Final Report

Technical Evaluation Report
of 1984 Meteorological Data
from the Diablo Canyon Nuclear Power Plant

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3/87

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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 in doses below the 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 Diablo Canyon meteorological data for use in emergency response and assessments of the radiological impact of routine releases.

The evaluation was performed by processing the 1984 Diablo Canyon data with existing NRC quality assurance computer codes (Snell 1984) and comparing the 1984 Diablo Canyon data to historical and concurrent meteorological data from the National Weather Service (NWS) station at Santa Maria, California (approximately 48 km southeast of Diablo Canyon) and from the Climatological Cooperative Network (CCN) stations at Pismo Beach, California (approximately 22 km southeast of Diablo Canyon) and Morro Bay, California (approximately 16 km north of Diablo Canyon). A NWS station and CCN stations were logical choices because, in most cases, the weather data were complete and the reliability and quality of the data were assured. Previous site data (6/67 through 10/69, 5/73 through 4/74, and 5/73 through 4/75) were also used in the comparative analysis. Much of the data are presented in graphical form to facilitate the comparisons between different sets of data for the same variable.

The 1984 Santa Maria yearly and monthly averaged meteorological data (e.g., temperature, precipitation, wind speed, etc.) were compared to the long-term (30 years in most cases) climatological means and extremes (NOAA 1980 through 1984) from Santa Maria to determine if 1984 was an anomalous year for the region including the Diablo Canyon site. In general, 1984 data were found to lie within the climatological extremes and did not show any anomalous tendencies, except in the month of April when a record low minimum temperature was set (-0.5°C).

The NRC quality assurance computer programs were developed to assess the quality and reliability of a utility'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 parameter at three different levels, JFREQ creates joint frequency distribution 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 by PNL for the evaluation were TEMP_DEWPT 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. 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 maximum temperatures from data at the nearby NWS station (e.g., Santa Maria, California).

2.0 Data and Measurement Site Description

The Pacific Gas and Electric Company (PG&E) submitted a magnetic tape containing hourly meteorological data from January 1, 1984 through December 31, 1984 for the Diablo Canyon nuclear power plant. The data were recorded at 10.0 meters and 76.0 meters on a single tower located onsite. Table 1 indicates which variables were recorded at each level.

Table 1

Variable	Level (meters)
Wind Speed and Direction	10.0
Wind Speed and Direction	76.0
Delta-Temperature	46.0-10.0
Delta-Temperature	76.0-10.0
Dry Bulb Temperature	10.0
Dry Bulb Temperature	76.0
Precipitation	N/A
Dew Point Temperature	10.0

The data were in the format as described in Section 2.3.3 of the Standard Review Plan (NRC 1981) and did not require special processing.

The variables analyzed in this report were the 10.0 meter and 76.0 meter wind speed and direction, 76.0-10.0 meter delta-temperature, 10.0 meter temperature, precipitation, and 10.0 meter dew point temperature. The 46.0-10.0 meter delta-temperature data were not specifically analyzed for this report, however, they were checked for internal consistency. The inspection revealed consistency among the 76.0-10.0 meter delta-temperature and 46.0-10.0 meter delta-temperature.

The site is located in the rugged coastal region of southwest California which is near the mouth of Diablo Creek and occupies a coastal terrace that ranges in elevation from 15 to 50 meters (MSL) and is approximately 300 meters wide. Plant grade is approximately 26 meters. The seaward edge of the terrace is a essentially a vertical cliff. East of the terrace and extending several kilometers inland are the Irish Hills, an area of steep brush-covered hillsides and deep canyons, which are part of the San Luis Mountains. Higher elevations range from 430 meters to 490 meters within 5-10 kilometers of the site.

Onsite meteorological measurements are made from an 80 meter tower located approximately 370 meters south of the containment and support buildings (Fig. 1,

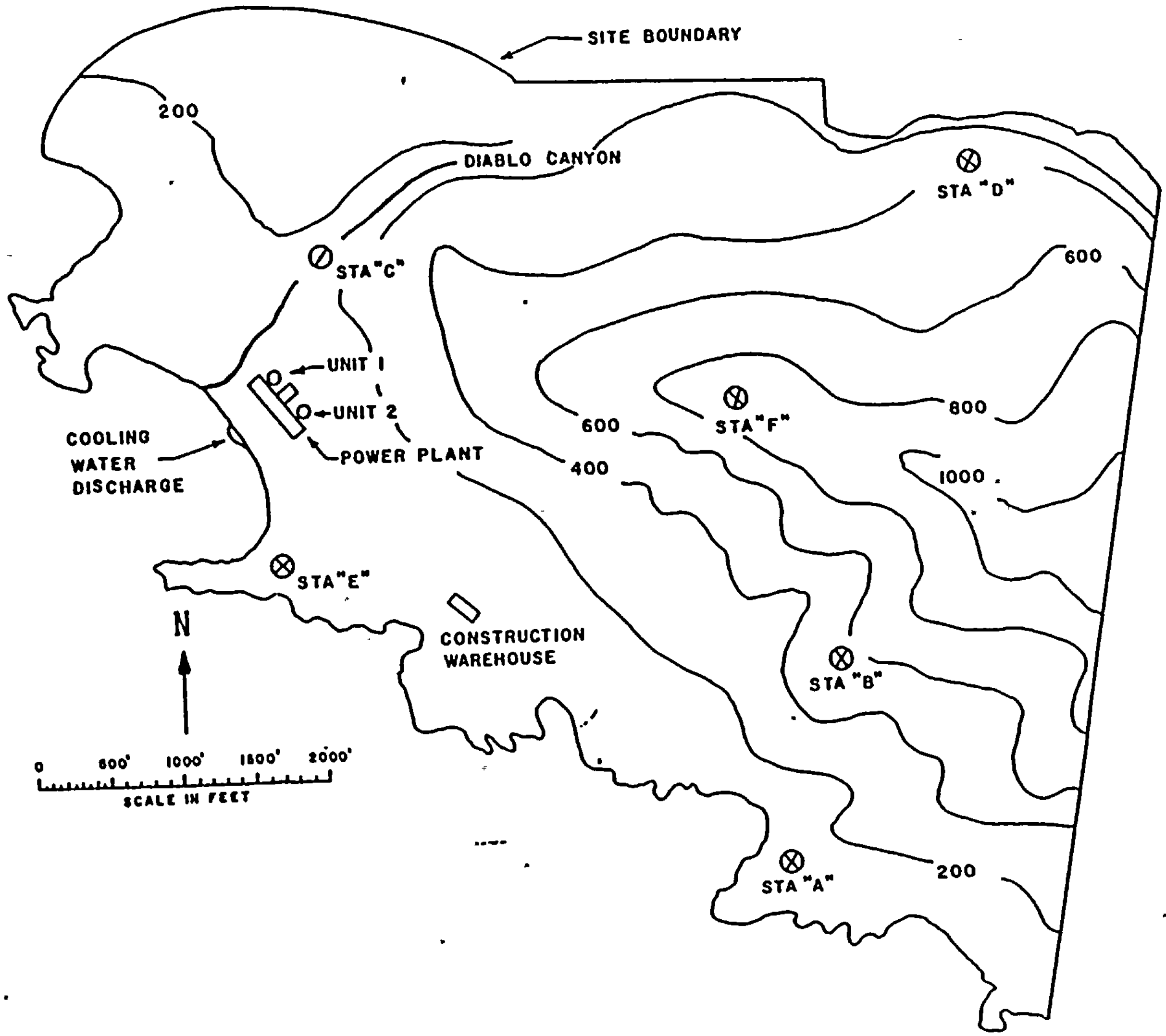


Figure 1
(From Pacific Gas & Electric 1972)

designated STA "E"). The immediate area surrounding the tower is essentially free of obstructions (e.g., trees, buildings, etc.) (Verholek 1977).

3.0 Limitations of Comparative Analysis

The 1984 Diablo Canyon meteorological data were evaluated by comparisons with previous site data and concurrent and historical meteorological data from a nearby NWS station and nearby CCN stations. This kind of comparative analysis provides insight into the climatological representativeness of the Diablo Canyon meteorological data. However, it is recognized that different regional and local meteorological characteristics exist within the southwest California coastal area. 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 concerns caused by small-scale influences such as buildings and local terrain.

4.0 Data Evaluation

Data reliability and quality of the 1984 Diablo Canyon meteorological data set were assessed using the NRC quality assurance codes. Climatological representativeness was evaluated through comparisons with previous site data, data from the Santa Maria NWS station, and data from the Pismo Beach and Morro Bay CCN stations.

Meteorological data from Santa Maria NWS station were used to perform a comparative analysis with the 1984 Diablo Canyon wind speed, wind direction, dry bulb temperature, and dew point temperature because it was the closest NWS station that recorded twenty-four hourly observations per day. In addition, the dry bulb temperature and precipitation data from Pismo Beach and Morro Bay were also used in the comparative analysis because of their close proximity to the Diablo Canyon plant. Previous site data were used to evaluate the delta-temperature, wind speed, and wind direction data.

4.1 General Discussion

The 1984 Diablo Canyon meteorological data set consists of variables measured at 76.0 and 10.0 meters. Evaluations were performed on data recovery, 10.0 meter wind speed and direction, 76.0 meter wind speed and direction, 10.0 meter dry bulb temperature, precipitation, and 10.0 meter dew point temperature.

4.2 Evaluations

The following subsections discuss the reliability, quality and climatological representativeness of the 1984 Diablo Canyon meteorological data.

4.2.1 Data Recovery

The MISS program evaluates the reliability of meteorological data by calculating the percentage of data recovery for several variables. Table 2 shows the percent of data recovery for all variables analyzed and for variables used in internal comparisons in this report.

Table 2

Variables	Level (meters)	Data Recovery (Percent)
Delta-Temperature	46.0-10.0	92.9
Delta-Temperature	76.0-10.0	98.9
Wind Speed	10.0	98.9
Wind Direction	10.0	98.9
Wind Speed	76.0	99.0
Wind Direction	76.0	99.0
Dry Bulb Temperature	10.0	99.0
Precipitation	Not Available	93.5
Dew Point Temperature	10.0	71.6

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. Also, joint frequency distribution of wind speed, wind direction, and delta-temperature should have a recovery rate of at least 90%. As Table 2 shows, all of the variables have data recoveries (i.e., reliability) well above 90%, except for the dew point temperature. Although the other variables appear to be properly maintained, it appears the 10.0 meter dew point temperature instrumentation and/or recording system were not properly maintained throughout the 1984 data set.

The DATE program indicated all possible hours (8784) of all variables were present in the data set.

4.2.2 Delta-Temperature

The 1984 Diablo Canyon 76.0-10.0 meter stability classes were compared with previous 76.0-8.0 meter stability classes (Pacific Gas and Electric Co. 1972) from May 1973 through April 1974 and from July 1967 through October 1969 (Fig. 2). The stability classes were determined using the NRC delta-temperature method (Appendix A). The comparison indicates a close relationship between the two data sets except in the D and E stability classes. The discrepancy is most likely due to the difference in depth (i.e., 76.0 - 10.0 meters vs. 76.0 - 8.0 meters) for which the delta-temperature was calculated because the 1974 and 1969 data sets (delta-temperature 76.0 - 10.0 meters) are more closely related to each other than to the 1984 data set. However, the difference could be caused by other factors such as the year-to-year variability of weather patterns and/or a difference in the type and manufacturer of the delta-temperature sensor. In any event, differences between adjacent stability classes are expected on a year-by-year basis.

From examinations of onsite delta-temperature distributions it appears the 1984 76.0-10.0 meter delta-temperature data were climatologically representative of the shoreline environment, of high quality, and, also, reliable due to its high data recovery (99.0%).

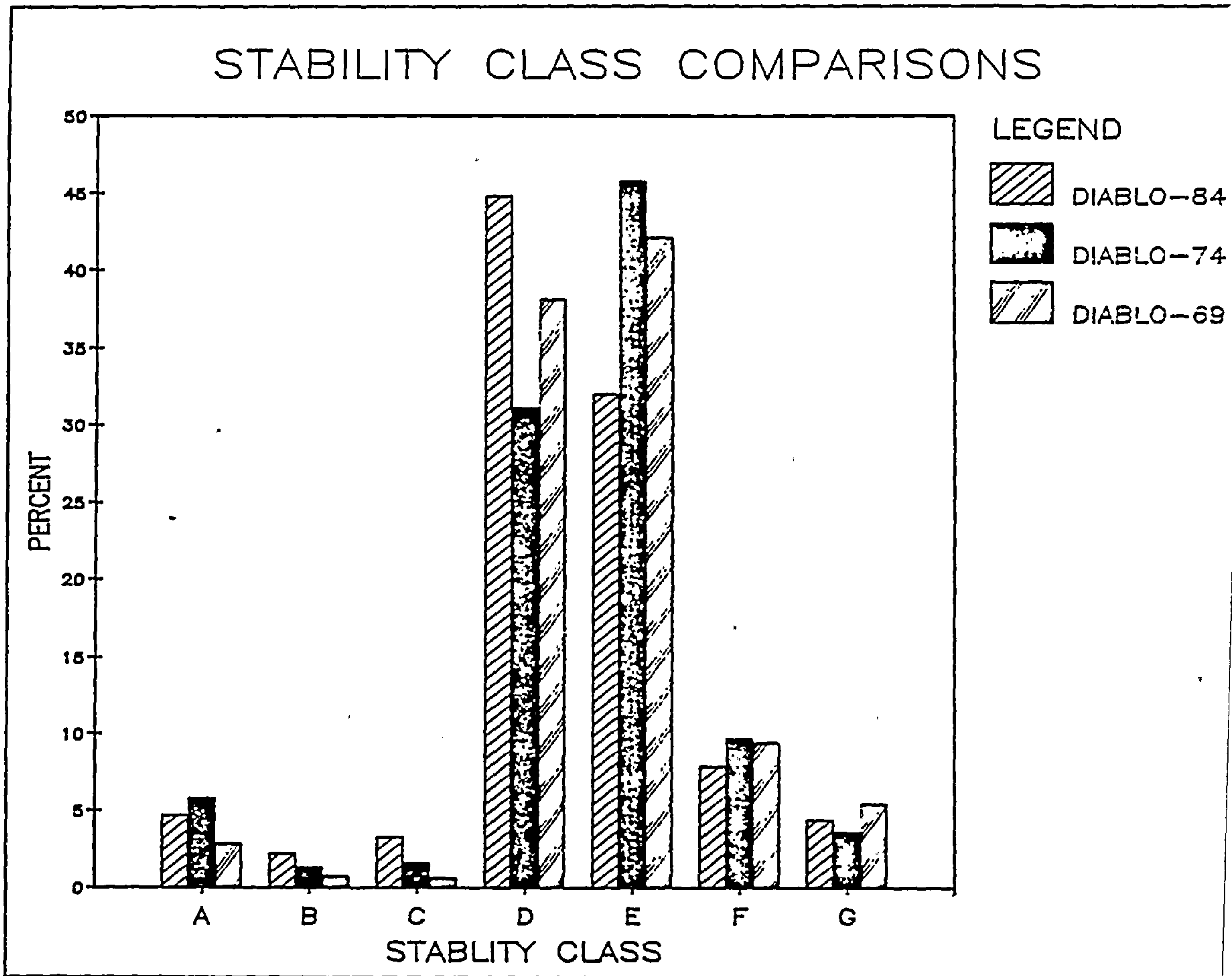

STABILITY CLASS COMPARISONS
LEGEND
DIABLO—84
DIABLO—74
DIABLO—69
PERCENT
50
45
40
35
30
25
20
15
10
5
0
A
B
C
D
E
F
G
STABLITY CLASS

Figure 2

4.2.3 10.0 Meter Wind Direction and Speed

A comparison between wind directions from the 1984 Diablo Canyon data set at 10.0 meters, May 1973 through April 1974 Diablo Canyon data (Pacific Gas Electric Co. 1972) at 7.6 meters, and 1984 Santa Maria data at 10.4 meters are shown in Figure 3. The comparison shows a reasonably close relationship among the data sets with the majority of the wind directions occurring in the northwest sector. The differences between the data sets can be attributed to local terrain influences and/or varying weather patterns on a year-by-year basis.

A comparison between wind speeds from the same sets as discussed above is shown in Figure 4. The comparison shows a reasonably close relationship among the data sets. Again, the differences between the data sets can be attributed to local terrain influences and/or varying weather patterns on a year-by-year basis.

From examinations of the 1984 Diablo Canyon 10.0 meter wind direction and speed frequency distributions it appears the data were climatologically representative of the shoreline environment, of high quality and, also, reliable because of their high data recovery (98.9% and 98.9%, respectively). The data would be representative and reliable for use in emergency response actions or routine dose assessments.

4.2.4 76.0 Meter Wind Direction and Speed

An intercomparison between the 1984 Diablo Canyon 76.0 meter wind direction and 10.0 meter wind direction is presented in Figure 5. The comparison shows a close relationship except in the southeast, west, west-northwest and north-northwest sectors. The differences appear to be caused by the frictional effects induced by terrain roughness. This influence tends to turn winds counter clockwise in the lower layers. For example, the 76.0 meter wind direction frequency distribution contains a higher occurrence of northwest directions compared to the 10.0 meter wind direction frequency distribution which contains a higher frequency of west-northwest and west wind directions.

In conjunction with an intercomparison of wind directions was an intercomparison of wind speeds (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 high wind speeds.

Examinations of the 76.0 meter wind direction and speed indicate that the data were climatologically representative of the shoreline environment, of high quality, and, also, are reliable due to their high data recovery (99.0% and 99.0%, respectively). The data would be representative and reliable for use in emergency response actions or routine dose assessments.

4.2.5 10.0 Meter Dry Bulb Temperature

The 1984 Diablo Canyon 10.0 meter monthly average and extreme maximum and minimum dry bulb temperature data were compared with 1985 2.0 meter dry bulb temperature data from Pismo Beach and Morro Bay (NOAA 1984b) (Fig. 7). Data

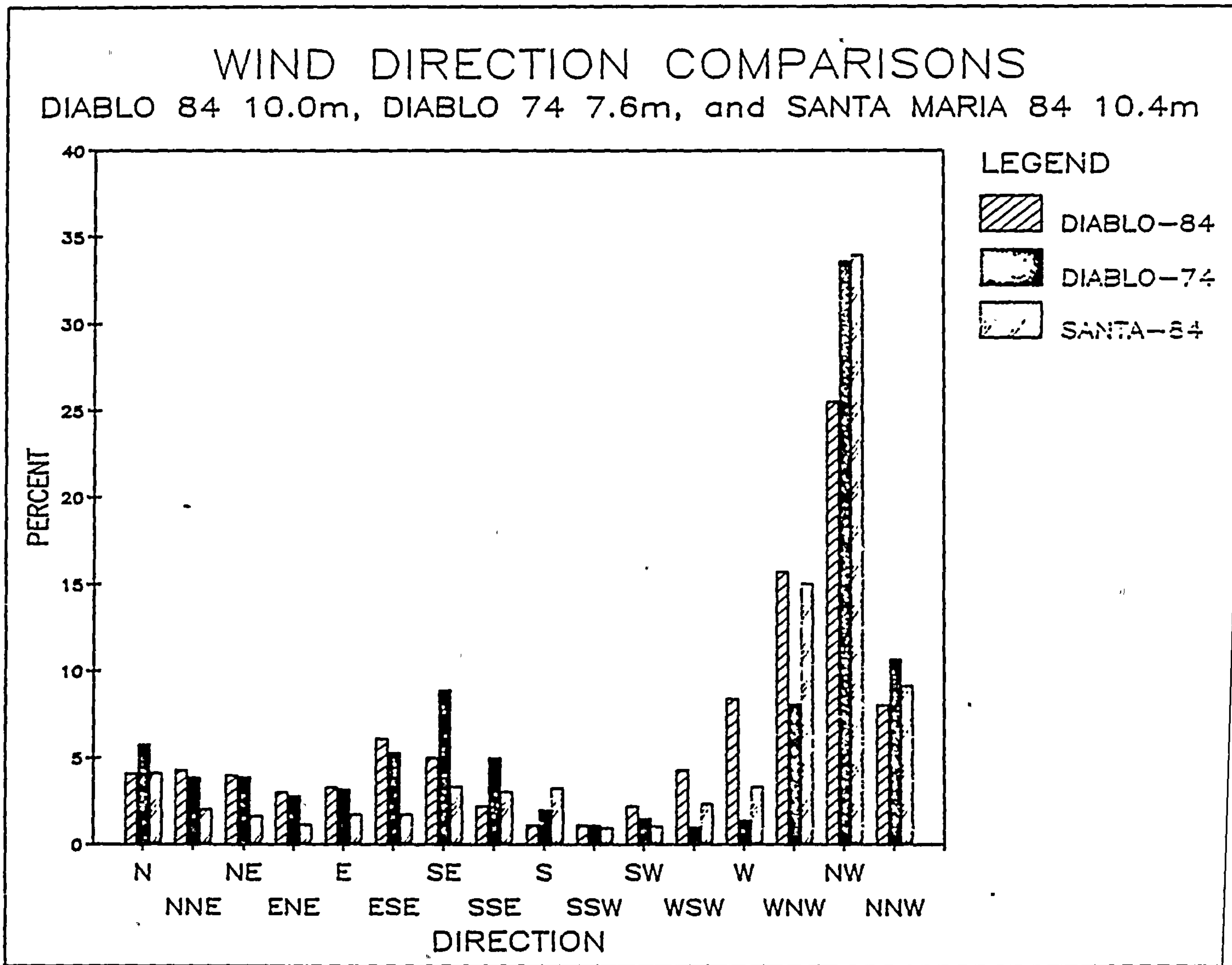
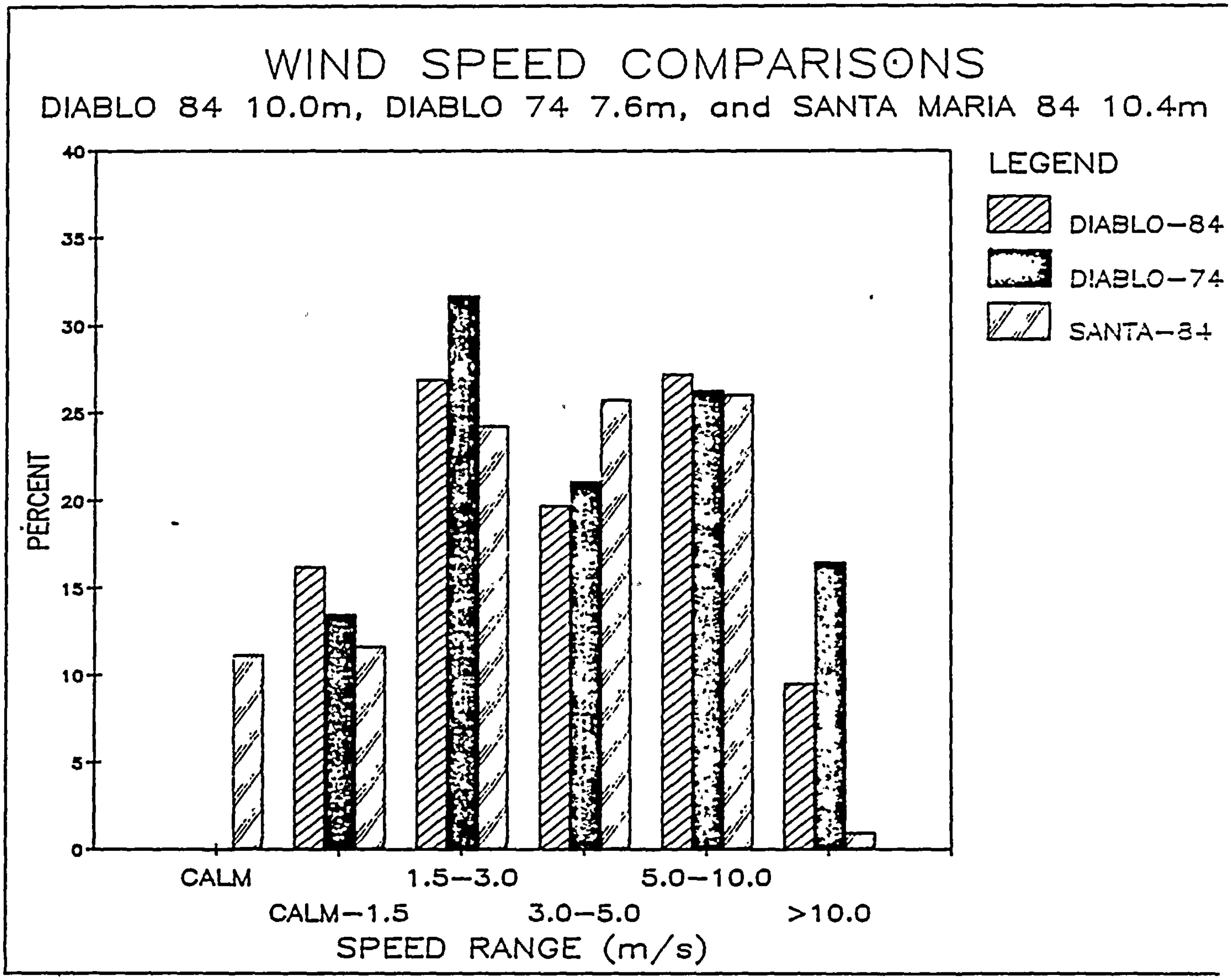

WIND DIRECTION COMPARISONS
DIABLO 84 10.0m, DIABLO 74 7.6m, and SANTA MARIA 84 10.4m
LEGEND
DIABLO-84
DIABLO-74
SANTA-84
PERCENT
0
5
10
15
20
25
30
35
40
N
NNE
NE
ENE
E
ESE
SE
SSE
S
SSW
SW
WSW
W
WNW
NW
NNW
DIRECTION

Figure 3



WIND SPEED COMPARISONS
DIABLO 84 10.0m, DIABLO 74 7.6m, and SANTA MARIA 84 10.4m
LEGEND
DIABLO-84
DIABLO-74
SANTA-84
PERCENT
0
5
10
15
20
25
30
35
40
CALM
CALM-1.5
1.5-3.0
3.0-5.0
5.0-10.0
>10.0
SPEED RANGE (m/s)

Figure 4

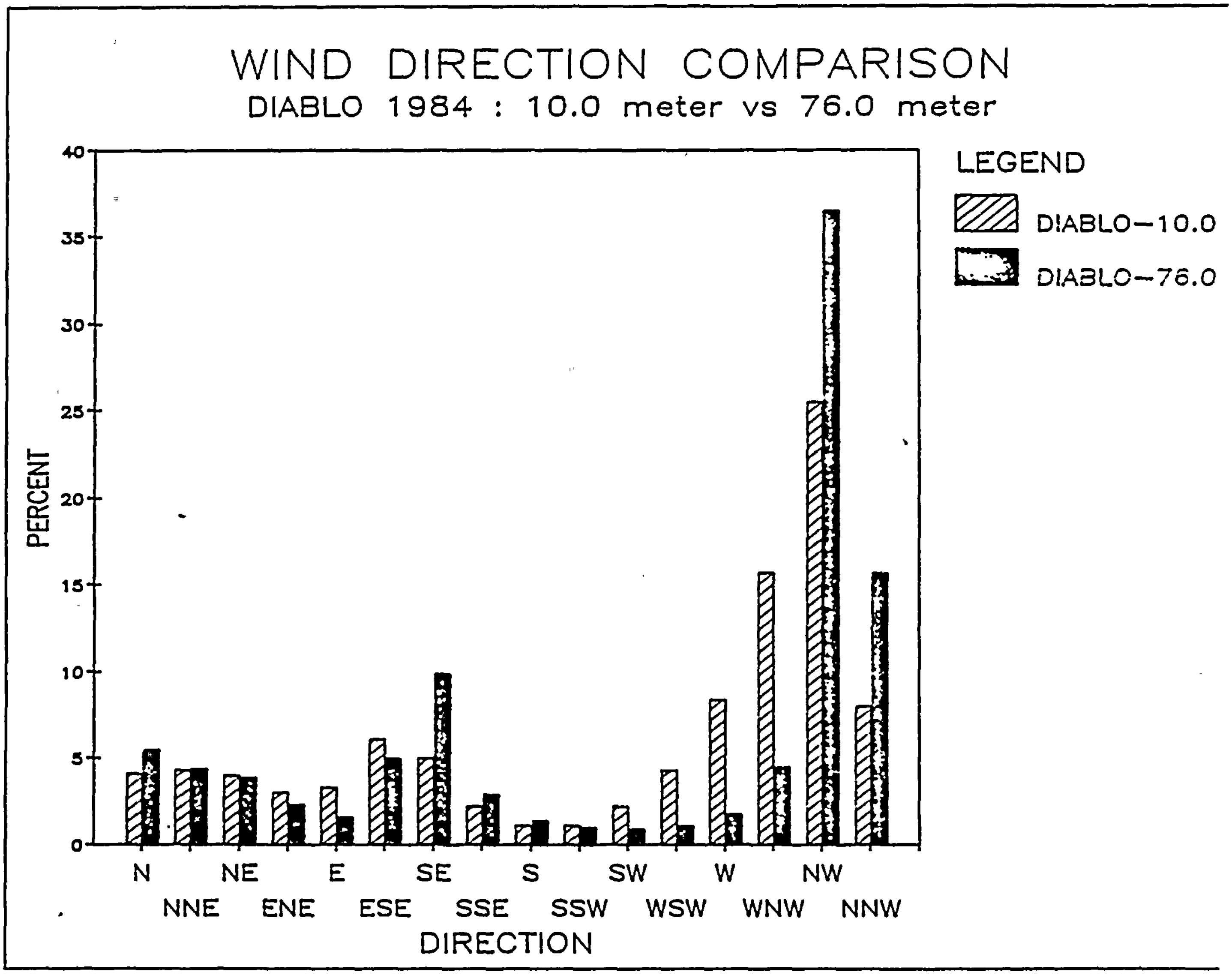

WIND DIRECTION COMPARISON
DIABLO 1984 : 10.0 meter vs 76.0 meter
LEGEND
DIABLO-10.0
DIABLO-76.0
PERCENT
0
5
10
15
20
25
30
35
40
N
NNE
NE
ENE
E
ESE
SE
SSE
S
SSW
SW
WSW
W
WNW
NW
NNW
DIRECTION

Figure 5

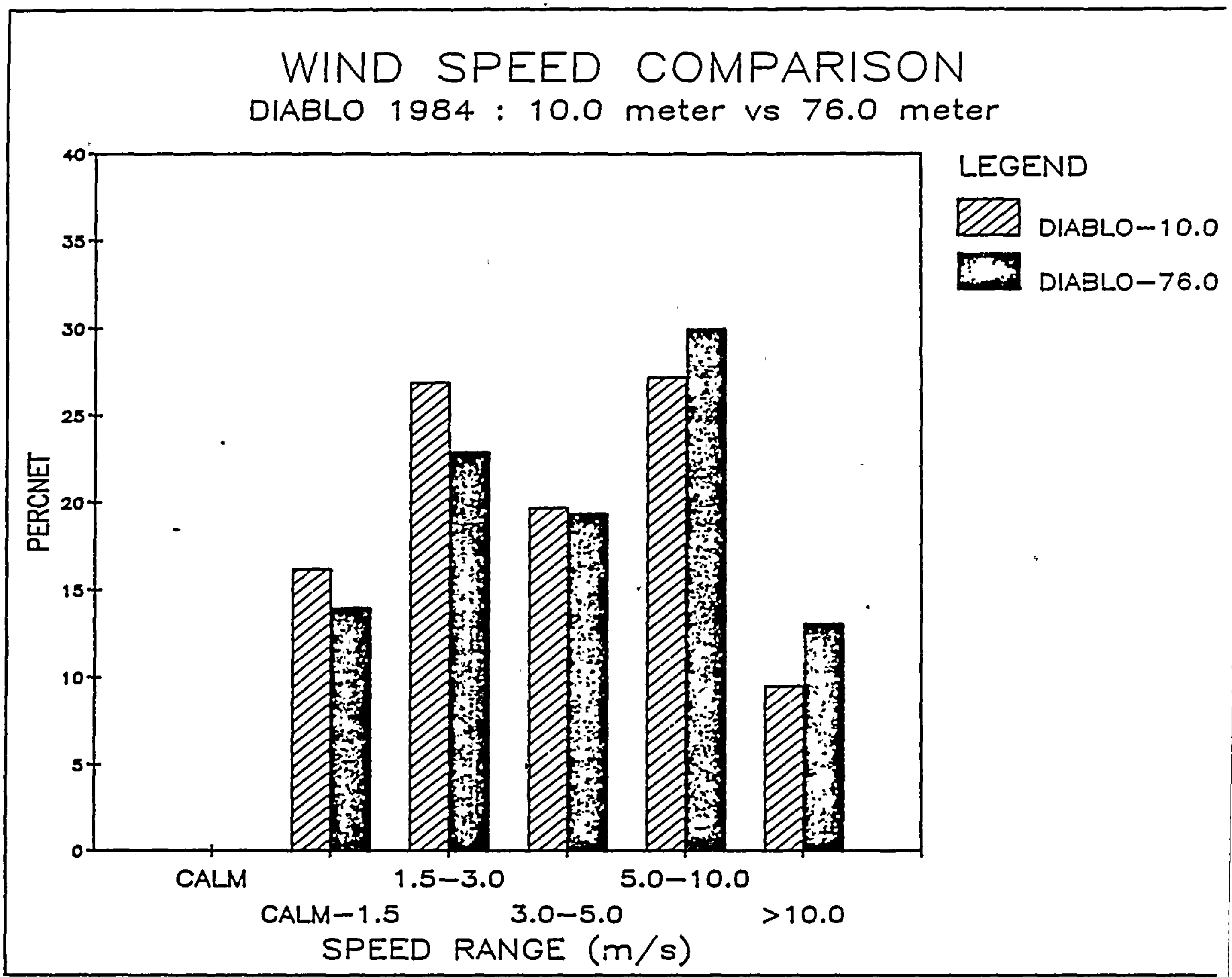
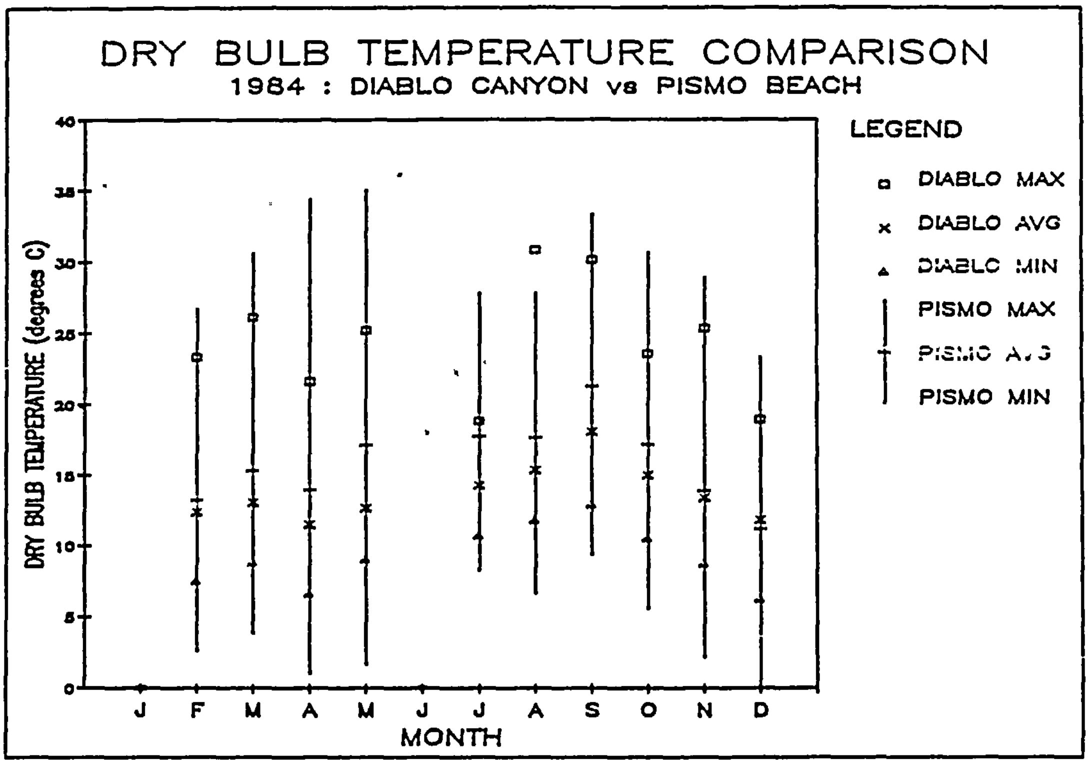

WIND SPEED COMPARISON
DIABLO 1984 : 10.0 meter vs 76.0 meter
LEGEND
DIABLO-10.0
DIABLO-76.0
PERCNET
0
5
10
15
20
25
30
35
40
CALM
CALM-1.5
1.5-3.0
3.0-5.0
5.0-10.0
>10.0
SPEED RANGE (m/s)

Figure 6


DRY BULB TEMPERATURE COMPARISON
1984 : DIABLO CANYON vs PISMO BEACH
DRY BULB TEMPERATURE (degrees C)
MONTH
J F M A M J J A S O N D
LEGEND
DIABLO MAX
DIABLO AVG
DIABLO MIN
PISMO MAX
PISMO MIN

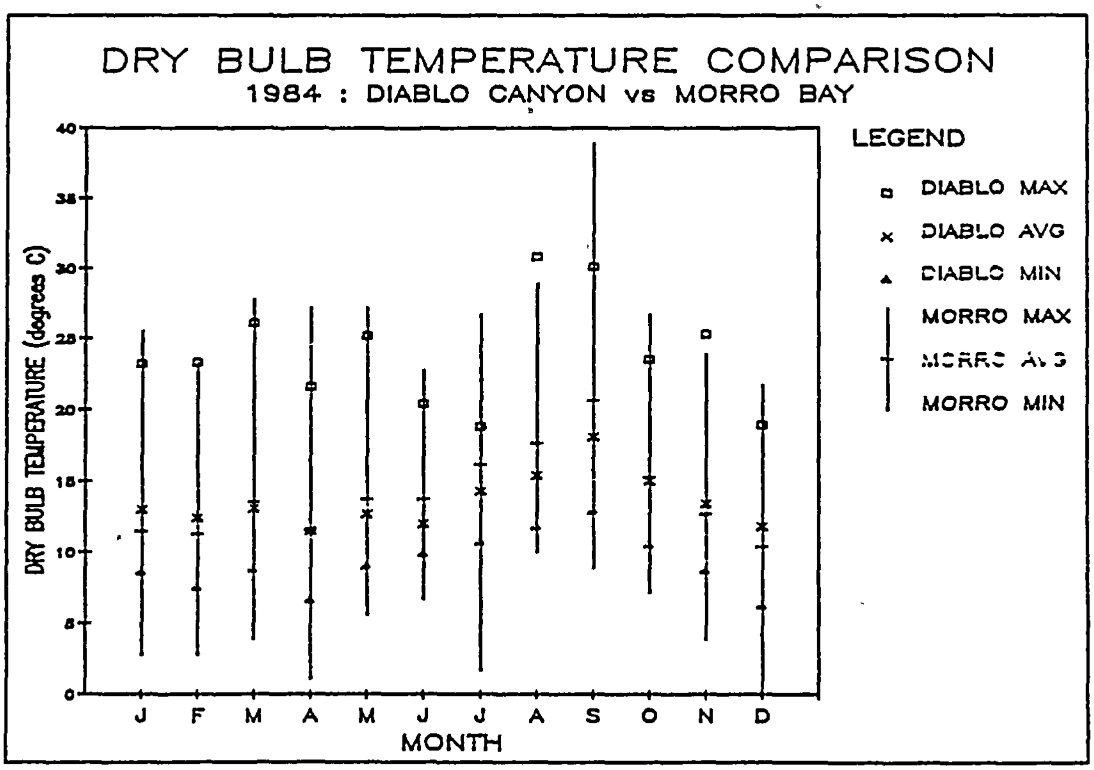

DRY BULB TEMPERATURE COMPARISON
1984 : DIABLO CANYON vs MORRO BAY
DRY BULB TEMPERATURE (degrees C)
MONTH
J F M A M J J A S O N D
LEGEND
DIABLO MAX
DIABLO AVG
DIABLO MIN
MORRO MAX
MORRO MIN

Figure 7

were missing for January and June from Pismo Beach. The comparisons indicate some large differences among the extreme values and a few of the monthly averages. Additional comparisons among CCN stations also indicated large differences among the extreme and monthly average values. The differences are more than likely due to the variation in sensor height and/or the complex terrain associated with the coastal region. A comparison between 1984 Diablo Canyon extreme and monthly average temperatures and the long-term (i.e., 30 years) climatological extreme and monthly average temperatures from Santa Maria is shown in Figure 8. The comparison was made in order to ensure the Diablo Canyon data were within reasonable limits. The comparison shows that the 1984 Diablo Canyon extreme temperature data lies within the climatological extreme temperatures from Santa Maria. Also, the monthly averages agreed reasonably well.

It appears the 1984 Diablo Canyon 10.0 meter dry bulb temperature data were climatologically representative of the shoreline environment, of high quality, and, also, reliable due to their high data recovery (99.0%). The data would be reliable and representative for use in emergency response actions and routine dose calculations.

4.2.6 Precipitation

The 1984 Diablo Canyon monthly precipitation data were compared with corresponding precipitation data from Santa Maria, Pismo Beach and Morro Bay (NOAA 1984b) (Fig. 9). Data at Pismo Beach was missing for the months January and June. The comparison shows essentially the same bimodal distribution among the data sets with maximums occurring in March, November, and December. The only discrepancy occurs in May where Diablo Canyon shows approximately 20 millimeters of precipitation compared to zero at the other sites. The only likely explanation for this accumulation would be the occurrence of a local thunderstorm.

Annual totals were also reasonably close; Diablo Canyon 238.5 mm, Santa Maria 189.6 mm, Pismo Beach 224.0 mm, and Morro Bay 197.3 mm.

It appears the 1984 Diablo Canyon precipitation data were climatologically representative of the shoreline environment, of high quality, and, also, are reliable due to their high data recovery (93.5%). The data would be reliable and representative for use in emergency response actions and routine dose calculations.

4.2.7 10.0 Meter Dew Point Temperature

The 1984 Diablo Canyon extreme maximum and minimum and monthly average dew point temperature data were compared with corresponding dew point temperature data from Santa Maria (NOAA 1984a) (Fig. 10). Data at the Diablo Canyon site were missing during the months of June and August, the most probable cause being instrument failure. The comparison shows a close relationship among the data sets.

It appears the 1984 Diablo Canyon dew point temperature data were climatologically representative of the shoreline environment, and of high

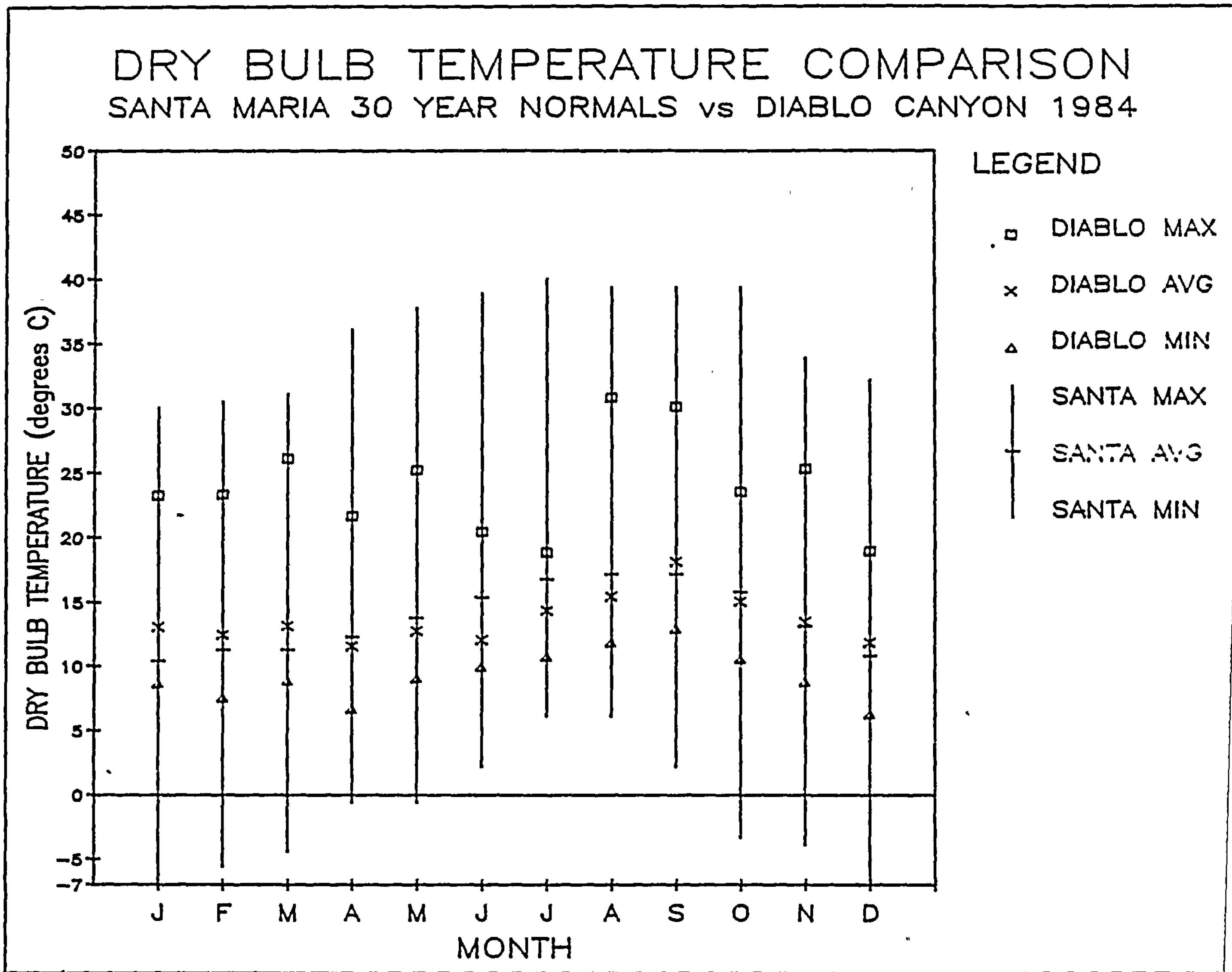

DRY BULB TEMPERATURE COMPARISON
SANTA MARIA 30 YEAR NORMALS vs DIABLO CANYON 1984
DRY BULB TEMPERATURE (degrees C)
50
45
40
35
30
25
20
15
10
5
0
-5
-7
J
F
M
A
M
J
J
A
S
O
N
D
MONTH
LEGEND
DIABLO MAX
DIABLO AVG
DIABLO MIN
SANTA MAX
SANTA AVG
SANTA MIN

Figure 8

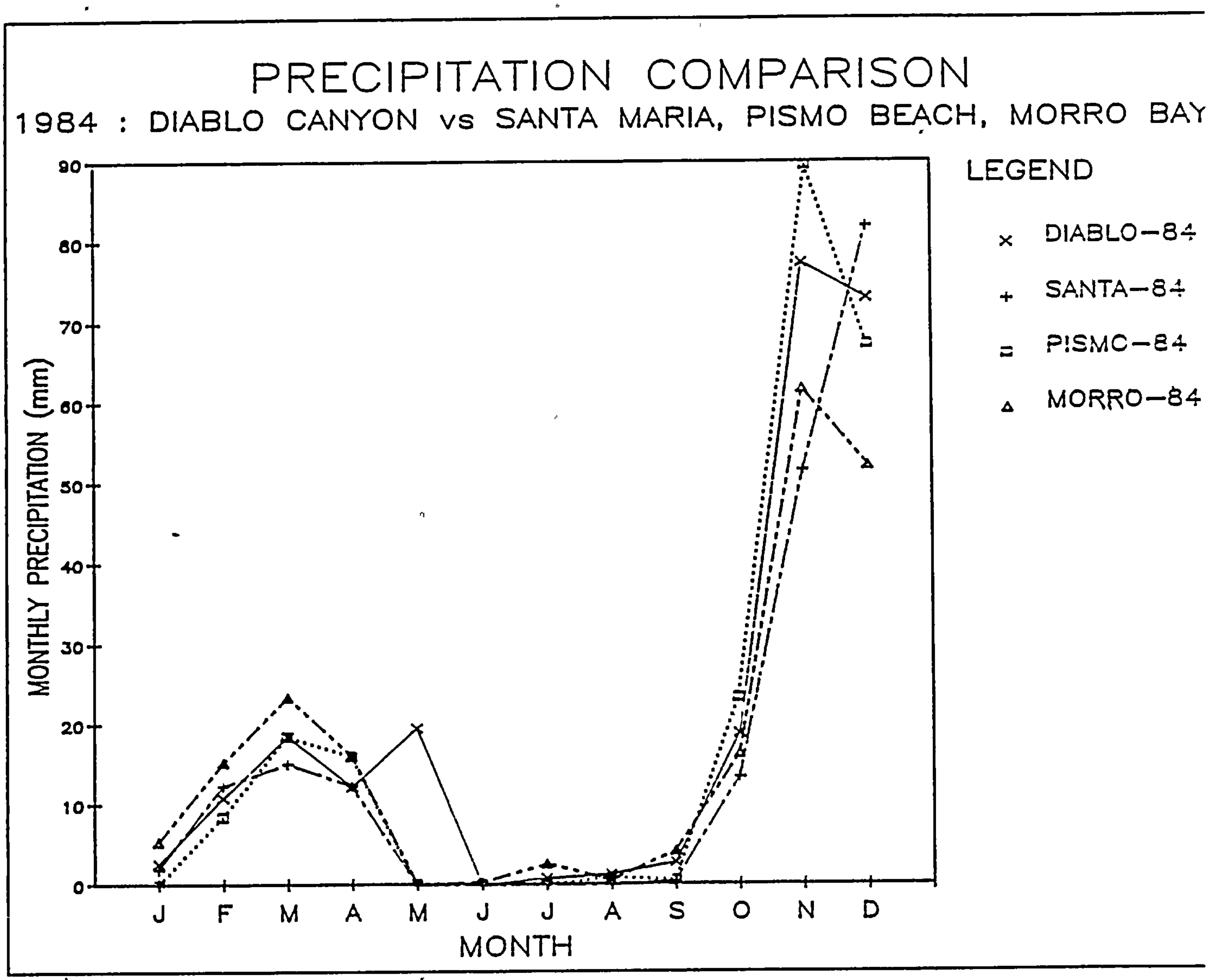
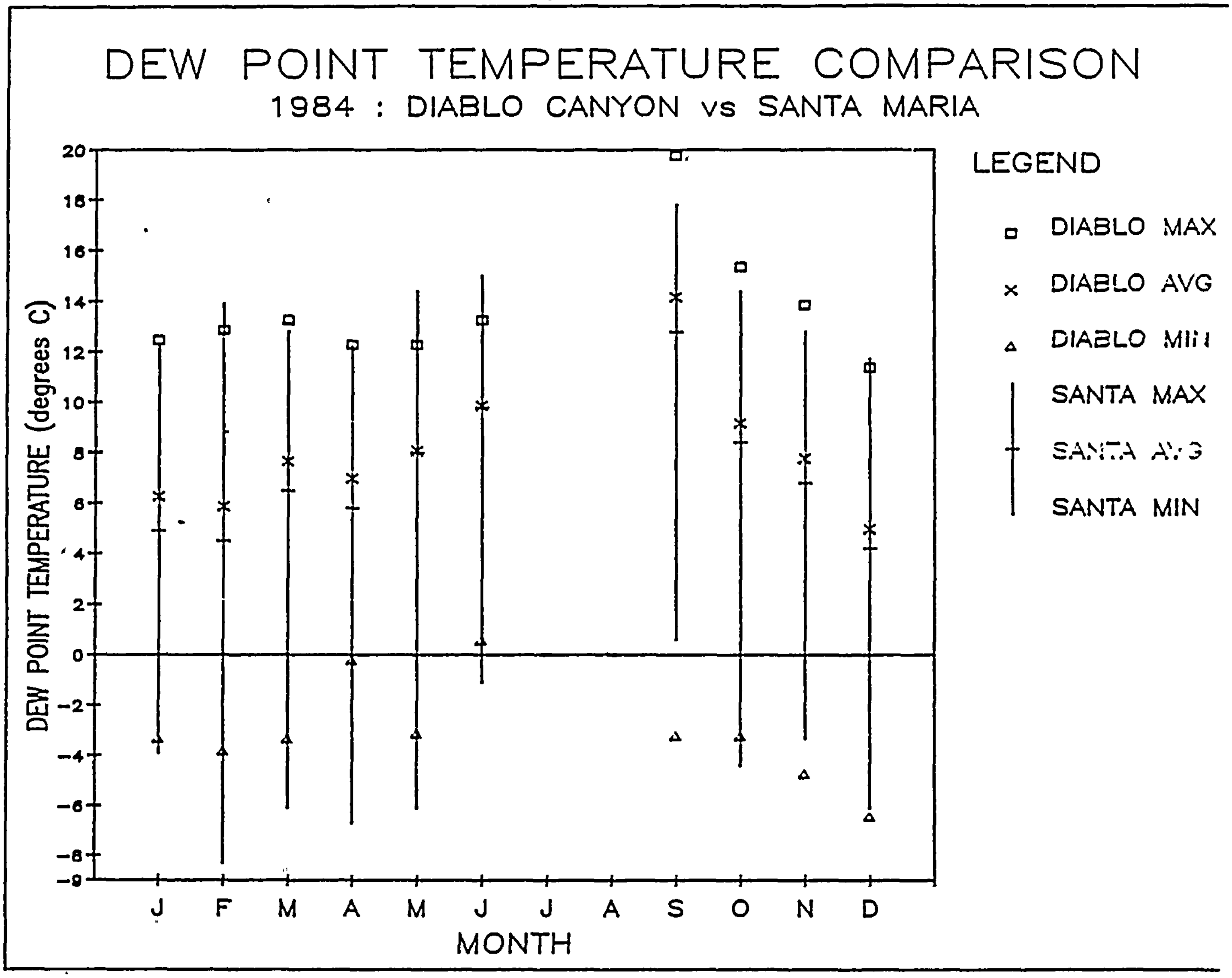

PRECIPITATION COMPARISON
1984 : DIABLO CANYON vs SANTA MARIA, PISMO BEACH, MORRO BAY
LEGEND
DIABLO-84
SANTA-84
PISMO-84
MORRO-84
MONTHLY PRECIPITATION (mm)
90
80
70
60
50
40
30
20
10
0
J
F
M
A
M
J
J
A
S
O
N
D
MONTH

Figure 9



DEW POINT TEMPERATURE COMPARISON
1984 : DIABLO CANYON vs SANTA MARIA
DEW POINT TEMPERATURE (degrees C)
20
18
16
14
12
10
8
6
4
2
0
-2
-4
-6
-8
-9
J
F
M
A
M
J
J
A
S
O
N
D
MONTH
LEGEND
DIABLO MAX
DIABLO AVG
DIABLO MIN
SANTA MAX
SANTA AVG
SANTA MIN

Figure 10

quality. However, the data are not reliable because their low data recovery (71.6%). Thus, the data could not be relied on for use in emergency response situations or routine dose assessments.

4.2.8 Shoreline Environment vs. Site Boundary Environment

Although the 1984 Diablo Canyon hourly meteorological data appear to be climatologically representative for the shoreline environment, they may not necessarily indicate meteorological conditions inland near the site boundary. The coastal environment tends to be more stable with higher wind speeds while inland locations are relatively unstable with lower wind speeds. Consequently, meteorological conditions near the site boundary need to be considered in order to provide credible dose calculations during onshore flow situations.

5.0 Conclusion

The quality, reliability, and representativeness 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.

Examinations of the Diablo Canyon 1984 data set indicate the data appeared to be climatologically representative, of high quality, and reliable and would not affect PG&E's ability to provide credible dose calculations and recommendations for protective actions in an emergency situation as well as doses calculated to assess the impacts of routine releases of radioactive material to the atmosphere. However, as discussed in Section 4.2.8, these data were only applicable to the shoreline environment and should not be applied to the site boundary under certain conditions (e.g., onshore flow). This warrants the need for additional information along the site boundary, if it does not already exist.

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APPENDIX A

APPENDIX A

NRC Delta-Temperature Scheme

Delta-T (°C/100m)	Numeric Category	Stability Class
$\Delta T \leq -1.9$	1	A
$-1.9 < \Delta T \leq -1.7$	2	B
$-1.7 < \Delta T \leq -1.5$	3	C
$-1.5 < \Delta T \leq -0.5$	4	D
$-0.5 < \Delta T \leq 1.5$	5	E
$1.5 < \Delta T \leq 4.0$	6	F
$4.0 < \Delta T$	7	G