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M.E.P. Company

PROBABILITIES OF EMISSION LIMITATION -

ANALYSIS OF METEOROLOGICAL DATA

Syncrude Canada Ltd., Professional Paper 1977-2

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INTRODUCTION

Promet Environmental Group Ltd. was retained to perform an analysis of the meteorological data available from the Tar Sands area. The probabilities of occurrence of various meteorological parameters will be used as a basis for estimating the frequencies of occurrence and costs associated with Emission Control at Syncrude's Mildred Lake operation.

DATA BASE

The minisoundings which were carried out at Lease C-17 in the Athabasca Tar Sands from 1974 to 1976 form the data base for this study.

ANALYSIS

The minisoundings were divided into four groups:

Group A - soundings with mixing heights between 300 and 700m.

Group B - mixing heights less than 300m or greater than 700m.

Subgroup B1- soundings with potential temperature gradient(θ') less than $-0.5^{\circ}\text{C}/100\text{m}$.

Subgroup B2- soundings with potential temperature gradient(θ') $-0.5^{\circ}\text{C}/100\text{m} \leq \theta' \leq 0.5^{\circ}\text{C}/100\text{m}$.

Subgroup B3- soundings with potential temperature gradient(θ') greater than $0.5^{\circ}\text{C}/100\text{m}$.

For each group histograms were drawn up to graphically display the data. The height of each bar in the histogram represents $P(x_2)$, the probability that a value of parameter x falls in cell 2. The data for each histogram was grouped into 10 cells(N) of equal width(CW). Maximum and minimum parameter values for each group were used to determine the limits of the cells. Mean values for the parameters were calculated by the formula
$$\bar{x} = \frac{n}{\sum_{i=1}^n} x_i$$

where n =total number of data points and x_i = i^{th} observation.

Standard deviations were calculated by the formula

$$s = \sqrt{\frac{\sum_{i=1}^n (x - \bar{x})^2}{(n-1)}}$$

RESULTS

The tables separate the data into different potential temperature gradient categories, each showing means and standard deviations for the parameters. Table 1 shows the number distributions of the data. Table 2 shows the probability of occurrence (as a percentage) for each parameter. Probability distributions for the four groups are shown in Table 3. $P(Y)$ is the probability that a sounding will belong to group Y. The probabilities of occurrence of each group are graphically displayed by means of histograms in Figures 1-5. A histogram of mixing heights is shown for group A in Figure 2. Figure 6 shows a wind rose of average frequencies per year for a ten year period (1957-1966), compiled from the regular hourly weather observations at Fort McMurray Airport.

TABLE 3. PROBABILITY DISTRIBUTIONS FOR THE FOUR GROUPS

<u>GROUP Y</u>	<u>TOTAL SOUNDINGS</u>	<u>P(Y)</u>
A	166	0.142
B1	67	0.057
B2	458	0.390
B3	<u>482</u>	<u>0.411</u>
	1173	1.000

TABLE NO. 1

GROUP	VARIABLE	MEAN	STANDARD DEVIATION	N	CW	D _{min}	NUMBER DISTRIBUTIONS										TOTAL	MISSING
							1	2	3	4	5	6	7	8	9	0		
A	T (°C)	7.3	13.5	10	6.0	-32.0	3	.8	.8	10	5	13	21	55	30	13	166	--
	U (m/s)	5.6	3.4	10	1.5	0.5	16	35	21	21	15	13	12	5	4	2	144	22
	θ' (°C/100m)	-1.18	.17	10	.12	-1.20	2	0	0	0	2	2	15	19	42	84	166	--
	H (m)	470.5	114.7	10	40.0	300	24	27	16	17	21	6	16	16	11	12	166	--
B 1	T (°C)	11.3	6.4	10	4.0	-13.0	1	0	3	4	6	14	20	15	3	1	67	--
	U (m/s)	4.8	2.9	10	1.3	0.5	9	10	23	6	4	6	1	4	1	2	66	1
	θ' (°C/100m)	-0.93	.35	10	.15	-2.00	2	1	2	3	1	9	5	15	10	19	67	--
B 2	T (°C)	7.1	12.8	10	7.0	-40.0	4	8	13	19	33	49	68	145	103	16	458	--
	U (m/s)	5.9	3.6	10	2.5	0.0	60	127	105	60	25	16	6	0	1	2	402	56
	θ' (°C/100m)	.07	.26	10	.10	-.50	24	24	24	46	38	74	66	61	50	51	458	--
B 3	T (°C)	2.4	9.1	10	7.0	-40.0	4	16	34	46	31	53	77	161	57	3	482	--
	U (m/s)	7.1	3.7	10	1.8	0.0	15	61	73	55	62	45	33	27	8	4	383	99
	θ' (°C/100m)	1.6	.97	10	.60	.50	191	124	84	40	26	3	6	3	2	3	482	--

Averages of parameters are taken over layer 0 to H for group A, with the exception of θ' which is over 0 to 3/4 H. For group B, the averages are over the layer 200 to 400 metres above ground.

GROUP A- 300m ≤ mixing height ≤ 700m

GROUP B- all other mixing heights

B 1- soundings with potential temperature gradient less than -0.5 °C/100m

B 2- soundings with potential temperature gradient -0.5 °C/100m ≤ θ' ≤ 0.5 °C/100m

B 3- soundings with potential temperature gradient > 0.5 °C/100m

N- number of cells in the histogram

T- average temperature

CW- width of the cell

U- average wind speed

D_{min}- lower limit of cell 1

θ'- average potential temperature gradient

TOTAL- number of occurrences per group

H- mixing height

TABLE NO. 2

GROUP	VARIABLE	MEAN	STANDARD DEVIATION	N	CW	D _{min}	PERCENTAGES OF OCCURRENCE										TOTAL	MISSING
							1	2	3	4	5	6	7	8	9	0		
A	T (°C)	7.3	13.5	10	6.0	-32.0	1.8	4.8	4.8	6.0	3.0	7.8	12.7	33.1	18.1	7.8	166	--
	U (m/s)	5.6	3.4	10	1.5	0.5	11.1	24.3	14.6	14.6	10.4	9.0	8.3	3.5	2.8	1.4	144	22
	θ' (°C/100m)	-1.8	.17	10	.12	-1.2	1.2	0.0	0.0	0.0	1.2	1.2	9.0	11.4	25.3	50.6	166	--
	H (m)	470.5	114.7	10	40.0	300	14.5	16.3	9.6	10.2	12.7	3.6	9.6	9.6	6.6	7.2	166	--
B 1	T (°C)	11.3	6.4	10	4.0	-13.0	1.5	0.0	4.5	6.0	9.0	21.0	30.0	22.0	4.5	1.5	67	--
	U (m/s)	4.8	2.9	10	1.3	-0.5	13.6	15.2	34.8	9.1	6.1	9.1	1.5	6.1	1.5	3.0	66	1
	θ' (°C/100m)	-.93	.35	10	.15	-2.00	3.0	1.5	3.0	4.5	1.5	13.4	7.5	22.4	14.9	28.4	67	--
B 2	T (°C)	7.1	12.8	10	7.0	-40.0	0.9	1.7	2.8	4.1	7.2	10.7	14.8	31.6	22.5	3.5	458	--
	U (m/s)	5.9	3.6	10	2.5	0.0	14.9	31.6	26.1	14.9	6.2	4.0	1.5	0.0	0.2	0.5	402	56
	θ' (°C/100m)	.07	.26	10	.10	-.50	5.2	5.2	5.2	10.0	8.3	16.2	14.4	13.3	11.0	11.1	458	--
B 3	T (°C)	2.4	9.1	10	7.0	-40.0	0.8	3.3	7.0	9.5	6.4	11.0	15.9	33.4	11.8	0.6	482	--
	U (m/s)	7.1	3.7	10	1.8	0.0	3.9	15.9	19.1	14.4	16.2	11.7	8.6	7.0	2.1	1.0	383	99
	θ' (°C/100m)	1.6	.97	10	.60	.50	39.5	25.7	17.4	8.3	5.4	0.6	1.2	0.6	0.4	0.6	482	--

Averages of parameters are taken over layer 0 to H for group A, with the exception of θ' which is over 0 to 3/4 H. For group B, the averages are over the layer 200 to 400 metres above ground.

GROUP A- 300m ≤ mixing height ≤ 700m

GROUP B- all other mixing heights

B 1-soundings with potential temperature gradient less than -0.5 °C/100m

B 2-soundings with potential temperature gradient -0.5 °C/100m ≤ θ' ≤ 0.5 °C/100m

B 3-soundings with potential temperature gradient > 0.5 °C/100m

N-number of cells in the histogram

CW-width of the cell

D_{min}- lower limit of cell 1

TOTAL- number of occurrences per group

T- average temperature

U- average wind speed

θ'- average potential temperature gradient

H- mixing height

Figure 1 Histograms of mean temperature and mean wind speed for group A.

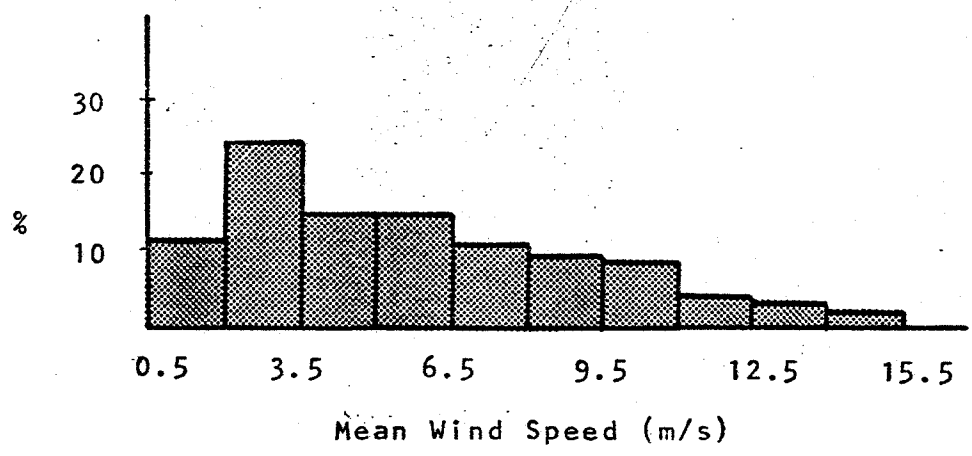
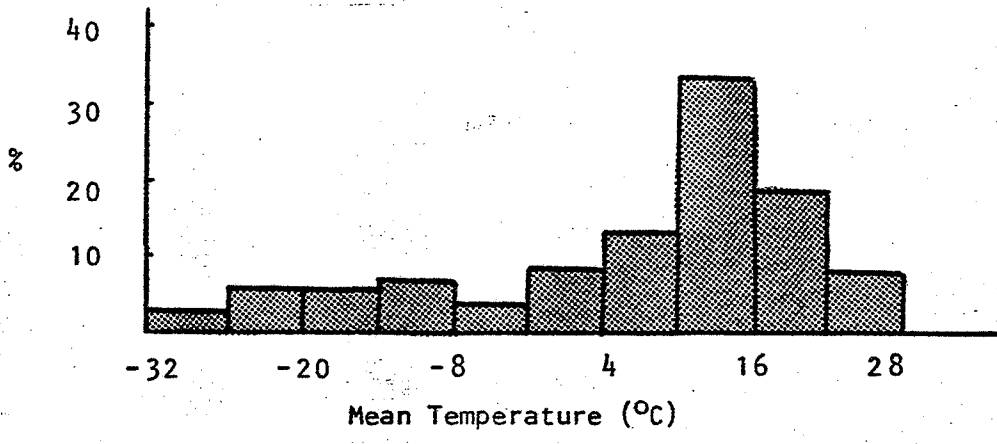


Figure 2 Histograms of mean potential temperature gradient and mixing height for group A.

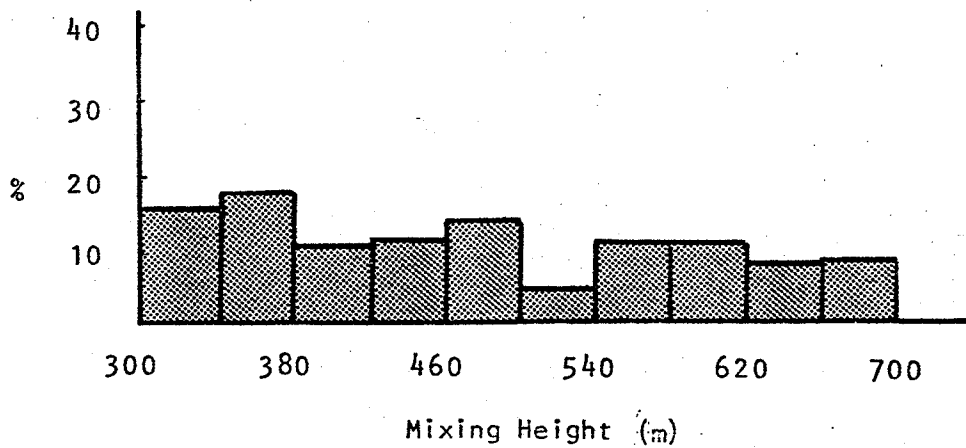
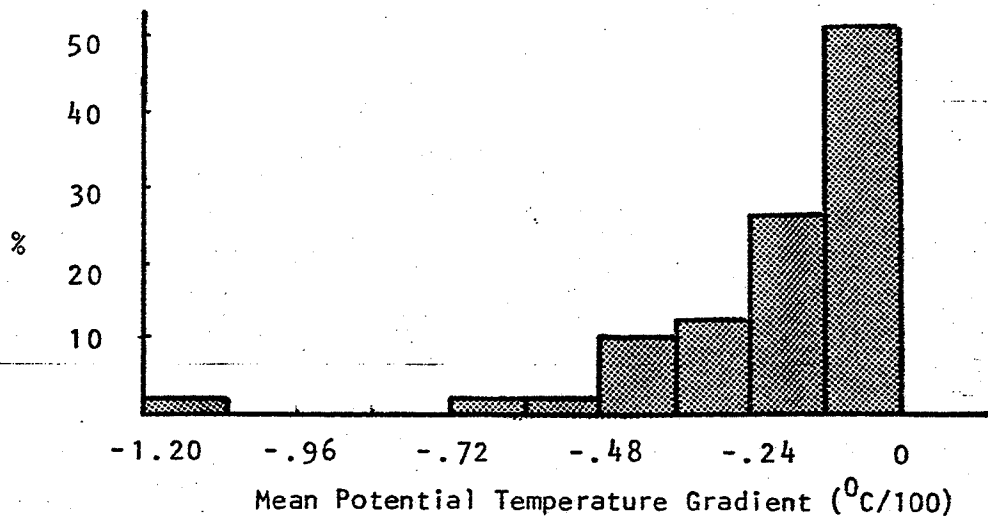


Figure 3 Histograms of mean temperature, mean wind speed and mean potential temperature gradient for group B1.

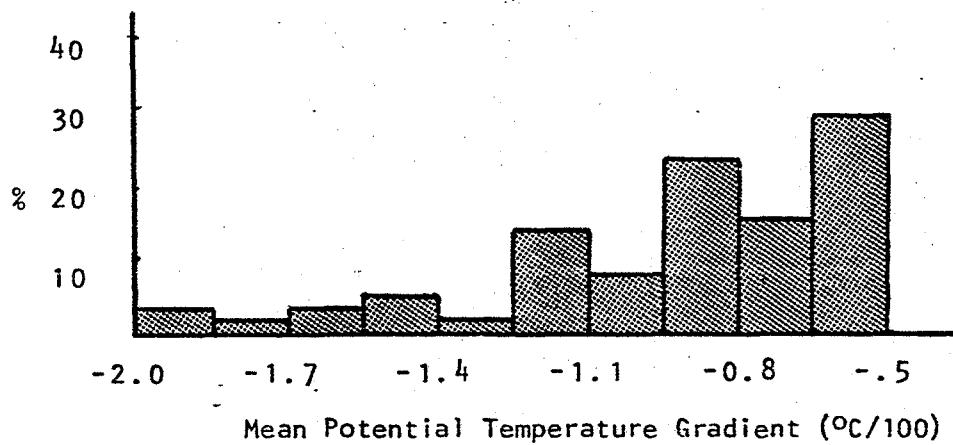
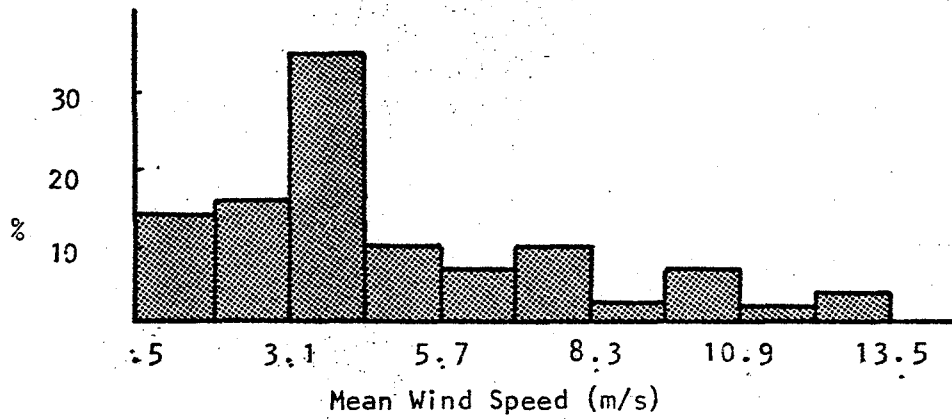
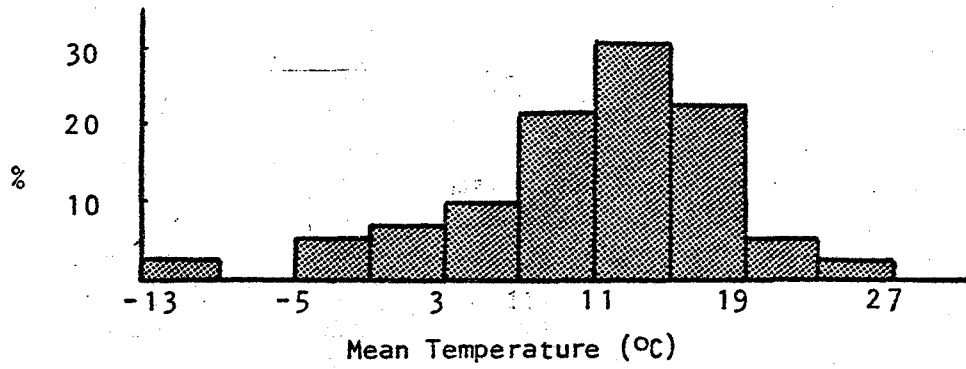


Figure 4 Histograms of mean temperature, mean wind speed and mean potential temperature gradient for group B2.

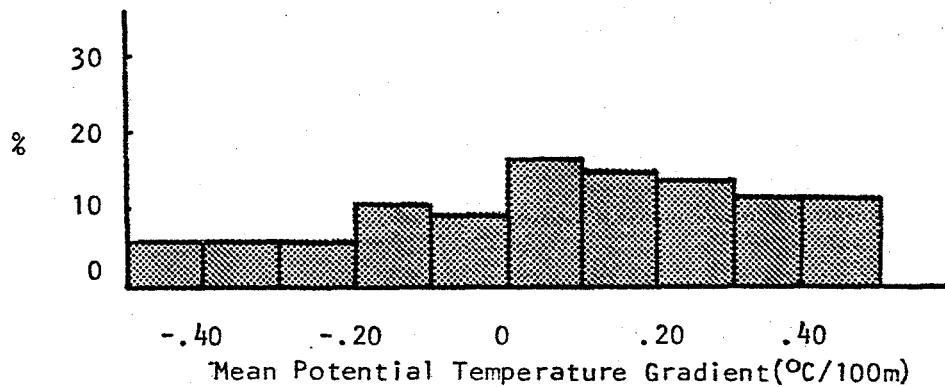
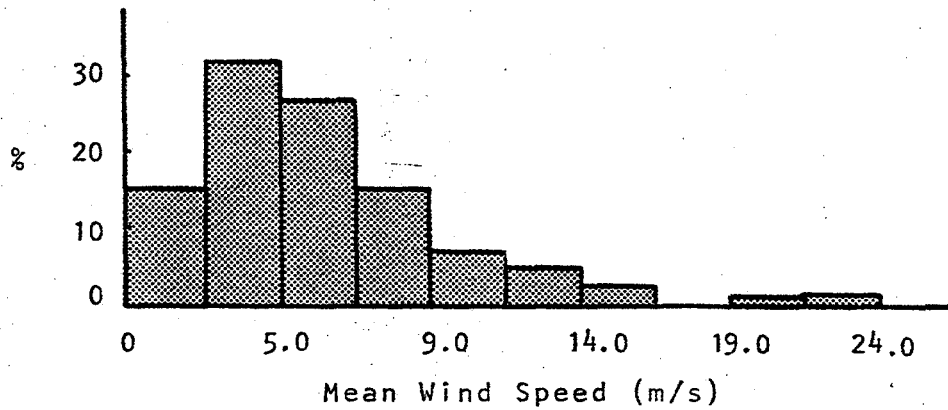
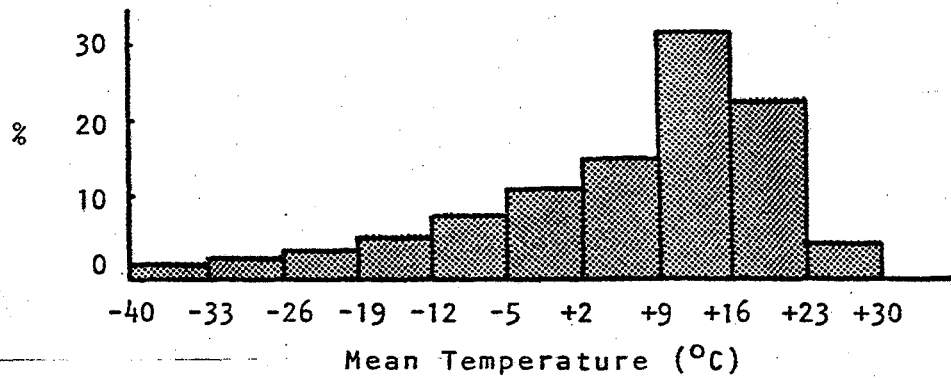


Figure 5 Histograms of mean temperature, mean wind speed and mean potential temperature gradient for group B3.

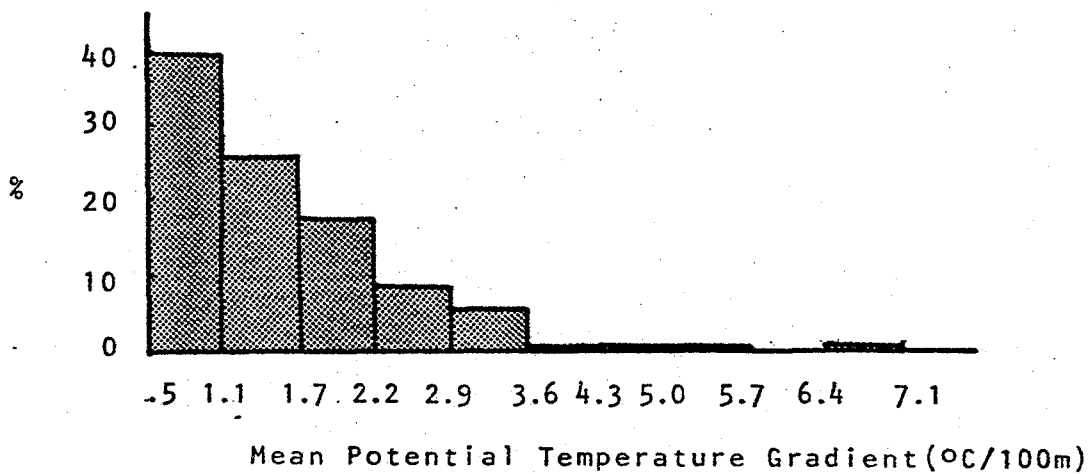
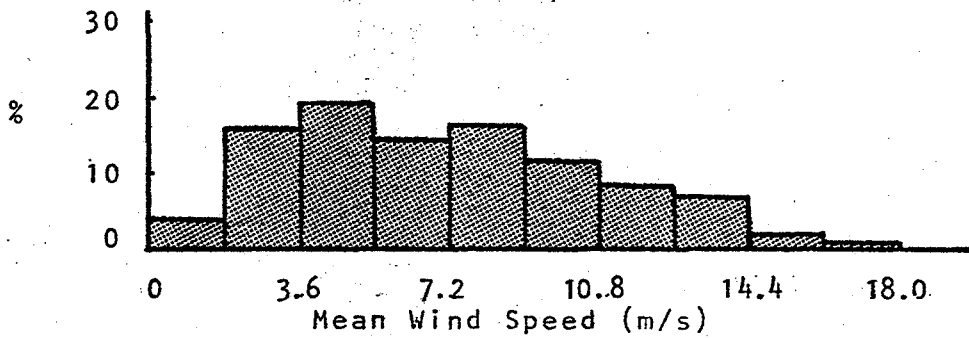
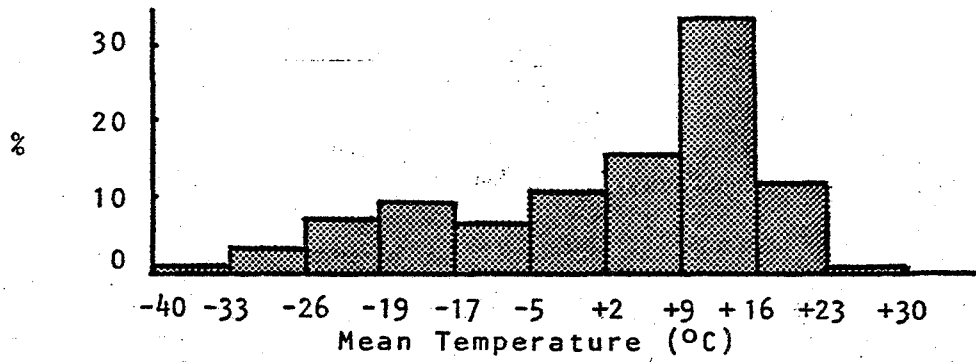


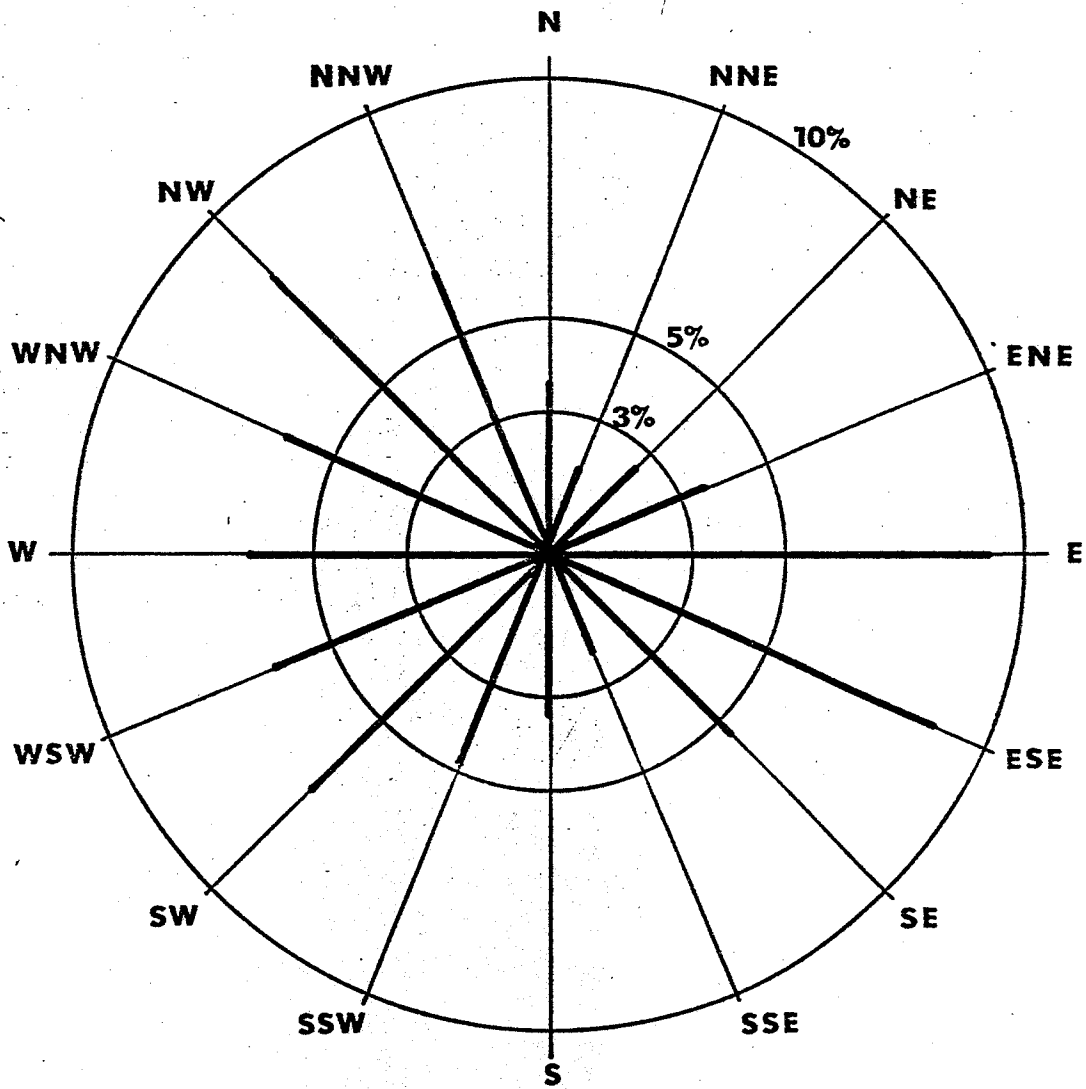
TABLE 4. Frequency distribution of wind direction compiled from regular hourly weather observations at Fort McMurray Airport.

<u>DIRECTION</u>	<u>PERCENT</u>
N	3.5
NNE	2.0
NE	2.6
ENE	3.6
E	9.3
ESE	9.0
SE	5.5
SSE	2.3
S	3.5
SSW	4.9
SW	7.1
WSW	6.3
W	6.3
WNW	6.1
NW	8.1
NNW	6.3
CALM	13.6
	<u>100</u>

Figure 6 Fort McMurray Airport

Average Wind Frequencies per year
January 1957 - December 1966

compiled from the regular hourly weather observations.



Calm: 13.6% **Avg. Wind Speed: 6.3 MPH**

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