0.
85.0	511.
85.5	1006.
111.0	1160.

DISTANCE ALONG RIVER KM.	UNIT GROSS POTENTIAL MEGAWATTS/KM	CUMULATIVE GROSS POTENTIAL MEGAWATTS
0.0		0.00
	0.05	
1.0		0.05
	0.07	
4.7		0.34
	0.03	
20.0		0.90
	0.08	
38.5		2.53
	0.23	
40.0		2.89
	0.26	
47.0		4.71
	0.28	
56.2		7.33
	0.91	
59.4		10.28
	1.12	
60.0		10.95
	1.15	
62.1		13.37
	1.01	
65.3		16.61
	1.03	
68.6		20.01
	1.47	
71.0		23.57
	1.36	
73.7		27.25
	1.31	
76.6		31.07
	1.79	
78.8		35.02
	1.18	
80.0		36.45
	1.21	
82.2		39.12
	2.34	
84.0		43.35
	2.14	
85.0		45.50
	3.20	
85.5		47.10
	4.26	
86.0		49.23
	2.69	
89.2		57.85
	2.14	
93.3		66.66
	0.51	
100.0		70.10
	0.53	
111.0		76.03

- HAWKE BROOK - GROSS POTENTIAL STUDY -

DISTANCE KM.	ELEVATION FEET
0.0	1300.
0.3	1200.
2.5	1100.
3.9	1000.
4.6	900.
11.3	800.
15.9	700.
23.3	600.
28.5	500.
39.0	400.
44.0	300.
54.8	200.
69.5	100.
90.0	0.

DISTANCE KM.	DISCHARGE CFS
0.0	0.
76.0	665.
76.5	1066.
90.0	1128.

DISTANCE ALONG RIVER KM.	UNIT GROSS POTENTIAL MEGAWATTS/KM	CUMULATIVE GROSS POTENTIAL MEGAWATTS
0.0		0.00
	0.03	
0.3		0.01
	0.04	
2.5		0.11
	0.16	
3.9		0.35
	0.44	
4.6		0.66
	0.08	
11.3		1.25
	0.21	
15.9		2.26
	0.17	
20.0		2.99
	0.21	
23.3		3.71
	0.36	
28.5		5.63
	0.23	
39.0		8.13
	0.58	
40.0		8.71
	0.62	
44.0		11.20
	0.33	
54.8		14.86
	0.28	
60.0		16.36
	0.32	
69.5		19.46
	0.26	
76.0		21.17
	0.35	
76.5		21.35
	0.44	
80.0		22.90
	0.45	
90.0		27.46

TABLE 1-7

ISLAND OF NEWFOUNDLAND

MAIN CHARACTERISTICS OF EXISTING HYDRO-ELECTRIC DEVELOPMENTS

HYDRO DEVELOPMENT	DRAINAGE AREA: DIRECT	SQUARE MILES	INDIRECT	SQUARE MILES	TOTAL SQUARE MILES	YEAR INSTALLED: FIRST UNIT	LATEST UNIT	NO. OF UNITS	OWNER	RATED HEAD (feet)	TOTAL INSTALLED TURBINE CAPACITY HP	COMMENTS
Bay D'Espoir	Salmon River	1040	Grey River	375	1415	1967	1967	3	NLPC	575	300,000	Construction completed in 1967 - Stage I
Bay D'Espoir			White Bear River Victoria River Lloyds River	456 408 184	1048	1968	1969	3	NLPC	575	300,000	Under construction - Stage II
Deer Lake	Humber River	1850	Indian River	92	1942	1925	1930	9	BPCL	247	170,000	
Grand Falls	Exploits River	3650			3650	1909	1938	4	PNL	109	43,500	Drainage area will be reduced by Lloyds and Victoria River diversion to 3058 sq. mi.
Bishops Falls	Exploits River	4360			4360	1909	1952	9	PNL	35	22,300	Drainage area will be reduced by Lloyds and Victoria River diversion to 3768 sq. mi.
Rattling Brook	Rattling Brook	146			146	1958	1958	2	NLPCL	307	17,000	
Mobile	Mobile River	43.4			43.4	1951		1	NLPCL	370	13,000	
Watsons Brook	Corner Brook	51			51	1958	1958	2	BPCL	559	12,000	
Horse Chops	Horse Chops Pond	34.6	Crossing Place River Cape Broyle North West River diversion	9.5 8.1 6.2	58.4	1953		1	NLPCL	276	10,000	
Tors Cove	Tors Cove	82			82	1942	1951	3	NLPCL	173	9,250	
Sandy Brook	Sandy Brook	175	West Stony Brook	21	196	1963		1	NLPCL	115	8,000	
Cape Broyle	Cape Broyle Pond	48.4	Crossing Place River Cape Broyle North West River diversion	9.5 8.1 6.2	73.2	1952		1	NLPCL	176	7,600	
Lookout Brook	Lookout Brook	32			32	1945	1958	3	NLPCL	573	7,300	
Petty Harbour	Redmans Brook	53.4			53.4	1908	1926	3	NLPCL	190	6,950	
New Chelsea	New Chelsea Brook	28			28	1957		1	NLPCL	275	5,600	
Seal Cove	Seal Cove River	30			30	1922	1927	2	NLPCL	190	4,540	
Pierres Brook	Pierres Brook	38.3	Witless Bay diversion	6.8	45.1	1931		1	NLPCL	263	4,500	
Rocky Pond	Tors Cove Pond	69			69	1943		1	NLPCL	107	4,200	
Lockston	Lockston	15			15	1956	1961	2	NLPCL	270	4,000	
Hearts Content	Hearts Content Brook	35			35	1960		1	NLPCL	150	3,600	
Buchans Brook	Buchans Brook	75			75	1927		1	ASRC	163	2,359	On standby basis
Topsail	Island Pond	7.3	Manuels Pond	15.8	23.1	1932		1	NLPCL	311	1,600	
Pitmans	New Chelsea	24			24	1959		1	NLPCL	65	1,200	
West Brook	St. Lawrence	18			18	1941		1	NLPCL	154	1,000	
Port Union	Whirl Pond	29			29	-		2	NLPCL	70	900	
Victoria	Rocky Pond	34			34	1960		1	NLPCL	-	750	
Snooks Arm	-	-				-		1	FMMCL	-	750	
Fall Pond	Waterfall Brook	13.1			13.1	1937		1	NLPCL	50	500	
Lawn	Lawn	31			31	1930		2	NLPCL	82	500	
Venams Bight	-	-			-	-		-	NLPC	-	480	On standby basis
Clarenville	Shoal Harbour River	6.5			6.5	-		2	NLPCL	56	150	

LEGEND AND SOURCE

NLPC - Newfoundland and Labrador Power Commission
BPCL - Bowater Power Company Limited
PNL - Price (Nfld) Pulp and Paper Limited
NLPCL - Newfoundland Light and Power Company Limited
ASRC - American Smelting and Refining Company Limited
FMMCL - First Maritime Mining Corporation Limited

TABLE 1-8

LABRADOR

MAIN CHARACTERISTICS OF EXISTING
HYDRO-ELECTRIC DEVELOPMENTS

		Menihek	Twin Falls
Drainage Area:	Name	Ashuanipi	Unknown River
	Square miles	7400	8800
Year Installed:	First unit	1954	1962
	Latest unit	1960	1968
Number of Units:		3	5
Owner:		Iron Ore Company of Canada	Twin Falls Power Company
Rated Head:		2 - 34 feet 1 - 40 feet	290 feet
Total Installed Turbine Capacity:		25,500 hp	358,000 hp (ultimate capacity)

TABLE 1-9

2 FISHERIES FOR FRESH WATER DEPENDENT SPECIES *

2.1 Potential

Until the beginning of the twentieth century, the fresh water fisheries resource of inland waters in Newfoundland was almost a complete unknown since the demand was easily satisfied in accessible areas and further investigation of the resource appeared unnecessary. Progress in assembling data was still modest until about two decades ago, but the subject is now receiving considerable attention from both the Federal and Provincial Authorities.

In 1949 the Newfoundland Department of Natural Resources was commissioned by the Government to make a brief survey of some of the major fresh water areas in the Island, primarily to sample their fish populations. After confederation with Canada, research activity into the fishery resource became a function of the Fisheries Research Board of Canada, and resource administration and management a responsibility of the Department of Fisheries proper. By agreement, however, the new Newfoundland Provincial Government maintained the management of its fresh water fisheries for seven years until 1956, while agreeing to co-operate with the Federal Government in those streams supporting anadromous species such as salmon. In 1956 full control and authority was turned back to the Federal Government.

In 1951 the St. John's Biological Station of the Fisheries Research Board of Canada began a survey of some of the major salmon runs of the Island. Additional information on other fresh water fisheries was made available as a result of these efforts. The studies began with the Gander and extended to the Terra Nova, Bay du Nord, and Little Codroy rivers; the latter study lasted from 1954 to 1963.

The Fish Culture Development Branch of the Canada Department of Fisheries was established in 1954, and carried out management activities such as fishway construction as well as routine protection and co-operative regulation enforcement. The Branch limited itself almost entirely to improving the fresh water habitat for anadromous fish until 1956.

A brief survey and report by Drs. W. B. Scott and E. J. Crossman[1] of the Department of Ichthyology and Herpetology of the Royal Ontario Museum completed in 1962 extended knowledge of the species in fresh water and estuarine areas.

*In the text this classification is abbreviated to Freshwater Fisheries.

The water requirements of the fresh water fisheries have to be assessed from the rather sparse information indicated above, supplemented by information from areas where studies have been carried out over a longer period. It is now evident that the fisheries constitute a potential resource of sizeable value as indicated in Section 5.

2.1.1 Atlantic Salmon

The Atlantic salmon, considered one of the world's great game fish, is the dominant sport fish in the Island. It has made rivers such as the Humber, Gander, and Harry's in Newfoundland and the Eagle and Forteau in Labrador famous to anglers. For this reason, the Canada Department of Fisheries has concentrated its efforts mainly on this species, and it is discussed in some detail herein. On the Island alone salmon can be caught in more than 300 different rivers. In 1966 there were 134 "scheduled" rivers considered to be good Atlantic salmon areas needing protection where only anglers using flies were permitted. Figure 2-1 shows the total recorded annual angling catch for all Newfoundland rivers from 1952 to 1966.

Some of the necessary physical qualities which determine a good salmon river are clean, fresh, steadily-flowing water, and favourable spawning and rearing grounds. The river should not have any barriers which block the ascent or impair the descent of migrating fish, and it should be devoid of or have an acceptably low level of pollution. This is more favourable if the river basin maintains only the normal number of predators such as fishers, mergansers, otters, and other creatures which normally feed on the young salmon. Along the length of the river and its tributaries, it is essential to guard against the human fish poacher, who is often considered the main threat to proper fisheries development.

Spawning areas must be easily accessible and extensive enough to enable the fish to spawn properly. Ideally, the river flow should be both adequate in volume and steady in velocity so that the eggs which are deposited in the gravel will not be damaged by dessication or scouring.

The fertilized eggs of the Atlantic salmon are deposited in a redd or nest which is cut in the river bottom by adult female salmon. She normally buries them beneath 6 to 12 inches of gravel so that there is an adequate percolation of oxygen carrying water through the gravel and yet the eggs are protected from ice action. After spawning the salmon, now devoid of sexual products, are called kelts. The eggs hatch in May, about 185 days after fertilization, the time depending on the water temperature. The young, known as alevins, are about an inch long and live in the gravel of the redd, nourished by the yolk sacs attached to their bellies. When these sacs are absorbed after about a month, the young fish, now known as fry, emerge from the gravel to become free swimming, and feed on very small forms of aquatic life in the stream. Fry are normally called parr when they are about 2 inches long and develop their so-called parr marks. The latter are dark oval blotches on the sides of the body with prominent red spots between them along the lateral line. Parr in rearing areas must have adequate food and a suitable supply of cool, clear water which flows steadily around them.

Parr eventually become silvery and develop into smolts which must have free and easy access to the sea. Those parr which reach a length in the order of 4 inches at the end of the growing season are likely to become smolts in the following spring.

The rate of growth of the young salmon is slow in fresh water, and it may only reach the required size to journey to the sea at an age varying from 2 to 7 years, and still weighing only a few ounces. In Newfoundland most smolts are 3 or 4 years old. During the saltwater life of the fish, which may last from 1 to 5 years, development is rapid and weights of 3 to 60 pounds are attained[2]. Normally, weights up to 6 pounds are reached by salmon returning to the fresh water after about one year at sea and weights ranging from 10 to 20 pounds after two years. Atlantic salmon, as opposed to their Pacific relatives, may spawn more than once.

Small salmon which have only spent one winter at sea are known as grilse. Generally when an Atlantic salmon is referred to simply by the word salmon, the specimen is older and larger than a grilse. The Canada Department of Fisheries compiles data on some rivers covering, among other things, the number of rod-days of the annual sport fishery and these data are classified under grilse and salmon. The latter are shown in Table 2-1 for some 39 river basins on the Island of Newfoundland.

An assessment of the potential of the fresh water fishery in Newfoundland and Labrador would have to be based primarily on trends in the number of Atlantic salmon, the dominant species in the rivers of the Province. This assumes that the overall fish habitat preservation is adequate and in balance with the angling pressure so as to maintain a relatively constant base upon which comparisons may be made with time. Should the assumption not be met, it would be necessary to derive a sliding scale of values to cover the variation of conditions with time in order to produce a common basis for comparison.

Potential could be measured better by using the fish count indices. However, as yet there are not sufficient fish-count data on the Island to make estimates of the Atlantic salmon stock size in absolute terms. Table 2-2, the fish count summary, gives only an index to the total population.

The Canada Department of Fisheries has made estimates of the ranges of present populations of Atlantic salmon in several rivers and from these, along with a knowledge of management data, estimated the potential ranges in total population as shown on Tables 2-3 and 2-4. The total Atlantic salmon run listed in the tables indicates the total productive capacity (adults) and includes probable contribution to the commercial and sport fisheries as well as spawning escapement for reproductive purposes.

In estimating the potential, it should be borne in mind that many of the downstream migrating fish, both kelts and smolts, leave fresh water and never return. Considerable numbers are taken by the commercial fisheries at various sizes, and many of the smolts reaching the sea are taken by predators or disappear for other reasons.

2.1.2 Other Fresh Water Species

The report by Scott and Crossman[1] involved the study of over 3,000 specimens from more than fifty localities on the Island.

There are 19 different species of fish listed in the report for the fresh and semi-brackish waters of the Island. These are sea lamprey, Atlantic sturgeon, alewife, American shad, Atlantic salmon, Arctic char, brook trout, American smelt, American eel, banded killifish, mummichog, tomcod, four species of stickleback, American sandlance, windowpane, and winter flounder. In addition, four species have been introduced to the Island. These are lake whitefish, pink salmon, rainbow trout, and brown trout. It should be noted that some of these fish such as American sandlance, windowpane, and winter flounder are normally salt water species, and are recorded here from incidental catches in semi-brackish areas.

There are little data available on the species of fresh water fish in Labrador. There are 17 species known to inhabit the Churchill River, and these are listed in Volume Six B, Part VIII. There are no statistics on the actual population of fresh water fish; consequently it is not possible to estimate the potential. Should such statistics become available, the climatologic, hydrologic, and topographic data included in Volume Two A and B might be useful in determining relationships between fresh water fish potential, natural conditions, and pollution load.

For preliminary estimates the only assumption which can be made about potential of species of fish other than Atlantic salmon is that Provincial streams will support anadromous brook trout populations of about the same size as populations of Atlantic salmon. The completion of an inventory of the fresh water resource would form the basis of estimating its economic potential and fulfill a fundamental requirement of a resource management program.

2.2 Quantity and Quality Requirements

It is almost impossible and certainly unwise to designate definite specific water quality or quantity requirements for any species of game fish because of the effect of ambient factors such as acclimation, history, age, size, and general activity. On the other hand, it is possible from the limited data at hand to specify a range in certain conditions under which game fish of the Province should prosper. Such a range, based mainly on the requirements of Atlantic salmon and trout, the most important types, is approximately as follows:

a) Temperature no greater than 25 deg C. The preferred temperature for salmon is about 14 deg C and speckled trout about 10.5 deg C.

b) Dissolved oxygen not less than 6 ppm although 7.5 ppm is more desireable.

c) pH range - 6.5 to 8.5.

d) Specific conductance. This is difficult to set because some rivers, such as the Miramichi, have values less than 100 mho x 10^{-6} throughout, some tributaries dropping to as low as 28 mho x 10^{-6}. The Exploits at Grand Falls is less than 50 mho x 10^{-6}.

e) Free carbon dioxide not over 2 cc per litre.

f) Ammonia not over 1.0 ppm.

g) Turbidity less than 25 units is possible although acclimated populations may exist moderately well in higher quantities.

h) Absence of toxic substances or pollutants.

Water meeting, or approximating, the above-noted limits is favourable for the mixed temperate zone fishes such as are found in Newfoundland and for their food organisms. As a matter of fact, these requirements generally are met in the rivers of Newfoundland; turbidities in excess of 25 units, however, have been encountered in the disposal of ore tailings in the Province, particularly in Wabush Lake. Similarly certain toxic substances such as copper, zinc, and sulphite waste liquor have threatened full use of rivers by fish notably in the Exploits River which is discussed more fully in Volume Six A, Part I.

Quantity requirements are even more difficult to assess since there is a close relationship between quantity and quality requirements, and the local topographic and hydraulic conditions are significant factors in determining the minimum water quantity. In the Province's conditions, it appears that the minimum monthly flow with a probability of 30 percent is accepted as a minimal requirement when flow diversions are considered. It is obvious, however, that a reduction in the average flow is likely to reduce fish populations.

2.3 Research and Development Measures

Tagging operations form part of the research work being carried out by the Resource Development Branch (formerly Fish Culture Development Branch) of the Canada Department of Fisheries. The information obtained therefrom is essential to the understanding of the life history and movements of fish and to facilitate the design of conservation measures, such as artificial spawning channels which have been successfully constructed on Noel Pauls Brook, a tributary to the Exploits River, and Indian River in Notre Dame Bay.

Tagging programs were carried out at Port aux Basques in 1937; at St. Anthony in 1938; at Bonavista in 1940; at Cape St. Charles, Labrador, in 1948; and at Francis Harbour Bright, Labrador, in 1950. In addition, a tagging operation together with some fish counts through a counting fence were completed on the Little Codroy River between the years 1954 and 1963.

A tagging operation with a fish trap was scheduled to be set up at Main Brook, Hare Bay, near the tip of the Great Northern Peninsula in the spring of 1968.

A rapidly developing Greenland fishery which has recorded the landings of some salmon from Newfoundland, the remaining Atlantic Provinces, and Europe, stresses the importance of fish tagging operations to learn the migratory habits, distribution, and actual spawning locations of the Atlantic salmon. Without such information there is no hope of reasonably applying control or other necessary remedies.

Information on survival and homing of the Atlantic salmon has arisen from experiments on at least four rivers in eastern Canada, one being located in Newfoundland (Little Codroy). In each river the seaward migrating smolts were counted and combinations of fins removed. Results from the Little Codroy, which of course are not exactly similar to others, indicate that about 2.3 percent of smolts survived to become adults. About 1.4 percentage points of these adults were taken by commercial fishery and the remaining 0.9 percentage points returned to the river.

Intensive research on the Little Codroy River also included a program of electrofishing. This method was used to determine distributions of marked fry and to establish population indices for parr and other species in various habitats. Thus, evaluations may be made of the characteristics of other river basins for proposed artificial introductions, if necessary.

Conditions suitable for spawning are given by Dymond[3] and results of some investigations on the Little Codroy River are discussed by Murray[4].

Further studies carried out by the Canada Department of Fisheries with electrofishing gear gave insight to the fry dispersal and the parr production capacity of Indian River, Notre Dame Bay. It was found that fry do not move more than 2 to 2.5 miles downstream from their spawning area and the resulting density of parr is 18 per 100 square yards[5].

In addition to the foregoing work carried out on the Indian River, programs have been and are being conducted to measure the sizes and proportions of artificial channel escapement, the characteristics of spawning, the movements of kelts or "spent" salmon and the count of smolts and fry from the artificial spawning channel. This channel, lined with a selected gradation of gravel and stone, is located approximately nine miles downstream of the dam which diverts the headwaters of Indian River into Birchy Lake for hydro power generation at Deer Lake. It was completed in 1962 to offer an alternate spawning ground to those lost by the diversion. Adult salmon were first given access to the channel in 1963.

During the years 1963 to 1966, an average of 136 kelts per year have been tagged and released from the Indian River channel. The majority of the recoveries have been made in the year following release by the commercial fishery operating within 30 to 40 miles of the river. A smolt count carried out in 1966, indicated that 72.9 percent of the smolts migrating to sea are three years of age or older. This smolt run started on May 26, peaked on June 7, and finished on June 16. The movement commenced when the water temperature reached and remained in excess of 7 deg C. It was closely followed by the fry run which peaked on June 17 and amounted to 33,875 individuals.

Six thousand fry were marked by removing their dorsal fins in 1965 and another 10,000 were similarly treated in 1966 in order to assess the contribution of the channel to the smolt and adult runs. To date, an insufficient number of marked fry have been recaptured to draw any conclusions from this phase of the study.

The Canada Department of Fisheries has located about 18 counting fences and counting traps on main rivers and tributaries in Newfoundland and in three areas of Labrador. The fish counts for these structures do not give accurately the populations or number of fish in the rivers at any one time, but do provide an index to the annual escapement or spawning run to the rivers as a means of recognizing by comparison from year to year any improvement or decline in the fishery. Estimates of the total number of fish could only be made by knowing all pertinent time and space variables governing the distribution of fish and the efficiency of the counting equipment. Unless such variables were known and considered, the fish count could, for instance, represent anywhere from 5 to 95 percent of the total run.

Ordinarily the fish count figures are broken down into the number of grilse and the number of salmon, as is done with the angling data. In some cases, however, only the total number of salmon of any size is recorded. The number of brook trout was recorded for the Little Codroy River during the years 1954, 1955, and 1956, and for the Lomond River in 1948 and 1950. In Labrador, the number of brook trout and arctic char were counted in Double Brooks and Sandhill River during 1967.

Such fish count results are given in Table 2 - 2. Generally as a check, the runs are counted for at least two years at the site of a newly constructed fishway with random counts continuing for an indefinite number of years. Fishways are now in operation at 8 different locations on the Island.

In addition to the various age and development classifications given to the Atlantic salmon, there are two basic types of the Salmo salar species both of which are found in Newfoundland and Labrador. These are the anadromous, sea run, or migratory Atlantic salmon, and the non-anadromous, landlocked, or non-migratory ouananiche. Very nearly all the rivers on the Island support anadromous salmon, apart from a few such as the Cat Arm River on the Great Northern Peninsula which has some very steep rapids and falls near its outlet. Landlocked salmon have been found in all major and many minor watersheds. No reports of findings of these ouananiche have been confirmed on the Great Northern peninsula. [1] However, this is likely a result of the lack of investigation and of angling pressure on the rivers and ponds of the northern inland areas.

Conservation measures taken to increase anadromous salmon populations in the Exploits River also benefited the landlocked salmon in the basin above the impassable Grand Falls. Steps have been taken to increase their population and construction of the planned fish passage facilities at Grand Falls will introduce anadromous salmon to the areas upstream. Measures which have already been carried out in the Exploits basin are outlined in this report in Volume Six A, Part I. Improvement measures carried out in the Terra Nova, Humber, White Bear, Grey, Salmon, and Conne rivers are also described in Volume Six.

Other rivers which have had natural obstructions either removed or by-passed are Bay du Nord, Torrent, Lomond, and North West (Port Blandford) rivers.

2.4 Objectives and Projects

The primary objective of both the Federal and Provincial fishery authorities in Newfoundland and Labrador is to protect and preserve the species which supplies in part the commercial fisheries and the development of sport fisheries. On a regional basis, an optimum use should be found for the fishery resource in the rivers which complies with the multiple purpose and conjunctive use of all available surface and groundwaters in that region or basin. Optimum use may include the release of water from upstream reservoirs to improve environmental conditions for fish development in some areas, and the use of non-indigenous fish, such as carp, to control extensive organic pollution.

Ideally the fish and fish habitats of all the rivers should be protected by proper conservation measures. In Newfoundland there are over 300 good salmon rivers on the Island alone, to say nothing of the enormous fishery resource which may be found in the mainland rivers of Labrador. Fish conservationists may, however, sometimes be required to accept the fact that a fish run must be sacrificed for other more important economic developments within an integrated river basin water resources management program. Nevertheless, if it is necessary to forsake the fishery in a river basin for the promotion of a noncompatible resource, every effort should be made to save the stock with various remedial measures and compromises even to the extent of considering artificial stocking or transfer to unused habitats.

An example of such an effort is the Rattling Brook salmon transfer which was necessitated by the construction of a hydro power dam on that stream and the demand for Atlantic salmon in the receiver stream, Great Rattling Brook. Although it might have been preferable to maintain the salmon run in its original habitat, this could not be done, and the complete success of the Rattling Brook transfer program illustrates the feasibility of one far-reaching conservation measure.

Some of the existing and foreseeable fisheries projects are listed as follows:

2.4.1 Harrys River

Studies are continuing for the provision of remedial measures in the river basin which will be required to protect the fishery and accommodate proposed industrial development schemes. Proposed facilities must accommodate a spawning escapement of 10,000 salmon to the river. Data on movements, numbers, behaviour, etc., are now being gathered through the use of a counting fence and other standard methods.

2.4.2 Humber River

The removal of approximately 400 to 500 adult salmon per year is continuing to stock Noel Pauls Brook.

The pollution situation in the Humber Arm is discussed in Volume Six A. A preliminary investigation of the degree of this pollution was to be carried out in 1968.

2.4.3 Exploits River

Biological studies will continue in Red Indian Lake and the river to assess the variation in pollution levels resulting from the partial impoundment of the base metal tailings at Buchans Mine, and the change from the calcium to sodium base sulphite pulp at the Grand Falls Mill. Domestic wastes will be measured on a continuing basis throughout the Exploits basin. Eight new sampling stations are to be established by the Department of Energy, Mines and Resources at strategic locations in the basin. Investigations will continue into the interrelationship between the salmon run and the river's critical discharge leading to a firm assessment of the effect of the Bay D'Espoir Stage II diversion.

Great Rattling Brook - the fishway count to assess the continuing success of the total transfer from Little Rattling Brook will go on along with the angling data collection.

Noel Pauls Brook and Mary Ann Brook - the smolt production and adult salmon return counts will commence in 1968 in order to study the success of the transfers. Fyke net assessments will be carried out each spring and electrofishing surveys will be carried out to observe the resident population. Further surveillance of the Pine and Unnamed Falls will assess the degree of obstruction imposed at low flows.

2.4.4 Indian River

Surveys of the egg to fry survival rates and the other development stage observations will continue in the determination of the spawning channel efficiency. Further investigations at Indian Pond are designed to evaluate its parr producing capabilities.

2.4.5 Black River and Come By Chance River

The effects of the proposed diversion of the Black River into the Come By Chance River requires the evaluation of anadromous and resident salmon movement.

2.4.6 Conne River

The effects of the increased flows in Bay D'Espoir will be studied as they may alter the salmon run up the Conne estuary. Angling records will determine the impact of the increased sport fishing pressure upon the river's stock.

2.4.7 Labrador Rivers

The fish counts will be continued and the effects of insecticide spraying around Labrador City will be evaluated.

2.4.8 Greenland

The migration of Atlantic salmon to Greenland will be evaluated and the homing characteristics noted with the tagging operations in various strategic locations.

2.4.9 Bay D'Espoir and Churchill Falls Hydro Developments

Reservoirs are to be investigated to determine the potential for recreational and commercial fishery.

2.4.10 North Harbour River

The potential for development of pink salmon in Newfoundland will continue to be investigated.

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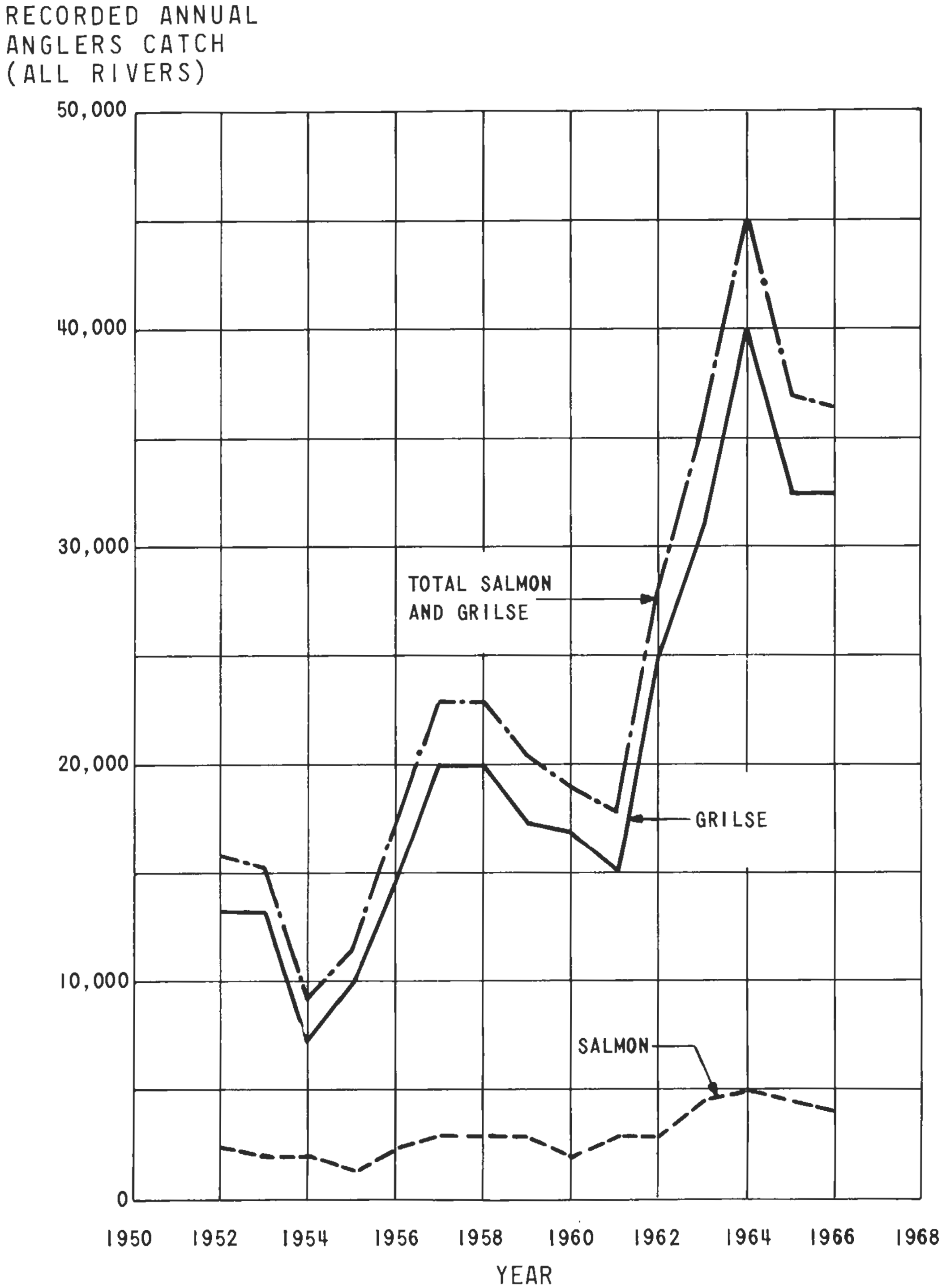
NEWFOUNDLAND
TOTAL RECORDED ANNUAL ANGLERS CATCH
OF ATLANTIC SALMON AND GRILSE



SOURCE: CANADA DEPARTMENT OF FISHERIES

FIGURE 2-1

SUMMARY OF NUMBERS AND WEIGHTS OF ATLANTIC SALMON CAUGHT BY ANGLERS

Name	Years Records Available	Total Years	Average Annual Rod-days	Average Annual Catch per Rod-day	Average Annual Catch Salmon and Grilse No. of Fish	Weight (lb)
Big Salmonier Brook	1953 to 55, 58, 59, 64	6	30	0.33	10	35
Biscay Bay River	1952 to 66	15	538	0.35	187	762
Black River	1965	1	55	0.27	15	50
Castors River	1952 to 66	15	191	1.05	202	1006
Cat Arm River	1963	1	17	0.29	5	15
Colinet River	1952 to 66	15	121	0.27	33	172
Come By Chance	1952 to 60, 1962 to 66	14	89	0.10	9	38
Covey Arm, West Arm Brook	1954, 1963, 1964, 1966	4	73	0.18	13	43
Conne River	1952 to 66	15	568	1.04	588	2184
Cooks Brook	1964 to 66	3	223	0.40	90	296
Exploits River	1952 to 66	15	1627	0.35	577	2608
Farmers Brook	1952 to 66	15	69	2.04	141	543
Gander River	1952 to 66	15	2023	0.90	1813	8910
Garia Brook	1952 to 66	15	86	0.52	45	196
Garnish River	1952 to 56, 1958 to 66	14	56	0.41	23	82
Goose Arm Brook	1955 to 66	12	280	0.08	23	98
Grandys Brook	1952 to 66	15	222	0.83	186	796
Grey River	1952 to 66	15	61	2.50	152	734
Hampden River	1961 to 64	4	24	0.33	8	28
Harrys River	1952 to 66	15	2103	0.61	1288	5779
Highlands River	1952 to 66	15	292	0.25	72	627
Humber River	1952 to 66	15	4066	0.61	2496	11,719
North Arm River	1952 to 56, 1958, 1963 to 64	8	60	0.17	10	40
North Harbour River	1952 to 66	15	188	0.16	30	111
North River	1957, 1963 to 66	5	127	0.05	6	24
Peters River	1954 to 56, 1958 to 60, 1962, 1964	8	21	0.29	6	30
Pipers Hole River	1952 to 66	15	169	0.17	28	111
Salmon River	1952 to 66	15	34	0.74	25	98
Salmonier River [1]	1952 to 66	15	1338	0.48	649	1924
Salmonier River [2]	1952 to 66	15	226	0.30	68	284
South River	1956 to 59, 1963 to 66	8	86	0.31	27	76
Southwest River and Bottom Brook	1952 to 66	15	874	0.56	489	2325
Taylor Brook	1965 to 66	2	79	0.09	7	25
Taylors Bay Brook	1963 to 66	4	30	0.40	12	46
Terra Nova River	1952 to 66	15	707	0.27	195	828
Terrenceville Brook	1952 to 58, 1960, 1962 to 66	13	35	0.25	9	36
Tides Brook	1952 to 66	15	307	0.27	84	350
Western Brook	1954 to 66	13	73	0.66	48	283
White Bear River	1952 to 66	15	85	0.69	59	286

* for 39 of the 134 scheduled Atlantic salmon rivers on the Island

[1] Avalon Peninsula
[2] Burin Peninsula

TABLE 2-1

RIVER	1948	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967
NEWFOUNDLAND																			
Bay du Nord					98^A 53^B	21^A 34^B	6^A 23^B												
Exploits River at Bishops Falls at Tote Brook at Great Rattling Brook											994^T	1170^T 201^T 103^T	957^T 11^T 372^T	180^T 1068^T	1267^T 99^T 528^T	1868^T	1433^T 777^T	1333^T 1412^T	2082^T 1204^T
Gander River at Salmon Brook			9700^T						965^T	1574^T	881^T	474^T	56^T						
Harrys River																			979^A 266^B
Humber River at Birchy Basin																			144^A 16^B
at Adies Stream																			1740^A 151^B
Indian River										923^T	456^T	519^T	154^T		289^T	1244^T	394^T	298^T	116^T
Lomond River	4^B 29^C	2^B 5^C											12^T	49^T	31^T	24^T	22^T	2^T	
Little Codroy						215^B 282^C	109^B 445^C	323^C											
Middlebrook at Gambo River								380^T	30^T	563^T	308^T								
Northwest River at Port Blandford	62^B	19^A 18^B																	
Rattling Brook								596^T	610^T	786^T	329^T	682^T	254^T	151^T	51^T	22^T			
Salmon Brook at Hare Bay																			767^T 30^T
Salmon River at Bay D'Est		69^A 30^B																	
Terra Nova River				425^A 26^B															
Torrent River																		40^T	51^T
LABRADOR																			
Double Brooks																			130^A 91^B 49^C 64^D
West Brooks																			14^A 1^B
Sandhill River																			676^A 103^B 108^C

LEGEND

A - Grilse
B - Salmon
C - Brook Trout
D - Arctic Char
T - Total

NEWFOUNDLAND AND LABRADOR

- FISH COUNT SUMMARY

TABLE 2-2

POTENTIAL ATLANTIC SALMON RUN

SELECTED RIVER BASINS

River	Total Atlantic Salmon Run Present	Total Atlantic Salmon Run Potential	Estimated Cost to Achieve Full Potential (dollars)	Comments
Exploits	1,500 to 4,000	135,000	1,200,000	-
Humber	24,000 to 40,000	59,000 to 75,000	400,000 to 500,000	Potential estimate excludes area upstream of Deer Lake hydro plant.
Lower White Bear	2,000 to 3,000	15,000 to 25,000	1,000,000	Flow releases from diverted upstream area required to realize full potential of lower area.
Lower Grey	4,000 to 6,000	10,000 to 15,000	310,000 to 480,000	Flow released from upstream area during dry periods.
Lower Salmon	nil	nil	*	Hydro development eliminated run.
Conne	4,000 to 12,000	slightly greater than present run	*	Potential has practically been reached.
Terra Nova	2,000 to 4,000	19,000	330,000 to 450,000	-
Gander	6,000 to 30,000	-	*	All tributaries accessible to fish.
Cat Arm	nil	10,000 to 20,000	*	Complete obstruction at river mouth.
Pipers Hole	150 to 300	16,000	145,000	Complete obstruction 12 miles from mouth.
Churchill	1,000	-	*	Complete obstruction at Falls.

Source: Canada. Department of Fisheries
* Estimate not available

TABLE 2-3

POTENTIAL ATLANTIC SALMON RUN

RIVERS IN STUDY AREAS

Study Area	River	Total Atlantic Salmon Run Present	Potential	Estimated Cost to Achieve Full Potential (dollars)	Comments
Come By Chance	Come By Chance	100 to 200	1,500	Water supply for industrial complex to provide facilities	Full potential may be developed if industrial complex is completed.
Come By Chance	North Harbour	180 to 250	4,500	*	Wide range of flows may affect present fish production.
Come By Chance	Black	200 to 300	5,000	150,000 to 200,000	Development will not take place if industrial complex is completed.
Come By Chance	North East	5,000 to 6,000	same as present	*	Maximum potential probably reached.
Come By Chance	South East	6,000	same as present	*	Maximum potential probably reached.
Corner Brook-Deer Lake	Serpentine	5,000 to 7,000	10,000 to 20,000	1,000,000	Basin is isolated.
Corner Brook-Deer Lake	Hughes Brook	100	2,000 to 2,500	*	Log driving activities have hindered development for fisheries.
Burin Peninsula	Main Brook	2,000 to 3,000	3,500	*	All tributaries are accessible to fish.
Burin Peninsula	Garnish	700 to 1,000	5,000 to 6,000	30,000 to 50,000	-
Burin Peninsula	Little St. Lawrence	200	1,500 to 2,000	5,000 to 10,000	Not a scheduled salmon river.
Burin Peninsula	Big Salmon Brook	200	700 to 1,000	5,000 to 7,500	Not a scheduled salmon river.
St. John's	Waterford	nil	-	*	Both rivers contain populations of brown and brook trout.
	Rennies	nil	-	*	
	North Arm	400	2,000 to 3,000	40,000	Studies required to determine reason river is not supporting its potential
	North and South Rivers	300 to 400	3,500 to 3,700	50,000 to 70,000	-
Bonavista	Little Catalina	nil	-	*	Not a scheduled salmon river.
	Port Union	nil	2,000 to 3,000	*	Hydro development eliminated present day run.
	Champney's Brook	200 to 600	2,400 to 3,600	*	-
Stephenville	Harry's	8,000 to 10,000	14,000 to 16,000	*	Rivers in this area may be adversely affected by a spray program in 1968.
	Little Barachois Brook	1,400 to 2,400	5,000	*	-
	Flat Bay Brook	8,000 to 12,000	same as present	*	Maximum potential probably reached.
	Southwest and Bottom Brooks	5,000 to 8,000	15,000 to 28,000	*	-

Source: Canada. Department of Fisheries
* Estimate not available

TABLE 2-4

3 LOG DRIVING

3.1 Present Day Conditions and Trends

For many years the general method of transporting logs to the mills consisted of dragging them to the rivers and streams by horses and using water to move them directly to the mills, or combining the use of log driving with rail and ship transport. This method is being replaced by a varying degree of mechanization, the first step being the employment of standard type trucks for the actual transportation of the logs, followed by the use of machines known as skidders for handling tree-lengths to where they can be loaded onto specially built trucks and trailers. Variations of these and supplementary measures are taking place across Canada.

Although rail facilities were used, particularly in the Terra Nova - Gander area, very little trucking of pulpwood took place on the Island prior to 1953 due, in part, to a lack of suitable roads. By 1966, however, it is estimated that about two-thirds of the Bowaters pulpwood and one-third of the Price pulpwood were being delivered to the mills by means other than log driving, and the trend has been a decreasing use of the waterways for moving logs. The progressive decrease in log driving is evident in statistics available from the Grand Falls mill. They show that log driving accounted for 92. 9 percent of the annual deliveries in 1951; 86. 3 percent in 1956; 84. 7 percent in 1961; and 64. 3 percent in 1966.

Price (Nfld) Pulp and Paper Limited still operates 25 dams having heads ranging from 4 to 14 feet within their timber limits, while Bowaters Newfoundland Limited maintain seven dams ranging from 6 to 8 feet. Four dams are in the Bay of Islands and one dam each in Frenchman's Pond, Adies Lake, and Birchy Basin. The majority of the Price logging dams have a head of 7 feet or less and the dams remaining in the Price system are located as follows: 12 on Victoria River and its tributaries; 7 on West Brook, southwest of Grand Falls; 3 above Gambo Pond; 2 on Harpoon Brook, downstream of Red Indian Lake; and 1 below Rushy Pond, upstream of Grand Falls.

The forests of Labrador have not been harvested to date and consequently log driving has not yet occurred in this area.

3.2 Potential

There is a physical potential for log driving in almost every stream, and it has been practiced in the past in almost every area where the forests have been harvested.

3.2.1 Island of Newfoundland

Even on relatively small streams, such as Hughes Brook (51 square mile area) which drains into Humber Arm, log driving has occurred. All the rivers where log driving is practised to any significant extent utilize low storage dams to increase river flow during the log driving periods. The use of these dams is essential even in the larger rivers on the Island.

As indicated in Section 3.1, log driving has decreased in recent years because of the increase in mechanization of woods operations, the construction of roads suitable for trucking, and the harvesting of the forests further from the main river. Nevertheless, regrowth of forested areas close to the main rivers, such as the Terra Nova and Gander, may revive interest in log driving practices when these areas are reharvested. Furthermore, log driving may well increase in some rivers as a result of combining log driving and trucking. As an example, if virgin forested areas are harvested on the east coast of the Great Northern Peninsula, the wood could be towed to Hampden on the south coast of White Bay, trucked to the Upper Humber River, dumped into the river, and driven to the mill[1].

Price (Nfld) Pulp and Paper Limited estimates that pulpwood is driven down the Exploits River to the mill at Grand Falls at costs considerably lower than the $10 to $15 per cord required to truck the wood. Consequently, although the general trend on the Island has been to less and less use of the waterways for moving logs, it is doubtful that trucking will completely replace log driving. In fact, there may even be an increase in present-day levels of annual mill deliveries by means of log driving. An analysis of comparative costs of log driving versus other means of transporting the wood is outside the scope of this study.

3.2.2 Labrador

It is expected that harvesting of the forest resources in Labrador will commence in the next few years and log driving may be used to some extent. The larger rivers in Labrador, however, may not require low storage dams to increase river flow during log driving periods. This is especially true in the Churchill River, where a regulated flow from the Churchill Falls plant of about 50,000 cfs will ensure flows which will be adequate for log driving of the main stem. Dams will probably be required on the tributaries when logging operations are carried out away from the main stem.

Although minimum runoff during the summer in Labrador is generally larger than on the Island, log driving on smaller rivers with areas of less than 2000 square miles will probably require some flow regulation. However, for the larger rivers, the Churchill, Naskaupi, Canairiktok, and Eagle, it is considered that log driving can be carried out at least in the downstream reach without the use of storage dams.

3.3 Changes in the Flow Regime and Water Quality

Log driving has necessitated the building of dams, usually of timber-crib construction, for holding areas and storage for flow releases during the log drive. Changes in the flow regime for one river on which log driving is practiced are shown in Figure 3-1. In this case the surges occurred during drought periods. The 1955 Report of the Royal Commission on Forestry[4] has this to say on the subject:

"From the economic standpoint this use of inland waterways comprise their greatest contribution to the provincial prosperity. Nevertheless these waterways have other values and uses that must be protected. The attention of the Commission has been directed to the fact that in many cases dams erected by the paper companies do not have the passways or fish ladders required by the Provincial regulations in effect before Confederation. It is alleged that fish have been impeded from reaching spawning grounds and that both commercial and sports fishing have suffered in consequence."

Other threats to the fisheries resource are as a result of:

scouring of spawning beds by the passage of logs;

the diversion of water from gravel bars causing deposited spawn to dry out and prevention of the utilization of spawning areas;

creation of log dams which hinder fish migration;

the deposition of bark which stifles bottom-dwelling fish food.

It has been estimated that at least five percent of the wood sinks to the bottom of rivers in this type of transportation system[3].

Evidence of the deposition of bark can be found in many of the Island's rivers. There is a natural barking action which occurs during log driving and frequently it is found that a large quantity of wood is already debarked when it reaches its destination. The amount of bark deposited in rivers used extensively for log driving is difficult to assess but it is probably quite substantial and may hinder the potential of the river for use by fish.

Werner[2] reports that wood wastes which form sediment beds can be a source of pollution problems.

The Department of Fisheries has requested the removal of log driving dams which have ceased to be of use and which present barriers to anadromous fish. This request has been carried out on several of the Island's rivers including the Conne, Gander, and Upper Humber Rivers.

3.4 Future Development

It is unlikely that the existing or new pulp and paper mills will require significant new log driving developments on the Island, especially since most of the wood input for the new mills will come from Labrador. Some new log driving dams may be required downstream of the Victoria diversion, if logging is to be continued on this river. Extension of log driving activity to the Great Northern Peninsula area is possible and this would require construction of new dams. Alternative methods of transportation of logs, including chip piping, may be a substitute for log driving in this area.

It is expected that harvesting of forest resources in Labrador will commence in the next few years and log driving may be used to a significant extent.

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NEWFOUNDLAND
EXAMPLE OF CHANGES IN RIVER FLOW
REGIME DUE TO LOG DRIVING

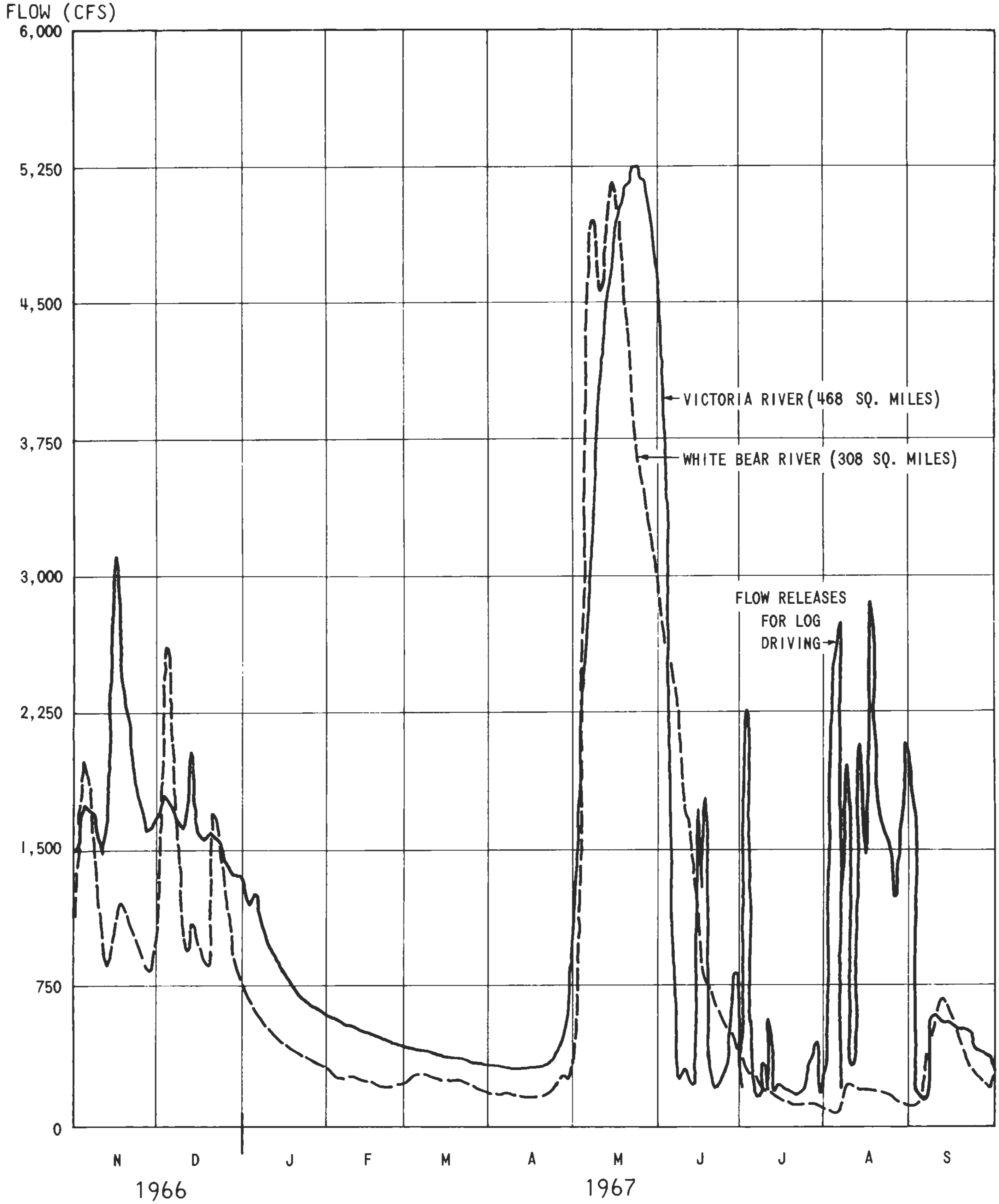

FIGURE 3-1

4 WILDLIFE

4.1 Introduction

The term "wildlife" as used in this section includes all non-domestic birds and land mammals on the Island and in Labrador. Information on wildlife population levels, wildlife commercial values, and the relationship of wildlife to water are contained in this section, and references are cited throughout the section giving detailed information concerning wildlife jurisdiction, protection, and management.

4.2 Present Day Conditions and Trends

The Division of Wildlife of the Resources Branch of the Provincial Department of Mines, Agriculture and Resources is responsible for administration, law enforcement, game management, and research functions in connection with wildlife in the Province. The Annual Reports of the Department provide details on these functions.

4.2.1 Land Mammals

There are 14 species of land mammals native to the Island of Newfoundland. An additional 10 have been introduced either intentionally or accidentally. In Labrador, there are about 42 species of land mammals. These land mammals are listed in Table 4-1[1].

There are very little data available on the continuously changing populations of most wildlife species found in the Province and available figures of population data can be considered as approximate only.

Moose comprise most of the big game harvest and have a present well distributed population on the Island of about 40,000[1]. Moose from the Island were introduced into southern Labrador in 1953 and reports indicate they are surviving. In addition, moose are believed to be moving into Labrador from the Province of Quebec.

Other than on the Avalon Peninsula and the northern sector of the Great Northern Peninsula there is little hope of the moose population significantly increasing on the Island. Spruce forests are slowly replacing the balsam fir stands and as this process continues, the moose populations may decline. Moose populations in sub-alpine habitats may decline considerably in years to come if the yield of sub-alpine fir stands is not prolonged. The results of the Canada Land Inventory, Forest Classification will best determine the danger level of this element. If reforestation and aforestation programs are to include a suitable insect resistant food species for moose, then the existing population may be maintained. At present, the winter food conditions for moose are more satisfactory in eastern and western regions than in central and southern Newfoundland.

Caribou, which comprise the second largest big game harvest in the Province, averaging about 350 animals annually in recent years, have declined in number considerably on the Island during the last half century. The present estimated Island population is approximately 10,000 animals and is but a remnant of the turn of the century populations. The main natural caribou herds on the Island are the Interior, the Avalon, the Humber River basin and the Great Northern Peninsula. The Interior herd is the largest having approximately 6,000 to 8,000 animals.

The caribou herds on the Island are now increasing through management practices and, provided the interior range is not seriously depleted, there should be no concern for the animals' future[1].

In Labrador, caribou have been important to the Eskimo for many years. There are three fairly distinct herds totaling about 27,000 animals. Recent studies in Quebec of this migratory population indicates that the total may be closer to 50,000. Hunting of the animals for sport has been allowed in recent years to qualified residents in Labrador. It is expected that more sport hunting will take place in the future.

Populations of the other land mammals listed in Table 4-1 are unknown. However, it is known that the pine marten and arctic hare are rare on the Island and the wolf and reindeer are now extinct.

Wildlife in Newfoundland and Labrador undoubtedly constitutes a valuable renewable resource. Not only does it provide a fascinating attraction to visitors who come for sightseeing, photography, or biological study, but it also provides a recreational and food resource for hunters.

Of the big game land mammals listed in Table 4-1, moose, caribou, and black bear contribute to the revenue of the Division of Wildlife from the sale of hunting licenses. About 63 percent of the total revenue received by the Division is from this source. The revenue from the sale of big game licenses for these three amounted to over $290,000 in 1966-67. The variation in revenue from license sales and the number of big game licenses sold in previous years is shown in Figure 4-1.

Sales of small game licenses, trappers licenses, fur dealers and fur farmers licenses, guides licenses, and fines and forfeitures also contribute to the revenue of the Division of Wildlife. About 12 percent of the total revenue received by the Division is from these sources which have amounted to just under $50,000 per year in the years 1963-64 to 1966-67.

The annual value of hunting has been estimated by the Tourist Development Division of the Department of Economic Development of the Government of Newfoundland and Labrador. Average values for the last three years, 1965-67, are listed below and include money spent for goods and services, such as licenses, guides, sale of arms and ammunition, taxidermy, and photographic and wildlife-watching equipment.

Type of Hunter	No. of Hunters	Estimated Expenditure/Hunter	Total Value
Big Game Resident	12,170	$ 70.00	$ 852,000
Big Game Non-resident	1,865	375.00	700,000
Small Game Resident	18,710	50.00	935,000
Small Game Non-resident	66	250.00	16,500
Bear Hunters	353	25.00	8,800
TOTAL (Average annual value of hunting - 1965 to 1967)			$2,512,300

The annual moose kill in the Province for the 1945-46 to 1966-67 period is shown in Figure 4 - 2. The average annual moose kill recorded for the last 10 year period of about 6500 provides in excess of 2,250,000 pounds of dressed meat assuming about 350 pounds per moose. This amounts to about $900,000 per year assuming a value of 40 cents per pound. The value of caribou meat is about $30,000 per year considering about 350 animals average 200 pounds of dressed meat valued at 40 cents per pound.

The snowshoe hare, a small game land mammal which, like the moose, has been intentionally introduced to the Province, has contributed to the Province's economy. This species provides a valuable source of fresh meat to many rural people. Most of these animals are taken by snares although the hunting of these animals with beagles is becoming an important sport. As an indication of the direct commercial value of the snowshoe hare, during 1967 over 430,000 were snared or shot, representing a cash value of about $430,000 or $1.00 per animal.

A summary of the estimated value of food obtained from the wildlife resource is as follows:

Source		Approximate Annual Value
Meat -	Moose	$ 900,000
	Caribou	30,000
	Snowshoe Hare	430,000
		$1,360,000

In addition, wildlife fur bearers contribute an average of $80,000 to the trappers in the Province as shown in Table 4 - 2. There is considerable potential economic value in the long-haired fur animals such as the fox and lynx which may be realized should the demand for these furs increase.

Besides the commercial values mentioned previously, there are recreational, biological and social values which, although difficult to measure, should be considered in water resource planning. There are also some minor negative values such as flooding of land by beaver dams.

4.2.2 Birds

There are 269 species of birds which have inhabited the Island at one time or another and it is anticipated that within the forecast period of this report, to 1981, the total list may include some 300 birds with newly recognized and established species.

Most of the birds are similar to those found on the nearby mainland. The birds of the Province are listed in the article by Tuck[2].

Ruffed grouse, and spruce grouse have been introduced to the Province in recent years by the Wildlife Division. Details on the management of these species can be found in the Annual Reports of the Department.

4.3 Water Resources and Wildlife

Fresh water is one of the essential requirements for birds and land mammals. Most species of wildlife could not exist without some open water.

4.3.1 Land Mammals

Some of the small fur-bearing animals in the Province are adapted to an existence in and near fresh water. These include the beaver, muskrat, otter and mink. Following is a general description of animals that are highly dependent on the fresh waters in the Province.

The beaver is highly dependent on water, making its lodge on a stream and using the water area for feeding and movement. The Newfoundland beaver has adapted to the Island habitat which would be termed poor in mainland areas. They utilize bog lakes where their food appears to be restricted to the tubers of the yellow pond lily, and the lily rootstocks and black spruce are used for building purposes. The pelt of the beaver provides a large part of the average value of the raw fur production (Table 4 - 2). The beaver is now generally distributed throughout the Island by the transplantation programs of the Department of Wildlife. Beaver were introduced from the Island to Labrador[1].

The otter is the second most valuable fur-bearing aquatic animal in the Province (Table 4 - 2). Otters are strong swimmers and are more agile and graceful in the water than on land. They eat almost anything they can find in water including clams, fish, frogs, insects, ducks, and muskrats[1]. The otter inhabits the sea as well as inland freshwater areas, and range in weight from ten to thirty pounds.

The Newfoundland muskrat is generally distributed throughout the Island but is most plentiful on the Avalon Peninsula and in the drainage basins of the large rivers[1]. The pelt of the Island muskrat is not as valuable as those on the neighbouring mainland. The species suffers from a scarcity of food plants in Newfoundland and the populations do not reach the abundance found in marshes of the mainland. The muskrat is relatively abundant in the marshes of the Codroy and Humber Rivers. Food plants include the yellow pond lily, pond weeds, sedges, and various grasses.

The wild mink on the Island is an escapee from the mink farming industry introduced in 1935. Labrador mink are natives and one of the most valuable of all wild mink. This species is not primarily aquatic but is a good swimmer capable of catching fish while swimming. They live along streams and remain close to marsh and stream areas in search of food.

The big game animals in Table 4-1 have a less evident connection to fresh water than the small fur-bearing species mentioned above.

The moose requires water for drinking and aquatic foods. In addition, the lowlands surrounding fresh water areas provide food. Water can also be used as a source of escape for the animal.

Of importance to this section is the possible correlation between fresh water areas and wildlife data. In this regard, studies by the Department of Wildlife have been attempted in Newfoundland since 1960 to determine the influence of watered areas upon the moose densities of the habitat. Attempts have been made to determine whether moose use ponds in the summer predominantly because palatable food species are found there, or to escape insects or hot weather and whether these ponds are necessary for the summer moose range. To date, the results of the research have unfortunately been disappointing and inconclusive and the work has been discontinued.

The caribou require water for drinking and indirectly for food which consists of lichens, grasses, sedges, and leafy plants.

The bear is less dependent on water, using it for drinking and to a lesser extent as a source of food.

The remainder of the species of land mammals found in the Province are also affected to some extent by fresh water and the resultant plant species that occur in lakes, bogs, and streams.

4.3.2 Birds

Waterfowl require water for many uses including nesting, feeding, escape, and resting. In rich marshy localities, which have built up where small brooks enter ponds or where beaver have dammed pond outlets, alders tend to grow and the ground cover is often a tall grass[2]. The backwaters are filled with yellow water lilies and aquatic plants. Black duck, teal, snipe, bittern, and swamp sparrows are typical birds in these marshy localities. During the winter, the bogs and barrens in the Province are almost devoid of bird life.

A list of some of the different species of birds which nest or live near the marshes, ponds, and rivers in the Province is shown in Table 4-3.

4.3.3 Water Resource Implications

Little is known about the quality of water required by wildlife although it is generally believed that wildlife is not adversely affected by wastewaters from domestic sources. Toxic algae have caused the death of domestic livestock and it is reasonable to believe that non-domestic land mammals would be similarly affected; no instances of such deaths have been reported in the Province.

Wildlife conservation and development in the Province should not be limited by the quality of the surface water available during the period of this study, with the possible exception of waters receiving potential toxicants from certain industrial wastewaters or from pesticides and herbicides. Pollution of sea coast waters by oil, probably resulting from ocean-going vessels, has produced frequent and significant kills of sea birds according to Monro and Sollman[3].

Quantity changes resulting from bogland drainage, flooding, and diversions also affect wildlife. Bogland drainage may affect both the feeding patterns and habitations of animals and birds. Losses of this nature would be part of any benefit/cost analysis of bogland development, particularly in large scale undertakings.

Changes in physical conditions resulting from flooding and diversions have broad implications. For example, loss of tributary streams had a serious effect on the beaver. Permanent flooding can have a two-fold effect. First it may prevent access by wildlife to certain areas. Secondly the lack of access for hunters prevents the cropping of species and may result in over-population which, in turn, results in forest damage from over-browsing.

Loss of wildlife habitat resulting from reservoirs created for hydroelectric developments has occurred in various Island locations in past years. In addition, hydroelectric developments under construction, such as Bay D'Espoir Stage II and Churchill Falls will affect wildlife habitat as large reservoirs are required for these developments and road access to wilderness areas permits increased harvesting of the big game animals. The full implications of these developments on wildlife populations are not known.

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NEWFOUNDLAND
NUMBER OF BIG GAME HUNTING LICENSES SOLD AND LICENSE REVENUE 1945-1967

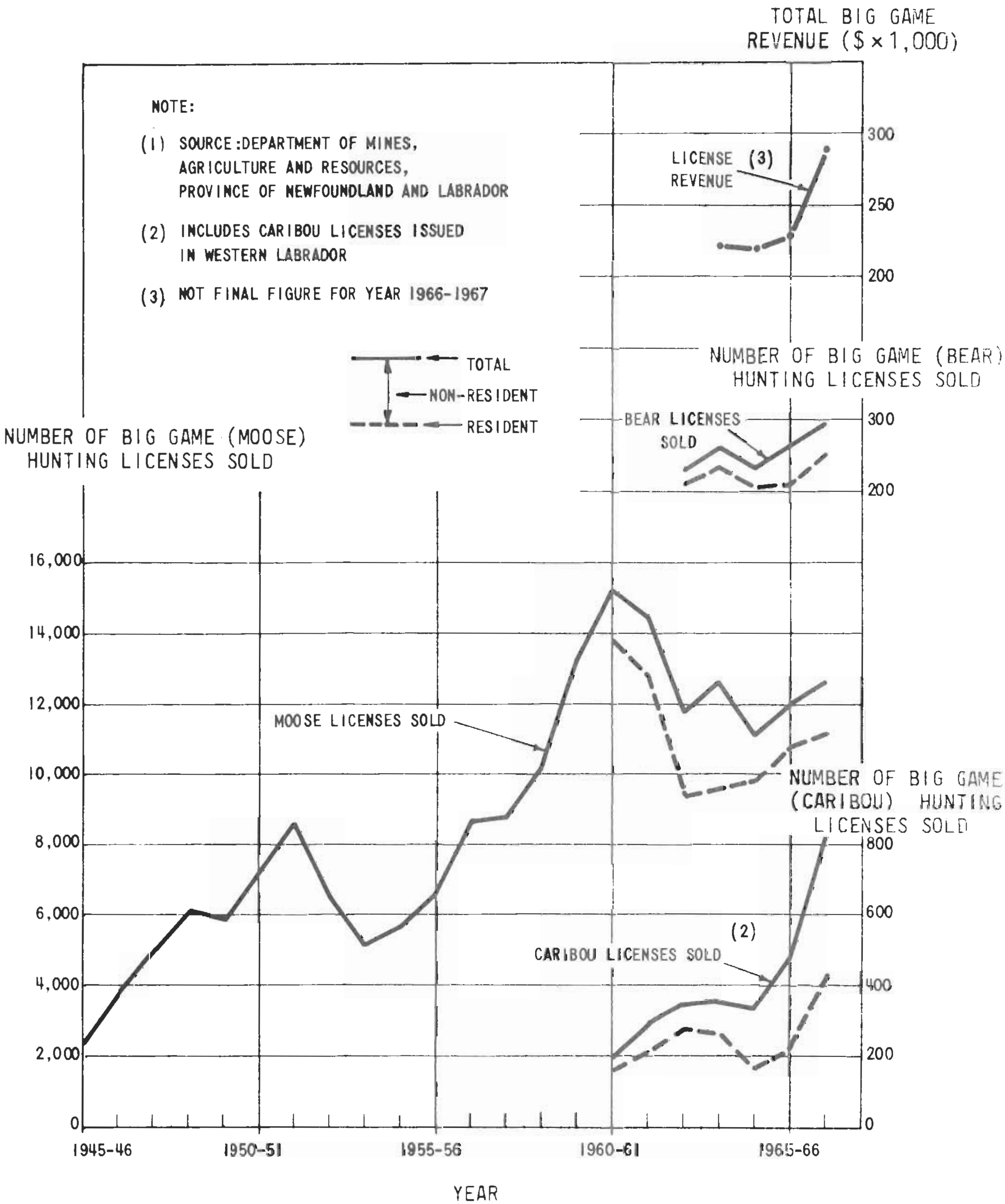

FIGURE 4-1

NEWFOUNDLAND
TOTAL RECORDED MOOSE KILL AND HUNTING SUCCESS RATIO 1945-67

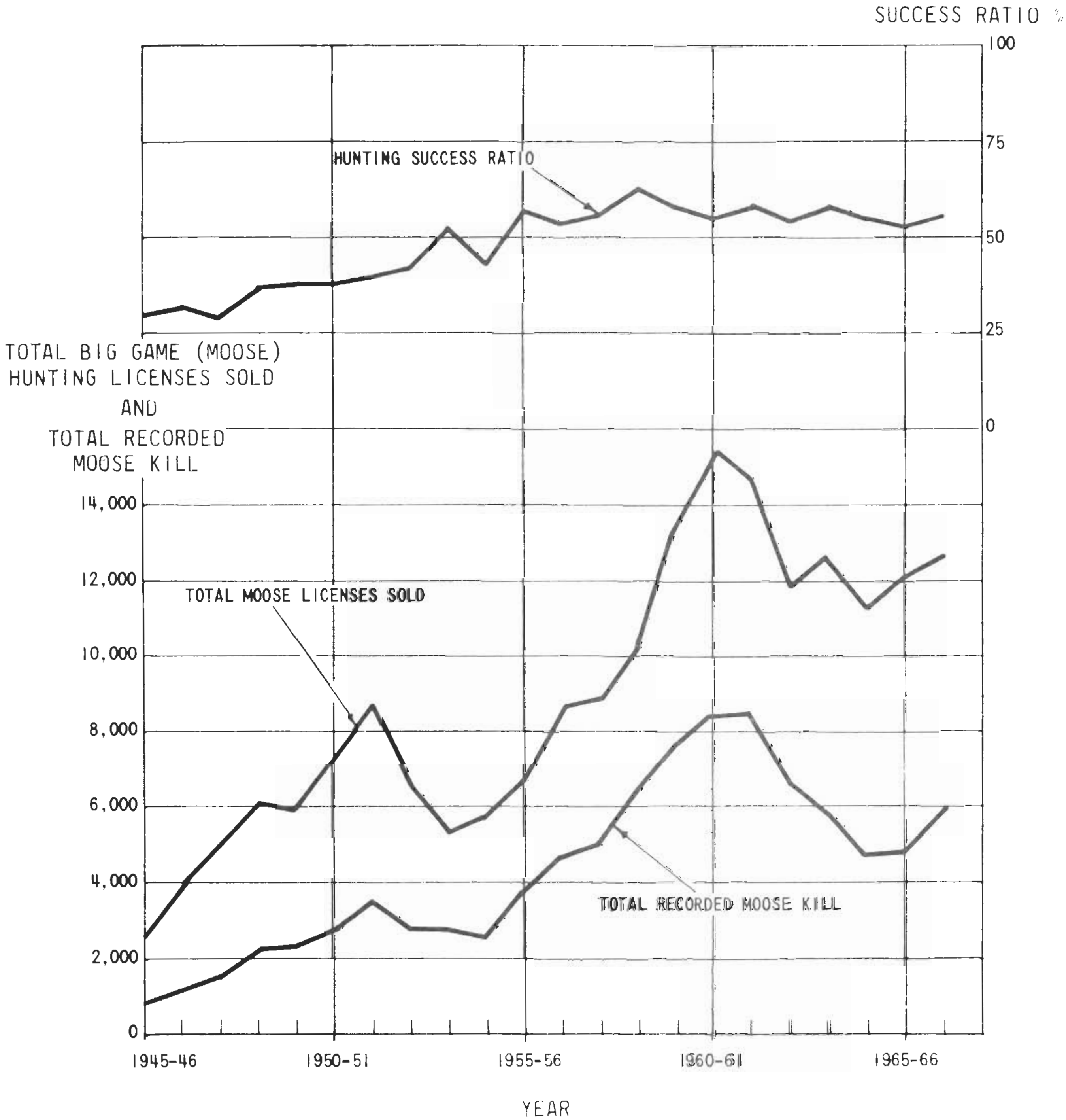

FIGURE 4-2

THE LAND MAMMALS OF NEWFOUNDLAND AND LABRADOR

NEWFOUNDLAND

Category	Common Name
Native	Little Brown Bat
	Long-eared Bat
	Black Bear
	** Pine Marten
	Beaver
	Short-tailed Weasel
	Otter
	Red Fox
	* Wolf
	Lynx
	Meadow Vole
	Muskrat
	** Arctic Hare
	Caribou
Accidentals	Polar Bear
	Arctic Fox
Intentional Introductions	Common Shrew
	Eastern Chipmunk
	Snowshoe Hare
	Moose
Accidental Introductions	Mink
	House Mouse
	Norway Rat
Experimental Introductions	Red Squirrel
	*Reindeer
	Buffalo

LABRADOR

Common Name	
Star-nosed Mole	Spruce Mouse
Masked Shrew	Red-backed Vole
Arctic Shrew	Meadow Vole
Water Shrew	Rock Vole
Little Brown Bat	Muskrat
Black Bear	Norway Rat
Polar Bear	House Mouse
Marten	Meadow Jumping Mouse
Fisher	Woodland Jumping Mouse
Short-tailed Weasel	Porcupine
Least Weasel	Arctic Hare
Mink	Snowshoe Hare
Wolverine	Moose
Otter	Woodland Caribou
Red Fox	Barrenground Caribou
Arctic Fox	
Wolf	
Lynx	
Woodchuck	
Red Squirrel	
Flying Squirrel	
Beaver	
Deer Mouse	
Northern Bay Lemming	
Brown Lemming	
Collared Lemming	

* extinct
** rare

Source: Peters, S. S., B. Sc., M. Sc., Ph. D.
Our Land and Sea Mammals
The Book of Newfoundland,
Volume Three. pp. 317-331

TABLE 4-1

NEWFOUNDLAND AND LABRADOR

VALUE OF RAW FUR PRODUCTION

Species	-----Average Value to Trapper----- 1965-66	1964-65	1963-64
Bear	30	60	60
Beaver	30, 120	32, 670	32, 270
Ermine	858	854	134
Fox	6, 175	10, 796	2, 279
Lynx	1, 280	6, 100	3, 032
Marten	996	220	3, 040
Mink (wild)	7, 720	8, 500	5, 976
Muskrat	3, 564	5, 792	3, 522
Otter	26, 475	21, 400	18, 200
Squirrel	283	290	83
Other	-	-	258
	$ 77, 501	$ 86, 682	$ 68, 854

NOTE: Ranch mink excluded

Source: Annual Reports of the Department of Mines, Agriculture and Resources

TABLE 4-2

GENERAL DATA ON RELATIONSHIP OF NEWFOUNDLAND BIRDS TO INLAND WATERS

Common Name	Nest Site	Seasonal Occurrence	Abundance
Common Loon	Lakes and remote large ponds	Overwinter in small numbers off the south coast	-
Pied-Billed Grebe	-	Seen in small ponds on Avalon in early winter	-
American Bittern	Marshy ponds and lakes	-	common
Canada Goose	Ponds in barrens, shores of large lakes	Some years they overwinter at Stephenville Crossing	common
Black Duck	Breed along coast	Overwinter frequently in small numbers	common
Green-Winged Teal	Breed in Province	Overwinter frequently in small numbers	common
Blue-Winged Teal	Nest in Codroy Valley and Humber Valley	-	-
Ring-Necked Duck	Nest in small sedgy bog ponds	-	common
Common Goldeneye	Nest on large lakes	Overwinter frequently in small numbers	common
Common Merganser	Breed in large trees along large lakes and rivers	Winter off coastline	-
Osprey	Summer residence along estuaries and large rivers and lakes	Migrate by mid September	common
Semipalmated Plover	Breed near large river mouths or on sandy beaches of large lakes	-	-
Piping Plover	Breed on Grand and Little Codroy Rivers	Generally summer only	-
Common Snipe	Breed on all bogs and marshy rivers	Occasionally overwinter	-
Spotted Sandpiper	Breed on every river and lake	Generally summer only	-
Solitary Sandpiper	Occur in central part of Island on Gander River and Exploits River	-	-
Greater Yellow Legs	Nest on bogs near lakes and large ponds	-	-
Pectoral Sandpiper	Sometimes inhabit grassy meadows along larger rivers and lakes	Generally summer only	-
Least Sandpiper	Breed on bogs	Generally summer only	-
Herring Gull	Nest on small islands in interior lakes and ponds	Year round	-
Common Tern	Breed along small ponds	Generally summer only	-
Belted Kingfisher	Nest along rivers and lakes	-	common
Common Yellow-Throat	Found in thickets along large rivers	Generally summer only	common
Swamp Sparrow	Found in wet bogs and marshes	Generally summer only	-
Rusty Blackbird	Breed along edges of bogs and ponds	Occasionally overwinter	-

Source: Tuck, L. M.,
"The Birds of Newfoundland"
The Book of Newfoundland, Volume Three, pp 265-316.

TABLE 4-3

5 RECREATION AND TOURISM

The report entitled "Reconnaissance Evaluation of Tourist Development Prospects in Newfoundland" by W. M. Baker[1] was used as the main source of general background on recreation and tourism in the Province. The water resource implications are the main interest of this section although current trends in the tourist industry are included.

5.1 Present Day Developments

The increasing recognition being given to tourism and recreation has resulted in continuing improvement in the records describing these activities. Because of this the data may not be strictly comparable over time and some of the increase may only reflect improved statistics.

The increased activity is coming from both the resident and off-Island population. While both are important to the economy, it is suggested that the development of facilities for the resident population is most important and that any additional activity necessary to attract off-Island tourists is a long range proposition. The development of facilities for the resident population may have considerable impact on the prevention of leakages over the study period.

Prior to Confederation, tourism played a very minor role in Newfoundland as the country was largely inaccessible except by air, coastal steamers, or the limited railway system[2]. It was not until 1965 that the Trans-Canada Highway was completed from Port aux Basques to St. John's. In that same year several new provincial parks were completed in preparation for the influx of tourists expected in 1966 as a result of the major campaign by the Newfoundland Government to attract visitors to the Province.

The results of the completion of the Trans-Canada Highway and the 1966 "Come Home Year" campaign by the Provincial Government are reflected in Figure 5 - 1. The figure shows that the estimated gross value of the travel industry rose from $33 million in 1965 to $55 million in 1967. These figures include estimated value of travel industry for: accommodation, hunting, fishing, transportation, gasoline sales and garage services, parks and camp sites and miscellaneous.

Another indication of trends in the tourist industry is the growth in the number of provincial parks and the increase in the number of visits to provincial, federal, and privately-sponsored parks on the Island. Figure 5 - 2 indicates that the number of visitors to provincial parks has increased from about 200, 000 in 1960 to about 1, 140, 000 in 1967. During the same period, the number of parks increased from 5 to 34. Also shown in the figure is the number of recorded visits to the Terra Nova National Park during 1964 to 1967, which increased from 61, 000 to 293, 000 during the four-year period. Although no figures were available on visits to the privately-sponsored Bowaters Park, it was estimated that attendance at this park was 100, 000 in 1964, increasing to 150, 000 in 1967. Consequently, it is estimated that total visits to all the parks on the Island, excluding small community parks, numbered over 1, 500, 000 in 1967. The locations of the parks are shown in Figures 5 - 3 and 5 - 4[3].

5.2 Water Requirements and Uses for Recreation

The Provincial parks system has been treated by the Government as an integral part of the tourist industry[4]. The vast majority of the parks use the fresh water resources to enhance the scenic quality of the landscape and the camping facilities and to support boating, fishing, or swimming.

Swimming and beach activities are two water based activities that have considerable appeal to the average vacationer. The report by Baker[1] states that a study conducted for the Outdoor Recreation Resource Review Commission indicated there is a major emphasis upon swimming and beach activities with tourist interest ranging from 33 to 38 percent. Moreover, a survey conducted in Terra Nova National Park indicated high interest in swimming and beach activities of about 31 percent.

In many areas of the Province the fresh water temperatures are cool by mainland standards. However, out of Province tourists are attracted by other considerations and for residents of the Province the water temperatures would not be unusual.

While the attraction of fresh and sea water swimming facilities may be of less importance than in other areas of the country, they should not be neglected. Consequently, one of the recommendations of the Baker Report was "that the Province of Newfoundland zealously protect and maintain the quality of all extensive natural beaches for they are a fairly scarce recreation and tourist resource".

Although the fresh waters of the Province are cool for swimming and beach activities, such water temperatures are a decided asset for many types of sport fishing. Newfoundland is justly famous for fishing, and the area is an acknowledged paradise for the sports angler. Over one hundred licensed salmon streams are available on the Island while various species of trout are found in virtually all the numerous ponds and lakes. Labrador has a large sport fishing potential as well, being populated by Atlantic salmon, ouananiche, Arctic char, speckled trout, lake trout, northern pike, and many other sport species.

According to the Canada Department of Fisheries, Canadians spend almost as much on sports fishing as they do on fish for food. The economic implication of this over the study period could be of considerable significance and the potential of this resource to the Provincial economy should not be underestimated.

The estimated economic value of angling in Newfoundland is discussed in detail in the report by Baker[1], and the data provided have been extended in Figure 5 - 5 to include the 1966 and 1967 figures. The graph indicates that non-resident anglers accounted for only 17 percent of the total economic value of angling in the Province in 1960. However, the estimated expenditures of the non-resident angler has increased and in 1967 accounted for 26 percent of the $3. 3 million total estimated expenditure in fresh water angling. Non-resident salmon fishermen numbered 1530 and non-resident trout fishermen numbered 1671 in 1967. In addition, there were 12, 692 resident salmon fishermen and an estimated 50, 000 resident trout fishermen. These figures indicate the great interest in fresh water sport angling in the Province, with about 12 percent of the resident population participating.

Another use of the water resource which is directly related to tourism and recreation is boating. To those who desire a vacation which is out of the ordinary, the Newfoundland Tourist Development Office recommends wilderness canoe trips. There are several routes available on the main rivers on the Island which include the Gander, Exploits, Terra Nova, and Humber. Canoeing and boating are popular among residents who participate in recreational water based activities as well as using water transportation for fishing and hunting trips.

The potential for water related tourist and recreation facilities will be further enhanced by the large catchments being created as part of the development of hydro power in the Province. Reference to this potential is made in the River Basin studies specifically in Volume Six A in connection with the Bay D'Espoir Development and in Volume Six B in connection with the Churchill River.

Use of the fresh waters for recreation places varying quality requirements on the resource according to the activity.

Waters suitable for swimming and water contact sports must be:

a) Aesthetically acceptable; that is free from obnoxious floating or suspended substances, objectionable colour, and turbidity and foul odours.

b) Free of toxic substances.

c) Reasonably free of pathogenic organisms.

The usual standard for aesthetic acceptability and toxic substances are generally qualitative and descriptive without being quantitative, although limits are frequently set by some regulatory agencies for such readily determinable parameters as temperature, pH, colour and turbidity. With respect to pathogenic organisms, it should be noted that present knowledge and technical procedures are insufficient to enable the development of precise quantitative standards to distinguish between safe and unsafe waters for swimming. In spite of this, the usually accepted standard for safe water for swimming is that the arithmetical mean coliform density not exceed 1000 per 100 millilitres, and that this concentration not be exceeded in more than 20 percent of the samples in any one month.

The fresh waters of Newfoundland with but very few exceptions are of excellent quality for swimming and water contact sports, except as mentioned for temperature. Certain smaller bodies of water near larger centres of population contain coliform in excess of the above-noted standard and are therefore not acceptable for swimming. Most fresh waters of the Province have not been influenced by man's activities and in their present natural (or near natural) condition are of excellent quality. In areas burnt over by forest fires many lakes and ponds have been fertilized with phosphates released through the burning of the forests. With the addition of this key nutrient the smaller lakes and ponds have become ideal for the growth of algae effectively making the lakes eutrophic and seriously impairing their use for recreational purposes.

Water that is polluted from a biological and public health standpoint, and thus rendered unfit for swimming, drinking, or fish survival, may still be adequate insofar as visual or landscape impact is concerned. In general touring, all that is necessary from a quality standpoint is that noxious odors, floating matter, and unsightly colouration are kept at a minimum so as not to impair the aesthetic appeal. Most fresh waters in the Province are adequate as far as landscape impact is concerned. However there are areas which are unsuitable for swimming and water sports, such as in the highly populated areas of St. John's where the stream flowing into Quidi Vidi Lake has noticeable odors during hot summer days. Furthermore, the rivers utilized for log driving can be considered somewhat less than appealing for landscape tours.

Although use of fresh water for recreational pursuits is generally unhindered by use conflicts, there are problems emerging in various parts of the Island. In the St. John's area, Quidi Vidi and Windsor Lakes have a high convenience value in being close to a large portion of the population of the Island. However, Quidi Vidi Lake has been used as a receiving body for domestic and industrial wastewaters. This use has resulted in the deterioration of water quality almost imperceptibly over the years until the lake has to be declared unfit for swimming although it is still used for boating. Recreational use of Windsor Lake, located just outside St. John's is prohibited because this lake is the major source of the city's water supply. These conflicts of use can be partially offset by the provision of swimming pools, although generally these facilities provide limited opportunity and during high-use periods become extremely crowded compared to natural lakes.

The above conflicts in use between recreation, wastewater disposal, and water supply were cited as an example of situations which may develop in other areas of the Island of relatively high population densities where multiple use of the water resource will increase. Pollution problems generally increase almost imperceptibly and, unfortunately, remedial action is generally delayed until a public health hazard has been demonstrated. Frequently, rectification costs have then grown beyond the economic resources of the community. The multiple use of any water resource usually creates problems which can best be resolved within the framework of a water management policy under the jurisdiction of an effective authority.

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NEWFOUNDLAND AND LABRADOR
ESTIMATED VALUE OF TRAVEL INDUSTRY 1957-67

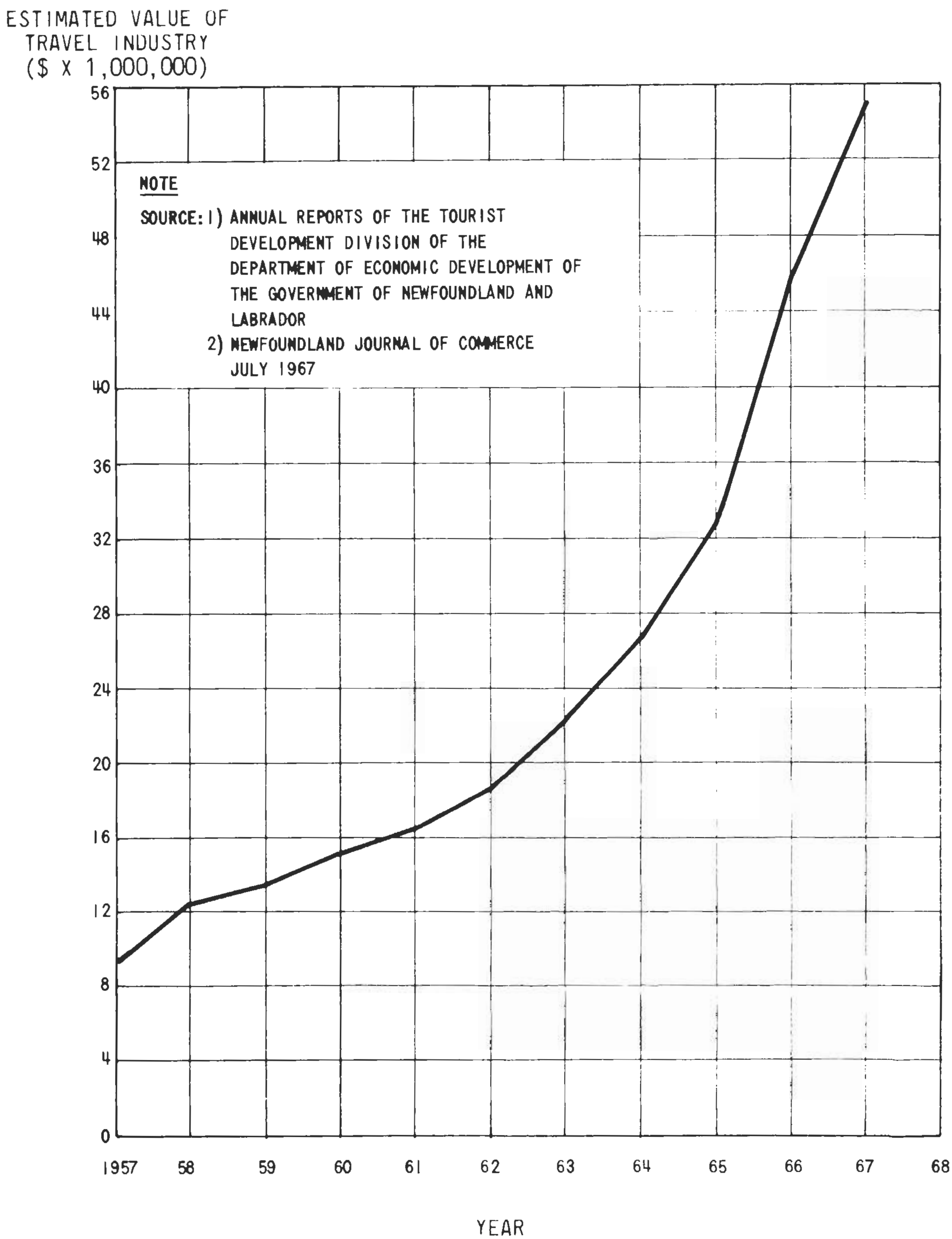


FIGURE 5-1

NEWFOUNDLAND
GROWTH OF PROVINCIAL PARKS AND
RECORDED NUMBER OF PARK VISITS 1958-67

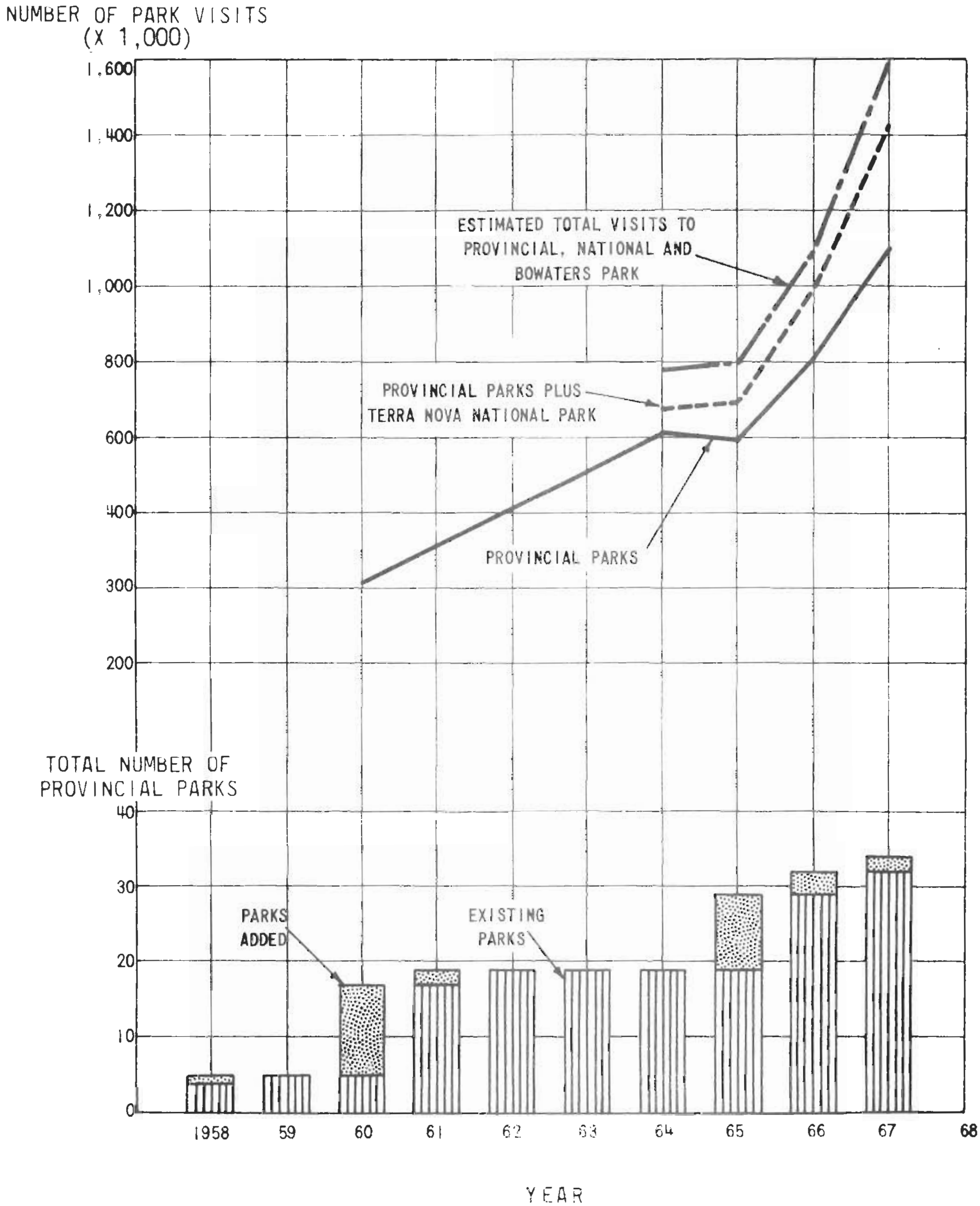
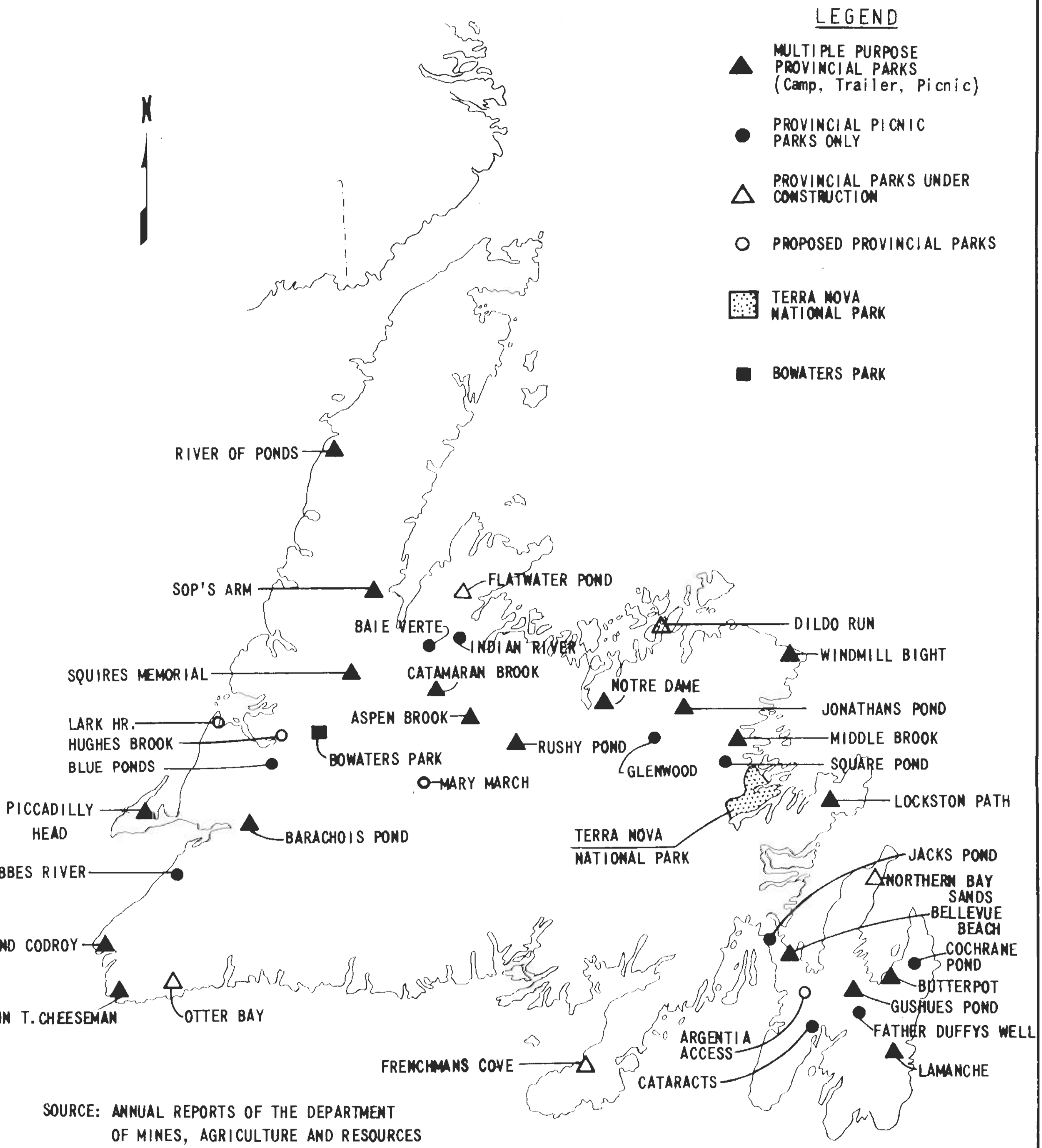


FIGURE 5-2

NEWFOUNDLAND
LOCATION OF PARKS

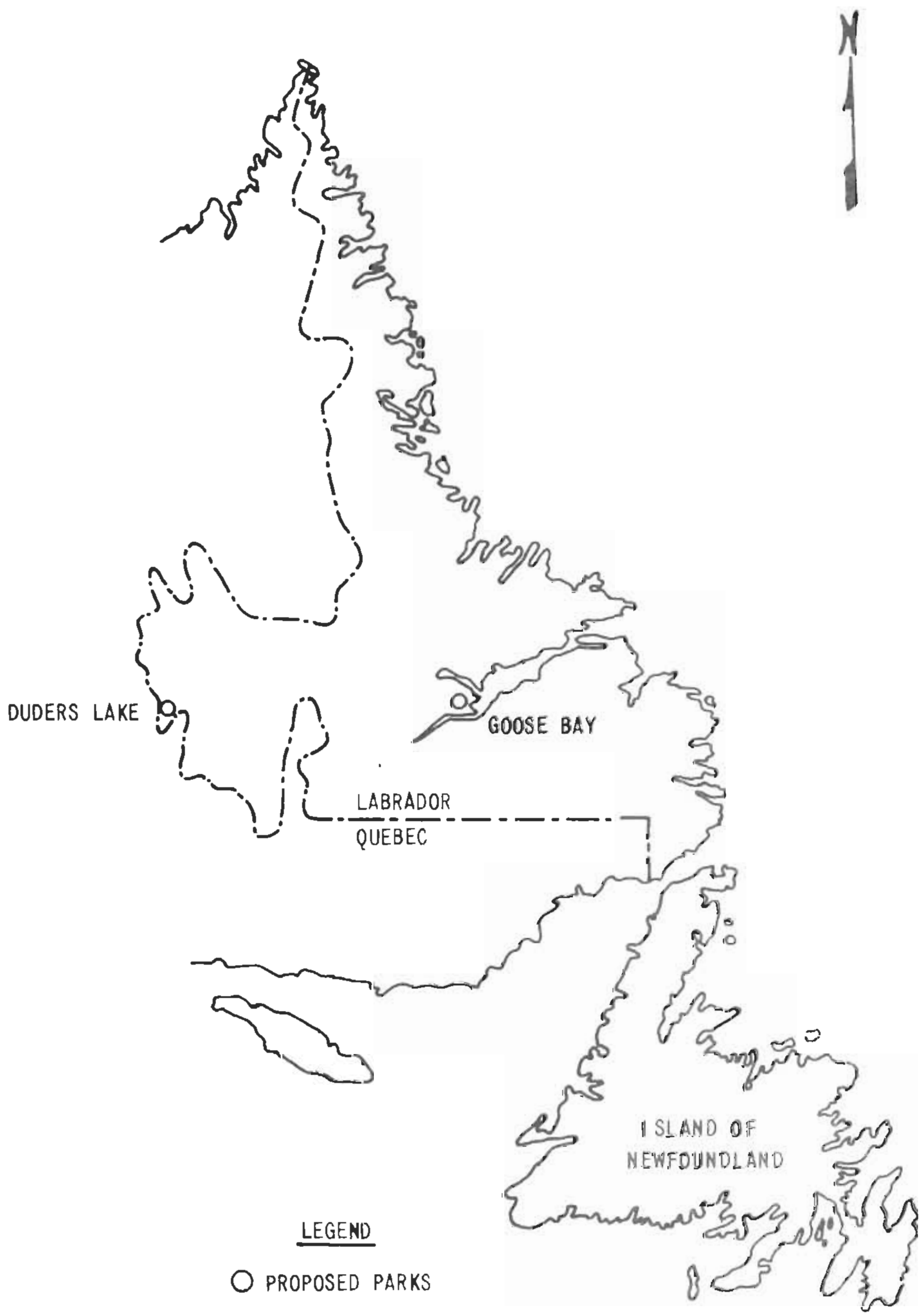


SOURCE: ANNUAL REPORTS OF THE DEPARTMENT OF MINES, AGRICULTURE AND RESOURCES PROVINCE OF NEWFOUNDLAND AND LABRADOR

NOTE: FOR PROVINCIAL PARKS IN LABRADOR SEE FIGURE 5-4

FIGURE 5-3

LABRADOR
LOCATION OF PROVINCIAL PARKS

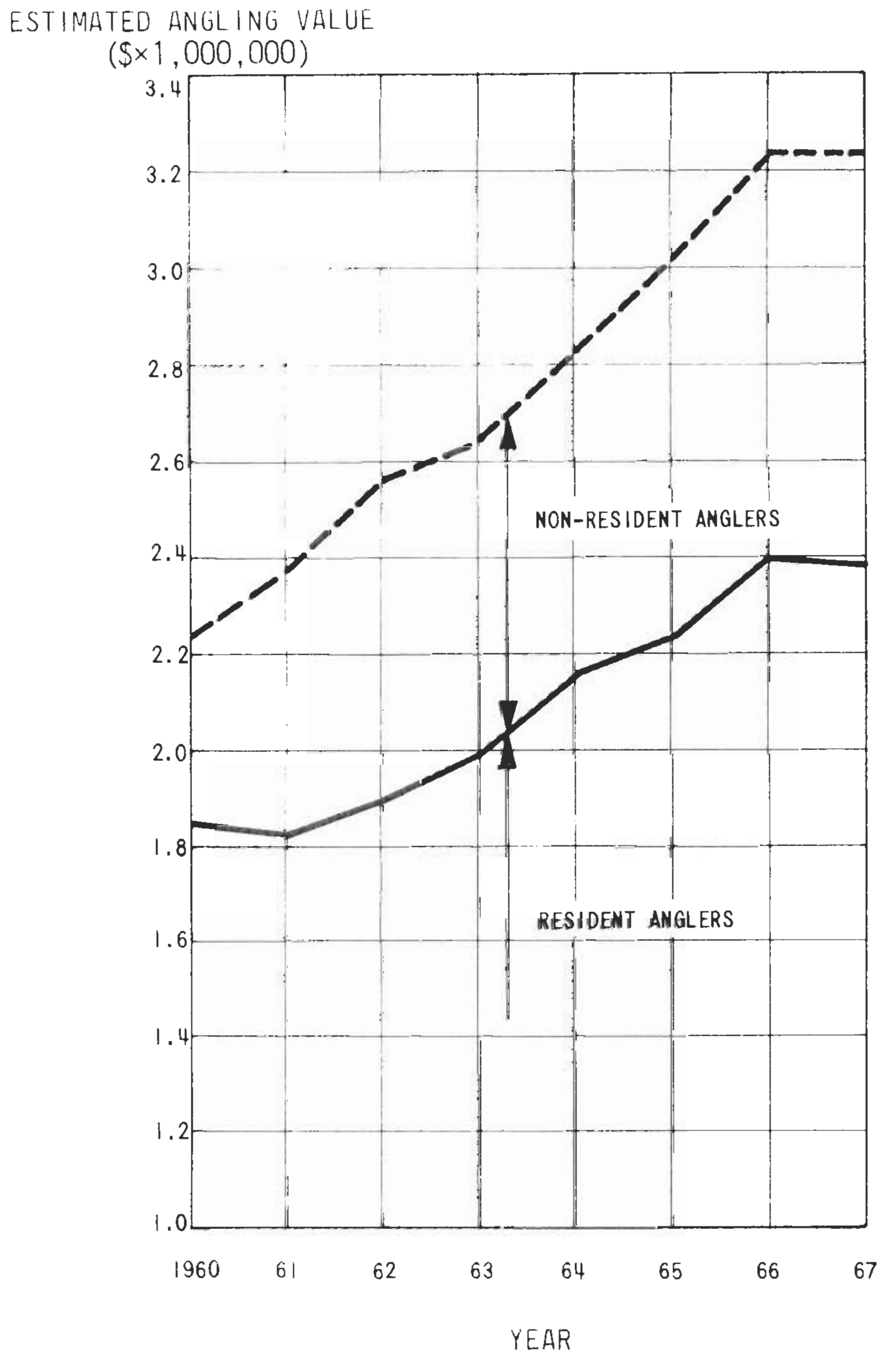


NOTE: 1) FOR PROVINCIAL PARKS IN THE ISLAND OF NEWFOUNDLAND SEE FIGURE 5-3

2) SOURCE: ANNUAL REPORT OF THE DEPARTMENT OF MINES, AGRICULTURE AND RESOURCES. PROVINCE OF NEWFOUNDLAND AND LABRADOR

FIGURE 5-4

ESTIMATED ECONOMIC VALUE OF ANGLING IN NEWFOUNDLAND AND LABRADOR



SOURCE: ANNUAL REPORTS OF THE TOURIST DEVELOPMENT DIVISION OF THE GOVERNMENT OF NEWFOUNDLAND AND LABRADOR

FIGURE 5-5

6 "NEGATIVE" WATER DEMAND

The general methodology in Volume One describes this category of water demand, and this section deals with its causes, effects, and water resources implications on a Province-wide scale. Volumes Five, Six, and Seven contain more detailed discussions.

In the Province's conditions the "negative" demand is related to erosion and sedimentation and resulting soil, reservoir, and estuary conservation problems; flooding and mine dewatering; and bog and marsh drainage.

All these aspects of "negative" demand are discussed with the exception of the mine dewatering problems, which have very local and particular characteristics. The data available on recorded mine dewatering flows are, however, indicated in Volume Three A, Section 7.5.2; and these may be used as indications of the order of magnitude of the mine dewatering flows which may be involved in the Island's conditions when new mines are developed.

6.1 Erosion

On the Island and in Labrador, erosion of the surficial materials is occurring very slowly and even where natural causes or man's activities have accelerated erosion locally, it is only of minor economic significance. Erosion of the more resistant bedrock is extremely slow, even on the sea coast.

Run-off water, assisted by the effects of gravity is the most important agent of surface erosion and carries material downslope to the streams and rivers which in turn erode their channels in sections of faster water and deposit sediment in slacker water or in the sea. In the humid climate of the Province, erosion due to wind is of lesser importance. Weathering by other means such as freezing and thawing, solution and the activities of plants and organisms is essentially a more long-term process.

The most important factor in inhibiting erosion is vegetation, the effect of which is discussed in the succeeding section.

6.1.1 Effect of Vegetation

In the Province most of the soil and surficial materials are covered by natural vegetation, consisting of forests, swamps and bogs, and scrub and grasses.

The rootlets of the vegetation bind the soil and enable it to absorb water and resist the effect of run-off and wind without being eroded. Forests break the impact of rain and prevent rapid melting of the snow. It is only when the vegetation is removed that erosion can take place rapidly. This may occur following forest fires or landslips or where man's activities have accelerated erosion by deforestation, excavation, concentration of run-off or diversion of streams and rivers.

Since agriculture is practised on only a small percentage of the total area of the Island, soil erosion is not of major concern. Tilled soil, even when good agricultural practices are followed is more susceptible to erosion than ground covered by natural vegetation, but due to the coarse nature of Island soils they are relatively erosion-resistant.

6.1.2 Areas of Erosion

Surface erosion following forest burn was reported on the Bonavista North Peninsula following a severe fire in 1961, and at Miguel Hill near Great Rattling Brook south of Grand Falls. Following forest cutting, erosion has been noted at Birchy Ridge near Birchy Lake, and on a slope above the north side of Victoria Lake near its southeast end. Erosion was not severe and provincial foresters feel that woods road construction may be responsible for more erosion than the actual deforestation.

Construction activity around the Province has in some instances caused local minor erosion but usually any such erosion has been kept to a minimum by grading and the provision of adequate drainage facilities.

Although not of major importance, there are several areas in the Province where wind erosion of deposits of marine or glacial origin has led to wind blown sands and dune formation. Sand dunes are capable of inundating considerable areas now covered by vegetation and could create local problems for land use and development.

The most extensive area of wind erosion occurs in Labrador in the vicinity of Goose Bay and the lower Churchill River valley. There are also several areas of water and glacial-laid deposits exhibiting sand dunes on the west coast of the Island, notably north of Cow Head, and along the inner part of St. George's Bay. Most of these dunes are forming adjacent to the few sandy beaches of the geologically recent shoreline from which the winds are deriving deposits. Dunes in the northern sections of the west coast are fresh and are constantly shifting and burying the sparse forest and vegetation. On occasion sand has drifted across Highway 73 which follows the seacoast at a short distance inland. Dunes in St. George's Bay, however, are low and essentially fixed by a thin cover of vegetation.

The water resources implications are closely linked with sedimentation and accordingly will be covered in Section 6.2.

6.2 Sedimentation

The previous section covered the usual source of sedimentation, that is, the product of erosion carried by the waterways, and indicated that it is not a widespread problem in the Province. Localized instances do exist, however, with water resources implications necessitating a brief coverage.

6.2.1 Nature of Material, its Transportation, and Deposition

Under present day conditions suspended sediment transport is not common in the Province except under high river stage or flood conditions and water courses are relatively clear and free flowing. Most of the soil particles reaching the rivers are relatively course grained and contribute to the bed load under usual flow conditions.

Sedimentation of the streams and rivers inland generally is found occurring downstream of rapids where much of the energy of the river has been dissipated and the hydraulic carrying capacity for sediments has been lost. Along the lower courses of some rivers where surficial materials have been eroded since the end of the last glacial period, some alluvial material may have partially, or almost totally, filled some of the glacial lake or pond basins or beach bar-dammed lagoons. An example of the latter occurs at St. Stephenville Pond, St. Georges Bay. Other examples of occurrences of water laid sediments are given on page 6-4.

Where man-made structures such as dams for water supply storage, hydro-power generation, or log driving operations have been built minor amounts of sediment may accumulate upstream, as described in Section 6.2.2, with a corresponding decrease in sediment transport downstream and in some cases the benefit of reduced bank erosion due to flow regulation.

In contrast, organic sedimentation is widespread in shallow basins in the lower relief, drift covered areas which occupy much of the Province. In the innumerable bogs, swamps and marshes the accumulation of organic material is slowly continuing and the bogs are gradually encroaching on the surrounding land. The development of basin bogs tends to have a general regulating effect on the water course in the basin due to retardation of the runoff.

Water Laid Sediments

Seacoast	Estuarine	Inland
Cow Head Harbour	Churchill River	Lower Churchill
St. Paul's Bay	Come By Chance River	Exploits River at confluence of Sandy Brook
York Harbour, Bay of Islands	North Harbour River	Exploits River adjacent to Rushy Pond
Stephenville Pond	Exploits River	Exploits River adjacent to Langsdowns
Two Guts Pond, Port au Port Bay	Gander River	Exploits River below rapids at Middle Brook
Belvans Cove	Grand Codroy River	Noel Paul's Brook below headwater rapids
Table Point	Little Codroy River	Lower Humber River adjacent to Steady Brook, Russel and Harrison
Deer Cove	Crabbs River	Deer Lake
South of Bateau Cove	Robinson's River	Upper Humber River above Adies River, below rapids in headwaters, and below rapids above Harriman's Steady
Hawke Bay and Harbour	Barachois Brook	Gregory River
Back Arm, St. John Bay	Flat Bay Brook	Parson's Pond River
Old Man Cove north to Barr'd Harbour	Deer Brook, Bonne Brook	Bear Cove Brook headwater pond
Castors Harbour	Middle Brook	
Squid Cove	McKenzie Brook	
St. Margaret Bay north to Gangeville	Lomond River	
Deadman Cove to Flower's Cove	Fox Island River	
Eddie's Cove, Strait of Belle Isle	West Brook, Windy Brook	
Hare Bay		

NOTE: The location of major surficial deposits in Labrador may be seen on the surficial hydrogeologic maps which accompany Volume Two of this report.

6.2.2 Problems Reported

Sedimentation on the Corner Brook River where several small multi-purpose dams have been constructed has been reported by Pafford[4].

Between the years 1930 and 1956, occasional measurements were taken of the sediment build-up in the Corner Brook reservoir behind dam site No. D-2, which has a tributary area of approximately 51.1 square miles. The amount of sediment deposited within about 700 feet upstream of the dam amounted to approximately 640,000 cubic feet or 43 percent of the reservoir capacity during the first six years of operation from 1930 to 1936. However, during the subsequent period from 1936 to 1956, only 80,000 cubic feet of sediment collected as conditions stabilized.

The Corner Brook River has a mean over-all gradient in excess of 2 percent which includes some very steep sections and waterfalls, and derives its sediments from the mountains lying between the Humber Arm (Bay of Islands) and Grand Lake. These mountains form a quasi-coastal range of the Long Range Mountains and are well forested, indicating that soils are present which will experience some bank erosion.

This indicates that in some of the steep rivers along the west sea coast, particularly in St. George's Bay, the Bay of Islands, and Bonne Bay, there is a considerable, although not alarming, amount of sediment deposition.

Because the use of the Province's rivers for navigational purposes is limited for all but shallow draft pleasure craft, it is felt that sediments will not create serious problems in this respect. Estuarine difficulties may result, however, from the barasways which typically develop at the mouth of erodable, uncontrolled west and southeast sea coast rivers. When a bar or barrier beach extends itself from one headland to another, the bay inside may become completely enclosed and turn into a marsh, or, if sufficient inland waters are received, it may turn into a shoreline lake.

Sedimentation problems at Grand Bank and Fortune on the Burin peninsula have been reported in Section 6.1.

4

6.2.3 Water Resources Implications

The general effects of erosion vary with time and can be extensive in some parts of the world; for example, many major rivers have completely changed their courses.

Conditions in the Province are such that extensive erosion has not taken place nor can it be expected. The water resources implications are relatively minor, but certain deleterious effects can be anticipated.

The erosion of forested or agricultural land has a two-fold effect. Firstly, the land will become less productive with resulting reduction in the natural surface storage, and secondly the deposition of the silt may have undesirable effects downstream.

Erosion of river bottoms and river banks affects spawning grounds for fish as well as causing loss of land which may be more or less serious according to its use.

Changes in the hydrologic regime result from the material which has been eroded being carried by the flowing water and eventually settling in lakes, reservoirs, and estuaries. The effective storage of lakes and reservoirs is eventually reduced, and silting in estuaries may change the river regime at its mouth. Examples of these effects are given on page 6 - 4.

6.3 Flooding

6.3.1 Present Day Conditions

Flooding problems in the Province are not of great significance today; however, local damage from flooding was recorded in a few areas. Flooding due to artificial storage has produced some damage to the forest resources.

6.3.1.1 Flooding in Natural Conditions

Flooding occasionally occurs in many areas of the Province due to poor drainage. It usually occurs as an expansion of the areas of lakes and marshes over the surrounding land rather than by overflow of river banks, because of the great natural storage available.

However, areas where the natural storage is small, such as in the southwestern area of the Island, flash floods occur and overflow of river banks is not uncommon. For example on the Isle aux Morts River at the Highway Bridge gauge where the drainage basin is only 79.5 square miles, an 11-foot increase in the water level was recorded over a 48-hour period in November 1966, with an increase in flow of 13,000 cfs. Occasionally these flash floods, which may be expected in areas with rugged topography, damage bridges and highways. Significant flooding may be caused by ice jams even in a river valley with large natural or artificial storage. The most important example of this type of flooding occurs periodically in the Grand Falls area. The following is an excerpt from an unpublished paper by a member of the Price (Nfld) Pulp and Paper Limited staff:

"Another contingency which must not be overlooked is the forming of an ice jam below Grand Falls by a heavy and continuous run of slob. This has happened several times but the most disastrous was in January 1927. At that time water and ice backed up through the gorge below the tailrace and the grinder room was flooded to a depth of 22 feet and it was possible to walk off the roof onto the ice. 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. A repetition of this would have more serious consequences at this time because of the power demand and the fact that all groundwood is now produced at Grand Falls.

"Figures obtained from the records show that from 1939 to 1955, inclusive, a total of 17,235 net tons of newsprint were lost through slob ice conditions or an average of 1014 tons per year. This represents $1,110,000 for the period or $65,000 per year. At present day prices this would amount to $143,000 per year. These figures will help to point out the necessity for year around control of the Exploits River to ensure adequate power for the operation of the A. N. D. mill at Grand Falls."

Some of the large rivers in Labrador can also have extreme variations in water level, due to their large drainage area, in spite of their vast natural storage. Records on the Churchill River at Muskrat Falls show a water level variation of 35 to 40 feet.

In specific cases, estimates of river levels in conditions of open flow may be obtained by means of backwater computations, using estimates of flows (Volume Two A, Section 18) and topographic surveys (including roughness estimates). Assessment of ice jam conditions and causes and means of correcting damaging natural conditions have to be analyzed in detail by examining the records of ice jams, comparing with similar conditions, and even carrying out model tests when the importance of the problem warrants it.

Although this section analyzes rivers in "natural conditions" in the sense that they are not directly affected by dams or similar structures, rivers may have their level regime changed by embankments, bridges, or possibly changes in the thermal regime. Thus it is difficult to estimate to what extent the large variation in the Isle aux Morts River is due to the increase in flow and what part to the obstruction of the river valley by the bridge which was downstream of the river gauge. Similarly, it is hard to estimate without a careful analysis to what extent the ice jam formation at Grand Falls is influenced by the dam upstream, the powerhouse, and other factors. Thus changes in the conditions in the basin (such as deforestation, Volume Three B, Section 8.4) can also contribute to change in the natural (original) regime of the river. In examining water management schemes, attention should be paid to the new industrial, residential, and transportation development from the viewpoint of their location in relation to flood water levels. As an example, attention should be paid to the dumping of tailings in lakes and rivers which could eventually increase the surface water levels in the area.

6.3.1.2 Flooding in Developed Conditions

The development of storage reservoirs in the Province has caused the flooding of significant land areas. It should be borne in mind that flow regulation downstream of a river section always brings about changes in the water level and its variation upstream.

On the Island, the damming of Grand Lake and Red Indian Lake has produced the flooding of some land areas the exact magnitude of which is difficult to assess with the available data. Other smaller storage developments have also produced temporary and permanent flooding (Rattling Brook, Sandy Brook, etc.).

Recently, reservoirs created in connection with the Bay D'Espoir Development have flooded land areas around Long Pond in the Salmon River basin, Meelpaeg Lake, Pudops Lake, and Ebbegunbaeg Lake in the Grey River basin, and the work under way for the same development will produce flooding around Granite Lake, Burnt Pond, and Victoria Lake (Figure 10-5, Volume Six A).

The main damage produced by this flooding is related to loss of productive forest, possible damage to wildlife and occasionally to adjacent construction. Because of lack of accurate inventory and knowledge of wildlife conditions, it is difficult to estimate the real effect of these storage developments.

Another factor to be considered is the ice instability upstream and especially downstream of a power plant which is used for peaking or has a variable load. It is possible that the Exploits River ice jams are partially related to the operation of the power plant, according to the pulp and paper mill requirements for power which used to drop significantly on Sundays.

6.3.2 Flooding Related to Planned and Forecast Development

Planned and forecast development may induce two types of flooding occurrences:

a) Due to intentional flooding for storage development.

b) Due to unintentional flooding resulting from direct or indirect changes in the river regime.

6.3.2.1 Intentional Flooding

Should development of the Cat Arm, Terra Nova, or other rivers for hydro power take place, some intentional flooding will occur (Section 1, Figure 1-5 and Volume Six B, Figure 14-1). In addition, flooding for storage required by industrial and municipal water supply will sometimes be required. The most suitable areas for development of water supply storage are given in Volume Five, Part II.

Careful planning is necessary to limit possible flood damage. Early decisions on the aforementioned hydro-electric developments could greatly reduce losses from flooding by planning forest cutting in the areas and controlling construction activity.

In Labrador, some intentional flooding of forested areas will probably occur in relation to the lower Churchill River developments (Volume Six B, Figure 28-4), and advanced planning will be important in minimizing losses from this.

Limiting intentional flooding to an established level and area requires the passage of the floods downstream of the storage structures. This is a problem related to the particular design of the storage structures and the hydrologic characteristics of the basin considered. Volume Two A, Section 18, gives the methods, relationships, and basic data required to compute the "maximum possible" flow and the related flood hydrograph as well as the minimum flows with various probabilities, and these can be used to assess, for planning purposes, the spilling capacity required for various new developments.

6.3.2.2 Unintentional Flooding

The following causes of unintentional flooding could be of some significance in the Province's condition:

a) Ice jams related to hydro-electric power plant operation.

b) Runoff concentration due to changes in the basin's surface conditions.

c) Obstruction of river cross-section including raising of the river bed bottom by sediments and debris.

It should be recognized that when a source of base energy is provided for the Island's system (Churchill Falls infeed or some other source), some of the existing large hydro-electric plants will move from their present position at the bottom of the load curve to a position closer to the peak. This will lead to some daily variations in the water levels upstream and larger daily variation in the flows and levels downstream. This may contribute to the instability of the ice cover both upstream and downstream and to the consequent generation of ice jams.

Runoff concentrations can increase due to changes in the basins' surface conditions especially in deforested areas, or areas undergoing other development activity. Damages from this can be more significant in many cases because these floods are likely to carry significant amounts of sediment and/or ice floes. Such cases have been recorded in Newfoundland and indicate that future developments will need careful planning of the network of temporary excavations, provisional and final roads, systems of storm ditches and sewers, etc., in addition to careful planning of woods operations.

Flooding due to obstruction of river cross-sections other than by ice jams or raising of the river bed bottom could occur mainly because of improper design of bridges, release of mine tailings and other wastes, or improper logging techniques. Cases of highway bridges being washed away or temporarily put out of service by floods have been recorded in the Province.

The effect of tailings and other debris on river level changes is generally slow because most tailings are trapped in lakes in the Province's conditions, and therefore generally ignored. Nevertheless this can become significant in certain conditions and some investigation of this problem is recommended.

6.4 Bogs and Marshes

Authorities differ on the distinction between bogs and marshes. For consistency, this section follows the definition used in Volume Two A, Section 7 - Vegetation suggested by Damman[11]. According to this author, a bog is ". . . a wet, extremely nutrient - poor organic site with a vegetation in which sphagnum species play a very important role, and the remains of which make up a major part of the organic horizon", and a marsh is ". . . a rich site covered with a vegetation of sedges and grasses, a vegetation of periodically flooded aluvial soil or shore vegetation of nutrient rich ponds and lakes."

The areal distribution of bogs and marshes is shown on Figure 7-5, Volume Two A. This information was based on the 1:250,000 scale topographical maps which unfortunately group bogs and marshes under the same identification.

The following comments are confined to conditions on the Island, because it was felt that the estimated 4200 square miles of bogs and marshes in Labrador would not be significant in water resources terms during the forecast period.

6.4.1 Marshes

As shown in Volume Two A, Section 7, marshy areas are often covered by underdeveloped forest. An increase in forest production could probably be obtained by draining the marshes. However, since as a rule the marshes are located in depressions, the draining would involve pumping in most cases. Generally, the amount of water to be drained from the marshes could be considered equivalent to the annual runoff of the area in which the marsh was located. However, the possibility of marsh drainage over the forecast period appears remote because of the high costs involved.

6.4.2 Boglands

According to existing information the boglands of the Island offer considerable potential and are generally so located as to permit draining without pumping.

The bogland specialist for the Provincial Department of Agriculture, J. V. Healey, has estimated that 16 to 17 percent of the Island or about 4,480,000 acres is comprised of bogs in addition to some of the organic barrens of the south sea coast which have not been accurately assessed. A bogland drainage consultant to the Canada Department of Forestry, Dr. L. Heikurainen of Helsinki, Finland, classified eleven main types of bog and peat lands while recognizing the presence of many other types during a field trip to Newfoundland in 1967. Reports surrounding the work done by Dr. Heikurainen indicate that there are over 5,000,000 acres of bogland on the Island.

According to Rayment and Chancey[6], investigations over the past ten years have shown that, when properly drained, limed, and fertilized, these lands can be very productive especially when planted with forage crops and vegetables. A minimum depth of 3 to 4 feet of peat is required for agricultural development according to the Royal Commission report[5]. If the bog can be drained, its usefulness for cultivation is determined by its depth, although the depth of the peat will be reduced by reclamation because of settlement and shrinkage. Its potential is also influenced by the degree of humification which the constituent products have undergone.

The majority of the plant types found in the Newfoundland bogs are those which require little nutrition from the organic soil. Consequently the peat which is deposited in the bogs is very acidic (pH 3-5 and upward) and poor in calcium, nitrogen, lime content, vegetable nutrients and micro-nutrients. The Province's bogs are relatively uniform in this respect, varying only to a slight degree from region to region[7].

A highly humified peat has several disadvantages. It is more compact and more difficult to drain for agricultural purposes, and is unsuitable for crops which require tillage because frost action reduces it to powder and, when disturbed in dry weather, it is subject to wind erosion. This dust-like peat is unsatisfactory in its water supply to crops, its water holding capacity is low, and re-absorption of water is slow. The roots of plants introduced to highly humified peat lack firm support. The degree of humification is of much greater importance than the nutrient content of the peat. It is difficult to improve a humified bog for cultivation. On the other hand, one deficient in nutritive elements may be improved by fertilization, and the additional cost will be a small proportion of the total cost of reclamation.

Conservationists argue that a bog is essentially an energy sink and its only useful purpose should be to provide energy for the production of crops suitable for the grazing of wild game. The overall management should include consideration of wild fowl. Past experience in the Canadian mid-west has shown that excessive draining of marshes has resulted in severe depletion of the wild fowl that depend on them for existence.

If a bog is used for the production of peat moss or fuel, the material which is excavated is an unrenewable resource[8]. The potential resources in crops, which may be produced with reclamation of suitable bogland, and in livestock which may be fed on such crops is renewable for years. Therefore, while the excavation of a bog for saleable peat offers an immediate cash return, the optimum condition may point to agricultural development for long-term gains.

6.4.3 Bogland Reclamation

The following passages were abstracted from the article by Rayment and Chancey[6] which highlight concisely the very considerable investigations of boglands carried out on the Island over the past decade:

The effective drainage of boglands is the first step in bringing such lands into agricultural production. "Investigations covering drainage characteristics of peat deposits showed that water tables were very sensitive to rainfall, rising as much as 8 inches per inch of rainfall during heavy downpours."

Ditches are the most common form of drainage and experiments at the Colinet Research Station indicate "that spacings of 25 to 50 feet with depths of 24 to 30 inches are adequate for vegetable crops. Forage crops appear to respond favourably to spacing of 75 feet and depths of 24 inches. The ditches control the height of the natural water table which fluctuates during the year from a low of two feet to a high of 6 inches or less in the wet season".

After the bogs have been drained, additional work is required to condition the soil for agricultural use.

"The virgin peat is extremely acid (pH 3.5) and contains only traces of available nitrogen and phosphorous and low levels of potassium. Despite the extreme acidity most crops have grown well with moderate rate of applied limestone, probably due to the lack of aluminum and manganese which normally cause toxicity in highly acid mineral soils.

"All crops seeded on virgin peat require a very high nitrogen level if a yield is desired in the year of seeding. This is presumably due to the high nitrogen demand of decomposing peat, since response to rates in excess of 300 pounds of nitrogen per acre have been obtained with turnips and potatoes. Phosphorus rates at approximately half those of nitrogen have been satisfactory and while potassium is not a critical factor, it is a limiting one where high levels of nitrogen and phosphorous are used."

The bogland reclamation program was started in 1956 as a joint venture of the Federal and Provincial Governments. During the first three years of the scheme, 1000 acres of bog were ditched and drained at Colinet of which 500 acres were put to grass seed for sheep grazing, 300 acres have become a Federal Government experimental farm, and 200 acres are being used by the Province[9].

Initially, the unit costs for ditching, liming, rotovating, fertilizing, seeding, rolling, and transporting equipment came to about $125 per acre. Currently, these costs have approximately doubled although there is limited confidence in this estimate and Provincial Government officials are reviewing these costs.

From March 31, 1966, to March 31, 1967, $122,993.60 was spent on bogland reclamation and $112,216.25 was spent on clearing land for agricultural development. These expenditures include the cost of transporting equipment.

Table 6 - 1 lists the size and location of the boglands which have been drained to date. Figure 9 - 1 of Volume Three A shows the location of these drained bogs.

The Royal Commission[10] sector on Agriculture recognizes the fact that in order to achieve a desirable level of commercial agricultural activity efforts must be made to increase the size of the farm unit. "The development envisaged will in all probability require the clearing of mineral land and the reclamation of bogland on a scale greater than in the past".

6.4.4 Water Resources Implications

The drainage of boglands will affect receiving waters in terms of both quality and quantity. There will be an increase in the variation of the flow of the receiving water. The actual change in variation will depend on the area drained and the physical characteristics of the receiving body.

Generally speaking, there will be an initial decrease in the pH of the receiving body. This characteristic may change over time, particularly as a result of the liming practices used at the drained area. There will also be an increase in the organic matter and suspended materials present in the receiving body. Furthermore, there could be a danger of pollution of the receiving waters as a result of the application of fertilizers and herbicides to the developed boglands.

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Note there are no references 1, 2, or 3 in this section.

NEWFOUNDLAND

BOGLAND RECLAMATION BY AREA

BOGLAND RECLAMATION BY AREA

AREA		ACRES DRAINED	ACRES SEEDED	PASTURE COMMUNITY	PASTURE PRIVATE
St. Georges		80	30	X	
Robinsons		150	150	X	
Stephenville					
Shearston		100	100	X	
South Branch		100			
		58	58		
Doyles		50	50		X
Lumsden		50	50		X
Comfort Cove		100	100	X	
Bishops Falls		35	27		
Spencers Bridge, Glovertown		100			
Musgravetown		58	58		X
Bloomfield		60	60		
George's Brook		40	27		
Goulds		55	50		X
Big Pond		30	15		
Portugal Cove		12	12		X
Cochrane Pond[1]		100	100	X	
Foxtrap[2]		100	100	X	
		10	10		X
Bay Roberts		35	35	X	
Carbonear		12	12		X
Heart's Delight Road		12	12		X
Hodgway Road-Goulds Road		30	15		X
Ocean Pond		15	15		X
Witburn		50	30		X
Colinet		500		X	
Colinet-Harricott	(Provincial)	200	160	X	
	(Federal)	175	175	Experimental	
	(Federal)	125		Experimental	
St. Shott's		200	100	Co-operative	
				X	
Winterland		1211	1131	X	
Taylor's Bay		40		Demonstration	
		3893	2682		

[1] Plus 1000 acres potential

[2] Plus 2000 acres potential