"Polarization and frequency dependence of VHF/UHF signal statistics over long water paths"

Final Report for the period
April 1, 1982 to March 31, 1983

by

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Preface

This Final Report (Apr.1/82 to Mar.31/83) is the third in a series stemming from observations on VHF and UHF propagation over long salt-water paths in the Sable Island-Halifax-Canso Straits area, conducted by Saint Mary's University under a research contract with Communications Research Centre (D.O.C.). The report represents a summary of the various preliminary reports generated during the course of this contract, along with some recently obtained results. For the purposes of this final report, some of the preliminary reports (copies of which appear in the Appendices) have been modified and/or corrected; hence, the preliminary reports, as contained in this Final Report, supersede the original versions.

The purpose of this investigation has been to obtain VHF and UHF propagation data for the construction of models of VHF and UHF propagation phenomena over long over-sea paths. These models are required for the determination of interference and service ranges of maritime and off-shore VHF and UHF stations.

Summary of work performed during this contract

1. Preliminary observations of received signal strength as a function of transmitter antenna height at 432 MHz (see Report Appendices #5 and 6).
2. Preliminary analysis of VHF received signal for possible correlation with meteorological surface data (see Report Appendix #2).
3. Preliminary statistical analysis of VHF signal strength for the Sable-to-Halifax path (see Report Appendix #1).
4. Model calculations of expected signal strength on both paths: Sable-to-Halifax, and Sable-to-Seaview (see Report Appendix #3).
5. Co-authored a paper with R.E. Grantham (of Maritime Tel & Tel), which was presented at an AGARD conference (see Report Appendix #7).
6. Repaired antennas and tower (SMU#1) on Sable Island, accidentally damaged by a falling tower nearby.
7. Relocated equipment, including transmission lines, to the 'new' transmitter building on Sable Island.
8. Completed the installation of all items pertaining to the 1296 MHz system for the Sable-to-Halifax path (see Report Appendix #4).
9. Installed a second 2.3m reflector and feed, including clock-driven coax-relay and transmission line on SMU tower #2 (see Report Appendix #4).
10. Installed a second UHF beacon (this on 431.900 MHz) and circularly polarized antenna on SMU tower #1 on Sable Island (see Report Appendix #4).
11. Installed a circularly polarized antenna for UHF (432MHz) and transmission line at Seaview.
12. Modified the circularly polarized antenna on VHF (147.850 MHz) on Sable Island to minimize possible perturbing effects from the metallic structural components of the tower's platform (see Report Appendix #4).

Summary of work performed during this contract(cont'd)

13. Installed two circularly polarized antennas(opposing sense) with clock-driven selector swittch, at Saint Mary's University (see Report Appendix #4).

14. Modified the antenna system for 1296 MHz at Saint Mary's University to enable polarization analysis; the dipole in the transmitting antenna on Sable Island was slanted at 45^{o}(see Report Appendix #4).

15. Commenced automatic digitized monitoring of the 147.950 MHz signal at Saint Mary's University, using a CRC-supplied data logging system(as of March 6, 1983).

Recommendations for further study

1. Continue monitoring on both VHF and UHF; where possible, use digital recording techniques to facilitate subsequent data analysis.
2. Continue observations pertaining to polarization effects.
3. Continue with analysis of data already obtained in this work.

Section 1: Signal statistics for VHF propagation from Sable to Seaview and Sable to Halifax, May, 1981.

Introduction: This is a preliminary quantitative analysis of data obtained from our observations, and represents only a small fraction of the available data. The month of May, 1981 was selected for this initial analysis because the propagation showed a wide range of behaviour, from periods of rapid and deep fading to periods of stable and enhanced signal levels (cf. Report Appendix #1 for a preliminary report).

Procedure: The available data is in the form of pen chart-recordings. Lines were drawn, corresponding to convenient voltage levels, on the chart recordings, and then the time spent by the signal above each of these lines (thresholds) was obtained by a combination of hand-integration and visual inspection. It is thought that the resulting statistics have an uncertainty not exceeding 2 or 3 db.

Results: The quantitative statistical results are given in tabulated form in Table 1-1. This data, for comparison purposes, was plotted on Rayleigh coordinates in Figure 1-1. Inspection of this graph indicates that the observed data is noticeably non-Rayleigh in behaviour, exhibiting a much larger slope than the Rayleigh model.

As expected, the received signal level at Seaview is larger than at Halifax (the distances being 190 and 300 km respectively), and the difference is approximately 8 db. This difference is thought to be in practical agreement with propagation curves for the North Sea area, as found in CCIR Recommendation 370-3 (for example, their Figure 1).

Our preliminary analysis of received signal strength at Seaview (190 km from Sable) and at Halifax (300 km from Sable) in the 2-meter band and the corresponding data from CCIR Recommendation 370-3 for the North Sea area (for 190 and 300 km) is plotted in Figure 1-2.

The CCIR data for h_1 = 37.5 m was selected on the basis that this corresponds most closely to the parameters in our data. Although the CCIR data represents statistics for 50% of the locations surveyed, as well as a number of other conditions, this data was plotted 'as is' for the sake of obtaining a preliminary look at possible correlations between our data and that in the Recommendation mentioned above. It is also noted that the CCIR data does not specify any dependence of its data on polarization. It is further noted that the North Sea data from CCIR was selected on the assumption that this most closely corresponds to climatic conditions in our region.

Taking into account the various approximations and assumptions mentioned above, inspection of the data in Figure 1-2 indicates that the signal levels at both Seaview and Halifax exceed the CCIR predictions by approximately 8 db in both the Sable-to-Halifax and Sable-to-Seaview paths for 'percent time ordinate exceeded' ranging from 1% to 50%. Given the estimated uncertainty in our data (several db) and the CCIR allusion to somewhat higher signal levels at more southerly latitudes, it could be concluded that the CCIR Recommendation does, in fact, predict fairly well the signal levels observed by us in the Sable-Halifax-Seaview area. Moreover, the CCIR curves represent annual averages whereas our data pertains to near-summer propagation conditions. If this is taken into account, then the agreement between the CCIR predictions in Recommendation 370-3 and our data is even more persuasive.

(Note: This conclusion takes into account the recently discovered systematic error associated with the Seaview data, as indicated in Table 1-1).

Table 1-1

Signal statistics for the Sable-to-Halifax and Sable-to-Seaview paths, as estimated from the chart recordings for the levels indicated. Data for May, 1981.

Signal level (uV)	(db relative to 0.2uV)	Percent time exceeded at Halifax	Percent time exceeded at Seaview *	Signal level adjusted for 1kW(erp), db(uV/m)
0.1	-6	--	72	-8
0.2	0	57	68	-4
0.4	6	38	--	+1
0.45	7	--	60	+2
1.0	14	7	23	+12
2.0	20	--	7	+18
3.0	24	1.7	--	+21

* Note: A systematic error of approximately 3db was found in the Seaview data at the time of writing. Specifically, the Seaview signal levels are too low by about 3db.

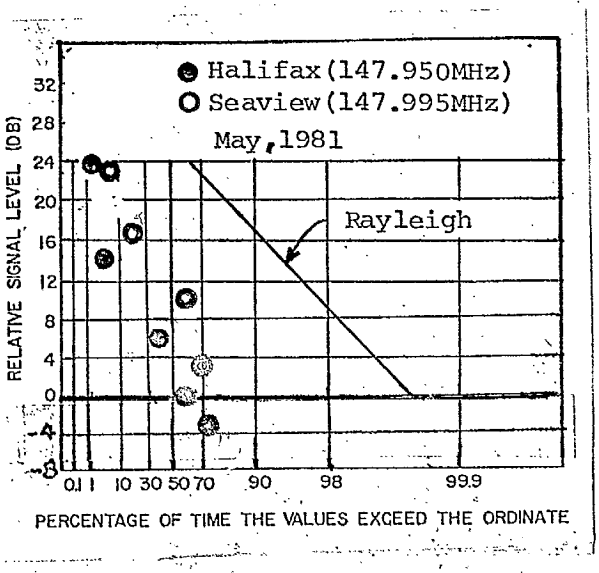
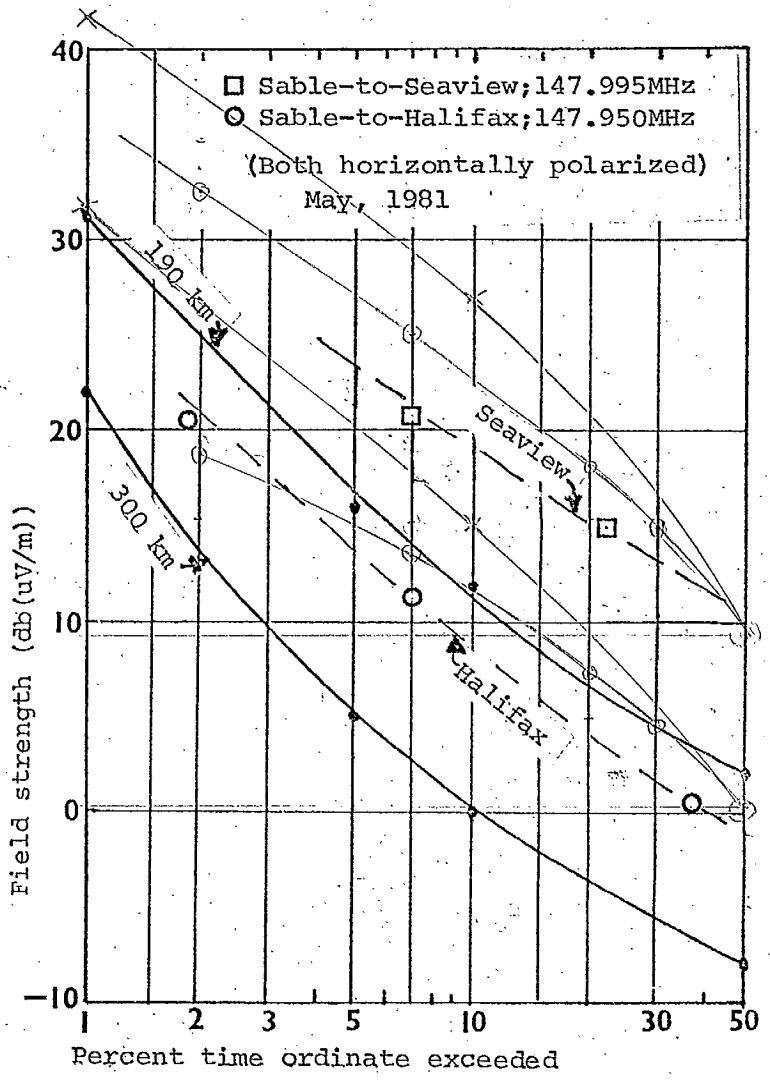


Figure 1-1

Signal statistics for Halifax and Seaview on 147.950 and 147.995 MHz respectively, both horizontally polarized, for May, 1981, plotted on the usual 'Rayleigh' coordinates. A line representing Rayleigh behaviour is included for comparison. The reference level is 0.2uV(0db)

Note: This graph takes into account the systematic error in the Seaview data as mentioned on page 1-3.

Figure 1-2: Comparison of observed signal statistics with CCIR data.



Note: This graph takes into account the systematic error in the Seaview data as mentioned on page 1-3.

Note: The two solid lines, marked 190 km and 300 km, are derived from the CCIR Recommendation 370-3, using its Figures 1,2a,3a, and 4b, all of which pertain to propagation in the North Sea area. The curves corresponding to h_1=37.5 m were used. No corrections were made in transferring data from the CCIR curves.

Section 2: Search for correlation between propagation and surface meteorological data.

A preliminary attempt was made to examine the available VHF propagation data on both the Sable-to-Seaview and the Sable-to-Halifax paths and to search for possible correlations with the available meteorological surface data(MSD). On the basis of convenience, the months of May and June of 1981 were selected for this preliminary attempt; an account of the analysis of the two sets of data(propagation and MSD) is found in Report Appendix #2.

The data was analyzed for instances of coincidence between discontinuities in propagation and discontinuities in MSD. In both cases, the identification of 'discontinuity' was at the discretion of the viewer. It is also noted at this point that this preliminary attempt to find correlations was based on the assumption that the propagation is essentially tropospheric and that consequently only the surface conditions would be relevant.

In general, the attempt did not yield any noticeable number of coincidences between discontintuities in propagation and MSD. By way of explanation, it is presumed that the available MSD does not generally represent the surface conditions along the two propagation paths.

Section 3: Some model calculations of expected signal levels.

Some preliminary calculations were made of expected signal levels using two different models: 'free-space', and 'Bullington's modified free-space'. The details of the calculations are given in Report Appendix #3, and a summary of the results in given in Table 1-2 below. These two models are not expected to agree with the observed signal levels, but are meant only to provide 'reference' quantities. However, it will be noticed that the Bullington model (representing an averaged value) does predict signal levels which are not all that unrepresentative of the observed values. A closer comparison between the Bullington model and the observed values is not possible at this time due to a lack of calculated 'average values' for our data. Inspection of the received signal

Table 1-2: Model calculations for the two VHF paths studied.

Path description (ant. effic. = 50%)	Model and predicted signal level (uV)	
	free-space	Bullington
Sable to Seaview, 147.995 MHz, 190 km, tx power =15 W, tx & rx ant. gains=9dbd each.	110	0.31
Sable to Halifax, 147.950 MHz, 300 km, tx power =15 W, tx & rx ant. gains=9dbd each	62	0.043

Section 4: Polarization effects

Preliminary observations have been made pertaining to possible differential attenuation between horizontal and vertical components of a wave propagating from Sable to Halifax.

Experimental details and results: On Sable, there are presently three antennas relevant to this particular study, as follows: a horizontally polarized antenna on 147.950 MHz; a circularly polarized antenna on 147.850 MHz, and a linearly polarized antenna slanted at 45° (see Figure 1-3 below) on 147.900 MHz. At Halifax (Saint Mary's University), there is an 'analyzing' antenna, consisting of a linearly polarized antenna capable of being rotated about its long axis (see Report Appendix #4 for further details).

The procedure involves an examination of all three signals, thus providing for some 'control' variables in the experiment. In other words, the analyzing antenna should see a horizontally polarized wave when looking at 147.950 MHz, and an isotropically polarized wave when looking at 147.850 MHz, if there is neither polarization rotation nor differential attenuation, etc.

The antennas for 147.950 and 147.900 MHz were appropriately prepared towards the end of December, 1982. Due to time constraints, only the radiation on 147.900 (the slanted yagi) was examined on Sable at a point along the Sable-to Halifax path approximately 3 km west of the transmitting antenna. Using a linearly polarized yagi, and visual estimation of angular position, it was concluded that the radiation was, indeed, slanted at 45° to the horizontal, with an uncertainty of no more than a few degrees. (Note: at the time of this test, the circularly polarized antenna was not suitably positioned).

The first observations at Halifax were not made until mid-February, primarily because signal levels were not sufficient for this type of observation. However, on the basis of several observations, it was

concluded that there was an 'apparent' rotation of the plane of polarization by some 20° (45° slant) in the 147.900 MHz signal. During each of these observations, there was no measureable rotation in the polarization from the 147.950 MHz (horizontal) beacon. The radiation from the circularly polarized antenna could not be adequately examined due to relatively rapid fluctuations in the signal. These fluctuations did not unduly affect observations on the two linearly polarized signals because the analyzing antenna was adjusted to the 'null' position (see Figure 1-3).

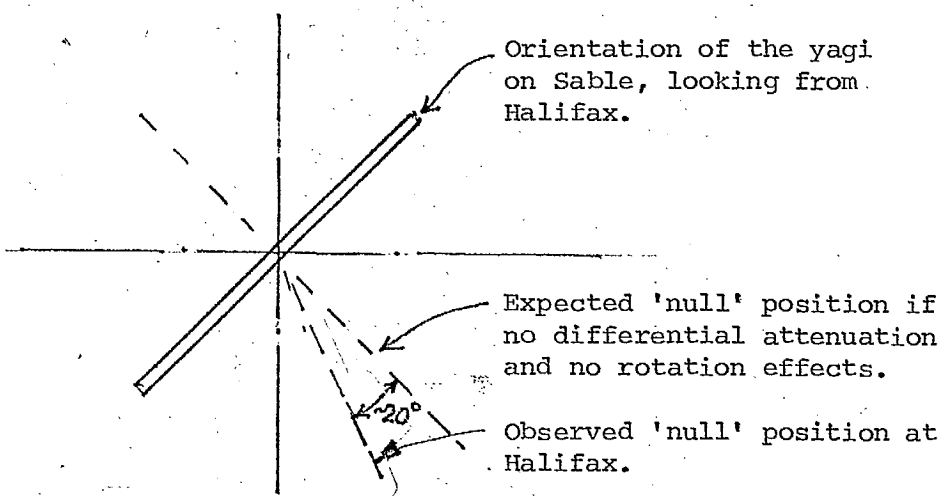


Figure 1-3: Orientation of the linearly polarized antenna on 147.900 MHz relative to a viewer on the propagation path.

Conclusion: On the basis of the observations on Sable (Dec.1982) and Halifax (Feb.1983), and assuming that no changes occurred in the antenna on Sable in the interim, it is concluded that the observed 'apparent' roatation is associated with a differential attenuation of approximately 3 db, in favour of the horizontal component.

Section 1: Received signal strength as a function of transmitting antenna height.

Some preliminary observations were made of the received signal strength as a function of the transmitting antenna height, on 431.950 MHz, to test for possible diversity applications. The two transmitting antennas were on the same tower, and alternately connected to the beacon by means of a clock-controlled coaxial switch system. Further details are found in Report Appendix #5 and #6. The received signal was monitored at two locations: Saint Mary's University and the residence of Mr. Elmer Naugler, Halifax.

For the period from June 7 to July 17, 1982, it was found that the signal from the higher antenna was dominant for approximately 90% of the time, whereas the lower antenna was dominant for approximately 2% of the time; these estimates pertain to signals which did not show appreciable fading over a time interval of several minutes. When, however, the signal was relatively unstable, with fades occurring at fractional-minute rates, it was observed that the signal would alternate between the two antennas, as indicated in Figure 1 of Report Appendix #6. This would suggest that diversity techniques would be beneficial.

The observations in this particular experiment are considered to be too incomplete to enable any general conclusion, aside from saying that the higher antenna yields a stronger signal, most of the time.

Section 2: Model calculations for 431.950 MHz.

Some preliminary calculations were made of the expected signal levels using three different 'models': "free space"; "Bullington-modified free space"; and an "equivalent distance" method(Sofaer and Stark). The details of the calculations are given in Report Appendix #3, and a summary of the results of the calculations is given below in Table 2-1.

Observations on this frequency have been made only on the Sable-to-Halifax path(300km nominal), and on the basis of these observations, it is thought that the predictions using the 'equivalent distance' method for 10% threshold agree favarourably with our observations. However, this statement is meant to be qualitative only, awaiting quantitative analysis of our data. The signal levels for 1% threshold appear to overestimate our observations, but again, our data awaits quantitative analysis.

The signal levels derived from the Bullington-modified free space model appear to underestimate significantly the observed median level, but a quantitative analysis of our data would need to be made.

Table 2-1

Path description (radiation efficiency =50%)	Model calculations of signal level(uV)			
	Free space	Bullington	Equivalent distance (Sofaer and Stark)	
			1%	10%
432MHz,180 miles (300km nominal), tx power =15W, tx &rx ant. gains =18db each.	174	0.055	38	0.4
As above, except tx & rx ant.gains =9db each.	22	0.0069	5	0.05
432 MHz,100 miles (nominal), tx power =15W, tx & rx ant. gains =18db each.	309	0.55	214	5
As above, except that tx & rx ant. gains=9db each.	39	0.069	27	0.6

Appendix #1

Report
Appendix #1

"Signal Statistics for 147.950 MHz (horizontal polarization) propagation from Sable Island to Halifax, during May, 1981" (a preliminary report).

Principal Investigator: W. P. Lonc, VE1SMU, Saint Mary's University

Date: November 5, 1982

Abstract:

A preliminary analysis of propagation data for the Sable Island to Halifax, path for the month of May, 1981, on 147.950 MHz indicates a definite non-Rayleigh relationship between the signal strength (in db. above 0.2 uV) and the percent time spent above the related signal strength.

Introduction:

A preliminary statistical analysis of propagation data, obtained in an earlier investigation, pertaining to the Sable Island to Halifax path on 147.950 MHz was made by a visual examination of the chart recordings. Data was available for a total of 29 days for the month of May, 1981. Inspection of the chart recordings for this period indicates a variety of propagation features, ranging from rather low signal level accompanied by fast, deep, fading (eg. May 1), to periods of very high signal levels accompanied by very few, if any, fades (eg. late evening of May 9).

Although it is quite likely that the data represents at least two, relatively well-defined, mechanisms (associated with the features mentioned above) operating during this month, and that the data should, strictly speaking, take this supposition into account, there still remains the possibility that a simple analysis would also be of interest. Hence, the present analysis, in effect, presupposes that the data is sufficiently random and homogeneous to allow a simple averaging. Subsequent analysis of this data will attempt to take into account the non-homogeneous character of the data.

Procedure:

Lines were drawn on the chart recordings, corresponding to signal levels at 0.2, 0.4, 1.0, and 3.0 uV, and the amount of time (per day) spent above each signal level was estimated by a visual examination of the chart recordings. This method evidently contains rather large uncertainties when deep and rapid fading is present. However, it is thought that the uncertainty does not exceed acceptable (say, 20%) levels for the purposes of a preliminary report.

Results:

The numerical values of the estimates for each day are shown in Table 1; the average of these values (averaged over 29 days) are given in Table 2; and the values expressed as percentages (out of 24 hours) are given in Table 3.

The data from Table 3 is plotted on linear co-ordinates in Figure 1, and on Rayleigh-type co-ordinates in Figure 2. Inspection of Figure 2 indicates that the observed propagation is clearly of a non-Rayleigh type in its overall behaviour. However, a more detailed analysis of the data presumably could be made assuming that there is a Rayleigh component along with some other component (or components) not associated with Rayleigh type processes.

Report Appendix #1

Table 1: Numerical values of estimated (in hours) time above a given threshold voltage for each day of May, 1981. No data for May 23 and 24.

Date	Above 0.2uV	Above 0.4uV	Above 1.0uV	Above 3.0uV
1	7.0	2.0	0	0
2	4.0	0	0	0
3	10.0	6.25	0	0
4	14.0	9.0	0.2	0
5	14.0	11.5	0	0
6	14.2	11.8	0.1	0
7	7.0	3.5	0	0
8	8.5	0.2	0	0
9	18.7	6.0	1.5	0
10	11.8	4.5	0	0
11	16.8	10.3	1.2	0
12	18.5	14.6	1.4	0
13	16.5	10.8	.7	0
14	13.1	12.7	4.7	2.7
15	21.3	19.8	5.7	1.4
16	20.5	17.9	7.9	2.6
17	12.4	1.1	0.01	0
18	12.0	4.6	0	0
19	11.8	1.8	0	0
20	12.6	7.8	0.01	0
21	7.5	5.9	1.2	0
22	8.1	5.1	3.1	3.0
23	---	---	----	----
24	---	---	---	---
25	10.4	9.4	0.08	0
26	15.5	14.4	2.3	0.5
27	17.8	15.5	0.2	0
28	22.0	19.5	12.7	1.1
29	21.1	18.9	4.4	0.8
30	15.2	9.8	1.9	0.2
31	15.6	10.1	0.8	0
Totals:	397.90	264.75	50.1	12.3

Report
Appendix #1

Table 2: Average values(over 29 days) of the estimated time above a given threshold voltage for May, 1981. In hours.

Above 0.2 uV	Above 0.4 uV	Above 1.0 uV	Above 3.0 uV
13.7	9.13	1.73	0.4

Table 3: Average values (over 29 days) of the estimated time above a given threshold voltage for May, 1981, expressed as percentage, per 24 hours.

Above 0.2 uV	Above 0.4 uV	Above 1.0 uV	Above 3.0 uV
57.1	38.0	7.21	1.7

Table 4: Signal levels expressed in db above 0.2 uV.

0.2 uV	0 db
0.4	6
1.0	14
3.0	24

Report
Appendix #1

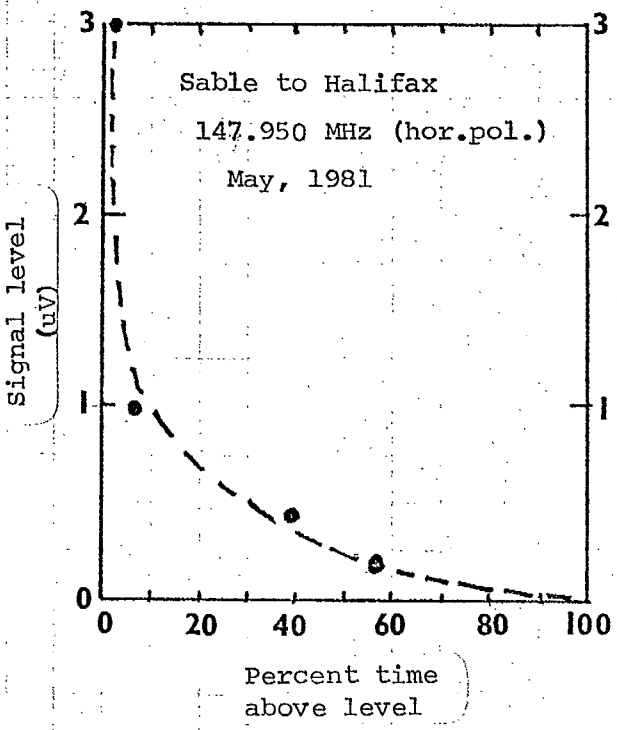


Figure 1:Signal statistics for propagation on 147.950 MHz, horizontally polarized, from Sable Island to Halifax, for May, 1981. The abscissa represents the percent time that the signal was observed to be above the corresponding level(in microvolts).

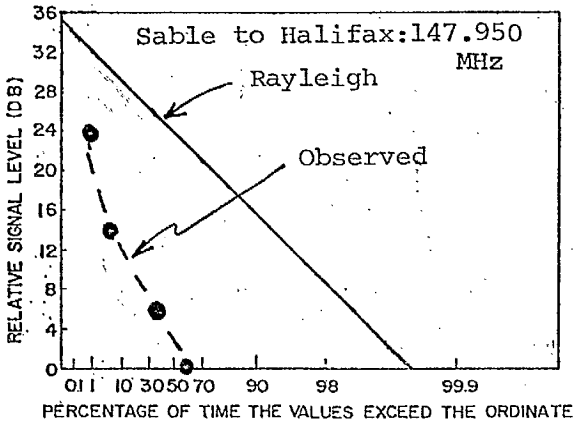


Figure 2: Signal statistics from Figure 1 plotted on the usual "Rayleigh" coordinates, with a line representing Rayleigh behaviour included for comparison.

Appendix #2

"An Initial Search for Possible Correlations between Propagation Enhancement Events and Meteorological Surface Data"(a preliminary Report)

Principal Investigator: W.P. Lonc, Saint Mary's Univ., VE1SMU

Research Assistant: W.D. Rawle, " " " , VE1AWS

Report date: August 2, 1982

DSS File No.
Serial No.

Abstract: Propagation enhancement events and available meteorological surface data pertaining to VHF links from Sable Island to Seaview and Sable Island to Halifax for May and June of 1981 were studied for indications of correlation. On the basis of this preliminary study, which consisted of a visual inspection of the data, the conclusion was drawn that no significant correlation exists in our data.

Introduction: As part of an ongoing study of VHF propagation over a long sea path between Sable Island and mainland Nova Scotia, some of the accumulated data was inspected for indications of possible correlations between salient features in the propagation and correspondingly salient features in the available meteorological surface data(MSD).

For purposes of an initial study, it was decided to look at 'propagation enhancements' as the salient propagation feature, and discontinuities in sea-level pressure, relative humidity, cloud amount, cloud ceiling, and temperature, as the salient features in the MSD. It should be noted that the available MSD is obtained from sites(i.e. the Main Station on Sable Island, Eddy Point, and Shearwater) which, in fact, do not lie on the pro-

pagation path, and also that no upper atmosphere data is included in this study. Hence, the conclusions drawn in this Report are thought to be valid only for the conditions stated--namely, only available MSD is considered.

It is presumed that significant correlations would have been observed if the MSD had been available from sites on the path of propagation.

Experimental Details: A detailed description of the equipment may be found in our Final Report for 1981-2. Briefly, three frequencies were employed:142.605 MHz(M.T.&T. channel), 147.995 MHz, and 147.950 MHz, with vertical polarization on the first frequency, and horizontal on the remaining two. The first frequency was monitored at both Seaview and Arichat, the second at Seaview, and the third at Halifax. The locations of the beacons, receivers, and meteorological sites are shown in Figures 1 to 4 . The monitors for the first frequency exhibit limiting in the monitored d.c. voltage, whereas the monitors for the remaining two exhibit a non-limiting response.

Results: For purposes of reference, photocopies of the data for each day of May and June of 1981 are given in Appendix A. The results of a visual inspection of this data are given in tabulated form on pages 3 to 9 in the Supplement to this Report.

Table 1(Supplement p.3) lists all the propagation events which were construed to be of the 'enhanced' kind, and a detailed examination of each event is given in Appendix B.

Table 2(Supplement p.7) lists the meteorological observing sites at which a discontinuity in one or more MSD parameters was observed to be in time-coincidence with a propagation discontinuity(of the 'enhanced' type) on the Sable to Halifax path. Table 3(Supplement p.8) gives similar information for the Sable to Seaview path.

In Table 4(Supplement p.9), column I lists the number of times that discontinuities in the MSD parameters were coincident with both the onset and termination of a propagation enhancement on either path: called a 'possible' correlation in the text. Column II converts the data in column I into percentages(relative to 35 events in all). Column III lists the number of times that discontinuities in MSD parameters were coincident with either the onset or the termination of a propagation enhancement for either path. Column IV converts the data in column III into percentages(again, relative to 35 events in all).

Discussion: If it be assumed that a physical relationship is associated with a MSD parameter and propagation enhancement only if a discontinuity in the parameter coincides with both the onset and termination of an enhancement(called a 'possible' correlation in the text), then our results show that there is only one parameter--namely, cloud height as observed on Sable Island--which correlates for at least 50% of the time(the calculated value is 51%, in Table 4, column II). Given that the observing site on Sable(compared with the sites at Seaview and Shearwater) is the closest of the three to the propagation path, it could be plausibly concluded that the cloud height is physically associated with propagation originating on Sable. However, inasmuch as the other MSD parameters observed on Sable exhibit correlations much less than 50%(Table 4, column 2), and since these remaining parameters, presumably, could also be physically associated with propagation, it appears more probable that the correlation between cloud height on Sable and propagation originating on Sable is not significant in our data.

Again, it should be noted that this Report is based on available surface weather data, none of which is obtained from sites directly on the propagation path. It is presumed that, if surface weather data had been available from sites directly on the propagation path, then there would have been,

perhaps, much stronger correlation in the parameters studied.

Conclusion: On the basis of the data examined in this Report, it is concluded that the available meteorological surface data shows no substantial correlation with propagation enhancements for May and June of 1981.

Figure 1: General features of the Sable Island and mainland Nova Scotia, showing approximate locations of Halifax, Seaview, Arichat, Eddy Point, Shearwater, and West Light area(Sable).

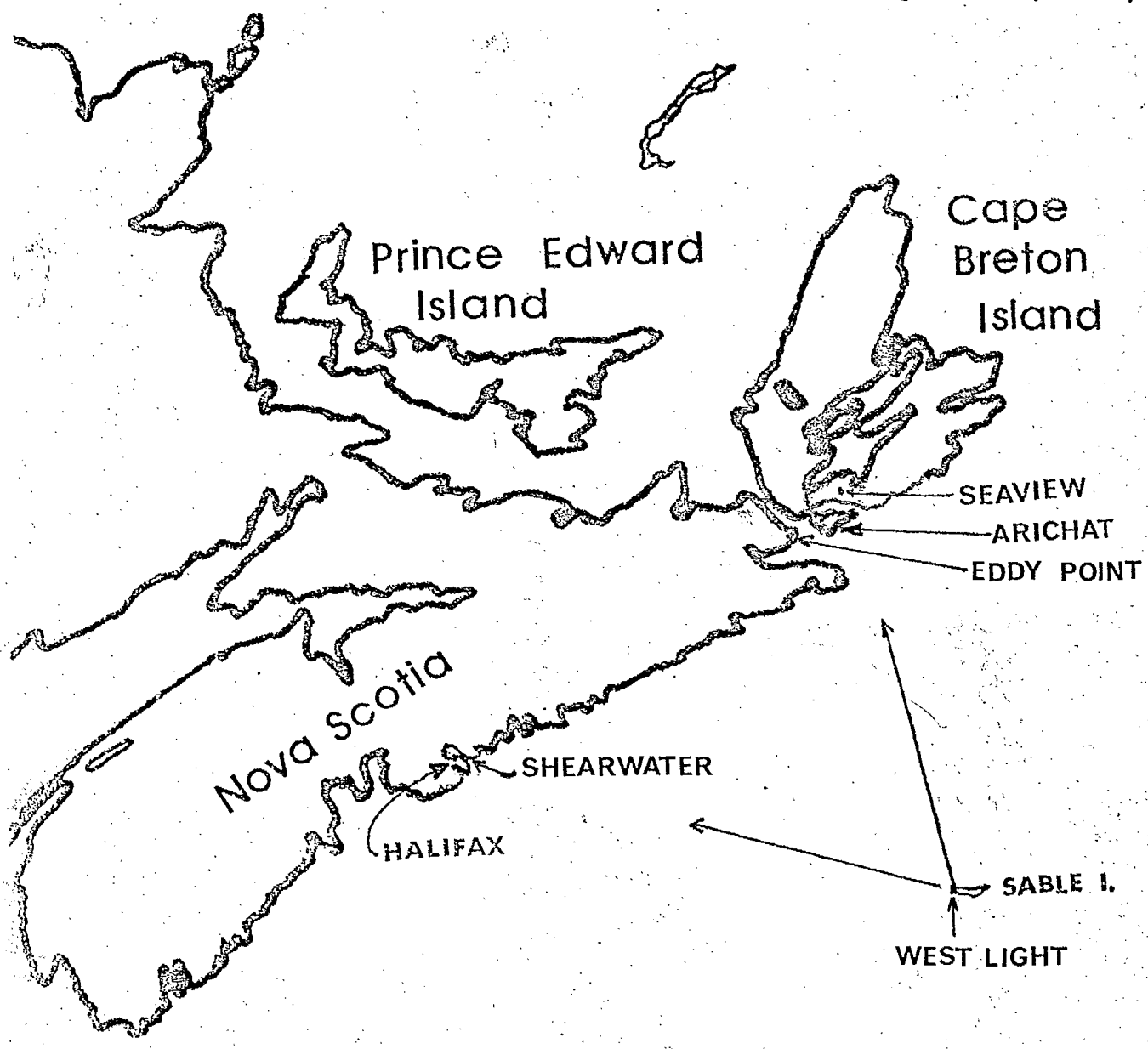


Figure 2 : Coast-line features of the Seaview-Arichat area, and location of antenna sites.

LEGEND

One inch equals approx. 4.5 miles or 7.25 kilometres

miles: 5 4 3 2 1 0 5 10 miles

kilometres: 5 4 3 2 1 0 5 10 15 kilometres

Figure 3 : General features of the Halifax area, showing Shearwater and Saint Mary's University

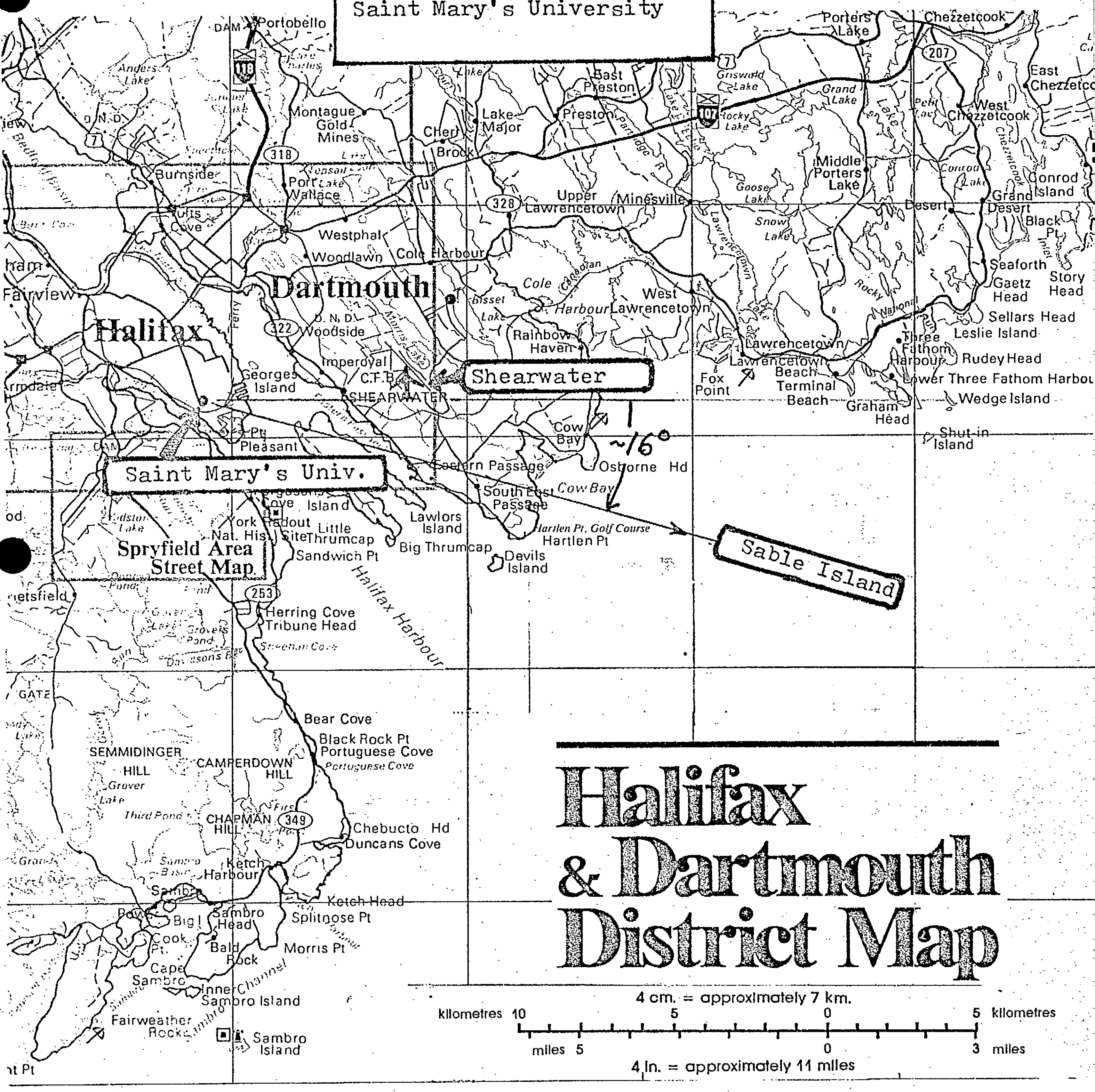
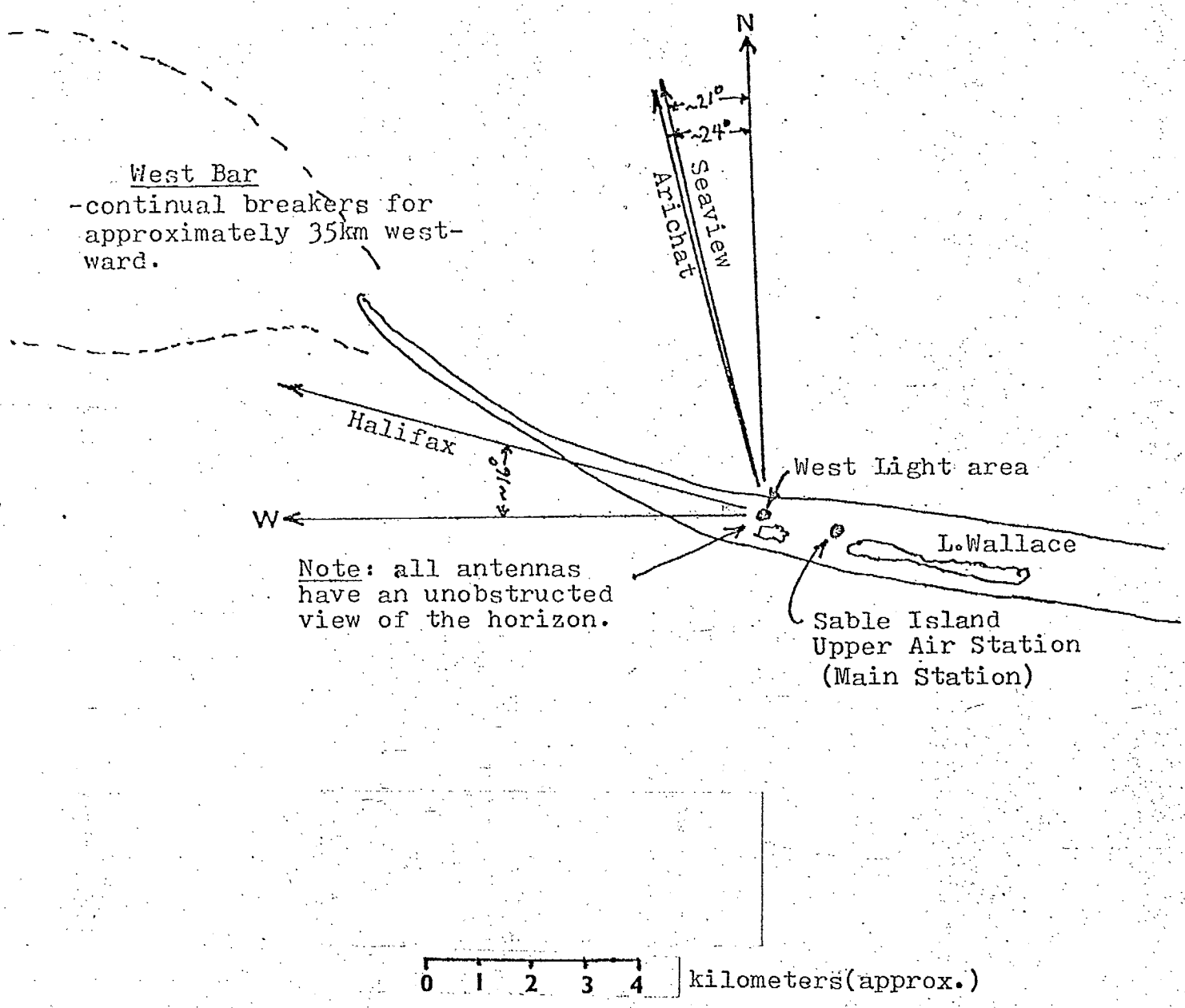


Figure 4 : General features of the west end of Sable Island.



Report Appendix #2

Supplementary Report p.1

AN INITIAL SEARCH FOR POSSIBLE CORRELATIONS BETWEEN PROPAGATION ENHANCEMENT EVENTS AND METEOROLOGICAL SURFACE DATA

by W. D. Rawle

An initial visual inspection of the chart recordings on the data panels for the months of May and June 1981 reveals periods of increased propagation. These periods of increased propagation, or propagation enhancements, are defined to be time intervals when there is a sudden, noticeable increase in received signal level accompanied by a sudden, noticeable decrease in the amount of deep fading on the signal. A listing of these propagation enhancements, observed during the months of May and June 1981, appears in Table 1.

An initial inspection of the available meteorological surface data, as displayed on the data panels (refer to Appendix C) for the months of May and June 1981, reveals disturbances or discontinuities, in the meteorological surface data which are, on occasion, coincident with the commencement and/or termination of a propagation enhancement. Two cases of this coincidental behaviour are observed. In the first case, both the commencement and the termination of a propagation enhancement are observed to be coincident with a discontinuity in a meteorological parameter; and this case is considered to be the basis for the existance of a possible correlation between the propagation enhancement and the observed discontinuity in the meteorological parameter. In the second case, either the commencement or the termination (but not both) of the enhancement, is observed to be coincident with a discontinuity in a meteorological parameter; and this case indicates that the propagation enhancement and the discontinuity

in the meteorological parameter are merely coincidental.

In the visual inspection of both the chart recordings and the available meteorological surface data, the observation day is defined to be from 0000LT to 2359LT. The meteorological observation facilities, as indicated in the analysis, are Sable Island, Shearwater, and Eddy Point. The chart recorder locations are Halifax and Seaview.

TABLE 1

Propagation Enhancement Events, May and June 1981

May 9/81

- A definite propagation enhancement occurs at Halifax from 2000LT to 2359LT.
- No activity at Seaview.

May 11/81

- A definite propagation enhancement occurs at Halifax from 0200LT - 0600LT.
- A definite propagation enhancement occurs at Seaview from 0200LT - 0600LT.
- A definite propagation enhancement commences at Seaview at 2300LT.

May 13/81

- The definite propagation enhancement which commenced at Seaview at 2300LT on May 11, terminates at 1800LT.
- No activity at Halifax.

May 14/81

- A definite propagation enhancement occurs at Halifax from 1100LT - 1300LT and from 1700LT - 1900LT.
- A definite propagation enhancement occurs at Seaview from 1200LT - 1400LT and from 1600LT - 2200LT.

May 15/81

- A definite propagation enhancement occurs at Halifax from 0500LT - 0700LT.
- A definite propagation enhancement occurs at Seaview from 0000LT - 0200LT and from 0800LT - 1000LT.

May 16/81

- A definite propagation enhancement occurs at Halifax from 1100LT - 1400LT.
- A definite propagation enhancement commences at Seaview at 0800LT.

Table 1 cont'd

May 17/81

- The definite propagation enhancement which commences at Seaview at 0800LT on May 16, terminates at 0200LT.
- No activity at Halifax.

May 21/81

- A definite propagation enhancement commences at Seaview at 2200LT.
- Halifax data incomplete for this day.

May 22/81

- The definite propagation enhancement which commenced at Seaview at 2200LT on May 21, terminates 1300LT.
- A definite propagation enhancement occurs at Halifax from 0900LT - 1200LT.

May 26/81

- A definite propagation enhancement occurs at Halifax from 0300LT - 0400LT.
- A definite propagation enhancement occurs at Seaview from 0500LT - 0600LT.

May 29/81

- A definite propagation enhancement occurs at Seaview from 1000LT - 1600LT.
- No activity at Halifax.

Table 1 cont'd

June 1/81

- A definite propagation enhancement commences at Seaview at 2300LT.
- No activity at Halifax.

June 2/81

- The definite propagation enhancement which commenced at Seaview at 2300LT on June 1, terminates 0200LT.
- A definite propagation enhancement occurs at Seaview from 1300LT - 1500LT.
- A definite propagation enhancement occurs at Halifax from 1900LT - 2100LT.

June 3/81

- A definite propagation enhancement occurs at Halifax from 0500LT - 0800LT.
- No activity at Seaview.

June 14/81

- A definite propagation enhancement commences at Seaview at 1800LT.
- No data available for Halifax.

June 15/81

- The definite propagation enhancement which commenced at Seaview at 1800LT on June 14, terminates 0900LT.
- A definite propagation enhancement occurs at Seaview from 0300LT - 0800LT.
- No activity at Halifax.

June 19/81

- A definite propagation enhancement commences at Halifax at 1200LT.
- A definite propagation enhancement commences at Seaview at 1200LT.

Table 1 cont'd

June 20/81

- The definite propagation enhancement which commenced at Halifax at 1200LT on June 19, terminates at 0500LT.
- The definite propagation enhancement which commenced at Seaview at 1200LT on June 19, terminates at 0400LT.
- A definite propagation enhancement occurs at Halifax from 1900LT - 2200LT.
- A definite propagation enhancement occurs at Seaview from 1800LT - 2200LT.

June 24/81

- A definite propagation enhancement occurs at Halifax from 0600LT - 1000LT.
- A definite propagation enhancement occurs at Seaview from 0400LT - 1200LT.
- A definite propagation enhancement commences at Seaview at 1600LT.

June 25/81

- The definite propagation enhancement which commenced at Seaview at 1600LT on June 24, terminates 0200LT.
- A definite propagation enhancement occurs at Halifax from 1000LT - 1200LT.

June 26/81

- A definite propagation enhancement occurs at Halifax from 0100LT - 0400LT.
- A definite propagation enhancement occurs at Seaview from 0300LT - 0600LT.

SABLE - HALIFAX DATA

SEA LEVEL PRESSURE		RELATIVE HUMIDITY		CLOUD AMOUNT		CLOUD CEILING		TEMPERATURE	
POSSIBLE	DISMISSED	POSSIBLE	DISMISSED	POSSIBLE	DISMISSED	POSSIBLE	DISMISSED	POSSIBLE	DISMISSED
SI		SWR	SI	SI	SWR	SI	SI	SWR	SI
SI		SWR	EP	SI	EP	SI	SWR	EP	SWR
EP		SI	SWR	SI	EP	SWR	EP	SWR	EP
		SWR	EP	EP	SWR	SI	EP	SWR	SWR
		EP	SI	SI	EP	EP	SWR	EP	SI
		SI	SWR	SWR	EP	SE	SWR		EP
		SWR	SWR	SI	EP		EP		SWR
		EP	EP	SWR	SI		EP		EP
		SWR	EP	SWR	EP		EP		SI
		SWR	SWR	EP	SWR		SWR		EP
		EP	SI	SI	SWR		EP		EP
		SI	EP	SI	EP		SWR		
				EP	SI		SWR		
				SWR	EP		EP		
				EP	SWR				
				SI	SI				

Abbreviations

SI: Sable Island(Main Station)

EP: Eddy Point

SWR: Shearwater

Table 2 ..... Report Appendix #2 Supplementary Report p.7

Table 3

SABLE - SEAVIEW DATA

SEA LEVEL PRESSURE		RELATIVE HUMIDITY		CLOUD AMOUNT		CLOUD CEILING		TEMPERATURE	
POSSIBLE	DISMISSED	POSSIBLE	DISMISSED	POSSIBLE	DISMISSED	POSSIBLE	DISMISSED	POSSIBLE	DISMISSED
SI	SI	SI	EP	SI	SWR	SI	SI	SWR	SWR
SWR	SWR	SWR	SWR	SI	EP	EP	SWR	EP	EP
EP	EP	EP	EP	EP	SI	SI	EP	SWR	SI
SI	SWR	SI	SWR	SWR	SWR	SWR	SI	EP	SWR
EP	EP	EP	EP	EP	SI	SWR	SI	EP	SWR
SI	SWR	SI	EP	EP	EP	SI	SWR	SWR	EP
SWR	EP	SI	SI	SI	SI	EP	SI		EP
EP	EP	SWR	SI	SI	SWR		SI		EP
EP	SI	EP	SI	SWR	SI		SI		SWR
SI	EP	SWR	EP	SI	EP		EP		EP
EP	SWR	EP	SI	SWR	SI		SI		SI
	SI	EP	SWR	EP	SWR		EP		SWR
		EP	EP	SI	EP		SI		EP
				SI	SI		EP		
				SI	SWR		SWR		
				EP	EP		SWR		
				SI	EP		EP		
				SI	EP		SWR		
				SWR	SWR		EP		
					SWR				
					SWR				
					EP				
					EP				
					SI				

POPULATION = 35 events

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OCCURANCE - PERCENTAGE OF THE EVENTS UNDER STUDY

		I POSSIBLE	II PERCENTAGE	III COINCIDENT	IV PERCENTAGE
SEA LEVEL PRESSURE	Sable Island	(2)	5.7%	(4)	11%
	Shearwater	(0)	0%	(2)	5.7%
	Eddy Point	(1)	2.9%	(5)	14%
RELATIVE HUMIDITY	Sable Island	(6)	17%	(6)	17%
	Shearwater	(10)	29%	(7)	20%
	Eddy Point	(8)	23%	(12)	34%
CLOUD AMOUNT	Sable Island	(18)	51%	(10)	29%
	Shearwater	(8)	23%	(13)	37%
	Eddy Point	(9)	26%	(17)	49%
CLOUD CEILING	Sable Island	(7)	20%	(9)	26%
	Shearwater	(3)	8.6%	(11)	31%
	Eddy Point	(3)	8.6%	(13)	37%
TEMPERATURE	Sable Island	(0)	0%	(4)	11%
	Shearwater	(6)	17%	(8)	23%
	Eddy Point	(4)	11%	(11)	31%

Table 4

Conclusion:

A preliminary search for possible correlations between propagation enhancements and observed discontinuities in meteorological parameters yields results which are tabulated in Table 4. The percentages recorded in Table 4 represent the occurance of possible correlations (a possible correlation was defined as the occurance of a propagation enhancement with an observed disturbance of a meteorological parameter at both the commencement and termination of the enhancement) and coincidences (a coincidence was defined as the occurance of a propagation enhancement with an observed disturbance of a meteorological parameter at the commencement or termination of the enhancement but not both) during the thirty-five propagation enhancement events studied for the months of May and June, 1981. As indicated in Table 4, there are only two occasions where the occurance - percentage of possible correlation exceeds the occurance - percentages of coincidence for a particular meteorological parameter (refer to Appendix C) and a particular meteorological observation facility. In thirteen of the fifteen cases initially examined, the occurance-percentage of coincidence is greater than the occurance-percentage of possible correlation.

On the basis of this preliminary analysis, the conclusion has been drawn that there is no noticeable correlation between propagation enhancement events and available meteorological surface data.

Appendix A

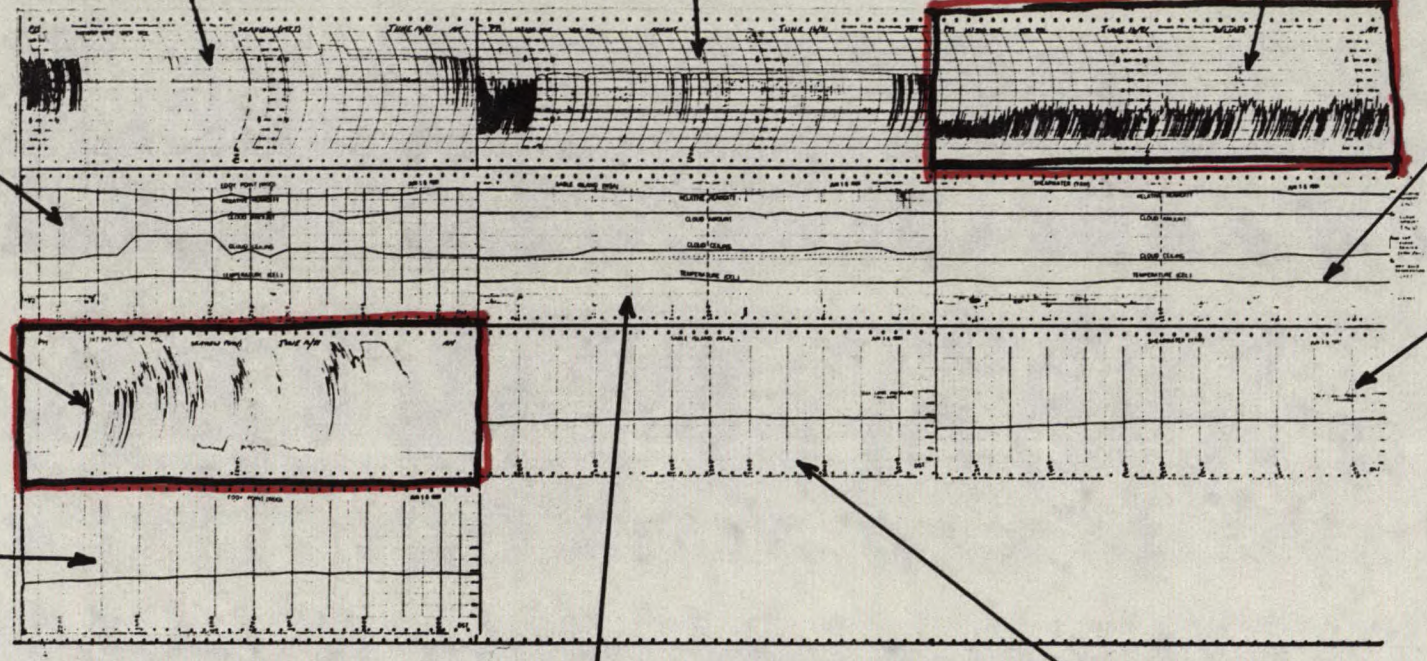
Photocopies of 'data panels'(montages, on a daily basis, of various propagation and meteorological data) for the month of May, 1981. Each page displays 3 data panels; the chart recording for propagation from Sable Island to Halifax on 147.950 MHz is located in the upper right hand corner of each data panel, and this chart recording is identified by an arrow in the right hand margin. The signal voltage levels are indicated on the chart recording.

N.B.
Please note that a systematic error exists in the identification of the signal-level lines on the Seaview(147.995 MHz) recordings. Specifically, the voltage-levels are approximately 3db too low. Hence, the signal level marked '1uV' should actually be 3db higher, i.e. '1.4uV', etc.

The chart recordings for Halifax(147.950 MHz) and Seaview(147.995 MHz) are outlined in colour.

This Appendix contains photographic copies of the original 'data panels'. The originals are approximately 136x90cm.

The panel for June 16, 1981 is employed as an example showing the identity of each chart on a panel. Note that the panels for May 1/81 to May 7/81,inclusive, have the Eddy Point graph for a sea-level pressure located where the Seaview reception on 147.995 is located in subsequent panels. The blank area at the bottom of the panel is to allow for inclusion of additional data at some future date. The calibrations of some charts are not legible. This is not considered significant because of the nature of the analysis.



Note #1: This chart displays the following (top to bottom), relative humidity; cloud amount, cloud ceiling, temperature (^{o}C), and precipitation, etc. (known as SIGMET data).

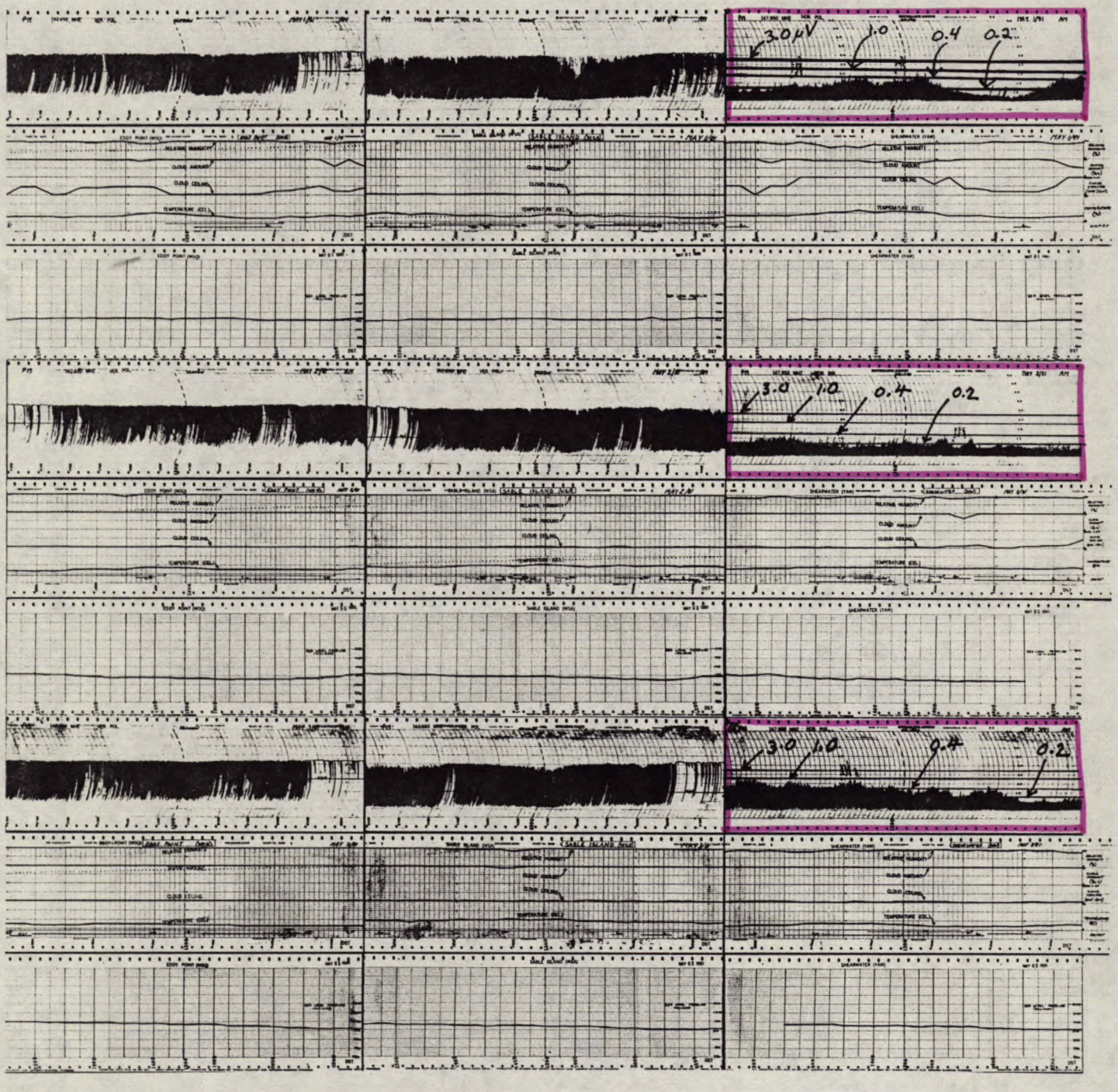
Note #2: This chart displays sea-level pressure only.

(V):vertical polarization
(H):horizontal "

Report

Appendix #2

May 1 to May 3 1981



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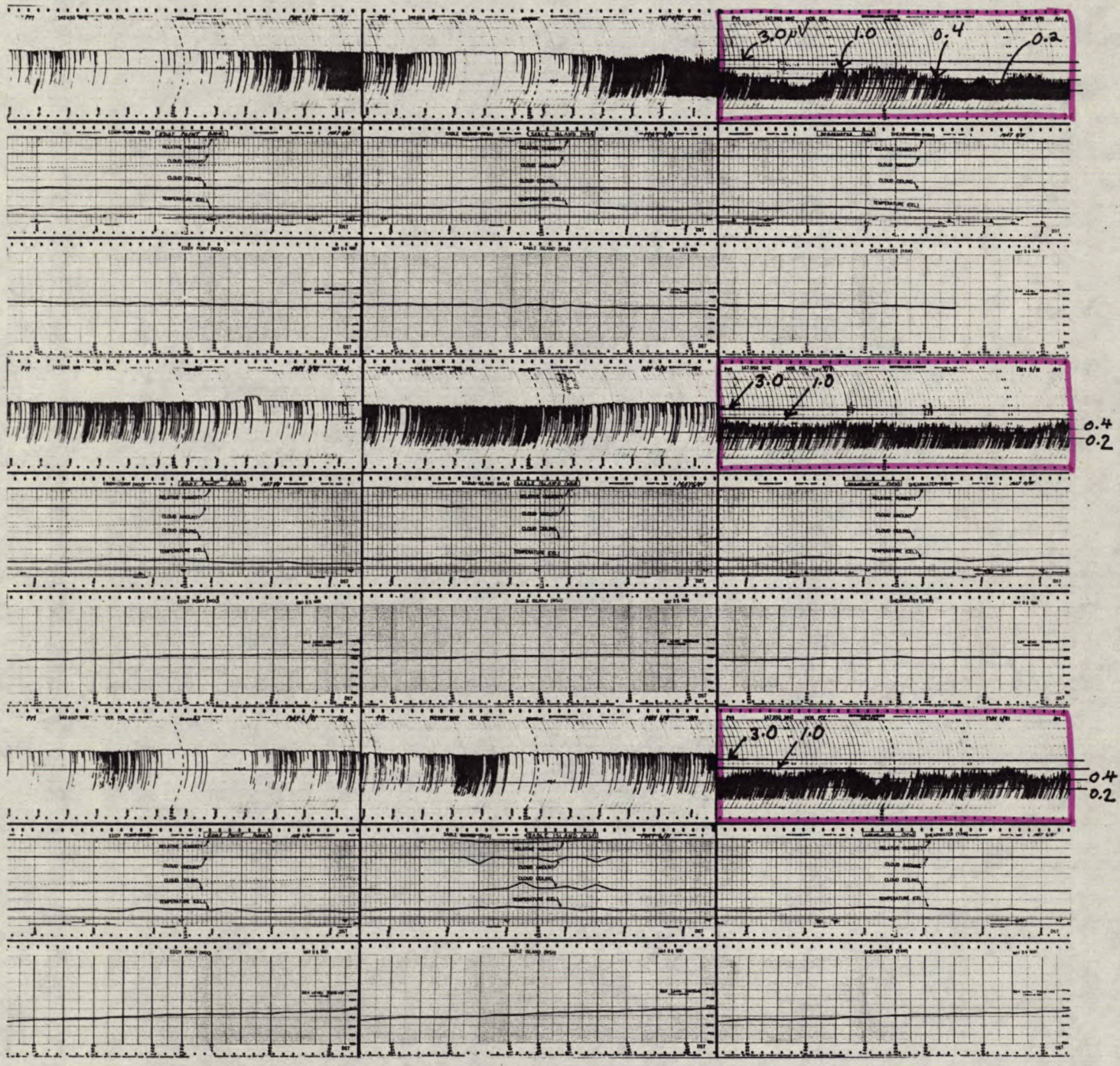
Appendix #2

May 4 to May 6 1981



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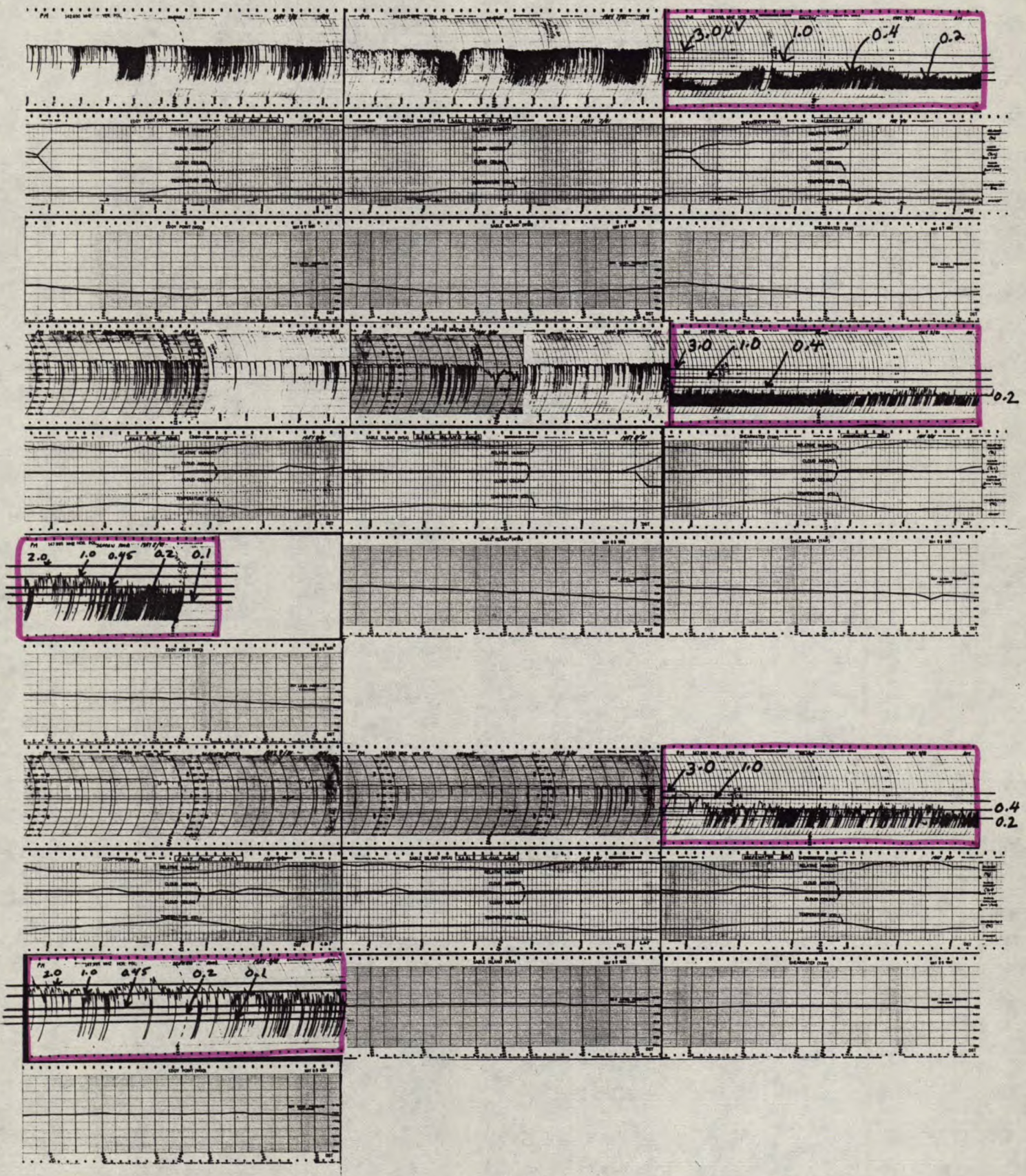
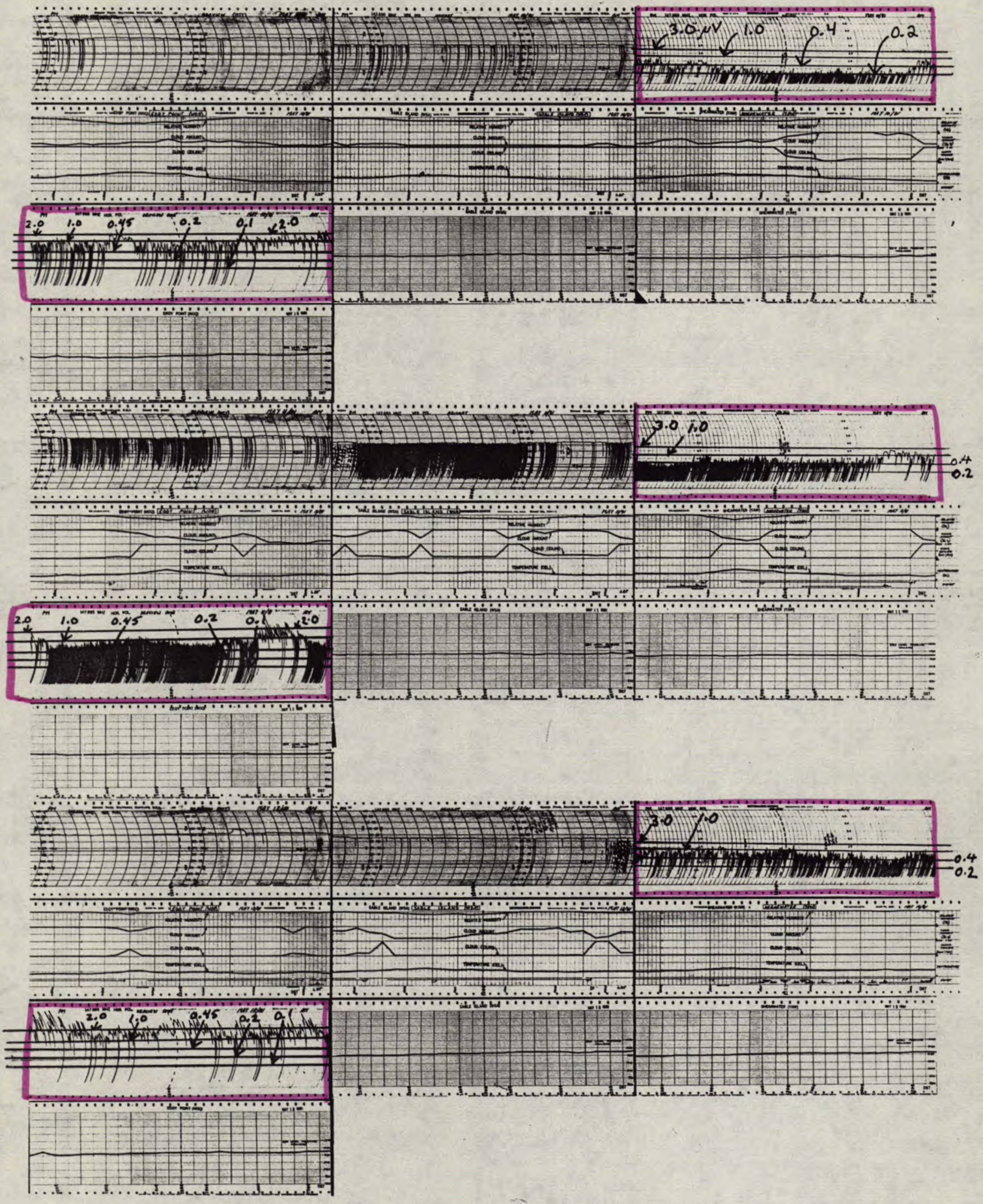
Appendix #2

May 7 to May 9 1981



May 10 to May 12 1981

Report
Appendix #2



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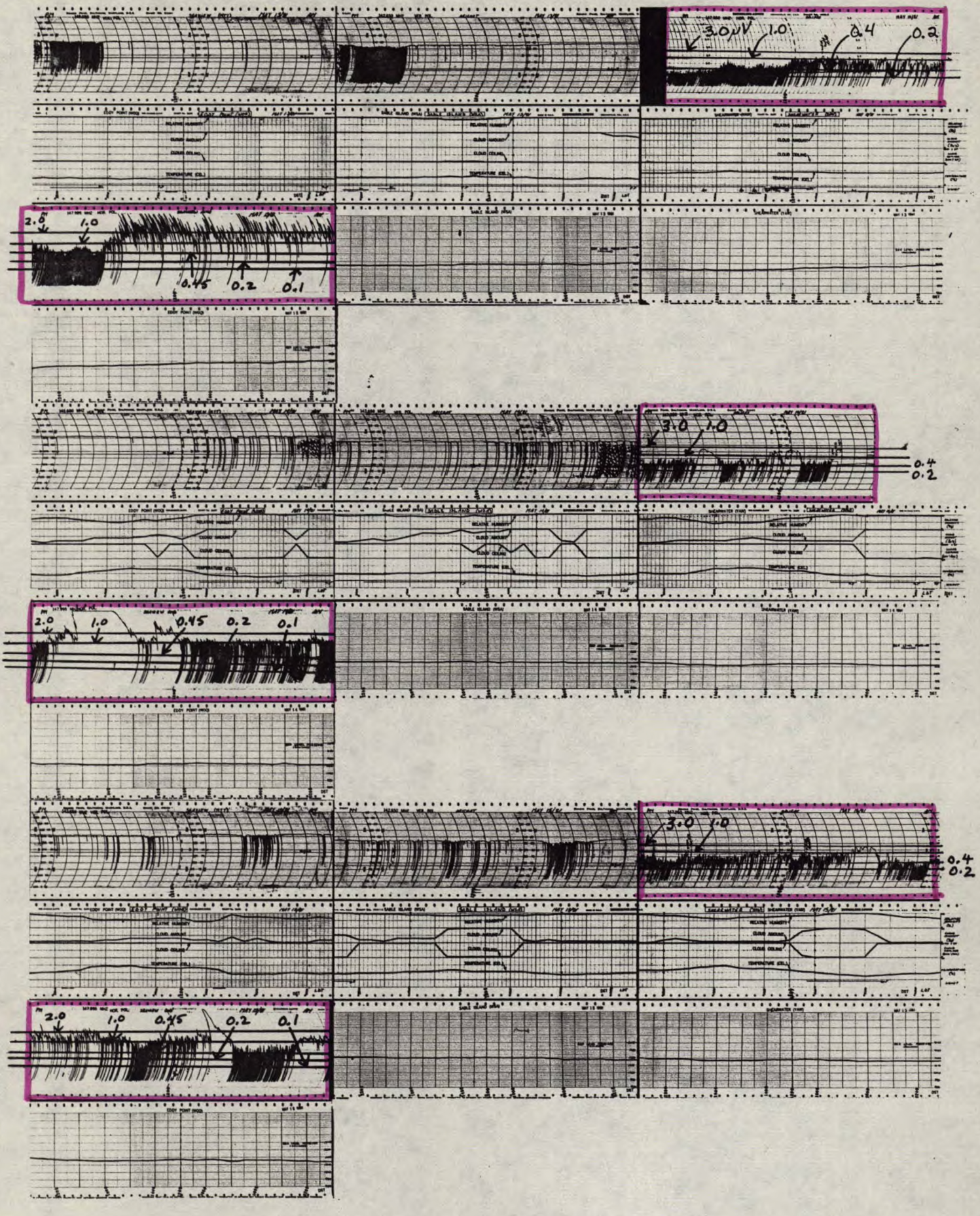
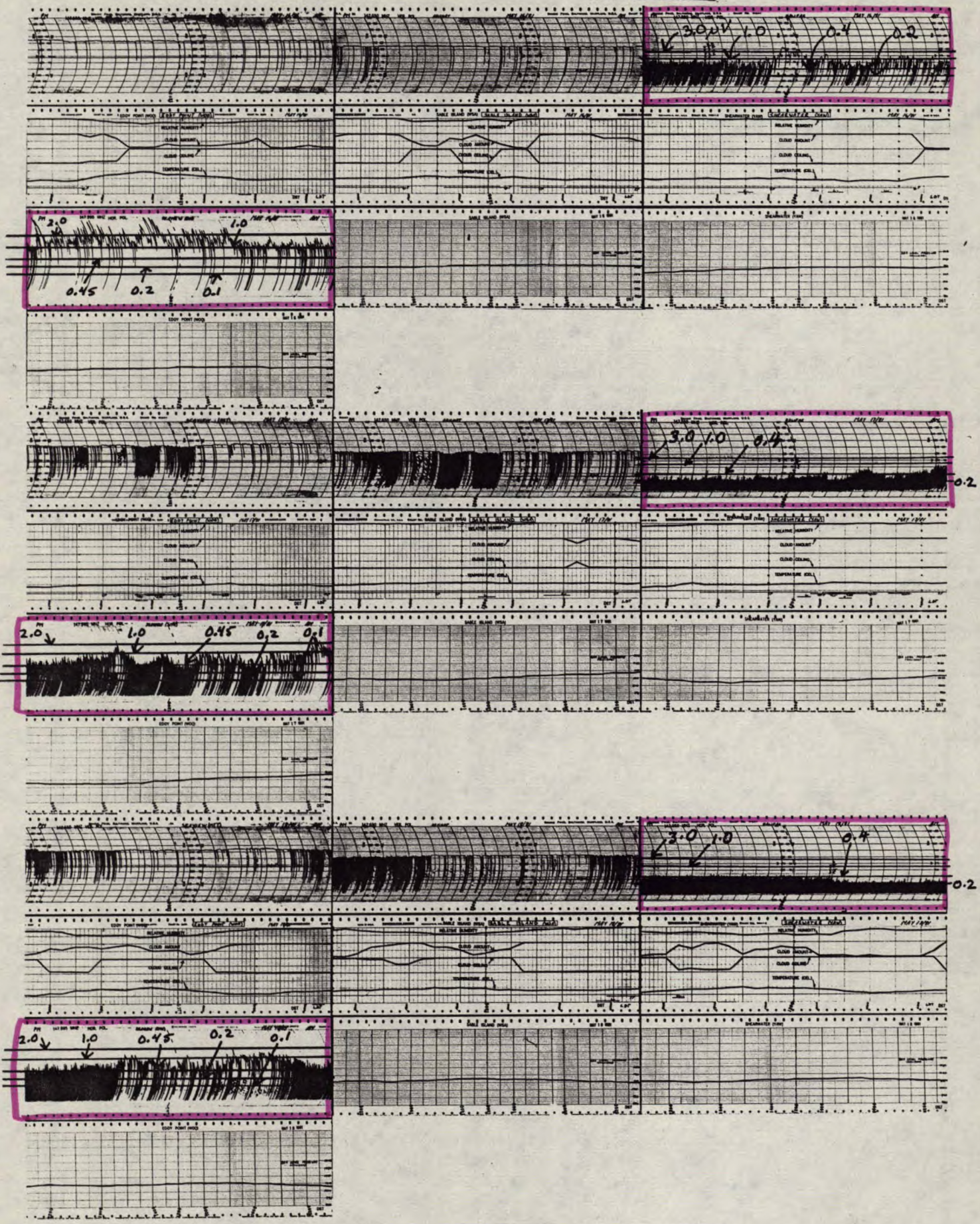
May 13 to May 15 1981 Appendix #2



Report

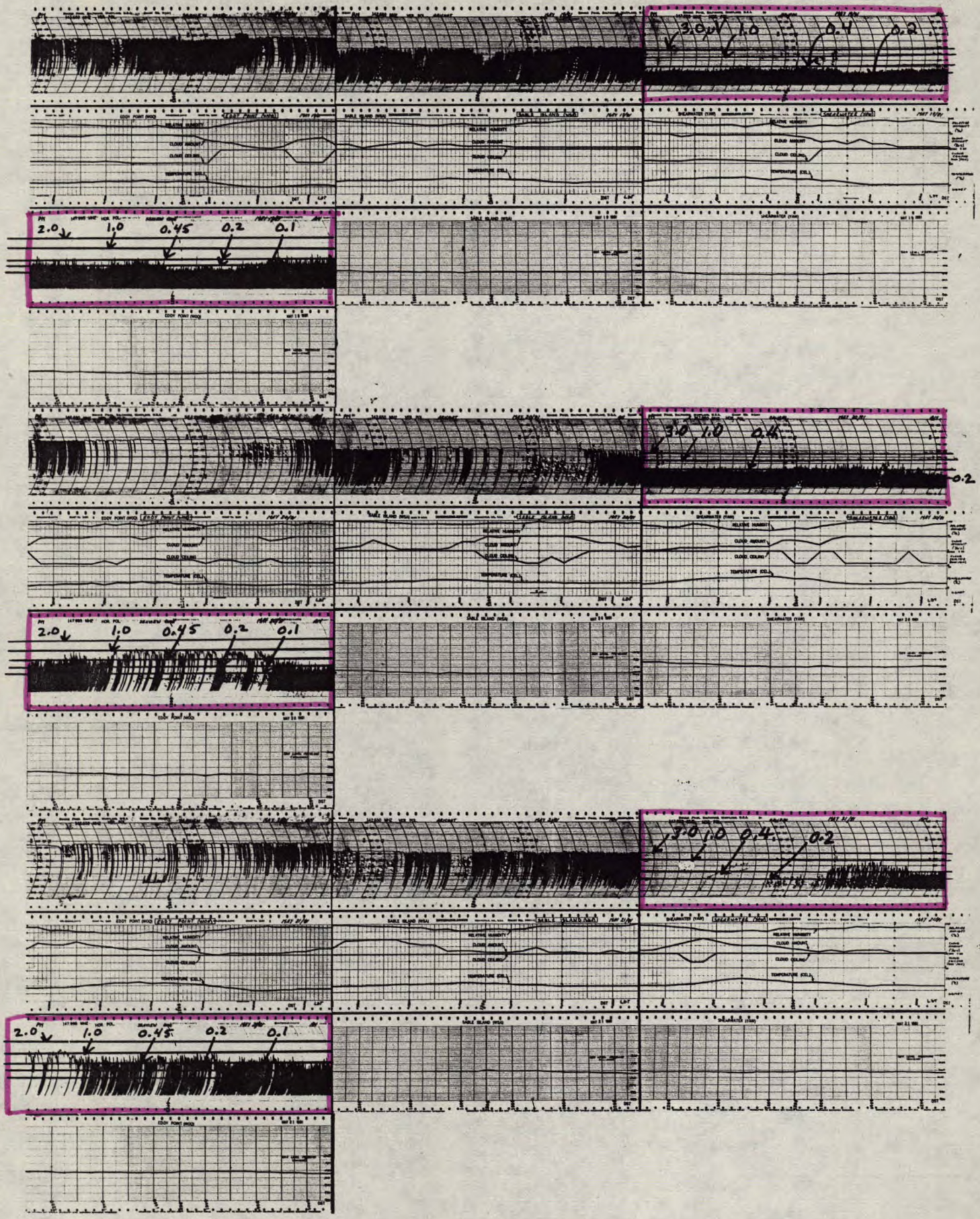
May 16 to May 18 1981 Appendix #2



May 19 to May 21 1981

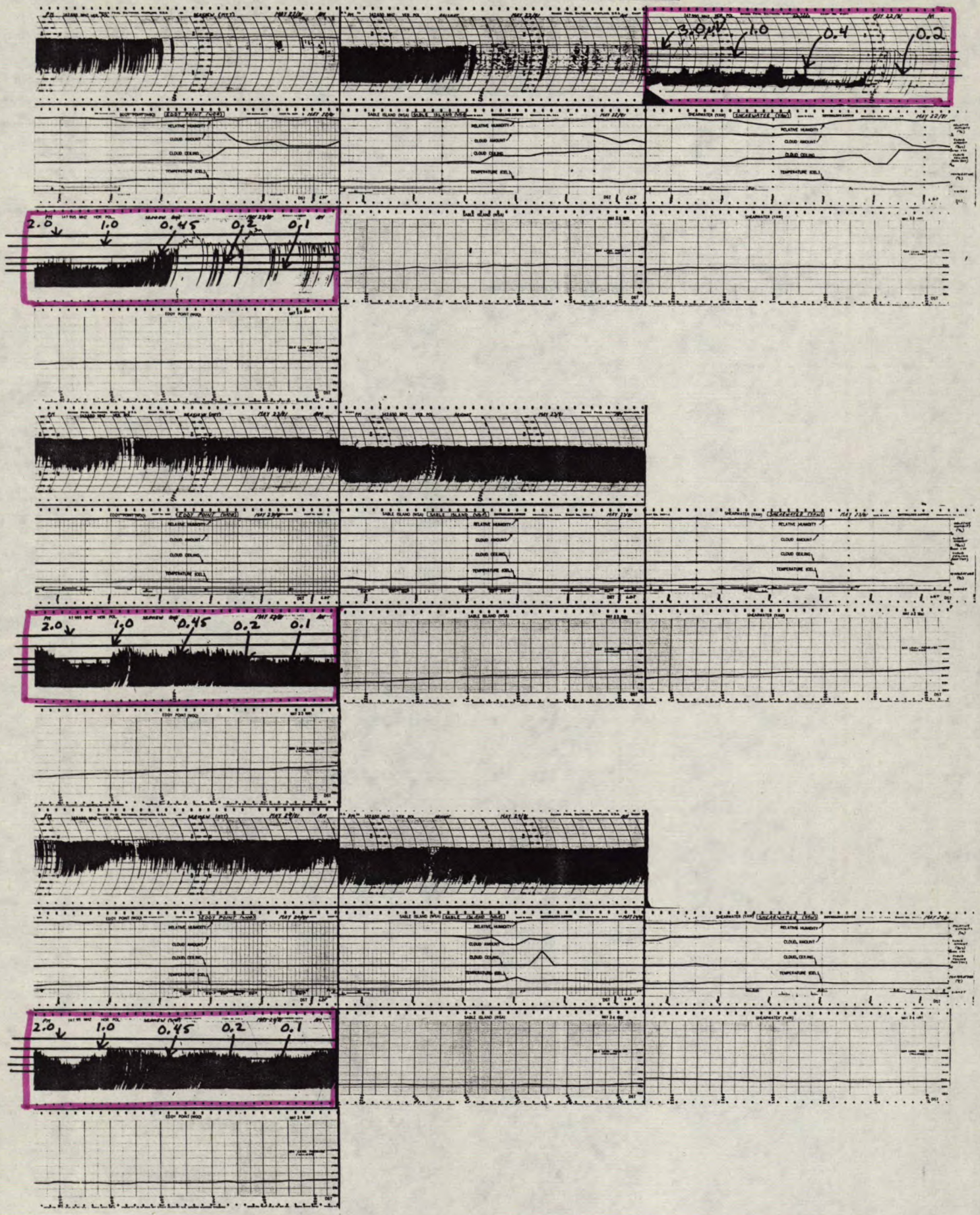
Report

Appendix #2



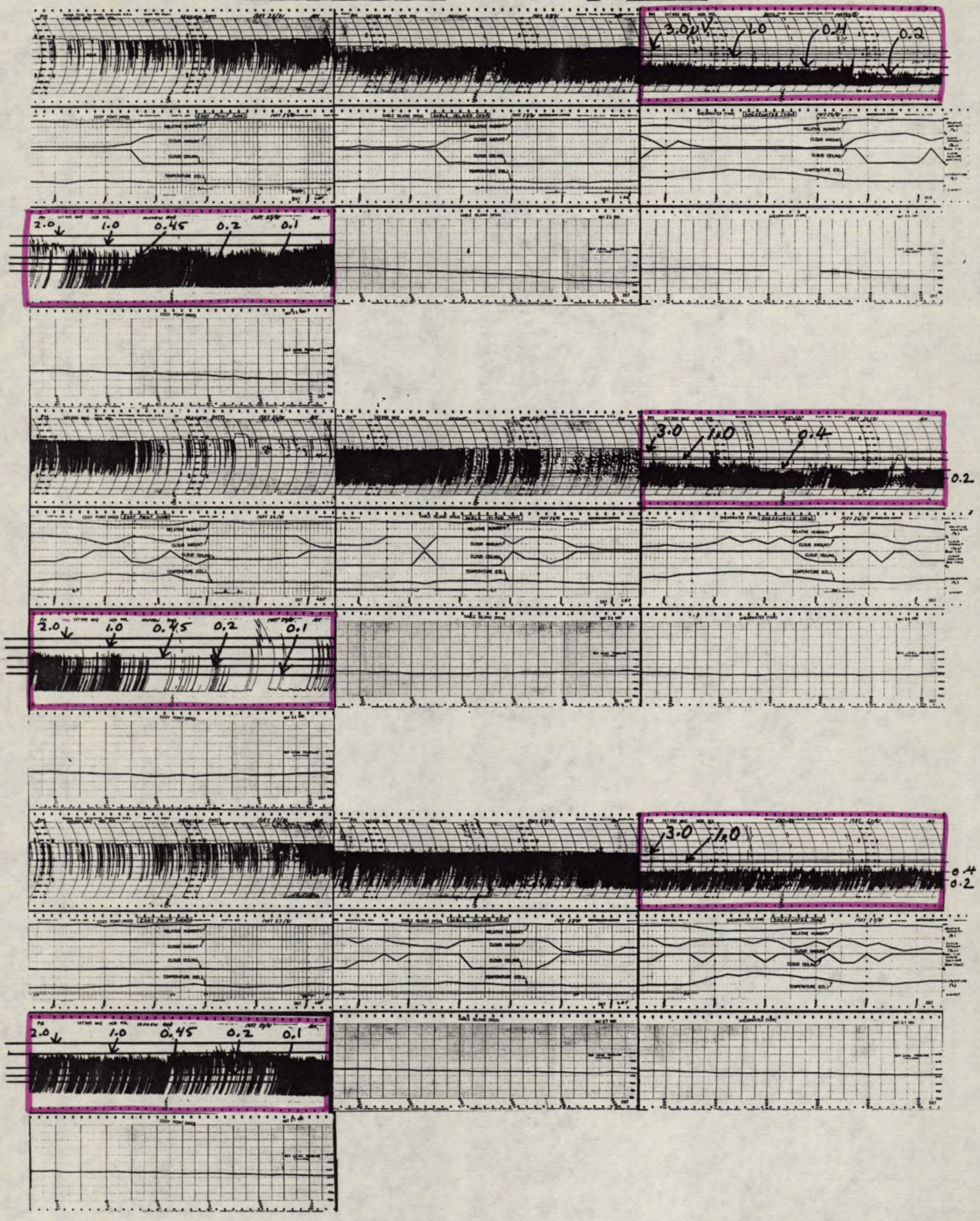
Report

May 22 to May 24 1981 Appendix #2



Report

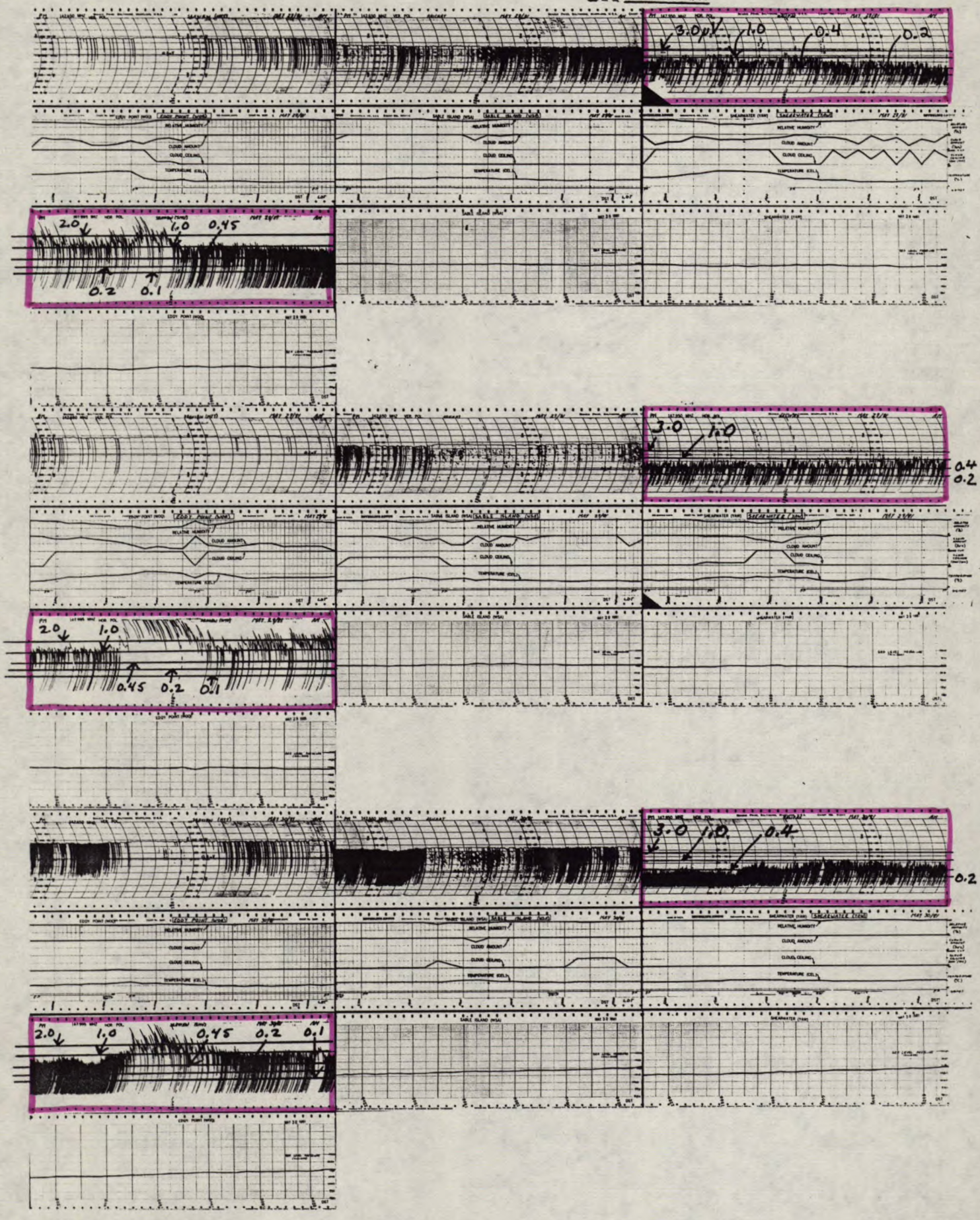
May 25 to May 27 1981 Appendix #2



May 28 to May 30 1981

Report

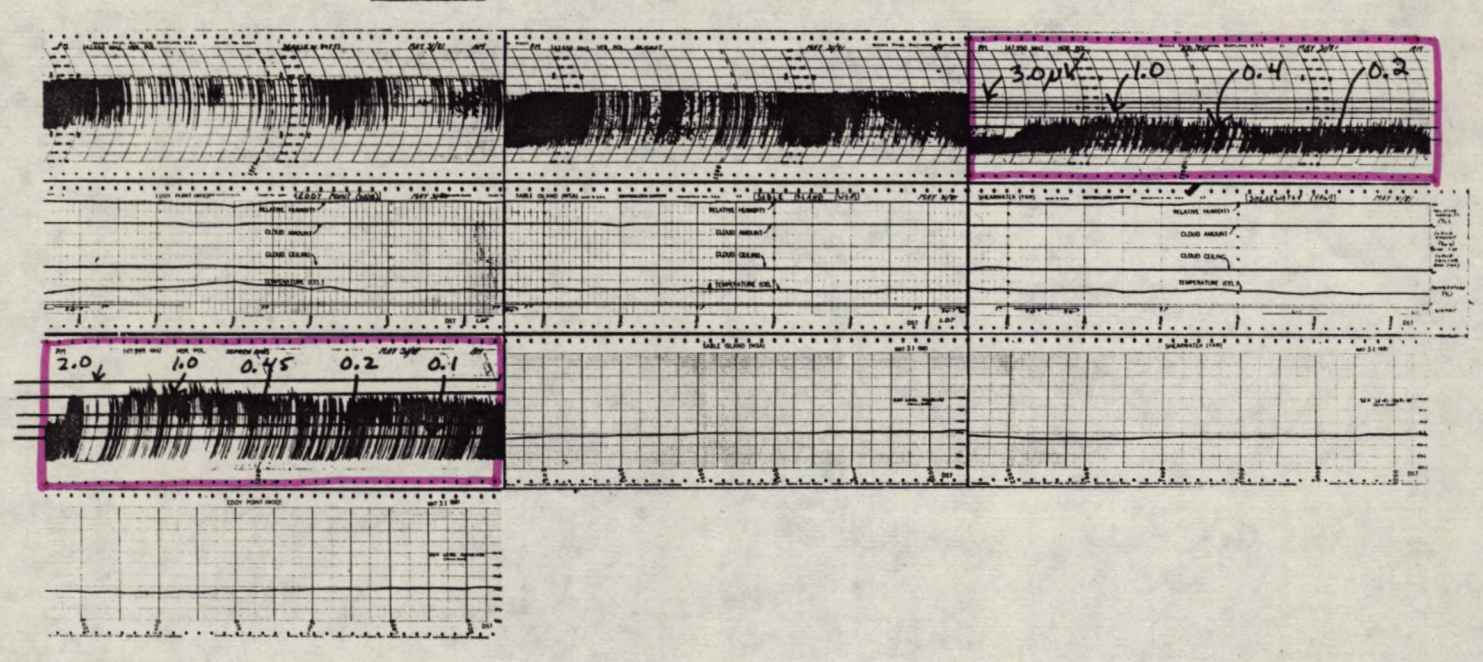
Appendix #2



Report

Appendix #2

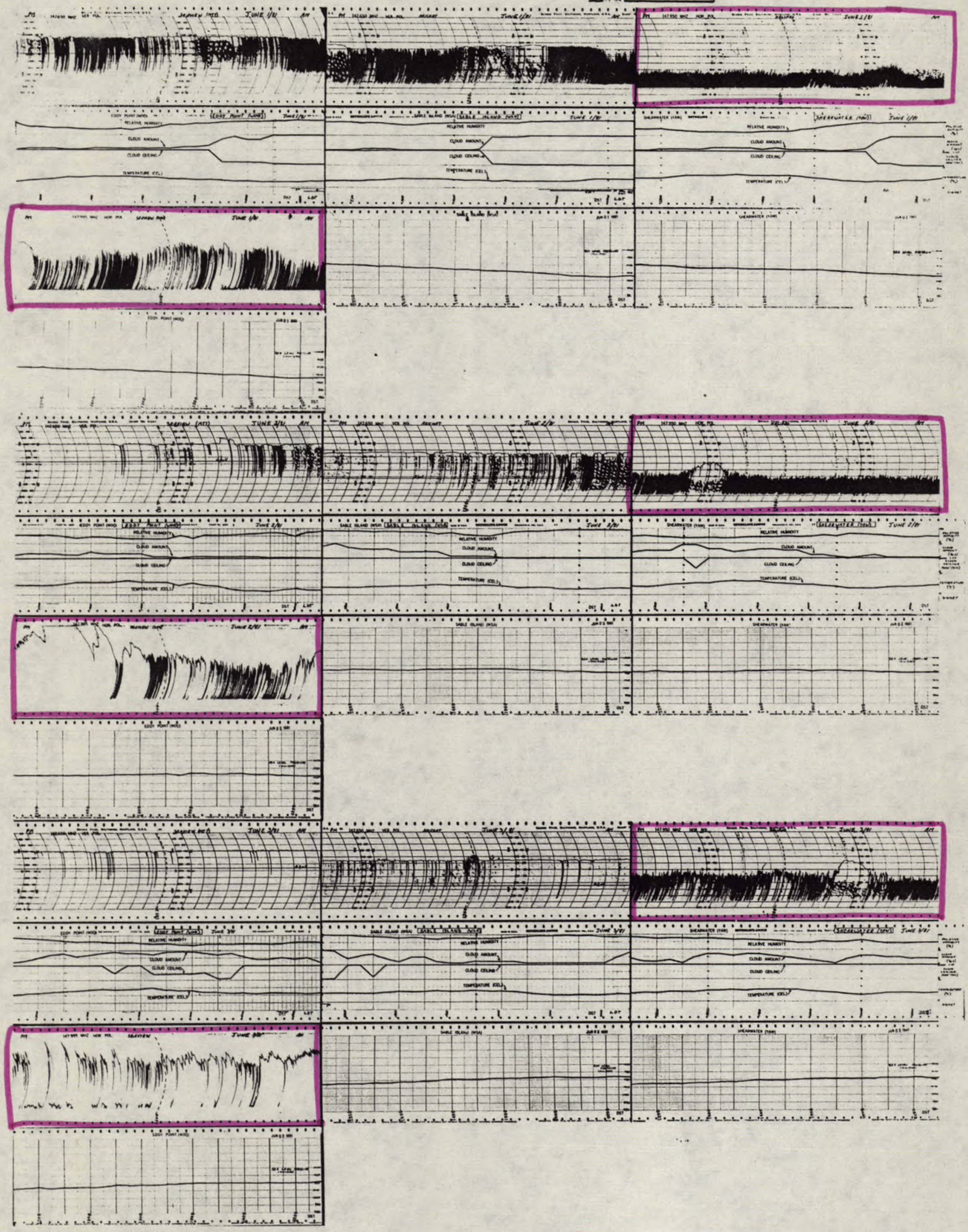
May 31 1981



June 1 to June 3 1981

Report

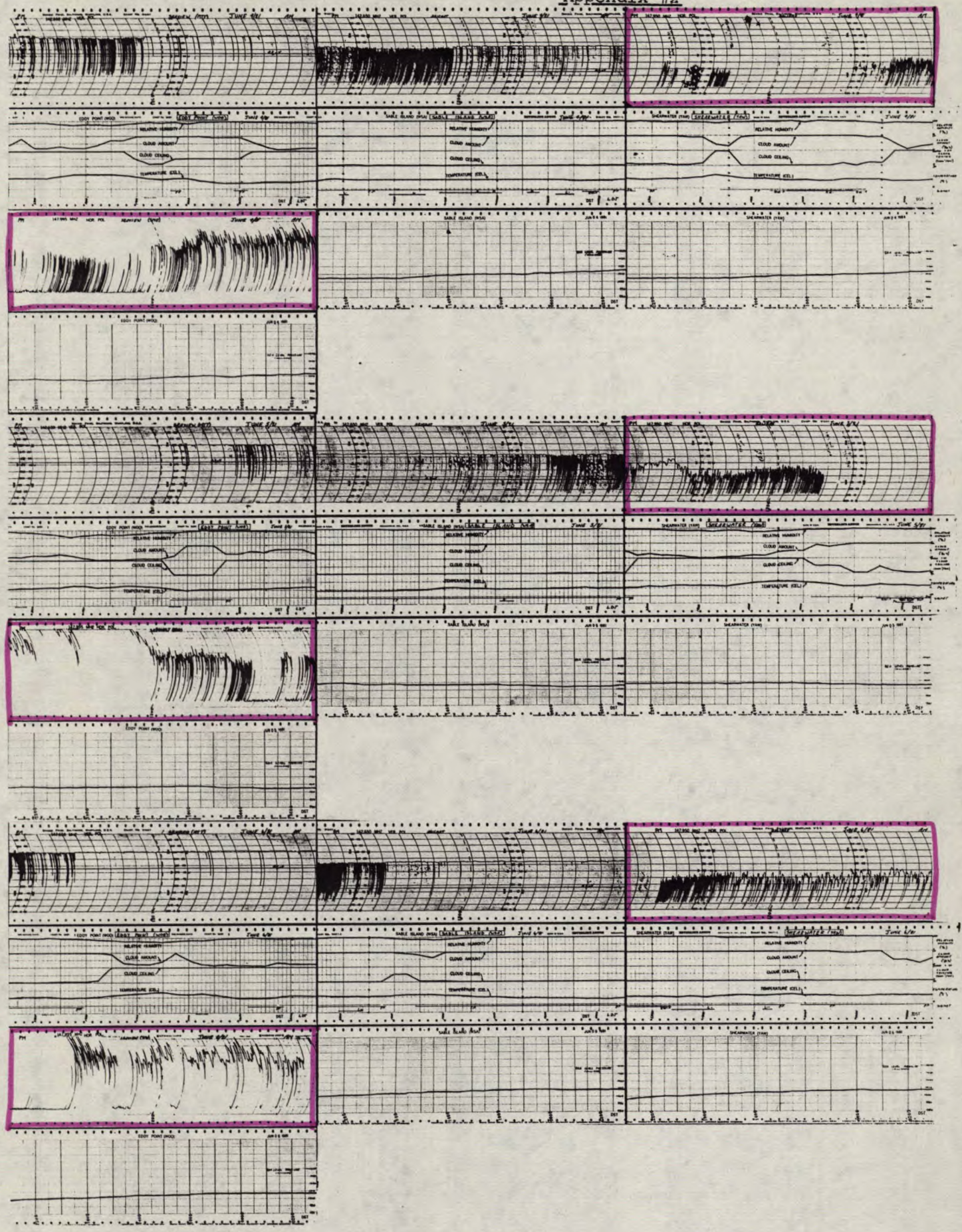
Appendix #2



June 4 to June 6 1981

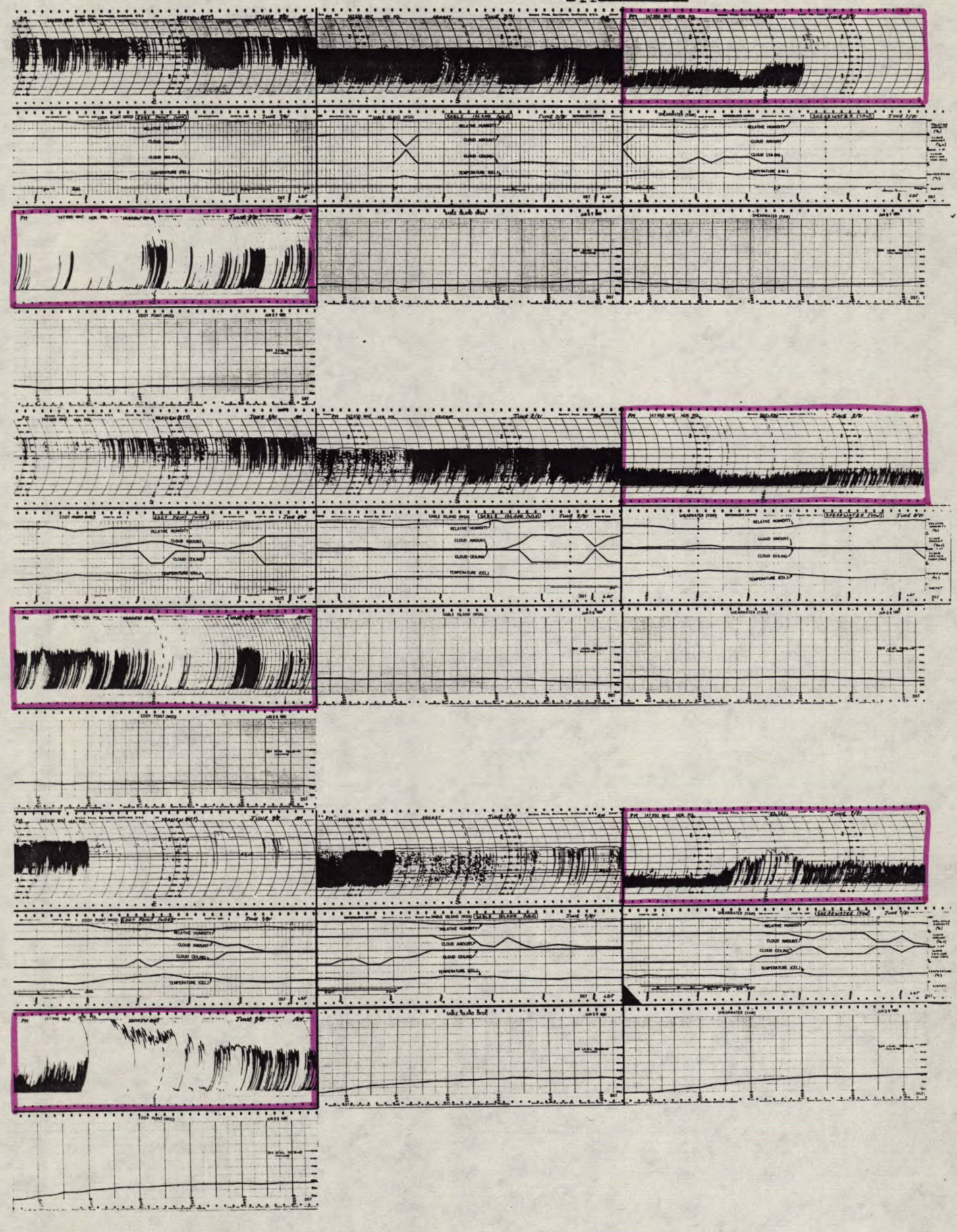
Report

Appendix #2



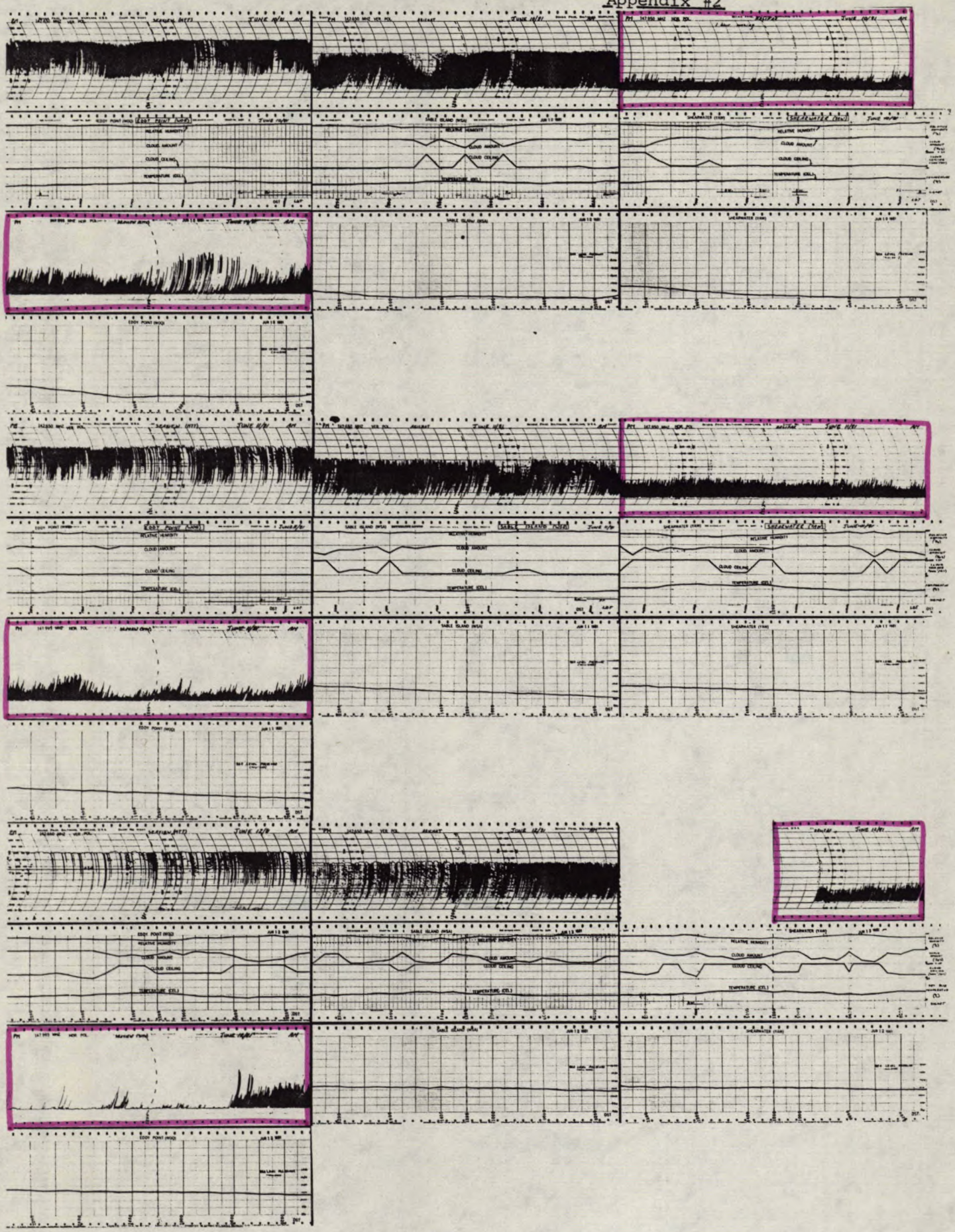
June 7 to June 9 1981 Report

Appendix #2



June 10 to June 12 1981 Report

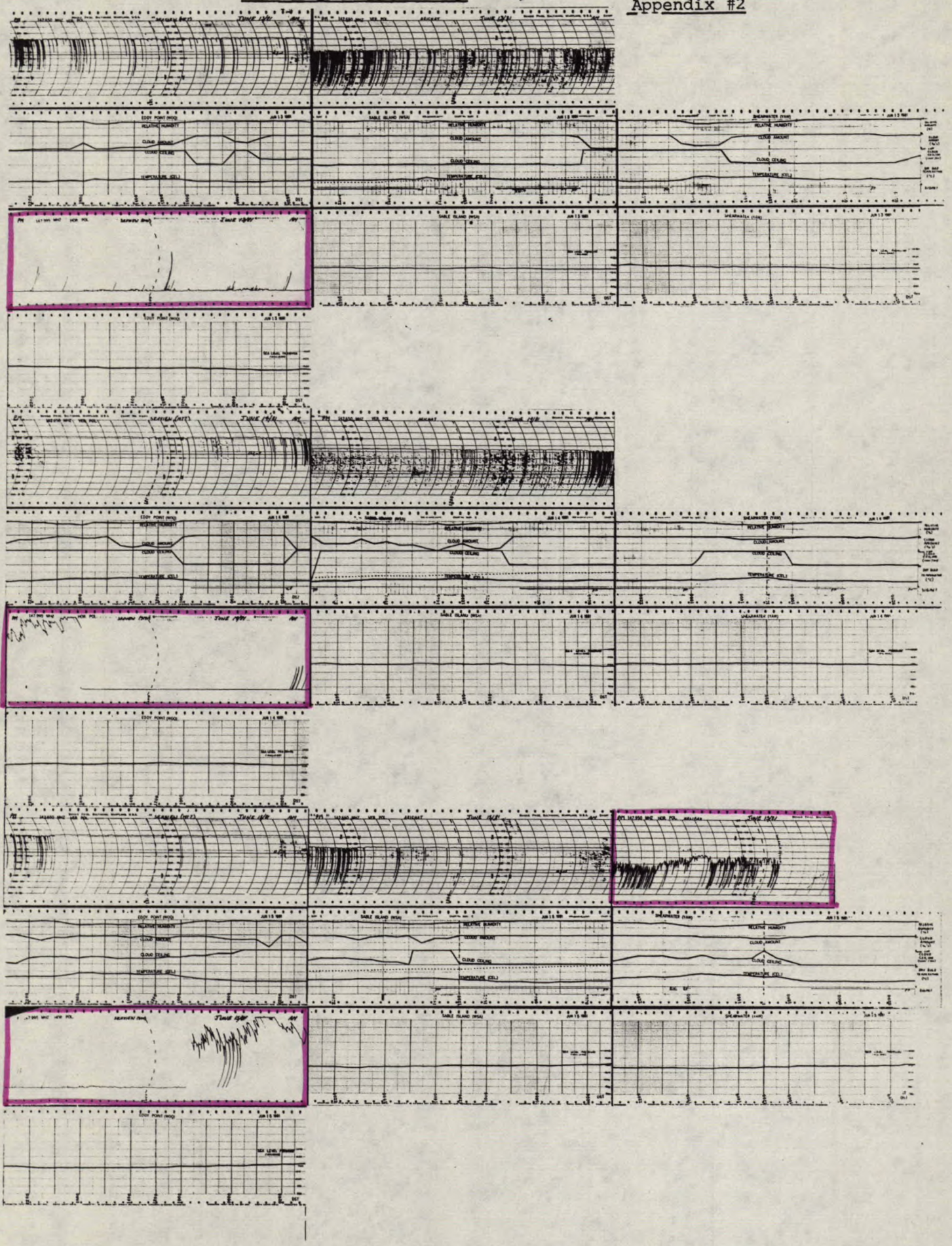
Appendix #2



June 13 to June 15 1981

Report

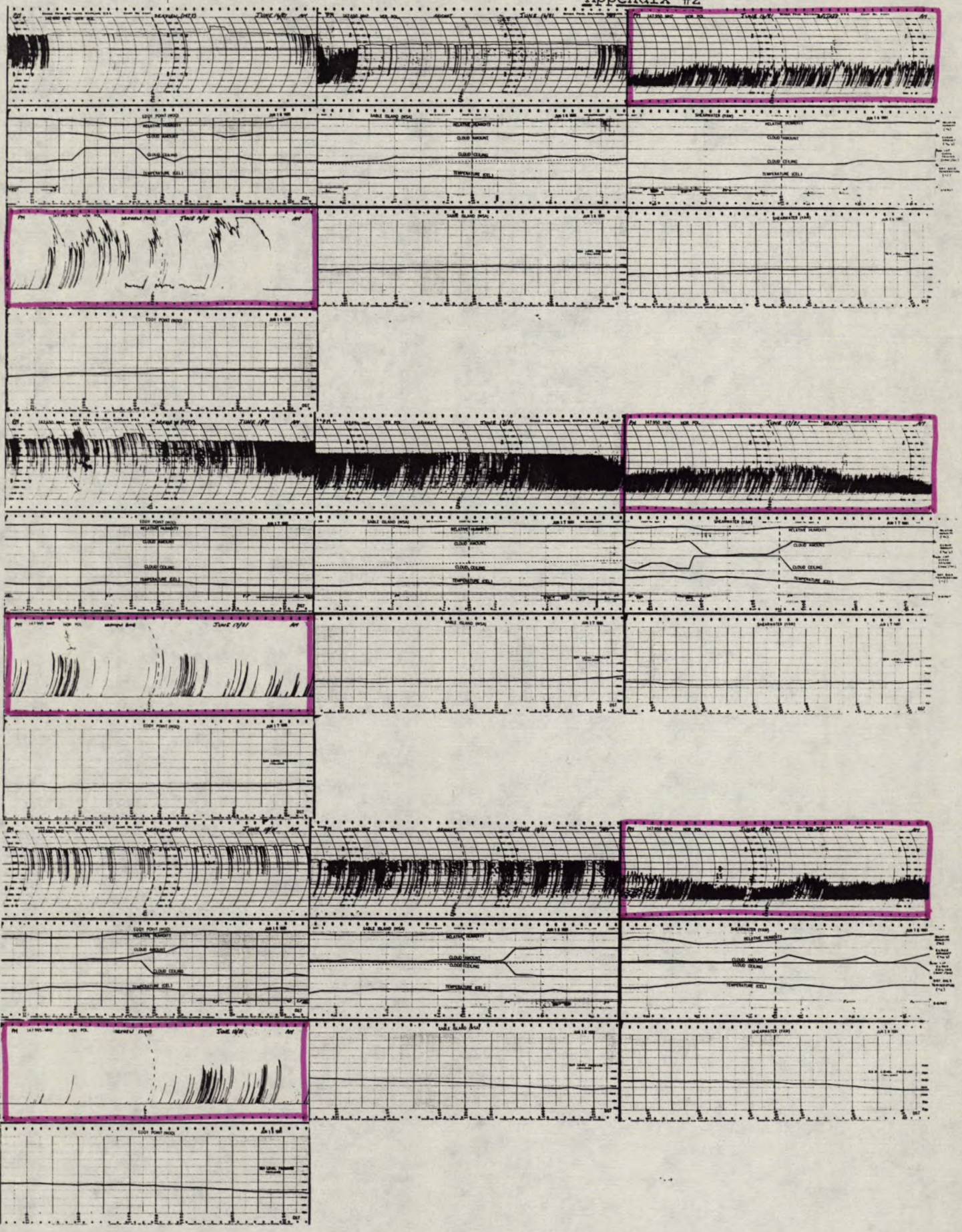
Appendix #2



June 16 to June 18 1981

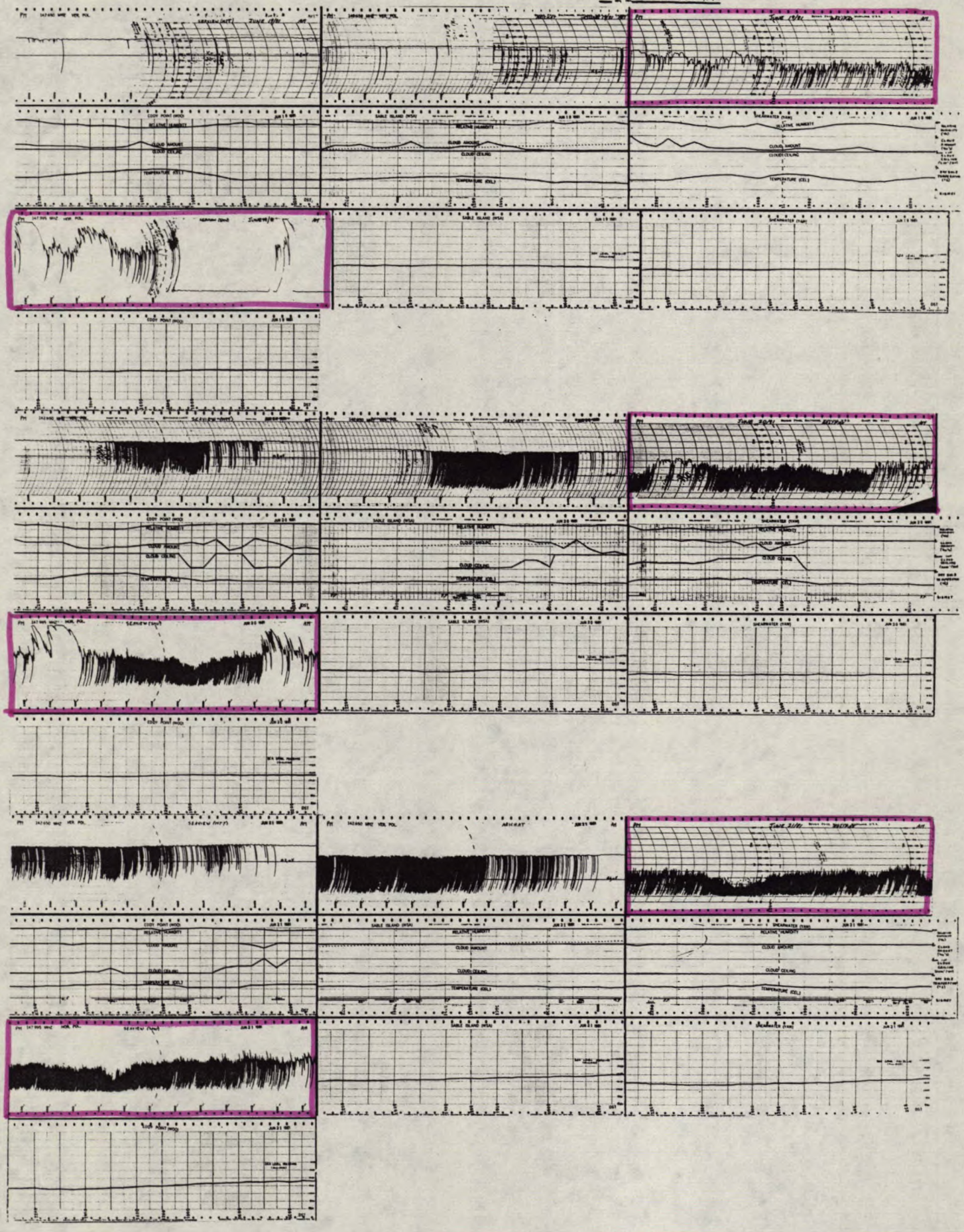
Report

Appendix #2



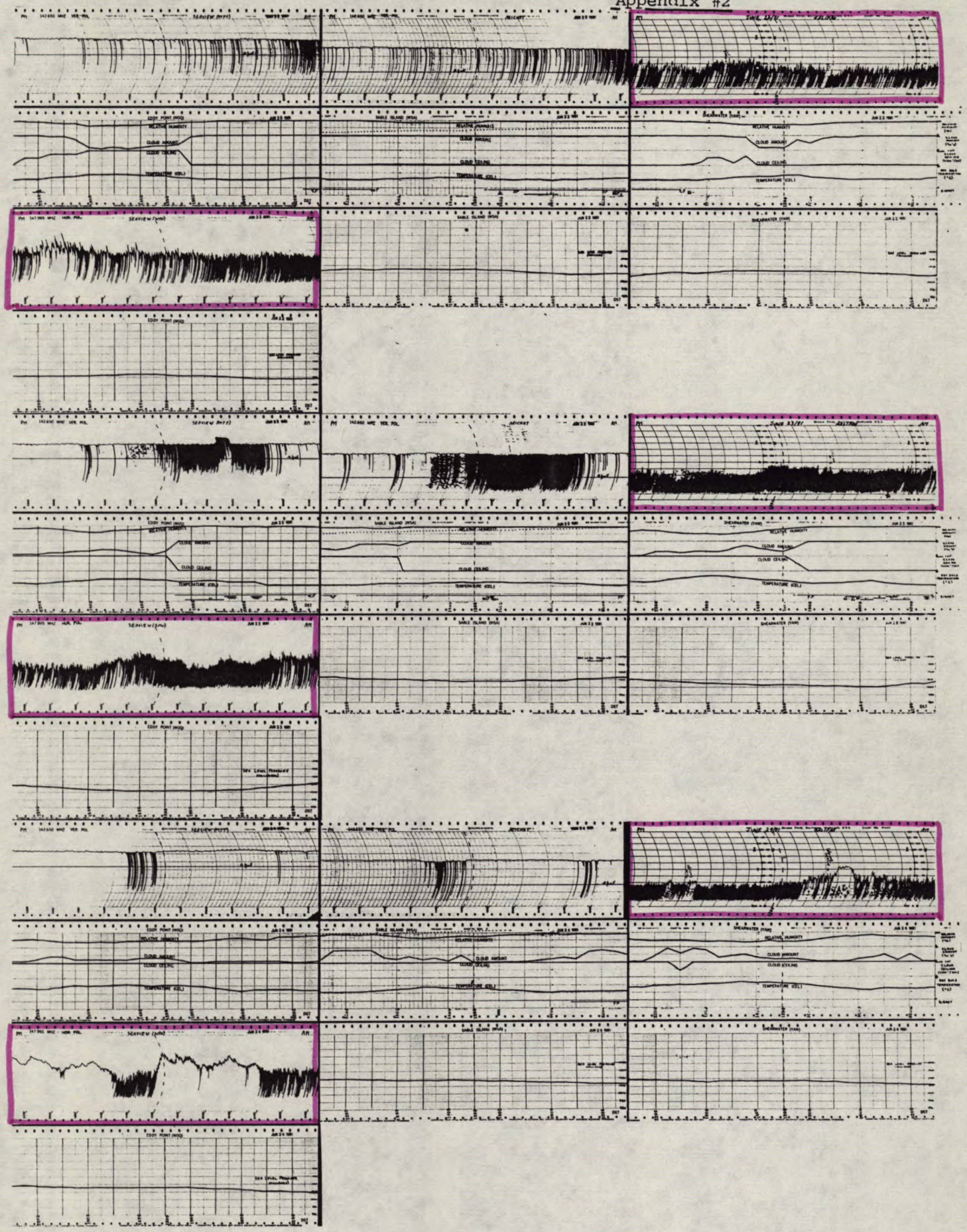
June 19 to June 21 1981 Report

Appendix #2



June 22 to June 24 1981 Report

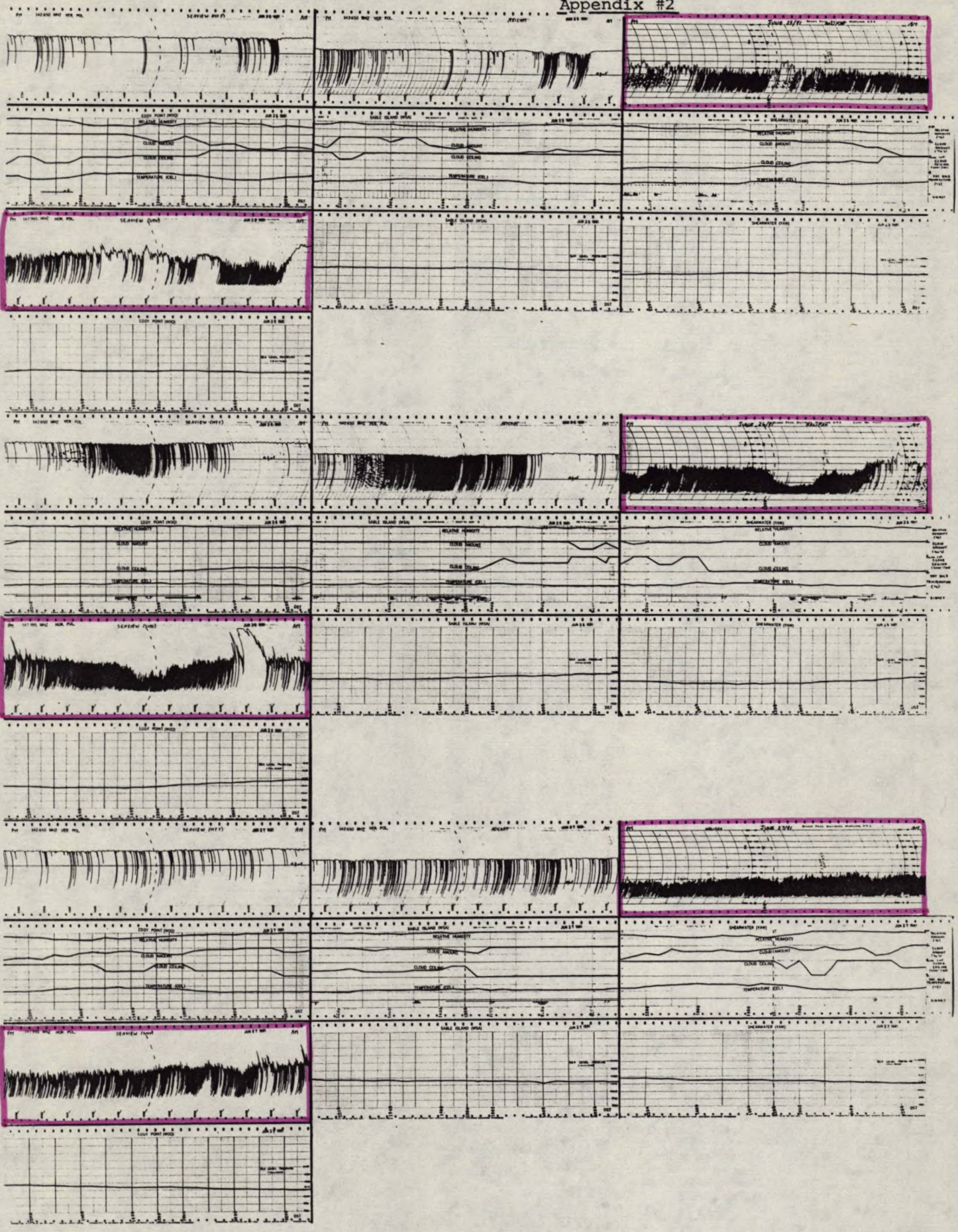
Appendix #2



June 25 to June 27 1981

Report

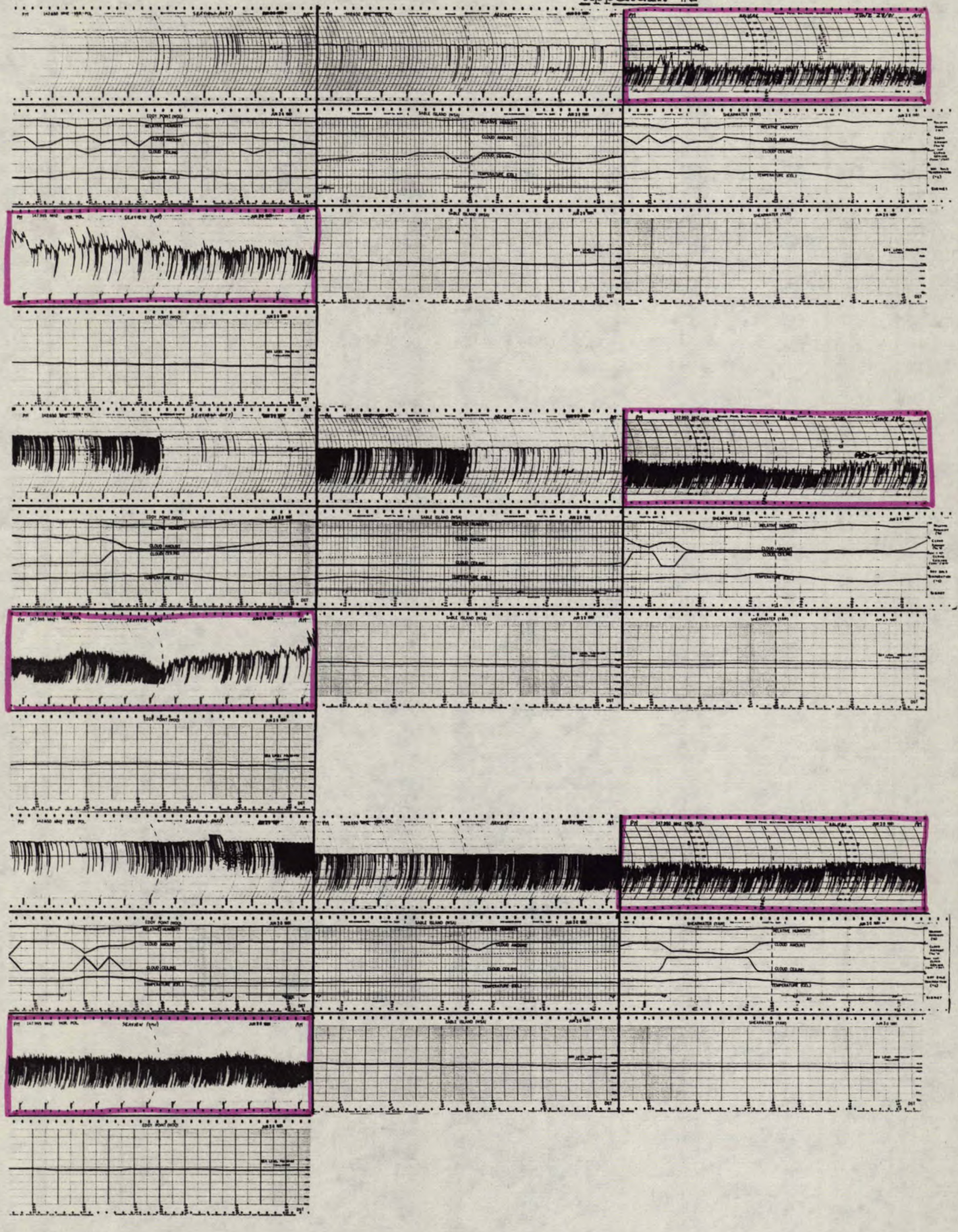
Appendix #2



June 28 to June 30 1981

Report

Appendix #2



APPENDIX B

Enhancement in Propagation at Halifax Commencing May 9, 2000 LT, Terminating May 9, 2359 LT

An enhancement in propagation is observed at Halifax commencing at 2000 LT and terminating at 2359 LT on May 9. An examination of the available meteorological data for the time interval surrounding the commencement of this enhancement reveals no significant discontinuities in cloud amount, cloud ceiling, temperature and sea level pressure at Sable Island, Shearwater and Eddy Point. No significant discontinuities in relative humidity are observed at Sable Island and Eddy Point. A significant discontinuity in relative humidity is observed at Shearwater.

An examination of the available meteorological data of the time interval surrounding the termination of this enhancement again reveals no significant discontinuities in cloud amount, cloud ceiling, temperature, and sea level pressure at Sable Island, Shearwater, and Eddy Point. No significant discontinuities in relative humidity are observed at Sable Island and Eddy Point. A significant discontinuity in relative humidity is observed at Shearwater.

The discontinuity in relative humidity at both the commencement and termination of this enhancement, as observed at Shearwater, indicates a possible correlation.

Enhancement in Propagation at Halifax, Commencing May 11, 0200 LT, Terminating May 11, 0600 LT

An enhancement in propagation is observed at Halifax commencing at 0200 LT and terminating at 0600 LT on May 11. An examination of the available meteorological data for the time interval surrounding the commencement of this enhancement reveals no significant discontinuities

in relative humidity, temperature, and sea level pressure at Sable Island, Shearwater and Eddy Point. No significant discontinuities in cloud ceiling are observed at Eddy Point. A discontinuity in cloud amount is observed at all three meteorological observation facilities. A discontinuity in cloud ceiling is observed at Sable Island and Shearwater.

An examination of the available meteorological data for the time interval surrounding the termination of this enhancement again reveals no significant discontinuities in relative humidity, temperature, and sea level pressure at Sable Island, Shearwater, and Eddy Point. No significant discontinuities in cloud amount are observed at Sable Island and Shearwater. No significant discontinuities in cloud ceiling are observed at Shearwater and Eddy Point. A discontinuity in cloud ceiling is observed at Eddy Point. A discontinuity in cloud amount is observed at Sable Island.

The discontinuity in cloud amount at both the commencement and termination of this enhancement, as observed at Sable Island, indicates a possible correlation. The apparent correlation between enhancement commencement and the discontinuity in cloud ceiling, as observed at Sable Island and Shearwater, may be assumed to be merely coincidental because of the continuous cloud ceiling conditions observed during enhancement termination. The apparent correlation between enhancement commencement and the discontinuity in cloud amount, as observed at Shearwater and Eddy Point, may be assumed to be merely coincidental because of the continuous cloud amount conditions observed during enhancement termination. The apparent correlation between enhancement termination and the discontinuity

in cloud ceiling, as observed at Eddy Point, may also be assumed to be merely coincidental because of the continuous cloud ceiling conditions observed during enhancement commencement.

Enhancement in Propagation at Seaview Commencing May 11 0200 LT, Terminating May 0600 LT

An enhancement in propagation is observed at Seaview commencing at 0200 LT and terminating at 0600 LT on May 11. An examination of the available meteorological data for the time interval surrounding the commencement of this enhancement reveals no significant discontinuities in relative humidity, temperature, at sea level pressure at Sable Island, Shearwater and Eddy Point. No significant discontinuities in cloud ceiling are observed at Eddy Point. A discontinuity in cloud amount is observed at all three meteorological observation facilities. A discontinuity in cloud ceiling is observed at Sable Island and Shearwater.

An examination of the available meteorological data for the time interval surrounding the termination of this enhancement again reveals no significant discontinuities in relative humidity, temperature, and sea level pressure at Sable Island, Shearwater, and Eddy Point. No significant discontinuities in cloud amount are observed at Sable Island and Shearwater. No significant discontinuities in cloud ceiling are observed at Shearwater and Eddy Point. A discontinuity in cloud ceiling is observed at Eddy Point. A discontinuity in cloud amount is observed at Sable Island.

The discontinuity in cloud amount at both the commencement and termination of this enhancement, as observed at Sable Island, indicates a possible correlation. The apparent correlation between enhancement commencement and the discontinuity in cloud ceiling, as observed

at Sable Island and Shearwater, may be assumed to be merely coincidental because of the continuous cloud ceiling conditions observed during enhancement termination. The apparent correlation between enhancement commencement and the discontinuity in cloud amount, as observed at Shearwater and Eddy Point, may be assumed to be merely coincidental because of the continuous cloud amount conditions observed during enhancement termination. The apparent correlation between enhancement termination and the discontinuity in cloud ceiling, as observed at Eddy Point, may also assumed to be merely coincidental because of the continuous cloud ceiling conditions observed during enhancement commencement.

Enhancement in Propagation at Seaview Commencing May 11, 2300 LT, Terminating May 13, 1800 LT

An enhancement in propagation is observed at Seaview commencing at 2300 LT on May 11 and terminating at 1800 LT on May 13. An examination of the available meteorological data for the time interval surrounding the commencement of this enhancement reveals no significant discontinuities in relative humidity, temperature, and sea level pressure at Sable Island, Shearwater, and Eddy Point. No significant discontinuities in cloud amount and cloud ceiling are observed at Shearwater and Eddy Point. Significant discontinuities in cloud amount and cloud ceiling are observed at Sable Island.

An examination of the available meteorological data for the time interval surrounding the termination of this enhancement reveals no significant discontinuities in relative humidity, cloud amount, cloud ceiling, temperature, and sea level pressure at Sable Island, Shearwater, and Eddy Point.

The apparent correlation between enhancement commencement and the discontinuities in cloud amount and cloud ceiling, as observed at Sable Island, may be assumed to be merely coincidental because of the continuous cloud amount and cloud ceiling conditions observed during enhancement termination.

Enhancement in Propagation at Halifax Commencing May 14, 1100 LT, Terminating May 14, 1300 LT

An enhancement in propagation is observed at Halifax commencing at 1100 LT and terminating at 1300 LT on May 14. An examination of the available meteorological data for the time interval surrounding the commencement of this enhancement reveals no significant discontinuities in temperature and sea level pressure at Sable Island, Shearwater, and Eddy Point. No significant discontinuities in cloud amount and cloud ceiling are observed at Shearwater and Eddy Point. No significant discontinuities in relative humidity are observed at Sable Island and Eddy Point. Significant discontinuities in cloud amount and cloud ceiling are observed at Sable Island. A significant discontinuity in relative humidity is observed at Shearwater.

An examination of the available meteorological data for the time interval surrounding the termination of this enhancement reveals no significant discontinuities in sea level pressure at Sable Island, Shearwater, and Eddy Point. No significant discontinuities in cloud amount and cloud ceiling are observed at Shearwater. Significant discontinuities in relative humidity and temperature are observed at all three meteorological observation facilities. Significant discontinuities in cloud amount and cloud ceiling are observed at Sable Island and Eddy Point.

The discontinuities in cloud amount and cloud ceiling at both the commencement and termination of this enhancement, as observed at Sable Island, indicate a possible correlation. The discontinuity in relative humidity at both the commencement and termination of this enhancement, as observed at Shearwater, also indicates a possible correlation. The apparent correlation between enhancement termination and the discontinuity in temperature, as observed at Sable Island, Shearwater and Eddy Point may be assumed to be merely coincidental because of the continuous temperature conditions observed during enhancement commencement. The apparent correlation between enhancement termination and the discontinuity in relative humidity, as observed at Sable Island and Eddy Point, may be assumed to be merely coincidental because of the continuous relative humidity conditions observed during enhancement commencement. The apparent correlation between enhancement termination and the discontinuities in cloud amount and cloud ceiling, as observed at Eddy Point, may also be assumed to be merely coincidental because of the continuous cloud amount and cloud ceiling conditions observed during enhancement commencement.

Enhancement in Propagation at Halifax Commencing May 14, 1700 LT, Terminating May 14, 1900 LT

An enhancement in propagation is observed at Halifax commencing at 1700 LT and terminating at 1900 LT on May 14. An examination of the available meteorological data for the time interval surrounding the commencement of this enhancement reveals no significant discontinuities in relative humidity, cloud ceiling, temperature and sea level pressure at Sable Island, Shearwater, and Eddy Point. No significant discontinuities in cloud

amount are observed at Shearwater and Eddy Point. A significant discontinuity in cloud amount is observed at Sable Island.

An examination of the available meteorological data for the time interval surrounding the termination of this enhancement reveals no significant discontinuities in cloud ceiling, temperature, and sea level pressure at Sable Island, Shearwater, and Eddy Point. No significant discontinuities in relative humidity are observed at Sable Island and Eddy Point. No significant discontinuities in cloud amount are observed at Shearwater and Eddy Point. No significant discontinuities in relative humidity are observed at Shearwater. A significant discontinuity in cloud amount is observed at Sable Island.

The discontinuity in cloud amount at both the commencement and termination of this enhancement, as observed at Sable Island, indicates a possible correlation. The apparent correlation between enhancement termination and the discontinuity in relative humidity, as observed at Shearwater, may be assumed to be merely coincidental because of the continuous relative humidity conditions observed during enhancement commencement.

Enhancement in Propagation at Seaview Commencing May 14, 1200 LT, Terminating May 14, 1400 LT

An enhancement in propagation is observed at Seaview commencing at 1200 LT and terminating at 1400 LT on May 14. An examination of the available meteorological data for the time interval surrounding the commencement of this enhancement reveals no significant discontinuities in temperature and relative humidity at Sable Island, Shearwater, and Eddy Point. No significant discontinuities

in cloud amount and cloud ceiling are observed at Shearwater. A significant discontinuity in relative humidity is observed at all three meteorological observation facilities. Significant discontinuities in cloud amount and cloud ceiling are observed at Sable Island and Eddy Point.

An examination of the available meteorological data for the time interval surrounding the termination of this enhancement reveals no significant discontinuities in sea level pressure at Sable Island, Shearwater, and Eddy Point. Significant discontinuities in relative humidity and cloud amount are observed at all three meteorological observation facilities. Significant discontinuities in cloud ceiling are observed at Sable Island and Eddy Point. Significant discontinuities in temperature are observed at Shearwater and Eddy Point.

The discontinuity in relative humidity at both the commencement and termination of this enhancement, as observed at Sable Island, Shearwater, and Eddy Point, indicates a possible correlation. The discontinuities in cloud amount and cloud ceiling at both the commencement and termination of this enhancement, as observed at Sable Island and Eddy Point, also indicates a possible correlation. The apparent correlation between enhancement termination and the discontinuity in temperature, as observed at Shearwater and Eddy Point, may be assumed to be merely coincidental because of the continuous temperature conditions observed during enhancement commencement. The apparent correlation between enhancement termination and the discontinuity in cloud amount, as observed at Shearwater, may also be assumed to be merely coincidental because of the continuous cloud amount conditions observed during enhancement commencement.

APPENDIX B

Enhancement in Propagation at Seaview Commencing May 14, 1600 LT, Terminating May 14, 2200 LT

An enhancement in propagation is observed at Seaview commencing at 1600 LT and terminating at 2200 LT on May 14. An examination of the available meteorological data for the time interval surrounding the commencement of this enhancement reveals no significant discontinuities in cloud ceiling, temperature and sea level pressure at Sable Island, Shearwater and Eddy Point. No significant discontinuities in relative humidity are observed at Sable Island and Shearwater. No significant discontinuities in cloud amount are observed at Sable Island. A significant discontinuity in cloud amount is observed at Shearwater and Eddy Point. A significant discontinuity in relative humidity is observed at Eddy Point.

An examination of the available meteorological data for the time interval surrounding the termination of this enhancement reveals no significant discontinuities in relative humidity, cloud ceiling, temperature and sea level pressure at Sable Island, Shearwater and Eddy Point. A significant discontinuity in cloud amount is observed at all three meteorological observation facilities.

The discontinuity in cloud amount at both the commencement and termination of this enhancement, as observed at Shearwater and Eddy Point, indicates a possible correlation. The apparent correlation between enhancement commencement and the discontinuity in relative humidity, as observed at Eddy Point, may be assumed to be merely coincidental because of the continuous cloud amount conditions observed during enhancement termination. The apparent correlation between enhancement termination and the discontinuity in cloud amount, as observed at Sable Island, may also

be assumed to be merely coincidental because of the continuous cloud amount conditions observed during enhancement commencement.

Enhancement in Propagation at Halifax Commencing May 15, 0500 LT, Terminationg May 15, 0700 LT

An enhancement in propagation is observed at Halifax commencing at 0500 LT and terminating at 0700 LT on May 15.

An examination of the available meteorological data for the time interval surrounding the commencement of this enhancement reveals no significant discontinuities in relative humidity, temperature and sea level pressure at Sable Island, Shearwater and Eddy Point. No significant discontinuities in cloud amount are observed at Sable Island. Significant discontinuities in cloud amount and cloud ceiling are observed at Shearwater. A significant discontinuity in cloud amount is observed at Eddy Point.

An examination of the available meteorological data for the time interval surrounding the termination of this enhancement reveals no significant discontinuities in cloud ceiling, temperature and sea level pressure at Sable Island, Shearwater and Eddy Point. No significant discontinuities in relative humidity and cloud amount are observed at Sable Island and Shearwater. Significant discontinuities in cloud amount and relative humidity are observed at Eddy Point.

The discontinuity in cloud amount at both the commencement and termination of this enhancement, as observed at Eddy Point, indicates a possible correlation. The apparent correlation betwen enhancement commencement and the discontinuities in cloud amount and cloud ceiling, as observed at Shearwater, may be assumed to

be merely coincidental because of the continuous cloud amount and cloud ceiling conditions observed during enhancement termination. The apparent correlation between enhancement termination and the discontinuity in relative humidity, as observed at Eddy Point, may also be assumed to be merely coincidental because of the continuous relative humidity conditions observed during enhancement commencement.

Enhancement in Propagation at Seaview Commencing May 15, 0000 LT, Terminating May 15, 0200 LT

An enhancement in propagation is observed at Seaview commencing at 0000 LT and terminating at 1200 LT on May 15.

An examination of the available meteorological data for the time interval surrounding the commencement of this enhancement reveals no significant discontinuities in relative humidity, cloud amount, cloud ceiling, temperature and sea level pressure at Sable Island, Shearwater and Eddy Point.

An examination of the available meteorological data for the time interval surrounding the termination of this enhancement reveals no significant discontinuities in relative humidity, cloud ceiling, temperature, and sea level pressure at Sable Island, Shearwater and Eddy Point. No significant discontinuities in cloud amount are observed at Sable Island and Shearwater. A significant discontinuity in cloud amount is observed at Eddy Point.

The apparent correlation between enhancement termination and the discontinuity in cloud amount, as observed at Eddy Point, may be assumed to be merely coincidental because of the continuous cloud amount conditions observed during enhancement commencement.

Enhancement in Propagation at Seaview Commencing May 15, 0800 LT, Terminating May 15, 1000 LT

An enhancement in propagation is observed at Seaview commencing at 0800 LT and terminating at 1000 LT on May 15. An examination of the available meteorological data for the time interval surrounding the commencement of this enhancement reveals no significant discontinuities in cloud ceiling and sea level pressure at Sable Island, Shearwater and Eddy Point. No significant discontinuities are observed in relative humidity and cloud amount at Sable Island and Shearwater. No significant discontinuities in temperature are observed at Sable Island. A significant discontinuity in temperature is observed at Shearwater and Eddy Point. A significant discontinuity in relative humidity and cloud amount is observed at Eddy Point.

An examination of the available meteorological data for the time interval surrounding the termination of this enhancement reveals no significant discontinuities in sea level pressure at Sable Island, Shearwater and Eddy Point. No significant discontinuities in relative humidity are observed at Sable Island and Shearwater. No significant discontinuities in cloud ceiling are observed at Eddy Point. No significant discontinuities in temperature are observed at Sable Island. A significant discontinuity in cloud amount is observed at all three meteorological observation facilities. A significant discontinuity in cloud ceiling is observed at Sable Island and Shearwater. A significant discontinuity in temperature is observed at Shearwater and Eddy Point. A significant discontinuity in relative humidity is observed at Shearwater.

The discontinuity in temperature at both the commencement and termination of this enhancement, as observed at Shearwater and Eddy Point, indicates

a possible correlation. The discontinuity in cloud amount at both the commencement and termination of this enhancement, as observed at Eddy Point, also indicates a possible correlation. The apparent correlation between enhancement termination and the discontinuities in cloud amount and cloud ceiling, as observed at Sable Island, may be assumed to be merely coincidental because of the continuous cloud amount and cloud ceiling conditions observed during enhancement commencement. The apparent correlation between enhancement termination and discontinuities in relative humidity, cloud amount and cloud ceiling, as observed at Shearwater, may be assumed to be merely coincidental because of the continuous relative humidity, cloud amount, and cloud ceiling conditions observed during enhancement commencement. The apparent correlation between enhancement commencement and the discontinuity in relative humidity, as observed at Eddy Point, may also be assumed to be merely coincidental because of the continuous relative humidity conditions observed during enhancement termination.

Enhancement in Propagation at Halifax Commencing May 16, 1100 LT, Terminating May 16, 1400 LT

An enhancement in propagation is observed at Halifax commencing at 1100 LT and terminating at 1400 LT on May 16. An examination of the available meteorological data for the time interval surrounding the commencement of this enhancement reveals no significant discontinuities in temperature and sea level pressure at Sable Island, Shearwater, and Eddy Point. No significant discontinuities in relative humidity, cloud amount, and cloud ceiling are observed at Shearwater and Eddy Point. Significant discontinuities in relative humidity, cloud amount, and cloud ceiling are observed at Sable Island.

An examination of the available meteorological data for the time interval surrounding the termination of this enhancement reveals no significant discontinuities in relative humidity, temperature and sea level pressure at Sable Island, Shearwater and Eddy Point. No significant discontinuities in cloud amount and cloud ceiling are observed at Shearwater and Eddy Point. Significant discontinuities in cloud amount and cloud ceiling are observed at Sable Island.

The discontinuities in cloud amount and cloud ceiling at both the commencement and termination of this enhancement, as observed at Sable Island, indicate a possible correlation. The apparent correlation between enhancement commencement and the discontinuity in relative humidity, as observed at Sable Island, may be assumed to be merely coincidental because of the continuous relative humidity conditions observed during enhancement termination.

Enhancement in Propagation at Seaview Commencing May 16, 0800 LT, Terminating May 17, 0200 LT

An enhancement in propagation is observed at Seaview commencing at 0800 LT on May 16 and terminating at 0200 LT on May 17. An examination of the available meteorological data for the time interval surrounding the commencement of this enhancement reveals no significant discontinuities in sea level pressure at Sable Island, Shearwater and Eddy Point. No significant discontinuities in cloud amount and temperature are observed at Shearwater and Eddy Point. No significant discontinuities in relative humidity are observed at Sable Island and Shearwater. No significant discontinuities in cloud amount are observed at Shearwater.

Significant discontinuities in cloud amount, cloud ceiling, and temperature are observed at Sable Island. Significant discontinuities in relative humidity and cloud amount are observed at Eddy Point.

An examination of the available meteorological data for the time interval surrounding the termination of this enhancement reveals no significant discontinuities in cloud ceiling and temperature at Sable Island, Shearwater and Eddy Point. No significant discontinuities in relative humidity and cloud amount are observed at Shearwater and Eddy Point. No significant discontinuities in relative humidity are observed at Sable Island. A significant discontinuity in sea level pressure is observed at all three meteorological observation facilities. A significant discontinuity in cloud amount is observed at Sable Island.

The discontinuity in cloud amount at both the commencement and termination of this enhancement, as observed at Sable Island, indicates a possible correlation. The apparent correlation between enhancement "commencement" and the discontinuities in cloud ceiling and temperature, as observed at Sable Island, may be assumed to be merely coincidental because of the continuous cloud ceiling and temperature conditions observed during enhancement termination. The apparent correlation between enhancement "commencement" and the discontinuities in relative humidity and cloud amount, as observed at Eddy Point, may be assumed to be merely coincidental because of the continuous relative humidity and cloud amount conditions observed during enhancement termination. The apparent correlation between enhancement termination and the discontinuity in sea level pressure, as observed at Sable Island, Shearwater and Eddy Point, may also be assumed to be merely coincidental because of the continuous sea level pressure conditions observed during enhancement

commencement.

Enhancement in Propagation at Seaview Commencing May 21, 2200 LT, Terminating May 22, 1300 LT

An enhancement in propagation is observed at Seaview commencing at 2200 LT on May 21 and terminating at 1300 LT on May 22. An examination of the available meteorological data for the time interval surrounding the commencement of this enhancement reveals no significant discontinuities in cloud ceiling and sea level pressure at Sable Island, Shearwater and Eddy Point. No significant discontinuities in temperature are observed at Sable Island and Eddy Point. Significant discontinuities in relative humidity and cloud amount are observed at all three meteorological observation facilities. A significant discontinuity in temperature is observed at Shearwater.

An examination of the available meteorological data for the time interval surrounding the termination of this enhancement reveals no significant discontinuities in cloud amount and temperature at Sable Island, Shearwater, and Eddy Point. No significant discontinuities in cloud ceiling and sea level pressure are observed at Shearwater and Eddy Point. No significant discontinuities in relative humidity are observed at Sable Island. A significant discontinuity in relative humidity is observed at Shearwater and Eddy Point. Significant discontinuities in cloud amount and sea level pressure are observed at Sable Island.

The discontinuity in relative humidity at both the commencement and termination of this enhancement, as observed at Shearwater and Eddy Point, indicates a possible correlation. The apparent correlation between enhancement commencement and the discontinuity in cloud amount, as observed at Sable Island, Shearwater

and Eddy Point, may be assumed to be merely coincidental because of the continuous cloud amount conditions observed during enhancement termination. The apparent correlation between enhancement "commencement" and the discontinuity in relative humidity, as observed at Sable Island, may be assumed to be merely coincidental because of the continuous relative humidity conditions observed during enhancement termination. The apparent correlation between enhancement "termination" and the discontinuity in cloud ceiling, as observed at Sable Island, may be assumed to be merely coincidental because of the continuous cloud ceiling conditions observed during enhancement commencement. The apparent correlation between enhancement "commencement" and the discontinuity in temperature, as observed at Shearwater, may be assumed to be merely coincidental because of the continuous temperature conditions observed during enhancement "termination." The apparent correlation between enhancement termination and the discontinuity in sea level pressure, as observed at Sable Island, may also be assumed to be merely coincidental because of the continuous sea level pressure conditions observed during enhancement commencement.

Enhancement in Propagation at Halifax Commencing May 22, 0900 LT, Terminating May 22, 1200 LT

An enhancement in propagation is observed at Halifax commencing at 0900 LT and terminating 1200 LT on May 22. An examination of the available meteorological data for the time interval surrounding the commencement of this enhancement reveals no significant discontinuities in cloud amount at Sable Island and Shearwater. No significant discontinuities in temperature are observed

at Sable Island and Eddy Point. No significant discontinuities in sea level pressure are observed at Shearwater and Eddy Point. Significant discontinuities in relative humidity and cloud ceiling are observed at Sable Island, Shearwater and Eddy Point. A significant discontinuity in cloud amount is observed at Eddy Point. A significant discontinuity in temperature is observed at Shearwater. A significant discontinuity in sea level pressure is observed at Sable Island.

An examination of the available meteorological data for the time interval surrounding the termination of this enhancement reveals no significant discontinuities in cloud amount and temperature at Sable Island, Shearwater, and Eddy Point. No significant discontinuities in cloud ceiling and sea level pressure are observed at Shearwater and Eddy Point. A significant discontinuity in relative humidity is observed at all three meteorological observation facilities. Significant discontinuities in cloud ceiling and sea level pressure are observed at Sable Island.

The discontinuity in relative humidity at both the commencement and termination of this enhancement, as observed at Sable Island, Shearwater and Eddy Point, indicates a possible correlation. The discontinuities in cloud ceiling and sea level pressure at both the commencement and termination of this enhancement, as observed at Sable Island, also indicates a possible correlation. The apparent correlation between enhancement "commencement" and the discontinuity in cloud amount, as observed at Eddy Point, may be assumed to be merely coincidental because of the continuous cloud amount conditions observed during enhancement termination. The apparent correlation between enhancement "commencement" and the discontinuity in cloud ceiling, as observed at Shearwater and Eddy Point, may be assumed to be merely coincidental because of the continuous cloud ceiling conditions

observed during enhancement termination. The apparent correlation between enhancement commencement and the discontinuity in temperature, as observed at Shearwater, may also be assumed to be merely coincidental because of the continuous temperature conditions observed during enhancement termination.

Enhancement in Propagation at Halifax Commencing May 26, 0300 LT, Terminating May 26, 0400 LT

An enhancement in propagation is observed at Halifax commencing at 0300 LT and terminating at 0400 LT on May 26. An examination of the available meteorological data for the time interval surrounding the commencement of this enhancement reveals no significant discontinuities in temperature and sea level pressure at Sable Island, Shearwater and Eddy Point. No significant discontinuities in cloud ceiling are observed at Sable Island. No significant discontinuities in relative humidity are observed at Eddy Point. A significant discontinuity in cloud amount is observed at all three meteorological observation facilities. A significant discontinuity in relative humidity is observed at Sable Island and Shearwater. A significant discontinuity in cloud ceiling is observed at Shearwater and Eddy Point.

An examination of the available meteorological data for the time interval surrounding the termination of this enhancement again reveals no significant discontinuities in temperature and sea level pressure at Sable Island, Shearwater and Eddy Point. No significant discontinuities in cloud ceiling are observed at Sable Island and Eddy Point. No significant discontinuities in relative humidity and cloud amount are observed at Eddy Point.

The discontinuities in relative humidity and cloud amount at both the commencement and termination of this enhancement, as observed at Sable Island and Shearwater, indicates possible correlations. The discontinuity in cloud ceiling at both the commencement and termination of this enhancement, as observed at Shearwater, also indicates a possible correlation. The apparent correlation between enhancement commencement and the discontinuities in cloud amount and cloud ceiling, as observed at Eddy Point, may be assumed to be merely coincidental because of the continuous cloud amount and cloud ceiling conditions observed during enhancement termination.

Enhancement in Propagation at Seaview Commencing May 26, 0500 LT, Terminating May 26, 0600 LT

An enhancement in propagation is observed at Seaview commencing at 0500 LT and terminating at 0600 LT on May 26. An examination of the available meteorological data for the time interval surrounding the commencement of this enhancement reveals no significant discontinuities in relative humidity, temperature and sea level pressures at Sable Island, Shearwater and Eddy Point. No significant discontinuities in cloud amount are observed at Eddy Point. A significant discontinuity in cloud ceiling is observed at all three meteorological observation facilities. A significant discontinuity in cloud ceiling is observed at Sable Island and Shearwater.

An examination of the available meteorological data for the time interval surrounding the termination of this enhancement again reveals no significant discontinuities in relative humidity, temperature, and sea level pressure at Sable Island, Shearwater, and Eddy Point. No significant discontinuities in cloud amount and cloud ceiling are observed at Eddy Point.

Significant discontinuities in cloud amount and cloud ceiling are observed at Sable Island and Shearwater.

The discontinuities in cloud amount and cloud ceiling at both the commencement and termination of this enhancement, as observed at Sable Island and Shearwater, indicate possible correlations. The apparent correlation between enhancement commencement and the discontinuity in cloud ceiling, as observed at Eddy Point, may be assumed to be merely coincidental because of the continuous cloud ceiling conditions observed during enhancement termination.

Enhancement in Propagation at Seaview Commencing May 29, 1000 LT, Terminating May 29, 1600 LT

An enhancement in propagation is observed at Seaview commencing at 1000 LT and terminating at 1600 LT on May 29. An examination of the available meteorological data for the time interval surrounding the commencement of this enhancement reveals no significant discontinuities in sea level pressure at Sable Island and Shearwater. No significant discontinuities in relative humidity, cloud ceiling and temperature are observed at Sable Island. A significant discontinuity in cloud amount is observed at Sable Island, Shearwater, and Eddy Point. Significant discontinuities in relative humidity, cloud ceiling, and temperature are observed at Shearwater and Eddy Point. A significant discontinuity in sea level pressure is observed at Eddy Point.

An examination of the available meteorological data for the time interval surrounding the termination of this enhancement reveals no significant discontinuities in sea level pressure at Sable Island, Shearwater, and Eddy Point. No significant discontinuities in temperature are observed at Sable Island. No significant discontinuities

in cloud ceiling are observed at Eddy Point. Significant discontinuities in relative humidity and cloud amount are observed at all three meteorological observation facilities. A significant discontinuity in cloud ceiling is observed at Sable Island and Shearwater. A significant discontinuity in temperature is observed at Shearwater and Eddy Point.

The discontinuity in cloud amount at both the commencement and termination of this enhancement, as observed at Sable Island, Shearwater, and Eddy Point, indicates a possible correlation. The discontinuities in relative humidity and temperature at both the commencement and termination of this enhancement, as observed at Shearwater and Eddy Point, indicate a possible correlation. The discontinuity in cloud ceiling at both the commencement and termination of this enhancement, as observed at Shearwater, also indicates a possible correlation. The apparent correlation between enhancement termination and the discontinuity in relative humidity, as observed at Sable Island, may be assumed to be merely coincidental because of the continuous relative humidity conditions observed during enhancement commencement. The apparent correlation between enhancement termination and the discontinuity in cloud ceiling, as observed at Sable Island, may be assumed to be merely coincidental because of the continuous cloud ceiling conditions observed during enhancement commencement. The apparent correlation between enhancement commencement and the discontinuity in cloud ceiling, as observed at Eddy Point, may be assumed to be merely coincidental because of the continuous cloud ceiling conditions observed during enhancement termination. The apparent correlation between enhancement commencement and the discontinuity in sea level pressure, as observed at Eddy Point, may

be assumed to be merely coincidental because of the continuous sea level pressure conditions observed during enhancement termination.

Enhancement in Propagation at Seaview Commencing June 1, 2300 LT, Terminating June 2, 0200 LT

An enhancement in propagation is observed at Seaview commencing at 2300 LT on June 1 and terminating at 0200 LT on June 2. An examination of the available meteorological data for the time interval surrounding the commencement of this enhancement reveals no significant discontinuities in cloud amount and cloud ceiling at Sable Island, Shearwater and Eddy Point. No significant discontinuities in relative humidity and temperature are observed at Sable Island and Shearwater. A significant discontinuity in sea level pressure is observed at all three meteorological observation facilities. Significant discontinuities in relative humidity and temperature are observed at Eddy Point.

An examination of the available meteorological data for the time interval surrounding the termination of this enhancement reveals no significant discontinuities in cloud amount, cloud ceiling, and sea level pressure at Sable Island, Shearwater and Eddy Point. No significant discontinuities in relative humidity and temperature are observed at Sable Island and Shearwater. Significant discontinuities in relative humidity and cloud amount are observed at Eddy Point.

The discontinuities in relative humidity and temperature at both the commencemnt and termination of this enhancement, as observed at Eddy Point, indicate a possible correlation. The apparent correlation between enhancement commencement and the discontinuity in sea level pressure, as observed at Sable Island, Shearwater and Eddy Point, may be assumed

to be merely coincidental because of the continuous sea level pressure conditions observed during enhancement termination.

Enhancement in Propagation at Seaview Commencing June 2, 1300 LT, Terminating June 2, 1500 LT

An enhancement in propagation is observed at Seaview commencing at 1300 LT and terminating at 1500 LT on June 2.

An examination of the available meteorological data for the time interval surrounding the commencement of this enhancement reveals no significant discontinuities in cloud ceiling and sea level pressure at Sable Island, Shearwater and Eddy Point. No significant discontinuities in relative humidity are observed at Shearwater and Eddy Point. No significant discontinuities in cloud amount are observed at Sable Island and Shearwater. No significant discontinuities in temperature are observed at Sable Island and Eddy Point. A significant discontinuity in relative humidity is observed at Sable Island. A significant discontinuity in temperature is observed at Shearwater. A significant discontinuity in cloud amount is observed at Eddy Point.

An examination of the available meteorological data for the time interval surrounding the termination of this enhancement again reveals no significant discontinuities in cloud ceiling and sea level pressure at Sable Island, Shearwater, and Eddy Point. No significant discontinuities in relative humidity are observed at Shearwater and Eddy Point. No significant discontinuities in temperature are observed at Sable Island and Shearwater. No significant discontinuities in cloud amount are observed at Eddy Point.

The discontinuity in relative humidity at both the commencement and termination of this enhancement, as observed at Sable Island, indicates a possible correlation. The apparent correlation between enhancement termination and the discontinuity in cloud amount, as observed at Sable Island and Shearwater, may be assumed to be merely coincidental because of the continuous cloud amount conditions observed during enhancement commencement. The apparent correlation between enhancement commencement and the discontinuity in cloud amount, as observed at Eddy Point, may be assumed to be merely coincidental because of the continuous cloud amount conditions observed during enhancement termination. The apparent correlation between enhancement commencement and the discontinuity in temperature, as observed at Shearwater, may be assumed to be merely coincidental because of the continuous temperature conditions observed during enhancement termination. The apparent correlation between enhancement termination and the discontinuity in temperature, as observed at Eddy Point, may also be assumed to be merely coincidental because of the continuous temperature conditions observed during enhancement termination.

Enhancement in Propagation at Halifax Commencing June 2, 1900 LT, Terminating June 2, 2100 LT

An enhancement in propagation is observed at Halifax commencing at 1900 LT and terminating at 2100 LT on June 2. An examination of the available meteorological data for the time interval surrounding the commencement of this enhancement reveals no significant discontinuities in sea level pressure at Sable Island, Shearwater, and Eddy Point. No significant discontinuities in relative humidity are observed at Sable Island and Shearwater. No significant discontinuities in cloud

ceiling are observed at Sable Island and Eddy Point. No significant discontinuities in temperature are observed Sable Island. A significant discontinuity in cloud amount is observed at all three meteorological observation facilities. A significant discontinuity in temperature is observed at Shearwater and Eddy Point. A significant discontinuity in relative humidity is observed at Eddy Point. A significant discontinuity in cloud ceiling is observed at Shearwater.

An examination of the available meteorological data for the time interval surrounding the termination of this enhancement reveals no significant discontinuities in cloud ceiling and sea level pressure at Sable Island, Shearwater and Eddy Point. No significant discontinuities in relative humidity are observed at Sable Island and Shearwater. No significant discontinuities in cloud amount are observed at Eddy Point. No significant discontinuities in temperature are observed at Sable Island. A significant discontinuity in cloud amount is observed at Sable Island and Shearwater. A significant discontinuity in temperature is observed at Shearwater and Eddy Point. A significant discontinuity in relative humidity is observed at Eddy Point.

The discontinuity in cloud amount at both the commencement and termination of this enhancement, as observed at Sable Island and Shearwater, indicates a possible correlation. The discontinuity in temperature at both the commencement and termination of this enhancement, as observed at Shearwater and Eddy Point, indicates a possible correlation. The discontinuity in relative humidity at both the commencement and termination of this enhancement, as observed at Eddy Point, also indicates a possible correlation. The

apparent correlation between enhancement commencement and the discontinuity in cloud amount, as observed at Eddy Point, may be assumed to be merely coincidental because of the continuous cloud amount conditions observed during enhancement termination.

Enhancement in Propagation at Halifax Commencing June 3, 0500 LT, Terminating June 3, 0800 LT

An enhancement in propagation is observed at Halifax commencing at 0500 LT and terminating at 0800 LT on June 3. An examination of the available meteorological data surrounding the commencement of this enhancement reveals no significant discontinuities in cloud ceiling and sea level pressure at Sable Island, Shearwater, and Eddy Point. No significant discontinuities in relative humidity and temperature are observed at Sable Island and Eddy Point. No significant discontinuities in cloud amount are observed at Sable Island. A significant discontinuity in cloud amount is observed at Shearwater and Eddy Point. Significant discontinuities in relative humidity and temperature are observed at Shearwater.

An examination of the available meteorological data for the time interval surrounding the termination of this enhancement reveals no significant discontinuities in sea level pressure at Sable Island, Shearwater and Eddy Point. No significant discontinuities in relative humidity are observed at Shearwater and Eddy Point. No significant discontinuities in cloud ceiling are observed at Sable Island and Shearwater. No significant discontinuities in temperature are observed at Eddy Point. A significant discontinuity in cloud amount is observed at all three meteorological observation facilities. A significant discontinuity in temperature is observed at Sable Island and Shearwater. A significant discontinuity in relative humidity is observed at Sable Island. A significant discontinuity

in cloud ceiling is observed at Eddy Point.

The discontinuity in cloud amount at both the commencement and termination of this enhancement, as observed at Shearwater and Eddy Point, indicates a possible correlation. The discontinuity in temperature at both the commencement and termination of this enhancement, as observed at Shearwater, also indicates a possible correlation. The apparent correlation between enhancement termination and the discontinuity in relative humidity, as observed at Sable Island, may be assumed to be merely coincidental because of the continuous relative humidity conditions observed during enhancement commencement. The apparent correlation between enhancement commencement and the discontinuity in relative humidity, as observed at Shearwater, may be assumed to be merely coincidental because of the continuous relative humidity conditions observed during enhancement termination. The apparent correlation between enhancement termination and the discontinuity in cloud amount, as observed at Sable Island, may be assumed to be merely coincidental because of the continuous cloud amount conditions observed during enhancement commencement. The apparent correlation between enhancement termination and the discontinuity in cloud ceiling, as observed at Eddy Point, may be assumed to be merely coincidental because of the continuous cloud ceiling conditions observed during enhancement commencement. The apparent correlation between enhancement termination and the discontinuity in temperature, as observed at Sable Island, may also be assumed to be merely coincidental because of the continuous temperature conditions observed during enhancement commencement.

Enhancement in Propagation at Seaview Commencing June 14, 1800 LT, Terminating June 15, 0900 LT

An enhancement in propagation is observed at Seaview

commencing at 1800 LT on June 14 and terminating at 0900 LT on June 15. An examination of the available meteorological data for the time interval surrounding the commencement of this enhancement reveals no significant discontinuities in temperature at Sable Island, Shearwater and Eddy Point. No significant discontinuities in relative humidity and sea level pressure are observed at Sable Island and Shearwater. No significant discontinuities in cloud ceiling are observed at Sable Island and Eddy Point. No significant discontinuities in cloud amount are observed at Shearwater. A significant discontinuity in cloud amount is observed at Sable Island and Eddy Point. Significant discontinuities in relative humidity and sea level pressure are observed at Eddy Point. A significant discontinuity in cloud ceiling is observed at Shearwater.

An examination of the available meteorological data for the time interval surrounding the termination of this enhancement reveals no significant discontinuities in sea level pressure at Sable Island, Shearwater, and Eddy Point. No significant discontinuities in relative humidity and temperature are observed at Sable Island and Shearwater. No significant discontinuities in cloud amount are observed at Shearwater and Eddy Point. No significant discontinuities in cloud ceiling are observed at Shearwater. A significant discontinuity in cloud ceiling is observed at Sable Island and Eddy Point. Significant discontinuities in relative humidity and temperature are observed at Eddy Point. A significant discontinuity in cloud amount is observed at Sable Island.

The discontinuity in relative humidity at both the commencement and termination of this enhancement, as observed at Eddy Point, indicates a possible correlation. The discontinuity in cloud amount at both the commencement and termination of this enhancement, as observed at Sable Island, also indicates a possible correlation. The apparent correlation between enhancement termination and

the discontinuity in cloud ceiling, as observed at Sable Island and Eddy Point, may be assumed to be merely coincidental because of the continuous cloud ceiling conditions observed during enhancement commencement. The apparent correlation between enhancement commencement and the discontinuities in cloud amount and sea level pressure, as observed at Eddy Point, may be assumed to be merely coincidental because of the continuous cloud amount and sea level pressure conditions observed during enhancement termination. The apparent correlation between enhancement commencement and the discontinuity in cloud ceiling, as observed at Shearwater, may be assumed to be merely coincidental because of the continuous cloud ceiling conditions observed during enhancement termination. The apparent correlation between enhancement termination and the discontinuity in temperature, as observed at Eddy Point, may also be assumed to be merely coincidental because of the continuous temperature conditions observed during enhancement commencement.

Enhancement in Propagation at Halifax Commencing June 15, 1600 LT, Terminating June 15, 2100 LT

An enhancement in propagation is observed at Halifax commencing at 1600 LT and terminating at 2100 LT on June 15. An examination of the available meteorological data for the time interval surrounding the commencement of this enhancement reveals no significant discontinuities in sea level pressure at Sable Island, Shearwater, and Eddy Point. No significant discontinuities in relative humidity are observed at Sable Island and Eddy Point.

No significant discontinuities in cloud amount are observed at Shearwater and Eddy Point. No significant discontinuities in temperature are observed at Sable Island and Shearwater. A significant discontinuity in cloud ceiling is observed at all three meteorological observation facilities. A significant discontinuity in relative humidity is observed at Shearwater. A significant discontinuity in cloud amount is observed at Sable Island. A significant discontinuity in temperature is observed at Eddy Point.

An examination of the available meteorological data for the time interval surrounding the termination of this enhancement reveals no significant discontinuities in temperature and sea level pressure at Sable Island, Shearwater, and Eddy Point. No significant discontinuities in relative humidity are observed at Sable Island and Eddy Point. No significant discontinuities in cloud amount and cloud ceiling are observed at Shearwater. Significant discontinuities in cloud amount and cloud ceiling are observed at Sable Island and Eddy Point. A significant discontinuity in relative humidity is observed at Shearwater.

The discontinuity in cloud ceiling at both the commencement and termination of this enhancement, as observed at Sable Island and Eddy Point, indicates a possible correlation. The discontinuity in relative humidity at both the commencement and termination of this enhancement, as observed at Shearwater, indicates a possible correlation. The discontinuity in cloud amount at both the commencement and termination of this enhancement, as observed at Sable Island, also indicates a possible correlation. The apparent correlation between enhancement termination and the discontinuity in cloud amount, as observed at Eddy Point, may be assumed to be merely coincidental because

of the continuous cloud amount conditions observed during enhancement commencement. The apparent correlation between enhancement commencement and the discontinuity in cloud ceiling, as observed at Shearwater, may be assumed to be merely coincidental because of the continuous cloud ceiling conditions observed during enhancement termination. The apparent correlation between enhancement commencement and the discontinuity in temperature, as observed at Eddy Point, may also be assumed to be merely coincidental because of the continuous temperature conditions observed during enhancement termination.

Enhancement in Propagation at Seaview Commencing June 16, 0300 LT, Terminating June 16, 0800 LT

An enhancement in propagation is observed at Seaview commencing at 0300 LT and terminating at 0800 LT on June 16. An examination of the available meteorological data for the time interval surrounding the commencement of this enhancement reveals no significant discontinuities in sea level pressure at Sable Island, Shearwater, and Eddy Point. No significant discontinuities in relative humidity and temperature are observed at Sable Island and Shearwater. No significant discontinuities in cloud amount are observed at Shearwater and Eddy Point. No significant discontinuities in cloud ceiling are observed at Shearwater. A significant discontinuity in cloud ceiling is observed at Sable Island and Eddy Point. Significant discontinuities in relative humidity and cloud ceiling are observed at Eddy Point. A significant discontinuity in cloud amount is observed at Sable Island.

An examination of the available meteorological data for the time interval surrounding the termination of this enhancement reveals no significant discontinuities in temperature and sea level pressure at Sable Island, Shearwater, and Eddy Point. No significant discontinuities in relative humidity are observed at Sable Island and Eddy Point. No significant discontinuities in cloud amount are observed at Shearwater. A significant discontinuity in cloud ceiling is observed at all three meteorological observation facilities. A significant discontinuity in cloud amount is observed at Sable Island and Eddy Point. A significant discontinuity in relative humidity is observed at Shearwater.

The discontinuity in cloud ceiling at both the commencement and termination of this enhancement, as observed at Sable Island and Eddy Point, indicates a possible correlation. The discontinuity in cloud amount and both the commencement and termination of this enhancement, as observed at Sable Island, also indicates a possible correlation. The apparent correlation between enhancement termination and the discontinuities in relative humidity and cloud ceiling, as observed at Shearwater, may be assumed to be merely coincidental because of the continuous relative humidity and cloud ceiling conditions observed during enhancement commencement. The apparent correlation between enhancement commencement and the discontinuities in relative humidity and temperature, as observed at Eddy Point, may be assumed to be merely coincidental because of the continuous relative humidity and temperature conditions observed during enhancement termination. The apparent correlation between enhancement termination and the discontinuity in cloud amount, as observed at Eddy Point, may also be assumed to be merely coincidental because of the continuous cloud amount conditions observed during

enhancement commencement.

Enhancement in Propagation at Halifax Commencing June 19, 1200 LT, Terminating June 20, 0500 LT

An enhancement in propagation is observed at Halifax commencing at 1200 LT on June 19 and terminating at 0500 LT on June 20. An examination of the available meteorological data for the time interval surrounding the commencement of this enhancement reveals no significant discontinuities in cloud ceiling and sea level pressure at Sable Island, Shearwater, and Eddy Point. No significant discontinuities in temperature are observed at Sable Island and Eddy Point. No significant discontinuities in relative humidity are observed at Sable Island. A significant discontinuity in cloud amount is observed at all three meteorological observation facilities. A significant discontinuity in relative humidity is observed at Shearwater and Eddy Point. A significant discontinuity in temperature is observed at Shearwater.

An examination of the available meteorological data for the time interval surrounding the termination of this enhancement reveals no significant discontinuities in relative humidity, temperature, and sea level pressure at Sable Island, Shearwater and Eddy Point. No significant discontinuities in cloud ceiling are observed at Sable Island and Shearwater. No significant discontinuities in cloud amount are observed at Shearwater. A significant discontinuity in cloud amount is observed at Sable Island and Eddy Point. A significant discontinuity in cloud ceiling is observed at Eddy Point.

The discontinuity in cloud amount at both the commencement and termination of this enhancement, as

observed at Sable Island and Eddy Point, indicates a possible correlation. The apparent correlation between enhancement commencement and the discontinuities in relative humidity, cloud amount, and temperature, as observed at Shearwater, may be assumed to be merely coincidental because of the continuous relative humidity,cloud amount, and temperature conditions observed during enhancement termination. The apparent correlation between enhancement commencement and the discontinuity in relative humidity, as observed at Eddy Point, may be assumed to be merely coincidental because of the continuous relative humidity conditions observed during enhancement termination. The apparent correlation between enhancement termination and the discontinuity in cloud ceiling, as observed at Eddy Point, may also be assumed to be merely coincidental because of the continuous cloud ceiling conditions observed during enhancement commencement.

Enhancement in Propagation at Seaview Commencing June 19, 1200 LT, Terminating June 20, 0400 LT

An enhancement in propagation is observed at Seaview commencing at 1200 LT on June 19 and terminating at 0400 LT on June 20. An examination of the available meteorological data for the time interval surrounding the commencement of this enhancement reveals no significant discontinuities in cloud ceiling and sea level pressure at Sable Island, Shearwater, and Eddy Point. No significant discontinuities in temperature are observed at Sable Island and Eddy Point. No significant discontinuities in relative humidity are observed at Sable Island. A significant discontinuity in cloud amount is observed at all three metoeorological observation facilities. A significant discontinuity in relative humidity is observed at Shearwater and

and Eddy Point. A significant discontinuity in temperature is observed at Shearwater.

An examination of the available meteorological data for the time interval surrounding the termination of this enhancement reveals no significant discontinuities in relative humidity, temperature, and sea level pressure at Sable Island, Shearwater, and Eddy Point. No significant discontinuites in cloud ceiling are observed at Sable Island and Shearwater. No significant discontinuities in cloud amount are observed at Shearwater. A significant discontinuity in cloud amount is observed at Sable Island and Eddy Point. A significant discontinuity in cloud ceiling is observed at Eddy Point.

The discontinuity in cloud amount at both the commencement and termination of this enhancement, as observed at Sable Island and Eddy Point, indicates a possible correlation. The apparent correlation between enhancement commencement and the discontinuities in relative humidity, cloud amount, and temperature, as observed at Shearwater, may be assumed to be merely coincidental because of the continuous relative humidity, cloud amount, and temperature conditions observed during enhancement termination. The apparent correlation between enhancment commencement and the discontinuities in relative humidity, as observed at Eddy Point, may be assumed to be merely coincidental because of the continuous relative humidity conditions observed during enhancement termination. The apparent correlation between enhancement termination and the discontinuity in cloud ceiling, as observed at Eddy Point, may also be assumed to be merely coincidental because of the continuous cloud ceiling conditions observed during enhancement termination.

Enhancement in Propagation at Halifax Commencing June 20, 1900 LT, Terminating June 20, 2200 LT

An enhancement in propagation is observed at Halifax commencing at 1900 LT and terminating at 2200 LT on June 20. An examination of the available meteorological data for the time interval surrounding the commencement of this enhancement reveals no significant discontinuities in sea level pressure at Sable Island, Shearwater and Eddy Point. No significant discontinuities in relative humidity and temperature are observed at Sable Island and Shearwater. No significant discontinuities in cloud ceiling are observed at Sable Island and Eddy Point. No significant discontinuities in cloud amount are observed at Sable Island. A signficant discontinuity in cloud amount is observed at Shearwater and Eddy Point. Significant discontinuities in relative humidity and temperature are observed at Eddy Point. A significant discontinuity in cloud ceiling is observed at Shearwater.

An examination of the available meteorological data for the time interval surrounding the termination of this enhancement reveals no significant discontinuities in cloud amount, cloud ceiling, temperature, and sea level pressure at Sable Island, Shearwater, and Eddy Point. No significant discontinuities in relative humidity are observed at Sable Island and Eddy Point. A significant discontinuity in relative humidity is observed at Shearwater.

The apparent correlation between enhancement commencement and the discontinuity in cloud amount, as observed at Shearwater and Eddy Point, may be assumed to be merely coincidental because of the continuous

cloud amount conditions observed during enhancement termination. The apparent correlation between enhancement commencement and the discontinuities in relative humidity and temperature, as observed at Eddy Point, may be assumed to be merely coincidental because of the continuous relative humidity and temperature conditions observed during enhancement termination. The apparent correlation between enhancement commencement and the discontinuity in cloud ceiling, as observed at Shearwater, may be assumed to be merely coincidental because of the continuous cloud ceiling conditions observed during enhancement termination. The apparent correlation between enhancement termination and the discontinuity in relative humidity, as observed at Shearwater, may also be assumed to be merely coincidental because of the continuous relative humidity conditions observed during enhancement commencement.

Enhancement in Propagation at Seaview Commencing June 20, 1800 LT, Terminating June 20, 2200 LT

An enhancement in propagation is observed at Seaview commencing at 1800 LT and terminating at 2200 LT on June 20. An examination of the available meteorological data for the time interval surrounding the commencement of this enhancement reveals no significant discontinuities in sea level pressure at Sable Island, Shearwater and Eddy Point. No significant discontinuities in relative humidity, cloud amount, and cloud ceiling are observed at Sable Island and Eddy Point. No significant discontinuities in temperature are observed at Sable Island and Shearwater. Significant discontinuities in relative humidity, cloud amount, and cloud ceiling are observed at Shearwater. A significant discontinuity in temperature is observed at Eddy Point.

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An examination of the available meteorological data for the time interval surrounding the termination of this enhancement reveals no significant discontinuities in cloud amount, cloud ceiling, temperature, and sea level pressure at Sable Island, Shearwater, and Eddy Point. No significant discontinuities in relative humidity are observed at Sable Island and Eddy Point. A signficant discontinuity in relative humidity is observed at Shearwater.

The discontinuity in relative humidity at both the commencement and termination of this enhancement, as observed at Shearwater, indicates a possible correlation. The apparent correlation between enhancement commencement and the discontinuities in cloud amount and cloud ceiling, as observed at Shearwater, may be assumed to be merely coincidental because of the continuous cloud amount and cloud ceiling conditions observed during enhancement termination. The apparent correlation between enhancement commencement and the discontinuity in temperature, as observed at Eddy Point, may also be assumed to be merely coincidental because of the continuous temperature conditions observed during enhancement termination.

Enhancement in Propagation at Halifax Commencing June 24, 0600 LT, Terminating June 24, 1000 LT

An enhancement in propagation is observed at Halifax commencing at 0600 LT and terminating at 1000 LT on June 24. An examination of the available meteorological data for the time interval surrounding the commencement of this enhancement reveals no significant discontinuities in cloud ceiling and sea level pressure at Sable Island, Shearwater and Eddy Point. No

significant discontinuities in relative humidity and cloud ceiling are observed at Sable Island and Eddy Point. No significant discontinuities in cloud amount are observed at Eddy Point. Significant discontinuities in relative humidity and temperature are observed at Shearwater and Eddy Point. A significant discontinuity in cloud amount is observed at Sable Island and Shearwater.

An examination of the available meteorlogical data for the time interval surrounding the termination of this enhancement again reveals no significant discontinuities in cloud ceiling and sea level pressure at Sable Island, Shearwater and Eddy Point. No significant discontinuities in relative humidity are observed at Eddy Point. No significant discontinuities in cloud amount are observed at Sable Island. Significant discontinuities in relative humidity and temperature are observed at Sable Island and Shearwater. A significant discontinuity in cloud amount is observed at Shearwater and Eddy Point.

The discontinuities in relative humidity, cloud amount, and temperature at both the commencement and termination of this enhancement, as observed at Shearwater, indicate possible correlations. The apparent correlation between enhancement termination and the discontinuities in relative humidity and temperature, as observed at Sable Island, may be assumed to be merely coincidental because of the continuous relative humidity and temperature conditions observed during enhancement commencement. The apparent correlation between enhancement commencement and the discontinuities in relative humidity and temperature, as observed at Eddy Point, may be assumed to be merely coincidental because of the continuous relative humidity and temperature

conditions observed during enhancement termination. The apparent correlation between enhancement commencement and the discontinuity in cloud amount, as observed at Sable Island, may be assumed to be merely coincidental because of the continuous cloud amount conditions observed during enhancement termination. The apparent correlation between enhancement termination and the discontinuity in cloud amount, as observed at Eddy Point, may also be assumed to be merely coincidental because of the continuous cloud amount conditions observed during enhancement commencement.

Enhancement in Propagation at Seaview Commencing June 24, 0400 LT, Terminating June 24, 1200 LT

An enhancement in propagation is observed at Seaview commencing at 0400 LT and terminating at 1200 LT on June 24. An examination of the available meteorological data for the time interval surrounding the commencement of this enhancement reveals no significant discontinuities in cloud ceiling and sea level pressure at Sable Island, Shearwater, and Eddy Point. No significant discontinuities in relative humidity are observed at Sable Island and Shearwater. No significant discontinuities in temperature are observed at Sable Island and Eddy Point. No significant discontinuities in cloud amount are observed at Eddy Point. A significant discontinuity in cloud amount is observed at Sable Island and Shearwater. A significant discontinuity in relative humidity is observed at Eddy Point. A significant discontinuity in temperature is observed at Shearwater.

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An examination of the available meteorological data for the time interval surrounding the termination of this enhancement reveals no significant discontinuities in relative humidity, cloud ceiling, and sea level pressure at Sable Island, Shearwater and Eddy Point. No significant discontinuities in temperature are observed at Sable Island and Eddy Point. No significant discontinuities in cloud amount are observed at Shearwater. A significant discontinuity in cloud amount is observed at Sable Island and Eddy Point. A significant discontinuity in temperature is observed at Shearwater.

The discontinuity in cloud amount at both the commencement and termination of this enhancement, as observed at Sable Island, indicates a possible correlation. The discontinuity in temperature at both the commencement and termination of this enhancement, as observed at Shearwater, also indicates a possible correlation. The apparent correlation between enhancement commencement and the discontinuity in relative humidity, as observed at Eddy Point, may be assumed to be merely coincidental because of the continuous relative humidity conditions observed during enhancement termination. The apparent correlation between enhancement commencement and the discontinuity in cloud amount, as observed at Shearwater, may be assumed to be merely coincidental because of the continuous cloud amount conditions observed during enhancement termination. The apparent correlation between enhancement termination and the discontinuity in cloud amount, as observed at Eddy Point, may also be assumed to be merely coincidental because of the continuous cloud amount conditions observed during enhancement commencement.

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Enhancement in Propagation at Seaview Commencing June 24, 1600 LT, Terminating June 25, 0200 LT

An enhancement in propagation is observed at Seaview commencing at 1600 LT on June 24 and terminating at 0200 LT on June 25. An examination of the available meteorological data for the time interval surrounding the commencement of this enhancement reveals no significant discontinuities in relative humidity, cloud ceiling, and sea level pressure at Sable Island, Shearwater and Eddy Point. No significant discontinuities in cloud amount and temperature are observed at Eddy Point. Significant discontinuities in cloud amount and temperature are observed at Sable Island and Shearwater.

An examination of the available meteorological data for the time interval surrounding the termination of this enhancement reveals no significant discontinuities in cloud ceiling and sea level pressure at Sable Island, Shearwater, and Eddy Point. No significant discontinuities in relative humidity and temperature are observed at Sable Island and Shearwater. A significant discontinuity in cloud amount is observed at all three meteorological observation facilities. Significant discontinuities in relative humidity and temperature are observed at Eddy Point.

The discontinuity in cloud amount at both the commencement and termination of this enhancement, as observed at Sable Island and Shearwater, indicates a possible correlation. The apparent correlation between enhancement commencement and the discontinuity in temperature, as observed at Sable Island and Shearwater, may be assumed to be merely coincidental because of the continuous temperature conditions observed during enhancement termination. The apparent correlation between enhancement termination and the discontinuities in relative humidity, cloud amount, and

temperature, as observed at Eddy Point, may also be assumed to be merely coincidental because of the continuous relative humidity, cloud amount, and temperature conditions observed during enhancement commencement.

Enhancement in Propagation at Halifax Commencing June 25, 1000 LT, Terminating June 25, 1200 LT

An enhancement in propagation is observed at Halifax commencing at 1000 LT and terminating at 1200 LT on June 25. An examination of the available meteorological data for the time interval surrounding the commencement of this enhancement reveals no significant discontinuities in sea level pressure at Sable Island, Shearwater, and Eddy Point. No significant discontinuities in relative humidity and temperature are observed at Sable Island and Shearwater. No significant discontinuities in cloud ceiling are observed at Sable Island and Eddy Point. No significant discontinuities in cloud amount are observed at Sable Island. A significant discontinuity in cloud amount is observed at Shearwater and Eddy Point. Significant discontinuities in relative humidity and temperature are observed at Eddy Point. A significant discontinuity in temperature is observed at Shearwater.

An examination of the available meteorological data for the time interval surrounding the termination of this enhancement reveals no significant discontinuities in cloud ceiling and sea level pressure at Sable Island, Shearwater, and Eddy Point. No significant discontinuities in relative humidity and temperature are observed at Sable Island and Shearwater. No significant discontinuities in cloud amount are observed at Shearwater. A significant discontinuity in cloud amount

is observed at Sable Island and Eddy Point. Significant discontinuities in relative humidity and temperature are observed at Eddy Point.

The discontinuities in relative humidity, cloud amount, and temperature at both the commencement and termination of this enhancement, as observed at Eddy Point, indicate a possible correlation. The apparent correlation between enhancement commencement and the discontinuities in cloud amount and cloud ceiling, as observed at Shearwater, may be assumed to be merely coincidental because of the continuous cloud amount and cloud ceiling conditions observed during enhancement termination. The apparent correlation between enhancement termination and the discontinuity in cloud amount, as observed at Sable Island, may also be assumed to be merely coincidental because of the continuous cloud amount conditions observed during enhancement commencement.

Enhancement in Propagation at Halifax Commencing June 26, 0100 LT, Terminating June 26, 0400 LT

An enhancement in propagation is observed at Halifax commencing at 0100 LT and terminating at 0400 LT on June 26. An examination of the available meteorological data for the time interval surrounding the commencement of this enhancement reveals no significant discontinuities in relative humidity and cloud amount at Shearwater and Eddy Point. No significant discontinuities in cloud ceiling, temperature, and sea level pressure are observed at Shearwater. No significant discontinuities in temperature are observed at Sable Island. Significant discontinuities in cloud ceiling and sea level pressure are observed at Sable Island and Eddy Point. Significant discontinuities in relative humidity and cloud amount are

observed at Sable Island. A significant discontinuity in temperature is observed at Eddy Point.

An examination of the available meteorological data for the time interval surrounding the termination of this enhancement reveals no significant discontinuities in sea level pressure at Sable Island, Shearwater, and Eddy Point. No significant discontinuities in relative humidity, cloud amount, and cloud ceiling are observed at Shearwater and Eddy Point. No significant discontinuities in sea level pressure are observed at Shearwater. A significant discontinuity in sea level pressure is observed at Sable Island and Eddy Point. Significant discontinuities in relative humidity, cloud amount, and cloud ceiling are observed at Sable Island.

The discontinuity in sea level pressure at both the commencement and termination of this enhancement, as observed at Sable Island and Eddy Point, indicates a possible correlation. The discontinuities in relative humidity, cloud amount, and cloud ceiling at both the commencement and termination of this enhancement, as observed at Sable Island, also indicate a possible correlation. The apparent correlation between enhancement commencement and the discontinuities in cloud ceiling and temperature, as observed at Eddy Point, may be assumed to be merely coincidental because of the continuous cloud ceiling and temperature conditions observed during enhancement termination.

Enhancement in Propagation at Seaview Commencing June 26, 0300 LT, Terminating June 26, 0600 LT

An enhancement in propagation is observed at Seaview commencing at 0300 LT and terminating at 0600 LT on June 26. An examination of the available meteorological data for the time interval surrounding the commencement

of this enhancement reveals no significant discontinuities in cloud ceiling and temperature at Sable Island, Shearwater, and Eddy Point. No significant discontinuities in relative humidity and cloud amount are observed at Shearwater and Eddy Point. No significant discontinuities in sea level pressure are observed at Shearwater. A significant discontinuity in sea level pressure is observed at Sable Island and Eddy Point. Significant discontinuities in relative humidity and cloud amount are observed at Sable Island.

An examination of the available meteorological data for the time interval surrounding the termination of this enhancement reveals no significant discontinuities in cloud amount, temperature, and sea level pressure at Sable Island, Shearwater, and Eddy Point. No significant discontinuities in relative humidity are observed at Shearwater and Eddy Point. No significant discontinuities in cloud ceiling are observed at Sable Island and Shearwater. A significant discontinuity in relative humidity is observed at Sable Island. A significant discontinuity in cloud ceiling is observed at Eddy Point.

The discontinuity in relative humidity at both the commencement and termination of this enhancement, as observed at Sable Island, indicates a possible correlation. The apparent correlation between enhancement commencement and the discontinuity in sea level pressure, as observed at Sable Island and Eddy Point, may be assumed to be merely coincidental because of the continuous sea level pressure conditions observed during enhancement termination. The apparent correlation between enhancement commencement and the discontinuity in cloud amount, as observed at Sable Island, may be assumed to be merely coincidental because of the continuous cloud amount conditions

observed during enhancement termination. The apparent correlation between enhancement termination and the discontinuity in cloud ceiling, as observed at Eddy Point, may also be assumed to be merely coincidental because of the continuous cloud ceiling conditions observed during enhancement commencement.

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by W.D. Rawle

A Guide to Atmospheric Environment Service Document 63-2322 Surface Weather Records

The purpose of this appendix is to explain the method by which meteorological data, which is employed in this project, is extracted from the 63-2322 Surface Weather Record, (which is the primary record of meteorological surface observations made by Atmospheric Environment Service facilities in Canada). Each meteorological parameter employed in this project will be itemized and a discussion of its origins will follow.

DATE - TIME

To determine the actual time of occurance of the observed meteorological conditions, refer to COLUMN 28 and COLUMN 29. The date and time are recorded as GREENWICH MEAN TIME. To obtain ATLANTIC STANDARD TIME, subtract four hours.

RELATIVE HUMIDITY

The relative humidity, expressed as a percentage, is found in COLUMN 24.

CLOUD AMOUNT

The cloud amount, expressed in tenths of the sky covered by cloud, is found in COLUMN 26. An "X" denotes the sky to be completely covered by cloud; i.e. $^{10}/_{10}$.

CLOUD CEILING

The cloud ceiling is obtained from COLUMN 30, Sky Condition. Each group of numbers in column 30 represents the height above the observing station

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of a cloud layer aloft, or, in the case of a surface based layer, the vertical visibility into that layer. Each group of numbers is followed by a layer classification abbreviation. These abbreviations are as follows:

SYMBOL	TERM	EXPLANATION
CLR	Clear	The sky condition when no cloud or obscuring phenomenon is present.
-X	Partially Obscured	A surface based layer with a summation opacity of 1/10 but less than 10/10.
X	Obscured	A surface based layer with a summation opacity of 10/10.
SCT	Scattered	A layer aloft with a summation amount of 5/10 or less.
BKN	Broken	A layer aloft with a summation amount of 6/10 to 9/10 inclusive.
OVC	Overcast	A layer aloft with a summation amount of 10/10.

Occasionally, a thin cloud layer is observed. A thin cloud layer is one which covers a portion of the sky but is partially transparent. The condition is denoted by a "—" preceding SCT, BKN, or OVC.

The term summation opacity represents the portion, in tenths of the whole sky, concealed by cloud layers at and below a given level. Summation amount represents the amount, in tenths of the whole sky, covered by cloud layer at and below that level.

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The cloud ceiling is defined as the lesser of:

(a) the height above ground of the base of the lowest layer aloft, at which the summation opacity is 6/10 or more of the whole sky.

(b) the vertical visibility in a surface based layer which completely obscures the whole sky.

The layer at which the cloud ceiling is observed is denoted by a single letter directly preceding the height of that layer. The letter indicates the ceiling classification, the method by which the cloud ceiling was determined.

For layers aloft:

ABBREVIATION	CLASSIFICATION
M	measured
A	aircraft
B	balloon
E	estimated

For surface based layers which completely obscure the sky:

ABBREVIATION	CLASSIFICATION
A	aircraft
P	precipitation
W	indefinite

Therefore, to obtain the cloud ceiling from COLUMN 30, the cloud layer which comprises the ceiling is identified. It is the cloud layer height preceded by one of the above ceiling classification abbreviations. The corresponding number group represents the height of the cloud ceiling in hundreds of feet.

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TEMPERATURE

The surface temperature, otherwise known as the dry-bulb temperature, is recorded in both units and tenths of degrees Celsius and in whole degrees Celsius. This information is located in COLUMN 34.

SEA LEVEL PRESSURE

The corrected sea level pressure is found in COLUMN 33. It is recorded in millibars and tenths with the initial 9 or 10 and the decimal point omitted.

SIG MET

Weather and Obstructions to Vision.

"Sig Met", significant meteorological occurances may be found in COLUMN 32. Each weather phenomenom is abbreviated and tabulated as to its type and intensity. Each weather type is abbreviated as follows:

Weather Phenomena and Symbols

GENERAL CATEGORY	SPECIFIC PHENOMENA	SYMBOLS
Tornadoes and Thunderstorms	Tornado	Tornado
	Waterspout	Waterspout
	Funnel Cloud	Funnel Cloud
	Thunderstorm	T, T+
Precipitation	Rain	R--,R-,R,R+
	Rain Shower	RW--,RW-,RW,RW+
	Drizzle	L--,L-,L,L+
	Freezing Rain	ZR--,ZR-,ZR,ZR+
	Freezing Drizzle	ZL--,ZL-,ZL,ZL+
	Snow	S--,S-,S,S+
	Snow Grains	SG--,SG-,SG,SG+

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GENERAL CATEGORY	SPECIFIC PHENOMENA	SYMBOLS
	Ice Crystals	IC
	Ice Pellets	IP--,IP-,IP,IP+
	Ice Pellet Showers	IPW--,IPW-,IPW,IPW+
	Snow Showers	SW--,SW-,SW,SW+
	Snow Pellets	SP--,SP-,SP,SP+
	Hail	A--,A-,A,A+
	Fog	F
	Ice Fog	IF
Obstructions to Vision (6 miles or less)	Haze	H
	Smoke	K
	Blowing Snow	BS
	Blowing Sand	BN
	Blowing Dust	BD
	Dust Haze	D

The intensity indicators, associated with each abbreviation, are interpreted as follows:

"+"	heavy
" "	moderate
"-"	light
"--"	very light

A more detailed explanation of any or all of the above meteorological conditions may be found in the "Manual of Surface Weather Observations, MANOBS," available by mail from:

The Assistant Deputy Minister
Atmospheric Environment Service
4905 Dufferin Street
Downsview, Ontario
M3H 5T4

Report Appendix #2

APPENDIX C

TYPICAL ENTRIES - FORM 63-2322

SURFACE WEATHER RECORD

AT UPLANDS PROVINCE ONTARIO FROM 0401 09 FEB 1972 TO 0400 10 FEB 1972 LST - GMT - 5 HOURS

CHECKED, CERTIFIED COMPLETE AND CORRECT BY M. A. [illegible]

I OBSERVED DATA AND COMPUTATIONS

NOTES AND INSTRUMENT DEFECTS AND CHANGES:

1800 MAX FROM 1800 08

0300 MIN FROM 1800 08

[illegible]

II HOURLY OBSERVATIONS

Corrected Wet Bulb °C (13)	14	15	16	17	18	19	Sky Condition (20)	21	Weather and Obstructions to Vision (22)	23	Dry-Bulb Temperature °C (24)	Dew-Point Temperature °C (25)	Wind 26	Wind 27	Wind 28	29	Clouds and Obscuring Phenomena Type/Opacity (40)	Remarks (41)	42	43
-[illegible]	71	6	6	R	09	0900	E40 -SCT	15+		215	-20 / -19.4	-24 / -23.9	35	08		010	C11	4412		PM
-13.9	78	3	3	R	09	1200	-X	3	F	200	-17 / -17.4	-18 / -17.9	01	04		008	E8	3308		PM
-12.6	81	10	10	R	09	1500	A15 X	2	F	145	-17 / -17.2	-18 / -18.4	02	03		002	E10	24XX		PM
-15.1	79	10	10	R	09	1800	E140 BKN 200 OVC	15		155	-16 / -14.9	-18 / -17.8	06	10		993	AS7 CS3	98XX		JD
-11.7	83	9	10	R	09	2100	E100 OVC	20		146	-12 / -11.8	-14 / -13.8	08	14		991	AS9	509X		JD
-7.3	81	10	10	R	10	0000	E70 OVC	7	S-	133	-7 / -7.1	-9 / -8.6	10	11		987	AS10	16XX		JD
-5.3	90	10	10	R	10	0300	8 SCT M50 OVC	3	S-	096	-6 / -6.2	-7 / -6.8	12	17		977	SF4 NS6	68XX		BM
-4.8	91	10	10	R	10	0600	5 SCT P8 X	1/8	S	084	-4 / -4.4	-6 / -5.4	16	20		959	SF5 S5	47XX		JM

Appendix #3

Report
Appendix #3

"Some Calculations of Expected Signal Levels for the Sable Island to mainland Nova Scotia Paths" (a preliminary Report)

Principal Investigator: W.P. Lonc, Saint Mary's University, VE1SMU
Research Assistant: W.D. Rawle, Technical University of Nova Scotia, VE1AWS.

Report Date: December 31, 1982

Introduction: Data obtained from on-going studies on the long trans-horizon salt-water paths between Sable Island and mainland Nova Scotia are eventually intended to be explained, if possible, on the basis of available propagation models. To this end, several calculations are presented in this preliminary report. The calculations are made on the basis of the following:

1. Free-space model.
2. Free-space model as modified according to Bullington's method.
3. Method given by Sofaer and Stark (equivalent-distance method).

Two paths are considered in our calculations: between Sable and Halifax, and between Sable and Seaview (see Figures 1 to 3 for appropriate maps). The frequencies relevant to our calculations are 148MHz, 432MHz, and 1296MHz. Only nominal values for the various quantites, such as antenna gain, antenna efficiency, power output, etc., are used in our calculations. In all cases, it is assumed that the calculations are independent of polarization. The calculations are given in detail in Appendix A.

The objective of these calculations is to obtain approximate values of expected signal levels for each of the various sets of conditions associated with each of the three 'models'. A summary of the results of the calculations is given in Table 1. Maps showing relative geographical placement of transmitting and receiving sites, as well as sketches showing antenna heights and line-of-sight profiles are given in Figures 1 to 5.

Brief Summaries of the Three Methods

1. Free Space model: This is a standard model, for which the path-loss α may be calculated from:

$$\alpha = 36.6 + 20\log_{10} f + 20\log_{10} d, \qquad \text{(in db)}$$

where f=frequency in MHz

d=distance in statute miles.

This model would imply that the antenna gains be given in terms of dbi. However, since the antenna gains used in our calculations are taken from manufacturers' specification sheets where they are given in terms of dbd, and since the discrepancy associated with using dbd rather than dbi is no more than 3db, and since only approximate results are expected in these calculations, then the distinction between dbi and dbd is ignored in our 'free space' calculations.

Presumably, the 'free space' values represent the upper limit on expected signal level at the receiving site, assuming that no additional gain mechanisms exist along the path.

2. Bullington's modification to free-space path loss: this is an empirical method, appearing in the form of a graph, pertaining to trans-horizon radio paths, and probably more valid for land rather than sea paths. The results are in terms of median signal levels (in db) below the free-space value. For the purposes of our calculations, this method offers a very simple procedure for obtaining another value for the expected signal level on the Sable to mainland paths, and, at best, has the status of an 'order of magnitude' calculation.

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3. Sofaer and Stark Method: this method was applied to a mixed land and sea path , at 560MHz, by Sofaer and Stark. The method accomodates a 100% sea path, and was therefore taken to be relevant to our data for both the Sable to Halifax and the Sable to Seaview paths: in both cases, the amount of land in the path is less than 10%, and hence considered to be negligible for the purposes of this calculation. The method was applied only to our data on 432MHz.

In general, the method enabled a graphical determination of an 'equivalent distance' given the distances (of land and sea components) and the percent-time that the signal strength would exceed some threshold value. In particular, the method was applied to two values of percentage: 1% and 10%. The method also includes correction factors known as 'site-variation-factors', but these were ignored in our calculations. Finally, our calculations are based on the 'CCIR curves' as reproduced in the Sofaer and Stark paper, and as applicable to a transmitting antenna height of 60m. Although the antenna heights on Sable Island are almost a factor of two lower, here again, for the purposes of our calculations, such a difference is taken to be negligible.

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Results: The results are summarized in Table 1. Column #1 contains expected signal levels (for various configurations relevant to the available equipment associated with the current project) for free space propagation. At the time of writing, there is no known instance of our data indicating signal levels greater than 'free space'.

Column #2 displays signal levels based on the Bullington modifications as discussed above. These levels are median values, and presumably averaged over a relatively long period of time. Comparisong of the values for case #1 with the results obtained from a statistical analysis of observed data for May, 1981 (as reported in our preliminary Report, dated Nov.5/82) indicates a factor of five difference between the 'Bullington value' (i.e. 0.043uV) and the observed median value (i.e.0.2uV) where it is assumed that the 50% value in the statistical analysis represents the median value. This factor (of 5) represents a difference of approximately 14db between the Bullington and the observed values.

Column #3 displays signal levels based on the Sofaer/Stark method and represent signal levels that exceed a threshold 1% of the time. Column #4 displays similar information, but for a threshold that is exceeded 10% of the time. Case #3 is relevant for comparison with our data. On the basis of our data, the Sofaer/Stark predictions are thought to compare rather favourably with our data for the past 18 months, but a statistical analysis of our data is not yet available.

Conclusion: On the basis of our observations, it would appear that both the Bullington and the Sofaer/Stark methods yield expected values for signal strength which are thought to be no more than perhaps 15db different from observed data on the Sable Island to Halifax path. Only the Bullington value pertains to our VHF path (case #1), whereas both the Bullington and the Safaer/Stark values pertain to our UHF (case #3) data.

Table 1: Summary of Calculations

case	Path description (radiation efficiency=50% in all cases)	Model calculations of expected signal level in uV			
		Free space	Bullington	Sofaer/Stark 1% threshold	Sofaer/Stark 10% threshold
1	148MHz, 180 miles, tx power = 15W, tx and rx antenna gains=9db each	62	0.043	N/A	N/A
2	148MHz, 100 miles, tx power=15W, tx and rx antenna gains=9db each	110	0.31	N/A	N/A
3	432MHz, 180 miles, tx power=15W, tx and rx antenna gains=18db each	174	0.055	38	0.4
4	432MHz, 100 miles, tx power=15W, tx and rx antenna gains=18db each	309	0.55	214	5
5	432MHz, 180 miles, tx power=15W, tx and rx antenna gains=9db each	22	0.0069	5	0.05
6	432MHz, 100 miles, tx power=15W, tx and rx antenna gains=9db each	39	0.069	27	0.6
7	1296MHz, 180 miles, tx power=2W, tx antenna gain=21db; rx antenna gain=27db	79	0.025	N/A	N/A
8	1296MHz, 100 miles, tx power=2W, tx antenna gain=21db, rx antenna gain=27db.	141	0.25	N/A	N/A
	column →	1	2	3	4

Figure 1

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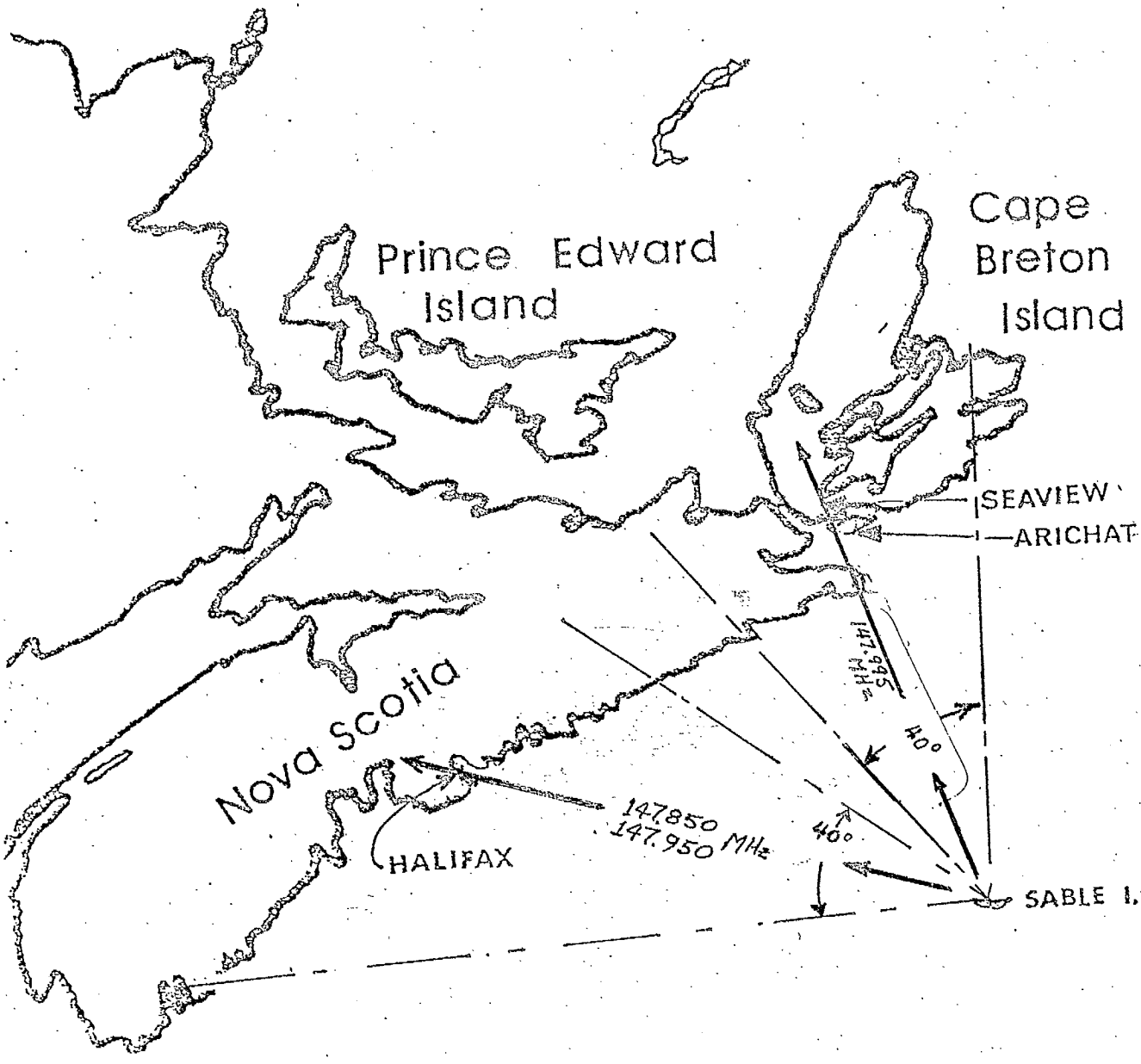

Approximate orientation of radiation patterns from three VHF beacons located on Sable Island. The half-power beam widths are assumed to have a nominal value of 40°.

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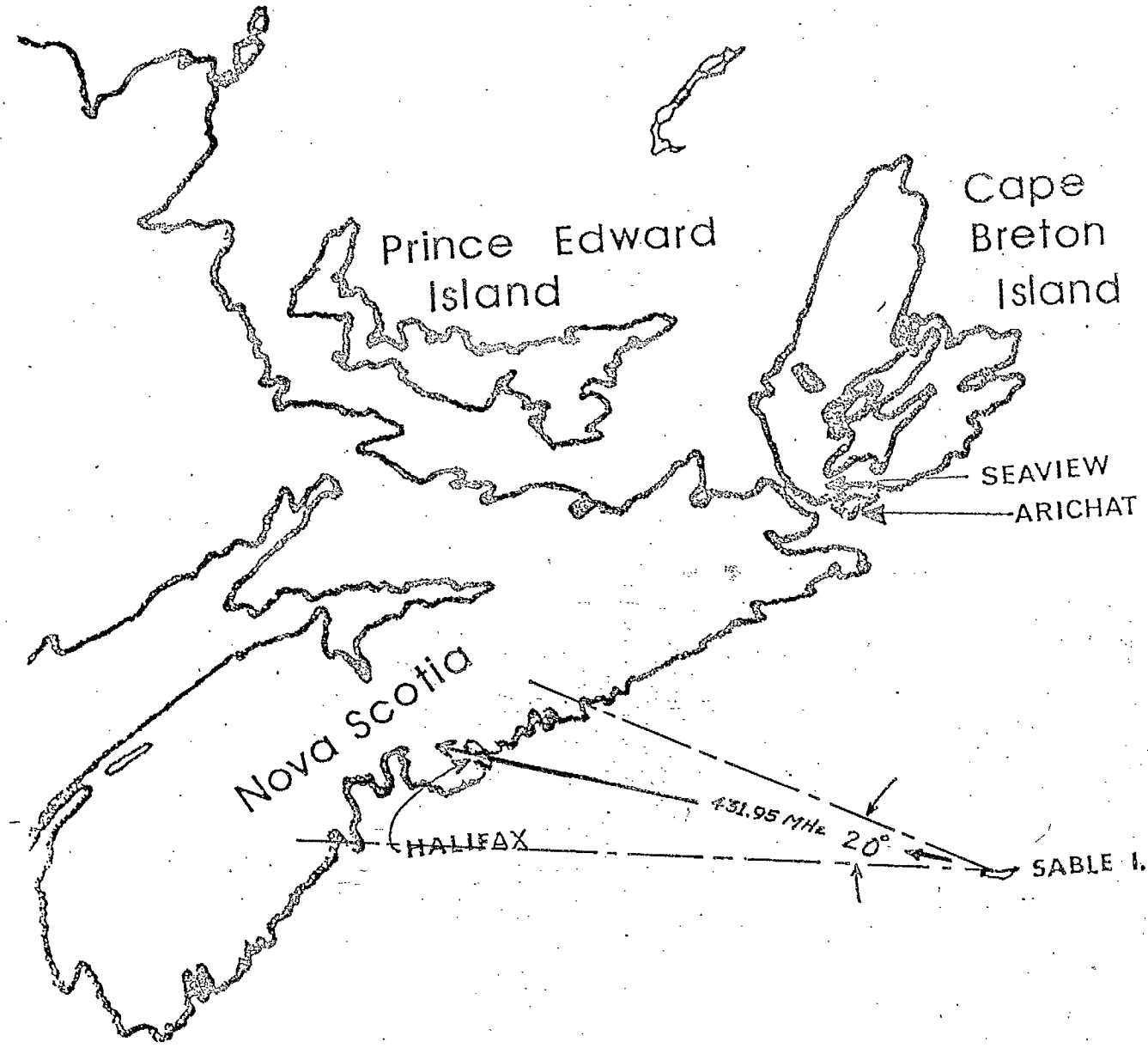
Figure 2



Approximate orientation of the radiation pattern from the low-UHF beacon located on Sable Island. The half-power beam width is assumed to have a nominal value of 20°.

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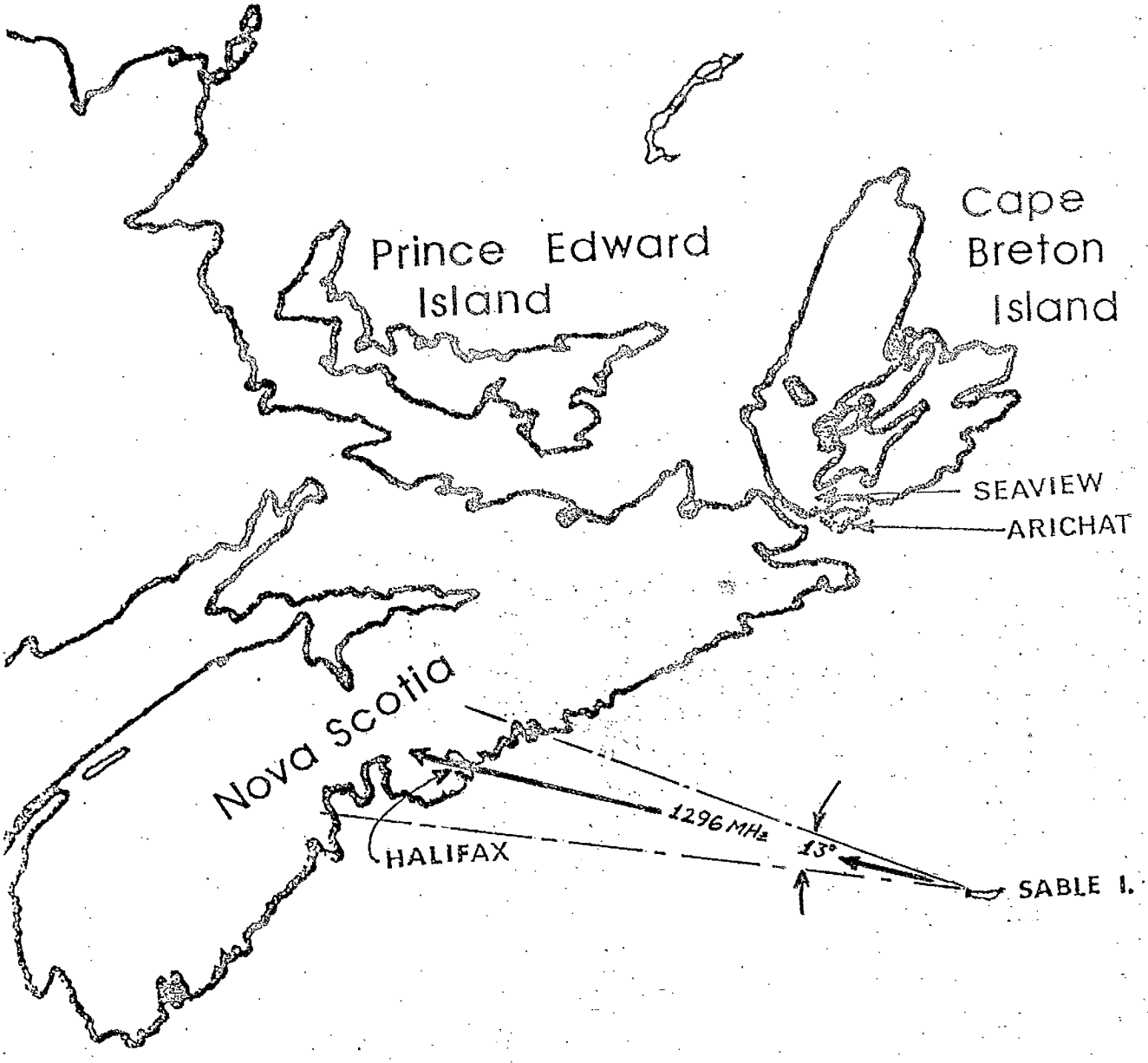
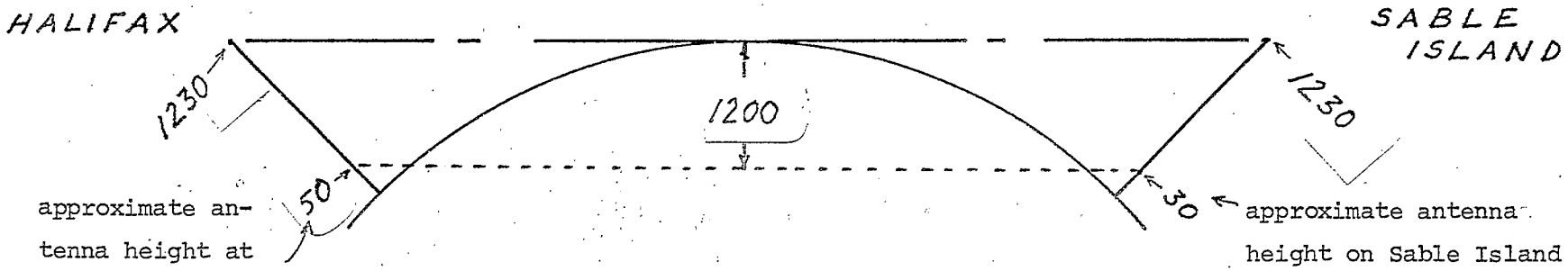
Figure 3



Approximate orientation of the radiation pattern from the high-UHF beacon located on Sable Island. The half-power beam width is assumed to have a nominal value of 13^{o}.



4/3 E.E.R. PROFILE

Elevations in meters

Figure not to scale

Figure 4

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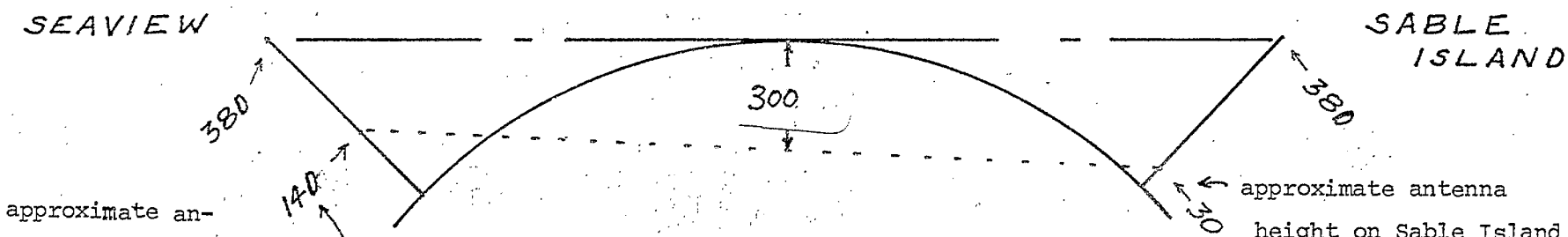

4/3 E.E.R. PROFILE.

Elevations in meters
Figure not to scale

Figure 5

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APPENDIX

by

W.D.Rawle

PART 1: SABLE ISLAND FREE SPACE PATH COMPUTATIONS

Theory: The free space path loss α is given as:

$$\alpha = 36.6 + 20 \log_{10} f + 20 \log_{10} d$$

where f = frequency in MHz

d = distance in statute miles

(from "Reference Data for Radio Engineers, 5th ed." by ITT, p.26:19)

Case 1: Sable-Halifax VHF

148 MHz, 180 statute mile path, transmitter power 15 watts, tx/rx antenna gain 9dB (nom), radiation efficiency 50% (including feedline loss)

$$\alpha = 36.6 + 20 \log_{10} (148 \text{ MHz}) + 20 \log_{10} (180 \text{ miles}) = 125 \text{ dB}$$

Path Analysis:	Transmitter output (15watts)	+11.8 dBW
	Radiation efficiency (50%)	-3 dB
	tx antenna gain	+9 dB
	α	-125 dB
	rx antenna gain	+9 dB
	Radiation efficiency (50%)	-3 dB
	Power level at rx terminals	-101.2 dBW
		$= 7.59 \times 10^{-11}$ Watts
	Voltage across 50Ω transmission line at rx terminals	61.6μV

Case 2: Sable-Seaview VHF

148 MHz, 100 statute mile path, transmitter power 15 watts, tx/rx antenna gain 9 dB (nom), radiation efficiency 50% (including feedline loss)

$\alpha = 36.6 + 20 \log_{10} (148 \text{ MHz}) + 20 \log_{10} (100 \text{ miles}) = 120 \text{ dB}$

Path Analysis:	Transmitter output (15 watts)	+11.8 dBW
	Radiation efficiency (50%)	-3 dB
	tx antenna gain	+9 dB
	α	-120 dB
	rx antenna gain	+9 dB
	Radiation efficiency (50%)	-3 dB
	Power level at rx terminals	-96.2 dBW
		$= 2.40 \times 10^{-10}$ watts
	Voltage across 50Ω transmission line at rx terminals	109.5 μV

Case 3: Sable-Halifax, Low UHF

432 MHz, 180 statute mile path, transmitter power 15 watts tx/rx antenna gain 18 dB (nom), radiation efficiency 50% (including feedline loss)

$\alpha = 36.6 + 20 \log_{10} (432 \text{ MHz}) + 20 \log_{10} (180 \text{ miles}) = 134 \text{ dB}$

Path Analysis:	Transmitter output (15 watts)	+11.8 dBW
	Radiation efficiency (50%)	-3 dB
	tx antenna gain	+18 dB
	α	-134 dB
	rx antenna gain	+18 dB
	Radiation efficiency (50%)	-3 dB

Power level at rx terminals	-92.2 dBW
	$= 6.03 \times 10^{-10}$ watts
Voltage across 50Ω transmission line at rx terminals	173.6 μV

Case 4: Sable-Seaview Low UHF

432 MHZ, 100 statute mile path, transmitter power 15 watts, tx/rx antenna gain, 18 dB (nom), radiation efficiency 50% (including feedline loss)

$\alpha = 36.6 + 20 \log_{10} (432 \text{ MHZ}) + 20 \log_{10} (100 \text{ miles}) = 129 \text{ dB}$

Path Analysis:	Transmitter output (15 watts)	+11.8 dBW
	Radiation efficiency (50%)	-3 dB
	tx antenna gain	+18 dB
	α	-129 dB
	rx antenna gain	+18 dB
	Radiation efficiency (50%)	-3 dB
	Power level at rx terminals	-87.2 dBW
		$= 1.91 \times 10^{-9}$ watts
	Voltage across 50Ω transmission line at rx terminals	308.7 μV

Case 5: Sable-Halifax Low UHF (employing yagis)

432 MHZ, 180 statute mile path, transmitter power 15 watts tx/rx antenna gain 9 dB (nom), radiation efficiency 50% (including feedline loss)

$\alpha = 36.6 + 20 \log_{10} (432 \text{ MHZ}) + 20 \log_{10} (180 \text{ miles}) = 134 \text{ dB}$

Path Analysis:	Transmitter output (15 watts)	+11.8 dBW
	Radiation efficiency (50%)	-3 dB
	tx antenna gain	+9 dB
	α	-134 dB
	rx antenna gain	+9 dB
	Radiation efficiency (50%)	-3 dB
	Power level at rx terminals	-110.2 dBW
		$= 9.55 \times 10^{-12}$ watts
	Voltage across 50Ω transmission line at rx terminals	21.9 μV

Case 6: Sable-Seaview Low UHF (employing yagis)

432 MHz, 100 statute mile path, transmitter power 15 watts, tx/rx antenna gain 9 dB (nom), radiation efficiency 50% (including feedline loss)

$\alpha = 36.6 + 20 \log_{10} (432 \text{ MHz}) + 20 \log_{10} (100 \text{ miles}) = 129 \text{ dB}$

Path Analysis:	Transmitter output (15 watts)	+11.8 dB
	Radiation efficiency (50%)	-3 dB
	tx antenna gain	+9 dB
	α	-129 dB
	rx antenna gain	+9 dB
	Radiation efficiency (50%)	-3 dB
	Power level at rx terminals	-105.2 dBW
		$= 3.02 \times 10^{-11}$ watts
	Voltage across 50Ω transmission line at rx terminals	38.9 μV

Case 7: Sable-Halifax High UHF

1296 MHz, 180 statute mile path, transmitter power 2 watts, tx antenna gain 21 dBi (nom), rx antenna gain 27 dBi (nom), radiation efficiency 50% (including feedline loss)

$\alpha = 36.6 + 20 \log_{10} (1296 \text{ MHz}) + 20 \log_{10} (180 \text{ miles}) = 144 \text{ dB}$

Path Analysis:		
	Transmitter output (2 watts)	+3.0 dBW
	Radiation efficiency (50%)	-3 dB
	tx antenna gain	+21 dB
	α	-144 dB
	rx antenna gain	+27 dB
	Radiation efficiency	-3 dB
	Power level at rx terminals	-99.0 dBW
		$= 1.26 \times 10^{-10}$ watts
	Voltage across 50Ω transmission line at rx terminals	79.3μV

Case 8: Sable-Seaview High UHF

1296 MHz, 100 statute mile path, transmitter power 2 watts, tx antenna gain 21 dBi (nom), rx antenna gain 27 dBi (nom), radiation efficiency 50% (including feedline loss)

$\alpha = 36.6 + 20 \log_{10} (1296 \text{ MHz}) + 20 \log_{10} (100 \text{ miles}) = 139 \text{ dB}$

Path Analysis:		
	Transmitter output (2 watts)	+3.0 dBW
	Radiation efficiency (50%)	-3 dB
	tx antenna gain	+21 dB
	α	-139 dB
	rx antenna gain	+27 dB
	Radiation efficiency (50%)	-3 dB

Power level at rx terminals -94.0 dBW

$= 3.98 \times 10^{-10}$ watts

Voltage across 50Ω transmission line at rx terminals 141.1μV

PART 2: SABLE ISLAND 'BULLINGTON' PATH COMPUTATIONS

Theory: For communications circuits which greatly exceed radio optical range limits, Bullington has experimentally derived a modification to free space path loss figures. The modification presented in graphical form yields median signal levels only. No attempt is made in this analysis to produce a 90% signal level availability.

(from "Point to Point Radio Relay Systems 44 MHz to 13000 MHz" by RCA Services Ltd., p. 150, Fig. 14 - 20)

Case 1: Sable-Halifax VHF

148 MHz, 180 statute mile path, transmitter power 15 watts tx/rx antenna gain 9 dB (nom), radiation efficiency 50% (including feedline loss), α = 125 dB, Bullington modification -63 dB

Path Analysis:	Transmitter output (15 watts)	+11.8 dBW
	Radiation efficiency (50%)	-3 dB
	tx antenna gain	+9 dB

α	-125 dB
Bullington modification	-63 dB
rx antenna gain	+9 dB
Radiation efficiency (50%)	-3 dB
Power level at rx terminals	-164.2 dBW
	$= 3.80 \times 10^{-17}$ watts
Voltage across 50Ω transmission line at rx terminals	0.044μV

Case 2: Sable-Seaview VHF

148 MHz, 100 statute mile path, transmitter power 15 watts tx/rx antenna gain 9 dBi (nom), radiation efficiency 50% (including feedline loss), α = 120 dB, Bullington modification -51 dB

Path Analysis:	Transmitter output (15 watts)	+11.8 dBw
	Radiation efficiency (50%)	-3 dB
	tx antenna gain	+9 dB
	α	-120 dB
	Bullington modification	-51 dB
	rx antenna gain	+9 dB
	Radiation efficiency (50%)	-3 dB
	Power level at rx terminals	-147.2 dB
		$= 1.91 \times 10^{-15}$ watts
	Voltage across 50Ω transmission line at rx terminals	0.31μV

Case 3: Sable-Halifax Low UHF

432 MHz, 180 statute mile path, transmitter power 15 watts tx/rx antenna gain 18 dB (nom), radiation efficiency 50% (including feedline loss), α = 134 dB, Bullington modification -70 dB

Path Analysis:	Transmitter output (15 watts)	+11.8 dBW
	Radiation efficiency (50%)	-3 dB
	tx antenna gain	+18 dB
	α	-134 dB
	Bullington modification	-70 dB
	rx antenna gain	+18 dB
	Radiation efficiency (50%)	-3 dB
	Power level at rx terminals	-162.2 dBW
		$= 6.03 \times 10^{-17}$ watts
	Voltage across 50Ω transmission line at rx terminals	0.055μV

Case 4: Sable-Seaview Low UHF

432 MHz, 100 statute mile path, transmitter power 15 watts, tx/rx antenna gain 18 dB (nom), radiation efficiency 50% (including feedline loss), α = 129 dB, Bullington modification -55 dB

Path Analysis:	Transmitter output (15 watts)	+11.8 dBW
	Radiation efficiency (50%)	-3 dB
	tx antenna gain	+18 dB
	α	-129 dB
	Bullington modification	-55 dB
	rx antenna gain	+18 dB
	Radiation efficiency (50%)	-3 dB

Power level at rx terminals	-142.2 dBW
	$= 6.03 \times 10^{-15}$ watts
Voltage across 50Ω transmission line at rx terminals	0.55μV

Case 5: Sable-Halifax Low UHF (employing yagis)

432 MHz, 180 statute mile path, transmitter power 15 watts, tx/rx antenna gain 9 dB (nom), radiation efficiency 50% (including feedline loss), α = 134 dB, Bullington modification -70 dB

Path Analysis:	Transmitter output (15 watts)	+11.8 dBW
	Radiation efficiency (50%)	-3 dB
	tx antenna gain	+9 dB
	α	-134 dB
	Bullington modification	-70 dB
	rx antenna gain	+9 dB
	Radiation efficiency (50%)	-3 dB
	Power level at rx terminals	-180.2 dBW
		$= 9.55 \times 10^{-19}$ watts
	Voltage across 50Ω transmission line at rx terminals	0.0069μV

Case 6: Sable-Seaview Low UHF (employing yagis)

432 MHz, 100 statute mile path, transmitter power 15 watts, tx/rx antenna gain 9 dB (nom), radiation efficiency 50% (including feedline loss), α = 129 dB, Bullington modification -55 dB

Path Analysis:	Transmitter output (15 watts)	+11.8 dBW
	Radiation efficiency (50%)	-3 dB
	tx antenna gain	+9 dB

α	-129 dB
Bullington modification	-55 dB
rx antenna gain	+9 dB
Radiation efficiency (50%)	-3 dB
Power level at rx terminals	-160.2 dBW
	$= 9.55 \times 10^{-17}$ watts
Voltage across 50Ω transmission line at rx terminals	0.069μV

Case 7: Sable-Halifax High UHF

1296 MHz, 180 statute mile path, transmitter power 2 watts tx antenna gain 21 dB (nom), rx antenna gain +27 dBi (nom), radiation efficiency 50% (including feedline loss) α = 144 dB, Bullington modification -70 dB

Path Analysis:	Transmitter output (2 watts)	+3.0 dB
	Radiation Efficiency (50%)	-3 dB
	tx antenna gain	+21 dB
	α	-144 dB
	Bullington modification	-70 dB
	rx antenna gain	27 dB
	Radiation efficiency (50%)	-3 dB
	Power level at rx terminals	-169.0 dBW
		$= 1.26 \times 10^{-17}$ watts
	Voltage across 50Ω transmission line at rx terminals	0.025μV

Case 8: Sable-Seaview High UHF

1296 MHz, 100 statute mile path, transmitter power 2 watts, tx antenna gain 21 dB (nom), rx antenna gain 27 dBi (nom), radiation efficiency 50% (including feedline loss) α = 139 dB, Bullington modification - 55 dB

Path Analysis:	Transmitter output (2 watts)	+3.0 dBW
	Radiation efficiency (50%)	-3 dB
	tx antenna gain	+21 dB
	α	-139 dB
	Bullington modification	-55 dB
	rx antenna gain	+27 dB
	Radiation efficiency (50%)	-3 dB
	Power level at rx terminals	-149.0 dBW
		$= 1.23 \times 10^{-15}$ watts
	Voltage across 50Ω transmission line at rx terminals	0.25μV

PART 3: SABLE ISLAND 'SOFAER/STARK' PATH COMPUTATIONS

Theory: This analysis employs CCIR time probability curves quoted by E. Sofaer and J. W. Stark. This method was verified by Sofaer and Stark in their 1961 560 MHz field intensity measurements. Calculations for Sable Island will be done for 432 MHz only.

(from "Tropospheric radio-wave propagation over mixed land and sea paths", E. Sofaer and J. W. Stark, Proc. IEE, Vol. 113, No. 8, August 1966)

1. From CCIR curves the following field intensities are obtained:

   (a) For a 180 statute mile over sea path (1 KW ERP):

   1% 45 dB (μV/m)

   10% 5 dB (μV/m)

   (b) For a 100 statute mile over sea path (1 KW ERP):

   1% 60 dB (μV/m)

   10% 27 dB (μV/m)

2. Empirical path loss computations for given probabilities:

   (a) 180 statute miles / 1%

$$E = 45 \text{ dB } (\mu V/m) = 178 \ \mu V/m$$

$$P = \frac{E^2}{120\pi} = 8.4 \times 10^{-11} \text{ watts/m}^2$$

A_r (isotropic radiator at 560 MHz)

$$= \frac{\lambda^2}{4\pi} = 2.284 \times 10^{-2} \text{ m}^2$$

Isotropic radiator received power

$= 1.9 \times 10^{-12}$ watts

$= -117.2$ dBW

tx output (1KW ERP)	+30	dBW
path loss for 1% time	147.2	dB

10%

$E = 5$ dB(μV/m) $= 1.78$ μV/m

$P = \frac{E^2}{120\pi} = 8.4 \times 10^{-13}$ watts/m^2

$A_r = 2.284 \times 10^{-2}$ m^2 (from above)

Isotropic radiator received power

$= 1.92 \times 10^{-16}$ watts

$= -157$ dBW

tx output (1KW ERP)	+30	dBW
Path loss for 10% time	187	dB

(b) 100 statute miles

1%

$E = 60$ dB (μV/m) $= 1.0$ mV/m

$P = \frac{E^2}{120\pi} = 2.7 \times 10^{-9}$ watts/m^2

$A_r = 2.284 \times 10^{-2}$ m^2 (from above)

Isotropic radiator received power

$= 6.1 \times 10^{-11}$ watts

$= -102$ dBW

tx output (1KW ERP)	+30	dBW
Path loss for 1% time	132	dB

10%

$E = 27$ dB (μV/m) $= 22$ μV/m

$$P = \frac{E^2}{120\pi} = 1.3 \times 10^{-12} \text{ watts/m}^2$$

$A_r = 2.284 \times 10^{-2}$ m^2 (from above)

Isotropic radiator received power

$= 3.0 \times 10^{-14}$ watts

$= -135$ dBW

tx output (1KW ERP)	+30 dBW
path loss for 10% time	165 dB

Case 1: Sable-Halifax Low UHF

432 MHz, 180 statute mile path, transmitter power 15 watts tx/rx antenna gain 18 dB (nom) radiation efficiency 50% (including feedline loss), path loss 1% : 147 dB; 10% : 187 dB

Path Analysis:	Transmitter output (15 watts)	+11.8 dBW
1%	Radiation efficiency (50%)	-3 dB
	tx antenna gain	+18 dB
	Path loss	147 dB
	rx antenna gain	+18 dB
	Radiation Efficiency	-3 dB
	Power level at rx terminals	105 dBW
	$= 2.9 \times 10^{-11}$ watts	
	Voltage across 50Ω transmission line at rx terminals	38uV

Path Analysis:	Transmitter output (15 watts)	+11.8 dBW
10%	Radiation efficiency (50%)	-3 dB
	tx antenna gain	18 dB
	Path loss	-187 dB
	rx antenna gain	+18 dB
	Radiation efficiency (50%)	-3 dB
	Power level at rx terminals	-145 dBW
	=	2.9×10^{-15} watts
	Voltage across 50Ω transmission line at rx terminals	0.4uV

Case 2: Sable-Seaview Low UHF

432 MHz, 100 statute mile path, transmitter power 15 watts tx/rx antenna gain 18 dB (nom), radiation efficiency 50% (including feedline loss), path loss 1% :132 dB; 10% : 165 dB

Path Analysis:	Transmitter output (15 watts)	+11.8 dBW
1%	Radiation efficiency (50%)	-3 dB
	tx antenna gain	+18 dB
	Path loss	-132 dB
	rx antenna gain	+18 dB
	Radiation efficiency (50%)	-3 dB
	Power level at rx terminals	-90 dBW
	=	9.1×10^{-10} watts
	Voltage across 50Ω transmission line at rx terminals	214uV

Path Analysis:	Transmitter output (15 watts)	+11.8 dBW
10%	Radiation efficiency (50%)	-3 dB
	tx antenna gain	+18 dB
	Path loss	-165 dB
	rx antenna gain	+18 dB
	Radiation efficiency (50%)	-3 dB
	power level at rx terminals	-123 dBW
	=	4.6×10^{-13} watts
	Voltage across 50Ω transmission line at rx terminals	5uV

Case 3: Sable-Halifax Low UHF (employing yagis)

432 MHz, 180 statute mile path, transmitter power 15 watts tx/rx antenna gain 9 dB (nom), radiation efficiency 50% (including feedline loss), path loss 1% : 147 dB ; 10% : 187 dB

Path Analysis:	Transmitter output (15 watts)	+11.8 dBW
1%	Radiation efficiency (50%)	-3 dB
	tx antenna gain	+9 dB
	Path loss	-147 dB
	rx antenna gain	+9 dB
	Radiation efficiency (50%)	-3 dB
	Power level at rx terminals	-123 dBW
	=	4.6×10^{-13} watts
	Voltage across 50Ω transmission line at rx terminals	5uV

Path Analysis:	Transmitter output (15 watts)	+11.8 dBW
10%	Radiation efficiency (50%)	-3 dB
	tx antenna gain	+9 dB
	Path loss	-187 dB
	rx antenna gain	+9 dB
	Radiation efficiency (50%)	-3 dB
	Power level at rx terminals	-163 dBW
	= 4.6×10^{-17}	watts
	Voltage across 50Ω transmission line at rx terminals	0.05uV

Case 4: Sable-Seaview Low UHF (employing yagis)

432 MHz, 100 statute mile path, transmitter power 15 watts tx/rx antenna gain 9 dB (nom), radiation efficiency 50% (including feedline loss), path loss 1% : 132 dB; 10% : 165 ? dB

Path Analysis:	Transmitter output (15 watts)	+11.8 dBW
1%	Radiation efficiency (50%)	-3 dB
	tx antenna gain	+9 dB
	Path loss	-132 dB
	rx antenna gain	+9 dB
	Radiation efficiency (50%)	-3 dB
	Power level at rx terminals	-108 dB
	= 1.4×10^{-11}	watts
	Voltage across 50Ω transmission line at rx terminals	27uV

Path Analysis:	Transmitter output (15 watts)	+11.8 dBW
10%	Radiation efficiency (50%)	-3 dB
	tx antenna gain	+9 dB
	Path loss	-165 dB
	rx antenna gain	+9 dB
	Radiation efficiency (50%)	-3 dB
	Power level at rx terminals	-141 dbW
	$= 7.2 \times 10^{-15}$ watts	
	Voltage across 50Ω transmission line at rx terminals	0.6uV

Appendix #4

Report Appendix #4

Memo: Summary of information pertaining to the Beacons and Antennas on Sable Island.

Principal Investigator: W.Lonc, VE1SMU

Date: December 27, 1982

This memorandum summarizes salient information pertaining to the beacons (associated with the current research contract) on Sable Island. There are 7 of these beacons on the island, and the associated antennas are located at a place known as the West Light area. All seven antennas are mounted on one or other of two towers; one of these towers, designated "SMU tower #1", is a 16 meter structure situated just east of the Transmitter Building and supports antennas for 147.950MHz, 147.995MHz, and 431.900MHz; the other tower, designated "SMU tower #2", is a 27 meter structure just south of the Transmitter Building and supports antennas for 147.850MHz, 147.900 MHz, 431.950MHz, and 1296MHz.

Tower #1 was constructed by the writer in the summer of 1980; tower #2 is the former West Light tower and has been made available by the Coast Guard over the past two years. Both towers are considered (by the writer) to be in very satisfactory condition for the purposes of this research project. There is no indication of any deterioration in either the guy-wires or the associated anchors and hardware.

The salient information pertaining to the beacons and antennas is given in Table 1. A sketch of the positioning and orientation of the antennas on tower #2 is given in Figure 1.

Table 1: Beacon and Antenna Details(on Sable Island)

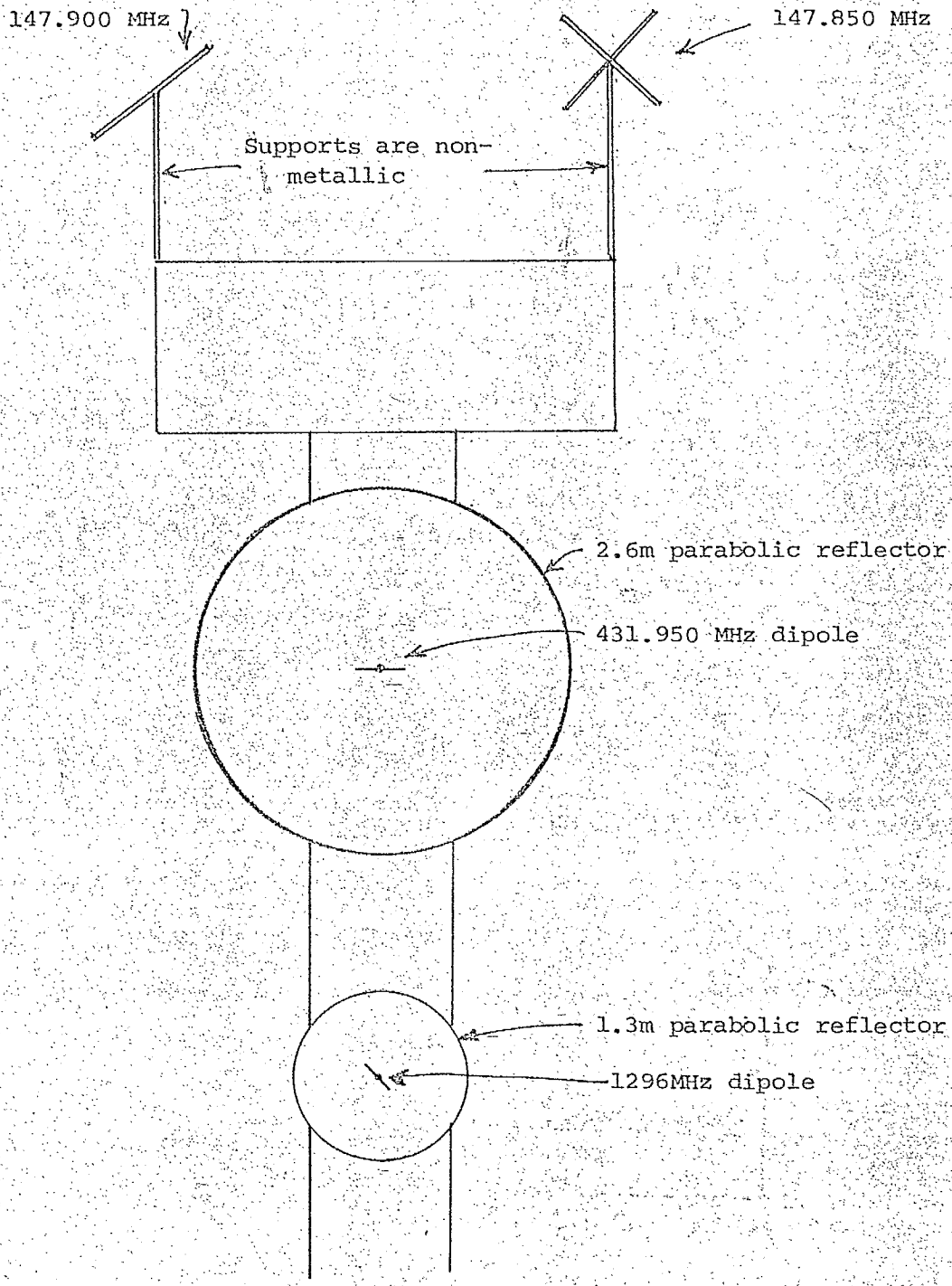
Frequency(MHz)	Beacon power (Watts)*	Antenna type	Polarization	Ant.gain (dbd)*	Direction	Location (tower)
147.850	15	crossed yagi	circular	10	Halifax	#2
147.900	10	yagi	linear,45° to the horizontal	10	"	#2
147.950	15	yagi	linear, horizontal	10	"	#1
147.995	15	yagi	"	10	Seaview	#1
431.900	5	crossed yagi	circular	10	Halifax	#1
431.950	10	2.6m parabolic	linear,horizontal.	18	"	#2
1296	1	1.3m parabolic	linear,45° to the horizontal.	21	"	#2

*The quantities shown represent nominal values only.

Figure 1: Arrangement of Antennas on SMU Tower #2:Sable Island

Note: This figure is not to scale.

: The figure represents a view looking east, towards the 'front' of the antennas.The angle between the longitudinal axes of the antennas and the East-West line is not shown.



Appendix #5

Report Appendix #5

Propagation on 431.950 MHz from Sable Island to Halifax using vertically separated antennas: Part 1 (a preliminary Report)

Report date: July 19/82
Report prepared by W.P. Lonc (principal investigator): VE1SMU
Data obtained with the collaboration of Mr. Elmer Naugler : VE1OD.

1. Introduction: A preliminary investigation was made of propagation on 431.950MHz from two vertically separated antennas on Sable Island, the antennas being fed alternately from a beacon transmitter. The investigation was made between June 17 and July 6, 1982, and was intended to provide some indication of possible differences in propagation associated with a configuration characterized by a vertical separation between antennas. The experiment could be useful in testing applicability of available propagation models to the Sable-Halifax path. It was observed that the signal from the upper antenna was dominant for approximately 90% of the time.

2. Experimental details:

A. On Sable Island:

(a) Beacon: 15W; AM modulated(100%); built-in VSWR monitor; 431.950 MHz; crystal-controlled.

(b) Antennas: 2.46m parabolic reflectors(wire mesh), with a dipole (plus reflector) at the focal point; the antennas are considered to be identical. The beam-width is calculated to be approximately 16° FWHP. One of the antennas(hereafter HIGH) is located near the top of the tower, and is approximately 25m from the ground. The other(hereafter LOW) is located near the bottom of the same tower, and is approximately 7m from the ground. The LOW antenna is partially obstructed by a sand dune some 30m in front of the tower(looking towards Halifax). Both antennas are fed by heliax transmission line, and both antennas are horizontally polarized.

(c) Switching equipment: A coaxial switch is controlled by a square-wave driving-voltage oscillating at approximately 1Hz. The switching equipment also includes provision for changing the modulation frequency from 400Hz to 300Hz synchronously with the coaxial switch;

the 400Hz tone is associated with the LOW antenna, and the 300Hz with the HIGH.

(d) Verification of performance: The relatively low switching rate enables a visual inspection of the VSWR for each antenna. The VSWR is estimated to be less than 1.1:1 for each antenna. Assuming all other factors to be equal, it is assumed that the antennas radiate the same power. The antennas are parallel to within 2^{o}. Hence, any difference in received power along the line of propagation is taken to be a result of propagation rather than transmitter/antenna factors. In addition to a visual inspection of the switching equipment to confirm that the antennas were being switched as intended, a supplementary test was made, in which a portable detector(with audio monitor) was placed near each antenna and the appropriate tone identified.

B. At Halifax

(a) Receiving site at the residence of Mr. Naugler: The site is shown on the outline map in Figure 1. The antenna is a multi-bay yagi system, and the receiving system was operated without AGC(automatic gain control). The output of the receiver could be monitored simultaneously on a voltmeter and loudspeaker.

(b) Receiving site at Saint Mary's University: The site is shown in Figure 1. The antenna is similar to those on Sable Island, and the receiving system was operated without AGC. The output of the receiver could be monitored simultaneously on a voltmeter, loudpeaker, and chart recorder.

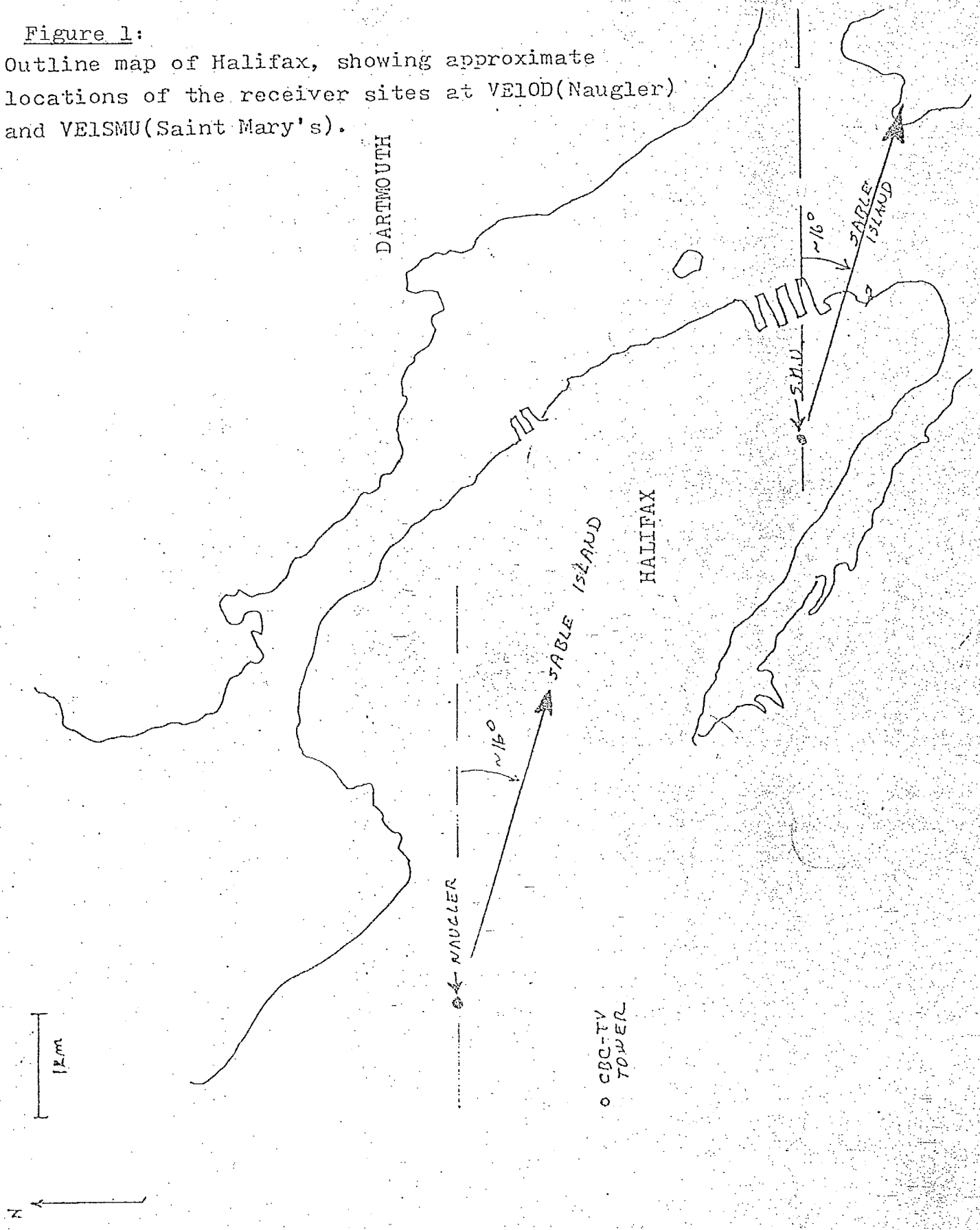
3. Observations: Over the period between June 17 and July 7, observations at both receiving sites were made primarily on the basis of visual inspection of a voltage-reading in conjunction with identification of the appropriate tone, and the observation consisted of a simple decision in terms of: 'larger than', 'equal to', or 'smaller than', and the decision was based on conditions at the instant of observation. Although this procedure lends itself to observer bias, etc.--in particular when there is fast fading of the signals--the preliminary nature of this investigation did not warrant more quantitative procedures at this time. In fact, some quantitative observations were made(mainly at Mr. Naugler's site), but this Report will restrict itself to the three simple

categories mentioned above. The observations were made between 7 am and 11:30 pm local time on a daily basis, and approximately 4 observations per day were made at each receiving site. A total of 198 observations were made.

Results: It was found that the signal from the HIGH antenna was stronger(and usually quite stronger) than the LOW approximately 90% of the time. The LOW antenna was stronger some 2% of the time.

4. Action to be taken: On the basis of the results, it is intended to repeat the experiment at various times over the next few months to obtain data representing different times of the year. Moreover, it is intended to extend the observations to include short time-scale behaviour(resolution in the order of 0.1 seconds) to provide data on events associated with fast-fading. It is also intended to obtain some quantitative observations of the relative magnitudes of received power. Estimates based on some of the observations in this Report indicate that the signal from the HIGH antenna was usually more than 6db stronger than the signal from the LOW antenna.

Figure 1:
Outline map of Halifax, showing approximate locations of the receiver sites at VE1OD(Naugler) and VE1SMU(Saint Mary's).



Report Appendix #6

Propagation on 431.950 MHz from Sable Island to Halifax using vertically separated antennas: Part 2 (a preliminary Report)

Report date: July 21/82

Report prepared by W.P. Lonc (principal investigator), VE1SMU.

1. Introduction: It has been observed, when signal reception is relatively weak, that the difference between signals received from antennas located at two different heights on Sable Island changes both magnitude and sign. The alternation takes place over a time interval of a few seconds. This preliminary Report presents data obtained around 7:11 pm on July 8, 1982. The experiment could be useful in testing applicability of available propagation models to the Sable-Halifax path.

2. Experimental details:

A. On Sable Island: see the preceding Report(July 19/82).

B. At Halifax: Only the receiving site at Saint Mary's University is relevant to this Report(see the preceding Report, July 19/82). The chart-recorder has a response-time of less than 1/10 sec.

3. Observations: Although the effect has been observed on several occasions, only the data obtained around 7:11 pm on July 8/82 will be presented in this preliminary Report. The data under discussion is found in Figure 1. Inspection of the data shows that the pulses numbered 1 to 9 inclusive are associated with the HIGH antenna, and that the signal from the HIGH antenna is dominant during this time interval. Beginning with pulse #10, however, it is the signal from the LOW antenna which is now dominant. The chart-speed is 2.5 mm/sec., so that the time associated with this event--i.e. exchange of relative magnitude-- lasts for several seconds. In other words, although the signal from the HIGH antenna is usually stronger than the LOW, this observation shows that occasionally(and for several seconds) the signal from the LOW antenna will be dominant. Preliminary observations also indicate that under the conditions of this experiment(i.e. relatively weak signals with fast fading) the non-dominant signal will drop below the receiver noise level.

In contrast to the conditions mentioned above, the behaviour of the signal is usually characterized by a much more gradual change in signal amplitude, as well as a definite dominance of the HIGH antenna's signal over that of the LOW antenna. A typical representation of usual behaviour is shown in Figure 2.

It should be noted that the observations made in this Report pertain to a period of time beginning about June 17/82 and ending at the time of writing this Report, and that this period contains a number of enhanced propagation events. During an enhanced propagation event, the signal strength is noticeably larger and remains so--with relatively little fading-- for several hours or more.

4. Action to be taken: It is intended to repeat the experiment at various times over the next few months to obtain data representing different times of the year. An attempt will also be made to test for depolarization effects, as well as correlation with metereological factors.

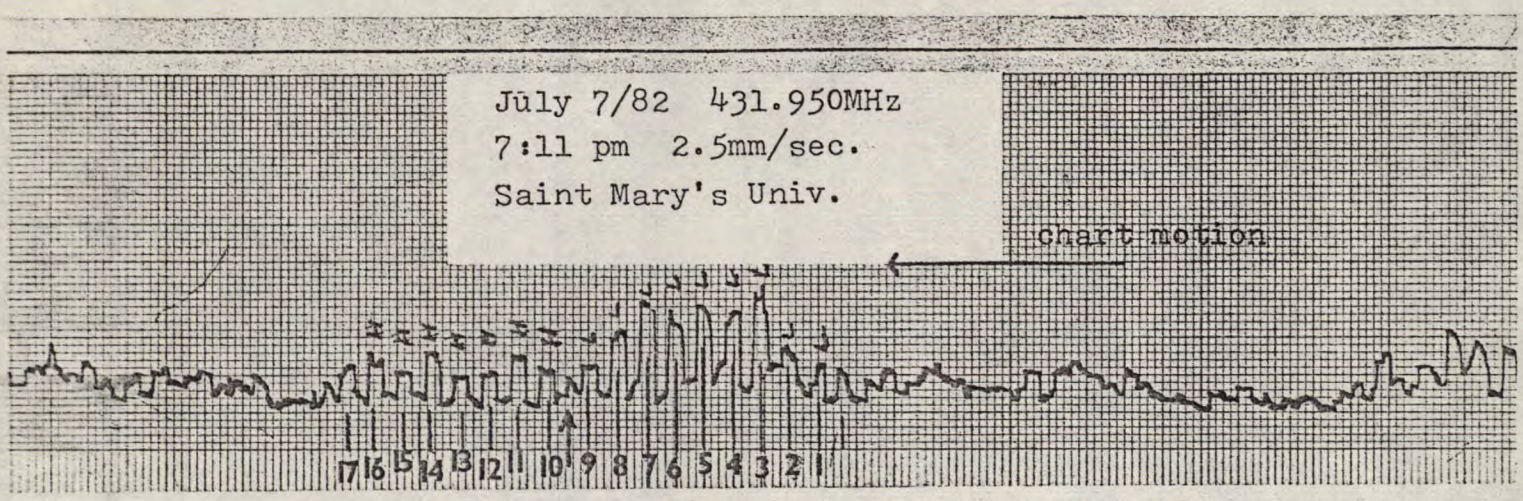


Figure 1: Data showing an alternation in signal strength associated with the lower(H) and upper(L) transmitting antennas. For pulses 1 to 9, L>H; for 10 to 17, H>L.

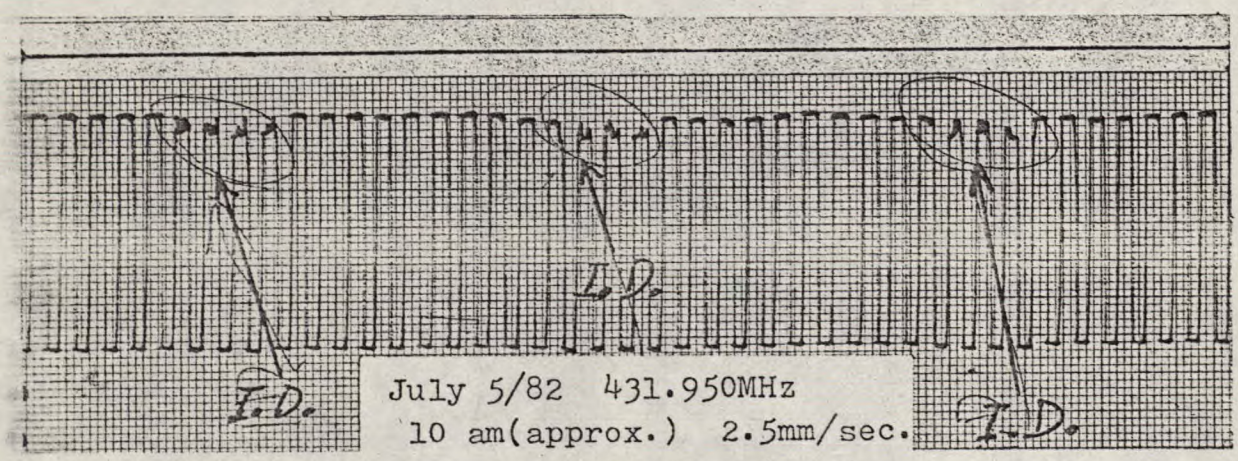


Figure 2: Data showing a noticeably constant signal level from each antenna. In this recording, L>H throughout. The areas indicated by arrows are associated with signal-level change when the Morse-code identification occurs.

Appendix #7

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Propagation Aspects of Frequency Sharing, Interference and System Diversity

NORTH ATLANTIC TREATY ORGANIZATION

DISTRIBUTION AND AVAILABILITY
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VHF/UHF PROPAGATION STUDIES ON LONG OVER THE HORIZON SALT WATER RADIO PATHS

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SUMMARY

Received Signal Levels have been monitored and recorded over a number of long range (300 KM) salt water radio paths for the past year and a half. Preliminary anlysis of the data reveals that mean signal levels received are higher than anticipated and that a usable path can be established with 1KW ERP levels.

The propagation is characterized by short deep fades and there are only rare occasions when the signal drops below usable limits for extended periods. The type of fading reported by Wickerts and Nilsson (1973) has been observed.

A strong seasonal effect has been recorded. Path reliability approaches 100% during the summer and as low as 50% during the winter.

The fast fading effect can be reduced significantly with space diversity reception and the reliability could exceed 95% with simple diversity arrangements. Space and frequency diversity, if required, would offer near 98% reliability for voice communications.

Circular polarization appears to suffer less from fast fades than linear polarization and observations are continuing in this area.

The differences in performance between UHF (400) and VHF (140) are not pronounced. Certainly not to the degree as observed over land paths.

This paper outlines the nature of both short term and long term path tests being conducted, and describes the preliminary observations based on initial analysis of the data collected.

1. INTRODUCTION

Until recently the residents and staff of Sable Island have not had reliable communications services. One HF Teletype circuit and one MF marine telephone circuit were used to provide both data and voice communication services to and from the Island. These services were not of the quality or reliability required to serve the Island and proved to be inadequate with the increase in off-shore oil exploration in the Sable Island region.

Maritime Telegraph and Telephone Company Limited (MT&T) recognized the need to offer its services to the Sable Island area and has since become the prime provider of communications services to this region.

Sable Island is located in the Atlantic Ocean off the eastern coast of Canada. The island is approximately 200 KM east of the coast of the province of Nova Scotia. (Fig 1)

The Island is a crescent shaped sand bar some 20 KM long and less than 1 KM wide at the widest part. There is a weather station and an upper air station maintained on the Island which is staffed by employees of the Atmospheric Environment Services (AES) branch of the Canadian Government. The Island has become more prominent recently as it is located in an area of increased oil and gas exploration. The exploration results have been positive and activity in the region is steadily increasing.

Our initial investigation to provide service to the area was to attempt the establishment of a VHF path from the mainland to Sable Island - a distance of approximately 200 KM.

Normal sources of information used by MT&T for path calculations, such as Bullington and Okamara, appeared to be somewhat lacking in their treatment of long over-the-horizon salt water paths. This lead us to conduct our own investigation through actual testing. Initial results from a 4 day test, in November 1979, encouraged us to establish a permanent installation in December of 1980. It should be noted that cost was a significant factor and circuit requirements in 1980 were minimal. VHF spectrum assignment availability seemed sufficient to meet initial demand.

The initial short term results yielded signal levels in excess of what was anticipated and it was decided to record the signal level continuously to observe and study the long term performance of VHF (and later UHF) radio over a 200 KM salt water path.

A request was made to the Department of Communications (DOC) of the Canadian Government for research assistance. Through this request a grant was established for Saint Mary's University (SMU) of Halifax, N.S., to assist us in the collection and analysis of data from this and similar radio paths.

2. SYSTEM DESCRIPTION

The path from Sable Island to Nova Scotia was established using standard off-the-shelf commercial grade FM radio equipment. Effective Radiated Power (ERP) levels were kept within reasonable limits (1 KW) to preclude reuse of the assigned channel, over too wide an area.

Initial VHF paths were established between Sable Island and Seaview, N.S. and between Sable Island and Halifax, N.S. Later, a second VHF site at Arichat (18 KM from Seaview) was established. Also a UHF path was established between Sable Island and Halifax and a UHF path will be established, in October /82, between Sable Island and Arichat, N.S. All radio receivers on the NS coast are equipped with chart recorders and continuous data has been recorded for 1 1/2 years.

The Nova Scotia coastline is shown in detail, in Fig. 2, at the Seaview and Arichat sites. Bearings to Sable Island are indicated. Figure 3 indicates the direction of bearings from Sable Island to the receiver sites on the mainland. Figure 4 shows the coastline at the Saint Mary's University site.

The equipment used on the Sable-Island Seaview link was manufactured by Canadian Motorola and consists of their standard MICOR, 100 watt, continuous duty, duplex base stations. The antennas consist of a pair of phased 6 element yagi antennas, manufactured by Sinclair Radio Labs of Canada. The ERP for this path was established at 1100 watts. The path loss, according to Bullington, was calculated as 173dB and recevied signal estimated at 0.3 microvolts.

All antennas have an unobstructed view of the horizon.

3. PATH OBSERVATIONS

Received signal levels are much higher than anticipated. Signal levels of 10 microvolts or more are common. There are periods of sustained high level received signal and also long periods during which the received signal level suffers from rapid deep fades. There are only very rare instances when the signal suffers a sustained fade (below 0.2 Microvolts) for a long period (minutes to hours).

As reported by Wickerts and Nilsson at AGARD in 1973 (Wickerts and Nilsson et al 8), received signals across or along over-water radio paths were divided into three different types - A, B and C. Signal A is characterized by a low mean signal level with rapid superimposed fading. Signal type B has a higher mean level with less rapid fading but deeper minima than signal type A. Signal type C is a stable very high signal, which sometimes has deep fading minima of short duration.

For the duration of our monitoring period we have observed similar types of signals and Fig 5 is a good representation of this observation. This data is from December 24, 1980 and in one day it can be noted that all three types of signals were received. From 0001 hours local time, December 24, to 0800 hours of the same day, signal type A (low mean, very rapid fades) was received. From 0800 hours to 1800 hours, signal type C (high signal level, a few deep fades) was received; and from 1800 hours to 2200 hours, Signal type B (higher mean than A with slower fading, deeper minima) was received.

There are long periods during the winter months where signal types A and B persisted with occasional periods of type C signal being received. During the warmer month, however B and C type signals dominate, with only very rare occurances of type A being recorded.

No attempt is being made here to explain the mechanisms producing each type of received signal. It is interesting to note however that similar results were observed and that further study may be beneficial.

It should be noted that the speed of the chart recorder was very slow. Only fades greater than one half second were recorded, and more than one fade per minute produced a solid band trace on the chart recordings.

3.1 Propagation Statistics for Sable to Seaview - 142.605 MHz, vertically polarized.

The Received Signal level for the VHF telephone link from Sable Island to Seaview, on 142.605 MHz, (vertical polarization) has been recorded on a continuing basis from December 23, 1980. Each 24 hour-segment of the original chart-recording was examined visually, and an estimate made of "percentage usable time" with reference to a 0.2 microvolt datum line, as well as with reference to the fading behaviour. The estimates are qualitative, and represent what is thought to be a "worst case" interpretation of the data. The daily estimates were then averaged for each calendar month (Fig. 6). The monthly averages were then averaged for a 12-month period, resulting in approximately 75% for the "percent usable time" on this link. This is thought to be a "worst case" value.

On the basis of several experiments in which chart-recordings were made at higher feed-speeds, so that the signal's transition-rates could be observed to within 1 second, it was noted that much of the fading was short-lived, (1 second or so), suggesting the conclusion that estimates of usability, as obtained from the normal feed-speed recordings (18"/24 hrs), tended to be too pessimistic for a period of time marked by frequent fast-fading. (Signal Type A and B) Evidently, this correction factor would not apply to periods of time during which there was long-term fade of the signal below the 0.2 microvolt datum. (Severe A Type Signal)

Hence, the actual value for the "percent usable time" average over one year is thought to be perhaps as much as 10% higher, which means that the "Percent usable time" average over one year could be as high as 85%.

Note that during the summer months the reliability exceeds 90%, illustrating the shift from A type signal to C type signal during this period.

3.2 Time-occurrence of fading on the Sable to Seaview - diversity observations

Observations, with associated statistics, were made at Seaview and Arichat of the time-occurrence of fast fades for purposes of possible diversity configurations to improve the "percent usable time" on this link. Several configurations of the experiment were employed, as described below. Higher speeds were used on chart recorders to allow detailed examination of the received signal levels. Samples of a few hours each were taken.

3.2.1 Comparison of the signal at Seaview and Arichat on 142.605 MHz. This constituted a simple one-variable diversity experiment, where the geographical separation between receiver sites is 18 KM and is the only significant difference between the two sites. It was found that a significant number of fades at Seaview were not coincident with fades at Arichat, thereby suggesting that diversity could be useful.

It was observed that the drop-out time due to fading could have been reduced at Seaview by a factor of about 2, with this diversity arrangement. Recent additions to the experimental installation have included space diversity reception between Seaview and Sable Island and although no winter season data has been recorded, the reliability of the path during the summer of 1982 indicates 95% reliability.

3.2.2 Comparison of the signals at Seaview at two different antenna heights, at 142.605 Mhz, vertical polarization. In general, the experiment indicated that the difference in antenna heights was also clearly associated with some non-coincidence between fading events. It was estimated that of a total of 30 fades in the primary channel (called MTT#1), connected with the top-most antenna on the microwave tower at Seaview, only 5 fades were fully coincident with fades in the second channel (called MTT#2), connected with an antenna at the mid-point of the tower. In addition, it was estimated that perhaps another 10 fades in the MTT#1 channel were in partial coincidence with fades in the MTT#2 channel. Here again, indicating that a substantial improvement is possible even with single site space diversity.

3.2.3 Comparison of signals at Seaview at two different frequencies and two different polarization. This experiment entailed signal strength measurements for two channels:MTT#2(142.605MHZ,vert.pol.) and SMU(147.995MHZ,hor.pol.). The antennas associated with these receivers are within 2 meters of each other, at the mid-point of the tower. A cursory visual examination of the data indicated that perhaps fewer than 50% of the fades in the two channels coincided significantly. Inasmuch as this experiment is a function of at least two variables--frequency and polarization--the differences in fading behaviour cannot be persuasively ascribed to either one of the variables exclusively.

3.2.4 Comparison of signals at Seaview combining three variables: frequency, antenna height, and polarization. This experiment, combines two of the observations above. In other words, there are three signals being monitored: one on MTT#1 (142.605MHz vert.pol.), antenna on the top of the tower; one on MTT#2(142.605MHz vert. pol.), antenna at the mid-point of the tower; and one on SMU(147.995MHz, hor.pol.), antenna at the mid-point of the tower. The configuration of the experiment was determined primarily from the equipment (receivers and antennas) already in place. In general, it was observed that there was no full coincidence of fading among the three channels. In particular, of 22 fades in the MTT#1 channel, there was only one fade from the remaining channels in full coincidence with MTT#1, and perhaps 5 fades which were in partial coincidence. The observation indicates the substantial improvement that would be obtained by use of both frequency and space diversity.

Based on the short term observations of these diversity arrangements, continuing efforts are being made during the latter part of 1982 and into 1983, to record received signal levels on a number of diversity arrangements.

4. PROPAGATION STATISTICS FOR SABLE TO SEAVIEW ON 142.605HMz, VERTICALLY POLARIZED, VS SURFACE WEATHER

A preliminary attempt has been made to correlate the observed propagation on the Sable to Seaview path with the available surface meteorological or "met" data. In particular, only two features of propagation will be examined: noticeable attenuation, marked by relatively gradual transitions; and enhancements, marked by relatively sudden transitions. For example, the "data panel" (Fig. 7) for May 1 note the pronounced attenuation (gradual) during the early part of the day, taking into account the fact that the charts for Seaview and Arichat are associated with FM receivers (limiting occurs above 10 microvolts). The "data panel" for May 11, (Fig. 8) on the other hand, exhibits a sudden enhancement, again, during the early part of the day.

In attempting to correlate propagation behaviour with surface "met" data, it should be noted that the "met" data could, perhaps, be of limited significance. For example, on Sable Island, the "met" data is gathered at a point approximately 1.5km east of the beacon site, whereas the propagation path of interest is to the west and presumably depends on "met" factors in the line of the path. Similarly, for the Canso Straits area, the "met" data is obtained at Eddy Point, which is approximately 30km transverse to a line joining Sable and Seaview, and approximately 20km transverse to a line joining Sable and Arichat. For the Halifax area, the "met" data from Shearwater represents conditions approximately 2km transverse to a line joining Sable and SMU. Of the three cases, only the last one represents a relevant sampling of the surface "met" conditions along the acutal propagation path. However, even in this case, the data is less then ideal as the met date is collected near one end of the path. Therefore the surface "met" data for Sable Island may not always appear to correlate with the propagation from Sable because the propagation is presumably determined to a large extent by the "met" conditions west of the antennas; in particular, it is presumed that the conditions near the water from the Island to the horizon are the dominant factors. Hence, any discontinuity in propagation may or may not be accompanied by a discontinuity in the Sable Island "met" conditions measured, and may not necessarily exist in the exact line of the path.

With these preliminary considerations in mind, an examination of the data panels for May, June, July(part), and October, suggests that there is no clear-cut correlation between the propagation data recorded and the "met" data obtained. Occasionally, however, there is correlation, such as for June 20 (Fig 9). Here, there is a correlation between rain on Sable Island and gradual attenuation at all three receiving sites. Since there is no concomitant precipitation reported at either Eddy Point or Shearwater, then it would appear that precipitation at the beginning of the path is the significant factor.

If the sudden enhancements are examined, such as for early and later parts of June 20, there appears to be no corresponding discontinuity in the "met" data at any of the sites, except perhaps the discontinuity in "cloud amount" and "cloud ceiling" for Sable and Shearwater. However, even here, the correlation exists (perhaps) for the discontinuity in the early part of the day, but does not exist for the discontinuity towards the end of the day.

Examining the data for May 11 (fig. 8), sudden enhancements again occur: in the early part of the day for all four monitors, and the later part of the day for the 3 monitors in the Seaview-Arichat area. There is perhaps some correlation between the first enhancement and the "cloud ceiling/cloud amount" data for Sable, but similar discontinuities in "cloud ceiling/cloud amount" for Sable later in the day are not accompanied by enhancements. Regarding attenuation effects, which begin around 10AM in the Seaview/Arichat data and around 1PM or so in the Halifax data, the only precipitation reported is a light rain in the Shearwater data; there is no rain reported at either Sable Island or Eddy Point.

In general, and by way of a very tentative and approximate statement, it was observed that there is some correlation, for the four months in question, between precipitation at Sable and gradual attenuation in propogation. Regarding the sudden enhancements, however, there appears to be no correlation whatsoever. These observations are made on the basis of a cursory visual examination of the original data panels. It is again noted that the "met" data represents "surface" weather conditions only.

5. COMPARISON OF SIGNALS FROM HORIZONTALLY AND CIRCULARLY POLARIZED ANTENNAS ON SABLE AT 147.950MHz AND 147.850MHz RESPECTIVELY. The experiment was performed to enable a preliminary look at the possibility of significant differences in fading between plane (horizontal) and circular polarization on the Sable to Halifax path. It should be noted that the channel involving circular polarization consisted of one circularly polarized antenna: the one on Sable. The receiving antenna at SMU on this channel (147.850MHz) was horizontally polarized, it being assumed that this arrangement would give some indication of a difference between the two channels. It is also being assumed that the difference in frequency between the two channels is not significant for this test.

The experiment, consisting of some 20 observations, each of approximately 5 minutes duration, and these observations were made during the latter part of April and the early part of May, 1981. In general, it was observed that there was a noticeable difference between the two channels in terms of fading behaviour, and that the signal from the circularly polarized antenna on Sable had noticeably less fading associated with it than the signal from the horizontally polarized source. Continuous recording of circular polarized signals will begin in late 1982.

6. COMPARISON OF SIGNALS ON VHF AND UHF ON THE SABLE TO HALIFAX PATH. Experiments to compare VHF(147.950MHz) and UHF(431.950MHz) reception on the Sable to Halifax path have also been conducted. Horizontal polarization was used on both channels.

The experiment compared the signal strength at SMU for both channels, and represents reception at antennas located within a couple of meters of each other. In addition, some further data was obtained at various times during the winter of 1981-2; some of this data is in the form of chart recordings, and some as occasional listening tests.

In general, it has been observed that the UHF signal has been more intense and noticeably less marked by "Type A" fast fading than the VHF signal. This was especially apparent during the winter, during which time the VHF signal at SMU was not detectible, whereas the UHF signal was almost always detectible. There is a difference in antenna gains which might account for much of the difference in intensity. However, this does not account for all of the difference observed. UHF monitoring and recording of results will be increased in 1982-83 with additional paths being established and monitored over a long term.

7. CONCLUSIONS

On the basis of these observations, it is conculded that there is a marked seasonal dependence of signal strength on VHF between Sable and the Canso Straits area, going from almost 100% usability in the summer months, to perhaps 50% in the winter. A "worst case" average value for the year appears to be in the order of 75%. If account is taken of the fact that most of the fades are relatively fast, (1 second or so in duration), then the average value for the year could possibly be as high as 85%. This value is predicted on single-channel reception, i.e. without diversity.

It could be concluded that fast-fades on VHF for the Sable to Seaview/Arichat path show noticeable dependence on geographical separation, antenna height, and some combination of frequency and polarization. Hence, a multi-channel receiver system, in a diversity configuration, should show a marked decrease in fast-fading in the combined system. Reliability during the summer approaches 100%. Annual reliability could exceed 95%.

On the basis of these observations and surface weather it can be concluded that the available surface weather data shows no correlation with the propagation data, especially in reference to sudden enhancements in signal level. There could be, however, some non-insignificant correlation with precipitation (as reported for the surface), but a more detailed analysis of the "data panels" is required and is being continued. Presumably, given the relatively large geographical area, there could be precipitation events (localized) along the propagation paths which would not be observed at the weather-report sites.

In reference to possible dependence on linear polarization, the VHF data for the Sable to Canso Straits path does not exhibit any readily discernable difference. The comparison, of course, is complicated by the fact that the two MTT receivers are accessed after limiting. Hence, on the basis of the recorded data, polarization is not a major concern. It should be noted, however that the data is begin examined in such a way that short-term depolarization effects--in the order of a few seconds--would not be apparent in the course of a cursory examination of the data. Hence, depolarization could be present, but on a very short time-scale. Circular Polarization appears to offer some improvement over linear or plane polarization.

Concerning VHF compared with UHF, it could be concluded that UHF on the Sable to Halifax path is also less prone to fast-fading than is the VHF. The UHF performance appears as good as VHF and is now being recorded over a long term over two paths.

8. RECOMMEDATIONS FOR CONTINUED STUDY

1. Continue data acquisition on VHF for the Seaview, Arichat, and Halifax sites, to obtain improved statistics.
2. Undertake a more detailed analysis of the available data to obtain some quantitative indication of the correlation between discontinuities in propagation and discontinuities in surface weather.
3. Obtain upper-atmosphere data for 1981 (especially the summer) for the Sable Island area, with a view to correlating temperature inversions with sudden enhancements in propagation.
4. Perform more detailed observations on possible depolarization events on both VHF and UHF.
5. Obtain vertical-profile weather data on the west end of Sable Island to enable detailed discussion of "duct-assisted" propagation over the Sable to Nova Scotia mainland path.
6. Monitor diversity systems to determine extent of fast-fade compensation.
7. Measure time occurrences of A, B and C type signals in an attempt to correlate occurrences of each type with potential controlling mechanisms, and upper air weather correlation.

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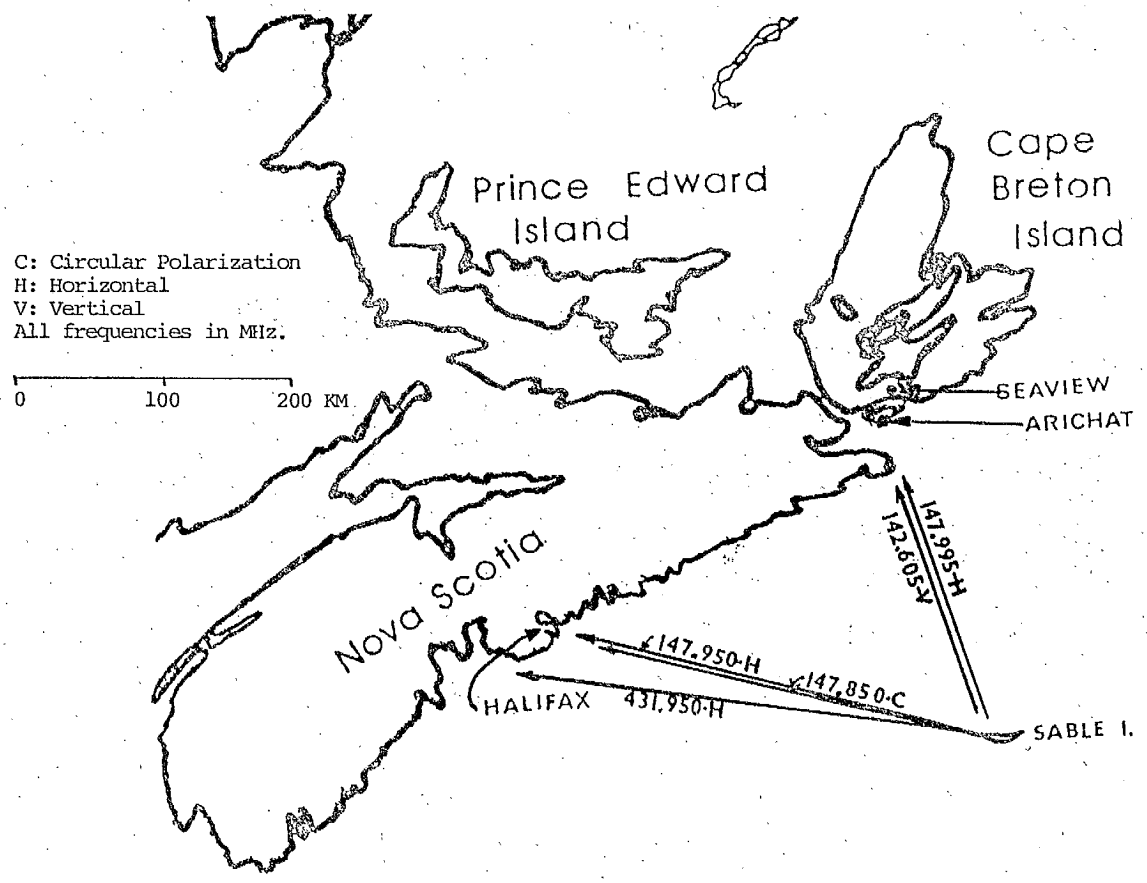


Figure 1: General coastline features and orientation of transmission paths.

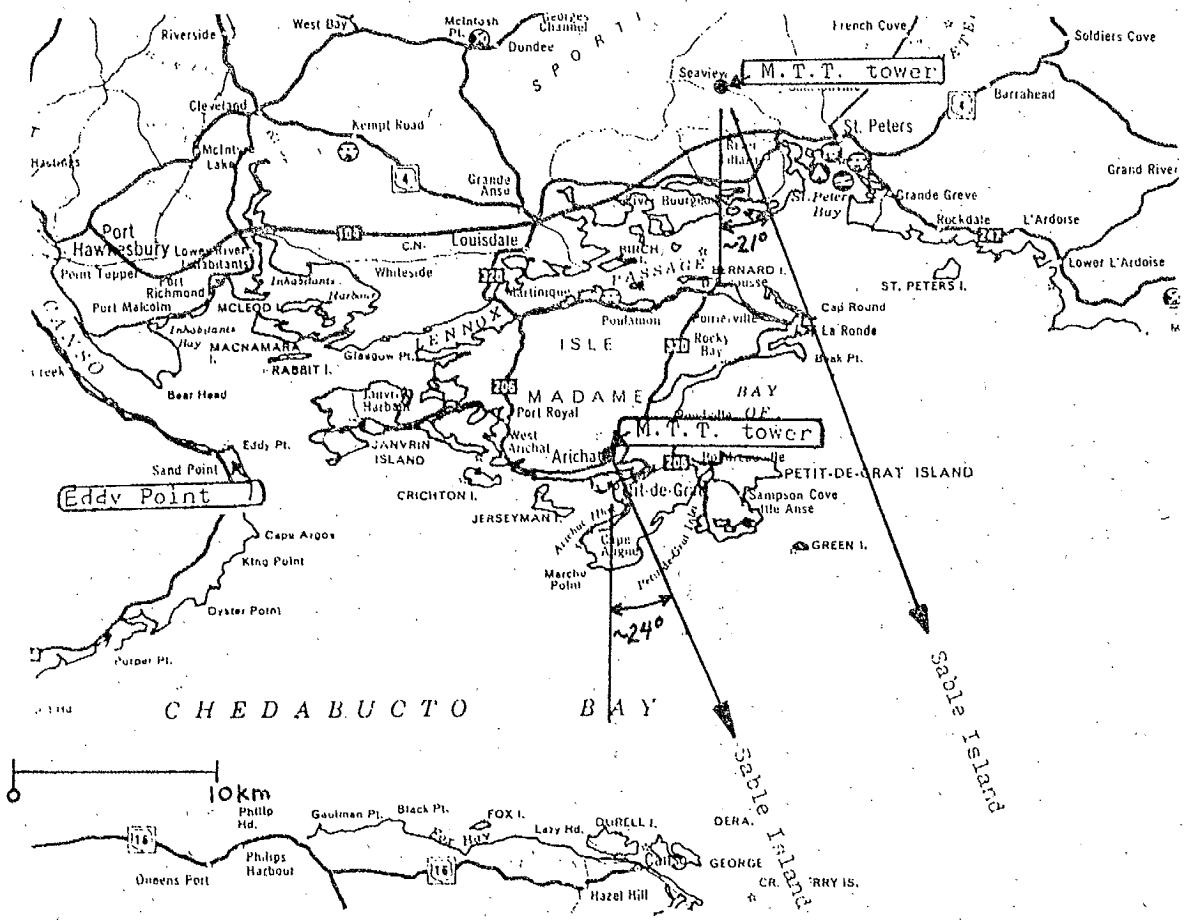


Figure 2: Coast-line features of the Seaview-Arichat area, and location of antenna sites.

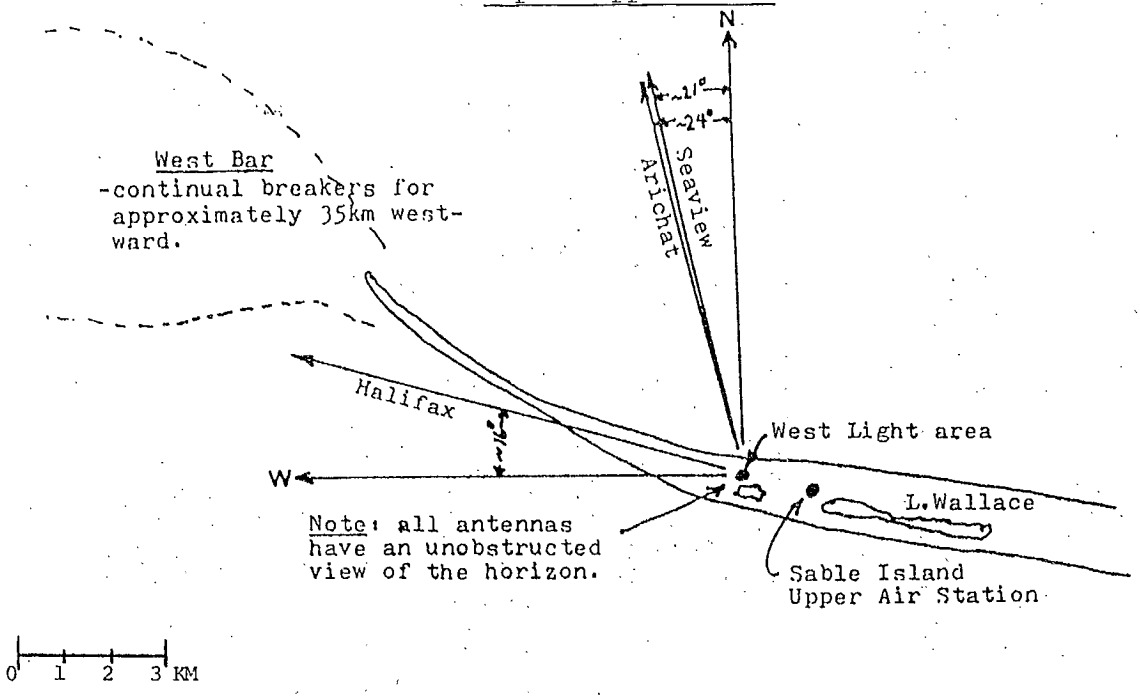


Figure 3: General features of the west end of Sable Island

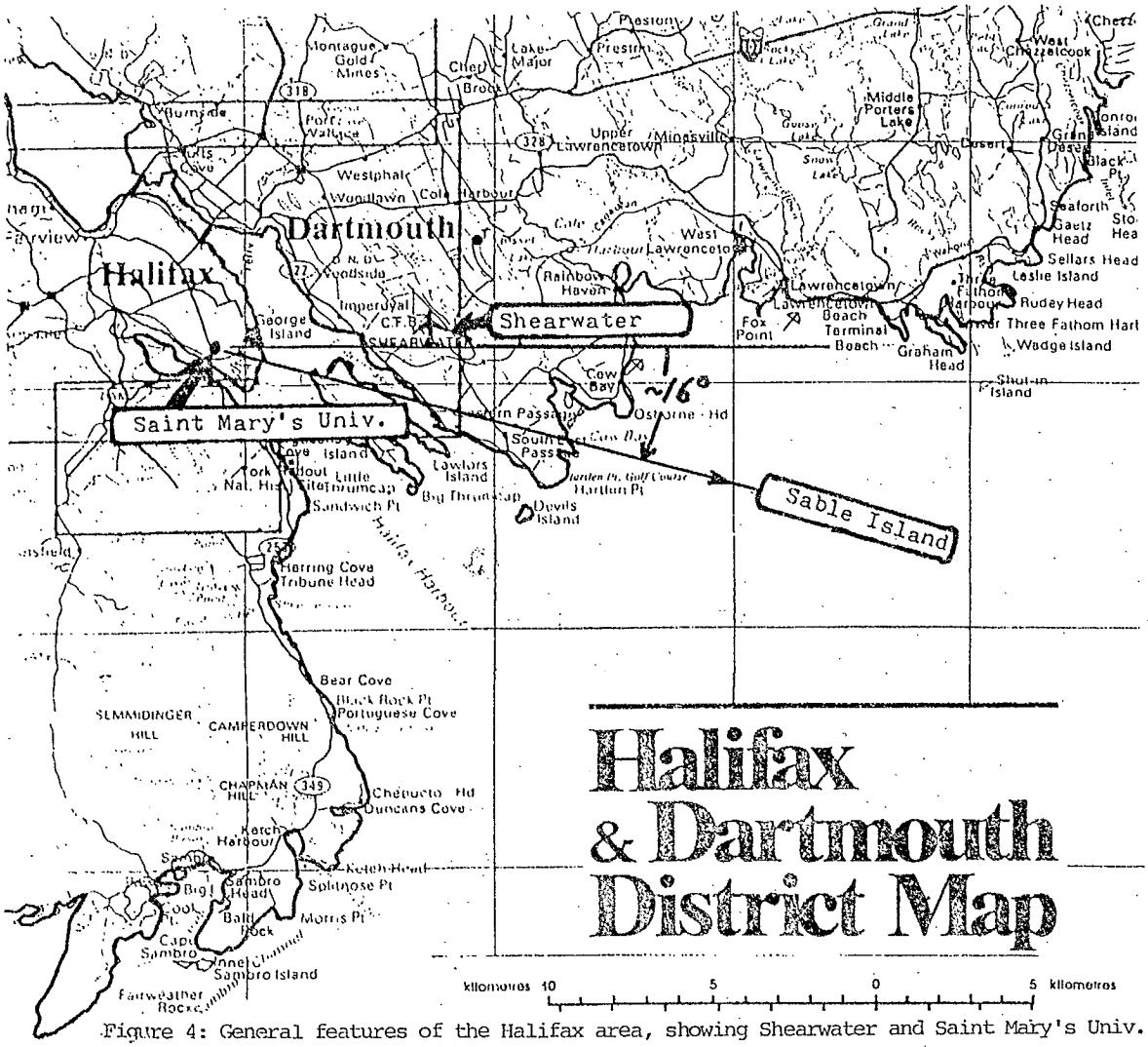


Figure 4: General features of the Halifax area, showing Shearwater and Saint Mary's Univ.

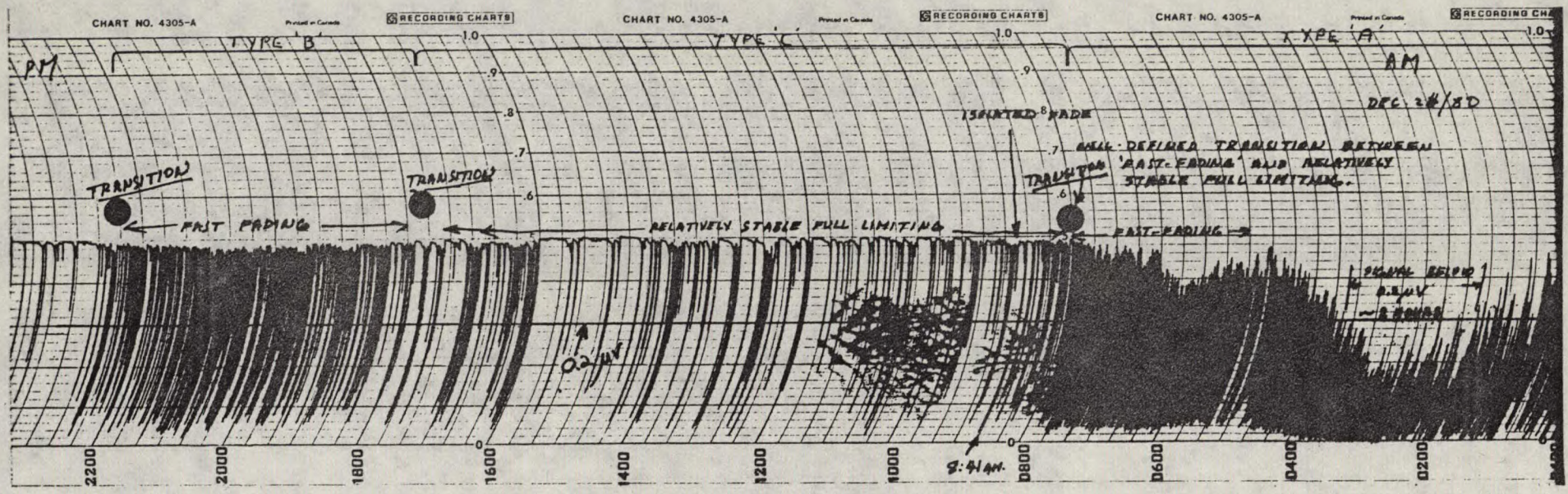


Figure 5: Received Signal Level at Seaview - 24 Dec 1980

142.605MHz (V)

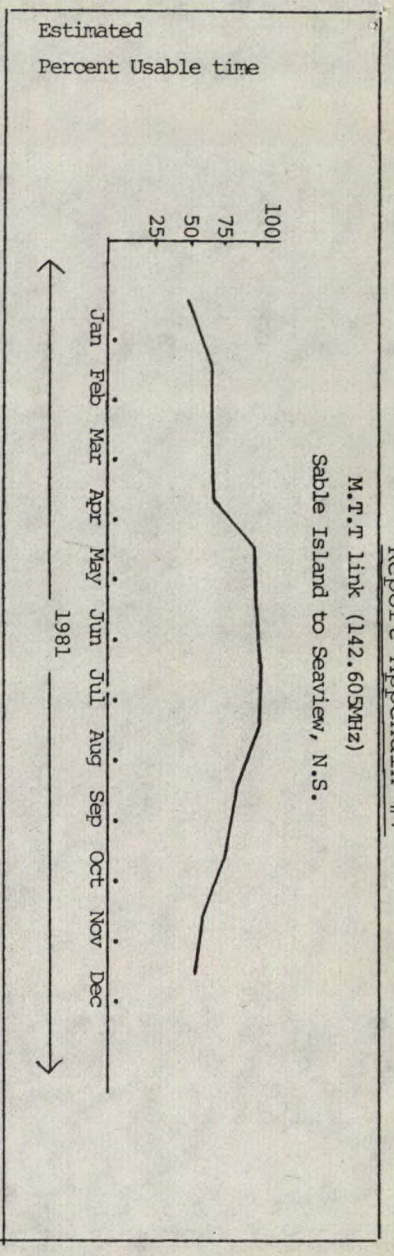


Figure 6: Monthly averages of signal strength at Seaview, as estimated from chart recordings.

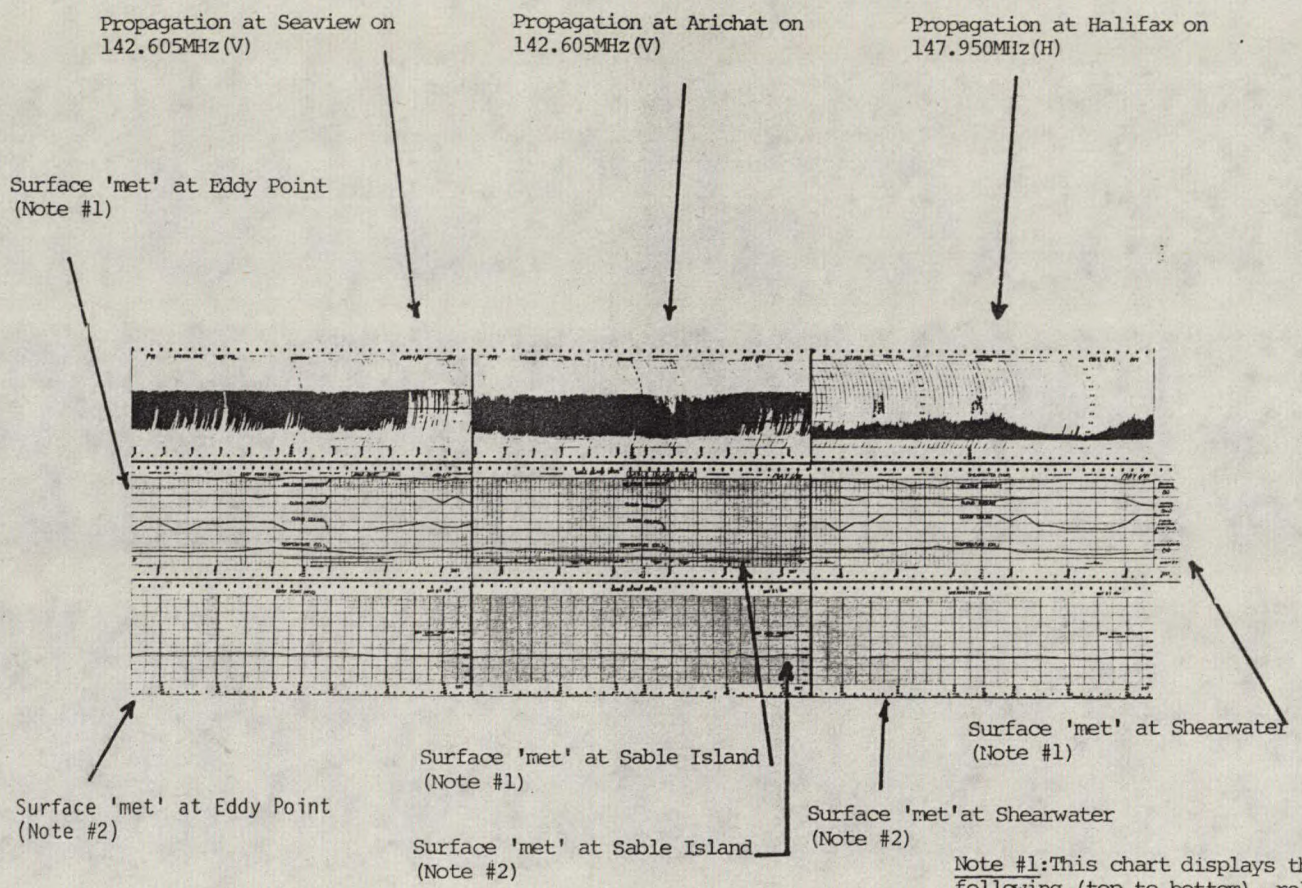
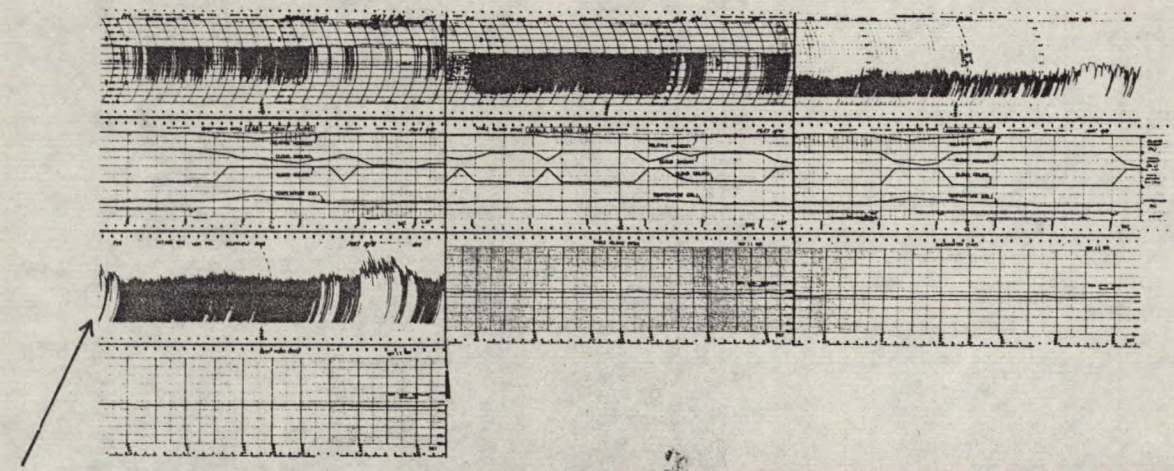


Figure 7: Data Panel-May 1,1980

Note #1:This chart displays the following (top to bottom), relative humidity; cloud amount, cloud ceiling, temperature (^{o}C), and precipitation, etc. (known as SIGMET data).

Note #2:This chart displays sea-level pressure only.



Propagation at Seaview on
147.995MHz(H)

Figure 8: May 11/81 data panel

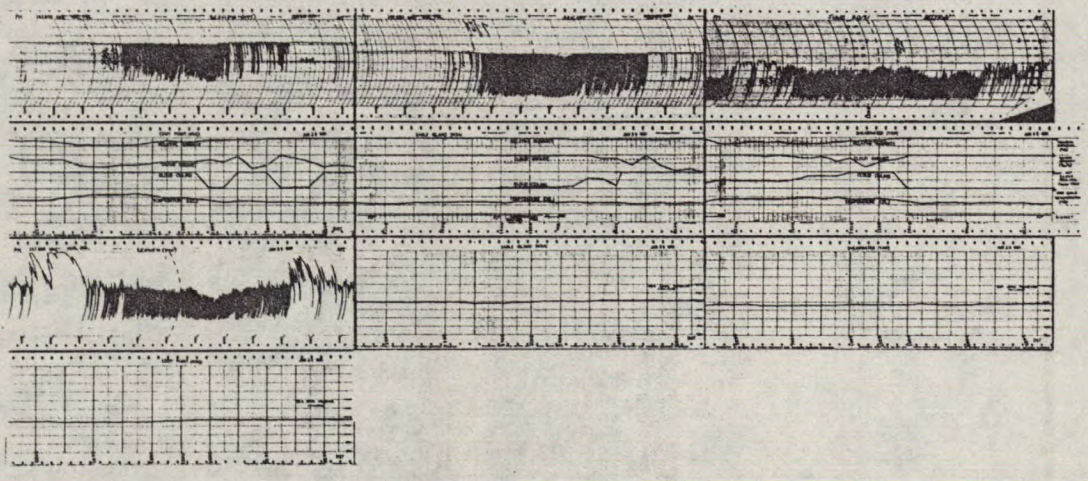


Figure 9: June 20/81 data panel