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An Air Pollution Study of the National Capital Region

Surveillance Report
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Air Pollution Control
Directorate

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AN AIR POLLUTION STUDY OF
THE NATIONAL CAPITAL REGION

by

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Air Pollution Control Directorate

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Department of the Environment

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INTRODUCTION

The first air pollution sampling station in Ottawa was established during May 1956 at the War Service Records Building on Slater Street. In June of the same year another station was set up at St. Vincent's Hospital on Cambridge Avenue. Sampling continued at these stations for about a year. In 1959 the monitoring at the War Service Records Building was reactivated and continued until 1965. Results of these surveys have been presented in several papers [1,2].

The present air pollution study of the National Capital Region was initiated as a result of a request from the Minister of Public Works to the Minister of National Health and Welfare in February 1967. In July 1967 a meeting of representatives from Ontario, Quebec and the federal government was held in Ottawa to plan and organize an air pollution study.

The objectives of the program were:

1. To determine existing levels of air pollution.
2. To estimate emissions of commercial, industrial and domestic sources.
3. To evaluate the contribution of federal government buildings.
4. To predict future trends.

Shortly thereafter, sampling stations were selected and an air monitoring program was initiated. This report summarizes the data collected on existing levels of air pollution. Future reports will cover objectives 2, 3, and 4.

SAMPLING NETWORK

The sampling network for the National Capital survey consisted of 5 stations and a total of 14 instruments (see Figure 1).

The parameters that were measured at each station are summarized below:

	STATION				
	A	B	C	D	E
	Hydro Building	Experimental Farm	Board of Education	Post Office	Language Centre
Type of Station	Commercial	Residential	Commercial	Commercial	Residential
Parameter					
Dustfall	X	X	X[iv]	X[iii]	
Suspended Particulates	X[i]			X[ii]	X[ii]
Soiling Index	X	X	X	X[ii]	X[ii]
Sulphur Dioxide	X			X[ii]	

i. Commencing June 1969

ii. Commencing September 1969

iii. Commencing April 1970

iv. Commencing May 1970

SAMPLING PROCEDURES

Dustfall

Dustfall comprises the larger size particulates which settle out under the influence of gravity. The collector used for dustfall is the Nipher snow gauge, which was developed by the Meteorological Service, Department of Transport, Canada to give accurate snowfall measurements. Sanderson et al[(3)] have determined that this collector showed the lowest differences between duplicate determinations of dustfall.

The collector consists of an inverted bell-shaped shield of spun aluminum, screwed into a 3 in. pipe. A copper container of precisely 5 in. ID and 20 in. high is set in the shield and is the collecting basin[(3)].

The collector is exposed for a period of one month. The total dustfall is weighed and is analyzed for the total insoluble, soluble, ash and combustible material present in the sample. Dustfall results are expressed in units of tons per square mile per month.

Suspended Particulates

To sample for the smaller particulates which remain suspended in the air and do not settle out in the dustfall containers, a High Volume Sampler is used. As the name implies, a large volume of air (approximately 40 c.f.m.) is drawn through a preweighed glass fiber filter and the exposed filter is removed and reweighed to determine the amount of the suspended particulates collected. The results are expressed in units of micrograms of particulates per cubic meter ($\mu g/m^3$) of sampled air. In this survey the General Metal Works Model 2000H sampler was used to take 24-hour samples. To avoid bias, random samples (with an average of one sample per week) were taken.

Soiling Index

The soiling index is an indication of the soiling potential of the pollutants in the atmosphere. A measured volume of air is continuously drawn through a circular area on a filter paper tape producing a stain or spot as a result of the particulate matter deposited. Samples are taken automatically by a tape sampler for a specified period, normally 2 hours, and light transmission measurements are carried out on the spots to derive the "coefficient of haze" (COH). One COH unit is defined as that quantity of particulate matter which produces an optical density of 0.01 with light at 400 mμ wavelength[(4)]. The soiling index is expressed as the number of COH units per 1000 linear feet of air drawn through the filter. In this survey A.I.S.I. Model F2 samplers were used.

Sulphur Dioxide (SO_2)

Sulphur dioxide in the atmosphere is measured continuously by means of conductivity or coulometry. At the Hydro Building (Station A) a Thomas Autometer (conductometric) was used. In the conductometric method a weak solution of H_2SO_4 plus H_2O_2 is passed through a mixing column at a fixed rate. The outside air is drawn in the opposite direction through the mixing column, also at a fixed rate. Any SO_2 present in the air dissolves in the solution to form H_2SO_4 and the change in electrical conductivity of the solution is recorded in terms of parts per hundred million (p.p.h.m.) of SO_2.

At the Post Office (Station D) an Atlas (Coulometric) SO_2 monitor was used. This monitor operates on the principle of continuous coulometric consumption of iodine from a sodium iodide solution by the SO_2 from the air. The corresponding flow of current between the two electrodes caused by the upset of the equilibrium in the sodium iodide solution is quantitatively related to the SO_2 concentration in the air. The SO_2 concentration is continuously recorded as parts per hundred million.

Meteorological Data

The character of the winds at a particular site plays an important part in determining ground level concentrations of air pollutants. Strong winds disperse pollutants over a much larger area in a given time interval than do light winds, resulting in lower levels of pollution at any point in the affected area. Wind directions which carry pollution emissions away from the community lessen the air pollution problem compared to wind directions towards the community. Wind direction frequencies may also be used to identify sources of pollution.

At the Ottawa International Airport, wind speed and direction at the 10 meter level were measured on an hourly basis by staff of the Atmospheric Environment Service, Department of the Environment. The instrument used was a U-2-A (Munroe) detector and recorder.

RESULTS AND INTERPRETATION

Dustfall

Figure 2 shows the average monthly dustfall values at the Hydro Building (A) and the Experimental Farm(B). During each month the dustfall values at Station A were higher than those at Station B. The average dustfall at Station A for a three year period was 57.1 tons/square mile/month and at Station B it was 15.0 tons/square mile/month. A significant peak occurred at Station A during March 1969.

Figure 3 shows average monthly dustfall values at the Post Office (D) and the Board of Education (C). Dustfall readings at these stations were initiated during 1970. The average value at Station D was 27.9 tons/ square mile/month and at Station C it was 18.2 tons/square mile/month.

The seasonal variation of dustfall at the Hydro Building (A) and the Experimental Farm (B) is shown in Figure 4. The breakdown of the seasons used for this study is as follows: Winter (Dec., Jan. and Feb.), Spring (March, April and May), Summer (June, July and August) and Autumn (Sept., Oct., and Nov.). For each season the average dustfall at the Hydro Building (A) was 2-7 times that at the Experimental Farm (B).

At the Hydro Building (A) the seasonal fluctuations were quite pronounced. The high values during spring can be attributed to several factors. There is considerable dust which has been contained by the snow cover and when the snow melts in the spring this dust becomes entrained in the air. Also, for a portion of the spring season there is residential and commercial heating which contribute to the high dustfall.

At the Experimental Farm (B) the seasonal variation of dustfall was minimal. The low values occurred during winter and the high values occurred during spring and summer. In winter, the snow cover prevents entrainment of the ground dust in the air. In the spring and summer, dust from the open fields surrounding this station contributes to the high dustfall values.

A comparison of monthly dustfall values during 1968 and 1970, averaged for the Hydro Building (A) and the Experimental Farm (B), is shown in Figure 5. The annual mean during 1969 (35.5 tons/square mile/month) fell in between the 1968 and 1970 means. The average dustfall at these two stations had decreased by 3.9 tons per square mile per month (or 10.2%) during the three year period.

<u>Suspended Particulates</u>

In Figure 6 the average suspended particulate concentration for each month is shown. With the exception of the Language Centre (E), the highest concentrations occurred during April because of entrainment of ground dust in the air by vehicular traffic and strong winds. The high concentration during October at Station E was presumed to be from the building's heating plant. For this reason, this station was removed from the survey in March, 1971. In general, the highest suspended particulate concentrations were recorded at the Hydro Building (A) where the annual mean was 121.5 $\mu g/m^3$. The lowest concentrations were recorded at the Language Centre (E) where the annual mean was 58.4 $\mu g/m^3$. This variation may be expected since one station is in a commercial area and the other one is in a residential area.

In Figure 7 the samples for each day of the week were averaged, i.e. the mean concentration for each day of the week was obtained. Once again the highest concentrations were at the Hydro Building (A) and the lowest were at the Language Centre (E). At all stations the concentrations of suspended particulates were lower during the week-end than during Monday to Friday, reflecting the decrease in vehicular traffic and industrial activity during this period. The decrease in week-end concentrations at Station A was 50%.

Soiling Index

Figure 8 shows the seasonal variation of COH values at three stations over a three year period. The most striking aspect of this graph is the annual peak during the winter season at each station. This peak is attributed to the increase in aerosol matter from commercial and residential heating plants. The lowest values were recorded during summer, when commercial and residential heating was at a minimum. The stations that have been classified as commercial, i.e., the Hydro Building (A) and the Board of Education (C), had higher COH values than the Experimental Farm (B) which has been classified as residential.

Figure 9 shows the seasonal variation of COH values at the remaining two stations, i.e., the Language Centre (E) and the Post Office (D). The influence of the heating plant at Station E is apparent. During summer the COH value was lower here than at Station D which is a commercial station. During winter, however, the COH value at Station E was substantially greater than at Station D. As mentioned previously, Station E was removed from the survey in March 1971.

Figure 10 shows the annual cycle of COH values for 1968 and 1970 and is based on combined averages for three stations (i.e. A, B, and C). The annual mean during 1969 at these stations was 0.32 COH units. The annual cycle indicates a maximum during December and January and a minimum during June, July and August. The winter maximum is related to increase in particulate emissions from the commercial and residential heating plants. On the other hand, in summer, heating plants are operating at minimum capacity; vegetation covers open fields, and the winds are light. All of these contribute to low COH values. It is interesting to note that between 1968 and 1970 there was a decrease in the average soiling index of 0.14 COH units (or 38%).

Figure 11 shows COH values for January and July averaged by the hour of the day at the Hydro Building (A) from 1968 to 1970 (i.e. the value of .62 at 0100 hours on the January curve was obtained by taking the arithmetic mean of 93 readings which occurred at 0100 hours). On the average, the COH values recorded during January are approximately three times those recorded during July. Both curves show an early morning maximum presumed to be due to fumigation (at 0700 hours) and a subsequent decrease in COH values due to the heating of a progressively deeper layer and mixing of pollutants through this layer. The increase in COH values in January at 1700 hours is probably due to an urban evening fumigation effect and the increase in vehicular traffic and domestic activity at this time. In July this increase is minor and occurs in the late evening.

In Figure 12 the COH values at the Hydro Building (A) during January and July averaged by the day of the week are presented. In general, the Monday to Friday COH values were higher than those on the week-end. In January the week-day readings were 20% higher than the week-end ones. In July the increase during Monday to Friday was 75%. The difference between week-end and week-day readings was 0.14 COH units in winter and 0.11 COH units in summer, suggesting that the week-day contributors made a constant addition of 0.11 to 0.14 COH units throughout the year.

Sulphur Dioxide SO_2

Seasonal variation of SO_2 at the Hydro Building (A) and the Post Office (D) is presented in Figure 13 and 14 respectively. Station D is shown only for five seasons since the SO_2 monitor was only installed there in September 1969. The winter peaks which are evident for both stations were most likely caused by increased residential and commercial emissions during this season. In general, the SO_2 levels at Station D (2.3 p.p.h.m. average) were lower than those at Station A (4.5 p.p.h.m. average). The difference in SO_2 levels between these two stations was most noticeable during winter. This would indicate that the effect of the heating plants on levels of SO_2 at Station D was less than at Station A. During the other seasons the difference in SO_2 levels between the two stations was not significant.

Figure 15 shows the monthly variation of SO_2 concentrations at the Hydro Building (A) and the Post Office (D) during 1970. For both stations the effect of the commercial and residential heating plants during winter is obvious with high concentrations occurring in winter and low ones in summer.

Figure 16 shows SO_2 concentrations averaged over hourly time periods at the Hydro Building (A) for January and July. In general, the SO_2 concentrations during January were four times the SO_2 concentrations during July. Both monthly curves reveal an early morning maximum due to fumigation and a subsequent decrease to normal levels. In January this decrease occurred between 0900 and 1000 hours and in July after 0800 hours. In January there was an early evening increase in concentration after 1600 hours which some researchers have attributed to an evening fumigation. In July the increase (which is minor) occurred after 1900 hours.

Figure 17 shows the weekly cycle of SO_2 concentrations at the Hydro Building (A) during January and July. This SO_2 cycle is not as pronounced as the COH cycle (Figure 10). This would lead to the conclusion that the SO_2 concentrations that were recorded at this station were not from sources that operate on a five day week but rather from sources that were in continuous operation, e.g. heating plants.

Meteorological Data

Wind roses for Ottawa International Airport (which is 7 miles south of the centre of the city) are shown on Figure 18. It is obvious from the wind roses that the predominant wind direction for each season was from the west. During spring and winter over 50% of the time the wind was from the west, northwest or east. During summer and autumn over 50% of the time the wind was from the south, south-west or west. During summer 65.5% of the time the winds were less than 10 m.p.h. During the other three seasons the frequency of winds less than 10 m.p.h. was roughly equal to that of winds over 10 m.p.h.

Wind direction frequencies associated with the daily maximum SO_2 concentrations are shown in Figure 19. During each season the predominant wind directions are west and north-west. This indicates that the major sources of SO_2 for all seasons were located in a west and/or north-west direction from the Hydro Building (A). The wind speeds associated with the daily maximum concentrations were mostly in the 10 m.p.h. or greater class for all seasons except summer. During summer the daily maximum SO_2 concentrations occurred with lighter winds (i.e. 0-9 m.p.h.) and 5.0% of the time the daily maximum occurred with calm conditions. During autumn, the wind directions associated with daily maxima were more evenly distributed although west and northwest occurrences still remained relatively high.

Figure 20 shows the wind direction frequencies associated with the daily maximum COH values. There is no distinct correlation with wind directions as there was in Figure 19. For all seasons, approximately 20% of the daily maximum COH readings were associated with west winds. During summer the daily maximum was associated with lighter winds (i.e. 0-9 m.p.h.), whereas in the other seasons it was associated with stronger winds.

DISCUSSION

Dustfall

Dustfall is a useful indicator of the amount of material deposited from stack emissions and in general it constitutes a nuisance to the community.

Monthly dustfall values at a station are known to vary by as much as 600%(5). Also, collectors of different shapes and physical dimensions make it difficult to compare dustfall values obtained in different cities. For these reasons only trends of improvement or deterioration over a long period of time should be used as indicators of changing conditions.

Guidelines for Dustfall in Allegheny County, Pennsylvania have the following classification(5):

	Tons/square mile/month
Slight	0-20
Moderate	20-40
Heavy	40-100
Very Heavy	> 100

Using this classification, Station A during the three year period (1968-1970) had the following dustfall values: moderate 25%, heavy 72%, and very heavy 3%. Station B for the same period had: slight 97%, and moderate 3%.

The Ontario ambient air quality criteria require the concentration of dustfall not to exceed 20 tons/square mile/month and the annual arithmetic mean not to exceed 13 tons/square mile/month[6]. Table I shows that all four stations in this survey failed to meet these criteria during 1970.

Table I

Station	Percentage of concentrations ≤ 20 tons/sq. mi./month	Annual arithmetic mean (tons/sq.mi./month)
A	0.0	53.3
B	75.0	16.4
C	63.0	18.2
D	43.0	27.9

Sanderson et al [3] found that the Nipher snow gauge (which was used in this survey) collected as much as 2.5 times the dustfall collected by other popular dustfall containers, e.g. polyethylene jars. On the basis of this, if polyethylene jars had been used in this survey all stations except Station A would have met these criteria. For this reason, trends in dustfall rather than absolute values are most meaningful. (see Figure 5)

Suspended Particulates

The suspended particulates do not settle in the vicinity of the source of emissions. These particulates travel with air currents and remain aloft for appreciable times. Those that are in the air in the vicinity of the high volume sampler are collected on the filter.

The decrease in week-end concentrations of suspended particulates was greater than expected. Stern [5] states that the average decrease in U.S. cities is about 15%. In the National Capital survey the decrease was over 40% (Figure 7).

In Ontario, the ambient air quality criteria require the concentration of suspended particulates not to exceed 90 $\mu g/m^3$ and the annual geometric mean not to exceed 60 $\mu g/m^3$[6]. The Environmental Protection Agency (EPA) of the U.S.A. set National Air Quality standards on April 30, 1971[7]. Two types of standards were set. Primary standards protect the public health. Secondary standards protect against effect on soil, water, vegetation, materials, animals, weather, visibility, personal comfort and well-being. The primary standards require the annual geometric mean not to exceed 75 $\mu g/m^3$ and the maximum 24-hour concentration of 260 μg/m^3 not to be exceeded more than once a year.

Table II shows that during 1970 only Station E met part of the criteria as set out by Ontario. On the other hand, Station D and E met the EPA criteria and Station A met the criteria for the maximum 24-hour concentration.

Table II

Station	Percentage of concentrations $\leq$ 90 μg/m^3	Annual geometric mean μg/m^3	Occurrences of concentrations > 260 μg/m^3
A	25.0	110.6	1
D	62.0	75.0	0
E	76.0	45.8	0

Soiling Index

The darkness of stains produced by drawing polluted air through filter paper has been used to estimate concentrations of suspended matter for many years. The tape sampler is cheap, simple and rugged; however, it should be used with the knowledge that its measurements are arbitrary, artificial and relative rather than absolute. These measurements, however, can be useful, especially to determine long-term trends.

Average COH values in Britain during winter are 2 to 3 times the summer values[(5)]. In our survey the winter values were approximately 3 times the summer values (Figure 11). Other studies have found that the week-end decrease in COH values in urban areas is approximately 20%.[(5)]. In the present survey, results for week-ends in the month of January were 21% lower than those for week-days and the corresponding results in July were 73% lower during the week-ends (Figure 10).

In Allegheny County, Pennsylvania the following subjective classifications have been defined for soiling index [(5)]:

Pollution	COH units
Slight	0 - 1.0
Moderate	1.0 - 2.0
Heavy	2.0 - 3.0
Very Heavy	3.0 - 4.0

Using this classification, the Hydro Building (A) during January 1968, 1969 and 1970 fell into the slight pollution category 80% of the time, moderate pollution 18% of the time and heavy pollution 2% of the time. During July 1968, 1969, and 1970 this station fell into the category of slight pollution 98.5% of the time and moderate pollution 1.5% of the time.

The Ontario ambient air quality criteria require the soiling index not to exceed 1.0 COH units as a 24-hour mean and the annual arithmetic mean not to exceed 0.45 COH units[6].

Table III indicates that during 1970 all five stations had an annual arithmetic mean of less than 0.45 COH units but four of them exceeded 1.0 COH units as a 24 hour mean on several occasions.

Table III

Station	Percentage of 24-hour means $\leq$ 1.0 COH units	Annual arithmetic mean (COH units)
A	97.6	0.38
B	100.0	0.06
C	98.9	0.23
D	98.0	0.29
E	96.6	0.30

Sulphur Dioxide SO_2

Sulphur dioxide is a nonflammable, non-explosive, colourless gas. In concentrations of 30 p.p.h.m. to 100 p.p.h.m. in air, most people can detect it by taste; in concentrations greater than 300 p.p.h.m. it has a pungent, irritating odour to most people[8].

The ambient air quality criteria for Ontario require the concentrations of SO_2 not to exceed 25 p.p.h.m. as an hourly mean, 10 p.p.h.m. as a 24-hour mean and 2 p.p.h.m. as an annual arithmetic mean [6]. The EPA in its primary standards requires the annual arithmetic mean not to exceed 3 p.p.h.m. and the maximum 24-hour concentrations of 14 p.p.h.m. not to be exceeded more than once a year[7].

Table IV indicates that Station D met the EPA standards and the one hour criteria set out by Ontario. Station A, on the other hand, exceeded both the Ontario and the EPA criteria.

Table IV

Station	Percentage of 1 hour mean concentrations ≤ 25 p.p.h.m.	Occurrences of 24-hour concentrations > 14 p.p.h.m.	Percentage of 24-hour concentrations ≤10 p.p.h.m.	Annual arithmetic mean (p.p.h.m.)
A	99.8	9	91.5	4.4
D	100.0	0	99.1	2.2

Meteorological Data

Most primary pollutants, e.g. SO_2 and particulates, have two diurnal peaks, one on the morning, sometime between 0700 and 1000 hours and another in the evening, usually after sunset[9]. The morning peak is due to fumigation and the evening one is due to an urban evening fumigation effect. Both these peaks are apparent in the diurnal COH and SO_2 values (Figures 11 and 16).

The greatest number of daily maximum SO_2 readings were associated with west and northwest winds (Figure 19). Munn and Ross [1] found that the highest SO_2 values were associated with northwest and north winds. Munn [2] found that the peak SO_2 values were associated with northwest winds. For both of these studies [1,2] SO_2 was monitored at the War Service Records Building. Because of the relative locations of the two sampling stations (i.e. the Hydro Building and the War Service Records Building) the same sources that contributed to the maximum SO_2 values in the previous studies could also be the sources that produced the maximum concentration in this survey.

Munn and Ross [1] found that the highest COH values were obtained with northwest winds. Munn [2] found that the peak COH values were also associated with south and southwest winds. In the present survey, approximately 20% of the maximum daily COH values occurred with the winds from the west (Figure 20). It may be concluded that there was not a single major source of particulates.

Rather the particulates that were sampled came from a variety of small sources, e.g. ground dust, vehicular traffic and various manufacturing operations.

CONCLUSIONS

1. During the three year period studied (1968-1970) the readings obtained at the five stations in the survey either remained unchanged or showed an improvement.

2. Dustfall levels at the four stations measuring this parameter exceeded the Ontario ambient air quality criteria. However, dustfall values are dependant on the collector that is used; therefore, the trend in dustfall values is more important than the absolute values. The decrease in dustfall (10.2%) between 1968 and 1970 indicates a slight improvement in the quality of the ambient air with respect to this parameter.

3. Values for suspended particulates met either the EPA standards or the Ontario criteria at the Post Office (D) and the Language Centre (E) but not at the Hydro Building (A). For all stations the week-end decrease of suspended particulates (over 40%) was greater than expected.

4. At all five stations in the survey the COH values were at an acceptable level. The decrease in week-end values ranged from 20% (during January) to 75% (during July). The wind direction associated with daily maximum COH values indicates that these were not due to the contribution of a few large sources of particulates but rather the particulates originated from a variety of sources situated around the sampling locations. The decrease (38%) of COH values during the three year period indicates an improvement in the quality of the ambient air.

5. SO_2 levels at the Post Office (D) were acceptable whereas those at the Hydro Building (A) frequently exceeded an acceptable level. The highest concentrations of SO_2 were recorded during the heating

season. The wind direction associated with daily maximum SO_2 concentrations indicated that the major sources affecting the Hydro Building (A) were in a west and northwest direction from this station. There has been no significant change in SO_2 concentrations at this station during the three year period.

6. A continuing air pollution monitoring program is needed to determine future trends of air pollution in the National Capital Region. The program should be expanded to measure oxides of nitrogen, carbon monoxide, hydrocarbons, lead and oxidants in addition to the parameters presently being measured.

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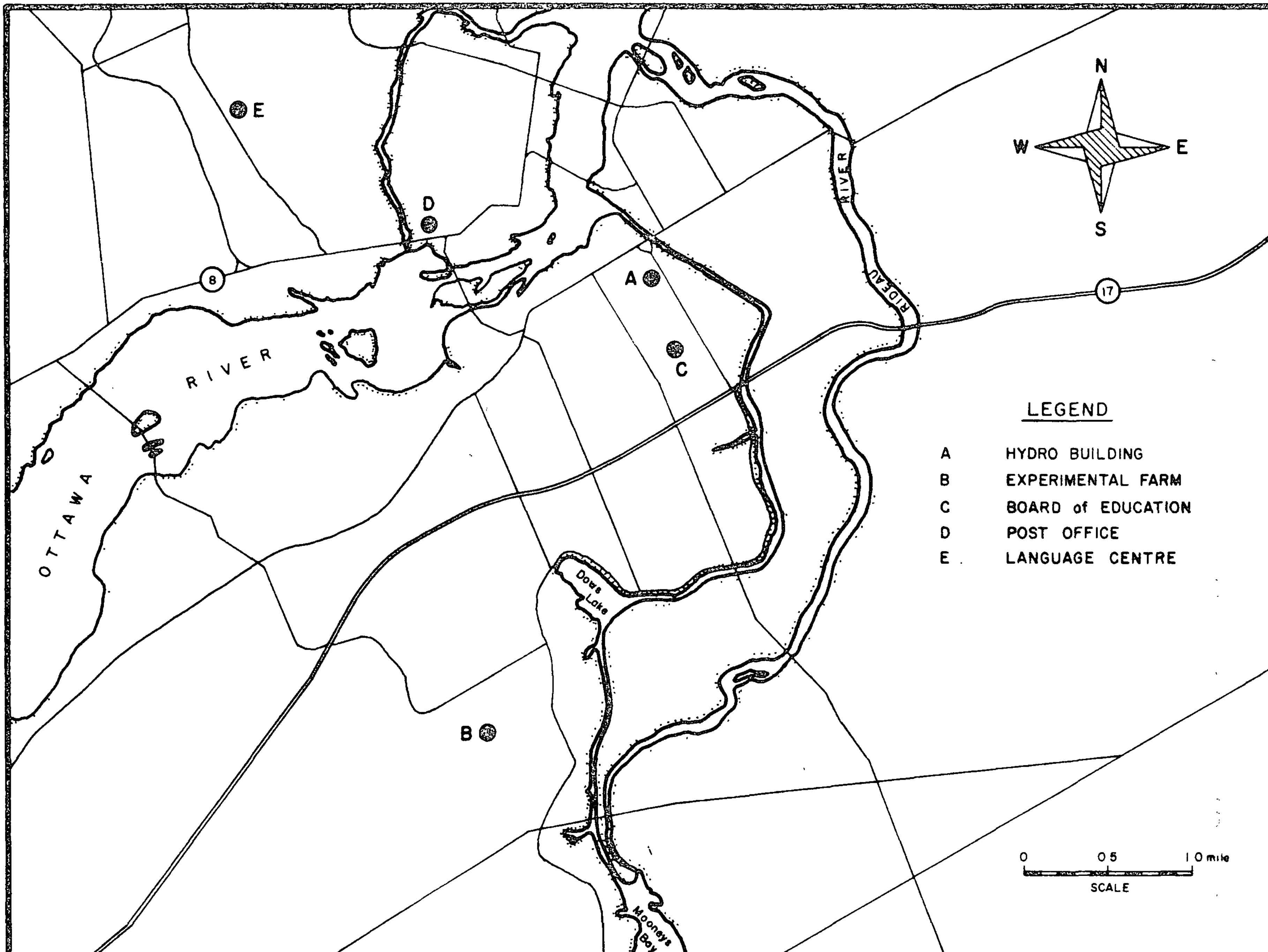


FIGURE I LOCATION OF STATIONS IN THE NATIONAL CAPITAL REGION AIR POLLUTION SURVEY

FIG. 2 MONTHLY DUSTFALL VALUES AT 2 STATIONS DURING 1968, 1969 AND 1970.

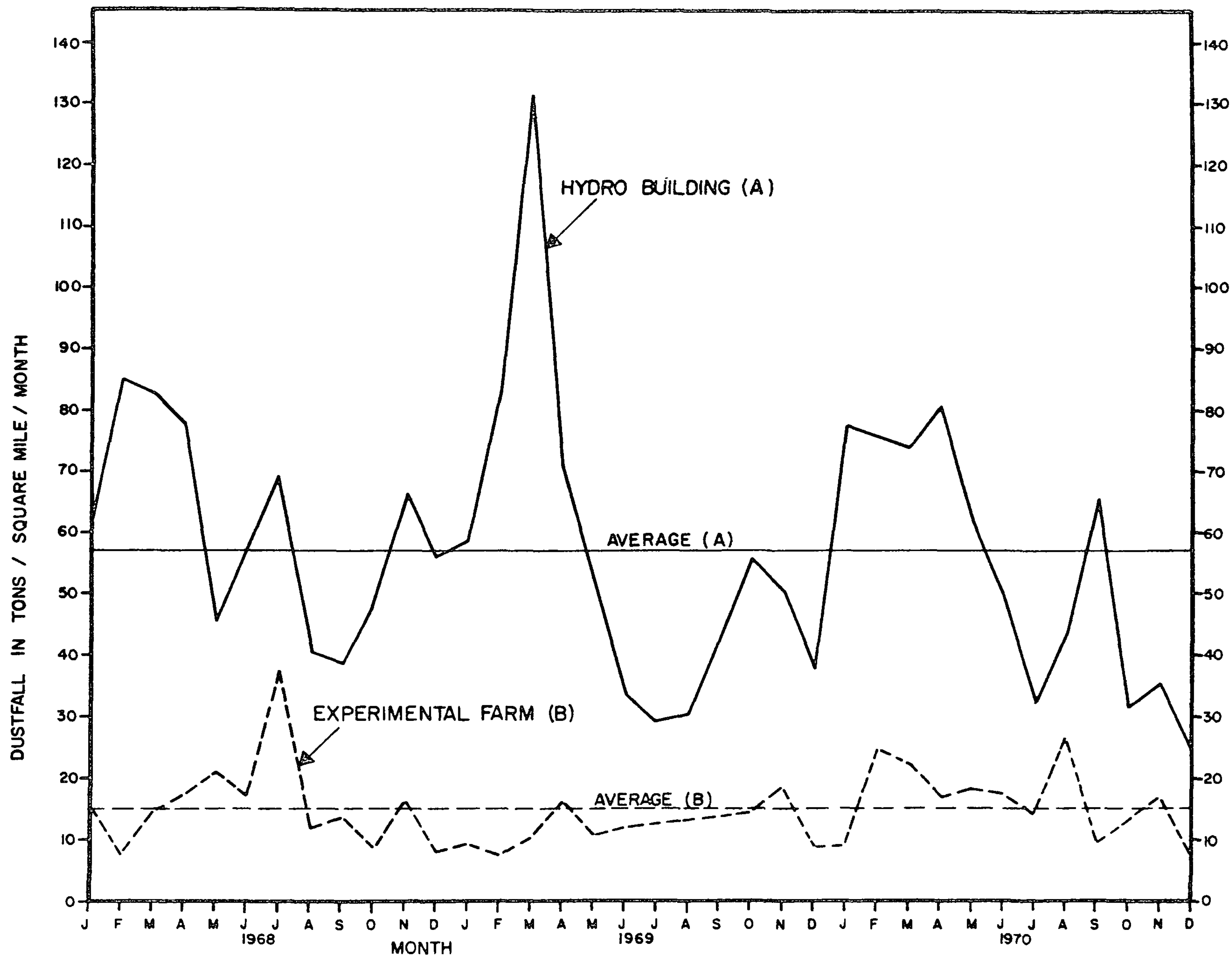


FIG. 3 MONTHLY DUSTFALL VALUES AT 2 STATIONS DURING 1970.

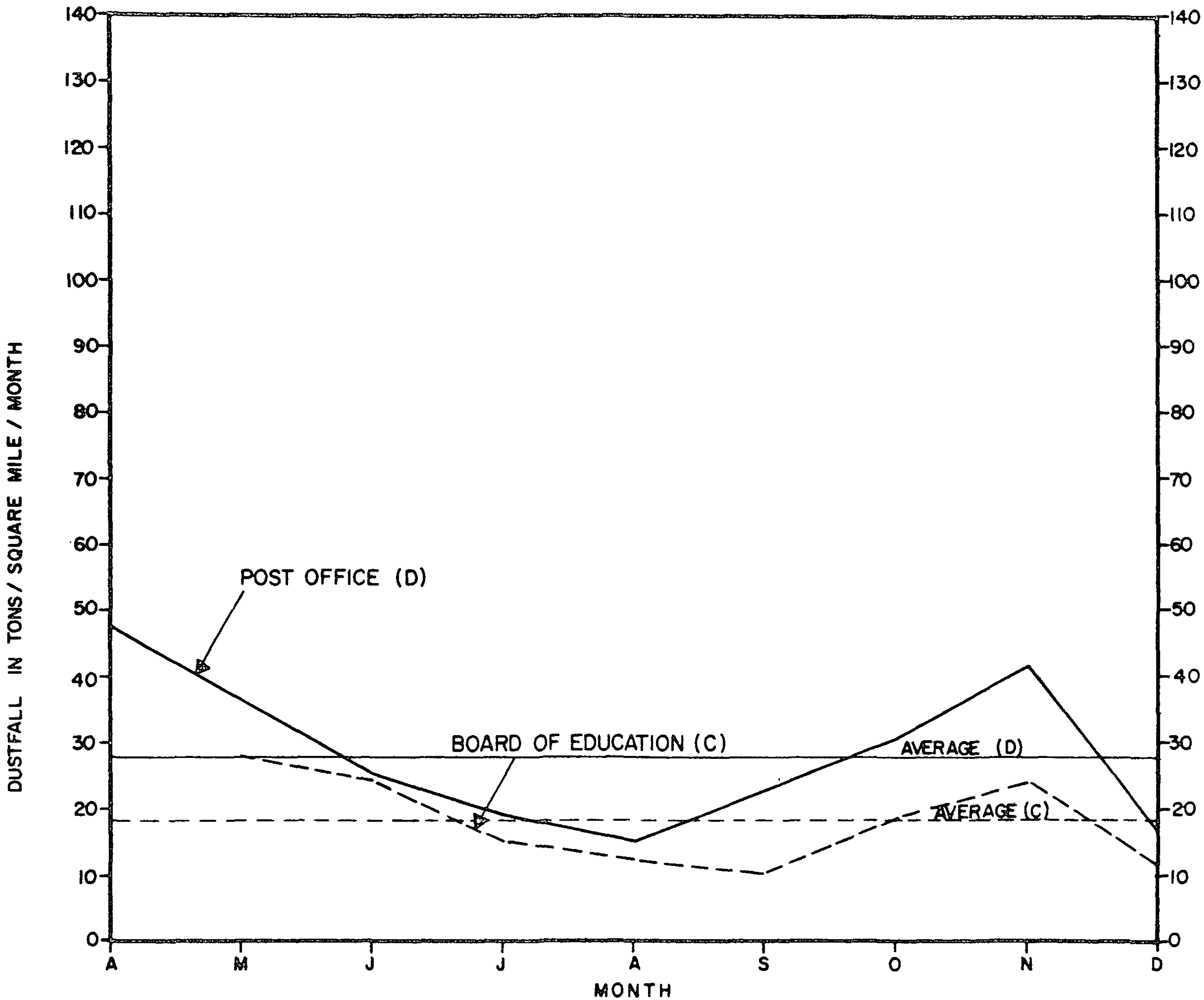


FIG 4 SEASONAL VARIATION OF DUSTFALL AT THE HYDRO BUILDING (A) AND THE EXPERIMENTAL FARM (B) FROM DEC. 1967 TO NOV. 1970.

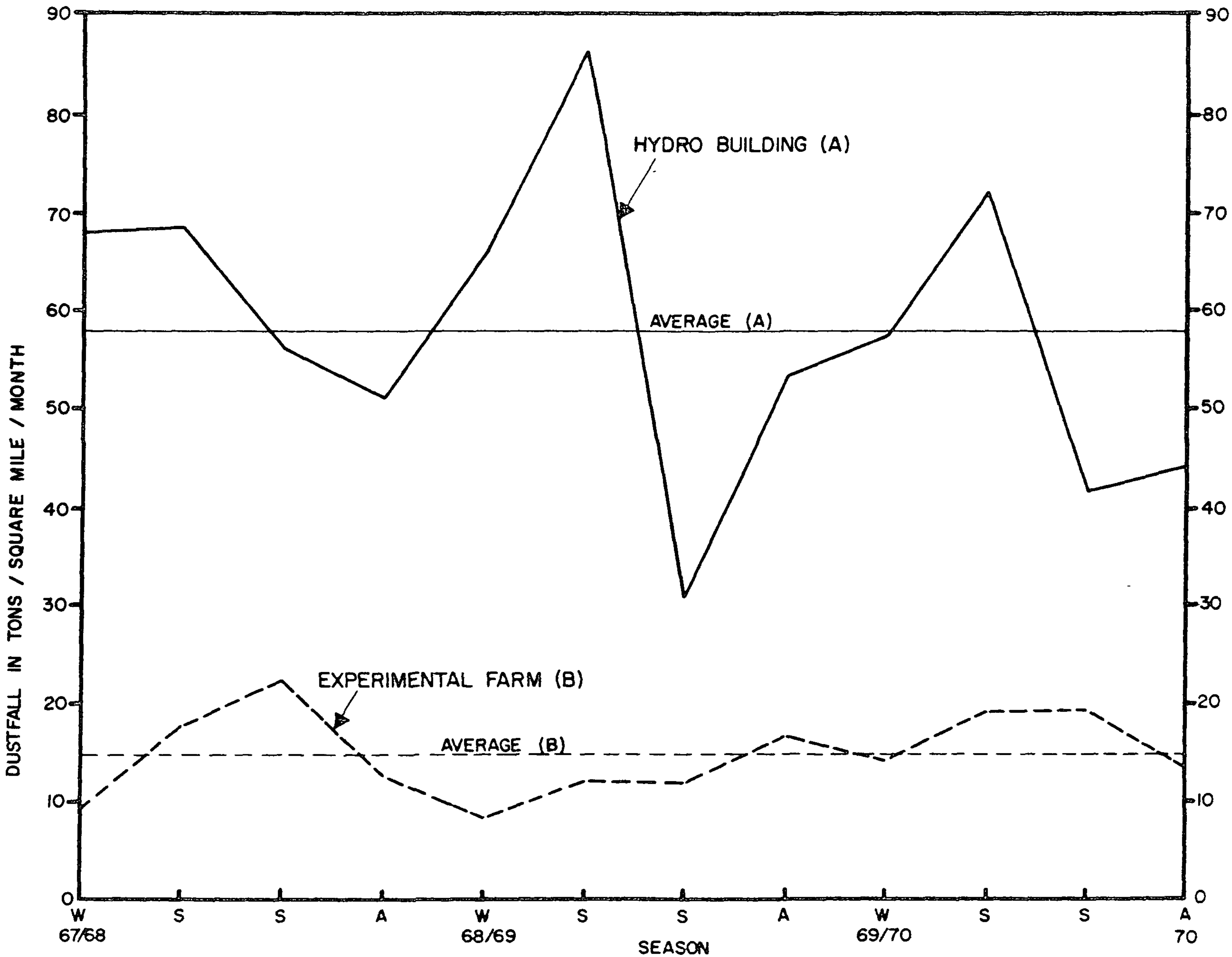


FIG 5 MONTHLY TREND OF AVERAGE DUSTFALL VALUES FOR 2 STATIONS (HYDRO BUILDING AND EXPERIMENTAL FARM) DURING 1968 (——) AND 1970 (- - - -).

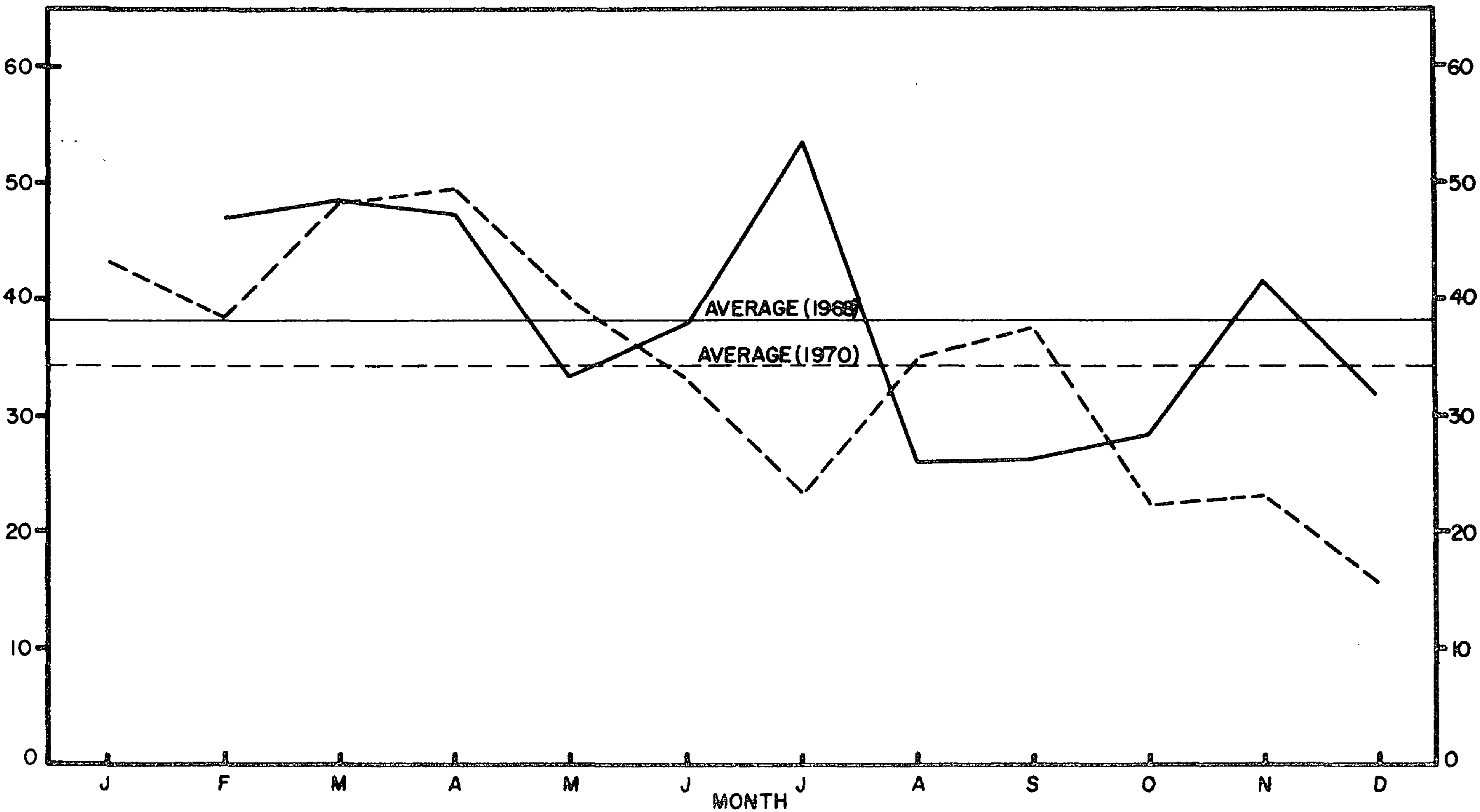


FIG 6 AVERAGE MONTHLY CONCENTRATIONS OF SUSPENDED PARTICULATES AT 3 STATIONS DURING 1969 AND 1970.

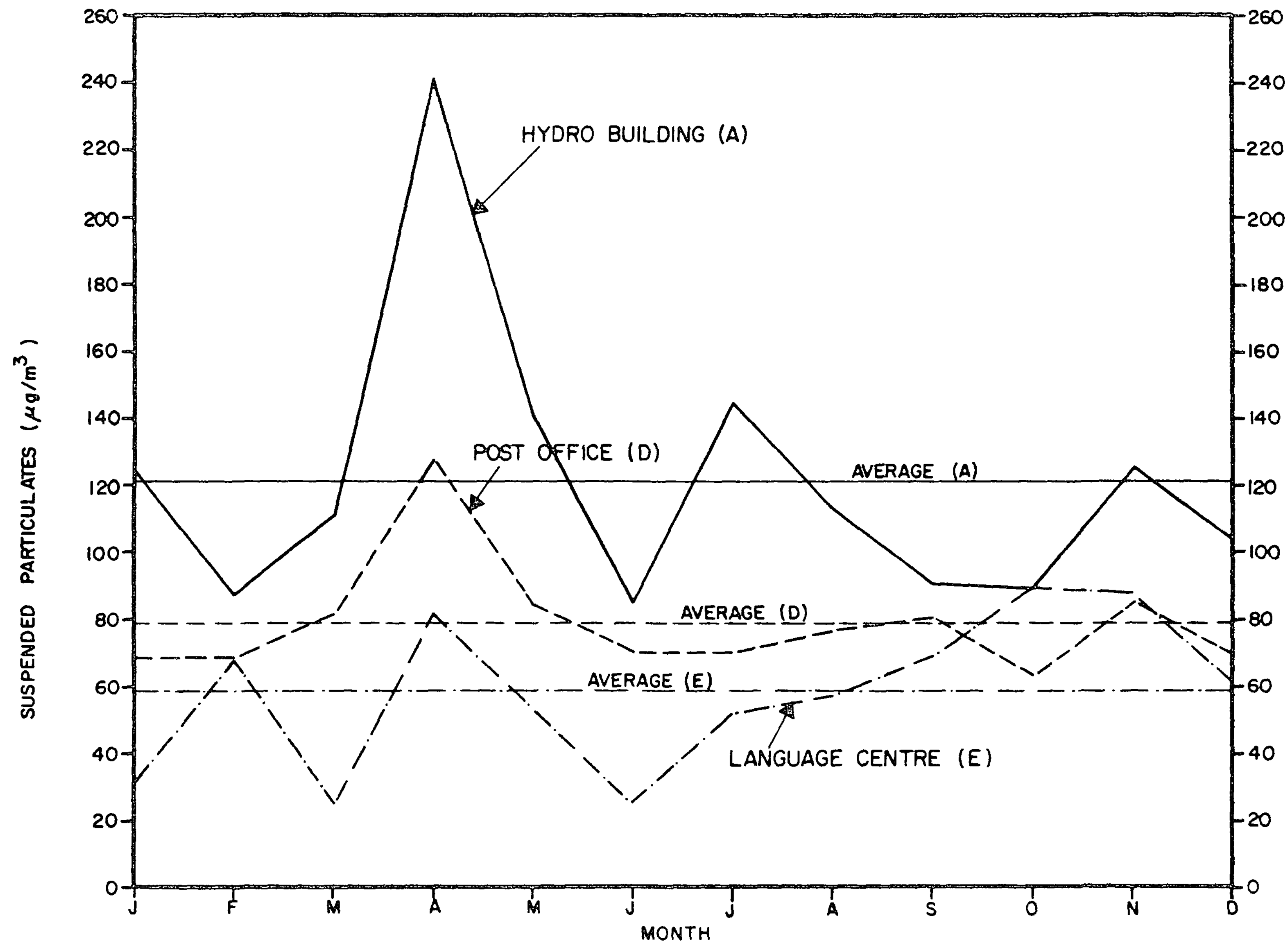
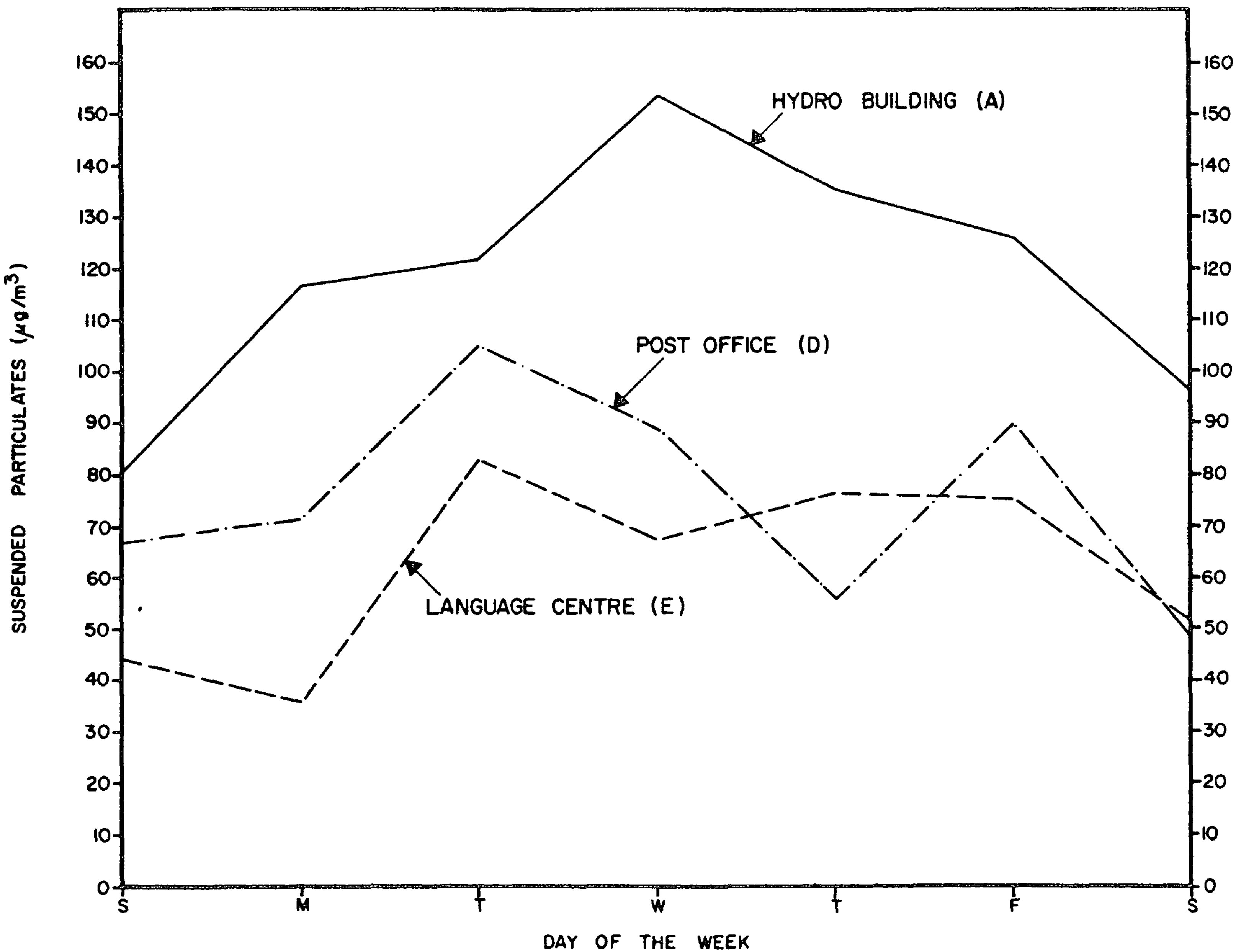


FIG. 7 WEEKLY CYCLE OF SUSPENDED PARTICULATES AT 3 STATIONS BASED ON 1969 AND 1970 CONCENTRATION.



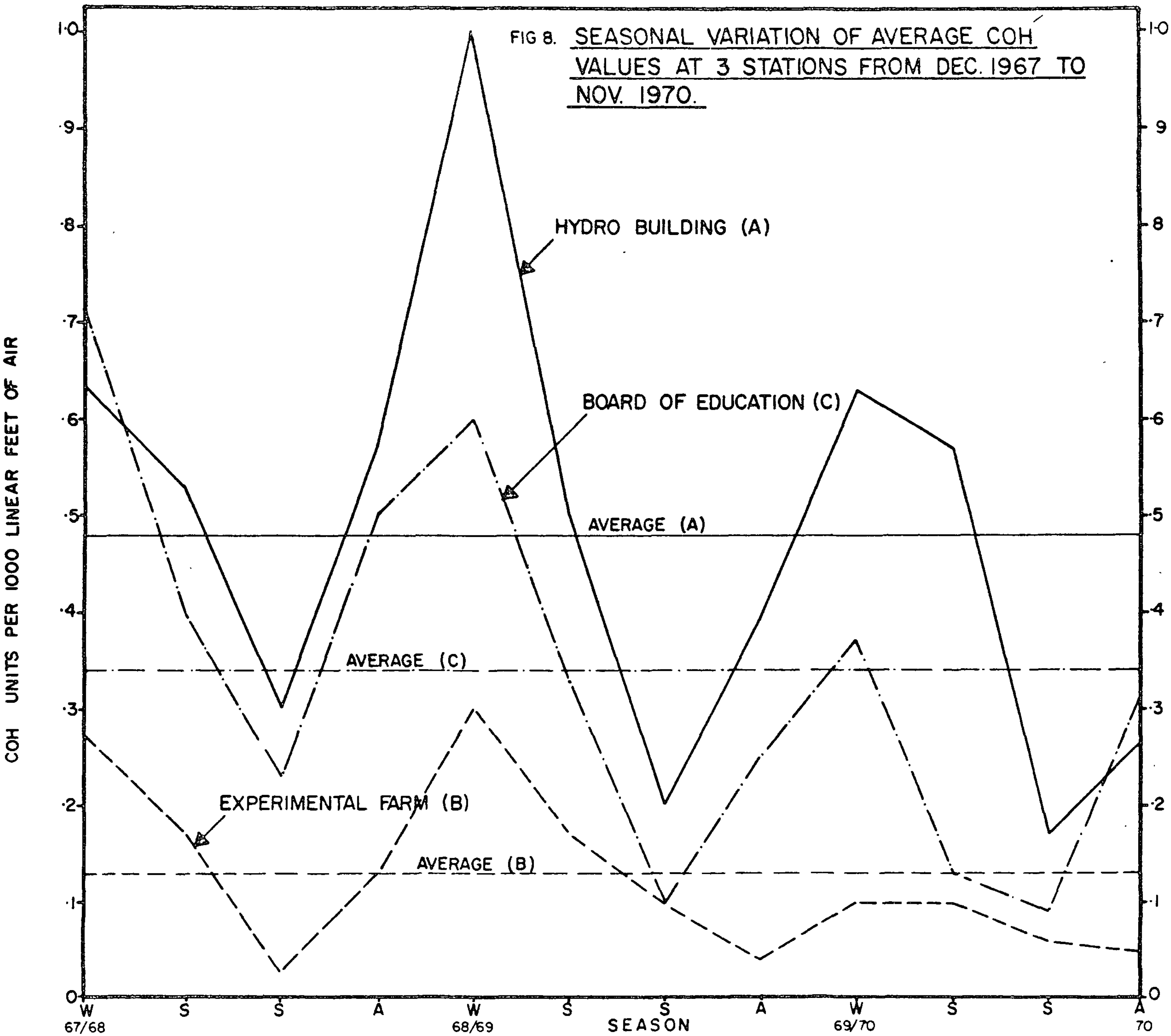


FIG 8. SEASONAL VARIATION OF AVERAGE COH VALUES AT 3 STATIONS FROM DEC. 1967 TO NOV. 1970.
HYDRO BUILDING (A)
BOARD OF EDUCATION (C)
AVERAGE (A)
AVERAGE (C)
EXPERIMENTAL FARM (B)
AVERAGE (B)
COH UNITS PER 1000 LINEAR FEET OF AIR
SEASON
W 67/68
S
S
A
W 68/69
S
S
A
W 69/70
S
S
A 70
0
·1
·2
·3
·4
·5
·6
·7
·8
·9
1·0

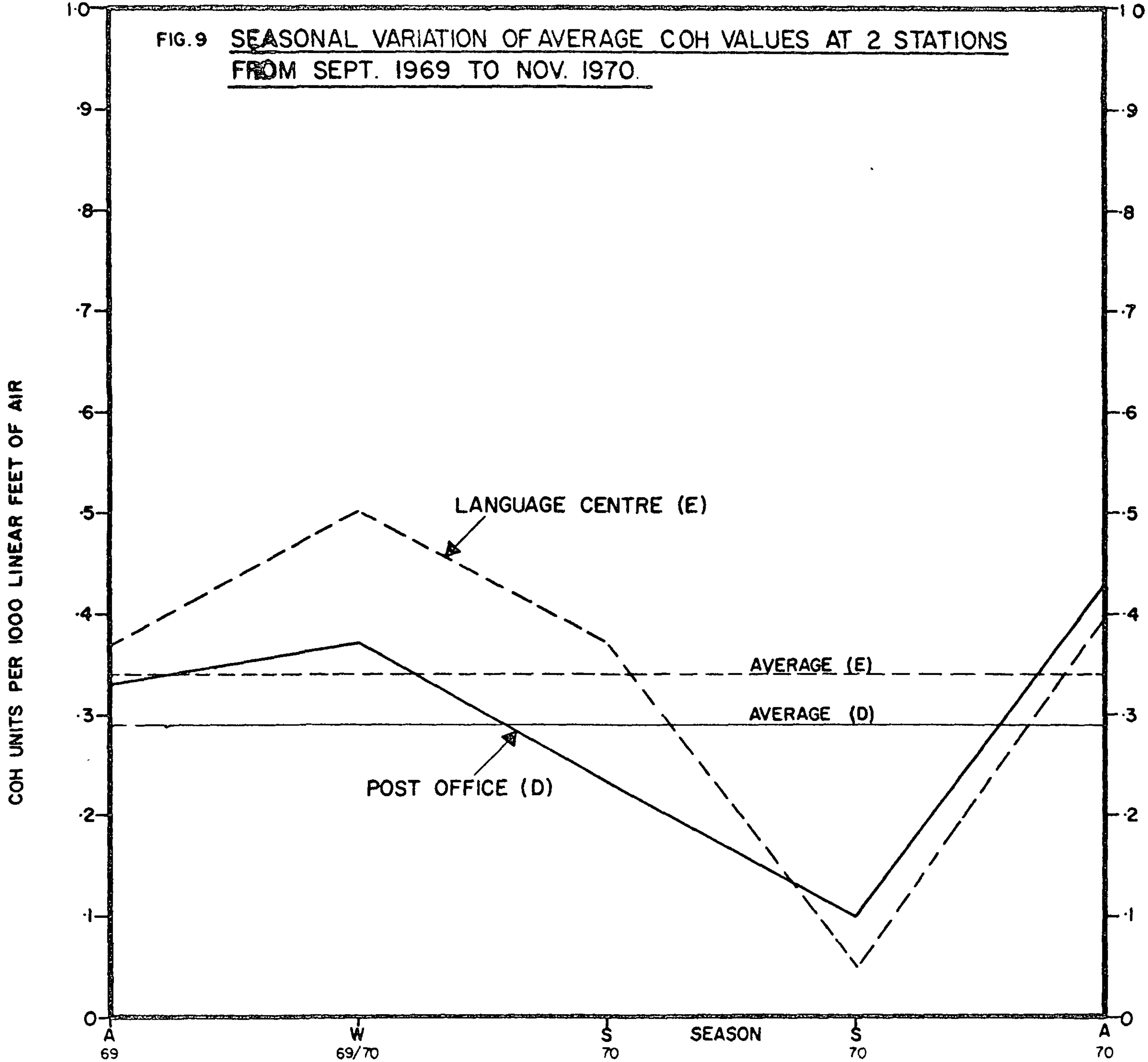


FIG. 9 SEASONAL VARIATION OF AVERAGE COH VALUES AT 2 STATIONS FROM SEPT. 1969 TO NOV. 1970.

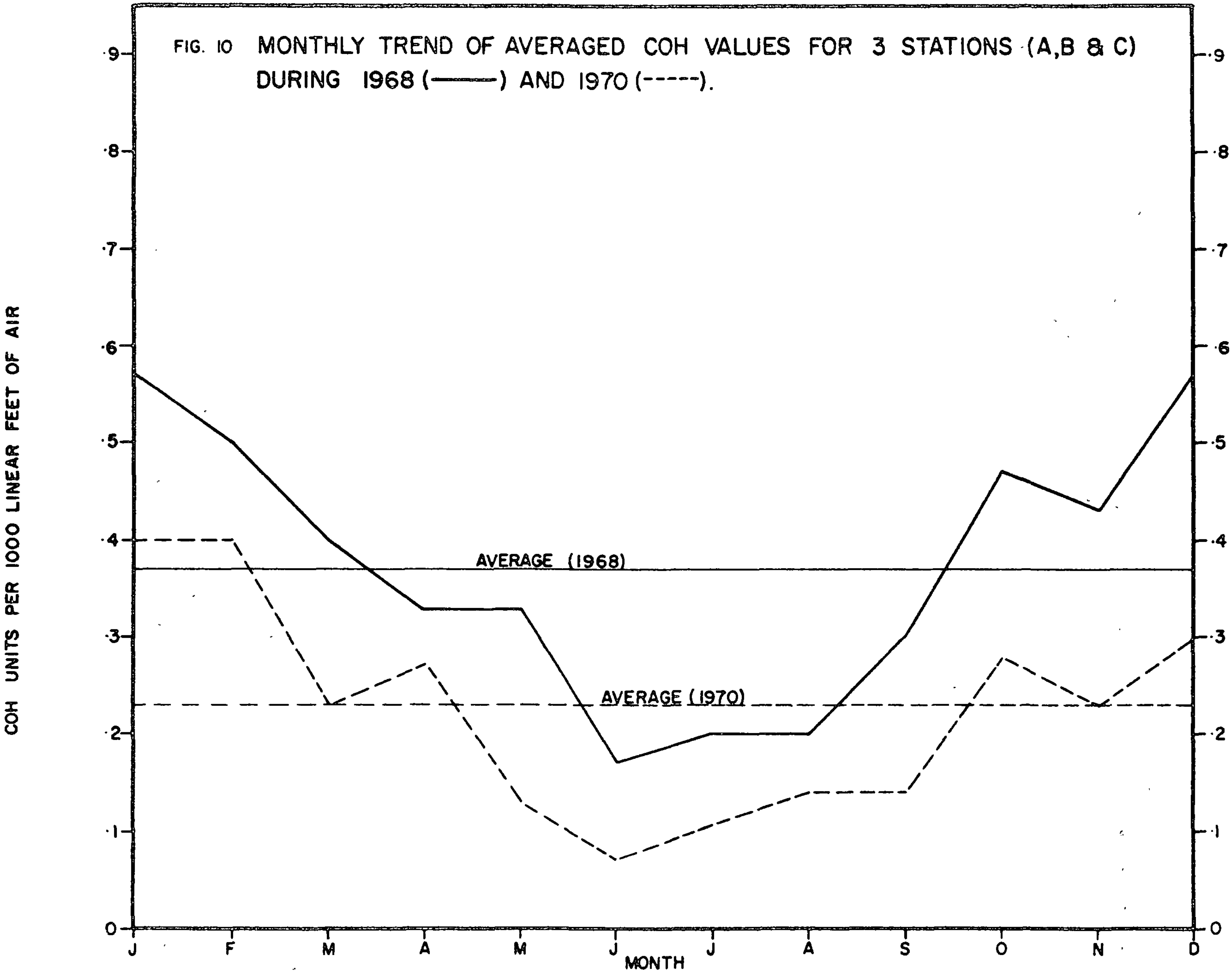


FIG. 10 MONTHLY TREND OF AVERAGED COH VALUES FOR 3 STATIONS (A,B & C) DURING 1968 (———) AND 1970 (-----).

FIG. 11 AVERAGE 2-HOUR COH VALUES AT THE HYDRO BUILDING (A) DURING JANUARY AND JULY BASED ON 1968, 1969 AND 1970 AVERAGES.

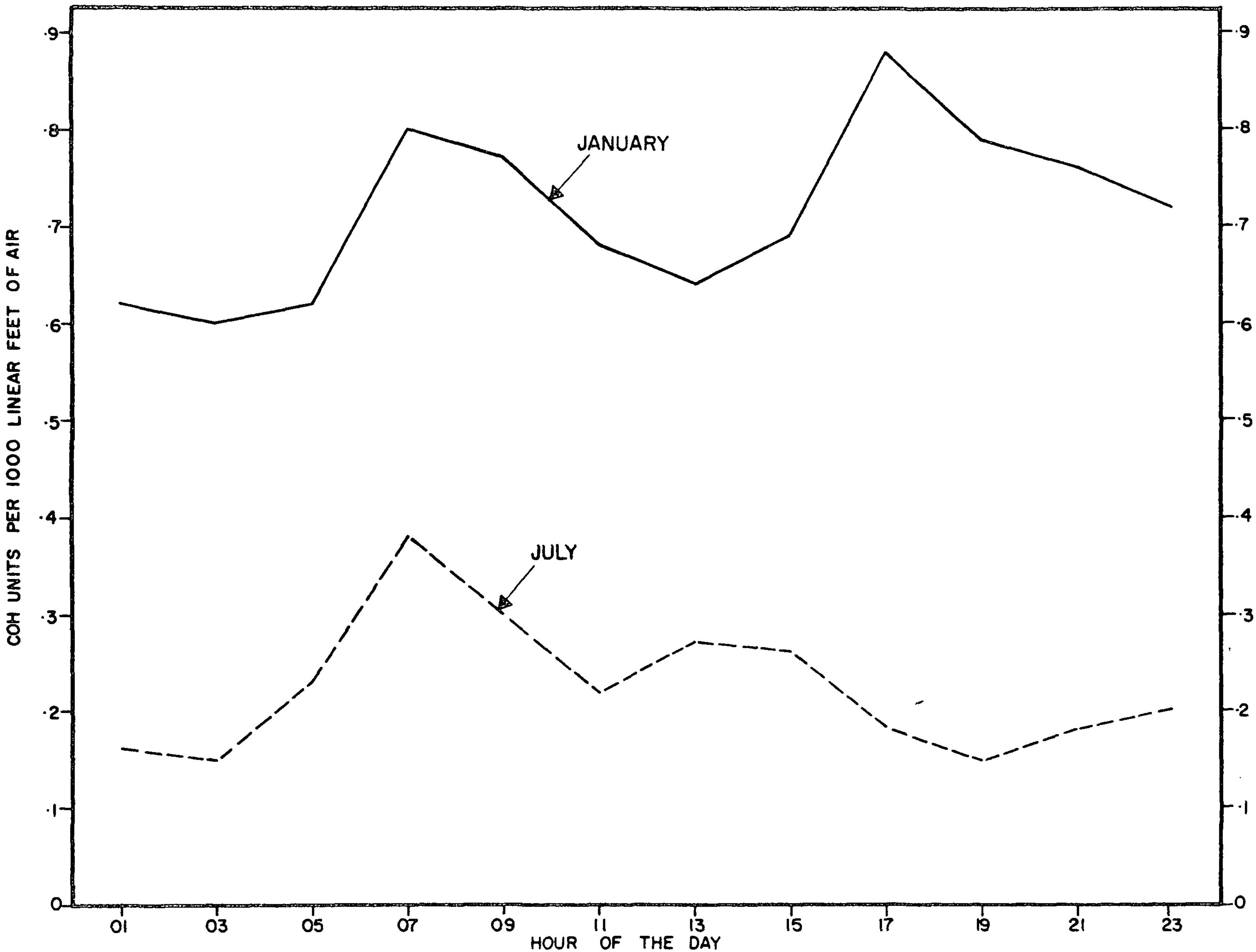


FIG. 12 AVERAGE DAILY COH VALUES BASED ON CONCENTRATIONS DURING JANUARY AND JULY OF 1968, 1969 AND 1970 AT THE HYDRO BUILDING (A).

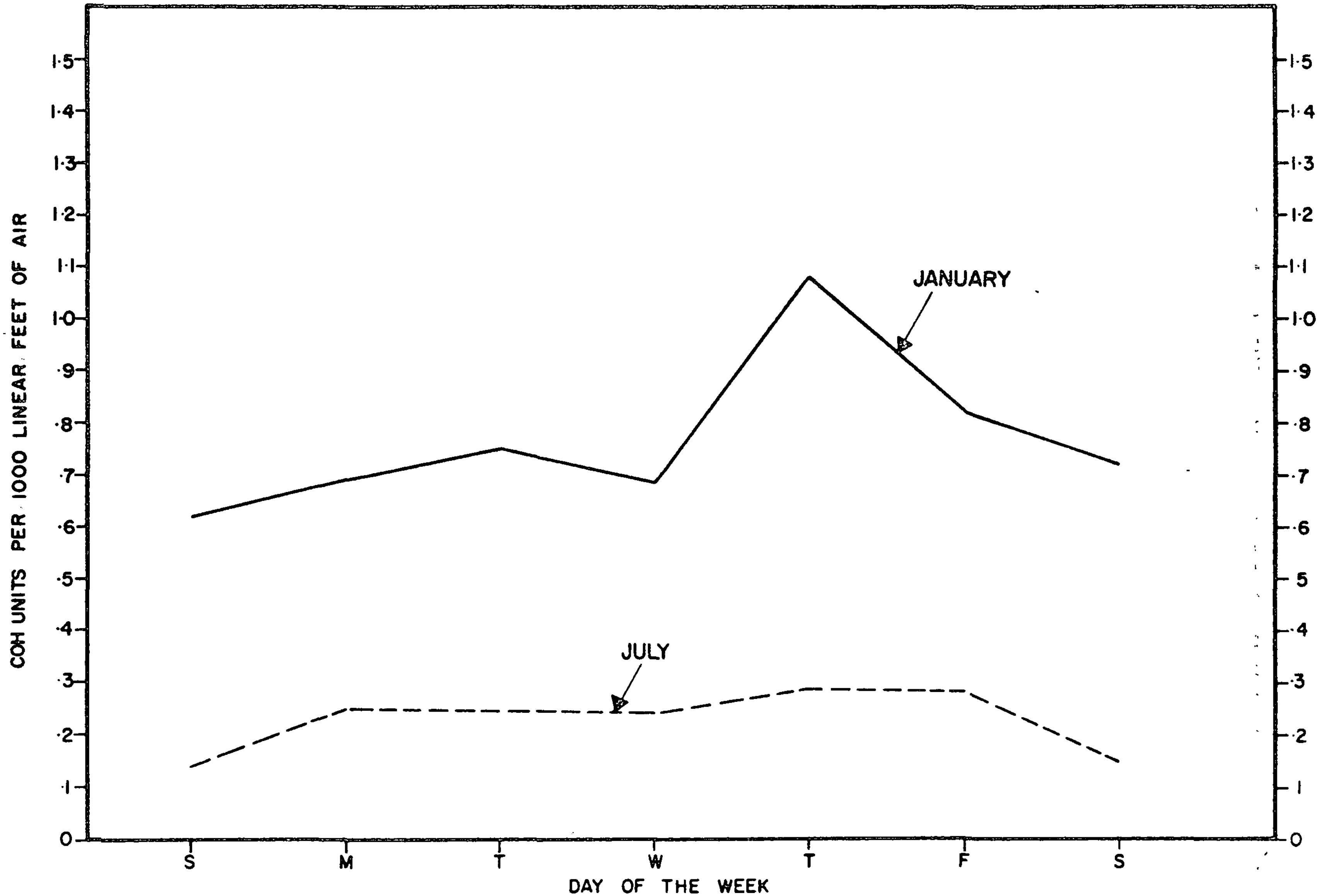


FIG 13 SEASONAL VARIATION OF SO2 AT THE HYDRO BUILDING (A) FROM DEC. 1967 TO NOV. 1970.

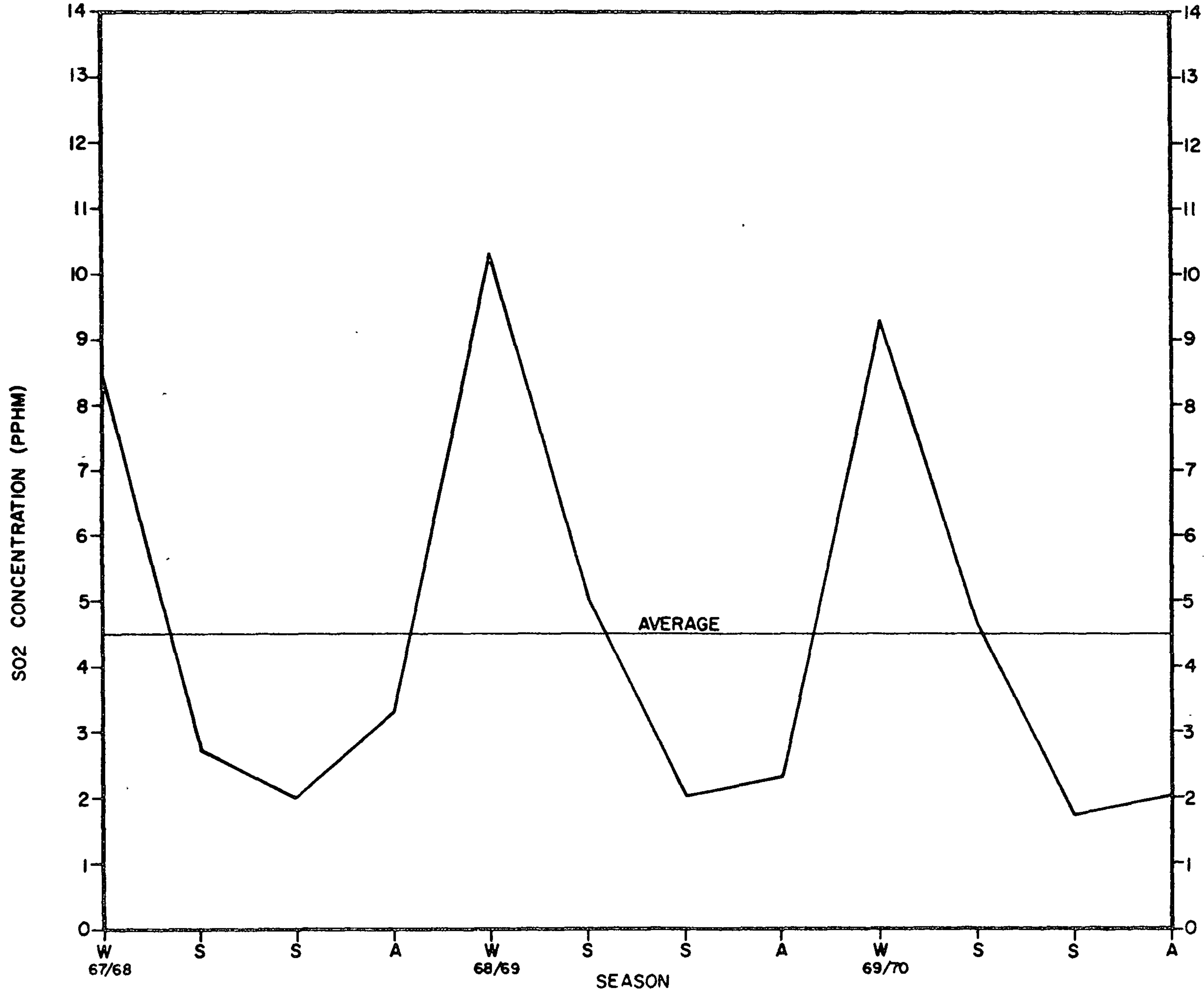


FIG. 14 SEASONAL VARIATION OF SO2 AT THE POST OFFICE (D) FROM SEPT. 1969 TO NOV. 1970.

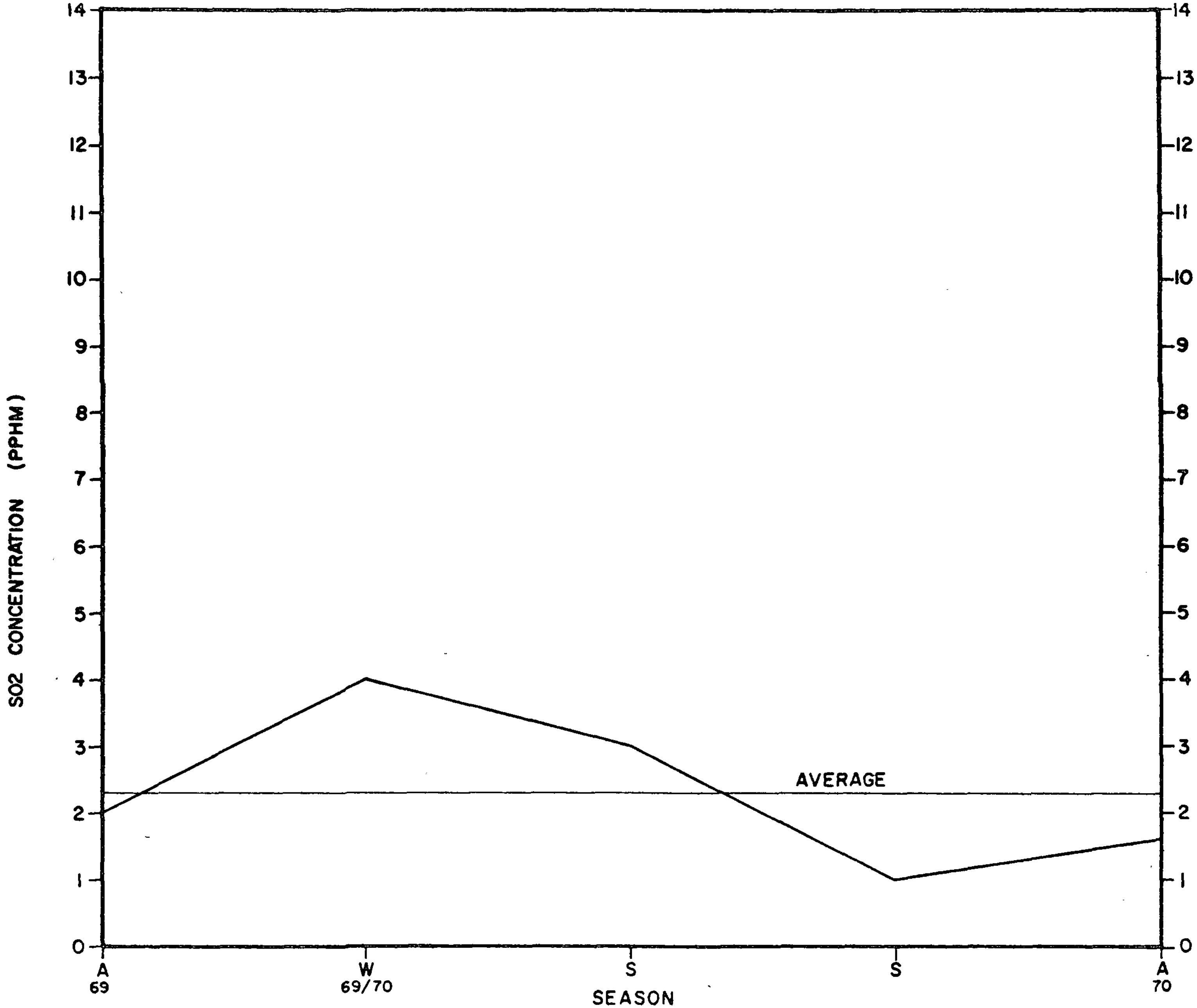


FIG. 15 AVERAGE MONTHLY SO2 CONCENTRATIONS AT THE HYDRO BUILDING (A) AND THE POST OFFICE (D) DURING 1970.

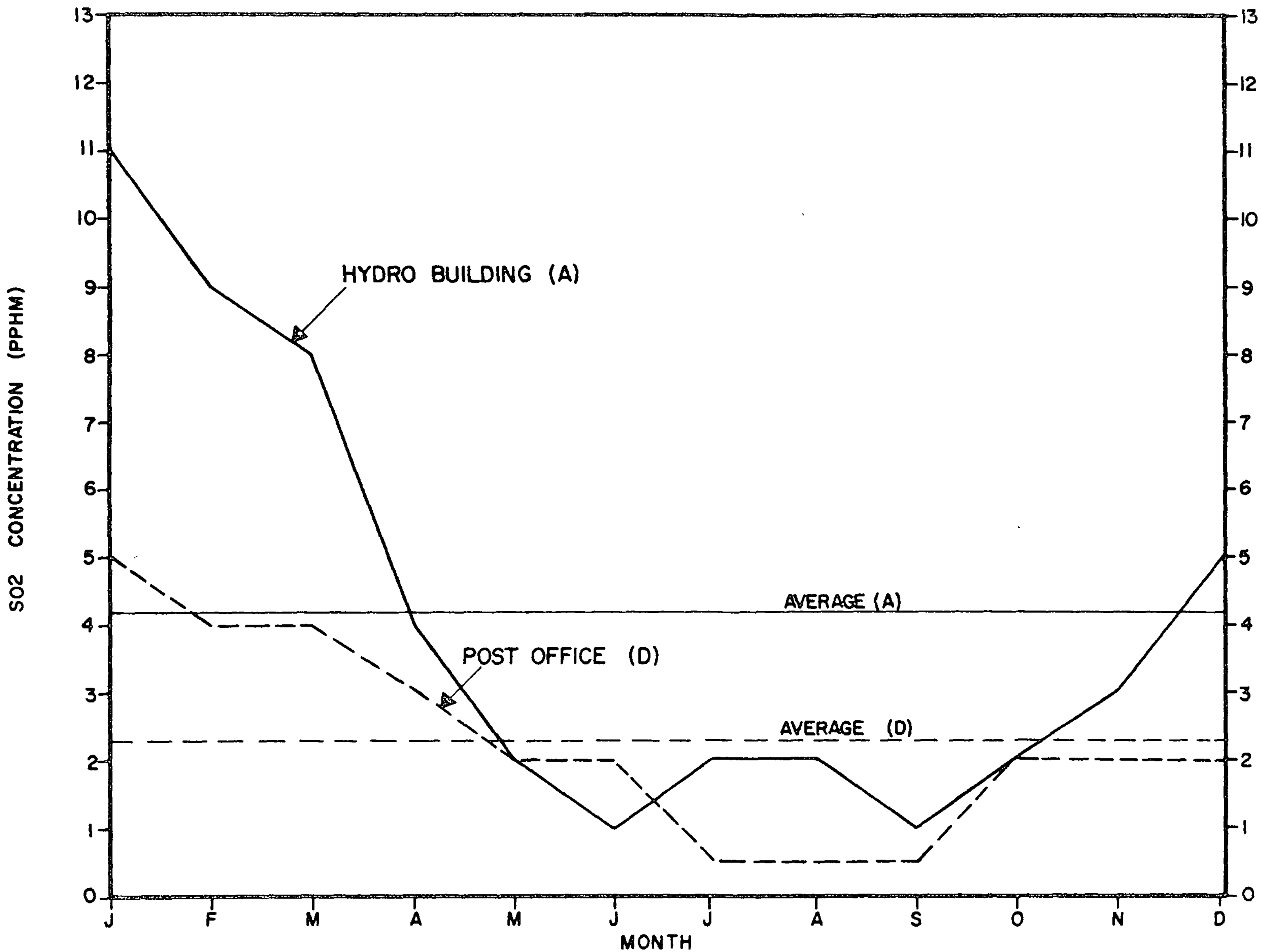


FIG. 16 AVERAGE HOURLY CONCENTRATIONS OF SO2 AT THE HYDRO BUILDING (A) DURING JANUARY AND JULY BASED ON 1968, 1969 AND 1970 AVERAGES.

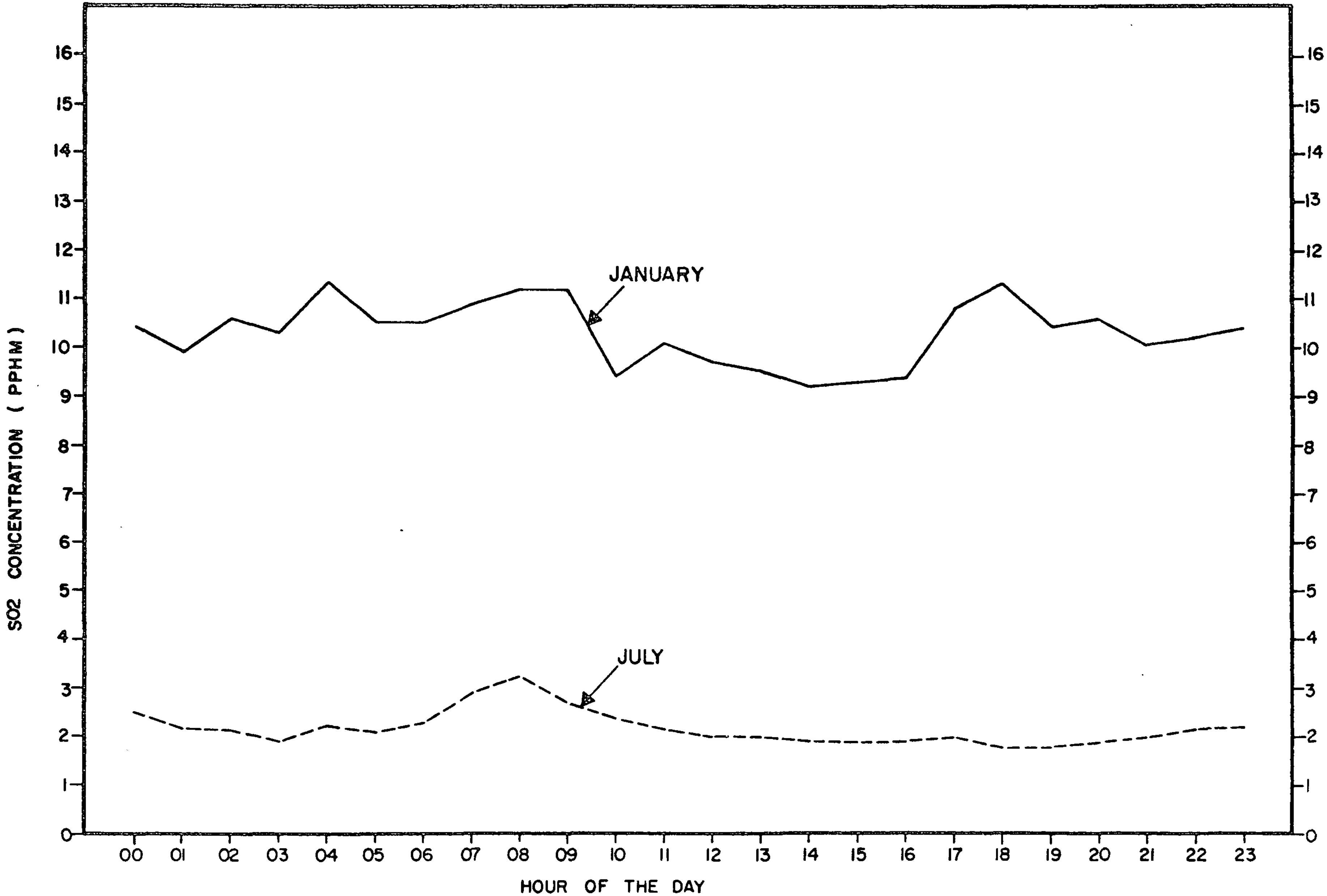


FIG. 17 AVERAGE DAILY SO2 CONCENTRATIONS DURING JANUARY AND JULY OF 1968, 1969 AND 1970 AT THE HYDRO BUILDING (A)

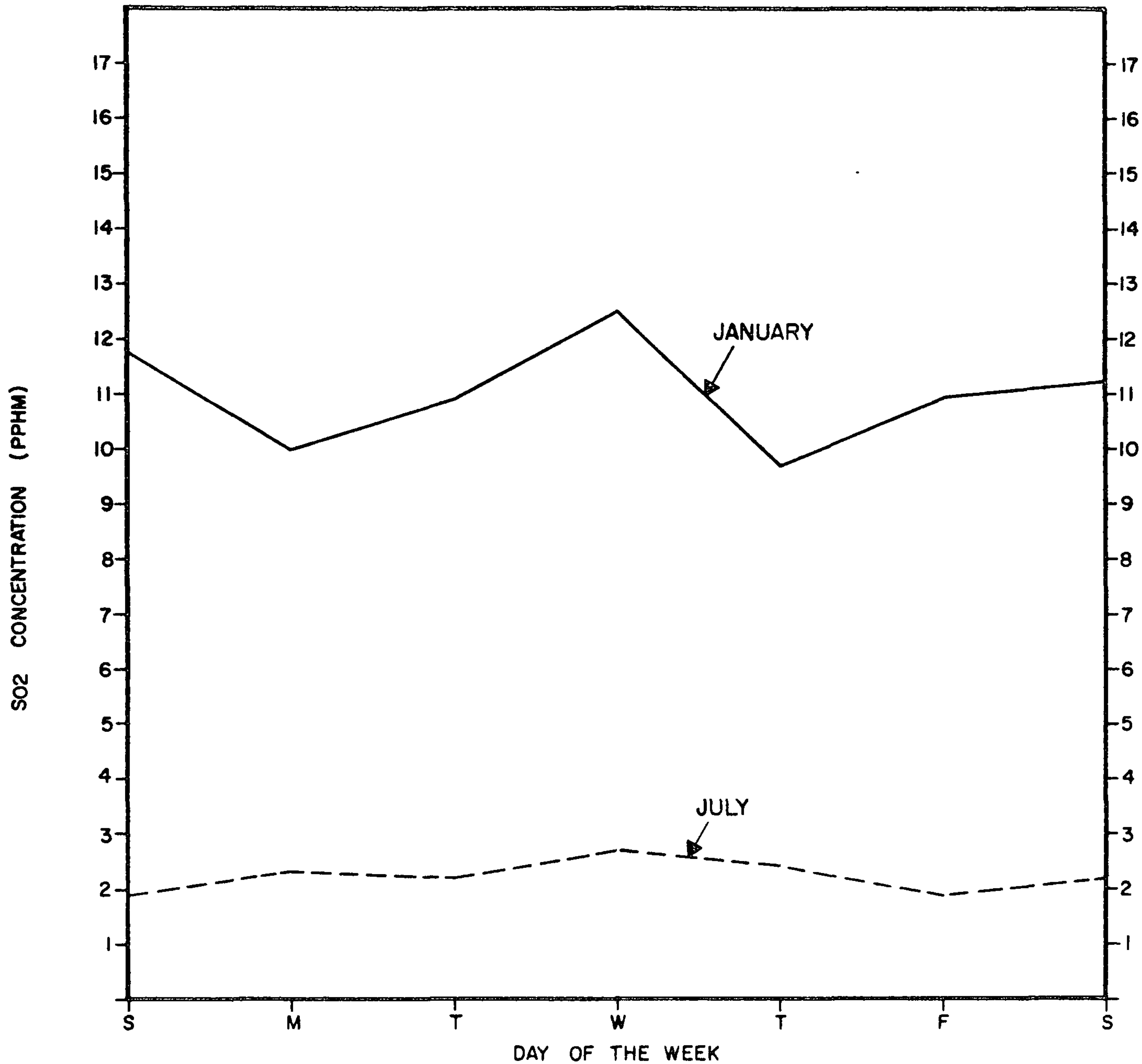


FIG. 18 SEASONAL WIND ROSES FOR OTTAWA INTERNATIONAL AIRPORT.

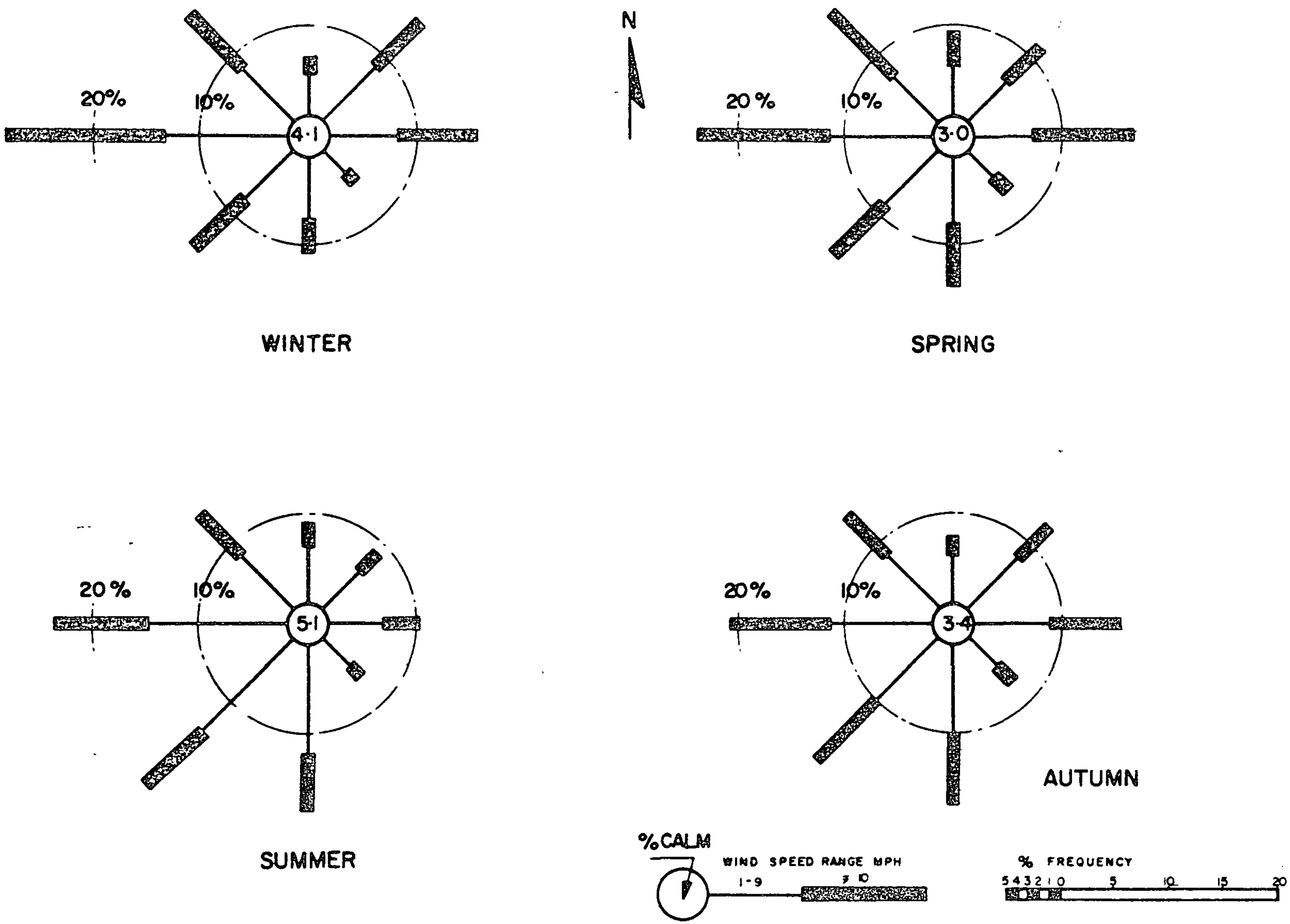


FIG. 19 WIND DIRECTION FREQUENCIES ASSOCIATED WITH DAILY MAXIMUM SO2 CONCENTRATIONS DURING 1970 AT THE HYDRO BUILDING (A).

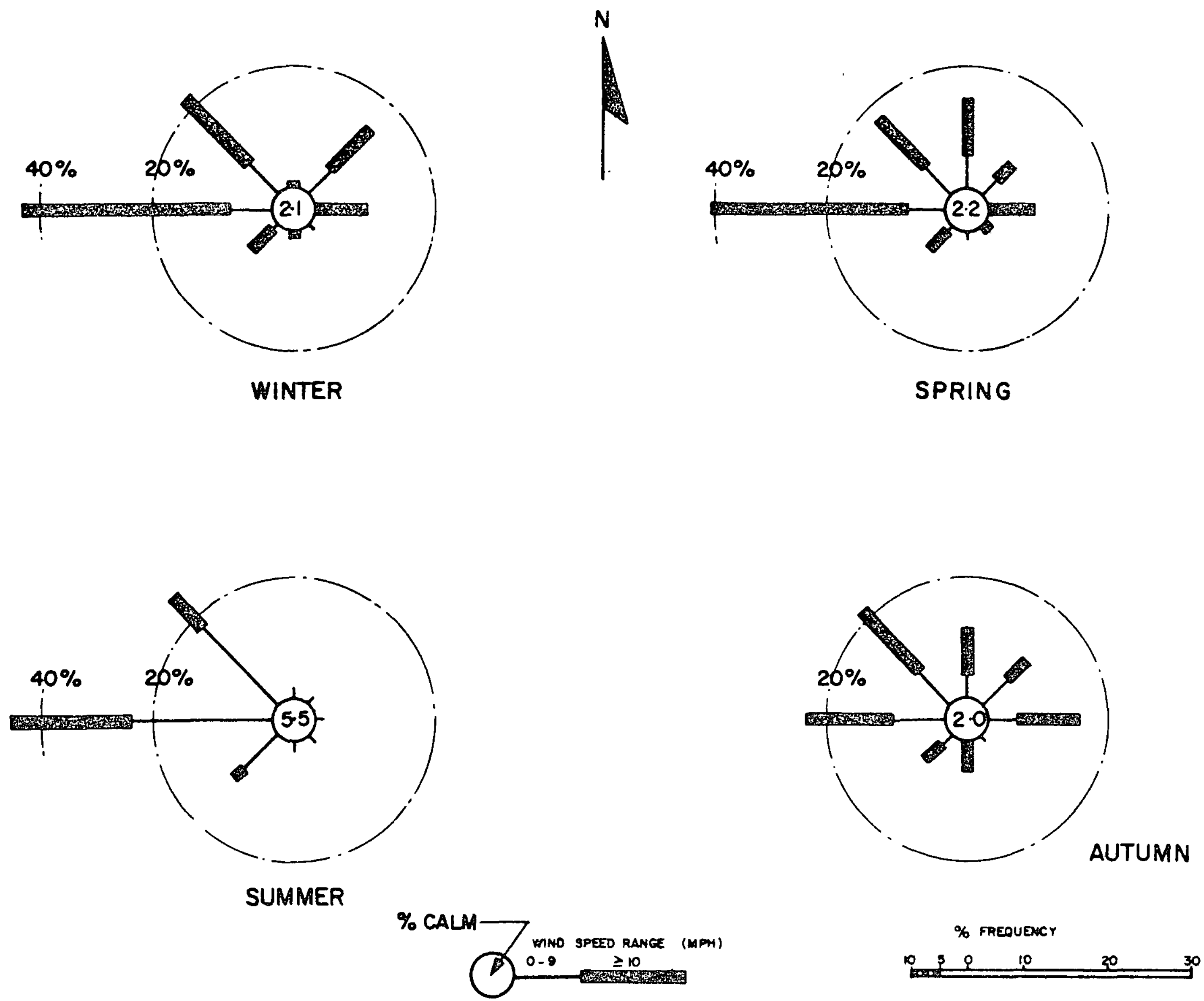


FIG. 20 WIND DIRECTION FREQUENCIES ASSOCIATED WITH DAILY MAXIMUM COH VALUES DURING 1970 AT THE HYDRO BUILDING (A)