NEWFOUNDLAND AND LABRADOR HYDRO

REPORT ON 1977/78 WEATHER STUDY

YEAR 1

Prepared By: Newfoundland and Labrador Hydro
Projects Division
Transmission Line Design

Dated: 1978 October 19

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1.0 OBJECTIVES

To outline the climatological program undertaken under W.O. 7005 and to summarize the data collected during the 1977/78 season.

To evaluate the effectiveness of the collectors:

1. Passive Ice Meters (PIM).
2. Rosemount Ice Detector - Anemometers.
3. Ice Accretion Test Towers.

2.0 HISTORICAL BACKGROUND

In 1973 work was initiated on the design of the HVDC Transmission Line associated with the Gull Island Project and during the fall of 1973 and the summer of 1974 two (2) meteorological evaluations of the potential routes were conducted. The lack of data necessary to confirm winds and icing predictions in various regions resulted in the establishment of a data collection program at four test sites during the winter of 1974/75 by Meteorology Research Inc. (MRI). This study encountered such massive loadings in the vicinity of the ridge of the Long Range Mountains near Portland Creek that it was thought prudent to investigate alternative routings for the HVDC in the Northern Peninsula region. A meteorological study of the eastern side of the Peninsula by MRI, in 1977, predicted substantial values of ice and wind loading. An ensuing evaluation of the routes by ShawMont, also in 1977, recommended the expansion of the test tower sites to the eastern side of the Peninsula in an attempt to confirm the MRI predictions. These towers were established and the same year Hydro implemented an island wide meteorological data collection program associated with two major design parameters of transmission lines, ice and wind loading.

This report presents the data obtained from the first collection season, 1977/78.

3.0 METHODOLOGY

To initiate the program, preliminary investigations were made into the types and availability of equipment suitable for the collection of meteorological data concerning ice and wind loading associated with transmission lines.

In January 1977 Work Order No. 7005 was established for the purpose of data collection relative to ice, wind and salt contamination and corrosion. Discussions were carried out with Quebec Hydro and based on their experience with Passive Ice Meters (PIM) it was decided to install a network of PIM's across Newfoundland and Labrador. In the following months contact was made with prospective observers and by the beginning of the 1977/78 observation season 30 meters were in place. Each observer was instructed on monitoring technique and issued a manual of instruction. Three installations of Rosemount Ice Detectors and Anemometers were installed at Yankee Point, Sunnyside and Four Mile Pond - Holyrood during the summer and fall of 1977. The sites at Yankee Point and Sunnyside were installed in conjunction with PIM's to further enhance the collected data.

As part of the ongoing program of data collection in the remote areas to be transversed by the HVDC the former MRI test sites were revamped and six (6) additional sites were installed. As recommended by ShawMont, four (4) of these sites were located on alternate routes of the HVDC and two (2) were located adjacent to Site 2 & 4 on the original route. Sites 2 and 4 were modified as detailed herein and all 10 sites became part of the 1977/78 monthly collection program.

Data collected during the months of 77/78 was tabulated and is summarized in this report.

4.0 INSTRUMENTATION

4.1 Passive Ice Meter

The Passive Ice Meters (PIM), Figure I, were installed at 30 locations throughout Newfoundland and Labrador during the summer of 1977. See Appendix I for list of sites.

The meters consisting of a system of rods and flat surfaces, placed in both horizontal and vertical planes, are designed as a medium to measure ice accretion. The rods simulate ice accretion on conductors and the flat surfaces simulate ice accretion on tower surfaces.

The PIM's sites were monitored from October 15, 1977 to May 15, 1978 with monthly reports being submitted as well as observation reports being completed twice daily during the presence of ice. The observation reports supply information as to the type and amount of ice, the direction of accumulation, the duration of icing and the climatic conditions which brought about the accumulation. See Appendix I for sample report forms.

Data from these sites is tabulated in Appendix II - Summary of Passive Ice Meter Reports.

4.2 Anemometer

Anemometer and analog recorders, Photo I and II , were installed at Yankee Point, Sunnyside and Four Mile Pond - Holyrood. These units operate on a year round basis.

4.0 INSTRUMENTATION (CONT'D)

The wind driven DC magneto generates an output voltage directly proportional to wind speed, which is inputed to a 2 channel recorder which records an analog trace on a paper chart. Simultaneously, a direction trace is obtained and recorded from a direction vane through a set of synchros.

From the chart paper the data is abstracted and summarized as instructed in the "Manual of Standards for Abstracting and Recording Wind Data". See Appendix IX. The summarized data is shown in Appendix III.

4.3 Rosemount Ice Detector

The Rosemount Ice Detectors were installed in conjunction with the anemometers at the above-mentioned sites. See Photo III and IV. This equipment operated on a continuing basis between December 1977 to May 15, 1978.

The Detector works on the principle of magnetostriction where ice accretion on the sensor changes the natural frequency of vibration of the probe and thereby produces an ice-warning signal. The signal, in turn, activates a built-in heater which de-ices the detector and prepares it for the detection of additional ice. The icing signals, which are recorded on a paper chart, give an indication of the duration of the icing storm and the amount of accumulation.

The data abstracted from the charts was correlated with information obtained from the PIM Program to further enhance that data. See Appendix IV.

4.0 INSTRUMENTATION (CONT'D)

4.4 Ice Accretion Test Towers

The Test Tower Sites, Photo V and VI, consisting of 30-foot guyed masts, are at a total of ten locations along the original and alternative routes of the HVDC line associated with the Gull Island Project. The towers do not have any instrumentation and are passive in nature. See Appendix V for locations.

The towers were visited on a monthly basis. Any ice accretion that was observed was measured and photographed and as well the type of ice and direction from which the ice accreted was recorded. During the monthly visits the wind speed and direction and temperature were also recorded. Ice samples were taken during one visit.

Two of the sites were modified, #2 and #4, by attaching 2-inch aluminum rods to the 20-foot and 30-foot levels of the towers. These rods were installed in N-S and E-W directions so that the effects of prevailing winds on ice accretion might be noted and to simulate the 2" conductor envisaged for the DC line.

Data from the site visits during the winter of 1977/78 as well as historical data from the winter of 1976/77 is recorded in Appendix VI.

4.5 Salt Contamination and Corrosion

No instrumentation was installed to measure salt contamination and corrosion, although a site visit was conducted to select sites to install such stations. It is anticipated these stations will be in service by the fall of 1978.

5.0 DISCUSSION OF PROGRAM

The estimation of the ice accretion hazard had long been recognized as an area of concern and since ice accretion had not been measured on a systematic basis, it became apparent that there was not an adequate data base for estimating design values.

Closely associated with ice loading on a conductor is wind loading which can occur either during or following the ice accumulation. For a long time these two loading conditions were assumed to be independent, but with the encountering of in-cloud icing storms, as in the case of the HVDC routing, it was considered necessary to evaluate the possible combined effects.

In the absence of measurements of ice accretion and the combined effects of wind and ice load on conductors, other climatological data from existing weather stations remote from line routings has been used to estimate loadings as affecting transmission lines. However, because of the associaton of ice accretion with microclimatic conditions and topography it has become evident that these estimates are chancy at best. This is substantiated by the losses incurred by Hydro in the past years due to structure failures attributed to icing storms.

The possibility of under and, in fact, over design of transmission lines has been increased dramatically with the routing of lines (i.e. the HVDC) through uninhabited regions where no climatological data has been collected, areas which are known to experience some of the worst icing storms in North America.

The primary concern in implementing the program was the selection of suitable

5.0 DISCUSSION OF PROGRAM (CONT'D)

devices to provide the required data. The lack of any one device that could record automatically both ice accretion and combined ice-wind load lead to the implementaiton of several systems.

Most widely used by Hydro is the Passive Ice Meter, PIM, which is designed to act as a medium for ice accretion. Placed throughout Newfoundland and Labrador in areas of high icing incidence, proposed line routing (i.e. HVDC) and existing lines these PIM's have established a starting point for a Province-wide icing profile.

The effectiveness of the Passive Ice Meter Program hinges on the designated observers; as these people have to observe, measure and record accurately as much information as can be obtained from the meter. Therefore, wherever possible the meters have been installed in conjunction with equipment operated by the Atmospheric Environment Services or their representatives. This collaboration gives Hydro access to information collected by the professional personnel associated with AES.

The Passive Ice Meter Program has proven to be very successful in the past year and, with time, will provide reliable data on which to base engineering design criteria.

As useful as these units may be in populated areas they can not be effectively used in remote areas as those transversed by the proposed HVDC line. Constant monitoring can not be carried out in these remote areas and as well the excessive icing experienced here would void the usefulness of these small scale collectors.

To provide data from these areas, ten test tower sites have been established along the Long Range Mountains on the Northern Peninsula and on coastal Labrador to act as ice collectors.

During the winter of 1976/77 ice accumulations at the four (4) initial sites (#1, #2, #3 and #4) was phenomenal. At Site #2 - Portland Creek Head, in December 1976, accumulations of 14" were noted on the 1/4" guy wire with 3' to 4' on the 18" mast. (Photo VII) At Site #4 - Labrador coast, in February 1977, accumulations of 13" of glaze were noted on the 1/4" guy wire with 28" to 36" of glaze on the 18" mast. (Photo VIII).

As a result of these findings two studies were instigated:- "Meteorological Evaluation of Eastern Side of the Great Northern Peninsula, Newfoundland" by Meteorology Research, Inc. in 1977 and "1977 Review of HVDC Line Routing in the Great Northern Peninsula Region" by ShawMont Newfoundland Limited in 1977 .

The first report by MRI evaluated the alternatives of rerouting the HVDC along the Eastern Side of the Long Range Mountains to avoid the excessive loading encountered at Site #2, Portland Creek and the 28 miles of line crossing the Long Range Mountains.

The second report by ShawMont recommended the expansion of the test tower sites to a total of 10 locations. Four along the Eastern Alternatives and two adjacent to, but at lower elevations than Site #2 and #4.

Before the winter of 1977/78 these six additional installations were completed and as well modifications were made to the towers at Site # 2 and # 4 by the addition of 2" by 8' aluminum rods to simulate conductors. The

5.0 DISCUSSION OF PROGRAM (CONT'D)

ten sites were visited monthly during the winter and, as outlined in another report on the "1978 Review of HVDC Line Routing in the Great Northern Peninsula Region", the MRI icing predictions for the Eastern Side of the Northern Peninsula were confirmed and discovered to be lower than these encountered at Site #2 but never-the-less still quite high. Conditions encountered at Site #4a adjacent to Site #4 were only marginally better while at Site #2a conditions were only 1/3 as severe as those at Site #2.

The 2" extension rods added to Site #2 and #4 were installed at 20 feet and 30 feet above the ground. Actual measurement of ice accumulation is therefore a problem. However, a photographic record of the accumulation is useful in that it shows how the build-up on these rods, which as the same diameter as the proposed HVDC conductor, compares with the build-up on the towers and guys. For example, during the January 1978 visit the rods at Site #2 had a build-up producing a wing shape which would possibly be the cause of a galloping condition should it occur on the conductor.

Ice samples taken from the sites were subjected to ice salinity tests and the results showed conclusively that the ice accumulations were free of salt contamination. The average salinity was only 0.012 ppt, considerably less than the 3 ppt level generated in ice formed at or near the coast. (See Appendix VIII).

Results of density tests did show that the density of the glaze samples agreed quite favourably with the commonly accepted value of glaze ice density of 0.9 gm/ml. (See Appendix VII.)

5.0 DISCUSSION OF PROGRAM (CONT'D)

Recommendations of the previously mentioned report suggests the continuance of the entire program and establishment of three (3) additional sites along the 28 mile heavy loading area associated with the original HVDC route and Site #2. It is hoped to confirm the ice accretion observed at Site #2a which indicated that with selective routing, taking advantage of natural sheltering and lowest possible elevation, the extreme icing areas may be avoided.

If the data collected during the winter of 1978/79 confirms the suspected advantage of selective routing then continuation of the program until reinstatement of the Gull Island Project will provide an adequate data base on which the section across the Long Range Mountains can be designed; thus reducing construction costs and improving the confidence level in the reliability of the line.

The two areas of the study previously mentioned, PIM's and Test Tower Sites provided valuable and irreplaceable information concerning icing. However, the measurement of the wind combined with ice is not being done at most of the stations.

There are three locations where Rosemount Ice Detectors are installed in conjunction with Anemometers and at two of these locations PIM's are also installed. These systems are far superior in technology and in capability than either of the above mentioned.

The data obtained from the Rosemount Ice Detector can be interpreted to determine the duration of an icing episode, the rate of accumulation of ice and an approximation of the amount of ice accreted.

The Detector initiates a signal at the beginning of an icing episode and

5.0 DISCUSSION OF PROGRAM (CONT'D)

continues to generate icing signals throughout the episode at a frequency dependent upon the accumulation rate of the ice. For example at Sunnyside on January 2, 1978 there were 15 signals generated in the period from 4:27 a.m. to 7:50 a.m. (Start to finish.) Each signal was generated after 0.02 inches of ice had accumulated, 15 signals represent 0.3 inches of ice in a period of 203 minutes for an accumulation rate of 0.001 in./minute or 0.09 in./hr. In arriving at the calculated accumulation of 0.3 inches it was assumed that there was no deterioration in the accumulated ice during the episode.

In the two areas where the PIM's are installed in conjunction with the Rosemounts it is hoped that a correlation can be worked out between the Rosemount record and the ice measured on the PIM.

As the PIM data is extracted by personal observation the detection of the start and finish of an icing episode is very unlikely indeed. Referring to the example above, the episode would have been complete before the observer made his morning check and recorded an accumulation of glaze, icicles and wet snow with a total accumulation of 0.22 inches.

Discrepencies in the calculated and measured quantities of ice accumulation are not readily explained. There is a difference of approximately 25 feet in elevation between the Rosemount and the PIM. As well, with the Rosemount it was assumed there was no loss in ice accumulation throughout the episode while measurements on the PIM were made of a very irregular surface, which could give rise to errors. (See Appendix IV).

5.0 DISCUSSION OF PROGRAM (CONT'D)

The anemometer further expands the data base with a permanent record of wind speed with an accuracy of ± 0.5 mi./hr. for speeds of 0 - 10 mi./hr. and ± 1.0 mi./hr. for speeds of 10 - 100 mi./hr. The accuracy of wind direction is ± 2^{0} over the complete range.

The peak gust speed on the recorder chart for the anemometer in use can be assumed to represent a 2 second gust.

The units in service at present have been checked by the Atmospheric Environmental Service of Canada for accuracy of their direction trace.

It is readily apparent that the combined Rosemount - Anemometer system is the most desirable in terms of data collection, however, there are some factors affecting the expansions of the network. The equipment and installation costs are high and the Rosemount must be installed where a 120 volt power supply is available.

At the 10 remote sites, along the Northern Peninsula and Coastal Labrador, the installation costs are also quite high and power supply is non-existant. Though there are self-powered anemometers and recorders available the over-riding factor here is the extreme icing conditions themselves. Attempts were made by MRI during 1974/75 to collect data on wind speed and direction and temperature using self-powered units but the extreme icing encountered encased the equipment with a resultant loss of valuable peak conditions. These systems were abandoned following the 1974/75 season and the towers now serve as Passive Ice Collectors only.

5.0 DISCUSSION OF PROGRAM (CONT'D)

The three existing systems have been very effective to date but not without design and operating problems. This is to be expected since the program was as much an experiment with equipment as it was a data collection endeavour.

A defect in the manufacture of the anemometers resulted in equipment damage and modification to the recorders associated with the Rosemount Ice Detector, to make the instruments compatible, failed with resultant damage to the recorders.

During the winter of 1977/78 wind damage to the power supply at Yankee Point caused electrical damage to the anomemeter recorder and very high winds at Four Mile Pond - Holyrood blew over the anomemeter mast damaging the equipment. Again this summer the anomemeter at Sunnyside was damaged by some undetermined force thought to be a wind-blown object or bird.

Though each case of damage resulted in loss of irreplaceable information, the design problems have been solved, all equipment is back in service and every effort has been made to insure the uniterrupted operation of the equipment during the coming season.

6.0 CONCLUSIONS AND RECOMMENDATIONS

Based on the review of the meteorological data collection program of 1977/78 it becomes apparent that the program is both effective and necessary.

This study has established the basis of a long term collection program of quantitative meteorological information concerning the ice and wind hazard. A program that will, with time, provide the statistically reliable data base needed to enhance transmission line design and routing.

During the past season the collection equipment has proven to be effective in providing the desired meteorological information. Widely dispersed throughout the areas of concern, the collectors have provided data relating to local microclimatic conditions which are closely associated with the icing hazard, data, which in the past has been estimated from climatological data available from widely dispersed weather stations.

It is recommended, in the light of one year's experience, that:

1. The collection program associated with the PIM's and Rosemount-Anemometer Sites be continued with selective expansion as the need arises.
2. The recommendations of the report on "1978 Review of HVDC Line Routing in the Great Northern Peninsula Region" be adopted.
   a. The installation of three (3) additional test tower sites along the 28 mile section over the ridge of the Long Range Mountains before the fall of 1978.
   b. Continue the monitoring of all test tower sites until the Project is re-instated.
   c. To arrange with Atmospheric Environmental Services (AES) to inform us

6.0 CONCLUSIONS AND RECOMMENDATIONS (CONT'D)

when a major storm is pending, so that observations can be taken directly after a storm.

d. To consult with MRI or like professional people to obtain opinions on the results of Site 2a to determine if Site 2a or Site 2 is the anomaly.

e. To approach the university, i.e. C-CORE to ascertain the type of programs being investigated.

3. A close liason be kept with industry and other agencies as to the latest development of equipment suitable for operation in the extreme icing conditions as encountered on the Ridge of the Long Range Mountains.

4. Emphasis be placed on the quality of information obtained from the studies.

5. The salt contamination aspects of the study be re-introduced to the program during the Fall of 1978.

6. To mark each tower site by a suitable method to determine the duration of the ice loading.

7. To improve the photographic record with the view to calibrating the photos, to see the difference in accumulation between visits and other pertinent details.

APPENDIX I

PASSIVE ICE METER LOCATIONS AND SAMPLE DATA SHEETS

APPENDIX I

PASSIVE ICE METER

	INSTALLATIONS	OBSERVERS
1.	Wabush Airport	Transport Canada
2.	Esker	CFLCo
3.	Churchill Falls	AES
4.	Goose Bay	AES
5.	Point Amour	Hydro
6.	St. Anthony	Hydro
7.	Yankee Point	Hydro
8.	Plum Point	AES
9.	Hawkes Bay	Hydro
10.	Daniels Harbour	AES
11.	Rocky Harbour	Parks Canada
12.	Stephenville	Transport Canada
13.	Port Aux Basques	Transport Canada
14.	Burnt Pond	Hydro
15.	Buchans	Hydro
16.	Deer Lake Airport	Transport Canada
17.	Hampden	Hydro
18.	Baie Verte	Advocate Mines Security
19.	Springdale	AES
20.	Stony Brook	Hydro
21.	Gander Airport	AES
22.	Bay D'Espoir	Hydro
23.	Sunnyside	Hydro
24.	St. Lawrence	Transport Canada
25.	Western Avalon	Hydro
26.	Holyrood	Hydro
27.	St. John's	AES
28.	"S" Turn	Hydro
29.	Port Blandford	Transport Canada
30.	Harbour Deep	Hydro

APPENDIX I

ICE METER OBSERVATIONS-MONTHLY DATA SHEET

STATION NO.	METER NO.	MONTH	YEAR
1 C24	NLH 24	01	1977

STATION: Stoney Brook

OBSERVER: W. Smith

DAY	HOUR	DEPOSIT YES	DEPOSIT NO
1	08		X
	18		X
2	08		X
	18		X
3	08		X
	18	X	
4	08	X	
	18	X	
5	08	X	
	18	X	
6	08	X	
	18		X
7	08		X
	18		X
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APPENDIX I

ICE METER OBSERVATIONS

STATION NO.	DAY	HOUR	MONTH	YEAR
C24	03	18	01	1977

STATION: Stoney Brook
OBSERVER: W. Smith

METER NO. NLH 24

TOP

Thickness: 0.6 ☐ CM ☒ IN

N / W / E / S — X (marked at the southwest corner)

TYPE OF DEPOSIT

- ☐ RIME
- ☒ GLAZE
- ☐ WET SNOW
- ☐ ICICLES
- MIXTURE (SPECIFY) — — — — — — —

METEOROLOGICAL DATA

TEMPERATURE	.	☐ °C ☐ °F
WIND SPEED		☐ MPH ☐ KT
WIND DIRECTION		
RAIN		☐ CM ☐ IN
SNOW		☐ CM ☐ IN

SIDE WITH THICKEST DEPOSIT

North ☐ South ☐ East ☐ West ☒

3/8" Rod-Total Dia.	0.8	☐ CM ☒ IN
1" Rod - Total Dia.	1.4	☐ CM ☒ IN
2" Rod - Total Dia.	.	☐ CM ☐ IN
Surface Thickness	0.8	☐ CM ☒ IN

3/8" Rod

1" Rod

2" Rod

SIDE VIEW

FRONT VIEW — X

SIDE WITH SECOND THICKEST DEPOSIT

North ☐ South ☒ East ☐ West ☐

3/8" Rod - Total Dia.	0.6	☐ CM ☒ IN
1" Rod - Total Dia.	1.1	☐ CM ☒ IN
2" Rod - Total Dia.	.	☐ CM ☐ IN
Surface Thickness	0.5	☐ CM ☒ IN

3/8" Rod

1" Rod

2" Rod

SIDE VIEW

FRONT VIEW — X

SAMPLE

REMARKS: SAMPLE

DURATION OF FREEZING PRECIPITATION

	DAY	HOUR
START	03	14
FINISH	03	22

APPENDIX II

SUMMARY OF PASSIVE ICE METER REPORTS

SUMMARY OF PASSIVE ICE METER REPORTS

(1977-1978)

LOCATION	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY
				MONTH			
Springdale	No Accum.	Trace of glaze short duration	Approx.15 days 1/2" glaze on surface	1/2" glaze on surface-5 days	Trace of rime - 1 day	No Accum.	No Accum.
St. Anthony	No Accum.	No Accum.	No Accum.	No Accum.	0.5" glaze & icicles	0.7" glaze	No Accum.
Sunnyside	No Accum.	Trace of wet snow-short dur.	Trace of glaze - 1 day	No Accum.	Wet Snow - 1 day	Trace glaze - 1 day	No Accum.
Buchans	Trace of Rime - 1 day	Trace of rime - 3 days	1/2" radial glaze - 2 days	No Accum.	No Accum.	Trace glaze - 1 day	No Accum.
Stony Brook	Trace of glaze - 1 day	Trace of glaze - 1 day	Trace of glaze & wet snow-2 days	Trace of glaze - 1 day	No Accum.	No Accum.	No Accum.
Esker	No Report	No Accum.	No Accum.	No Accum.	No Accum.	No Accum.	No Accum.
Yankee Point	No Accum.	1/2" glaze-3 days	No Accum.	No Accum.	1/4"-1/2" freezing rain & snow	No Accum.	No Accum.
Stephenville	Trace of wet snow	Trace of glaze short duration	Trace of glaze 1 day	Trace of glaze 1 day	Trace of glaze 2 days	Trace of wet snow, rime & glaze-3 days	No Accum.
Baie Verte	No Accum.	Trace of glaze	Trace of glaze	No report	No Accum.	No Accum.	No Accum.
Deer Lake	Trace of glaze 2 days	Trace of glaze 2 days	Trace of glaze 3 days	No Accum.	No Accum.	No Accum.	No Accum.
Churchill Falls	Trace of Rime short duration	No Accum.	Trace of rime short duration	No Accum.	No Accum.	No Accum.	No Accum.
Gander	Trace of glaze - 2 days	Trace of glaze - 3 days	1/2" radial glaze - 8 days	Trace 1.3cm glaze - 6 days	Trace glaze - 3 days	No Accum.	No Accum.
Pt. Amoure	No Report	No Report	Trace of glaze	Trace of glaze	No Accum.	No Accum.	No Accum.

APPENDIX II

SUMMARY OF PASSIVE ICE METER REPORTS

(1977-1978)

LOCATION	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY
			MONTH				
Goose Bay	.2cm -.5cm radice at end of month	two days-trace glaze	two days-wet snow with 1cm glaze	1cm frozen snow & glaze for 1st half of month 2cm rime, wet snow & icicles,-2 days	0.2cm. frozen wet snow	Trace icicles	No accum.
Hawke's Bay	No. Accum.	No. Accum.	No. Accum.	No Accum.	0.2cm. frozen wet Wet snow	Trace Icicles	No. Accum.
Bay D'Espoir	No Accum.	No Accum.	No Accum.	No Accum.	0.5cm Glaze	No Accum.	No Accum.
Burnt Dam	No Accum.	Trace of glaze	No Accum.	No. Accum.	No Accum.	No Accum.	No Accum.
Gros Morne Park	No Accum.	No Accum.	1 day trace of glaze	No Accum.	Trace glaze- 2 days	No Accum.	No Accum.
St. Lawrence	No Accum.	2" wet snow 2 days	6 days 1" glaze	Trace glaze -1 day	0.1 cm rime -2 days	Trace	No Accum.
Daniel's Harbour	No Accum.	No Accum.	Trace of glaze	No Accum.	Trace freezing rain-1 day	Trace freezing rain-1 day	No Accum.
Port-aux-Basques	No Accum.	Trace of wet snow & ice	Wet snow & rime short duration	No Accum.	No Accum.	No. Accum.	No Accum.
S Turn	No Accum.	No Accum.	No Accum.	No Accum.	No Accum.	No Accum.	No Accum.
Port Blandford	Wet Snow	8 days wet & frozen snow	Trace of frozen snow-1 day	No Accum.	No Accum.	No Accum.	No Accum.
Hampden	No Accum.	Trace of glaze - 4 days	Trace of glaze - 1 day	Trace of glaze - 3 days	3/8"-5/8" glaze-6 days	No Accum.	No Accum.
Plum Point	No Accum.	Wet snow & glaze-2 days	Trace of glaze -3 days	No Accum.	Trace glaze -2 days	No Accum.	No Accum.
Western Avalon	No Accum.	Trace of rime - 1 day	No Accum.	No Accum.	No Accum.	No Accum.	No Accum.

APPENDIX II

SUMMARY OF PASSIVE ICE METER REPORTS

(1977-1978)

LOCATION	MONTH						
	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY
Wabush	Trace of rime	Trace of glaze - 2 days	No Accum.	No Accum.	No Accum.	Trace glaze - 2 days	No Accum.
Holyrood	No Accum.	No Accum.	No Accum.	No Accum.	No Accum.	No Accum.	No Accum.
St. John's	No Accum.	0.7cm. glaze - 1 day	Trace glaze-2 days 1-2 cm glaze-1 day	Trace glaze - 1 day	Trace glaze - 1 day	1/2-1 cm glaze - 3 days	No Accum.
Harbour Deep	No Accum.	No Accum.	No Accum.	No Accum.	No Accum.	No Accum.	No Accum.

APPENDIX III

SUMMARY OF ANEMOMETER DATA

ABSTRACT OF THE WIND

SUMMARY

SUNNYSIDE

	Dec/77	Jan/78	Feb/78	Mar/78	Apr/78	May/78
Total Mileage for Month	8824	8924	8259	9898	7073	7327
Greatest Mileage in 24 Hrs.	586	585	546	659	487	509
Greatest Mileage and Prevailing Direction for 1 Hr.	SE-38 S-38	S-35	NW-31	S-38	N-26	SE-34
Date of Greatest Mileage for 1 Hr.	10th 27th	16th	16th	20th	3rd	22nd
Average Speed for Month (m.p.h.)	9.5	12.0	13.1	13.5	9.8	9.9
Longest Continued - Direction	North	Southwest	Northwest	SW/NW	Southwest	Southwest
- Hours	60	48	67	39/39	45	33
Prevailing Direction - by Mileage	South	Southwest	Southwest	Southwest	Southwest	South
- by Tot Hrs.	Northwest	Southwest	Southwest	Southwest	Southwest	Southwest
Peak Gust (m.p.h.)	S-65	S-60	N-57	NW-64	N-43	SE-56

ABSTRACT OF THE WIND

SUMMARY

YANKEE POINT

	Jan./78	Feb./78	March/78	April/78	May/78
Total Mileage for Month	OUT OF SERVICE	6223	9024	OUT OF SERVICE	5164
Greatest Mileage in 24 Hrs.		598	527		553
Greatest Mileage and Prevailing Direction for 1 Hr.		SW-30	NW-39		W-33
Date of Greatest Mileage for 1 Hr.		21st.	5th.		22nd.
Average Speed for Month (m.p.h.)		12.1	12.5		10.4
Longest Continued - Direction		NE	NE		NE
- Hours		50	64		53
Prevailing Direction - by Mileage		SW	NE		SW
- by Tot Hrs.		SW	NE		SW
Peak Gust (m.p.h.)		SW-47	NW-57		W-51

APPENDIX III

ABSTRACT OF THE WIND

SUMMARY

4-MILE POND - HOLYROOD

	Dec/77	Jan/78	Feb/78	Mar/78	Apr/78	May/78
Total Mileage for Month						
Greatest Mileage in 24 hrs.						
Greatest Mileage and Prevailing Direction for 1 hr.						
Date of Greatest Mileage for 1 hr.						
Average Speed for Month (m.p.h.)						
Longest Continued - Direction						
- Hours						
Prevailing Direction - by Mileage.						
- by Tot Hrs.						
Peak Gust (m.p.h.)	W-83					

The anemometer at this site was activated on November 23,1977 and on December 9, 1977 was severely damaged by a major wind storm which blew the anemometer from its support mast. While this system was out of operation, pending repairs to the anemometer, the system at Yaknee Point was put out of operation when the anemometer recorder there received extensive electrical damage. In light of the interest in the Yankee Point location it was decided to remove the recorder from 4 - Mile Pond and reactivate the Yankee Point site. This was done and the 4 - Mile Pond site was not placed back in service until August 3, 1978.

Peak gust prior to damage is as recorded below.

APPENDIX III

APPENDIX IV

ROSEMOUNT ICE DETECTOR DATA SUMMARIES

APPENDIX IV

ROSEMOUNT ICE DETECTOR

HOLYROOD

DATE	TIME	NO. OF ICING SIGNALS	CALCULATED ACCUMULATION (INCHES)
Feb. 27/78	4:35 a.m.-7:23 a.m.	4	.08
Feb. 28-Mar.1/78	10:50 a.m.-2:00 a.m.	59	1.18
Mar. 2/78	3:28 a.m.-8:22 a.m.	9	.18
Mar. 2-3/78	6:05 p.m.-1:44 p.m.	76	1.52
Mar. 5/78	1:15 a.m.-5:17 a.m.	24	0.48
Mar. 12/78	10:00 p.m.-11:56 p.m.	3	.06
Mar. 30/78	12:43 a.m.-6:43 a.m.	7	.14
Mar. 30-31/78	11:40 p.m.-1:31 a.m.	3	.06
April 1/78	12:16 a.m.-5:48 a.m.	6	.12
April 2/78	3:40 a.m.	1	.02
April 2/78	2:30 p.m.-5:01 p.m.	21	.42
April 2-3/78	11:27 p.m.-8:47 a.m.	29	.58
April 5/78	7:08 p.m.	1	.02
April 6/78	2:59 p.m.-5:07 p.m.	15	.30
April 8/78	3:46 a.m.-9:53 a.m.	4	.08
April 9/78	5:20 a.m.-1:55 p.m.	35	.70
April 10-11/78	11:56 p.m.-8:14 a.m.	27	.54
April 11/78	11:37 a.m.- Noon.	2	.04
April 12/78	7:43 p.m.-11:43 p.m.	5	.10
April 13/78	1:45 p.m.	1	.02
April 14/78	4:30 a.m.-7:56 a.m.	16	.32
April 14-15/78	7:27 p.m.-1:40 a.m.	46	.92
April 15/78	12:43 p.m.-5:53 p.m.	12	.24
April 15-16/78	10:36 p.m.-8:30 a.m.	7	.14

ROSEMOUNT ICE DETECTOR

HOLYROOD

DATE	TIME	NO. OF ICING SIGNALS	CALCULATED ACCUMULATION (INCHES)
May 6/78	9:58 a.m.-2:30 p.m.	6	.12
May 7/78	5:12 a.m.-10:00 a.m.	13	.26

APPENDIX IV

ROSEMOUNT ICE DETECTOR

SUNNYSIDE

DATE	TIME	NO. OF ICING SIGNALS	CALCULATED ACCUMULATION (INCHES)	ACCUMULATION FROM PIM
Dec. 28/77	4:06 p.m.-4:50 p.m.	3	.06	Nil
Dec. 28/77	10:43 p.m.-11:40 p.m.	2	.04	Nil
Dec. 29/77	12:13 a.m.-12:43 a.m.	2	.04	Nil
Dec. 31/77	10:37 p.m.	1	.02	Nil
Jan. 2/78	4:27 a.m.-7:50 a.m.	15	.3	Glaze, wet snow and icicles 7/32"
Jan. 3/78	2:14 p.m.	1	.02	Nil
Jan. 9/78	11:23 a.m.-11:43 a.m.	2	.04	Nil
Jan. 11/78	1:43 a.m.	1	.02	Nil
Jan. 14/78	2:10 p.m.-7:17 p.m.	4	.08	Glaze 1/32"
Jan. 19/78	1:07 a.m.-2:10 a.m.	6	.03	Nil
Jan. 26/78	7:55 a.m.	1	.02	Wet snow 1/4"
Mar. 2/78	11:32 a.m.	1	.02	Nil
Mar. 3/78	4:25 a.m.-6:16 a.m.	4	.08	Wet snow, trace
Mar. 5/78	5:25 a.m.-6:05 a.m.	2	.04	Nil
Mar. 13/78	6:29 a.m.-7:14 a.m.	3	.06	Nil
Mar. 15/78	9:37 a.m.	1	.02	Nil
Mar. 20/78	3:40 a.m.-12:29 p.m.	2	.02	Nil
Mar. 25/78	1:07 a.m.	1	.02	Nil
Mar. 28/78	1:07 a.m.-1:33 a.m.	2	.04	Nil
April 2/78	12:20 p.m.-5:10 p.m.	8	.16	Glaze, Trace
April 6/78	8:05 a.m.-8:30 a.m.	3	.06	Nil
April 8/78	11:27 p.m.	1	.02	Nil
April 9/78	7:22 a.m.	1	.02	Nil

APPENDIX IV

ROSEMOUNT ICE DETECTOR

SUNNYSIDE

DATE	TIME	NO. OF ICING SIGNALS	CALCULATED ACCUMULATION (INCHES)	ACCUMULATION FROM PIM
April 14/78	6:17 a.m.-7:00 p.m.	4	.08	Nil
April 25/78	2:23 a.m.-6:25 a.m.	2	.04	Nil
April 25/78	7:40 a.m.	1	.02	Nil

APPENDIX IV

ROSEMOUNT ICE DETECTOR

YANKEE POINT

DATE	TIME	NO. OF ICING SIGINALS	CALCULATED ACCUMULATION (INCHES)	ACCUMULATION FROM PIM

Note: The recorder used with the Rosemount Ice Detector became defective in early December 1977 consequently putting the system out of operation for the remainder of the icing season.

Prior to that date no icing signals were recorded.

APPENDIX V

TEST TOWER TABLE OF LOCATION

TEST TOWER

TABLE OF LOCATION

SITE	NAME	TOPO MAP	ELEV. (FT)	GRID REF.
1	Sheffield Lake	12 H/7	1350	322678
2	Portland Creek Head	12 I/4	2070+	617477
2a	Portland Creek - Inner Pd.	12 I/3	1850+	724439
3	Hills of St. John	12 I/15	1500+	128288
4	Lance au Loup	12 P/15	1700+	104406
4a	Lance au Loup	12 P/15	1550+	023375
5	Little Harbour Deep	12 I/2	1550+	165648
6	Blue Mountain	12 I/7	1550+	058823
7	Torrent River - Hawkes Bay	12 I/10	1330+	081079
8	Hooping Harbour	12 I/9	1250+	405115

APPENDIX VI

TEST TOWER - TABLE OF DATA

TABLE OF DATA

SITE #1 SHEFFIELD LAKE

DATE	WIND SPEED KNOTS	WIND DIRECTION	TEMP. °C.	ACCUMULATION NOTED	DIRECTION OF ACCUMULATION
11-76				Glaze formed on tower and guys. At ground level pennant shaped glaze 1/8" thick on west side of guy and 1/4" thick on east side. This doubled towards top of guy. Frozen snow formed over glaze.	East West
01-77				Very light frost clinging to tower and guys. - No ice.	–
02-77				At ground level the east side of the tower and guys was covered with 1/4" thickness of mixed glaze and rime. This increases to 1/2" near tower top.	East
03-77				Light rime formed on north face of tower and guys. 1/4" thick at eye level and 1-1/2" thick at tower top.	North
04-77	8	West		Bare	–

APPENDIX VI

TABLE OF DATA

SITE #1 SHEFFIELD LAKE

DATE	WIND SPEED KNOTS	WIND DIRECTION	TEMP. °C.	ACCUMULATION NOTED	DIRECTION OF ACCUMULATION
05-77	0		18	Bare	—
12-77	6-14	North	-12	Thin coat of glaze all over tower and guy wires. Northwest face of tower and guys covered by light rime; 3" thick at top of tower tapering to nothing on lower 6' of tower.	Northwest
01-78	28-40	West	- 2	Bare	—
02-78	4	West	- 9	Northwest face of tower and guys covered with glaze; pennant shaped; 1-3/4" thick at 5' level of tower and 1-1/4" thick on guy.	Northwest
03-78	4- 8	South	- 3	Bare	—
04-78	8	East	0	Bare	—

APPENDIX VI

TABLE OF DATA

SITE #2 PORTLAND CREEK

DATE	WIND SPEED KNOTS	WIND DIRECTION	TEMP. °C.	ACCUMULATION NOTED	DIRECTION OF ACCUMULATION
12-76				Massive accumulation of mixed glaze and rime on tower and guys. 18" tower completely encased and measured 3' wide at 5' above ground and increased to 4' at 10' above ground. 1/4" guy wire surrounded by 14" of same mixture.	Southwest
01-77				Tower and guys covered with build-up of 1/2" ice and covered by 3" - 4" of snow.	–
02-77				Tower and guys completely covered with light rime. 1/2" thick at the tower bottom and increasing to 4" thick at top.	–
03-77	13-22		- 2	Evidence of rime (1/4" - 1/2") was noted on tower. Top of tower completely encased in 12" - 14" of wet snow.	East

TABLE OF DATA

SITE #2 PORTLAND CREEK (CONT'D)

DATE	WIND SPEED KNOTS	WIND DIRECTION	TEMP. °C.	ACCUMULATION NOTED	DIRECTION OF ACCUMULATION
04-77	10-15			Patches of light rime were observed on both tower and guys. Thickness varied from 1/4" to 1/2".	–
05-77	0		16	Bare	–
11-77	10-12	Northwest	- 9	The west side of tower and guys were covered with hard rime varying in thickness from 1" at the bottom to 2" at the top. This was overlaid with light rime varying in thickness from 1/2" to 1".	West
01-78	9	West	-14	Tower and guys completely covered with a mixture of hard and soft rime formed as pennant to the west. At 5' level of tower 1" of hard rime covered by 5" soft rime. At tower top 2" of hard rime covered by 10" - 12" of soft rime.	West
02-78	10	West	- 7	Tower completely encased at top by mixture of glaze and soft rime. At 12' level of tower 1-1/2" glaze covered by 12" of soft rime was measured.	West

TABLE OF DATA

SITE #2 PORTLAND CREEK (CONT'D)

DATE	WIND SPEED KNOTS	WIND DIRECTION	TEMP. °C.	ACCUMULATION NOTED	DIRECTION OF ACCUMULATION
03-78	16-23	West-South west	-20	Pennant formation of soft rime on southwest face of tower and guys. Rime 2-1/2" deep at 5' level of tower and 10" deep at tower top.	Southwest
04-78	2	Southeast	+ 1	Tower almost encased at top by 5" - 6" glaze overlaid with thin layer of rime.	North

APPENDIX VI

TABLE OF DATA

SITE #2a PORTLAND CREEK - INNER POND

DATE	WIND SPEED KNOTS	WIND DIRECTION	TEMP. °C.	ACCUMULATION NOTED	DIRECTION OF ACCUMULATION
11-77	12	West	-12	Installation	—
01-78	6	West	-14	Patches of rime 1/4" thick on west face of tower.	West
02-78	12	West	- 7	Pennant formation of glaze spotted by soft rime on tower and guys. Glaze 2-1/2" - 3" deep at the 5' level of tower. Glaze 3" - 3-1/2" deep on guy.	Northeast
03-78	38-44	West	-19	Bare	—
04-78	2-3	Southeast	+ 1	Bare	—

APPENDIX VI

TABLE OF DATA

SITE #3 HILLS OF ST. JOHN

DATE	WIND SPEED KNOTS	WIND DIRECTION	TEMP. °C.	ACCUMULATION NOTED	DIRECTION OF ACCUMULATION
11-76				Accumulation of pennant shaped glaze and rime was observed with a total depth of 1" at the tower top.	–
01-77				Bare	–
02-77				Towers and guys had a slight accumulation of soft rime measuring 1/4" to 1/2" on the east face.	East
03-77				Slight deposits of soft rime on the towers.	
04-77				Bare	–
05-77				Bare	–
12-77	18-20	West	- 6	Bare	–

APPENDIX VI

TABLE OF DATA

SITE #3 HILLS OF ST. JOHN (CONT'D)

DATE	WIND SPEED KNOTS	WIND DIRECTION	TEMP. °C.	ACCUMULATION NOTED	DIRECTION OF ACCUMULATION
01-78	12	West	-15	Random pennants of 1/4" of glaze over west tower face and 1/4" pennant of glaze on guy wire.	West
02-78	30	West	- 7	Pennant shaped glaze covered the northwest face of the tower and guy. At 5' level of tower glaze measured 1 1/2" - 2" deep similarly on the guy it measured 1" to 2".	Northwest
				A second accumulation of 1/8" of glaze was observed on the west face of the tower.	West
03-78	26-30	West	-18	Bare	–
04-78	5-8	West	+1	Large accumulation of 4" - 6" of glaze clinging to top of tower.	North to Northwest

TABLE OF DATA

SITE #4 LANCE AU LOUP

DATE	WIND SPEED KNOTS	WIND DIRECTION	TEMP. °C.	ACCUMULATION NOTED	DIRECTION OF ACCUMULATION
11-76				Tower and guys were covered with a mixture of glaze covered by soft rime. Measurements on the tower were 6" deep by 2" wide pennant shaped to the east. Guys received similar accumulations.	East
01-77				Tower and guys were completely encased in glaze covered by a little rime. At 20' level guy was covered with 8" to 9" of solid ice. Tower body was covered by 3" to 4-1/2" of ice.	-
02-77				Tower and guys were completely encased in glaze covered by a little rime. Guys were covered by 8"-10" of solid ice. Lower portion of 18" tower was covered by ice measuring 28" across the face. The top measurements were estimated at 36" across the face.	East
03-77	17-26	West		Tower and guys completely encased by glaze covered by light rime coat. Accumulation on guys measured 9" to 13" in diameter. 18" tower face measured 21" to 24" across at bottom.	Southwest to Northeast

APPENDIX VI

TABLE OF DATA

SITE #4 LANCE AU LOUP (CONT'D)

DATE	WIND SPEED KNOTS	WIND DIRECTION	TEMP. °C.	ACCUMULATION NOTED	DIRECTION OF ACCUMULATION
04-77	41-52	Southwest		Old accumulation existed on tower body over laid by 2" to 3" of new glaze giving a total width of 37" across the east face of tower. 2" - 3" of glaze was measured on the lower portion of the guys.	East
05-77	10-13		7	Bare	–
12-77	28-32	North-North West	- 8	West side of tower and guys covered by a pennant of 3" of glaze overlaid by 1-1/2" to 2' of soft rime.	West
01-78	21	West	-20	1/8" of glaze in a pennant form clung to the side of both the tower and guys.	West
02-78	38	West	-13	The tower showed remnants of 2" - 3" of glaze overlaid by 5"-7" of soft rime with a 4" pennant of soft rime on the guys.	West-Southwest
				A second accumulation of soft rime measured 2" pennant on the tower and 1-3/4" on the guy.	West

APPENDIX VI

TABLE OF DATA

SITE #4 LANCE AU LOUP (CONT'D)

DATE	WIND SPEED KNOTS	WIND DIRECTION	TEMP. °C.	ACCUMULATION NOTED	DIRECTION OF ACCUMULATION
03-78	19-22	Northwest	-18	Pennants of glaze showing on both tower and guys. 1-3/4" glaze at 5' level of tower with 1-1/2" to 2" at tower top. 1/2" to 3/4" on guy.	Southeast
04-78	4-6	North-Northwest	+ 1	Upper section of tower was covered by 6" to 8" of hard rime. Melting had taken place so guys were bare.	North

APPENDIX VI

TABLE OF DATA

SITE #4a LANCE AU LOUP

DATE	WIND SPEED KNOTS	WIND DIRECTION	TEMP. °C.	ACCUMULATION NOTED	DIRECTION OF ACCUMULATION
12-77	8-10	North	-11	Installation	-
01-78	13	West	-20	Random spotting of glaze on tower surface and on guy.	West
02-78	30	West-Southwest	-12	Tower face and guy had been covered by hard rime. 4-3/4" pennant on tower face and 2" on guy.	East-Northeast
				A second accumulation of random spotted soft rime was also observed.	West-Southwest
03-78	20	West	-17	A 3/4" pennant of glaze was measured at the 8' level of the tower leg. A 3/4" pennant was measured on the guy.	Southeast
04-78	6-8	North Northwest	+ 1	Accumulations of 6" of rime clinging to very base of tower. Most of accumulation had melted.	North-Northwest

APPENDIX VI

TABLE OF DATA

SITE #5 LITTLE HARBOUR DEEP

DATE	WIND SPEED KNOTS	WIND DIRECTION	TEMP. °C.	ACCUMULATION NOTED	DIRECTION OF ACCUMULATION
12-77	15-23	North-Northwest	-14	Installation	-
01-78	-	-	-	Unable to reach site due to storm conditions.	-
02-78	13	Southwest	-10	Heavy accumulation of glaze formed on tower and guys. Pennant shaped glaze at 4' level of tower leg measured 3" - 4" thick and 6" across face. 4" - 4-1/2" pennant shaped glaze on guy.	Northeast
03-78	12-13	Southeast	- 9	Glaze formed on east face of tower and on guys. Pennant shaped glaze on guy measured 3/4" thick. Glaze on tower face measured 1" thick.	East
04-78	8	West	+ 1	Bare	-

APPENDIX VI

TABLE OF DATA

SITE #6 EAST OF BLUE MOUNTAIN

DATE	WIND SPEED KNOTS	WIND DIRECTION	TEMP. °C.	ACCUMULATION NOTED	DIRECTION OF ACCUMULATION
12-77	13	West-Northwest	-13	Installation	-
01-78	8	West	-14	Bare	-
02-78	20-22	West	- 7	Both tower and guys received heavy accumulations of glaze from 2 separate storms. A northeast wind deposited glaze on the tower face 1-3/4" thick and 4-1/2" across. A northwest wind deposited glaze on the tower face 1-3/4" thick and 2-3/4" across. The overall accumulation on the guys measured 3" - 3-1/2" diameter.	Northeast Northwest
03-78	38-44	West	-18	Bare	-
04-78	Calm	-	+ 1	Bare	-

APPENDIX VI

TABLE OF DATA

SITE #7 TORRENT RIVER - HAWKES BAY

DATE	WIND SPEED KNOTS	WIND DIRECTION	TEMP. °C.	ACCUMULATION NOTED	DIRECTION OF ACCUMULATION
12-77	4	South	- 6	Installation	-
01-78	6	West	-14	West face of tower and guys received a coat of glaze overlaid with a pennant of soft rime. Pennant on tower leg and guy was 3/4" deep.	West
02-78	32-40	West	- 7	Two accumulations of glaze were noted. one from the northeast and one from the northwest. Northeast storm left 1/4" opaque glaze at 5' level of tower leg. Northwest storm left 1/4" glaze at 5" level of leg. Guys had accumulations of ice 1/4" thick.	Northeast Northwest
03-78	28-32	West	-17	Tower and guys received an accumulation of glaze. Pennant at 5' level of tower leg measured 1" thick; pennant on guy measured 3/4" thick.	East-Northeast
04-78	8	West	+ 1	Bare	-

APPENDIX VI

TABLE OF DATA

SITE #8 HOOPING HARBOUR

DATE	WIND SPEED KNOTS	WIND DIRECTION	TEMP. °C.	ACCUMULATION NOTED	DIRECTION OF ACCUMULATION
12-77	6-7	South	- 5	Installation	-
01-78	6	West	-14	Bare	-
02-78	32-40	West-Southwest	- 8	Tower had received heavy accumulation of glaze. Pennant on tower face measured 1-3/4" thick, on inside of tower leg 2" of glaze had accumulated. Guys were bare but ice on ground indicated a heavy build up.	East
03-78	16	Southeast	-11	Tower and guys showed an accumulation of glaze. Ice on tower leg at 5' level was 3/4" thick. Ice on guys measured 1/4" in a pennant shape.	East
04-78	2	Southwest	+ 1	Bare	-

APPENDIX VI

APPENDIX VII

ICE DENSITY TEST RESULTS

ICE DENSITY TEST RESULTS

SITE NUMBER	DENSITY, gm/ml	RANKING (Heaviest to Lightest)
1	0.848 ± .001	7
2	0.861 ± .001	5
2A	0.875 ± .001	1
3	0.872 ± .003	2
4	0.844 ± .001	9
4A	0.864 ± .002	4
5	0.845 ± .001	8
6	0.842 ± .001	10
7	0.853 ± .001	6
8	0.871 ± .002	3

NOTE:

Samples taken during vist of February, 1978.

APPENDIX VIII

SALINITY TEST RESULTS

APPENDIX VIII

SALINITY TEST RESULTS

SITE NUMBER	SALINITY (ppt)	SALINITY RATIO (dB) (Reference: 3 ppt)
1	.0098	-49.7
2	.0025	-61.6
2A	.020	-43.5
3	.015	-46.0
4	.018	-44.4
4A	.011	-48.7
5	.011	-48.7
6	.010	-49.5
7	.011	-48.7
8	.016	-45.5

NOTE:

Samples taken during visit of February, 1978.

APPENDIX IX

MANUAL OF STANDARDS FOR ABSTRACTING AND RECORDING WIND DATA

ABSTRACT OF WIND

1. The wind measuring equipment presently used by Newfoundland and Labrador Hydro, Projects Division, are the Aerovane Transmitter Model 120 and the Aerovane Wind Recorder Model 141, both by Bendix. These instruments are described in detail in Instruction Manuals 509754-J and 509843-L respectively. The following instructions deal with the abstracting of wind data from the Recorder Chart Trace and the procedures for completing Form 20-2215 - "Abstract of the Wind".

2. RECORDER CHART #518414.

The body of the chart is divided horizontally into two (2) sections; one for the wind direction record and the other for the wind speed record.

2.1. The wind direction section is spaced horizontally to allow for the recording of the directions to four (4) points of the compass with heavy lines for the four (4) points, intermediate light lines of 30° intervals and light lines at 10° intervals. It is divided vertically by heavy lines for each half hour and light lines for each ten (10) minutes. The directions of the four (4) quadrants (N,S,E,W) are printed in order to facilitate the selection of the prevailing direction. Hourly divisions are marked including a.m. and p.m. designation.

2.2. The wind speed section is divided horizontally by light lines for the recording of two (2) miles of wind, intermediate light lines for ten (10) miles of wind and heavy lines with numerical indication for twenty (20) miles of wind.

2.3. CHART CHANGING

2.3.1. The recorder chart advances at the rate of 3" per hour and accordingly should last two (2) weeks. Chart changing shall be at the convenience of the Operating Personnel, however, continuity of records is of the uttermost importance. If the change is made at any time other than that indicated on the new chart, the chart shall be corrected accordingly:

Example: ~~8 a.m.~~ 10 a.m. ~~9 a.m.~~ 11 a.m.

2.4. ENTRIES ON RECORDER CHART

2.4.1. Before putting the new chart on the drum of the recorder, enter the station name, time, year, month and day at the beginning of the chart. All entries shall be printed or written clearly.

2.4.1.1. After the chart has been removed from the drum, enter the station name, time, year, month and day at the end of the chart. All entries shall be printed or written clearly.

2.5. HOW TO ABSTRACT WIND DATA

2.5.1. The following are general guidance instructions for interpreting the direction and speed traces on the wind recorder chart #518414.

2.5.2. MEAN WIND DIRECTION. The mean wind direction for any period (one (1) minute, ten (10) minutes, one (1) hour, etc.,) shall be estimated by visual inspection of the direction trace of the recorder chart, to determine the direction occuring most frequently during the period. When two (2) or more mean wind directions appear to be equally valid for the period, the last shall be reported.

2.5.3. MEAN WIND SPEED. The mean wind speed for any period (one (1) minute, ten (10) minutes, one (1) hour, etc.,) shall be determined from the speed trace of the recorder chart. A transparent straight-edge may be used as an aid in determining the mean speed. The straight-edge should be placed on the speed trace for the period, parallel to the horizontal edge of the chart, and in such a position that the edge of the ruler divides the speed trace into equal areas, above and below the edge. The edge of the ruler, so positioned, now indicates the mean wind speed.

2.6. DISPOSAL OF RECORDER CHARTS

At the end of each month, the complete set of recorder charts shall be forwarded promptly through appropriate channels to Newfoundland and Labrador Hydro, Projects Division.

2.6.1. Stations shall ensure that the set of charts is complete for the month, returned in the appropriate container and identified on the container as to station.

2.6.2. Stations completing "Abstract of the Wind" Form shall forward that form along with the charts for the month.

3. ABSTRACT OF THE WIND - FORM 20-2215.

3.1. This form is used in preparing a monthly report of hourly wind data as abstracted from the recorder chart.

3.1. Stations required to complete this form will be advised by the Projects Division.

3.2. ENTRIES ON FORM 20-2215

3.2.1. In the spaces provided at the top of the form, enter the station name, province, month, year and standard time zone.

3.2.2. In the main body of Form 20-2215, opposite the appropriate dates in the hour-ending columns, record the mean hourly wind directions and mean speed values as abstracted from the recorder chart. For example, an entry of NW 30 on the chart, for the hour ending 9 a.m. (space between 8 a.m. and 9 a.m.) would be entered on Form 20-2215, in column for hour ending 9.

3.2.3. Footings to the Main Body of the Form

3.2.3.1. Sums. In the row designated 'Sums', enter the monthly totals of miles for each hour of the day.

3.2.3.2. Means. In the row designated 'Means', enter the average wind speeds to the nearest mile per hour for each hour of the day. The 'Mean' is determined by dividing the 'Sum' in the row above, by the number of days in the month. If the record is incomplete, the divisor shall be the total number of days on which a wind record was obtained at that hour.

3.2.3.3. Directions. In the nine (9) rows designated by compass directions and 'Calm', enter the number of occurrences of each direction in the hour concerned. For example, for the first space, count the number of occurrences of 'N' (North) and enter the number in the row designated 'N', etc.

3.2.3.4. Sums. Enter the sum of the direction entries and calm for each of the hours. The sum of occurrences of North, etc., for each hour should be the same as the number of days in the month, provided the record was complete for the appropriate hour.

3.2.3.5. At the extreme right-hand end of the rows the total for each row shall be entered. These totals show the number of hours during the month when the wind blew from each of the directions concerned.

3.2.4. Side Columns

3.2.4.1. Total Mileage. In the mileage column enter the total number of miles of wind run each day. This will be the sum of 24-hourly values. At the bottom of this column enter the sum and the mean of the daily mileages.

3.2.4.2. Mean Hourly Speed. Divide the total mileage for each day by twenty-four (24) and determine the mean hourly speed to the nearest tenth of a mile per hour. Enter these values in the appropriate spaces in the mean hourly speed column. At the bottom of the column enter the mean hourly speed for the month. (Divide total mileage for the month by total hours).

3.2.4.3. Maximum hourly velocity. Determine the greatest number of miles recorded for any hour of the day and enter the prevailing direction and speed for that hour.

3.2.4.4. Miles from each direction. Determine the total mileage for each day from each of the eight (8) compass points and enter these values in the appropRite spaces.

3.2.4.5. Sums and Means. Determine the total mileage, from each of the eight (8) compass points and enter these values in the spaces reserved for sums. Determine the means by dividing the total mileages by the number of hours during which the wind blew from the corresponding direction. Enter these values in the spaces reserved for Means.

3.2.5. Checks

As a check on the accuracy of the additions, the following values should be identical:

(a) The total mileage for the month as obtained from the 24-hour totals.

(b) The sum of the total mileages for each day.

(c) The sum total of the mileages from the eight (8) points of the compass.

3.2.6. General Summary

A general summary for the month is required in the lower right-hand corner of the form.

3.2.6.1. Maximum Speeds. Spaces are provided for entering the number of days when maximum hourly winds occured within specified limits. This data shall be determined from entries in the maximum hourly velocity column.

3.2.6.2. Total Mileage for Month. Enter the total mileage for the month as obtained from the total mileage column.

3.2.6.3. Greatest Mileage in 24 hours. Determine the greatest daily mileage from the total mileage column and enter it in the space provided.

3.2.6.4. Greatest Mileage and Prevailing Direction for one (1) Hour. Determine this value from the maximum hourly velocity column and enter it in the space provided.

3.2.6.5. Date of Greatest Mileage for one (1) Hour. Determine the date of the greatest mileage for one (1) hour and enter it in the space provided.

3.2.6.6 Average Speed for Month. Obtain the average speed for the month from the mean hourly speed column and enter it in the space provided.

3.2.6.7. Longest Continued Direction. This is determined from examination of the hourly data. Enter the direction from which the wind blew continuously for the greatest number of hours. Enter also the number of continuous hours.

3.2.6.8. Prevailing Direction.

(a) By Mileage. From the "miles from each direction" column select the direction from which the greatest number of miles occured and enter it in the space provided.

(b) By Total Hours. From the rows designated by "Compass Directions" check the totals for each row and select the direction from which the wind blew for the greatest number of hours. Enter this direction in the space provided.

Our Postal Address:

Newfoundland & Labrador Hydro,
P.O. Box 9100,
Donovans Industrial Park,
St. John's, Newfoundland,
A1A 2X8.

ATTN: Mr. Wayne Squires

HYDRO

ABSTRACT OF THE WIND

STANDARD OF TIME USED: ______

STATION ______
PROVINCE ______
MONTH ______ 19 ___

Prevailing wind direction with total number of miles for each hour

HOUR ENDING

DATE	1 Dir. Mi	2 Dir. Mi	3 Dir. Mi	4 Dir. Mi	5 Dir. Mi	6 Dir. Mi	7 Dir. Mi	8 Dir. Mi	9 Dir. Mi	10 Dir. Mi	11 Dir. Mi	12 Dir. Mi	13 Dir. Mi	14 Dir. Mi	15 Dir. Mi	16 Dir. Mi	17 Dir. Mi	18 Dir. Mi	19 Dir. Mi	20 Dir. Mi	21 Dir. Mi	22 Dir. Mi	23 Dir. Mi	24 Dir. Mi	Total Mileage
1																									
2																									
3																									
4																									
5																									
6																									
7																									
8																									
9																									
10																									
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26																									
27																									
28																									
29																									
30																									
31																									
SUMS																									
MEANS																									
N																									
NE																									
E																									
SE																									
S																									
SW																									
W																									
NW																									
C																									

DATE	Mean Hourly Speed	Maximum Hourly Velocity	N	NE	E	SE	S	SW	W	NW
			Number of miles from each direction							
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
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16										
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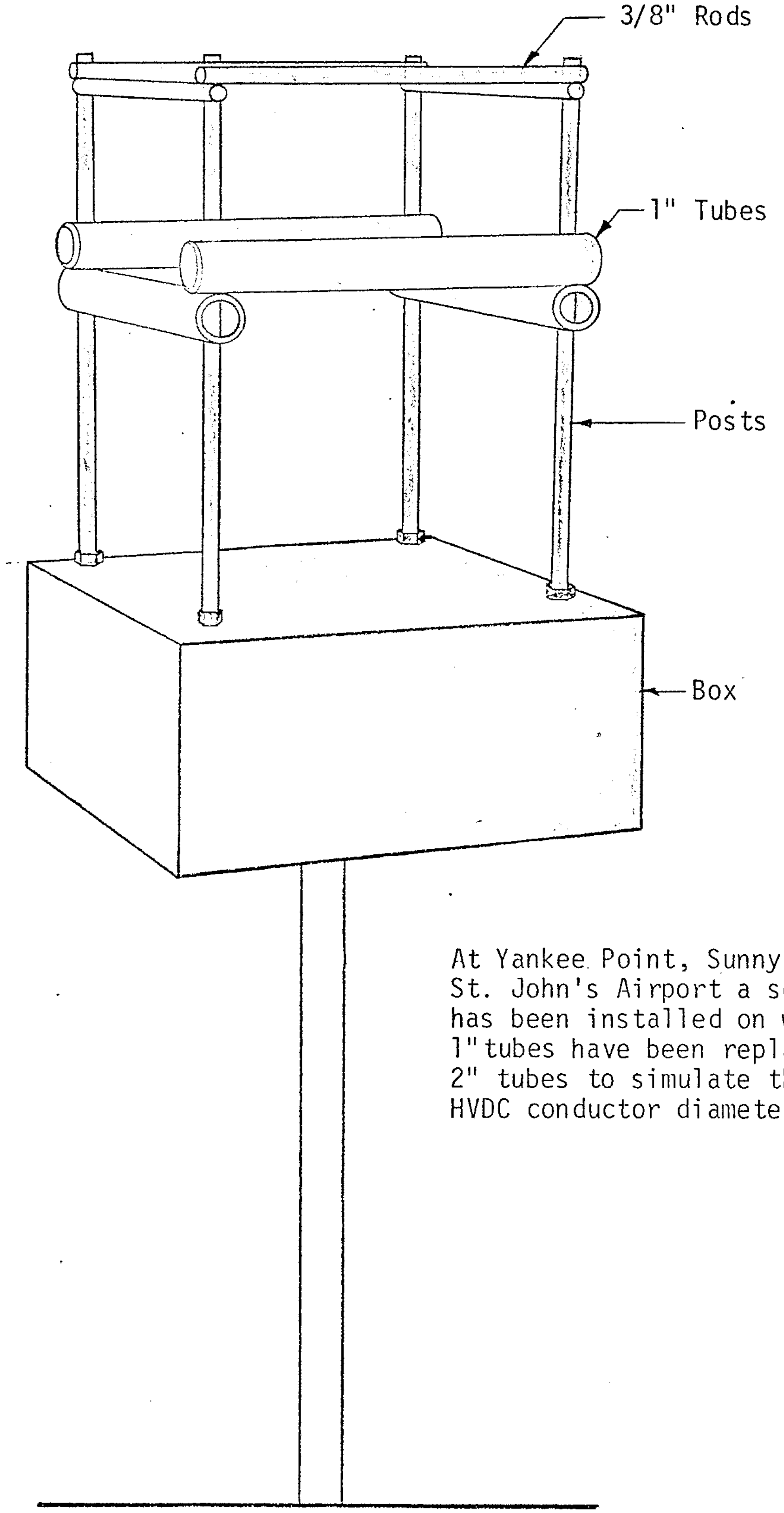
24										
25										
26										
27										
28										
29										
30										
31										
SUMS										
MEANS										

Number of days when maximum hourly velocity fell within limits

0 - 18	19 - 24	25 - 31	32 - 38	39 and over

TOTAL MILEAGE FOR MONTH ______
GREATEST MILEAGE IN 24 HOURS ______
GREATEST MILEAGE AND PREVAILING DIRECTION FOR 1 HOUR ______
DATE OF GREATEST MILEAGE FOR 1 HOUR ______
AVERAGE SPEED FOR MONTH ______
LONGEST CONTINUED DIRECTION ______ HOURS ______
PREVAILING DIRECTION-BY MILEAGE ______ BY TOTAL HOURS ______



At Yankee Point, Sunnyside and St. John's Airport a second PIM has been installed on which the 1" tubes have been replaced by 2" tubes to simulate the proposed HVDC conductor diameter.

FIGURE I

PASSIVE ICE METER

Photo I - Anemometer

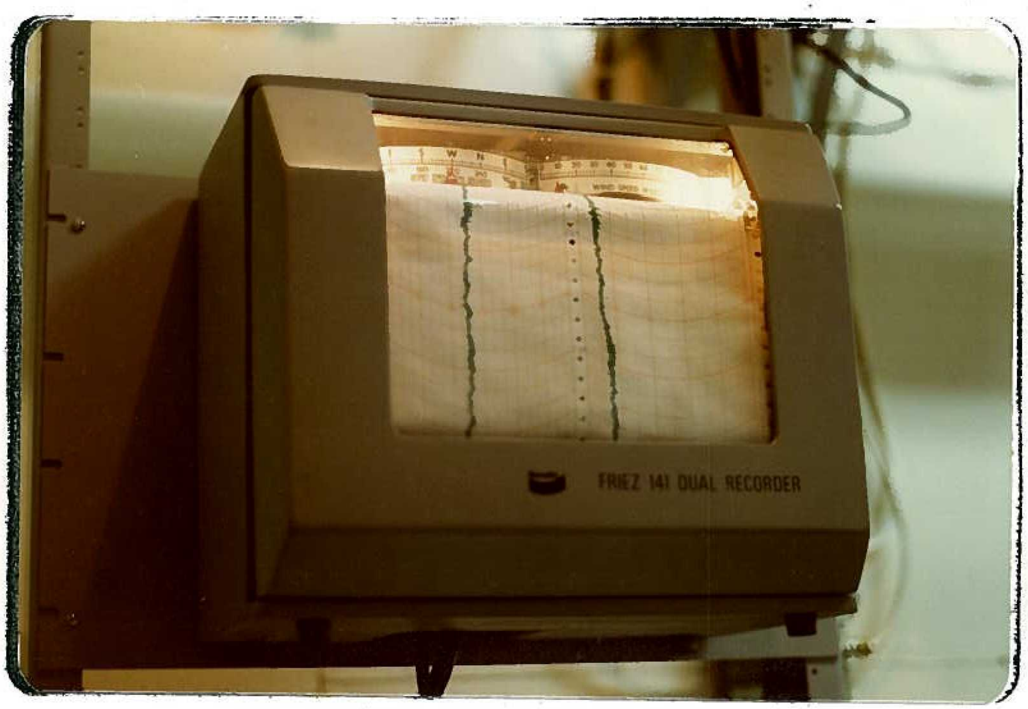


Photo II - Anemometer Recorder

Photo III - Rosemount Ice Detector

Photo IV - Rosemount - Controller and Recorder

Photo V - New Test Site

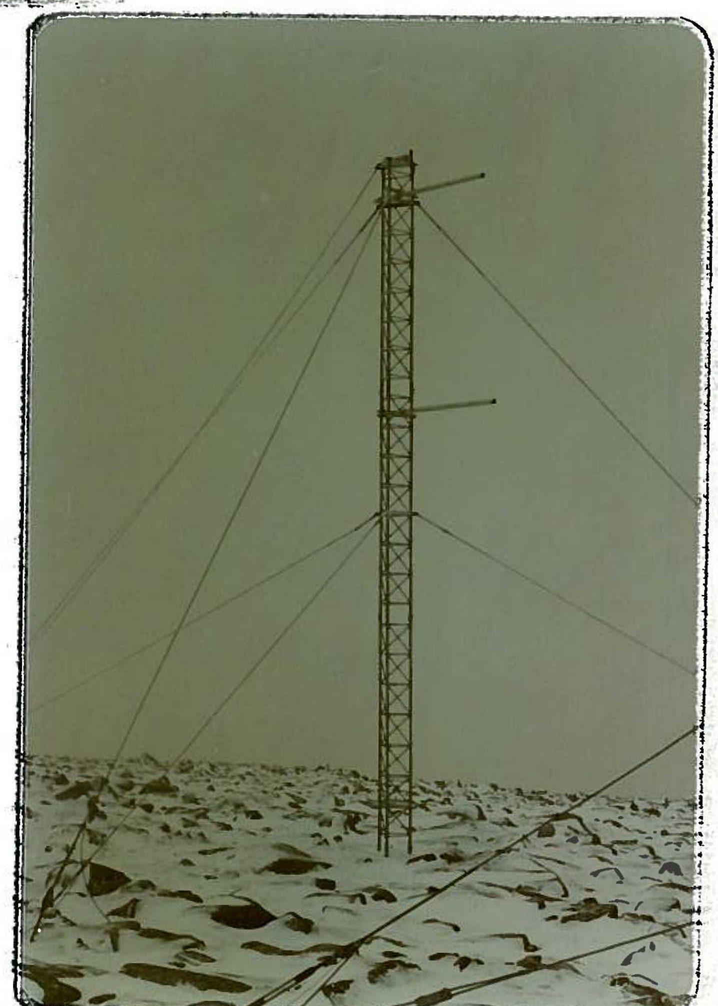
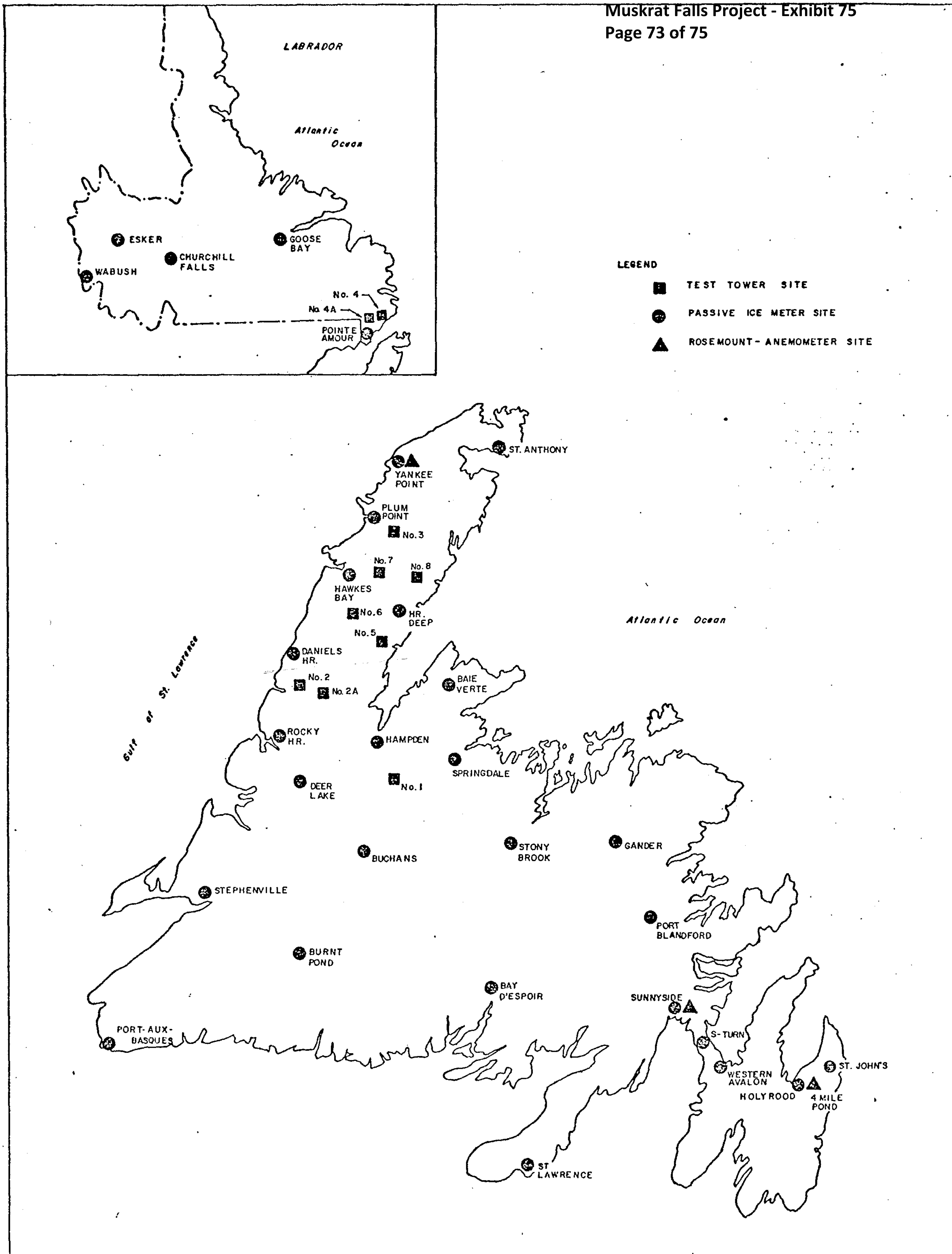


Photo VI - Original - Modified Test Site

Photo VII Site #2. Portland Creek - December 1976

Photo VIII - Site #4.

Labrador - February 1977


LABRADOR
Atlantic Ocean
ESKER
CHURCHILL FALLS
GOOSE BAY
WABUSH
No. 4
No. 4A
POINTE AMOUR
LEGEND
TEST TOWER SITE
PASSIVE ICE METER SITE
ROSEMOUNT - ANEMOMETER SITE
ST. ANTHONY
YANKEE POINT
PLUM POINT
No. 3
No. 7
No. 8
HAWKES BAY
No. 6
HR. DEEP
No. 5
Atlantic Ocean
DANIELS HR.
No. 2
No. 2A
BAIE VERTE
Gulf of St. Lawrence
ROCKY HR.
HAMPDEN
SPRINGDALE
DEER LAKE
No. 1
BUCHANS
STONY BROOK
GANDER
STEPHENVILLE
PORT BLANDFORD
BURNT POND
BAY D'ESPOIR
SUNNYSIDE
PORT-AUX-BASQUES
S-TURN
ST. JOHN'S
WESTERN AVALON
HOLYROOD
4 MILE POND
ST LAWRENCE

*GLAZE - density 0.9 to 0.92 g/ml is equal to pure ice. Glaze grows in a clear, smooth structure with no air bubbles. For this case, the freezing rate of the droplets is less than the impingement rate, which allows part of the drop to splash or flow around the conductor before freezing. Glaze is usually formed from freezing precipitation, rain or drizzle, or from clouds with large liquid water content and large drop sizes. While glaze contains no air bubbles as such, in strong wind situations it will grow in irregular shapes incorporating pockets of air.

*Rime - density 0.3 to 0.9 g/ml is frequently classified as soft rime or hard rime. Soft rime with density less than 0.6 g/ml grows in a granular structure that is white and opaque with many air bubbles within the structure. It usually grows in a triangular or pennant shape pointed into the wind. The granular structure results from the rate of freezing of the individual drops, each drop freezing completely before another one impinges on the surface. Hard rime with desnity from 0.6 to 0.9 g/ml tends to grow in a layered structure with clear ice mixed with ice containing air bubbles. In this case the freezing rate of the droplets is equal to the impingement rate of the droplets.

*Wet Snow - density 0.3 to 0.8 g/ml is usually defined as snow which falls with temperatures $\geq 31^{o}F$ ($-0.5^{o}C$). Under these conditions the snow is sticky enough to adhere to surfaces

Wet Snow (Cont'd) - easily and accumulate rapidly. Wet snow tends to build on tops and windward surfaces of structures and in cylindrical layers around conductors. At temperatures colder than about -2^{o}C, snow particles are usually too dry to adhere to surfaces in appreciable quantities.

*Hoarfrost - density less than 0.3 g/ml is a deposit of interlocking ice crystals formed by direct sublimation of water vapor in the air onto objects. The deposition of hoarfrost is similar to the process by which dew is formed, except the temperature of the frosted object must be below freezing. It forms when air with a dewpoint below freezing is brought to saturation by cooling. Hoarfrost is feathery in appearance and will occasionally build to large diameters with very little weight. Normally hoarfrost does not consititute a significant loading problem; however, it is a very good collector of supercooled fog or cloud droplets and in a subfreezing, light wind, fog situation will gradually become soft rime of significant volume and weight.

*Loading and Strength of Transmission Line Systems, Report No. A 77 230-6. IEEE Transmission and Distribution Committee of the IEEE Power Engineering Society.