GULL ISLAND - MARITIMES

TRANSMISSION

DEPARTMENT OF REGIONAL ECONOMIC EXPANSION

GOVERNMENT OF CANADA

GULL ISLAND - MARITIMES

TRANSMISSION

Prepared By

Shawmont Newfoundland Limited
P.O. Box 9600
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Report No. SMR-18-78

September 1978

ShawMont Newfoundland Limited

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17 October 1978
File: SME 6724-9

Department of Regional Economic Expansion
Environment of Canada
Atlatnic Region
770 Main Street
Moncton, N.B.
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Attention: Mr. R.H. Bower,
Director, Regional Initiatives

Gentlemen:

Report on Gull Island - Maritimes Transmission

With reference to the above report No. SMR-18-78, we enclose additional information concerning the estimates contained therein. This information is presented in the form of revised pages to be added to the 25 copies of the report already forwarded.

The report summary indicates the appropriate nature of these estimates made within the restrictions of a limited budget. The approximate estimates can be expected to have an accuracy consistent with an initial concept without detailed analysis, that is the actual cost could lie in the range of +40 to -25 percent of the figures given.

Cash flows have been added to the tabulated figures and certain corrections provided in the replacement pages and tables. It is suggested that these and the redrawn map figures be inserted into the report copies.

Yours very truly,

MHBaker

jpr A.S. Demers
President

MHB/vw
Encl.
cc: Mr. R.A. Robertson
Mr. N. Rivington

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27 September 1978
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Department of Regional Economic Expansion
Government of Canada
Atlantic Region
770 Mark Street
Moncton, N.B. E1C 8P9

Attention: Mr. R.H. Bower
Director, Regional Initiatives

Gentlemen:

Report on Gull Island - Maritimes Transmission

We have pleasure in forwarding 25 copies of our report concerning estimates of eight alternative arrangements to transmit a total of 1400 MW from Gull Island in Labrador to either Moncton, N.B. or Dickey-Lincoln, Maine. The report states that the estimates are approximate and they should therefore be treated with discretion.

The report answers to the requirements of Contract reference number 3066 dated 10th July 1978.

We shall be pleased to offer any clarifications or further details that you may require.

Yours very truly,

A.S. Demers
President

MHB/cm
cc: Mr. R.A. Robertson
Mr. N. Rivington

GULL ISLAND - MARITIMES TRANSMISSION

CONTENTS

TABLES

TABLE

FIGURES

FIGURE

1. INTRODUCTION

In late July 1978, Shawmont Newfoundland Limited was requested by the Department of Regional Economic Expansion (Moncton, N.B. office) to provide estimates for transmission facilities from the Gull Island and Muskrat Falls sites in Labrador to two possible locations. The alternative receiving points were Moncton (Salisbury) N.B., and the Dickey-Lincoln hydro site in Maine, on the St. John river 50 kilometres west of Edmundston, N.B. The power to be transmitted from Labrador to these sites would be made up of 800 MW from the 1600 MW Gull Island Plant (half of its capacity being provided for this purpose and half to Newfoundland) plus 600 MW from Muskrat Falls.

Eight separate transmission alternatives are evaluated. Two were derived from a 1975 report by Acres "Gull Island Power Project - An Appraisal of the Benefit to Newfoundland of Constructing the Development For Sales Outside the Province".

All alternatives make use of the existing Hydro Quebec system as far as possible. Four alternatives, designated 'A', deliver power near Moncton, N.B., and four 'B' alternatives deliver to Dickey-Lincoln, Maine, U.S.A.

In two alternatives, additional transmission capacity of 2350 MW is provided from the north to the south shore of the St. Lawrence River, suitable for the capacity of hydro plants on the Moisie and Romaine rivers.

2. SUMMARY

Eight alternatives are estimated to give capital cost, the annual charge to defray it, the GWh delivered per year and the resultant mill rates to supply half of Gull Island output plus all of Muskrat capacity to two alternative locations. One location is Dickey-Lincoln, Me., from where additional transmission would be required to load centres. The cost of delivered energy from Gull Island and Muskrat at Dickey-Lincoln would vary from 45 to 53 mills/kWh depending on the alternative. These costs are installed costs in 1985 based on prices prevailing in 1978 escalated at 7% including interest during construction and all overheads. The accuracy of these figures is consistent with a preliminary estimate: actual costs could be from 40 percent above to 25 percent below the figures given.

The alternative delivery point is Moncton, N.B., at which energy would cost 46 to 58 mills/kWh in 1985 depending on the alternative.

No transmission is provided for the 200-300 MW called back from Churchill Falls, on the basis that after supplying Labrador loads this energy would be transmitted over existing facilities. Two alternatives provide additional transfer capacity of about 2380 MW (total 3730 MW) from the north shore to the south shore of the St. Lawrence River, delivering to the 315 kV system there at an added cost of 10 to 12 mills/kWh. This assumes that delivery of power is equally divided between the south shore and New Brunswick or Maine receiving points.

3. STUDY OBJECTIVES

The Acres report cited above gave costs in 1975 of transmission from Gull Island to Moncton over two alternate routes: one ac, that is an additional 735 kV line in parallel with existing lines as far as Quebec City, continuing with a single circuit to Moncton at which a back-to-back dc station was required, and one dc alternative from Manicouagan, using cables across the St. Lawrence River and continuing with a dc line overland to Moncton.

DREE's requirements in 1978 were for a re-evaluation of costs of these alternatives, the inclusion of an all-dc alternative direct from Gull Island, and the provision in one alternative of additional capacity of about 2000 MW to the south shore system of Hydro Quebec.

4. STUDY LIMITATIONS

For the costs given in this report, certain approximations were made as follows:

- no detailed route examination was made for overhead transmission lines or marine cables, except by reference to small scale maps.
- no meteorological study was carried out, reference being made to findings on the former Gull Island studies.
- no load flows or stability studies were carried out to determine power flows, the effect on loadings in other circuits in Quebec or New Brunswick, nor any stability limitations that may be imposed by the transmission alternatives presented.
- the cost of marine cables was roughly estimated from information from one supplier only, assuming without site investigation that cables could be laid by ploughing onto the bed of the St. Lawrence River.
- the cost of dc terminal equipment was roughly estimated from a total station installed cost per kW of throughput capacity to include all equipment, both ac and dc normally required at a dc terminal.
- escalation at 7% would apply through a construction period from 1979 to 1985.
- interest at 10% was assumed during construction period.
- no provision is made to transmit the 200 MW call-back from the Churchill Falls contract to New Brunswick or Maine.

5. ALTERNATIVE TRANSMISSIONS

The existing Churchill Falls to Quebec 735 kV lines are valuable as a backbone on which to build extensions. Without detailed study of the 735 kV system it has not been possible to determine if there is spare transmission capacity from Labrador.

The existing 735 kV system can, however, provide an alternative emergency outlet for Labrador power in emergency, such as a line outage, to avoid spilling water. (This has been assumed without detailed study.) A direct interconnection is necessary between Gull Island and Churchill Falls, which also provides the means to optimize the outputs of the two plants under all streamflow conditions. Since in this report a single line only from Labrador to the Maritimes is considered to be within reasonable cost, its outage requires that the Quebec system provide an emergency outlet to avoid spilling water. The line outage removes the supply to the Maritimes which would have to turn to alternative sources, until the line is restored. This may be an important consideration in the determination of reserves in the receiving systems.

The alternatives described below each provide a transmission capacity of 1400 MW from Gull Island to A) Moncton, N.B. or B) Dickey-Lincoln, Me. All alternatives provide for a direct-current line when connecting Labrador to the Maritimes because it is assumed that the Labrador plants are synchronized to Quebec which remains unsynchronized to the New Brunswick or Maine systems.

The Muskrat to Gull Island transmission is common to all alternatives and consists of two 230 kV circuits on single circuit towers. These circuits would have two conductors per phase to carry the full plant output over one circuit, that is 1500 amps per phase. By providing two single-circuit links there is sufficient capacity to extract Muskrat power during a tower outage. At Gull Island 230/735 kV transformers are necessary, and a unit size of 750 MVA (three phase) was selected.

5.1 Alternative 1A

This is an all ac alternative from Gull Island to New Brunswick with a dc back-to-back converter station at the receiving point.

Two new 735 kV lines are built from Gull Island, one to Churchill Falls and one direct to Montagnais. One additional 735 kV line is built in parallel with the existing three from Montagnais via Arnaud and Manicouagan to Lévis (Quebec City). One new 735 kV line is built eastward from Lévis to Grand Falls, N.B., where a back-to-back dc converter is installed. Transmission then continues to Moncton at 345 kV over one double circuit 345 kV line.

The Gull Island - Churchill Falls 735 kV line is added to provide firm transmission from the new plants to the existing system, in the least expensive manner. If any one 735 kV line section is out of service, full power can be taken from Gull Island and Muskrat.

The supply to the load at Moncton is less reliable, however, since if the 735 kV Lévis - G. Falls line, or the double circuit G. Falls - Moncton line is down, no power is delivered. Adjustments are necessary within existing systems to absorb the generation in Quebec and to accommodate the shortfall in New Brunswick until line repairs are made. The Lévis - Moncton section is sectioned at Grand Falls to avoid a very long 735 kV line section which would have difficulties in switching and voltage control. A back-to-back dc converter station is introduced at Grand Falls. This converter station will operate in parallel with the Eel River station but can be placed apart from it, since both stations have the ability to control power flow to avoid any transmission overload. Note that Eel River does not have sufficient capacity to act as stand-by to the Quebec-G. Falls-Moncton lines.

The 345 kV line is built in double-circuit construction from Grand Falls to Moncton, connected to the existing system at both points. It is capable of carrying 1400 MW with both circuits in service, but in practice the load will be affected by parallel circuit loadings in the New Brunswick system.

5.2 Alternative 1B

This is identical to Alternative 1A between Gull Island and Lévis (Quebec). One 735 kV line is taken directly from Lévis to Dickey-Lincoln, where a back-to-back dc converter station supplies the Maine-N.B. system at 230 kV. 230 kV was selected in this case because it appears to be a likely step-up voltage for the generation and is the least expensive for the dc termination. Transformers would be necessary for onward transmission to load centres in the United States at 500 kV or a higher voltage, but no such extensions have been included in the estimates.

5.3 Alternative 2A

In this alternative direct current transmission by submarine cable on the St. Lawrence river bed is introduced. A $\pm$ 400 kV converter station at Arnaud feeds one bipolar line to the north shore of the river. Six parallel single-core 400 kV cables, rated 1000 amps each, provide the 48 km river crossing between Pointe des Montes and Grosses Roches. Three of the cables are paralleled on each pole with switching arrangements to isolate a faulty cable. Normal current is 1725 amps, which can be carried by two cables per pole in the event of a cable outage.

From the south shore landing the dc line goes directly to Moncton by the most practical route. At Moncton a converter station connects to the 345 kV system.

The same 735 kV lines between Gull Island and Churchill Falls and between Gull Island and Arnaud are required as in Alternative 1A.

5.4 Alternative 2B

In this case, the $\pm$ 400 kV converter stations are at Manicouagan and Dickey-Lincoln. The dc line routes are shorter, and by selecting a

submarine cable crossing location between Grandes Bergeronnes and Trois Pistoles, a shorter cable length (29 kms) is possible. The 735 kV portion from Gull Island to Manic is as Alternative 1A.

5.5 Alternatives 3A and 3B

One bipolar ± 400 kV dc line is used for the full length of transmission in these alternatives. One converter station is installed at Gull Island, and the second at either Moncton (Alternative 3A) or Dickey (Alternative 3B). A new route between Gull Island and Manicouagan has been chosen largely independent of the 735 kV lines. Since it is not necessary to pass Montagnais, a separate lower-elevation route is selected to minimize ice loadings and increase reliability. Cable crossings and south shore routes are the same as Alternatives 2A and 2B, respectively.

One 735 kV ac line from Gull Island to Churchill Falls is necessary as in the other alternatives to provide an alternative outlet in the event of outage of the dc line. It will also allow an exchange of energy between the two plants for optimum control of the river flow. One circuit is sufficient to provide this emergency outlet, and a single 735 kV circuit is more economical than two 500 kV circuits. Two 750 MVA 735/230 kV transformers are sufficient at Gull Island, since this is a stand-by transmission for 1400 MW in this alternative.

5.6 Alternative 4A

This alternative provides the facility to transfer an additional 2380 MW across the St. Lawrence River to the Hydro Québec system in the Gaspé area. The additional power is derived from expected hydro developments on the Romaine River, 1416 MW in four sites, and the Moisie River, 976 MW in four sites. Adding the Gull Island (800 MW) and Muskrat (600 MW) outputs available to the Maritimes, gives a total of 3730 MW (after losses) to be transmitted. Two ± 400 kV dc bipoles are required from Arnaud, one terminating at Les Boules to supply the Quebec south shore, and one terminating at Moncton, N.B. The 735 kV arrangement is the same as Alternative 2A for the Gull Island-Churchill Falls and Gull Island-Arnaud sections.

For the ± 400 kV submarine cable crossing eight 1000 amp cables are required for each bipole, to allow full current with one cable out of service. The crossing location would be as described in 2A.

On the south shore, both dc lines enter Les Boules to allow switching between them. Thus if any one dc pole or line is out, the other can transmit twice the current. Parallel operation is envisaged under emergency conditions only. AC connections to the Hydro Quebec system on the south shore are described in Section 5.8 below.

Under normal operation, each bipole is assumed to carry an equal current of 2330 amps maximum for ease of operation, identical equipment, etc. Therefore New Brunswick in this case receives more power (1775 MW after losses) over the dc line, as opposed to 1275 MW after losses in

alternative 3A for example. The extra 500 MW can replace the present supply from Quebec to New Brunswick via Eel River (320 MW) and the border arrangements whereby a part of the north eastern N.B. load is fed directly from Quebec. Eel River becomes unloaded therefore, and can remain as a stand-by to transfer some power in either direction in the event of outages of terminal equipment or of the single bipolar line between Les Boules and Moncton. Within the New Brunswick system some readjustment is necessary to feed northern loads from Moncton rather than from Eel River, which may incur some further costs not estimated here. As in other alternatives, Eel River cannot provide complete stand-by transfer to New Brunswick.

5.7 Alternative 4B

As in Alternative 4A, 2380 MW from the Romaine and Moisie rivers are added to the Gull Island and Muskrat power for transmission to the south shore. The routes are similar to Alternative 2B. Both bipoles enter Riviere du Loup, where a dc switching station allows emergency paralleling of the two bipoles in the event of line outage. The dc converter equipment at Riviere du Loup feeds the power from one bipole to the 315 kV Hydro Quebec system. The second bipolar line continues to Dickey where a converter station supplies the 230 kV.

Eight 1000 amp 400 kV dc submarine cables are required at the same location suggested for alternative 2B that is between Grandes Bergeronnes and Trois Pistoles.

5.8 Québec - Gaspe System

For alternatives 4A and 4B, the injection of 1850 MW and the removal of the New Brunswick load at Eel River causes reversal of the power flow from Lévis. After supplying all local loads, about 300 MW in 1985, the 1550 MW surplus must be fed to Quebec City. However this arrangement may have merit in avoiding a fourth 735 kV on the north shore to Quebec from the Romaine and Moisie plants. From Riviere du Loup to Quebec there are four 315 kV circuits and these are assumed to be capable of carrying this load (520 MW per circuit if one is out of service). For Alternative 4B therefore, connection at Riviere du Loup between the dc converter and the 315 kV system is adequate. For Alternative 4A however, the converter station is required further east, connecting to the 315 kV station at Les Boules. In this case, two new circuits between Les Boules and Rimouski are required to parallel the existing two circuits to give a total of four 315 kV circuits to Lévis.

These estimates of transmission strengthening are made without detailed knowledge of the loads or transmission equipment in the Hydro Quebec system, and without load flow analysis, and for these reasons they must be considered as approximations only.

6. DERIVATION OF COSTS

6.1 Transmission Routes

The most direct transmission line routes were selected taking into account existing transmission line corridors, terminal station locations, road and railway access, topography, exposure to severe meteorological conditions and environmental impact. The routes are shown in figures 1 to 8.

For Alternatives 1A and 1B, routes parallel the existing 735 kV system as far as Lévis, and it has been assumed that a right-of-way can be obtained parallel to these lines. The Gull Island to Churchill Falls and Gull Island to Montagnais sections follow direct routes. From Lévis to Grand Falls, a Canadian route follows existing rights-of-way where possible. From Lévis in Alternative 1B, the line crosses to Maine in a direct route to Dickey, Me.

These 735 kV ac routes, which parallel the St. Lawrence River on both sides for much of its length, would be subject to the most severe environmental criticism and would have the highest land acquisition costs which have not been included in the comparative estimates.

The line routes were selected by examining topographic maps of 1:250,000, 1:500,000 and 1:1,000,000 scales.

6.2 Conductor Selection

Conductor bundle size and make-up for each line was selected taking into consideration normal and emergency loadings and optimum cost of capital plus energy losses.

For ac lines the following alloy conductors were selected:

- 230 kV single circuit Muskrat-Gull Island: twin 1.0 inch dia.
- 315 kV double circuit Quebec south shore: twin 1.25 inch dia.
- 345 kV double circuit in New Brunswick: three 1.1 inch dia.
- 735 kV single circuit: four 1.3 inch dia.

For the dc lines, an approximate conductor optimization was made to select twin 2.0 inch dia. alloy conductors for 1750 amperes normal maximum current and three 2.0 inch dia. for 2330 amperes. Losses were evaluated at 35 mills/kwh based on nuclear replacement. The optimum choice appeared to lie in the range of 2.0 to 2.4 inch diameter in each case and the 2.0 inch was chosen since the decrease in initial capital cost was considered significant despite a slightly higher total capitalized cost than optimum. Total capital cost, which includes direct costs except for right-of-way acquisition and project management and engineering, owner's administration, contingency, escalation and interest during construction amounts to twice the Direct Cost given on Table 1.

The assumptions contained in the calculation of losses, both for approximate conductor selection and for section 7 below include:

- transmitted power of 1400 MW over one line from Gull Island.
- transmitted power of 3730 MW over two bipoles from Arnaud or 3720 MW from Manic (Alternatives 4A or 4B).
- cost of losses 35 mills/kWh in 1985, capitalized over 50 years at 10% interest and 7% escalation.
- loss load factors of 0.56 for line losses, 0.75 for dc station losses and 0.90 for ac reactor and transformer losses.
- all ac power travels over the one new 735 kV line or one bipolar line from Gull Island, assuming that the existing Churchill Falls lines provide no capacity except under line outage conditions.

6.3 Transmission Line Costs

Using the routes and conductors selected above transmission line costs given in Table 1 were determined. Costs are direct costs only expressed in 1978 dollars, excluding right-of-way acquisition, and will be increased as explained in section 7 below to derive installed costs.

The following basic structure types were assumed for estimating purposes:

735 kV AC - Single Circuit Guyed V with two overhead shieldwires.

345 kV AC - Double Circuit Self-Supporting with two overhead shieldwires.

315 kV AC - Double Circuit Self-Supporting with two overhead shieldwires.

230 kV AC - Single Circuit Guyed V with two overhead shieldwires.

$\pm$ 400 kV DC - Single Bipole Guyed Mast with no overhead shieldwire.

All conductors were assumed to be of the aluminum alloy stranded type (AASC), 6101 alloy, since recent studies have shown technical advantages of this type over EC grade aluminum steel reinforced types (ACSR). The use of electrically equivalent aluminum steel reinforced type conductors would result in similar cost values.

All overhead shieldwires on the AC lines were assumed to be of extra high strength galvanized steel strand. No overhead shieldwires were considered necessary for the DC lines due to the relatively low isokeranic level and the assumption that most lightning faults would affect only one pole which can be quickly re-energized. It can be expected that detailed study would determine the need for shieldwires for a few kilometres close to each station and for counterpoise on some towers to bring all tower

footing resistances below a target value.

All costs are expressed in terms of September 1978 dollars and are based upon recent costs available from various sources, some of which are actual contract values for similar lines and others of which were extrapolated from recent detailed estimates for equipment lines with suitable factoring for escalation to September 1978 and differences in access, meteorological loadings and conductor cross-sectional areas.

Excluded from all capital costs are land acquisition costs, since these could not be determined within the scope of this report. Land cost will vary greatly from nearly zero where crown land is involved to many thousands of dollars per acre in populated regions such as the St. Lawrence River valley east of Quebec City.

6.4 Cable Crossings

The dc cable crossings are based on the conservative assumption of $\pm$ 400 kV dc as a maximum cable voltage. Clearly a detailed design study would examine the feasibility of a higher cable voltage because it could reduce the transmission line cost and losses.

Cable currents of 1000 amps are assumed and the terminations on each shore would include the facility to isolate any one cable and continue transmission at maximum current on the remaining cables. Thus for Alternatives 2 and 3, three cables per pole are required to transmit 1750 amps (total six cables). For Alternative 4, four cables per pole are required for 2330 amps (total sixteen cables for two bipoles). For the longer 48 km crossing (Alternatives 2A, 3A and 4A) six cables are estimated at $45 million plus $15 million installation, direct costs only. For the 29 km crossings (Alternatives 2B, 3B and 4B), costs are $27.5 million plus $15 million installation. No attempt to optimize the number of cables or the current rating has been made in this report.

6.5 DC Terminals

A list of terminal sizes for all alternatives is given in Table 10. The dc terminal costs were based on an overall approximate estimate, compiled from various sources, which gave $56.7 per kW per terminal direct costs only in 1978. This value is multiplied by two to give a total installed cost including engineering, administration and escalation and interest during construction, that is an installed 1985 cost. The basic cost covers a $\pm$ 400 kV installation complete with ac busbars, filters and transformers to an existing ac voltage of 230 kV as well as all dc equipment including switching arrangements for lines and cables and communications facilities. If synchronous condensers are necessary as is the case in the receiving terminal of Moncton for example, $4 per kW (direct cost) is added, and similar adjustments are made for other ac voltages, higher dc voltage, etc. Costs include line and cable paralleling equipment.

Losses in dc terminals were estimated at 1% of throughput in each terminal.

6.6 AC Terminals

Recent costs of ac equipment were used, assuming conventional equipment. Typical layouts of breaker-and-a-half were assumed for all ac busbars. 735 kV lines only have shunt reactors of 165 or 330 MVA (three phase), depending on line length, at both line ends, and each reactor has a load switch as currently used by Hydro Quebec.

Transformer sizes were assumed as follows:

Alternative	Location	Voltage, kV	Size, MVA
1A, 1B, 2A, 2B, 4A, 4B	Gull Island	735/230	3 x 750
1A	Grand Falls	735/230	3 x 750
1B	Dickey	735/230	3 x 750
2A	Arnaud	735/230	3 x 750
2B	Manic	none	
3A, 3B	Gull Island	735/230	2 x 750
4A	Arnaud	735/230	4 x 750
4B	Manic	none	

No transformers are included at Manic in Alternatives 2B and 4B on the assumption that power can be taken by the dc convertors from the existing 315 kV system and that this would not involve the need for new 735/315 kV transformers.

AC station losses are assumed to be 0.3 percent of rating for shunt reactors and transformers at maximum normal system load.

7. COSTS AND DELIVERED MILL RATES

Eight tables are included in this report to summarize total costs for installation in 1985 of the transmission of each alternative. These capital costs are twice the direct (1978) costs to allow for escalation at 7% and interest at 10% during construction plus all overheads. The tables also compare the annual charge to defray the capital cost of each step in the transmission, the delivered energy and the resulting cost in mills per kWh. Certain assumptions are implicit in this presentation:

- generation capacity of 800 MW at Gull Island for this transmission, 600 MW at Muskrat, 1416 MW at Romaine River and 976 MW at Moisie River.

- capacity factor of 0.71 for all the above generation stations.

- Capital cost of Gull Island is $1,534 millions, of which half is attributable to this transmission, and cost of Muskrat is $1,000 millions. Both are installed 1985 costs, complete to HV side of generator transformers (based on 1978 prices for construction in 1979-85).

- Transmission costs have annual charges of 12.5 percent of capital, made up of interest 10%, financing 1%, interim replacement 0.1%, insurance 0.1%, operation and maintenance 1%, and owner's overhead, 0.3%. Hydro generation has 12.7% annual charges.

- Capital cost of Romaine and Moisie river power, introduced at Arnaud for Alternative 4A or Manic for Alternative 4B is $4,066 millions ($1,700/kW total installed cost).

- For Alternative 4B, one additional 735 kV line between Arnaud and Manic is included for the Gull Island and Muskrat power. For Moisie and Romaine power a further 735 kV line to Manic may also be required but is not estimated herein.

- Delivery in each alternative is at a HV busbar at Dickey-Lincoln, Me. (230 kV) or Salisbury, near Moncton, N.B. (345 kV).

The tables (Tables 2 to 9) show costs, energy availability and mills/kWh from generation to delivery point. Comparing alternatives, the lowest delivered cost per kWh in 1985 at Dickey is Alternative 3B as follows:

Alternative 3B - 45.2 mills/kWh

2B - 48.3 mills/kWh

1B - 52.8 mills/kWh

For delivery at Moncton costs are:

Alternative 3A - 45.9 mills/kWh

2A - 48.9 mills/kWh

1A - 57,4 mills/kWh

Costs in mills/kWh for Alternatives 4A (46.7) and 4B (45.1) are equal to 2A and 2B under assumptions made.

Alternatives 4A and 4B provide transmission from north shore to south shore at an added cost of 10 to 12 mills/kWh under the assumptions listed.

Delivered power at Moncton in dollars per kW, considering total of generation and transmission cost and generated kW less losses, varies with the alternatives as follows:

- Alternative 3A: $2265/kW
- Alternative 4A: $2320/kW
- Alternative 2A: $2415/kW
- Alternative 1A: $2830/kW

Delivered power at Dickey-Lincoln is:

- Alternative 3B: $2230/kW
- Alternative 4B: $2240/kW
- Alternative 2B: $2385/kW
- Alternative 1B: $2605/kW

Cash flow tables for each alternative have also been prepared and are shown on tables 11-18 inclusive.

8. DISCUSSION

8.1 Comparison of Alternatives

The direct dc alternative provides the lowest cost of delivered power to either location, mainly due to lower line costs. Since every alternative requires a dc conversion because the Quebec/Labrador system is not synchronized to Maine/New Brunswick, the ac system gains no advantage from lower ac station costs. The dc alternatives involve shorter routes, made possible by the cable crossings, which allow lower transmission lengths as well as a lower per km transmission line cost. DC line losses are higher per km of transmission but lower in total.

The ac alternative requires a new 735 kV circuit along both the north and south shores east of Quebec City. This would entail severe environmental problems and high land costs which have not been estimated in this report.

The receiving point at Dickey can be supplied at a slightly lower cost than Moncton, but depends on generation at Dickey to provide fault level for the dc converters. Further transmission from Dickey to load centres to the South must be provided for both the power from Gull Island and the power generated at Dickey. The estimates provided here do not include such transmission.

The receiving point at Moncton has the advantage of connecting to an existing 345 kV system with connections to loads in New Brunswick, Nova Scotia and Maine. No provision has been made for any strengthening to the 345 kV network that would be required if 1300 or 1750 MW were injected there.

8.2 Additional Supply to Quebec South

Alternatives 4A and 4B provide for an additional 2392 MW generation on the north shore to be transmitted to the south shore of the St. Lawrence. This level of power is more than the south shore system can absorb without needing investment in uprating its transmission. Even when part of this generation is taken to Dickey or Moncton on the assumption that two dc lines in parallel would carry equal power to receiving points at separate locations, the received power is large for the Gaspé system. The surplus is transmitted back to Lévis (Quebec), requiring four 315 kV lines. For this purpose two circuits now operating at 220 kV would require uprating to 315 kV, with some rearrangement of the local loads they now serve. In the case of alternative 4A a double circuit 315 kV line is added between Les Boules and Rimouski to provide four circuits from Les Boules to Lévis.

8.3 Sensitivity

An important assumption made in this study is that the capacity factor of all plants is 0.71. If a higher capacity factor is chosen, i.e. more energy were available from the same installed generation capacity, a larger conductor size may be preferred for optimum design. There would therefore be a higher capital cost but also higher energy generated, some higher energy losses, giving a lower mill rate delivered.

The arbitrary choice of $1700/kW for 1985 installed generation costs in 1985 for Romaine and Moisie developments affects the overall costs for Alternatives 4A and 4B. Since the north shore costs of all four plants are pooled on tables 8 and 9 at the entry to the dc stations, and then distributed on the south shore half to the Quebec system and half to the New Brunswick or Maine delivery points, the sending-end capital costs are critical to the received costs evaluated. Also the quantity of power delivered to the south shore by this arrangement will affect delivered mill rates.

The results will also be sensitive to escalation and interest rates that may differ from the 7% and 10% values used herein. Cable crossing costs will be sensitive to feasibility of crossing near the routes indicated.

TABLE 1

Transmission Line Unit Costs
(direct costs only in September 1978 dollars, excluding right-of-way acquisition costs)

Voltage	Conductor & Tower	Route	Length (km)	Dollars/km
735 kV AC	4 x 1.3 inch Guyed V	Gull Is.-Churchill	190	280,000
		Gull Is.Montagnais	340	320,000
		Montagnais-Arnaud	220	320,000
		Arnaud-Manic	170	300,000
		Manic Saguenay R.	165	300,000
		Saguenay-Ile d'Orleans	183	280,000
		River crossings (Sag., St. Law.)	12	446,000
		Ile d'Orleans-Lévis	20	240,000
		Lévis-Que./N.B.	250	240,000
		Que./N.B.-Grand Falls	90	220,000
		Lévis-Que/Me	140	240,000
		Que/Me-Dickey Lincoln	50	260,000
345 kV AC double cct.	3 x 1.1 inch Self-supported	Grand Falls-Moncton	250	230,000
230 kV AC single cct.	2 x 1.0 inch Guyed V	Muskrat-Gull Island	60	130,000
± 400 kV DC bipolar	2 x 2.0 inch Guyed Mast	Gull Is.-Mingan	350	300,000
		Mingan-Arnaud	190	260,000
		Arnaud-Pte des Monts	140	230,000
		Grosses Roches-Matapedia	125	200,000
		Matapedia-Moncton	275	180,000
		Arnaud-Manic	170	230,000
		Manic-G. Bergeronnes	150	200,000
		Trois Pistoles-Que/Me	85	200,000
		Que/Me-Dickey	35	180,000
± 400 kV DC bipolar	3 x 2.0 inch Guyed Mast	Arnaud-Pte des Monts	140	270,000
		Grosses Roches-Les Boules	75	220,000
		Les Boules-Matapedia	100	260,000
		Matapedia-Moncton	275	230,000
		Manic-Gr. Bergeronnes	150	270,000
		Trois-Pistoles-R. du Loup	50	220,000
		R. du Loup-Que/Me	45	260,000
		Que/Me-Dickey	35	240,000
315 kV AC double cct.	2 x 1.25 inch Self-supported	Les Boules-Rimouski	55	230,000

TABLE 2

Alternative 1A

	Capital Cost $ millions	Annual Charge $ millions	GWh	mills/kWh
Half of Gull Is.	767	97.4	4975.7	19.6
Muskrat	1000	127	3731.8	34
	1767	224.4	8707.4	25.8
Gull-Muskrat	55.4	6.9	-43.4	
	1822.4	231.3	8664	26.7
Gull Is.-Churchill	115.7			
Gull Is.-Montagnais	289.2			
Montagnais-Arnaud	157.3			
Arnaud-Manic	118.7			
Manic-Lévis (incl. crossings)	334.9			
Total Gull Is.-Lévis	1015.8	127	-455.9	
Total to Lévis	2838.2	358.3	8208.1	43.7
Lévis-G. Falls	211.3			
G. Falls dc station	331.7	67.9	-310	
Total to G. Falls 345 kV	3381.2	426.2	7898.9	54
G. Falls-Moncton	121.4	15.2	-215.4	
Total	3502.6	441.4	7696.3	57.4

TABLE 3

Alternative 1B

	Capital Cost $ millions	Annual Charge $ millions	GWh	mills/kWh
Half of Gull Is.	767	97.4	4975.7	19.6
Muskrat	1000	127	3731.8	34
	1767	224.4	8707.4	25.8
Muskrat-Gull Is.	55.4	6.9	-43.4	
Total	1822.4	231.3	8664.	26.7
Gull Is.-Lévis (as Alt. 1A)	1015.8	127	-455.9	
	2838.2	358.3	8208.1	43.7
Lévis-Dickey	150			
Dickey DC station	341.7	61.5	-253.3	
Total	3329.9	419.8	7954.8	52.8

TABLE 4

Alternative 2A

	Capital Cost $ Millions	Annual Charge $ Millions	GWh	mills/kWh
Half of Gull Is.	767	97.4	4975.7	19.6
Muskrat	1000	127	3731.8	34
Total	1767	224.4	8707.4	25.8
Gull Is.-Muskrat	55.4	224.4	-43.4	
	1822.4	231.3	8664	26.7
Gull Is.-Churchill	106.2			
Gull Is.-Montagnais	288.2			
Montagnais-Arnaud	140.8		-310.6	
Arnaud ac Station	50.3			
Arnaud dc Station	178.8		-90.7	
Arnaud-St. Lawrence R.	64.4		-45.6	
Cables	120		-24.5	
St. Lawrence R.-Moncton	149		-127.5	
Moncton Station	177		-85.4	
Total Gull Is.-Moncton	1274.7	159.3	-684.3	
Total	3097.1	390.6	7979.7	48.9

TABLE 5

Alternative 2B

	Capital Cost $ millions	Annual Charge $ millions	GWh	mills/kWh
Half of Gull Is.	767	97.4	4975.7	19.6
Muskrat	1000	127	3731.8	34
Total	1767	224.4	8707.4	25.8
Gull Is.-Muskrat	55.4	6.9	-43.4	
	1822.4	231.3	8664	26.7
Gull Is.-Churchill	106.2			
Gull Is.-Montagnais	288.2			
Montagnais-Arnaud	157.3			
Arnaud-Manic	115.4		-364.6	
Manic DC station	178.2		-90.7	
Manic-St. Lawrence R.	69		-49.1	
Cable crossing	102.5		-14.7	
St. Lawrence R.-Dickey	46.6		-38.7	
Dickey DC station	185.2		-88.7	
Total Gull Is.-Dickey	1248.6	156.1	-646.5	
Total	3071	387.4	8017.5	48.3

TABLE 6

Alternative 3A

	Capital Cost $ millions	Annual Charge $ millions	GWh	mills/kWh
Half of Gull Is.	767	97.4	4975.7	19.6
Muskrat	1000	127	3731.8	34
Total	1767	224.4	8707.4	25.8
Gull Is.-Muskrat	59.8	7.5	-43.4	
Total	1826.8	231.9	8664	26.7
Gull Is.-Churchill Falls	157			
Gull Is. DC station	168		-92	
Gull Is.-St. Lawrence R.	373.2		-219.7	
Cable crossing	120		-24.5	
St. Lawrence R.-Moncton	149		-127.5	
Moncton DC station	153.6		-84	
Moncton AC station	6			
Total Gull Is.-Moncton	1126.8	140.9	-547.8	
Total	2953.6	372.8	8116.2	45.9

TABLE 7

Alternative 3B

	Capital Cost $ millions	Annual Charge $ millions	GWh	mills/kWh
Half of Gull Is.	767	97.4	4975.7	19.6
Muskrat	1000	127	3731.8	34
Total	1767	224.4	8707.4	25.8
Gull Is.-Muskrat	59.8	7.5	-43.4	
Total	1826.8	231.9	8664	26.7
Gull Is.-Churchill R.	157			
Gull Is. DC station	168		-92	
Gull Is.-St. Lawrence R.	456		-275.7	
Cable crossing	102.5		-14.7	
St. Lawrence R.-Dickey	46.6		-38.7	
Dickey DC station	164.4		84.7	
Total Gull Is.-Dickey	1094.5	136.8	-505.8	
Total	2921.3	368.7	8158.2	45.2

26.7
18.5

TABLE 8

Alternative 4A

	Capital Cost $ millions	Annual Charge $ millions	GWh	mills/kWh
Half of Gull Is.	767	97.4	4975.7	19.6
Muskrat	1000	127	3731.8	34
Total	1767	224.4	8707.4	25.8
Gull Is.-Muskrat	55.4	6.9	-43.4	
	1822.4	231.3	8664	26.7
Gull Is.-Arnaud (as Alt. 2A	535.2			
Arnaud ac	67.8	75.4	-310.6	
	2425.4	306.7	8353.4	36.7
Add Romaine and Moisie R. infeeds	4066	508	14877.3	34.2
Total	6491.4	814.7	23230.7	35.1
Arnaud dc station	452.9		-248	
Arnaud-St. Lawrence R.	151.2		-109.4	
Cable crossings	320		-66.8	
St. Lawrence R.-Les Boules	66		-57.9	
Arnaud to Les Boules Total	990.1	123.8	-482.1	
Total	7481.5	938.5	22748.6	41.2
Quebec South Shore delivery (50%)	3740.8	469.3	11374.3	41.2
Les Boules dc station	250.8		-121.6	
Les Boules-Rimouski	67.5	39.8	-133.4	
Total to Rimouski	4059.1	509.1	11119.3	45.8
Moncton delivery 50% at Les Boules	3740.8	469.3	11374.3	41.2
Les Boules-Moncton	178.5		-151.2	
Moncton dc station	211.2		-115.6	
ac station	6.4	49.5		
Total to Moncton	4136.9	518.8	11107.5	46.7

TABLE 9

Alternative 4B

	Capital Cost $ millions	Annual Charge $ millions	GWh	mills/kWh
Half of Gull Island	767	97.4	4975.7	19.6
Muskrat	1000	127	3731.8	34
Total	1767	224.4	8707.4	25.8
Gull Is.-Muskrat	55.4	6.9	-43.4	
Total	1822.4	231.3	8664	26.7
Gull Is.-Manic (as Alt. 2B)	653.7		-364.6	
Manic ac	15.9	83.7		
Total to Manic	2492	315	8299.4	37.3
Add Romaine & Moisie infeeds	4066	508	14877 3	34.3
Total	6558	823	23176.7	35.3
Manic dc station	469.7		-247.8	
Manic-St. Lawrence R.	167		-122.3	
Cable crossings	273		-40.1	
St. Lawrence-R. du Loup	44		-38.6	
Manic to R. du Loup Total	953.7	119.2	-448.8	
Total	7511.7	942.2	22727.9	41.5
Quebec South Shore delivery (50%)	3755.9	471.1	11364	41.5
R. du Loup dc station	244.2		-90.7	
R. du Loup ac station	4.4	31.1		
Total to R. du Loup	4004.5	502.2	11273.3	44.5
Dickey delivery (50% at R. du Loup	3755.9	471.1	11364	41.5
R. du Loup-Dickey	40.2		-32.2	
Dickey dc station	232.7	34.1	-120	
Total to Dickey	4028.8	505.2	11211.8	45.1

TABLE 10

DC Station Capacities

Alternative	Location	DC Station Size, MW	AC voltage Connections, kV
1A	Grand Falls, N.B. back to back	1340	735 and 345
1B	Dickey, Me. back to back	1340	735 and 230
2A	Arnaud	1380	230
	Moncton	1320	345
2B	Manic	1375	315
	Dickey	1345	230
3A	Gull Island	1400	230
	Moncton	1280	345
3B	Gull Island	1400	230
	Dickey	1290	230
4A	Arnaud	2 x 1865	230
	Les Boules	1850	315
	Moncton	1800	345
4B	Manic	2 x 1860	315
	Riviere de Loup	1835	315
	Dickey	1820	230

TABLE 11

Cash Flow for Alternative 1A
Transmission only

Year	1979	1980	1981	1982	1983	1984	Total
AC Stations							
Investment (1977 dollars)	6.1	8.5	29.3	36.6	30.5	11	122
Escalated (7%)	6.5	9.7	35.8	47.9	42.8	16.5	
Cumulative Total	6.5	16.9	54.5	107.8	161.4	194	
Interest (10%)	.7	1.7	5.4	10.8	16.1	19.4	
Total	7.5	18.6	59.9	118.6	177.5	213.4	
DC Stations							
Investment (1977 dollars)	9.5	13.3	45.5	56.9	47.4	17	189.6
Escalated (5%)	10.1	15.2	55.7	74.6	66.5	25.6	
Cumulative Total	10.1	26.3	84.6	167.7	250.9	301.6	
Interest (10%)	1.0	2.6	8.5	16.8	25.1	30.1	
Total	11.1	28.9	93.1	184.5	276	231.7	
AC Lines							
Investment (1977 dollars)	0	34.5	103.6	207.2	207.2	138.1	690.6
Escalated (7%)	0	39.5	126.9	271.6	290.6	207.3	
Cumulative total	0	39.5	170.4	459	795.5	1082.3	
Interest (10%)	0	4	17	45.9	79.5	108.2	
Total	0	43.5	187.4	504.9	875	1190.5	
Grand Total	18.3	91	340.4	808	1328.5	1735.6	

TABLE 12

Cash Flow for Alternative 1B
Transmission only

Year	1979	1980	1981	1982	1983	1984	Total
AC Stations							
Investment (1977 dollars)	6.1	8.5	29.1	36.3	30.3	10.9	121.2
Escalated (7%)	6.5	9.7	35.6	47.6	42.5	16.4	
Cumulative Total	6.5	16.8	54.1	107.2	160.4	192.8	
Interest (10%)	.6	1.7	5.4	10.7	16	19.2	
Total	7.1	18.5	59.5	117.9	176.4	212	
DC Station							
Investment (1977 dollars)	9.8	13.7	46.9	58.6	48.8	17.6	195.4
Escalated (7%)	10.4	15.7	57.4	76.8	68.5	26.4	
Cumulative Total	10.4	27.1	87.2	172.7	258.5	310.7	
Interest (10%)	1.0	2.7	8.7	17.3	25.8	31	
Total	11.4	29.8	95.9	190	284.3	341.7	
AC lines							
Investment (1977 dollars)	0	29.3	87.8	175.6	175.6	117.1	585.4
Escalated (7%)	0	33.5	107.6	230.2	246.3	175.8	
Cumulative Total	0	33.5	144.5	389.1	674.3	917.5	
Interest (10%)	0	3.4	14.4	38.9	67.4	91.7	
Total	0	36.4	158.9	428	741.7	1009.2	
Trand Total	18.5	85.2	314.3	735.9	1202.4	1562.9	

TABLE 13

Cash Flow for Alternative 2A
Transmission only

Year	1979	1980	1981	1982	1983	1984	Total
AC Stations							
Investment (1977 dollars)	4.1	5.8	19.9	24.9	20.7	7.5	82.9
Escalated (7%)	4.4	6.2	24.4	32.6	29.1	11.8	
Cumulative Total	4.4	11.1	36.6	72.8	109.2	131.9	
Interest (10%)	.4	1.1	3.6	7.3	10.9	13.2	
Total	4.8	12.2	40.2	80.1	120.1	145.1	
DC Stations & DC Cable							
Investment (1977 dollars)	13.6	19	65.2	81.6	68	24.5	271.9
Escalated (7%)	14.6	21.8	79.9	106.9	95.3	36.7	
Cumulative Total	14.6	37.8	121.5	240.5	359.9	432.7	
Interest (10%)	1.4	3.8	12.1	24.1	36.0	43.2	
Total	16	41.6	133.6	264.6	395.9	475.9	
AC & DC Lines							
Investment (1977 dollars)	0	20.6	61.7	123.4	123.4	82.3	411.4
Escalated (7%)		23.5	75.6	161.8	173.1	123.5	
Cumulative Total	0	23.5	101.5	273.4	473.8	644.7	
Interest (10%)		2.4	10.1	27.3	47.4	64.4	
Total	0	25.9	111.6	300.7	521.2	709.1	
Grand Total	20.8	79.7	285.4	645.4	1037.2	1330.1	

TABLE 14

Cash Flow for Alternative 2B
Transmission only

Year	1979	1980	1981	1982	1983	1984	Total
AC Stations							
Investment (1977 dollars)	3.6	5.0	17.1	21.4	17.8	6.4	71.3
Escalated (7%)	3.8	5.7	21.0	28.0	25.0	9.6	
Cumulative Total	3.8	9.9	31.9	63.1	94.4	113.4	
Interest (10%)	.4	1.0	3.2	6.3	9.4	11.3	
Total	4.2	10.9	35.1	69.4	103.8	124.7	
DC Stations & DC Cable							
Investment (1977 dollars)	13.3	18.6	63.9	79.9	66.6	24	266.3
Escalated (7%)	14.2	21.4	78.3	104.7	93.4	36	
Cumulative Total	14.2	37.	119.	235.6	352.5	423.7	
Interest (10%)	1.4	3.7	11.9	23.5	35.2	42.3	
Total	15.6	40.7	130.9	259.1	387.7	466	
AC & DC Lines							
Investment (1977 dollars)	0	20.7	62.1	124.1	124.1	82.8	413.8
Escalated (7%)		23.7	76	162.7	174.1	124.2	
Cumulative Total	0	23.7	102.1	275	476.6	648.5	
Interest (10%)	0	2.4	10.2	27.5	47.7	64.8	
Total	0	26.1	112.3	302.5	524.3	713.3	
Grand Total	19.8	77.7	278.3	631	1015.8	1304	

TABLE 15

Cash Flow for Alternative 3A
Transmission only

Year	1979	1980	1981	1982	1983	1984	Total
AC Stations							
Investment (1977 dollars)	2.4	3.4	11.7	14.6	12.2	4.4	48.7
Escalated (7%)	2.6	3.9	14.3	19.1	17.1	6.6	
Cumulative Total	2.6	6.8	21.8	43.1	64.4	77.5	
Interest (10%)	.26	.68	2.1	4.3	6.4	7.7	
Total	2.86	7.4	23.9	47.4	70.9	85.2	
DC Stations & DC Cable							
Investment (1977 dollars)	12.6	17.7	60.6	75.7	63.1	22.7	252.4
Escalated (7%)	13.5	20.2	74.2	99.2	88.5	34.1	
Cumulative Total	13.5	35.1	112.8	223.3	334.1	401.6	
Interest (10%)	1.35	3.5	11.3	22.3	33.4	40.2	
Total	14.85	38.6	124.0	245.6	367.5	441.7	
AC & DC Lines							
Investment (1977 dollars)	0	19.1	57.4	114.8	114.8	76.5	382.6
Escalated (7%)	0	21.9	70.3	150.5	161	114.9	
Cumulative Total	0	21.9	94.4	254.3	440.8	599.8	
Interest (10%)	0	2.2	9.4	25.4	44.1	60	
Total		24.1	103.9	279.8	484.9	659.8	
Grand Total	17.7	70.1	251.8	572.8	923.3	1186.7	

TABLE 16

Cash Flow for Alternative 3B
Transmission only

Year	1979	1980	1981	1982	1983	1984	Total
AC Stations							
Investment (1977 dollars)	2.3	3.2	10.9	13.6	11.3	4.1	45.4
Escalated (7%)	2.4	3.6	13.3	17.8	15.9	6.1	
Cumulative Total	2.4	6.3	20.2	40.0	59.9	72	
Interest (10%)	.24	.6	2.0	4.0	6	7.2	
Total	2.7	6.9	22.2	44	65.9	79.2	
DC Stations & DC Cable							
Investment (1977 dollars)	12.4	17.4	59.6	74.6	62.1	22.3	248.5
Escalated (7%)	13.3	19.9	73.1	97.7	87.1	33.6	
Cumulative Total	13.3	34.5	111.1	219.9	329	395.5	
Interest (10%)	1.3	3.5	11.1	22.0	32.9	39.4	
Total	14.6	38.0	122.2	241.9	361.9	434.9	
AC & DC Lines							
Investment (1977 dollars)	0	18.6	55.7	111.4	111.4	74.3	371.4
Escalated (7%)	0	21.3	68.2	146	156.2	111.5	
Cumulative Total	0	21.3	91.6	246.8	427.7	582	
Interest (10%)		2.1	9.2	24.7	42.8	58.2	
Total		23.4	100.8	271.5	470.5	690.2	
Grand Total	17.3	68.3	245.2	557.4	898.3	1154.3	

TABLE 17

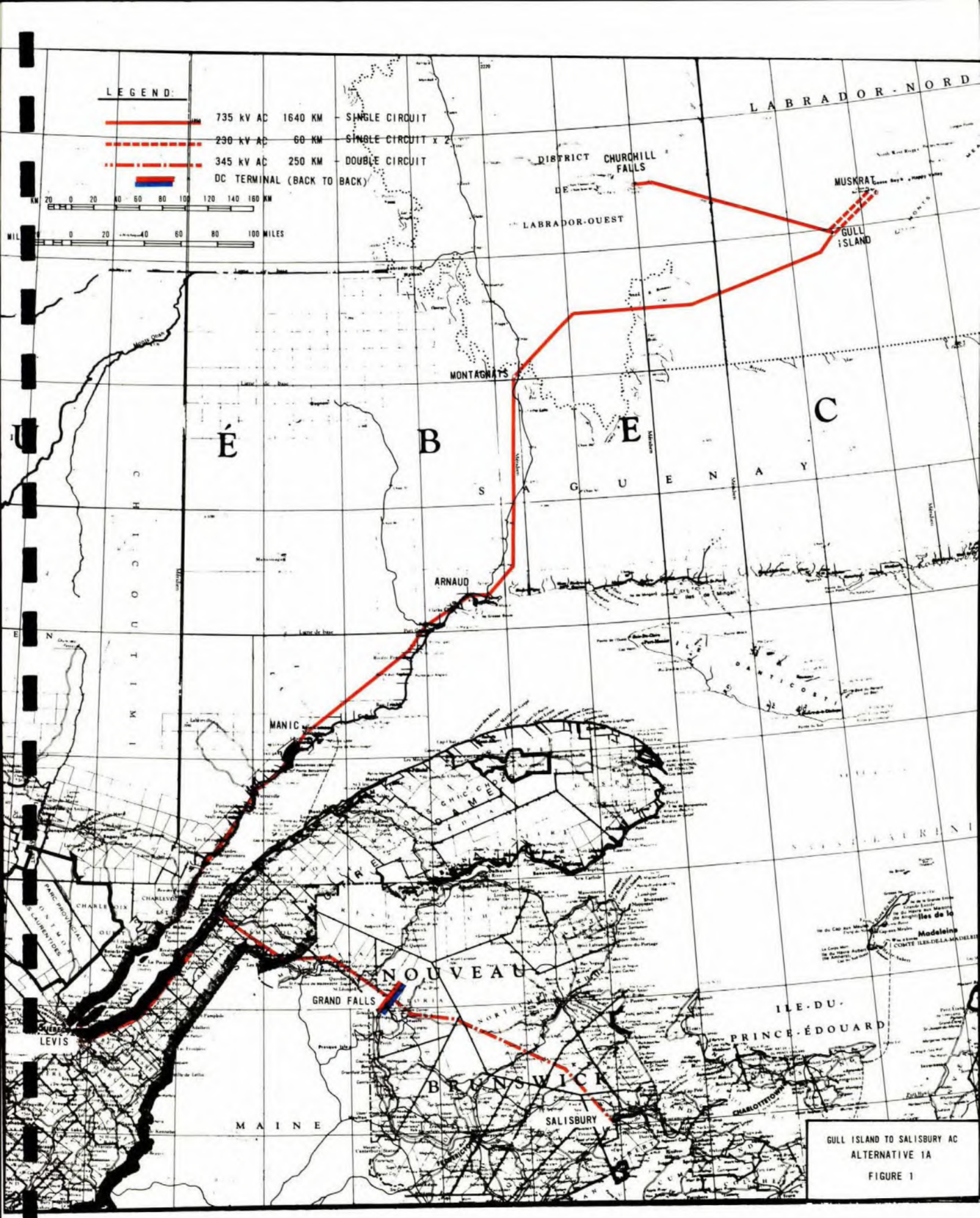
Cash Flow for Alternative 4A
Transmission only

Year	1979	1980	1981	1982	1983	1984	Total
AC Stations							
Investment (1977 dollars)	4.8	6.8	23.2	29	24.1	87	96.6
Escalated (7%)	5.2	7.7	28.4	38.1	33.9	12.9	
Cumulative Total	5.2	13.4	43.1	85.5	127.9	153.6	
Interest	.5	1.3	4.3	8.5	12.8	15.4	
Total	5.7	14.7	47.4	94	140.7	169	
DC Stations & DC Cables							
Investment (1977 dollars)	35.3	49.4	169.4	211.7	176.4	63.5	705.7
Escalated (7%)	37.8	56.5	207.5	277.5	247.5	95.3	
Cumulative Total	37.8	98.1	315.4	624.4	934.3	1123	
Interest	3.8	9.8	31.5	62.4	93.4	112	
Total	41.6	107.9	346.9	686.8	1027.7	1235	
AC & DC Lines							
Investment (1977 dollars)	0	27.8	83.4	166.9	166.9	111.2	556.2
Escalated (7%)		31.8	102.2	218.7	234	167	
Cumulative Total	0	31.8	137.2	369.7	640.7	871.8	
Interest (10%)		3.2	13.7	37	64.1	87.2	
Total	0	35	150.9	406.7	704.8	959	
Grand Total	47.3	157.6	545.2	1187.5	1873.2	2363	

TABLE 18

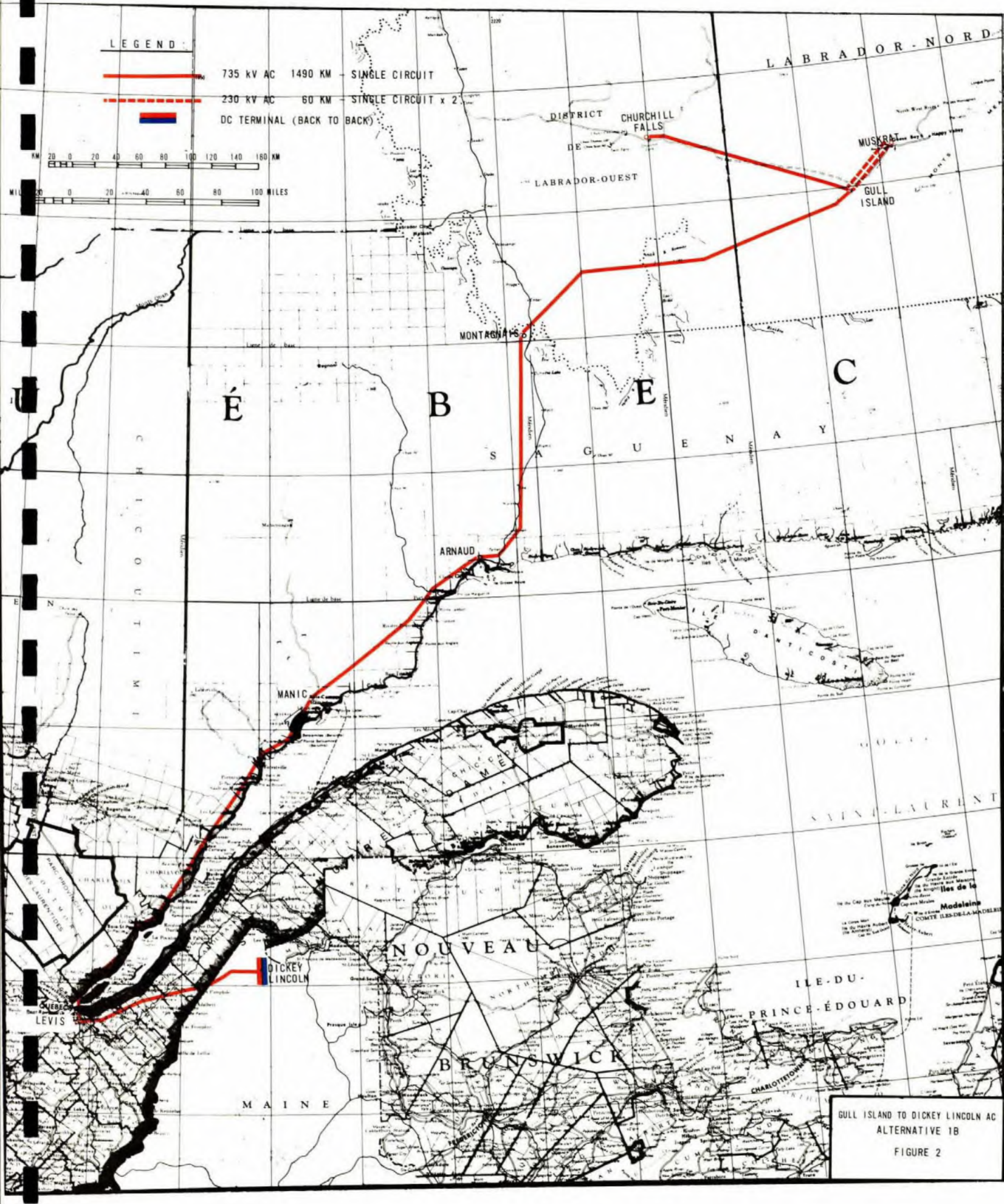
Cash Flow for Alternative 4B
Transmission only

Year	1979	1980	1981	1982	1983	1984	Total
AC Stations							
Investment (1977 dollars)	3.8	5.3	18	22.5	18.8	6.8	75.2
Escalated (7%)	4.0	6.0	22.1	29.6	26.4	10.2	
Cumulative Total	4.0	10.4	33.6	66.5	99.6	119.7	
Interest (10%)	.4	1.1	3.4	6.7	9.9	11.9	
Total	4.4	11.5	37	73.2	109.5	131.6	
DC Stations & DC Cables							
Investment (1977 dollars)	34.8	48.8	167.3	209.1	174.2	627	696.9
Escalated (7%)	37.3	55.8	204.9	274.1	244.4	93.7	
Cumulative Total	37.3	96.8	311.4	616.6	922.7	1108.7	
Interest	3.7	9.7	31.1	61.7	92.3	110.9	
Total	41	106.5	342.5	678.3	1015	1219.6	
AC & DC Lines							
Investment (1977 dollars)	0	24.6	73.9	147.7	147.7	98.5	492.4
Escalated (7%)		28.2	90.5	193.6	207.2	147.9	
Cumulative Total	0	28.2	121.5	327.3	567.2	771.8	
Interest (10%)		2.8	12.2	32.7	56.7	77.2	
Total	0	31	133.7	360	623.9	849	
Grand Total	45.4	149	513.2	1111.5	1748.4	2200.2	



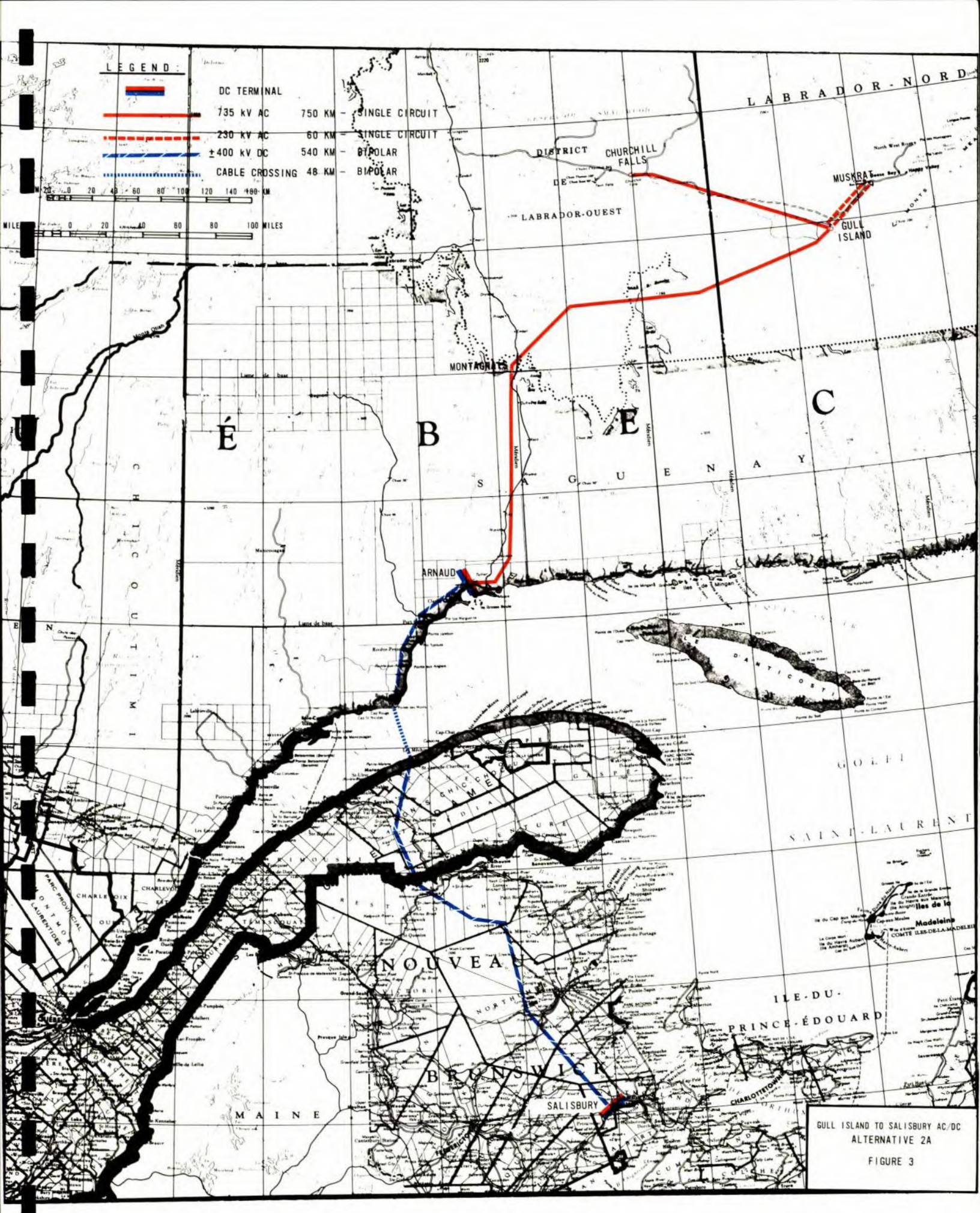
GULL ISLAND TO SALISBURY AC
ALTERNATIVE 1A

FIGURE 1



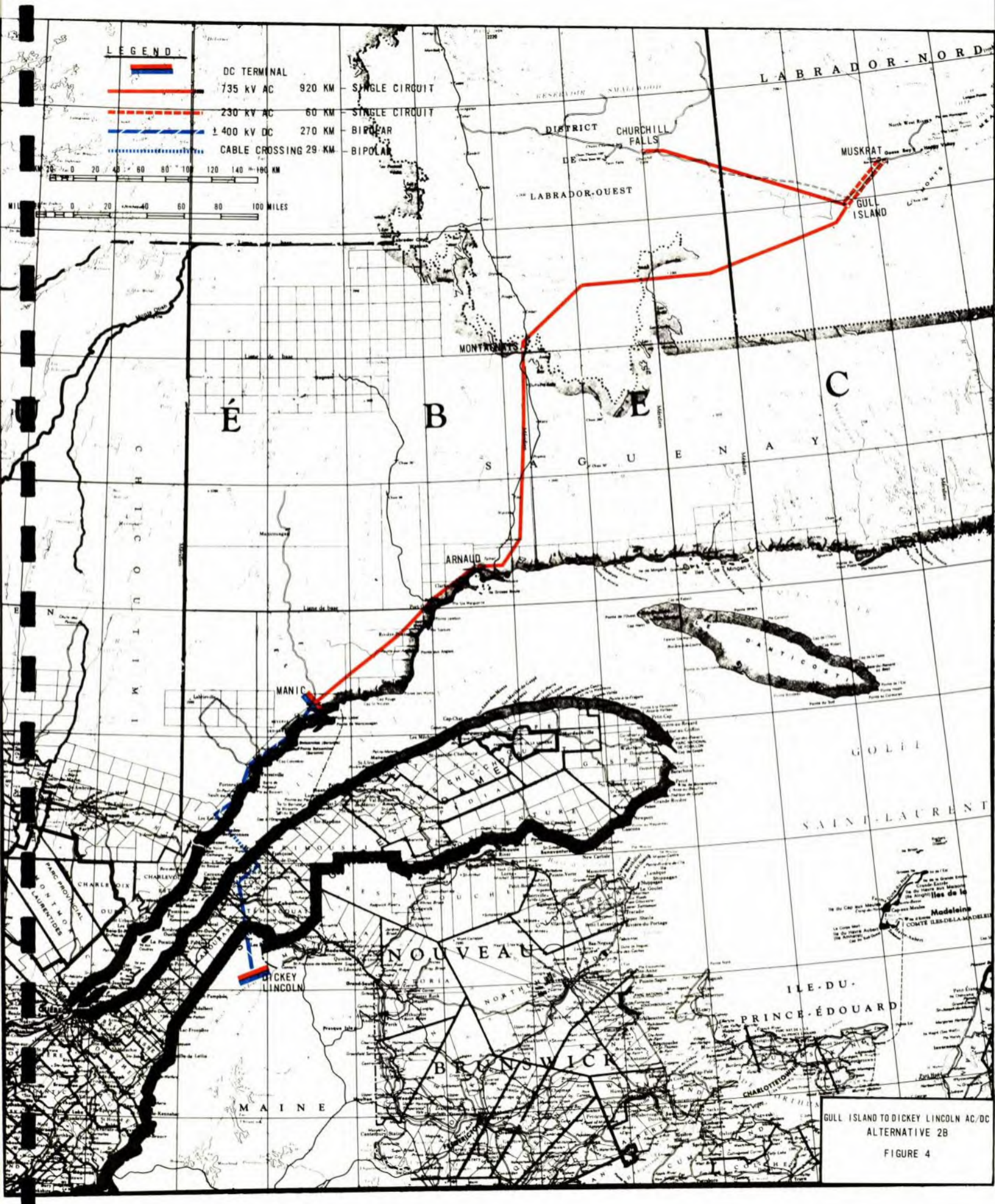
GULL ISLAND TO DICKEY LINCOLN AC
ALTERNATIVE 1B

FIGURE 2



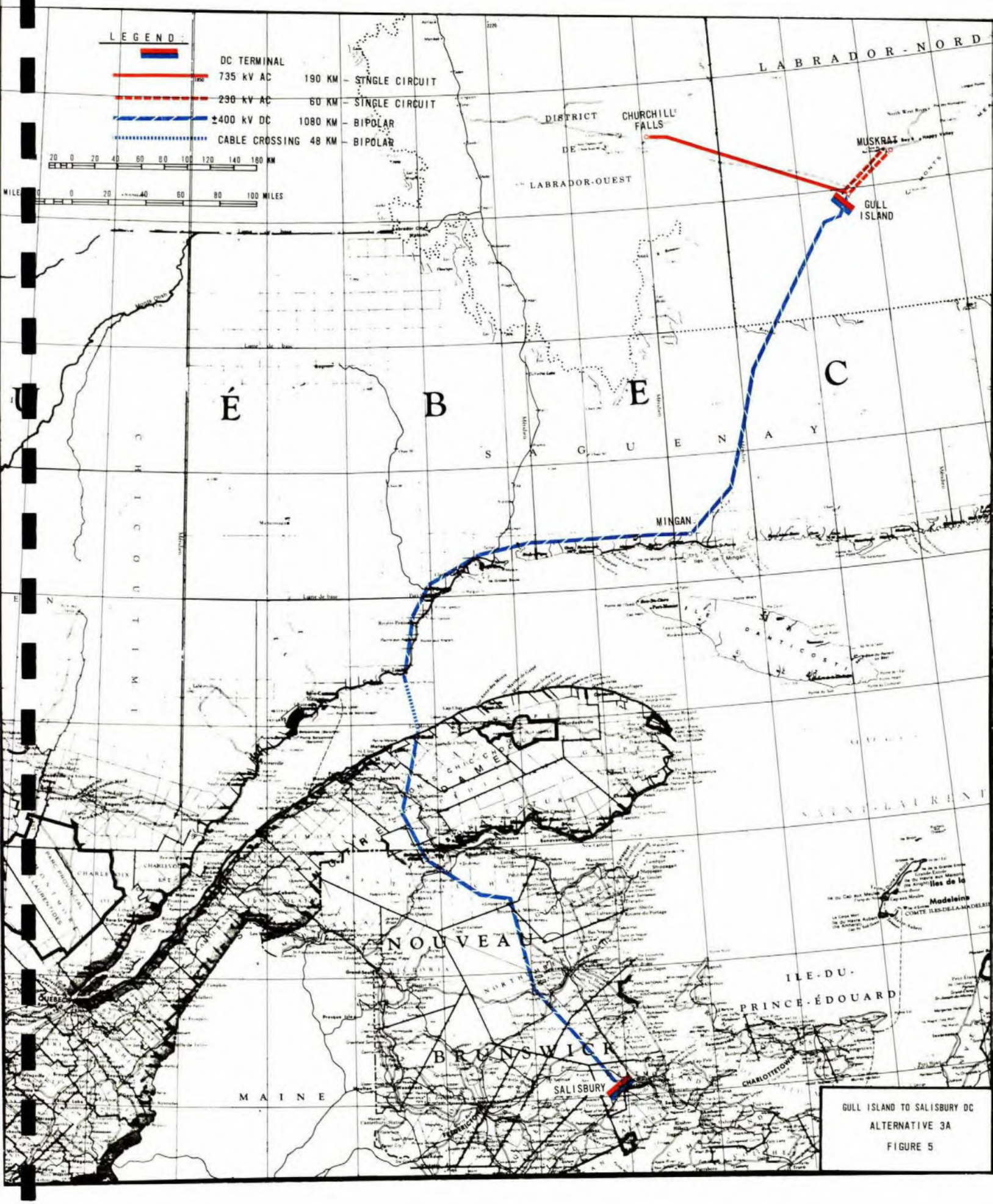
GULL ISLAND TO SALISBURY AC/DC
ALTERNATIVE 2A

FIGURE 3

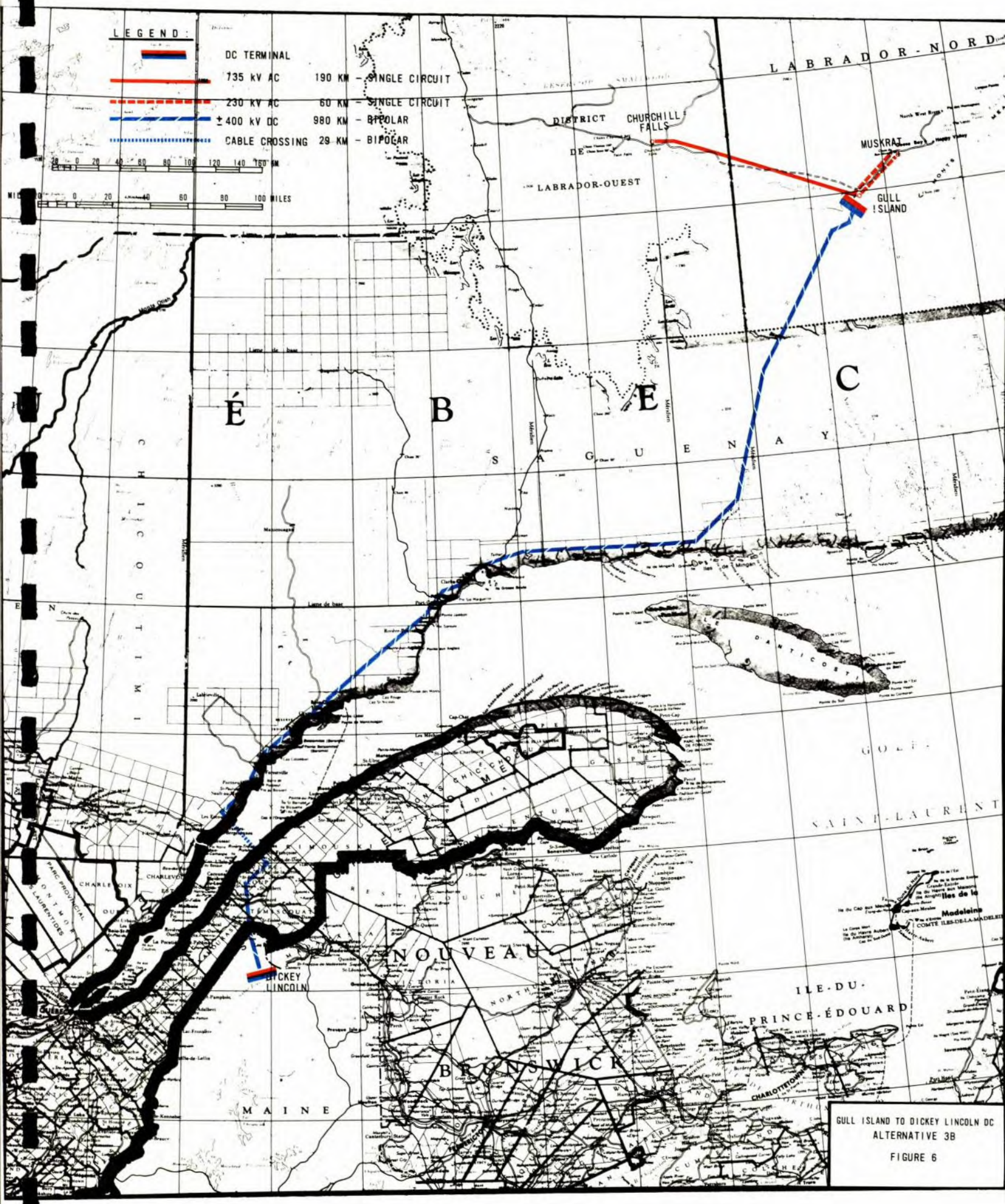


GULL ISLAND TO DICKEY LINCOLN AC/DC
ALTERNATIVE 2B

FIGURE 4

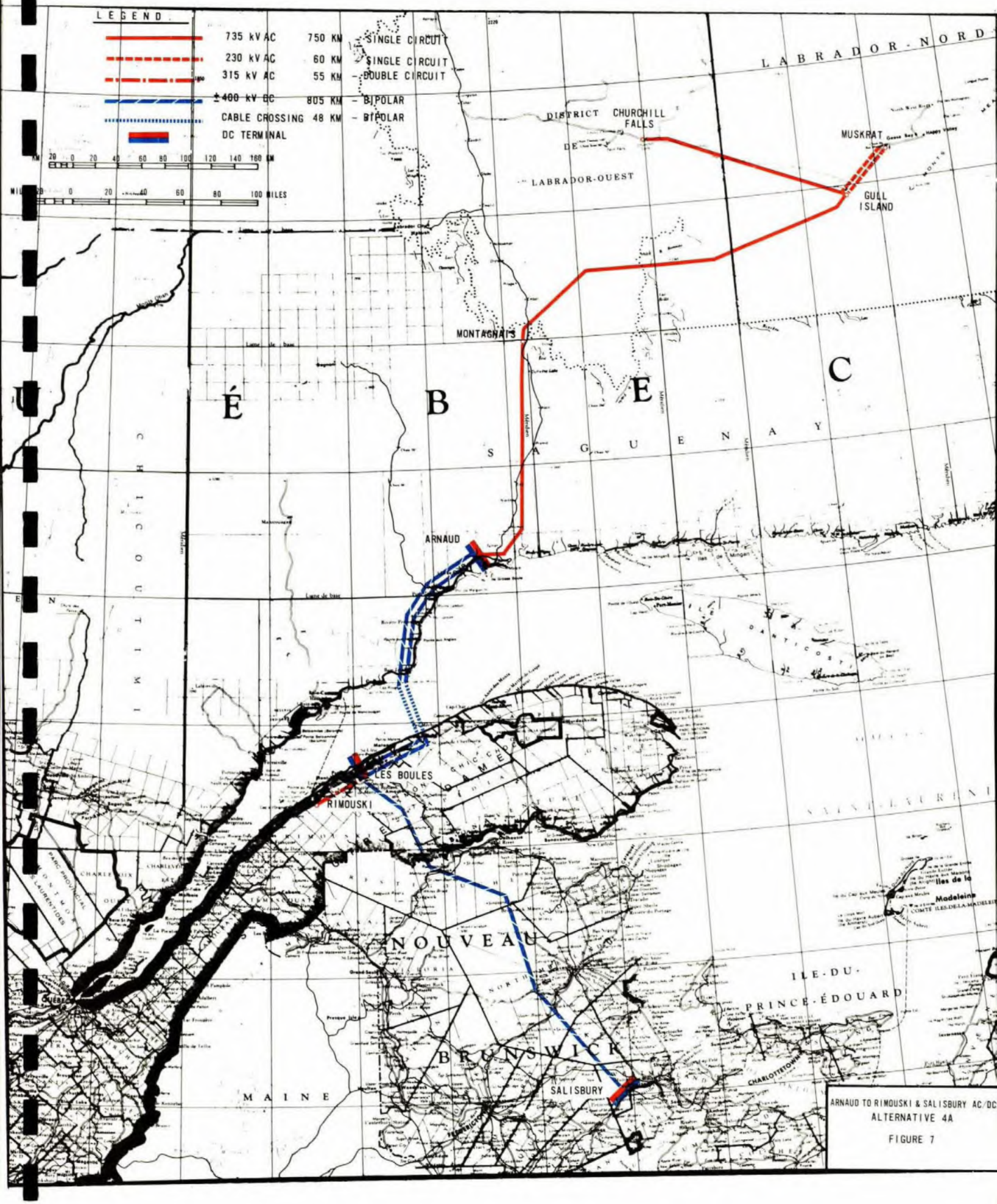


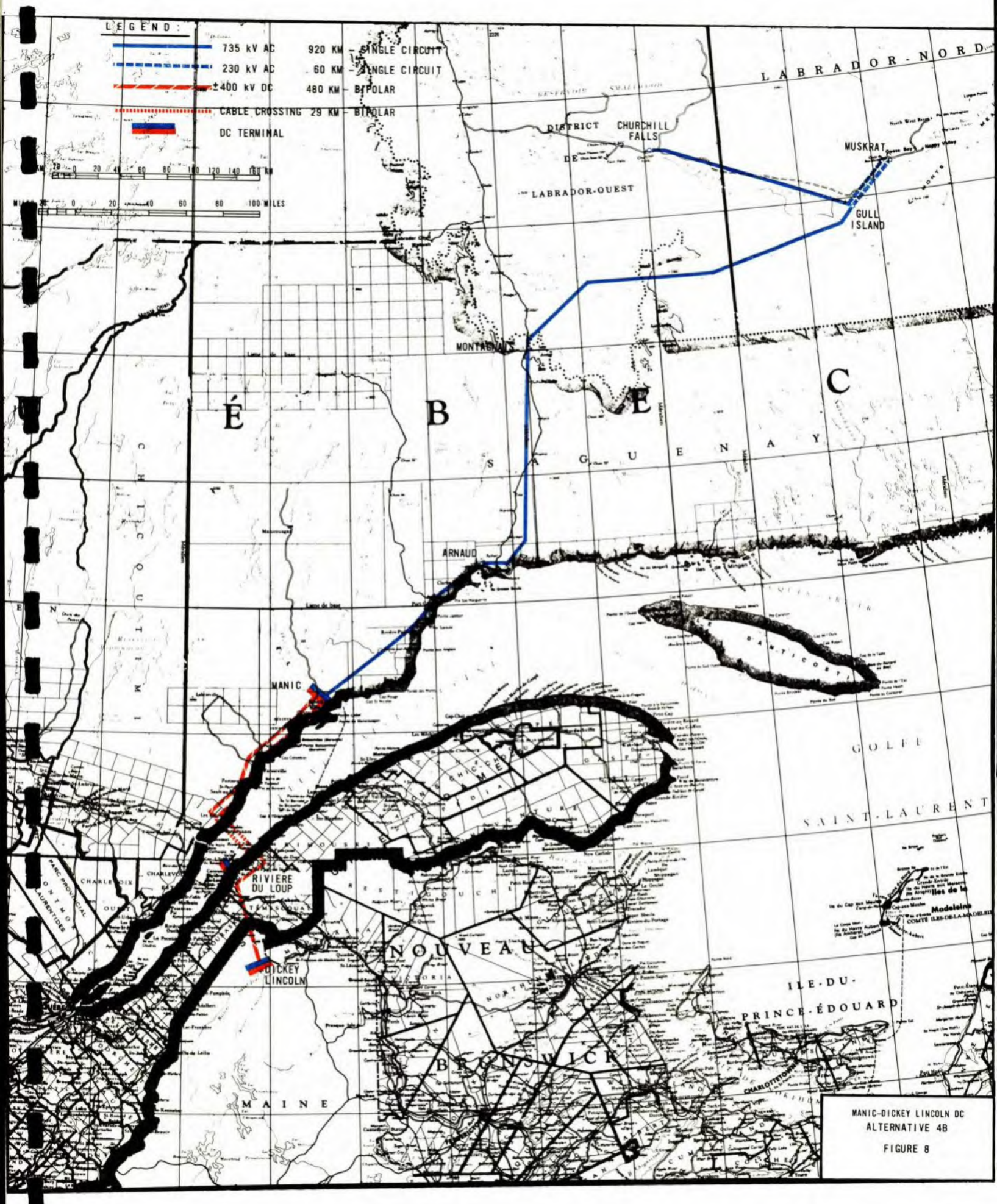
GULL ISLAND TO SALISBURY DC
ALTERNATIVE 3A
FIGURE 5



GULL ISLAND TO DICKEY LINCOLN DC
ALTERNATIVE 3B

FIGURE 6


LEGEND
735 kV AC 750 KM - SINGLE CIRCUIT
230 kV AC 60 KM - SINGLE CIRCUIT
315 kV AC 55 KM - DOUBLE CIRCUIT
±400 kV DC 805 KM - BIPOLAR
CABLE CROSSING 48 KM - BIPOLAR
DC TERMINAL
KM 20 0 20 40 60 80 100 120 140 160 KM
MILES 0 20 40 60 80 100 MILES
LABRADOR-NORD
DISTRICT CHURCHILL FALLS
DE
LABRADOR-OUEST
MUSKRAT
GULL ISLAND
MONTAGNAIS
ÉBEC
SAGUENAY
ARNAUD
LES BOULES
RIMOUSKI
NOUVEAU
BRUNSWICK
ILE-DU-
PRINCE-ÉDOUARD
CHARLOTTETOWN
SALISBURY
MAINE
Madeleine
ARNAUD TO RIMOUSKI & SALISBURY AC/DC
ALTERNATIVE 4A
FIGURE 7



MANIC-DICKEY LINCOLN DC
ALTERNATIVE 4B

FIGURE 8