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Technical Evaluation Report of 1984 Meteorological Data from the Donald C. Cook Nuclear Power Plant

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Table of Contents

1.0 Introduction

Meteorological data at operating reactor sites must be available for use in emergency response situations as well as to demonstrate that routine releases of radioactive material to the atmosphere result inadoses below guidelines of 10 CFR 50 Appendix I. As discussed in Information Notice No. 84-91 issued by the Office of Inspection and Enforcement, the quality of meteorological data collected at operating reactor sites is important to ensure appropriate integration into emergency response actions and to ensure appropriate assessments of the radiological impacts of routine releases.

This report describes and evaluates the quality, data reliability, and representativeness of the 1984 Donald C. Cook meteorological data for use in emergency response and assessments of the radiological impact of routine releases.

The evaluation was performed by processing the D. C. Cook 1984 data with existing NRC quality assurance computer codes (Snell 1982) and by processing concurrent meteorological data from the National Weather Service (NWS) station at South Bend, IN (approx. 40 km southwest of D. C. Cook) with computer codes specifically developed for this evaluation. A NWS station was a logical choice because, in most cases, the weather data were complete and the reliability and quality of the data were assured. Additionally, historical and concurrent annual and monthly local climatological data (NOAA 1980 through 1984) were also obtained from the South Bend NWS Station and from the climatological cooperative network stations Benton Harbor, MI (approx. 16 km northeast of D. C. Cook) and Eau Claire, MI (approx. 21 km east-northeast of D. C. Cook). Previous site data (5/75 through 4/76) and previous data (12/77 through 11/78) from the Palisades (approx. 40 km northeast of D. C. Cook) nuclear power site were provided by the NRC (NRC 1985). Much of the data are presented in graphical form to facilitate the comparisons between different sets of data for the same variable.

The 1984 South Bend meteorological data (e.g., wind speed, temperature, etc.) were compared to the long term (30 years in some cases) climatological means and extremes for South Bend to determine if 1984 was an anomalous year. The 1984 data were found to lie within the climatological extremes and did not show any anomalous tendencies.

The variables analyzed were delta-temperature, wind speed, wind direction, precipitation and temperature. Dew point was not analyzed due to its low data recovery (21.3%). Emphasis is placed on stability, wind speed and wind direction because of their integration into emergency response actions and assessment of the radiological impacts of routine releases. Analyses of precipitation and temperature provide further evaluation of the climatological representativeness.

The NRC quality assurance programs were developed to assess the quality and reliability of a licensee's meteorological data. These codes consist of the following programs: DATE, MISS, JFREQ, STABQ, and QA. DATE locates adjacent records that are not sequential in date or time, MISS tabulates the number of missing occurrences for each variable at three different levels, JFREQ creates

joint frequency distributions of wind speed, wind direction and stability, STABQ tabulates the stability classes by continuous periods of occurrence for up to three different levels using the delta-temperature method or sigma theta method, and QA flags questionable occurrences of wind speed, wind direction, temperature, dew point, delta-temperature and precipitation.

Codes specifically developed for the evaluation were TEMP_DEWPT, DELTA_T_CHK and SFC1440. The TEMP_DEWPT program tabulates the monthly averages, extreme minimum and extreme maximum temperature and dew point from the data submitted by the utility. DELTA_T_CHK compares the values of the delta-temperature sensor and the difference between the temperatures at the corresponding levels. The SFC1440 program produces a joint frequency distribution of wind speed and direction, categorizes wind speed occurrences and summarizes monthly averages and extreme minimum and extreme maximum temperatures from data at the nearby NWS station.

2.0 Data and Measuring Site Description

The consulting firm of Pickard, Lowe and Garrick (PLG) submitted a magnetic tape containing hourly meteorological data from January 1984 through December 1984 for the Donald C. Cook plant on behalf of the Indiana and Michigan Power Company. The data were recorded on a single tower located on site. Table 1 indicates what variables were recorded and the level at which they were recorded.

Table 1

Variable	Level (meters)
Wind Speed and Direction	15.2
Wind Speed and Direction	45.7
Temperature	9.1
Temperature	54.9
Dew Point	9.1
Precipitation	1.0
Delta-Temperature	54.9-9.1

The data were in the format as described in section 2.3.3 of the Standard Review Plan (NRC 1981). However, some of the precipitation values were in error. At times amounts of liquid water were allowed to accumulate in the rain gauge and remained in the gauge during nonprecipitation hours. Consequently, the accumulated amount was recorded in nonprecipitation hourly records. A program was developed to eliminate the accumulated amounts and replace them with the correct values.

The site is located in the southwestern corner of Michigan on the eastern shore of Lake Michigan. The site area consists primarily of wooded, rugged sand dunes. A sandy beach slopes gently upwards for about 60 meters from the lake before rising sharply into the dunes. The lake surface elevation is approximately 177 meters MSL while the plant elevation is about 185 meters MSL with the peaks of the highest sand dunes reaching elevations of

approximately 230 meters MSL. The site is open to the lake from south-southwest through north-northeast.

Onsite meteorological measurements are made on a 60.9 meter microwave repeater tower located approximately 107 meters east-northeast from the containment buildings (Fig.1). The tower is elevated with respect to the plant buildings. The tower base elevation is about 220 meters MSL while the top of the containment buildings are 235 meters MSL. The immediate area surrounding the tower is dominated by rugged sand dunes.

3.0 Limitations of Comparative Analysis

The 1984 Donald C. Cook meteorological data were evaluated by a comparison with previous site data and concurrent and historical meteorological data from nearby NWS stations. This kind of comparative analysis provides insight into the climatological representativeness of the Donald C. Cook data. However, it is recognized that different regional and local meteorological characteristics exist along Lake Michigan, especially among the sand dunes. In situations where a variable shows marginal discrepancies in the comparative analysis, it would be difficult to determine if the problem is the result of instrument malfunction, a response to regional or local meteorological characteristics or a local exposure concern caused by small-scale influences such as buildings and local terrain (e.g. sand dunes).

4.0 Data Evaluation

Data reliability and quality of the 1984 Donald C. Cook data set were assessed using the NRC quality assurance codes. Climatological representativeness was evaluated through comparisons with previous site data, data from NWS stations and data from the Palisades nuclear facility.

One NWS station (South Bend, IN) and two cooperative climatological stations (Eau Claire, MI and Benton Harbor, MI) were used to perform a comparative analysis. The South Bend NWS station was used for comparisons of wind speed and direction on a regional basis because it was the closest NWS station that recorded twenty-four hourly observations per day. Wind data from the Palisades nuclear site and previous D. C. Cook wind data were used for comparisons of wind data on a more local scale.

Stability data from the Palisades nuclear site and previous D. C. Cook stability data were used for a comparative analysis with the 1984 D. C. Cook stability data. Data from Benton Harbor were not used because the station only reports thirteen hourly observations per day. Twenty-hour hourly observations are needed because stability tends to be diurnal in nature. Therefore, any number of observations less than twenty-four will tend to show a bias in the overall distribution.

Precipitation and temperature data from Benton Harbor and Eau Claire were used for a comparative analysis with precipitation and temperature data from D. C. Cook. Benton Harbor and Eau Claire were chosen because they were the closest stations which have complete monthly and extreme precipitation and temperature data.

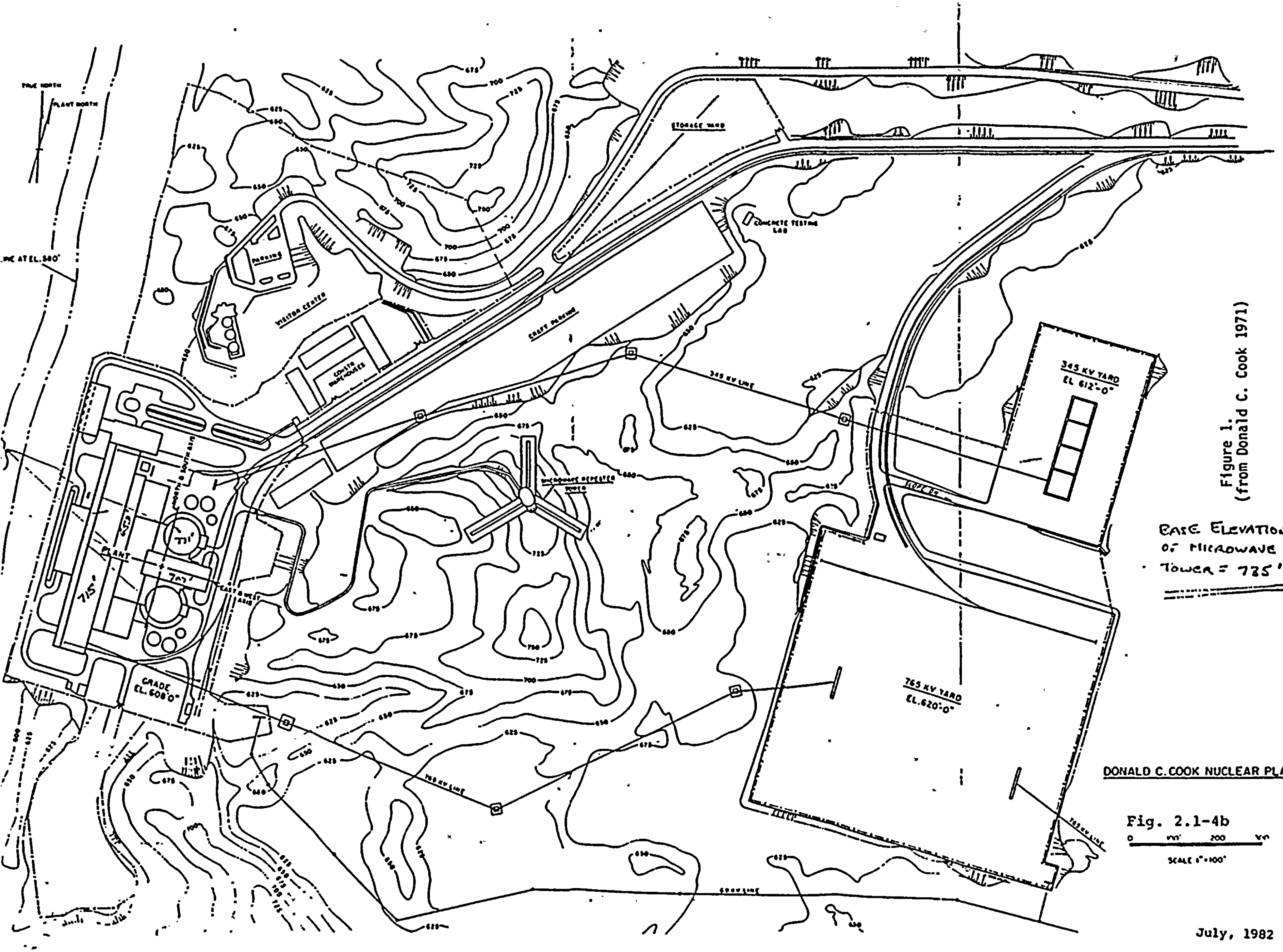


Figure 1.
(from Donald C. Cook 1971)

BASE ELEVATION OF MICROWAVE TOWER = 735'0"

DONALD C. COOK NUCLEAR PLANT

Fig. 2.1-4b

SCALE 1"=100'

July, 1982

4.1 General Discussion

The 1984 D. C. Cook meteorological data set consists of variables measured at 15.2 meters and 45.7 meters. Evaluations were performed on the data recovery, delta-temperature, 15.2 meter wind speed and direction, 45.7 meter wind speed and direction, one meter precipitation, and 9.1 meter temperature. The dew point was not analyzed because of its low data recovery (21.3%) and because was found to exceed the 15.2 meter temperature for most of the dew point occurrences.

4.2 Evaluations

The following subsections contain discussions regarding the reliability, quality, and climatological representativeness of the 1984 D. C. Cook meteorological data. Also, concerns regarding data quality and/or peculiarities which could impact the Indiana and Michigan Power Company's ability to respond to emergency situations or make routine dose calculations are discussed in this section.

4.2.1 Data Recovery

The MISS program evaluates the reliability of meteorological data by calculating the percentage of data recovery. Table 2 shows the percent of data recovery for all variables.

Table 2

Variable	Level (meters)	Data Recovery (Percent)
Wind Speed	45.7	98.9
Wind Speed	15.2	98.8
Wind Direction	45.7	98.6
Wind Direction	15.2	98.9
Temperature	54.9	57.0
Temperature	9.1	98.8
Dew Point	9.1	21.3
Precipitation	1.0	65.5
Delta-Temperature	(54.9-9.1)	98.8

Regulatory Guide 1.23 (NRC 1972) states that meteorological instruments should be inspected and serviced at a frequency which will assure at least 90% data recovery. As Table 2 shows, most of the variables have data recoveries well above 90% except for the temperature at 54.9 meters, dew point at 9.1 meters and precipitation at 1.0 meter. It appears the instruments that record those variables are poorly maintained and/or are not working properly. Although dew point is not a crucial part of the meteorology during an emergency response situation, the temperature at 54.9 meters and precipitation could provide valuable information. For example, if the delta-temperature data were not available the temperatures at 54.9 meters and 9.1 meters could be used to provide a gross indicator of atmospheric stability. Also, precipitation could be used to qualitatively assess the effect of "washout" within the plume for emergency response situations or routine dose assessments.

The DATE program indicated all possible hours (8724 hours) of all data were on tape.

4.2.2 Delta-Temperature

The 1984 D. C. Cook delta-temperature values were compared with previous (5/75 through 4/76) site data and previous (12/77 through 11/78) delta-temperature data from the Palisades nuclear site (Fig. 2). All data sets calculated the stability class using the delta-temperature method. The D. C. Cook delta-temperature is measured between the 54.9 meters and 9.1 meters and the Palisades is measured between 60.0 meters and 10.0 meters.

The 1984 D. C. Cook delta-temperature compares well with the other data sets except in the A and E stability class category. The QA program provides some insight into this peculiarity. There were a large number of A stability class occurrences during the months of May, June, July, August, and September when the local lapse rate (i.e. delta-temperature) exceeded the autoconvective lapse rate. The autoconvective lapse rate is defined as -3.4 ^{o}C/100m in the QA program. A closer inspection of these occurrences show that they occur under onshore flow situations during daylight hours. Meteorological considerations suggest that this situation could produce very unstable (e.g. delta-temperature less than -3.4 ^{o}C/100m) conditions because the lower layers of the atmosphere would tend to heat rather quickly due to the surrounding sand dunes and vegetation while the upper layers of the atmosphere would remain cool due to the onshore flow. These conditions would yield a large vertical temperature gradient. The reason for the relatively low number of E stability class occurrences is not completely obvious. Further analyses (not within the scope of this report) are needed to determine if the low occurrences are related to local meteorology or instrument malfunction.

The 1984 D. C. Cook delta-temperature values and the 1976 D. C. Cook delta-temperature values appear to differ because of meteorological variations. Therefore, it appears the 1984 D. C. Cook delta-temperature values are probably climatologically representative for the shoreline environment. In addition, the data shows high reliability (98.8%). Although the delta-temperature values are probably reliable and representative of the local shoreline environment, the overall concern is whether the delta-temperature values represent atmospheric stability at the site boundary and locations further inland where populous areas may be affected by accidental or routine releases of radioactive material. Subsection 4.2.5 discusses this concern more thoroughly.

4.2.3 15.2 Meter Wind Direction and Speed

A comparison between wind directions from the 1984 D. C. Cook data set at 10 meters, previous (5/75 through 4/76) D. C. Cook data at 15.2 meters, previous (12/77 through 11/78) Palisades data at 10 meters, and 1984 South Bend data at 6.4 meters are shown in Figure 3. The comparison shows a reasonably close relationship among the different data sets, except in the north, east-southeast, and southeast sectors. These discrepancies are probably caused by the 15.2 meter wind direction responding to small-scale influences such as building wakes and local terrain (e.g., sand dunes). Consequently, the data are likely representative of the wind direction in the immediate vicinity of the sand

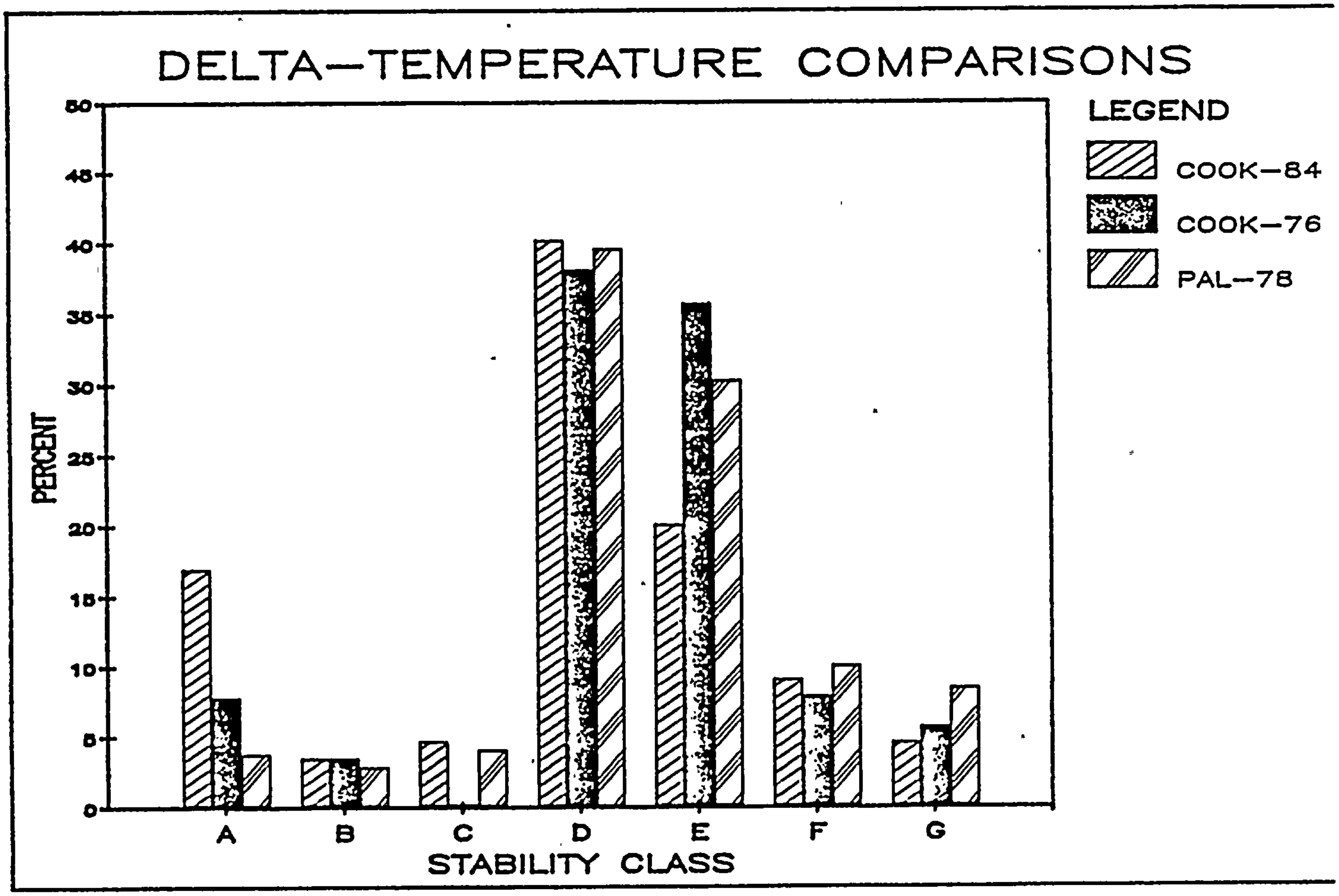

DELTA–TEMPERATURE COMPARISONS
LEGEND
COOK–84
COOK–76
PAL–78
PERCENT
50
45
40
35
30
25
20
15
10
5
0
A
B
C
D
E
F
G
STABILITY CLASS

Figure 2

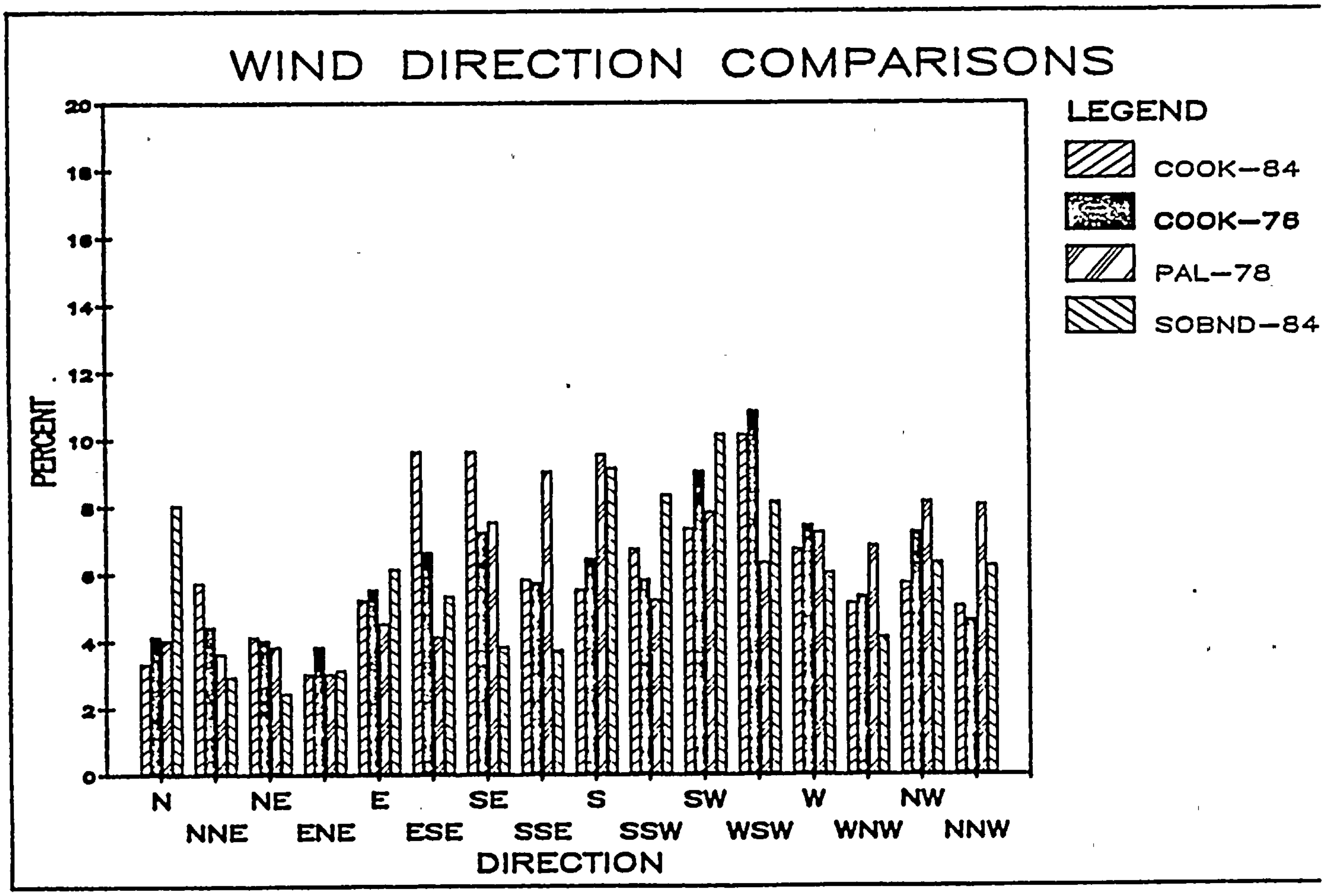

WIND DIRECTION COMPARISONS
LEGEND
COOK-84
COOK-78
PAL-78
SOBND-84
PERCENT
0
2
4
6
8
10
12
14
16
18
20
N
NNE
NE
ENE
E
ESE
SE
SSE
S
SSW
SW
WSW
W
WNW
NW
NNW
DIRECTION

Figure 3

dunes and plant buildings, but are probably not indicative of wind directions at site boundary and locations further inland.

The quality and data reliability of the 15.2 meter wind direction data were good as reflected by the absence of spurious values and high data recovery (98.9%).

A comparison between wind speeds from 1984 D. C. Cook data set at 10 meters, previous (12/77 through 11/78) Palisades data at 10 meters, and 1984 South Bend data at 6.4 meters are shown in Figure 4. The previous D. C. Cook data (5/75 through 4/76) was not included because the wind speed categories did not coincide with the other data sets. There appears to be some variability within the data especially in the 1.5 - 3.0 m/s and 3.0 - 5.0 m/s speed ranges. A likely explanation for the variability would be local exposure problems because of small-scale influences such as building wakes and local terrain (e.g., sand dunes). It appears the 15.2 wind speed data at D. C. Cook is representative of the immediate environment, but probably not representative of conditions at the site boundary or locations further inland.

The quality and data reliability of the 15.2 meter wind speed were good as reflected by the absence of spurious values and high data recovery (98.8%).

The analysis shows that the 15.2 meter wind data has a high degree of quality and would probably be reliable during emergency response situations or routine dose assessments. However, the representativeness of the data remains questionable. It appears the wind data is affected by the small-scale influences produced from building wakes and local terrain, and is probably not representative of site boundary or inland conditions where sand dunes do not exist. Subsection 4.2.5 discusses this situation more thoroughly.

4.2.4 <u>45.7 Meter Wind Direction and Speed</u>

The 1984 D. C. Cook 45.7 meter wind speed data showed a high degree of quality and data reliability because of high data recovery (98.6%) and absence of spurious values. However, a comparison between the 45.7 meter wind direction and the corresponding wind direction data at 15.2 meters (Fig. 5) showed some differences in the north, east-southeast, south, and west-southwest sectors. A likely explanation for the discrepancies in those sectors is the effect from small-scale influences such as building wakes and local terrain rather than instrument malfunction. As with the 15.2 wind data, the 45.7 meter wind direction appear representative of the immediate area, but are probably not representative of site boundary or inland conditions.

The 1984 D. C. Cook 45.7 meter wind speed was compared with the corresponding 15.2 meter wind speed (Fig. 6). The comparison shows the expected distribution between lower and upper level wind speeds; the lower level is skewed more toward lower wind speeds while the upper level is skewed more toward higher wind speeds. However, there appears to be a rather large increase between the two levels in the 5.0-10.0 m/s speed range. This phenomenon is most likely due to increased frictional affects at lower levels which are probably caused by the sand dune environment and building wakes. The 45.7 meter wind speed

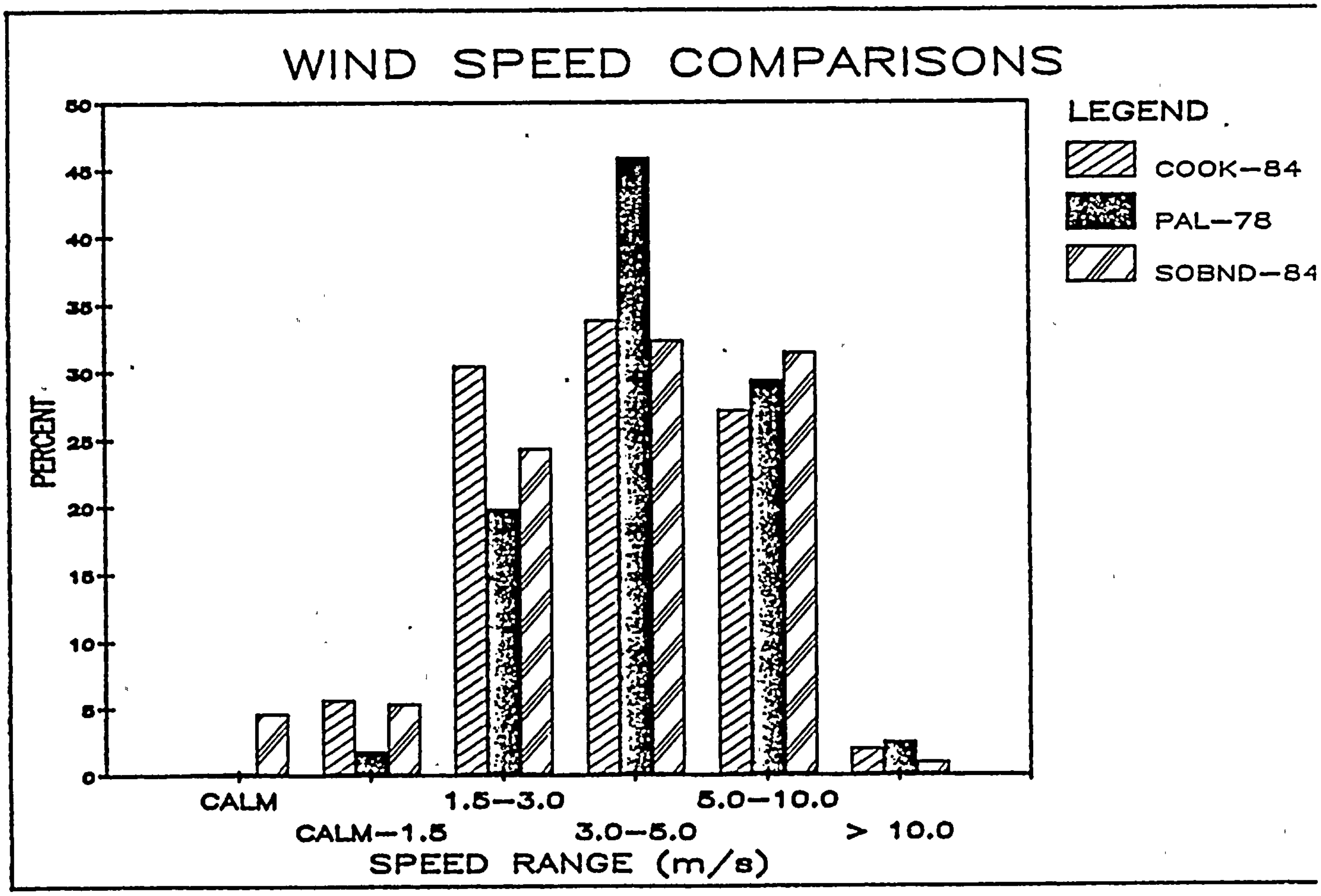

WIND SPEED COMPARISONS
LEGEND
COOK-84
PAL-78
SOBND-84
PERCENT
0
5
10
15
20
25
30
35
40
45
50
CALM
CALM-1.5
1.5-3.0
3.0-5.0
5.0-10.0
> 10.0
SPEED RANGE (m/s)

Figure 4

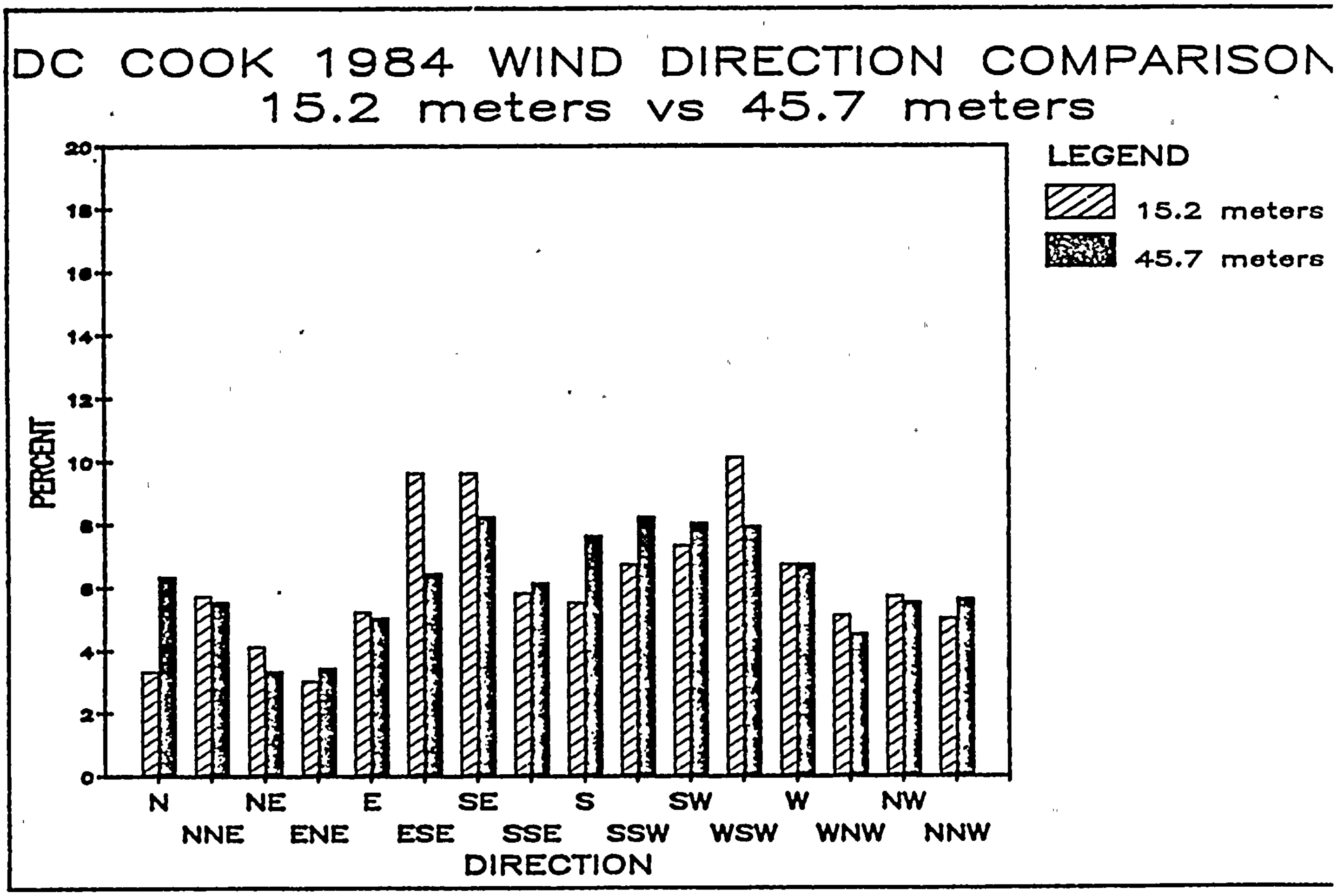

DC COOK 1984 WIND DIRECTION COMPARISON
15.2 meters vs 45.7 meters
LEGEND
15.2 meters
45.7 meters
PERCENT
0
2
4
6
8
10
12
14
16
18
20
N
NNE
NE
ENE
E
ESE
SE
SSE
S
SSW
SW
WSW
W
WNW
NW
NNW
DIRECTION

Figure 5

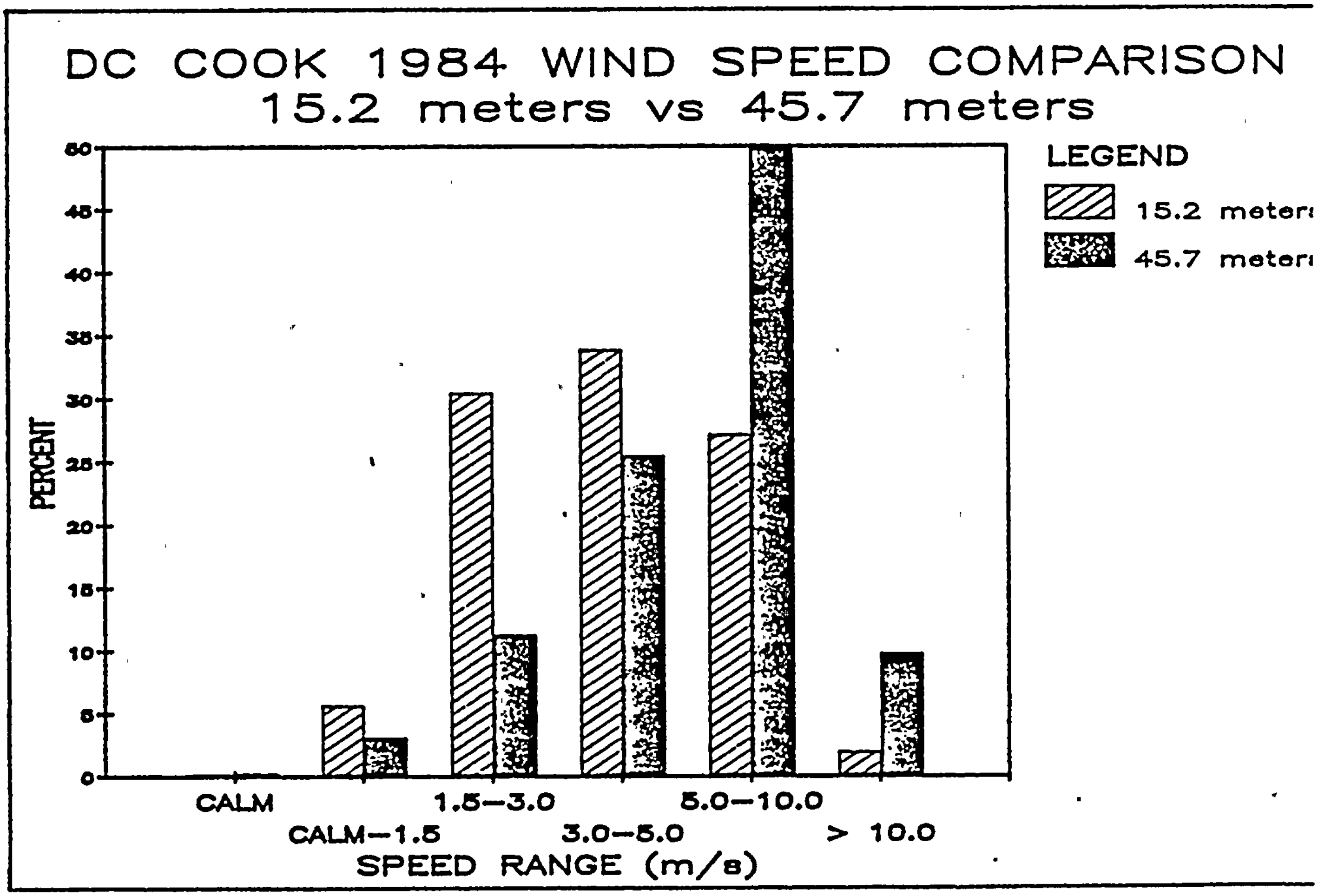

DC COOK 1984 WIND SPEED COMPARISON
15.2 meters vs 45.7 meters
LEGEND
15.2 meter
45.7 meter
PERCENT
0
5
10
15
20
25
30
35
40
45
50
CALM
CALM—1.5
1.5—3.0
3.0—5.0
5.0—10.0
> 10.0
SPEED RANGE (m/s)

Figure 6

appears to be climatologically representative of the sand dune environment, but probably does not reflect conditions at site boundaries or inland locations.

The quality and data reliability of the 45.7 meter wind speed data were good as reflected by the absence of spurious values and high data recovery (98.9%).

The analysis shows that the 45.7 meter wind data would probably be reliable during emergency response situations and routine dose calculations, but, as with the 15.2 wind data, the representativeness of the data remains suspect due to the location of the tower within the sand dune environment. The following subsection discusses this concern more thoroughly.

4.2.5 Local Exposure Concerns

The meteorological tower at D. C. Cook is located in a unique setting. Rugged sand dunes covered with vegetation surround the immediate area of the tower while the terrain slopes toward Lake Michigan just west of the tower. However, the sand dunes do not extend to the site boundary in most directions or to locations further inland. The tower is located approximately 107 meters west of the containment buildings. The elevation of the top of the buildings are approximately 15 meters above the base elevation of the tower. Considering these factors and some basic meteorological principles suggests that the wind data are probably affected by building wakes and surface friction as discussed in subsections 4.2.3 and 4.2.4. For example, this influence is seen in the comparison between the 15.2 meter and 45.7 meter wind speed in Figure 6. A large difference is evident in the 5.0-10.0 m/s speed range, which suggests that there is an abnormally large increase in wind speed between the 15.2 meter and 45.7 meter level. Additionally, the Final Safety Analysis Report (Donald C. Cook 1971) from the D. C. Cook plant discussed the unrepresentativeness of the 15.2 meter level wind speed on the main tower. This conclusion was based on a study which compared the 15.2 meter level wind speeds on the main meteorological tower to 15.2 meter level wind speeds from a satellite tower location two miles east of the main tower where terrain is flat. Table 3 shows the comparison between wind speeds from the 15.2 meter level and 61.0 meter level on the main tower and the 15.2 meter level on the satellite tower. Wind data from the 45.7 meter level on the main tower was not included in the comparison. The wind speed is shown as a function of turbulence class where turbulence classification I indicates very unstable conditions and turbulence classification IV indicates very stable conditions. The period of data is not specifically stated in the FSAR, but the report does mention that the data presented were taken over a three year period sometime between 1966 and 1968.

The table clearly indicates a lower wind speed at 15.2 meters on the main tower except in the turbulence class IV. Based on this information, it appears the wind data on the main tower is affected by the presence of the sand dunes and building wakes. Undoubtedly, this influence would have detrimental impacts on emergency response and routine dose dispersion models. For example, the lower wind speeds would yield higher concentration levels and slower plume movement while unrepresentative wind directions would give misleading transport directions.

Table 3

Mean Wind Speed
(m/s)

Turbulence Class	Main Tower (61 meters)	Main Tower (15.2 meters)	Satellite Tower (15.2 meters)
I	3.6	2.2	3.6
II	6.3	2.7	4.0
III	8.0	3.6	4.9
IV	3.6	1.8	1.3

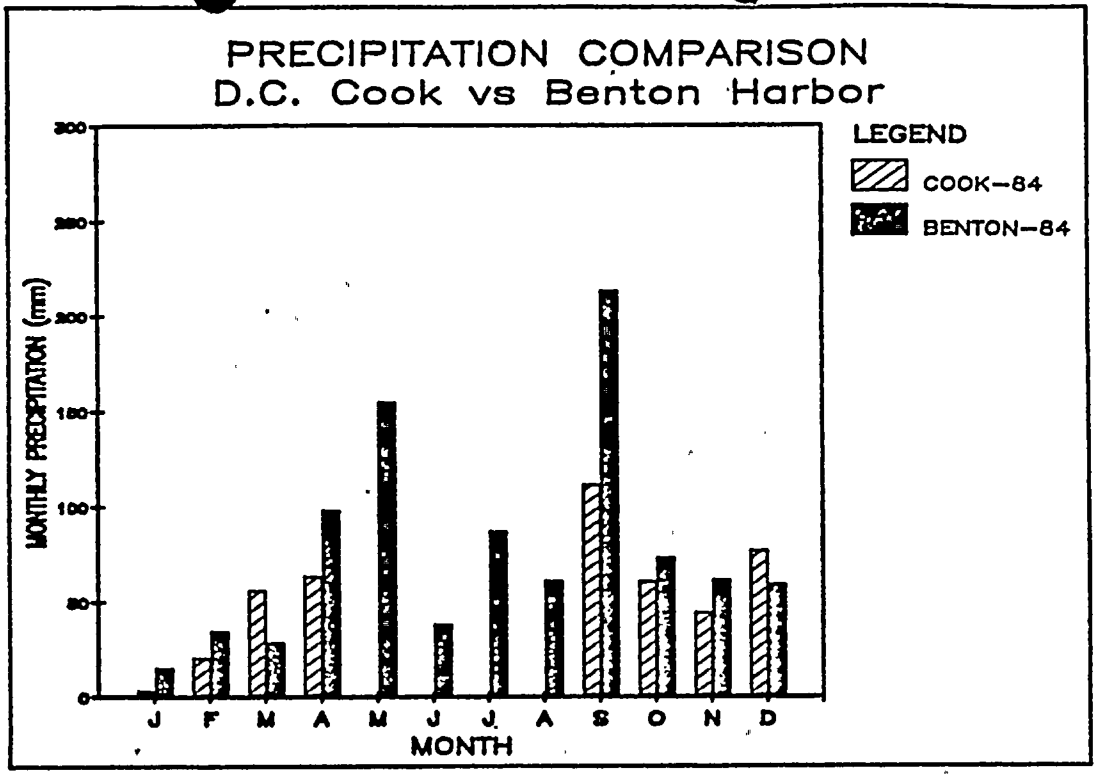
The delta-temperature values seem to be representative of the immediate shoreline environment. However, the question is whether they are representative of conditions at the site boundary and locations further inland, especially during onshore flow situations which occur approximately fifty percent of the time (based on the 1984 and 5/75 through 4/76 D. C. Cook data). During these situations very unstable conditions are experienced along the immediate shoreline while inland locations remain relatively stable. Using an unstable stability classification during this kind of meteorological event would have detrimental effects on emergency response actions and routine dose calculations by overestimating dispersion thereby underestimating dose. Specifically, the sigma-y and sigma-z dispersion coefficients would be overestimated thus overestimating the vertical and horizontal extent of the plume.

4.2.6 <u>One Meter Precipitation</u>

The 1984 D. C. Cook one meter monthly average precipitation data were compared with corresponding precipitation data from Benton Harbor and Eau Claire (Fig. 7). The months of May, June, July, and August do not show monthly averages for D. C. Cook because of missing data. Both comparisons show the D. C. Cook monthly averages are generally lower than the other monthly averages. It can not be determined if the 1984 D. C. Cook precipitation data is representative because a third (four months) of the data are missing and precipitation can vary widely on a local scale. Even if the data were representative it would not be reliable due to its low data recovery (65.5%). It appears the precipitation system is poorly maintained and probably would not be reliable during emergency response situations or routine dose calculations.

4.2.7 <u>15.2 Meter Temperature</u>

The 1984 D. C. Cook 15.2 meter monthly average and extreme temperature data were compared with corresponding temperature data from Benton Harbor and Eau Claire (Fig. 8). Both comparisons show a close relationship between the monthly average and extreme temperature data. It appears the 15.2 meter temperature data is climatologically representative and are reliable as reflected in its


PRECIPITATION COMPARISON
D.C. Cook vs Benton Harbor
LEGEND
COOK-84
BENTON-84
MONTHLY PRECIPITATION (mm)
J F M A M J J A S O N D
MONTH

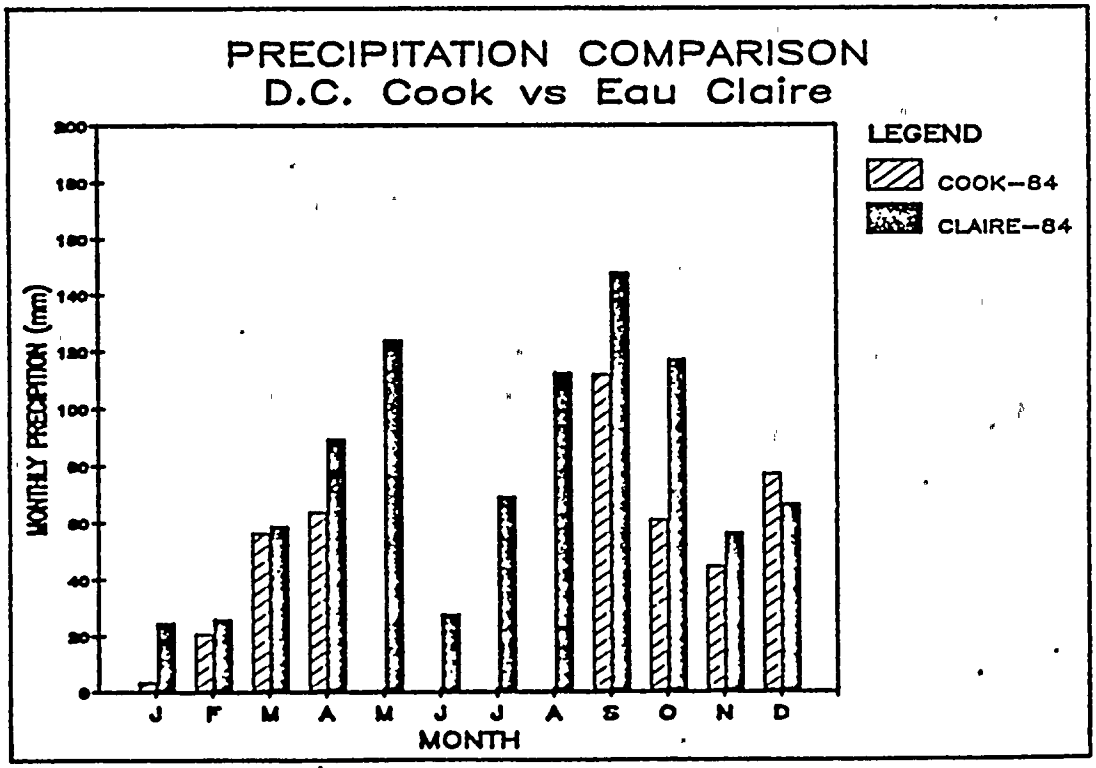
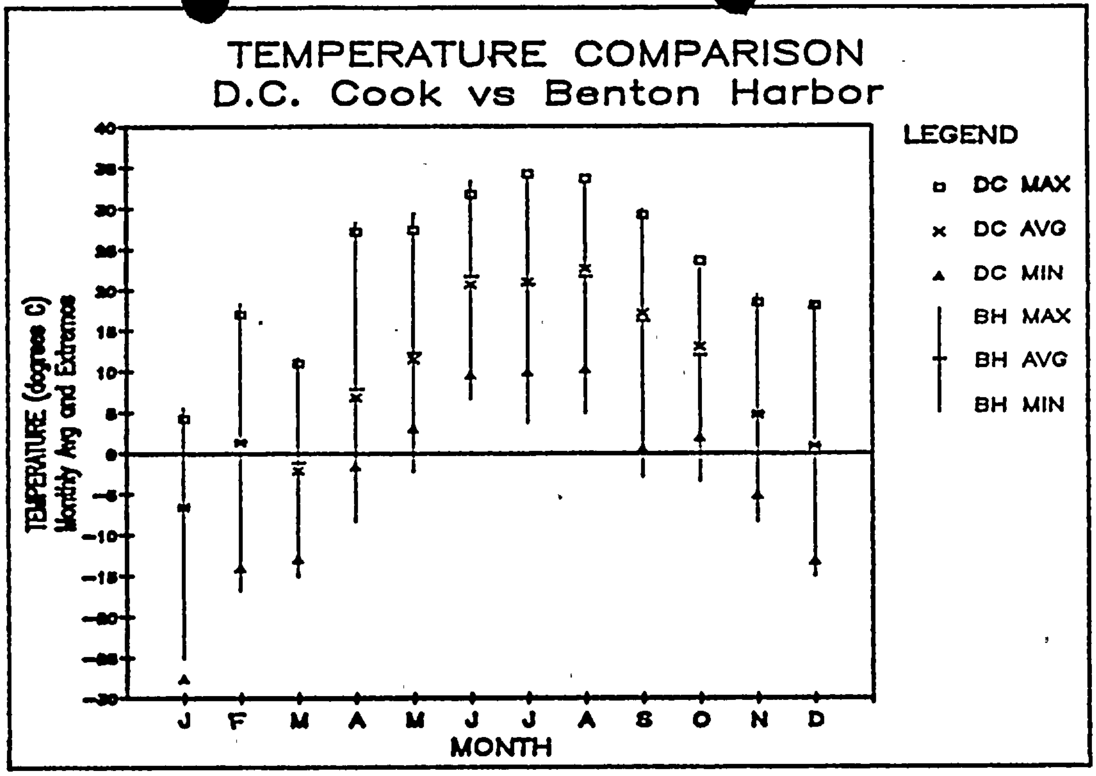

PRECIPITATION COMPARISON
D.C. Cook vs Eau Claire
LEGEND
COOK-84
CLAIRE-84
MONTHLY PRECIPITATION (mm)
J F M A M J J A S O N D
MONTH

Figure 7


TEMPERATURE COMPARISON
D.C. Cook vs Benton Harbor
LEGEND
DC MAX
DC AVG
DC MIN
BH MAX
BH AVG
BH MIN
TEMPERATURE (degrees C)
Monthly Avg and Extremes
J F M A M J J A S O N D
MONTH

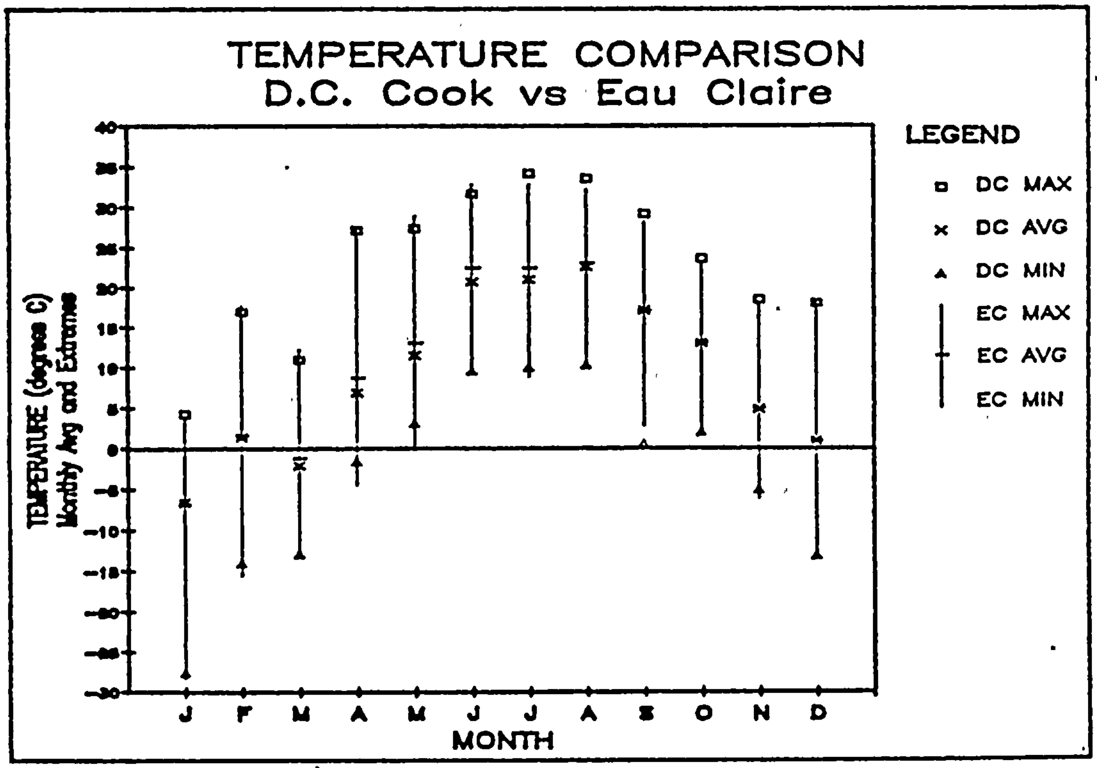

TEMPERATURE COMPARISON
D.C. Cook vs Eau Claire
LEGEND
DC MAX
DC AVG
DC MIN
EC MAX
EC AVG
EC MIN
TEMPERATURE (degrees C)
Monthly Avg and Extremes
J F M A M J J A S O N D
MONTH

Figure 8

data recovery (98.8%). The data would be representative and reliable during emergency response or routine dose calculations.

5.0 Conclusion

In general the 1984 D. C. Cook meteorological data showed a high degree of quality and reliability because of high data recoveries and the absence of spurious values within the data. Variables that indicated low reliability were the one meter precipitation, 45.7 meter temperature and the 9.1 meter dew point. The systems associated with those variables appear to be poorly maintained.

The representativeness of meteorological data is important to ensure appropriate integration into emergency response actions and to ensure appropriate assessments of the radiological impacts of routine releases. In addition, the meteorological data should be representative of areas away from the plant site to which a radioactive plume may travel (e.g., plume exposure EPZ) which for D. C. Cook is any transport direction east of north and east of south. Examinations of the 1984 meteorological data from D. C. Cook indicated the data was representative of the shoreline and sand dune environment, but may not reflect meteorological conditions at the site boundary and locations further inland (discussed in subsection 4.2.5). Thus, it appears the tower location is not appropriate. Consequently, using current on-site data (wind data and delta-temperature) for emergency response situations or routine dose calculations may result in erroneous dose values and could affect recommendations for protective action.

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