PHILLIPS ALASKA, INC.
NUIQSUT AMBIENT AIR QUALITY MONITORING PROGRAM
ANNUAL DATA REPORT
APRIL 1999 THROUGH MARCH 2000

Prepared for:

PHILLIPS ALASKA, INC.
Anchorage, Alaska

Prepared by:

SECOR INTERNATIONAL INCORPORATED
Fort Collins, Colorado

May 2000

SECOR
International Incorporated

May 31, 2000

Mr. Mike Stahl
Phillips Alaska, Inc.
700 G Street
Anchorage, AK 99510-0360

Re: *Nuiqsut Ambient Air Quality Monitoring Program Annual Data Report April 1999 Through March 2000*

Dear Mike,

Enclosed for your review and distribution are ten copies of the *Nuiqsut Ambient Air Quality Monitoring Program Annual Data Report: April 1999 Through March 2000.* We expect that copies of the report will be distributed as follows:

- six copies to the North Slope Borough,
- one copy to the village of Nuiqsut,
- one copy to the ADEC, and
- two copies for PAI's records.

Note that no data diskettes have been sent with any of the copies of the final report. We expect that you will transfer the diskettes from the three draft reports we sent you to the final report you send to ADEC, and to the two copies you will be keeping for yourself.

Please contact either me or Sims Duggins via phone at (970) 226-4040 or via e-mail (pmiller@secor.com or sduggins@secor.com) if you have any questions or comments regarding this report or any other aspect of the project. We appreciate the opportunity to assist you with this project.

Sincerely,
SECOR *International Incorporated*

Peter P. Miller II, CCM
Project Manager

PPM/

ref: 012.06507.009
enc: as stated

EXECUTIVE SUMMARY

This report summarizes the first year of data collected at the Nuiqsut Ambient Air Quality Monitoring Station from April 1, 1999 through March 31, 2000. The monitoring station is operated by Phillips Alaska, Inc. (PAI) with the assistance of SECOR International Incorporated (SECOR). The ambient monitoring program was established to address air quality concerns raised by the village of Nuiqsut and the North Slope Borough. PAI also has a condition in its PSD permit that requires the operation of an ambient air monitoring station. The project monitoring plan (SECOR 2000) fully describes the protocols used to collect dispersion meteorology and ambient air quality data which meet the quality assurance and data recovery requirements of the United States Environmental Protection Agency (EPA) Prevention of Significant Deterioration (PSD) program as administered by the Alaska Department of Environmental Conservation (ADEC) and other specific ADEC quality assurance requirements.

The monitoring station is instrumented and equipped to continuously measure the following parameters:

- nitrogen oxides (NO, NO_2, and NO_x),
- sulfur dioxide (SO_2),
- inhalable particulate matter less than 10 μm in diameter (PM_{10}),
- 10-meter wind speed, wind direction, and wind direction standard deviation (σ_θ), and
- 2-meter ambient temperature.

Official data collection began on April 9, 1999 for all parameters except PM_{10}, which began on April 25. The station performed well during the monitoring year. Air quality data recovery exceeded project goals for all quarters except the second quarter of 1999. Meteorological data recovery exceeded project goals for all months except in April 1999 and November 1999.

Equivalent National Ambient Air Quality Standards (NAAQS) and Alaska Ambient Air Quality Standards (AAAQS) have been established for NO_2, SO_2, and PM_{10}. These standards represent thresholds above which risk to public health and welfare becomes an issue. Because the AAAQS and NAAQS are identical to each other, the term AAAQS will be used to refer to both.

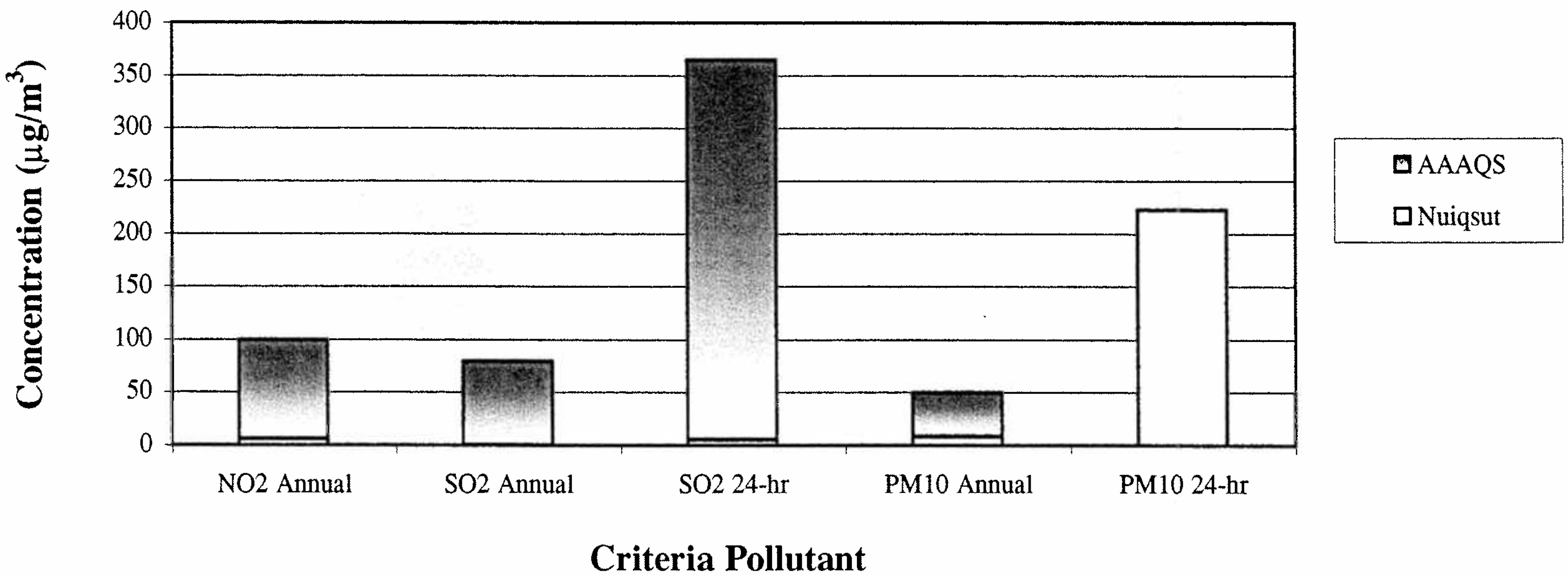
Monitored NO_2 and SO_2 concentrations were well below the AAAQS for the reporting period. However, PM_{10} levels were measured which exceeded the 24-hour, but not the annual AAAQS. Figure 1 and Tables 1 and 2 provide summaries of the ambient air quality data collected during

the reporting period compared to the appropriate AAAQS. As shown in these figures and tables, measured concentrations of all monitored pollutants were well below the applicable AAAQS.

In general, the data shows that the annual average of hourly NO_2 concentrations was just above instrument detection, and well below applicable AAAQS. Summer seasonal averages were lower than winter seasonal averages as a result of increases in background values and in local NO_2 producing activities during the winter. The highest impacts were measured when winds transport air from the village to the monitoring site.

Annual SO_2 data showed that there was no single near-field or far-field source of measurable SO_2 identified in the data collected, which indicates that measured concentrations are representative of a regional background signature, consistent with the rural environment of the site.

Despite some high daily impacts occurring in the months of June through October, annual averaged PM_{10} concentrations were low compared to the AAAQS. In general, the data shows that measured PM_{10} concentrations are a result of naturally occurring wind blown fugitive dust. The single most identifiable source of wind blown fugitive emissions is the exposed river bank of the Nechelik channel to the east of the monitoring site. In general, when fugitive emissions from this source are not present, hourly concentrations drop below or just above instrument detection limit.



Annual concentrations are the average concentrations for the period April 1999 through March 2000.

FIGURE 1: SUMMARY OF AMBIENT AIR QUALITY DATA APRIL 1999 THROUGH MARCH 2000

TABLE 1

NUIQSUT AMBIENT AIR QUALITY MONITORING PROGRAM
MEASURED GASEOUS POLLUTANT CONCENTRATIONS COMPARED TO ALASKA AMBIENT AIR QUALITY STANDARDS
APRIL 1999 THROUGH MARCH 2000

Pollutant	Averaging Period	Maximum Period Average Concentration (ppm)	AAAQS (ppm)	Percent of AAAQS
NO_2	Annual	0.003	0.053	5.7
SO_2	3-hour	0.010	0.500	2.0
	24-hour	0.002	0.140	1.4
	Annual	0.000	0.030	0.0

TABLE 2

NUIQSUT AMBIENT AIR QUALITY MONITORING PROGRAM MEASURED PARTICULATE CONCENTRATIONS COMPARED TO ALASKA AMBIENT AIR QUALITY STANDARDS APRIL 1999 THROUGH MARCH 2000

Pollutant	Averaging Period	Maximum Period Average Concentration [1] ($\mu g/m^3$)	AAAQS ($\mu g/m^3$)	Percent of AAAQS
PM_{10}	24-hour[2]	222.9	150	148.6
	24-hour[3]	128.4	150	85.6
	Annual	8.3	50	16.6

1 Standard conditions

2 Maximum 24-hour average concentration

3 Second highest 24-hour average concentration

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1.0 INTRODUCTION

1.1 Background/History

On February 1, 1999, Philips Alaska, Inc., then operating as ARCO Alaska, Inc., (PAI), was issued a construction permit (Permit #9873-AC033) to establish an oil and gas exploration and production complex approximately 14 kilometers (km) north of the village of Nuiqsut on the North Slope of Alaska. The project, called the Alpine Development Project, will consist of a main site which includes a production facility, an operating camp, and a temporary drilling operation, and a second drilling site approximately 5 km to the west of the main production facility.

In anticipation of the proposed Alpine Development Project, representatives of the village of Nuiqsut expressed an interest in characterizing the ambient air quality in the village before and after the Alpine Development Project. In response to village concerns, PAI offered direct assistance to implement the Nuiqsut Air Quality Monitoring Program in cooperation with the Alaska Department of Environmental Conservation (ADEC), the North Slope Borough, and the village of Nuiqsut. The spirit of this commitment is to better understand local ambient air quality in Nuiqsut. The spatial relationship between the major North Slope oil fields and the village of Nuiqsut is shown in Figure 1-1.

To address the village concerns and fulfill the permit requirements, PAI retained the services of SECOR International Incorporated (SECOR) to implement the Nuiqsut Ambient Air Quality Monitoring Program. The program consists of a single ambient air quality and dispersion meteorology monitoring station within the village of Nuiqsut, with data analysis and support provided from SECOR's Fort Collins, Colorado Air Resources Laboratory with the aid of locally hired on-site technical support. The station was installed in the spring of 1999, and brought online in two phases: continuous meteorology, ambient NO_x, and ambient SO_2 collection began on April 9, 1999, while ambient PM_{10} sampling began on April 25, 1999.

1.2 Project Implementation

Consistent with the goals of the Nuiqsut Ambient Air Quality Monitoring Program, the specific technical objectives of the program are to:

- determine if there are significant discernable air quality impacts at Nuiqsut from existing regional oil and gas operations,

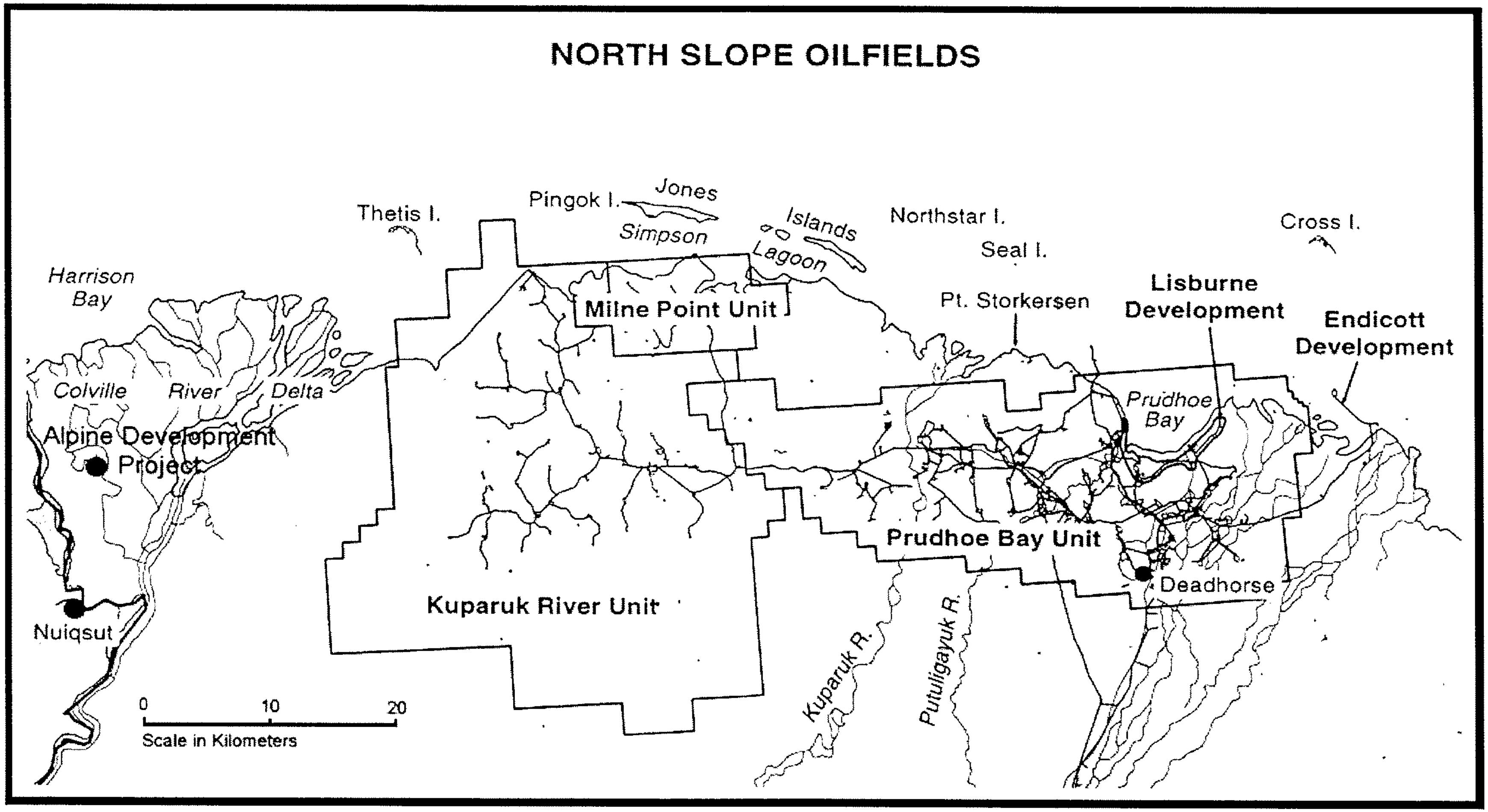


FIGURE 1-1: LOCATION OF REGIONAL NORTH SLOPE OIL FIELDS RELATIVE TO NUIQSUT

- establish current baseline conditions in the village prior to operation of the Alpine complex,

- establish potential changes to baseline air quality conditions after the Alpine facility becomes operational, and

- meet the ambient air quality and meteorological monitoring requirements set forth in the Alpine Development Project Permit No. 9873-AC033.

Though the program is primarily designed to characterize ambient air quality at Nuiqsut, it also fulfills permit requirements imposed by ADEC as described in Condition IV(C) of the Alpine Development Project construction permit. Simply stated, the permit requires the collection of at least one year of ambient NO_x, SO_2, PM_{10}, and dispersion meteorology data at the village of Nuiqsut.

To meet these objectives, the air quality monitoring station is instrumented and equipped to continuously measure the following parameters:

- nitrogen oxides (NO, NO_2, and NO_x),
- sulfur dioxide (SO_2),
- inhalable particulate matter less than 10 μm in diameter (PM_{10}),
- 10-meter wind speed, wind direction, and wind direction standard deviation (σ_θ), and
- 2-meter ambient temperature.

Table 1-1 shows the methods and instruments used to measure these parameters.

1.2.1 Nuiqsut Monitoring Station Location

The station has been sited so that impacts due to oil and gas operations to the north and east can be distinguished from near-field impacts due to the village of Nuiqsut which is located to the south and west. The location of the air quality monitoring station with respect to the local region, including major oil and gas operations, is shown in Figure 1-2. A detailed site specific map is included in Figure 1-3 to show the site relative to the village and near-field sources.

TABLE 1-1

NUIQSUT AMBIENT AIR QUALITY MONITORING PROGRAM MEASUREMENT METHODS

Parameter	Suggested Manufacturer/Model	Sample Frequency	Averaging Period	Measurement Range	Lower Detection Limit	Method
Nitrogen Oxides (NO_x, NO_2, NO)	Thermo Environmental Instruments (TECO) Model 42C	Continuous	1-hour	0 - 500 ppb	0.5 ppb	Chemiluminescence (EPA reference method RFNA-1289-074)
Sulfur Dioxide (SO_2)	Thermo Environmental Instruments (TECO) Model 43C	Continuous	1-hour	0 - 500 ppb	2 ppb	Pulsed Fluorescence (EPA equivalent method EQSA-0486-060)
Particulate Matter (PM_{10})	Rupprecht & Patashnick (R&P) Model 1400a TEOM® PM_{10}	Continuous	1-hour	$<5\ \mu g/m^3$ to several g/m^3	$<5\ \mu g/m^3$	Tapered Element Oscillating Microbalance (EPA equivalent method EQPM-1090-079)
Wind Speed (10 m)	R.M. Young Wind Monitor AQ - 05305	Continuous	1-hour	0 to 50 m/s	0.2 m/s	Propeller/Magnetically Induced AC
Wind Direction (10 m)	R.M. Young Wind Monitor AQ - 05305	Continuous	1-hour	0 to 360°	N/A	Vane/Potentiometer
Sigma-Theta (σ_θ) (10 m)	Computed by Data Logger	Continuous	1-hour	0 to 100°	N/A	Single Pass Estimator of Wind Direction Standard Deviation Yamartino (1984)
Temperature (2 m)	R.M. Young 41342	Continuous	1-hour	-50°C to 50°C	N/A	Motor aspirated/shielded platinum RTD

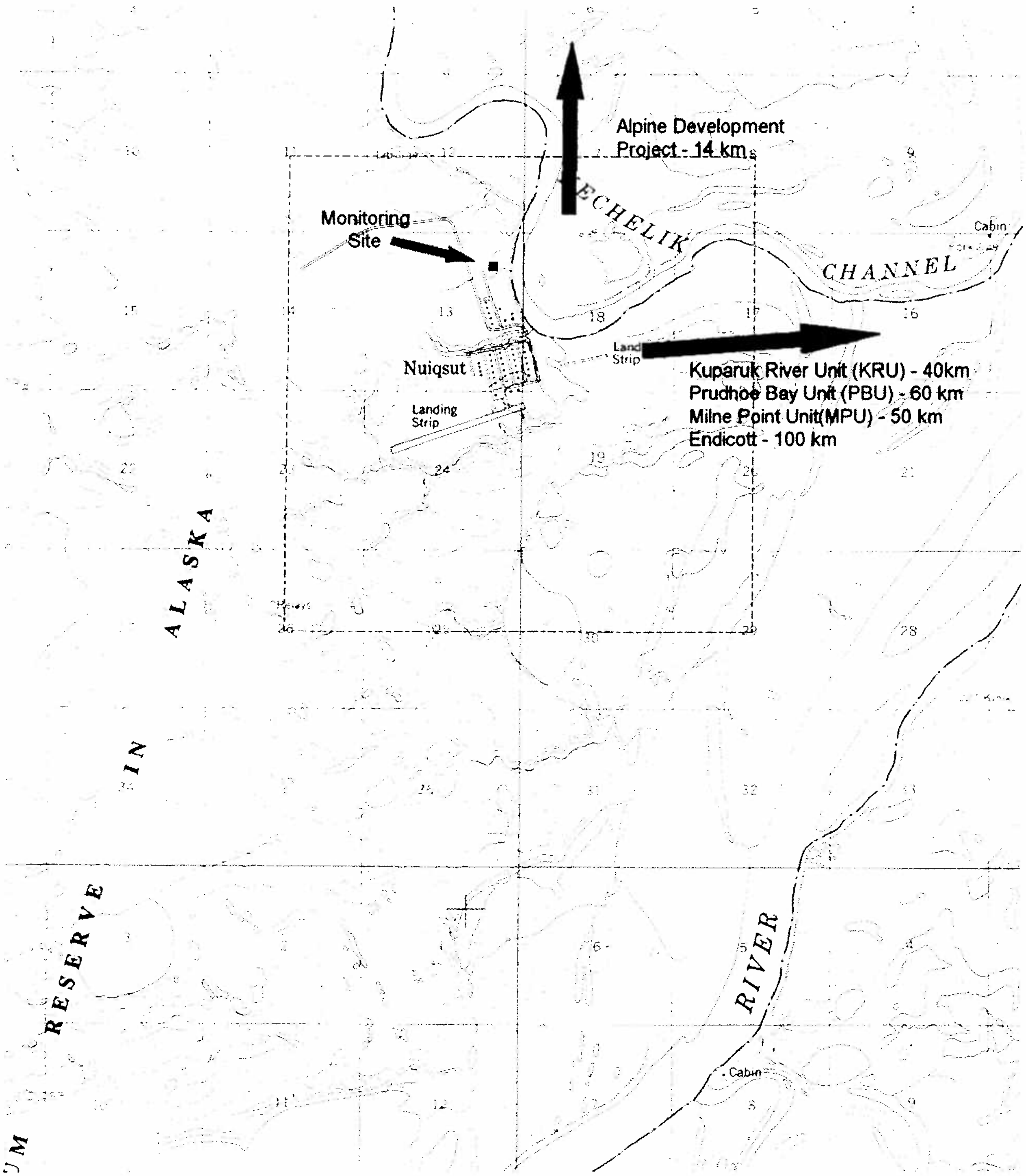


FIGURE 1-2: REGIONAL MAP

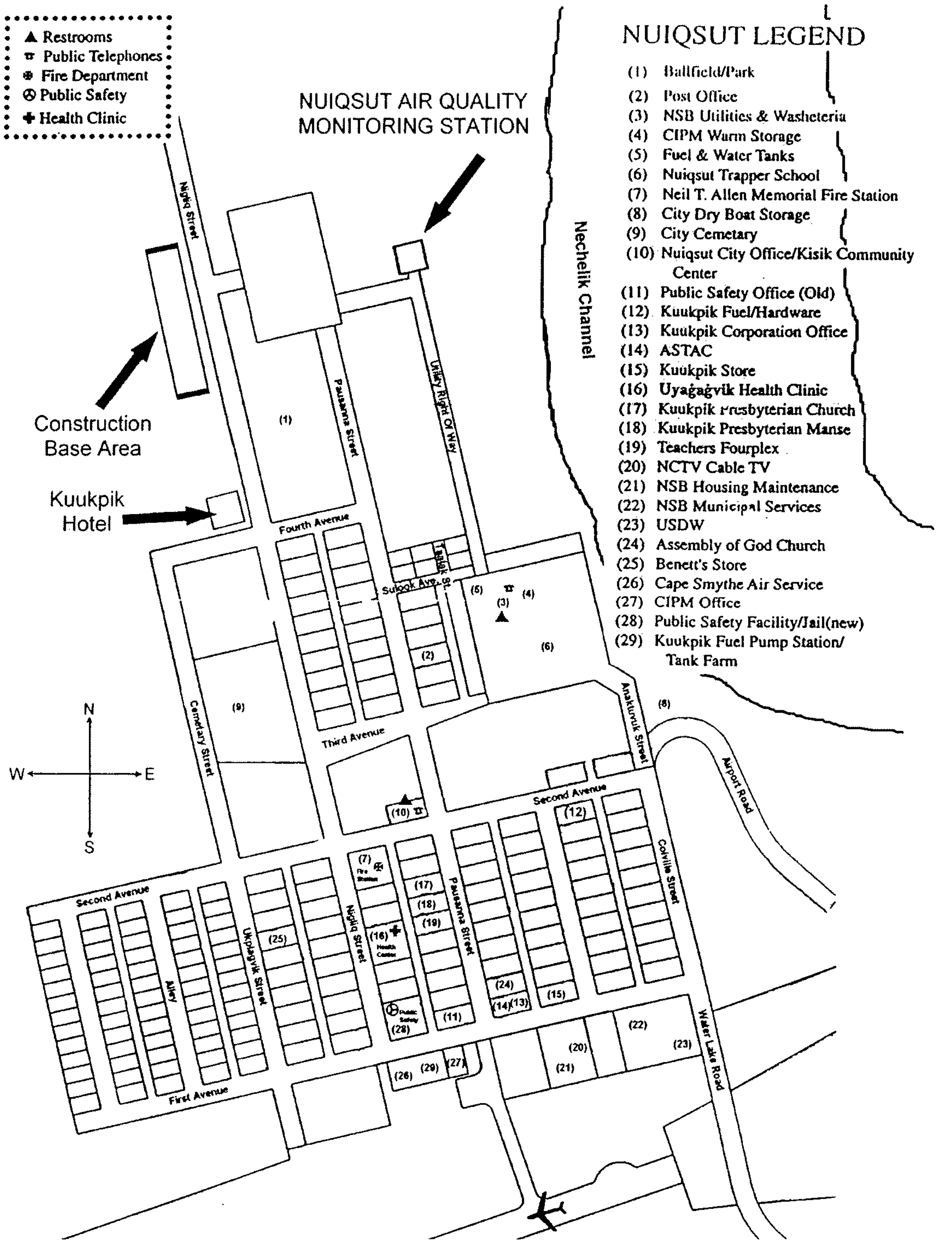


FIGURE 1-3: LOCAL MAP

1.2.2 Project Monitoring Plan

The original monitoring plan for this project (SECOR 1999) was submitted to ADEC in February 1999. ADEC issued comments on the monitoring plan on April 7, 1999 (ADEC 1999). A revised monitoring plan (SECOR 2000) (Monitoring Plan) was approved by ADEC in April 2000. The revised Monitoring Plan incorporates changes and additions recommended by ADEC. The Monitoring Plan describes the protocols used to collect dispersion meteorology and ambient air quality data which meet the quality assurance (QA) and data recovery requirements of the EPA Prevention of Significant Deterioration (PSD) program as administered by the ADEC and other specific ADEC QA requirements. Guideline documents cited by the project Monitoring Plan are:

- *Alaska Quality Assurance Manual for Ambient Air Quality Monitoring* (ADEC 1996),
- *Ambient Monitoring Guidelines for Prevention of Significant Deterioration* (EPA 1987),
- *On-Site Meteorological Program Guidance for Regulatory Modeling Applications (Revised August 1995)* (EPA 1987a),
- *Quality Assurance Handbook for Air Pollution Measurement Systems. Volume II: Ambient Air Specific Methods (Interim Edition)* (EPA 1994),
- *Quality Assurance Handbook for Air Pollution Measurement Systems. Volume IV: Meteorological Measurements* (EPA 1995), and
- Code of Federal Regulations 40 CFR Part 58–Ambient Air Quality Surveillance:

  Appendix A - *Quality Assurance Requirements for State and Local Air Monitoring Stations (SLAMS)*
  Appendix B - *Quality Assurance Requirements for Prevention of Significant Deterioration (PSD) Air Monitoring*
  Appendix C - *Ambient Air Quality Monitoring Methodology*
  Appendix E - *Probe Siting Criteria for Ambient Air Quality Monitoring*

1.3 Monitoring Report Overview

The report summarizes and documents the operation of the monitoring station and data collected during the first year of monitoring conducted at the village of Nuiqsut, defined by the 12-month period from April 1, 1999 through March 31, 2000. The report has been subdivided into several chapters. Chapter 2 discusses the performance of the monitoring network. Chapter 3 summarizes the air quality and meteorological data collected during the period. Appendix A contains the various statistical formulae used to determine data precision, accuracy, and recovery statistics. Appendix B summarizes the contents of the diskette containing validated hourly data for the reporting period.

2.0 STATION PERFORMANCE SUMMARY

This chapter presents a summary of events significant to station performance and contributing to data completeness, precision, and accuracy. Specific goals for data completeness, precision, and accuracy established in the Monitoring Plan are listed in Tables 2-1 through 2-3 for reference. Overall, station performance was good. Air quality data recovery exceeded project goals for all quarters except the second quarter of 1999. Meteorological data recovery exceeded project goals for all months except in April 1999 and November 1999. Data accuracy and precision goals for all parameters were exceeded during the reporting period.

2.1 Significant Project Events

Table 2-4 summarizes the significant project events for the monitoring period. In addition to these significant events, data were lost during routine maintenance visits, power failures, and due to a frozen wind speed and direction sensor.

2.2 Missing, Invalid, and Adjusted Data

Several routine adjustments have been made to the air quality data during the monitoring year to increase the quality of the data. These data processing procedures are discussed below, and are detailed in Appendix A and in the Monitoring Plan.

- All hourly SO_2 and NO_x data were adjusted according to the procedure outlined in EPA (1998). The adjustment procedure corrects data based on daily Level 1 zero/span and/or calibration results to eliminate instrument zero/span drift as completely as possible from the data. Without adjustment, zero or span drift of the instrumentation could be misinterpreted as low-level concentrations of NO_x or SO_2.

- All hourly SO_2 and NO_X data less than 0.000 ppm but greater than or equal to -0.001 ppm have been set to 0.000 ppm to conservatively remove negative biases from the data set that may remain after instrument drift corrections are applied. Values less than -0.001 ppm are also adjusted to 0.000 ppm but only after investigating for correctness.

- Measured PM_{10} concentrations greater than -10 $\mu g/m^3$ are considered valid unless there is a documented reason to invalidate the data. Measured concentrations of -10 $\mu g/m^3$ or less are considered invalid.

TABLE 2-1

NUIQSUT AMBIENT AIR QUALITY MONITORING PROGRAM
MINIMUM PRECISION, ACCURACY AND COMPLETENESS GOALS
METEOROLOGY DATA

Parameter	Accuracy [1]	Completeness
Horizontal Wind Speed	± (0.2 m/s + 5% of observed)	90% per month
Horizontal Wind Direction	± 5 compass degrees (total system accuracy) ± 3 degrees relative to the sensor mount (sensor linearity)	90% per month
Temperature	± 0.5°C	90% per month

[1] Based on calibrations and independent quality assurance performance audits.

TABLE 2-2

NUIQSUT AMBIENT AIR QUALITY MONITORING PROGRAM MINIMUM PRECISION, ACCURACY, AND COMPLETENESS GOALS CONTINUOUS AIR QUALITY ANALYZER DATA

Parameter	Precision [1]	Accuracy [2]	Completeness
Nitrogen Oxides and Sulfur Dioxide	±15% of input value Quarterly reported 95% probability limits less than ±15%	±15% of input value Slope ≥ 0.85 and ≤ 1.15 Intercept ≤ ±3% of FS $R^2 > 0.995$ NO_2 converter efficiency > 96%	80% per calendar quarter

1 Based on precision checks.

2 Based on calibrations and independent quality assurance performance audits.

TABLE 2-3

NUIQSUT AMBIENT AIR QUALITY MONITORING PROGRAM MINIMUM PRECISION, ACCURACY, AND COMPLETENESS GOALS CONTINUOUS PARTICULATE MONITORING DATA

Parameter	Precision [1]	Accuracy [2]	Completeness
PM_{10}	Main and auxiliary flow rate within ±2% of set points as indicated on monitor display	Main and auxiliary flow rate within ±2% of set points as indicated on monitor display Main (auxiliary) flow rate within ±7% of 3.0 ℓ/min (13.67 ℓ/min) as indicated by reference flow device Total flow rate within ±10% of 16.67 ℓ/min as indicated by reference flow device Mass transducer calibration constant within ±2.5% of factory-set value Temperature within ±1.0°C of actual Pressure within ±1.5% of actual	80% per calendar quarter

[1] Based on precision checks.

[2] Based on calibrations and independent quality assurance performance audits.

TABLE 2-4

NUIQSUT AMBIENT AIR QUALITY MONITORING PROGRAM
SIGNIFICANT PROJECT EVENTS
APRIL 1999 THROUGH MARCH 2000

Date	Event/Comment
April 9, 1999 through April 10, 1999	SECOR technicians install and calibrate meteorological, continuous air quality, and continuous particulate monitoring equipment. Valid data collection starts for meteorological, SO_2, and NO_x parameters.
April 24,1999 through April 27, 1999	Data collection by the ESC data logger ceases while logger is offline during EPROM chip replacement by SECOR field technician.
April 25, 1999	TEOM continuous particulate monitor programming is updated and valid data collection begins.
May 4, 1999 through May 5, 1999	Initial independent quality assurance performance and field systems audit performed by AMSTech.
May 27, 1999 through July 3, 1999	NO_x data missing as a result of a failed sample pump and blown fuses.
July 20, 1999	Quarterly calibration of air quality monitoring systems performed by SECOR technician.
September 12, 1999 through September 16, 1999	Power failure causes air quality monitor electrical bypass switch to open. Switch was reset by the independent auditor. Air quality data missing for the period.
September 16, 1999	Independent quality assurance performance audit of air quality monitoring systems.
October 19, 1999 through October 20, 1999	Quarterly calibration of air quality and meteorological monitoring systems performed by SECOR technician.

TABLE 2-4 (continued)

NUIQSUT AMBIENT AIR QUALITY MONITORING PROGRAM
SIGNIFICANT PROJECT EVENTS
APRIL 2000 THROUGH MARCH 2000

Date	Event/Comment
November 10, 1999 through November 17, 1999	All NO_x data corrected for an approximate 22 percent span drift caused by a short-duration power failure.
November 11, 1999 through November 17, 1999	ESC data logger offline; no digital data logged. Meteorological data unrecoverable, air quality data reduced from strip chart record.
November 17, 1999 through November 18, 1999	Independent quality assurance performance audit of air quality and meteorological monitoring systems.
February 24, 2000	Independent quality assurance performance audit of air quality monitoring system.
March 08, 2000	Quarterly calibration of air quality monitoring system performed by SECOR technician.

The following sub-sections provide details pertaining to adjusted data and to non-routine data losses for each specific portion of the monitoring network. Additional data losses for the period include those due to routine network operation and maintenance, calibrations, audits, and precision checks.

2.2.1 NO_x and SO_2 Data

Examination of monthly SO_2 average impacts by time of day showed that the hour containing the last half of the nightly Level 1 zero/span check (0300) displayed consistently higher SO_2 measurements. Measurements were elevated on average by 0.001 ppm, and were attributed to calibration gas contaminating ambient samples resulting from sample lines not completely being purged before sampling ambient air. To correct for this, 0.001 ppm was subtracted from the measured hourly average SO_2 data collected during the hour ending 0300 of each day of each quarter, with the exception of the fourth quarter 1999. During this quarter, the purging problem was not evident, and the correction was not necessary.

To take advantage of firmware releases designed to fix known programming flaws, a SECOR technician was on-site on April 24, 1999 to replace the EPROM chip in the Environmental Systems Corporation (ESC) data logger. The first replacement chip was faulty, and the data logger was offline until April 27, 1999 when a second replacement chip arrived on-site and was successfully installed.

NO_x data were invalidated starting at 0300 on May 27 to 1400 on July 16 due to a failed analyzer sample pump. Shortly after the pump was repaired, two instances of a blown fuse in the NO_x monitor caused data to be invalidated from 0500 on June 20 through 0000 on July 3.

On September 12, a power failure caused a system protection electrical bypass switch to open. The bypass switch is designed to delay power to the air quality analyzers during an extended power failure to prevent damaging potentially frozen sampler pumps once power is restored. When the power was restored, the bypass switch did not operate properly to return power to the instrument rack; therefore, the air quality analyzers remained offline until the bypass switch was manually reset by the independent quality assurance auditor when he arrived at the shelter on September 15.

A brief power failure caused a linear shift in the NO_x instrument span that affected the instrument from November 10, 1999 until November 16, 1999. Based on available nightly Level 1 zero/span results, and pre-adjustment calibrations, NO_x data were adjusted up 22.8 percent, NO_2 data were adjusted up 23.0 percent, and NO data were adjusted up 23.2 percent. No other site instrumentation was affected by the power failure.

On November 11, 1999 at 0500, the ESC data logger failed to respond to remote commands, and stopped logging data. On November 16, the logger was rebooted and the program restored. All air quality data were reduced from strip chart record during that period and no air quality data were lost.

2.2.2 PM_{10} Data

The PM_{10} monitor performed exceptionally well during the period. With the exception of the power failures discussed in Section 2.2.1, there were no significant losses of PM_{10} data during the period.

2.2.3 Meteorological Data

Several hours were lost during the period due to frozen wind speed and direction sensors. In addition, all meteorological data were lost from April 24, 1999 through April 27, 1999 because of a data logger repair, and November 11, 1999 through November 16, 1999 as a result of ESC data logger failure. Both events are discussed in more detail in Section 2.2.1.

2.3 Network Data Recovery

Data recovery percentages for each continuous air quality and meteorological parameter have been calculated based on the total number of hours of valid data collected versus the total number of possible hours in the period. Data missing due to routine maintenance, calibrations, quality assurance audits, and data which did not satisfy program criteria for accuracy and quality assurance were considered invalid when calculating data recovery. During the monitoring year, data recovery for all meteorological parameters exceeded the minimum project goal of 90 percent per month for all months except April 1999 and November 1999. Data recovery was low in April because of a data logger repair, and in November because of a malfunctioning data logger combined with a frozen wind sensor. Data recovery for all air quality parameters exceeded the minimum goal of 80 percent per calendar quarter for all but the second quarter of 1999. During this quarter, data recovery goals for NO_2 and NO only were not met due to a combination of a bad sample pump and a malfunctioning analyzer. Table 2-5 provides a summary of both monthly and quarterly data recovery for each parameter.

2.4 Precision Statistics

Precision statistics have been calculated for the NO_x and SO_2 analyzers based on the method outlined by the EPA (1993a) and summarized in Appendix A of this report.

The average percent differences ($\bar{d}_j$) between known input concentrations and the observed analyzer responses for the NO_x and SO_2 analyzers have been calculated along with the standard deviation of the percent differences (S_j), and the upper and lower 95 percent probability limits (U_{95}, L_{95}) based on the total number of precision checks (N) performed during the period. The NO_2, NO, and SO_2 precision results, shown in Table 2-6 and Table A-1 in Appendix A, indicate that the air quality analyzers operated within the tolerances listed in Table 2-1.

Precision of the PM_{10} monitor is evaluated each business day by determining whether the main and bypass flow rates are correct to within ± 2 percent of the respective set points. This method of determining the monitor precision is recommended as an alternate procedure (EPA 1995a), provided that the instrument's internal flow meter is stable, reliable, and accurate, and that the flow meter is audited with a flow rate transfer standard at least once every six months. All flow checks for the period indicated that the monitor operated within project specifications, and all quarterly calibrations and audits confirm proper operation of the internal flow meter.

2.5 Data Accuracy

Evaluation of the accuracy of air quality and meteorological data collected during the period was a continuous process conducted daily during data collection and validation. This included analysis of daily and seasonal temporal trends and analysis of data reasonableness based on local meteorological patterns and climatology.

The meteorological and ambient air quality monitoring systems are subjected to periodic calibrations and independent quality assurance performance audits. All calibration and audit equipment is documented as traceable to authoritative standards. The purpose of these calibration and audit checks is to challenge the monitoring systems with known inputs and to verify that each instrument response is accurate to within EPA-established tolerances. Consistent with the goals of the project Monitoring Plan, four quarterly calibrations of the air quality monitoring system,

TABLE 2-5

NUIQSUT AMBIENT AIR QUALITY MONITORING PROGRAM
CONTINUOUS AIR QUALITY AND METEOROLOGICAL
DATA RECOVERY STATISTICS
APRIL 1999 THROUGH MARCH 2000

PARAMETER	APR 99 (%)	MAY 99 (%)	JUN 99 (%)	JUL 99 (%)	AUG 99 (%)	SEP 99 (%)	OCT 99 (%)	NOV 99 (%)	DEC 99 (%)	JAN 00 (%)	FEB 00 (%)	MAR 00 (%)	Quarter 2, 1999 (%)	Quarter 3, 1999 (%)	Quarter 4, 1999 (%)	Quarter 1, 2000 (%)	ANNUAL 2000 (%)
Meteorological																	
10-m Wind Speed	85.7	99.7	100.0	99.7	100.0	99.4	99.7	47.2	97.6	98.0	95.0	98.1	96.2	99.7	81.9	97.1	93.6
10-m Wind Direction	85.7	99.7	100.0	99.7	100.0	99.4	99.7	80.4	98.3	98.0	95.0	98.1	96.2	99.7	92.9	97.1	96.5
10-m Sigma-Theta (σ_θ)	85.7	99.7	100.0	99.7	100.0	99.4	99.7	80.4	98.3	98.0	95.0	98.1	96.2	99.7	92.9	97.1	96.5
2-m Temperature	85.7	99.7	100.0	99.7	100.0	99.4	99.6	81.3	99.9	100.0	100.0	100.0	96.2	99.7	93.7	100.0	97.4
Air Quality																	
Nitrogen Dioxide (NO_2)	83.1	82.8	11.9	91.0	99.3	84.7	98.4	97.5	98.5	99.3	98.9	98.8	57.0	91.8	98.1	99.0	87.3
Nitric Oxide (NO)	83.1	82.8	11.9	91.0	99.3	84.7	98.4	97.5	98.5	99.3	98.9	98.8	57.0	91.8	98.1	99.0	87.3
Sulfur Dioxide (SO_2)	83.1	98.1	98.2	97.4	99.3	84.7	98.4	97.9	98.5	99.3	98.9	98.8	94.3	93.9	98.3	99.0	96.4
Particulate (PM_{10})	100.0	98.7	93.1	95.8	100.0	83.2	98.8	97.6	99.6	100.0	99.3	99.2	96.3	93.1	98.7	99.5	96.9
Meteorological Only	85.7	99.7	100.0	99.7	100.0	99.4	99.7	72.3	98.5	98.5	96.2	98.6	96.2	99.7	90.4	97.8	96.0
Air Quality Only	84.6	90.6	53.8	93.8	99.5	84.3	98.5	97.6	98.8	99.5	99.0	98.9	75.2	92.6	98.3	99.1	91.9
ALL CONTINUOUS PARAMETERS	85.2	95.2	76.9	96.8	99.7	91.9	99.1	85.0	98.6	99.0	97.6	98.7	85.9	96.2	94.3	98.5	94.0

TABLE 2-6

NUIQSUT AMBIENT AIR QUALITY MONITORING PROGRAM
NO_2, NO, AND SO_2 PRECISION STATISTICS
APRIL 1999 THROUGH MARCH 2000

Analyzer	Number of Precision Checks (N)	Average Percent Difference ($\bar{d}_j$)	Standard Deviation (S_j)	Upper 95% Probability Limit (U_{95})	Lower 95% Probability Limit (L_{95})
NO	55	1.7	4.3	10.2	-6.7
NO_2	52	2.0	4.1	10.0	-6.1
SO_2	58	-2.0	2.9	3.7	-7.7

and two semi-annual calibrations of the meteorological monitoring system were performed. In addition to these quality assurance activities performed by SECOR, four quarterly independent performance audits of the air quality monitoring system, two semi-annual independent performance audits of the meteorological monitoring system, one annual independent field systems audit, and one systems audit of the data handling, validation, processing, and reporting procedures at the Fort Collins SECOR office were performed by AMSTech during the period.

Specific calibration and independent quality assurance audit details, including data forms, can be found in the respective quarterly data reports.

3.0 MONITORING NETWORK DATA SUMMARY

This chapter provides a summary and analysis of the air quality and meteorology data collected at the Nuiqsut monitoring station during the monitoring year.

It is useful to discuss seasonal trends when analyzing annual data sets. The notion of seasons as it is typically understood at mid-latitudes loses meaning when applied to latitudes as far north as Nuiqsut. The ambiguity in defining seasons is linked to the fact that at high northern latitudes days of 24-hour darkness rapidly give way to days of 24-hour daylight, and freezing temperatures can be experienced during any month of the year. Instead of defining four seasons, the Barrow National Weather Service office suggests that this area experiences two seasons, winter and summer, separated by a month of rapid transition in May and October. Therefore, for the remainder of this report winter will be defined as November through April, and summer as June through September.

3.1 Air Quality Data

The criteria pollutants monitored as part of the Nuiqsut Ambient Air Quality Monitoring Program are nitrogen dioxide (NO_2), sulfur dioxide (SO_2), and inhalable particulate less than 10 μm in diameter (PM_{10}). Criteria pollutants are those air pollutants for which the ADEC has established Alaska Ambient Air Quality Standards (AAAQS). These standards provide a threshold above which risk to public health and welfare becomes an issue. The applicable AAAQS, along with ambient concentrations measured at the site, are presented in Table 3-1 and summarized by pollutant below.

3.1.1 Nitrogen Dioxide

Table 3-1 and Figures 3-1 through 3-5 present the table and plots used to summarize the NO_2 data collected during the monitoring year. In summary, the data shows that the annual average of hourly NO_2 concentrations is just above instrument detection, and well below applicable AAAQS. The low annual average is a reflection of the fact that nearly half of the measurements were below instrument detection. Since only half of the measurements are above detection, only a few meaningful trends could be found in the data set. Summer seasonal averages were lower than winter seasonal averages as a result of increases in background values, and in local NO_2 producing activities during the winter. The highest concentrations were measured when winds transport air

TABLE 3-1
NUIQSUT AMBIENT AIR QUALITY MONITORING PROGRAM
MEASURED NO_2, SO_2 and PM_{10} CONCENTRATIONS
APRIL 1999 THROUGH MARCH 2000

Monitoring Period	Period Average NO_2 Concentration (ppm)	Maximum 3-Hour SO_2 Concentration (ppm)	Maximum 24-Hour SO_2 Concentration (ppm)	Period Average SO_2 Concentration (ppm)	Maximum 24-Hour PM_{10} Concentration ($\mu g/m^3$)		Period Average PM_{10} Concentration ($\mu g/m^3$)	
					Standard	Actual	Standard	Actual
Apr-99	0.001	0.002	0.001	0.000	7.0	8.5	6.5	7.7
May-99	0.001	0.002	0.001	0.000	7.9	8.8	5.8	6.4
Jun-99	0.001	0.010	0.002	0.001	42.6	45.8	6.7	7.1
Jul-99	0.001	0.001	0.001	0.001	86.1	91.8	14.6	15.3
Aug-99	0.001	0.001	0.001	0.001	97.0	101.0	12.5	13.1
Sep-99	0.001	0.001	0.001	0.001	7.3	7.6	4.2	4.5
Oct-99	0.001	0.003	0.001	0.001	222.9	247.3	25.5	28.4
Nov-99	0.002	0.002	0.001	0.000	11.3	13.1	4.6	5.4
Dec-99	0.001	0.002	0.000	0.000	6.1	7.2	3.9	4.8
Jan-00	0.007	0.003	0.001	0.000	9.7	11.2	5.3	6.4
Feb-00	0.012	0.001	0.000	0.000	9.8	11.8	5.6	6.7
Mar-00	0.006	0.002	0.000	0.000	8.6	10.3	4.7	5.7
Apr 99 - Jun 99	0.001	0.010	0.002	0.000	42.6	45.8	6.3	7.1
Jul 99 - Sep 99	0.001	0.001	0.001	0.001	97.0	101.0	10.4	11.0
Oct 99 - Dec 99	0.001	0.003	0.001	0.000	222.9	247.3	11.3	12.9
Jan 00 - Mar 00	0.008	0.003	0.001	0.000	9.8	11.8	5.2	6.3
To Date	0.003	0.010	0.002	0.000	222.9	247.3	8.3	9.3
AAAQS	**0.053** [1]	**0.5**	**0.14**	**0.03** [1]	**150**	**n/a**	**50** [1]	**n/a**

[1] Annual average

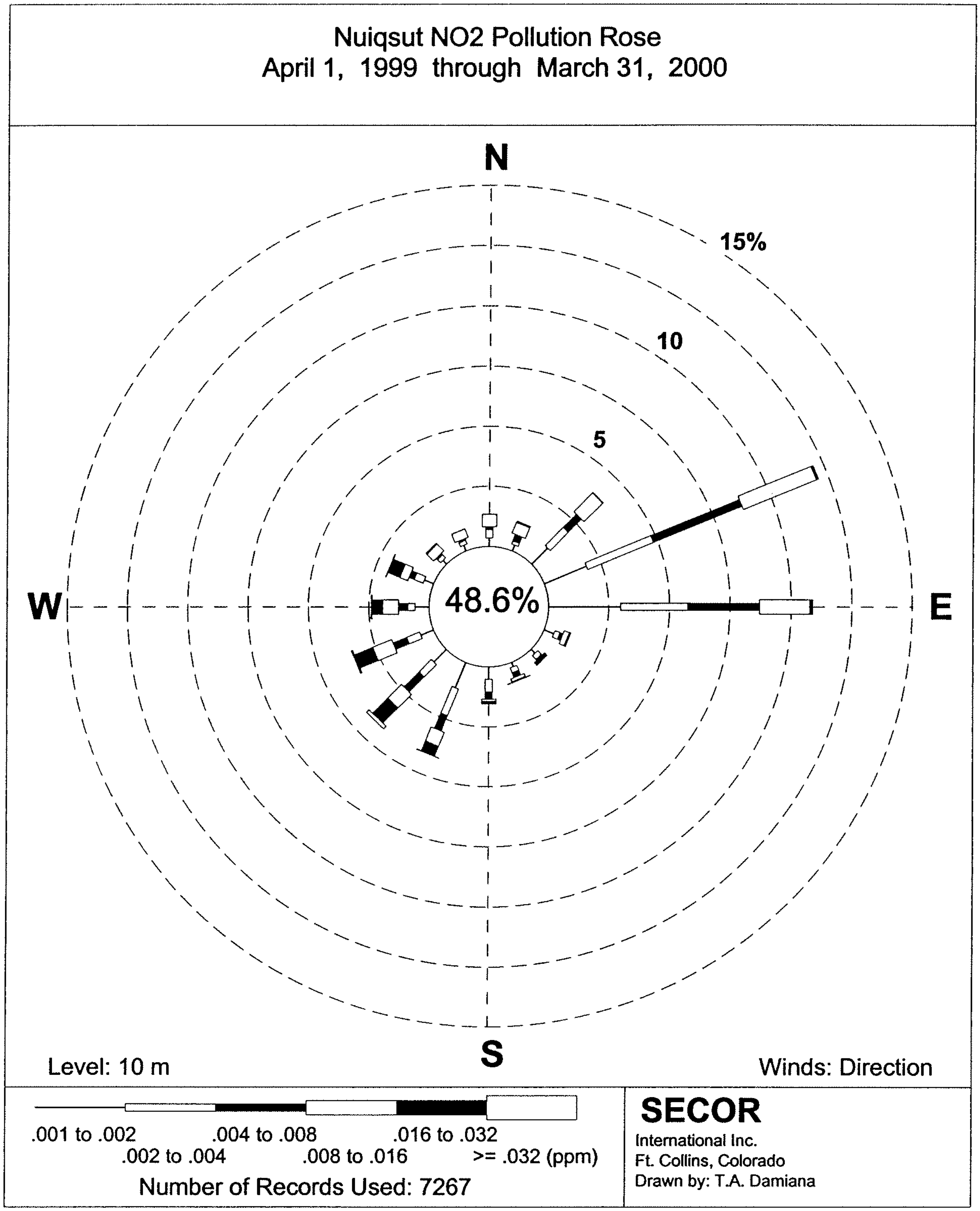


FIGURE 3-1: NO_2 FREQUENCY ANALYSIS BY WIND DIRECTION

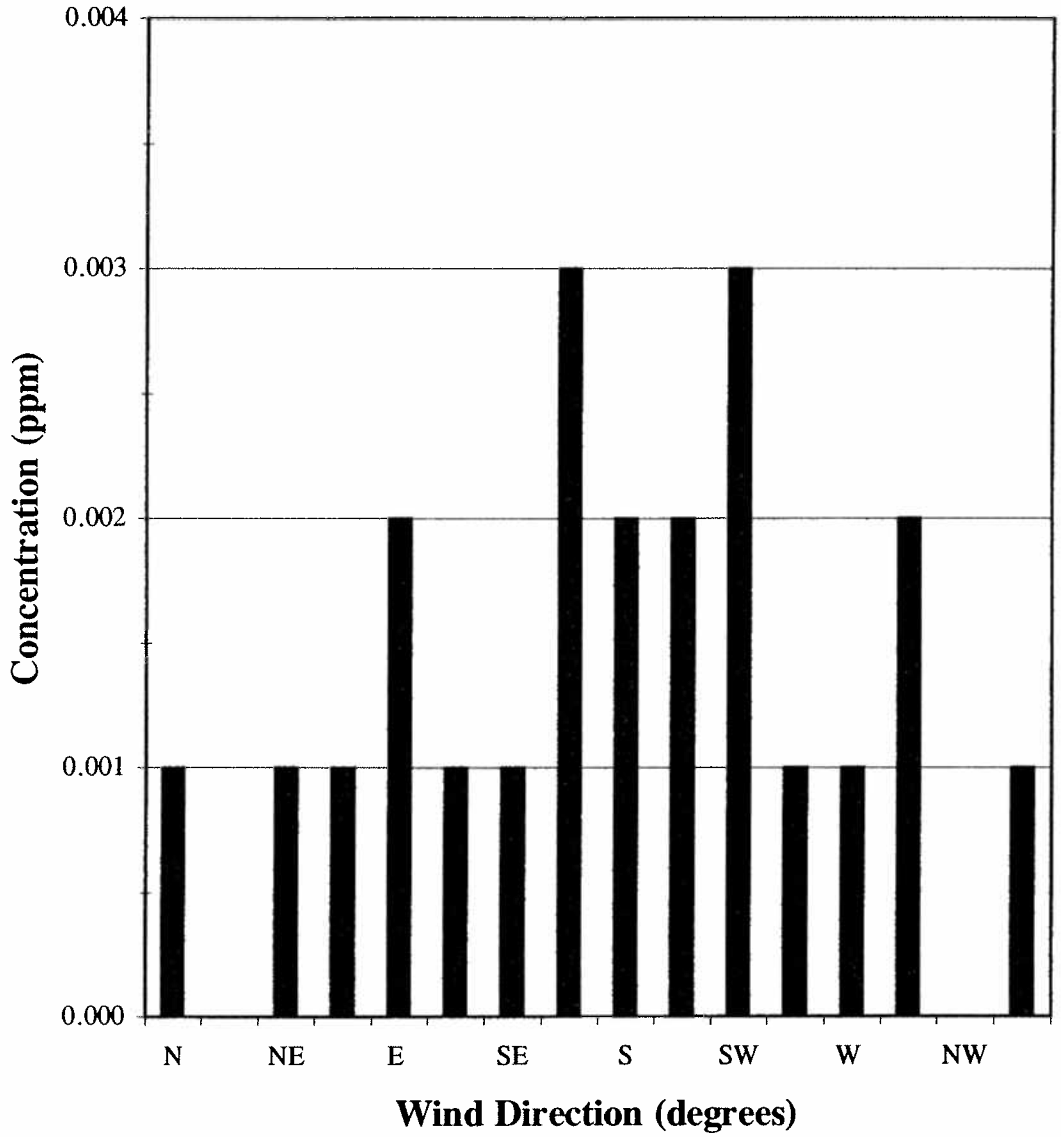


FIGURE 3-2: NO_2 CONCENTRATION BY WIND DIRECTION

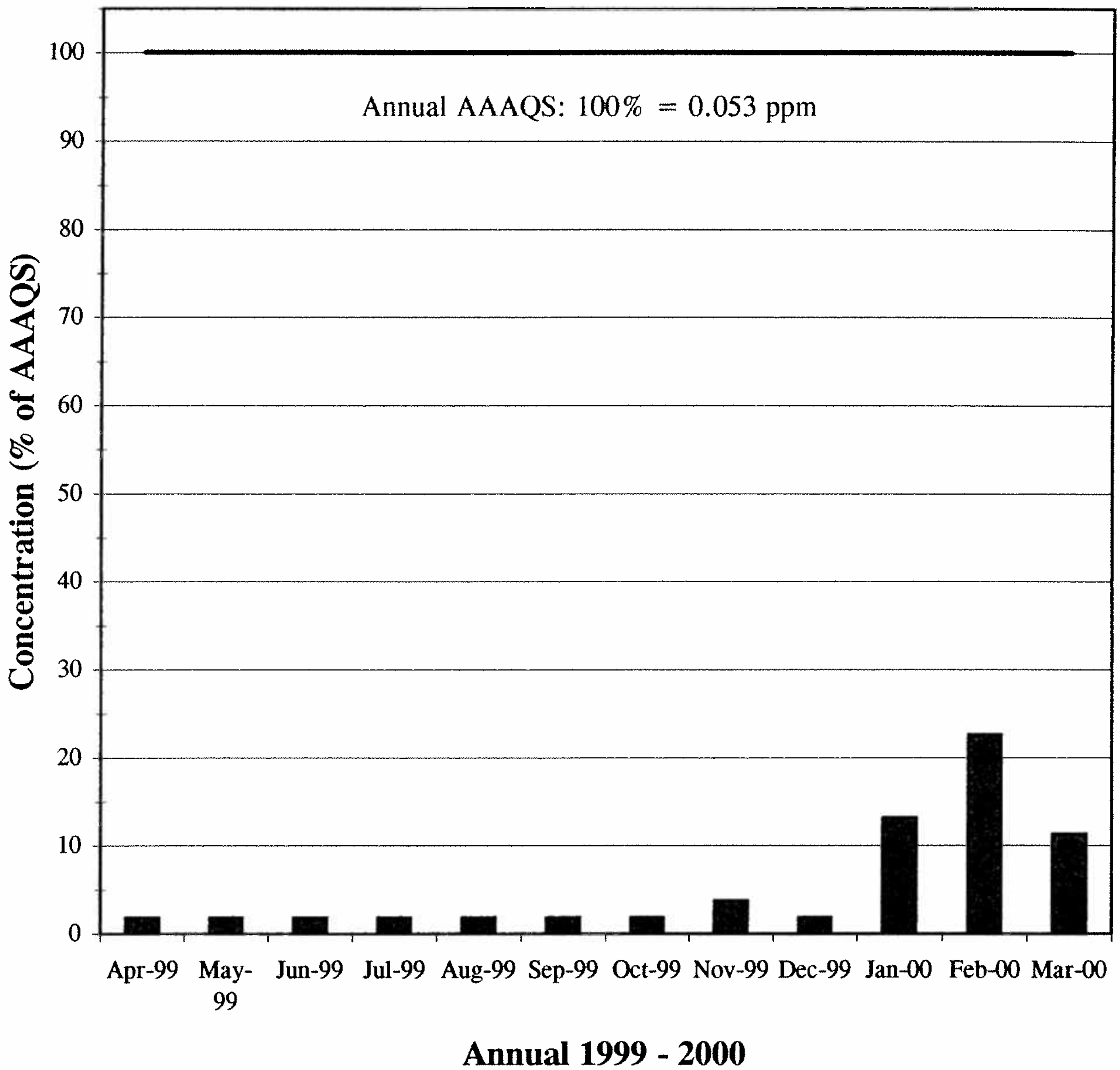


FIGURE 3-3: NO_2 CONCENTRATION BY MONTH

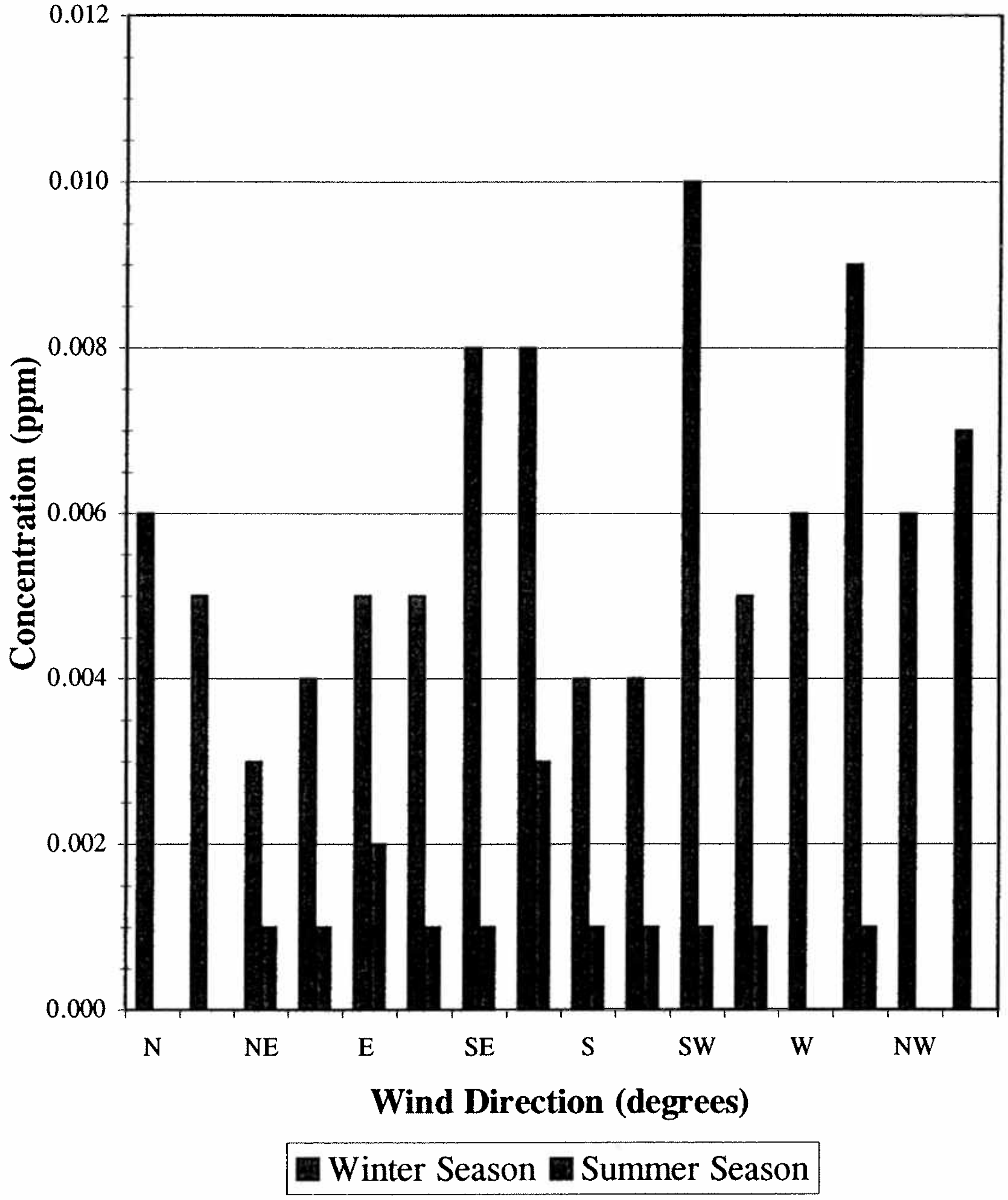


FIGURE 3-4: NO_2 CONCENTRATION BY WIND DIRECTION AND SEASON

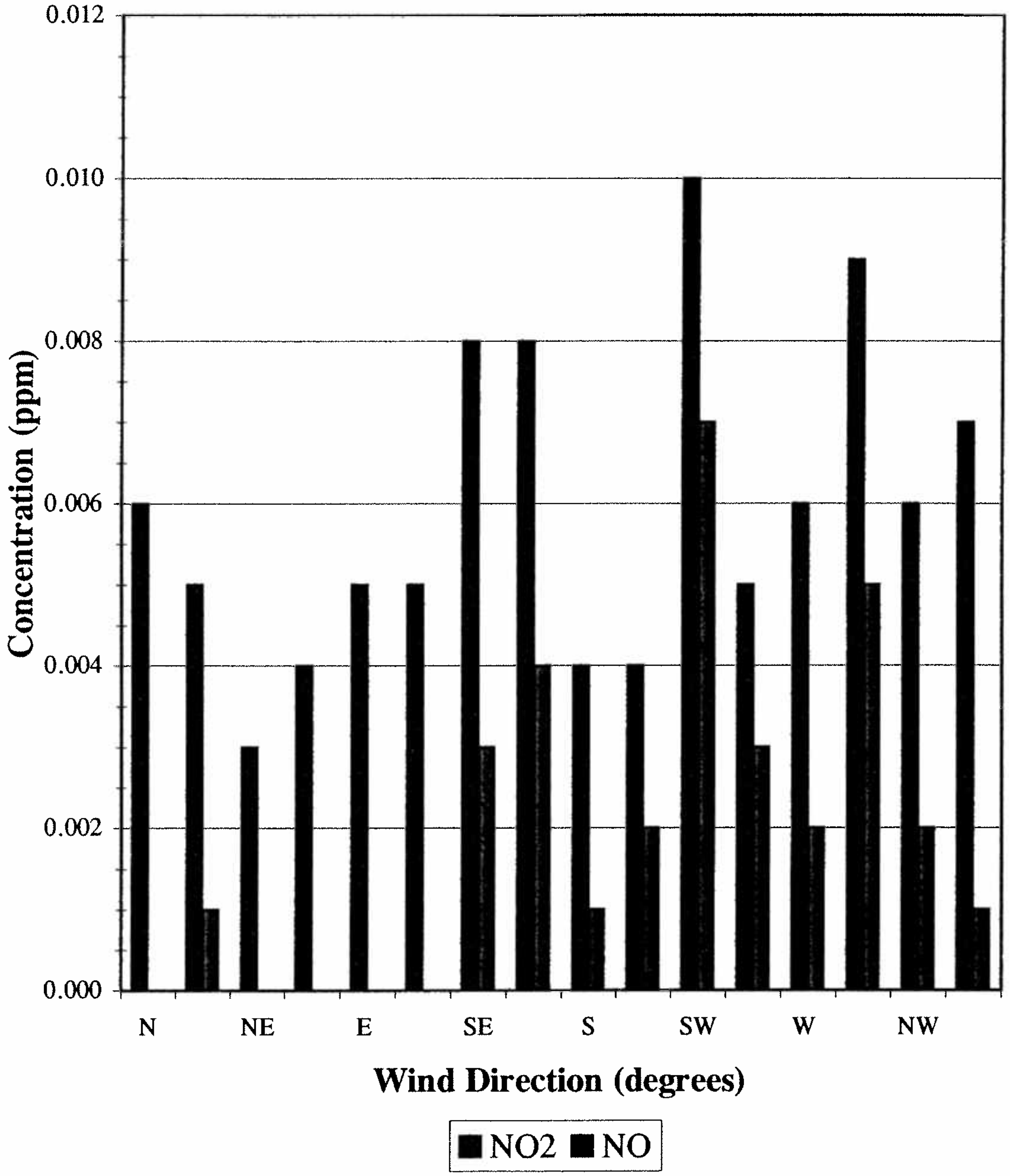


FIGURE 3-5: COMPARISON OF WINTERTIME NO AND NO_2 CONCENTRATIONS BY WIND DIRECTION

from the village to the monitoring site. This trend is a result of the proximity of the village sources to the monitoring site and not an indication of the amount of NO_2 produced or the number of sources in the village.

Table 3-1 compares measured impacts to applicable AAAQS. The annual average NO_2 concentration was 0.003 ppm compared to the annual NO_2 AAAQS of 0.053 ppm. Had it not been for the high first quarter 2000 average of 0.008 ppm, the annual average would have been at the instrument detection limit of 0.001 ppm. Even with the first quarter 2000 included in the average, the annual average NO_2 concentration is still just above instrument detection and only 5.7 percent of the AAAQS.

The highest hourly concentration measured during the monitoring year was 0.053 ppm and was measured during light winds from the southwest in the early morning of February 23, 2000. Based on the direction, magnitude, and timing of the concentration, this measurement probably resulted from parked but running vehicles or construction equipment in the vicinity of the Kuukpik Hotel.

A frequency analysis of hourly NO_2 measurements by wind direction is shown in Figure 3-1. This analysis shows the following characteristics of the ambient NO_2 concentrations measured at Nuiqsut:

- Almost half of the hourly measurements (48.6 percent) were below 0.001 ppm, as shown in the center ring of the plot.

- The highest concentrations (reflected in the width of the plot spokes) were measured during south-southwesterly through west-northwesterly winds which transport air from the village to the monitoring site.

- The top one percent of measurements from the south-southeast through west-northwest directions were 0.016 ppm or higher, and from the northeast through easterly directions were between 0.008 and 0.016 ppm. One percent of the measurements (73 hours) represents a statistically significant sample to show and compare fixed source strength, rather than transient sources which tend to produce statistically insignificant short duration-maximums. Source geometry dictates that winds from the northeast through easterly directions represent remote sources (i.e., North Slope oil and gas production facilities) transporting background air to the village, and winds from the south-southwest through west-northwesterly directions represent maximums associated with activities in and around the village. Based on the one percent maximums, and the source geometry, it can be concluded that maximum concentrations measured from remote sources were lower than those from sources associated with the village because these sources are closer to the monitoring site. As the distance to the source increases, so does the plume dispersion, resulting in a decrease in measured concentration. Outside the village, the next closest North Slope sources are at the Alpine complex, located over 14 kilometers to the north, and the Kuparuk River Unit, located over 40 kilometers to the east. This large disparity in the distance to sources makes the magnitude of the measured concentrations a better indicator of the proximity of the source rather than the source strength.

The average NO_2 concentrations as a function of wind direction for the monitoring year are presented in Figure 3-2. Average concentrations by wind direction show slightly higher values when winds are from south-southeast through southwest. Again, this is a reflection of the fact that the nearest sources are those located in Nuiqsut while all other sources are located at least 14 kilometers from the monitoring station.

Monthly average NO_2 concentrations for the monitoring year are presented in Figure 3-3. This figure shows that, with the exception of the last three months of the monitoring year, monthly averages reflect the nearly undetectable annual average of 0.001 ppm. In the last three months of the monitoring year, the monthly average jumped to 0.008 ppm. As was discussed in the first quarter 2000 report, this resulted from both an increase in winter background levels, and an increase in local NO_2 producing activities. Local NO_2 producing activities that were known to increase include residential heating activities and utility construction activities immediately south of the monitoring site.

The differences between summer and winter seasonal averaged hourly impacts as a function of wind direction are shown in Figure 3-4. This figure makes it clear that average concentrations measured during all wind directions transporting background air to the village (northwest through southeast) during the winter were almost 0.005 ppm higher than during the summer. This is a good indication that remote NO_2 producing activities increased during the winter. Seasonally averaged hourly impacts measured when winds were from the village show the same 0.005 ppm increase during the winter, supporting the conclusion that near-field NO_2 producing activities increased during the winter as well.

Figure 3-5 illustrates a special characteristic of NO_2 impacts which is particularly visible in the winter at Nuiqsut. One of the precursors to atmospheric NO_2 is nitric oxide (NO), which is a typical by-product of any combustion process. Once NO is released into the atmosphere, it readily reacts with O_3 to produce NO_2 according to the reaction:

$$NO + O_3 \rightarrow NO_2 + O_2$$

Provided there is an abundance of O_3, this rapid reaction dictates that the farther from the combustion source the NO is transported, the higher the ratio of NO_2 to NO becomes. Figure 3-5 shows the average winter concentrations of NO and NO_2 as a function of wind direction. Clearly, concentrations measured from northwest through east-southeasterly directions have a high ratio of NO_2 to NO or a complete absence of NO, indicating large transport times and distances for plumes from combustion sources from this direction. This is a clear indication that most of the impacts measured from these wind directions are background air from remote sources. Conversely, the low NO_2 to NO ratio from southeast through west-northwesterly directions, or from the village, indicate the close proximity of the sources to the monitoring station.

3.1.2 Sulfur Dioxide

There were only 87 hours during the monitoring year when measured SO_2 concentrations were 0.002 ppm or higher. Of these, only 18 SO_2 measurements were above 0.003 ppm. The small amount of measurements above what could be instrument drift (0.002 ppm) makes a discussion of meaningful trends impossible. What has been true for each quarter is the case for the monitoring year; there was no single near-field or far-field source of measurable SO_2 indicated by the data collected. Without identifiable sources, measured concentrations are representative of a regional background signature. The low average concentrations measured are consistent with the rural environment of the site.

Table 3-1 lists the measured maximum 3-hour (running) and 24-hour (midnight-to-midnight) average SO_2 concentrations for each month of the quarter, as well as the annual average SO_2 concentration. Concentrations for all three averaging periods were near the instrument detection limit and are well below the applicable AAAQS.

3.1.3 Inhalable Particulate Matter (PM_{10})

Table 3-1 and Table 3-2, and Figures 3-6 through 3-9 present the table and figures used to summarize the PM_{10} data collected this monitoring year. Daily averaged PM_{10} concentrations violated the AAAQS on one occasion in early October. Despite this and other high daily impacts, annual averaged impacts were low compared to the AAAQS. Annually averaged PM_{10}

TABLE 3-2
NUIQSUT AIR QUALITY PROGRAM
MAXIMUM DAILY AVERAGED PM_{10} MEASUREMENTS
APRIL 1999 THROUGH MARCH 2000

Ranking	24-hour PM_{10} Concentration ($\mu g/m^3$)	24-hour Period		Wind Speed (m/s)	Wind Direction (degrees)
		Year	Date		
1	222.9	1999	October 4	11.3	83.3
2	128.4	1999	October 5	13.3	82.2
3	97.0	1999	August 3	6.6	98.0
4	92.2	1999	October 6	14.4	81.7
5	86.1	1999	July 25	7.8	82.0
6	82.9	1999	October 3	9.7	80.7
7	68.3	1999	July 14	6.3	88.6
8	55.3	1999	July 26	8.8	73.6
9	44.8	1999	October 2	12.0	80.5
10	42.6	1999	June 21	10.8	74.2
11	38.5	1999	August 6	3.3	6.2
12	28.2	1999	August 21	9.6	89.6
13	24.5	1999	July 13	5.8	92.2
14	23.1	1999	June 16	8.4	70.8
15	22.9	1999	August 7	4.5	56.9

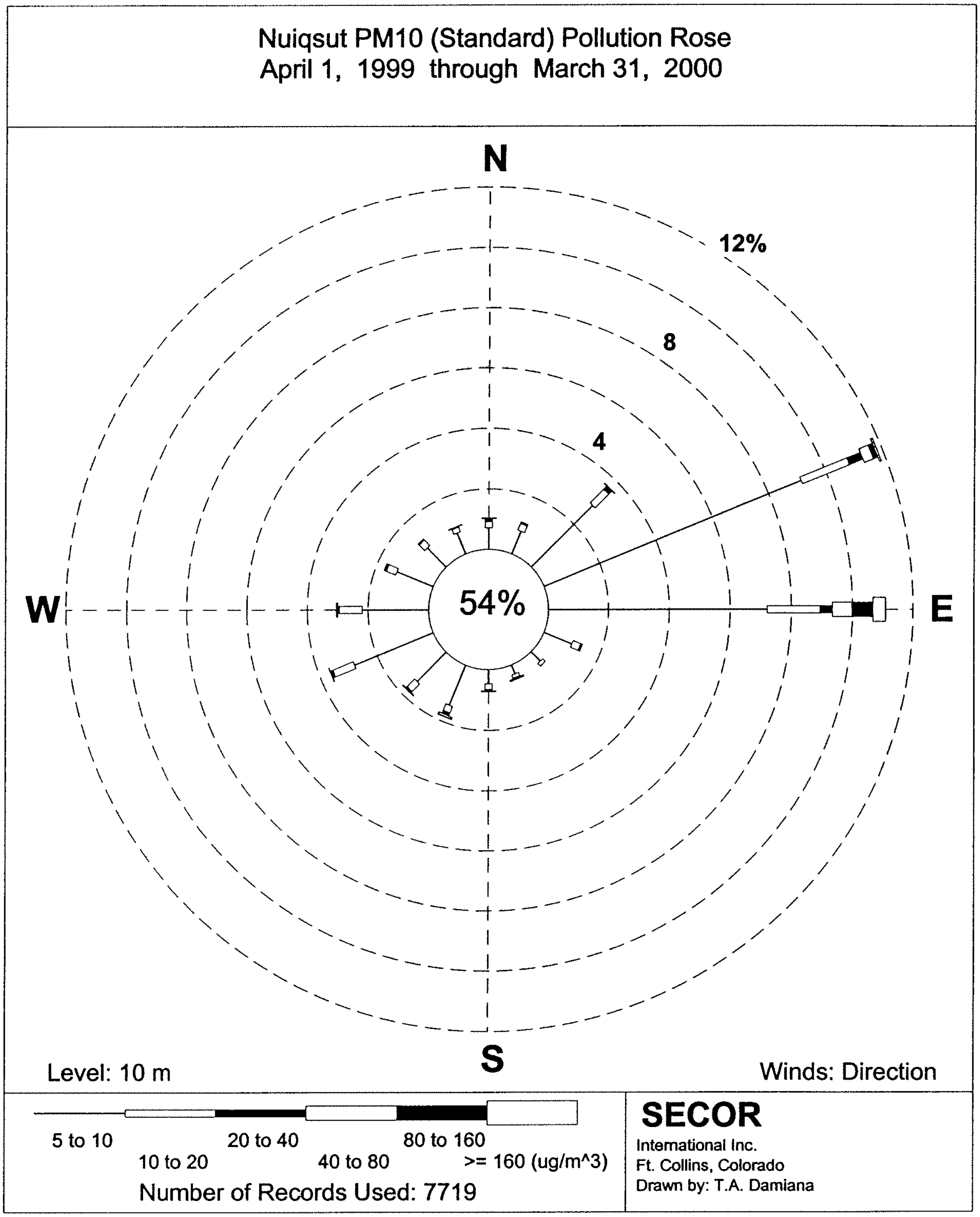


FIGURE 3-6: PM_{10} FREQUENCY ANALYSIS BY WIND DIRECTION

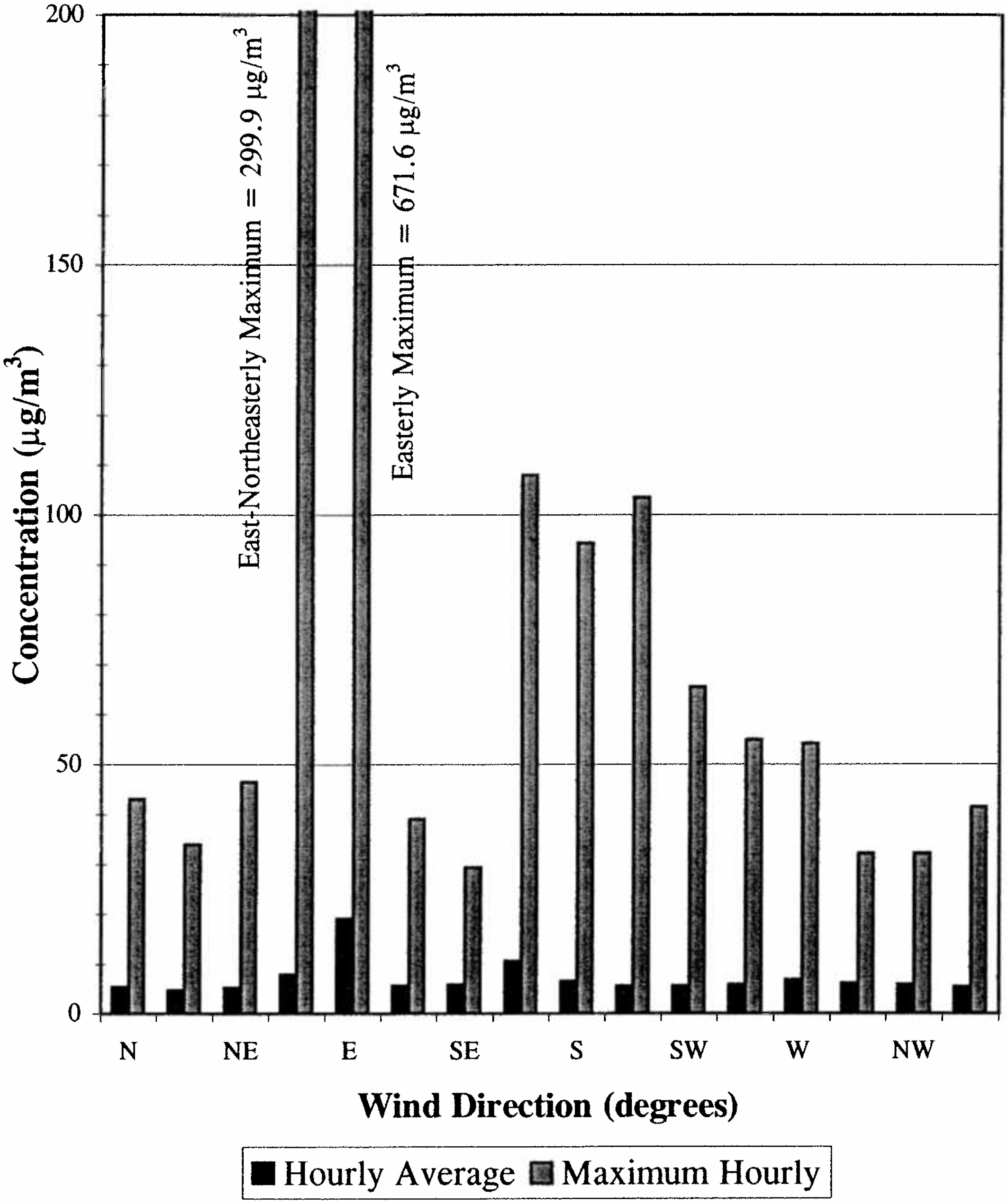


FIGURE 3-7: PM_{10} CONCENTRATION BY WIND DIRECTION

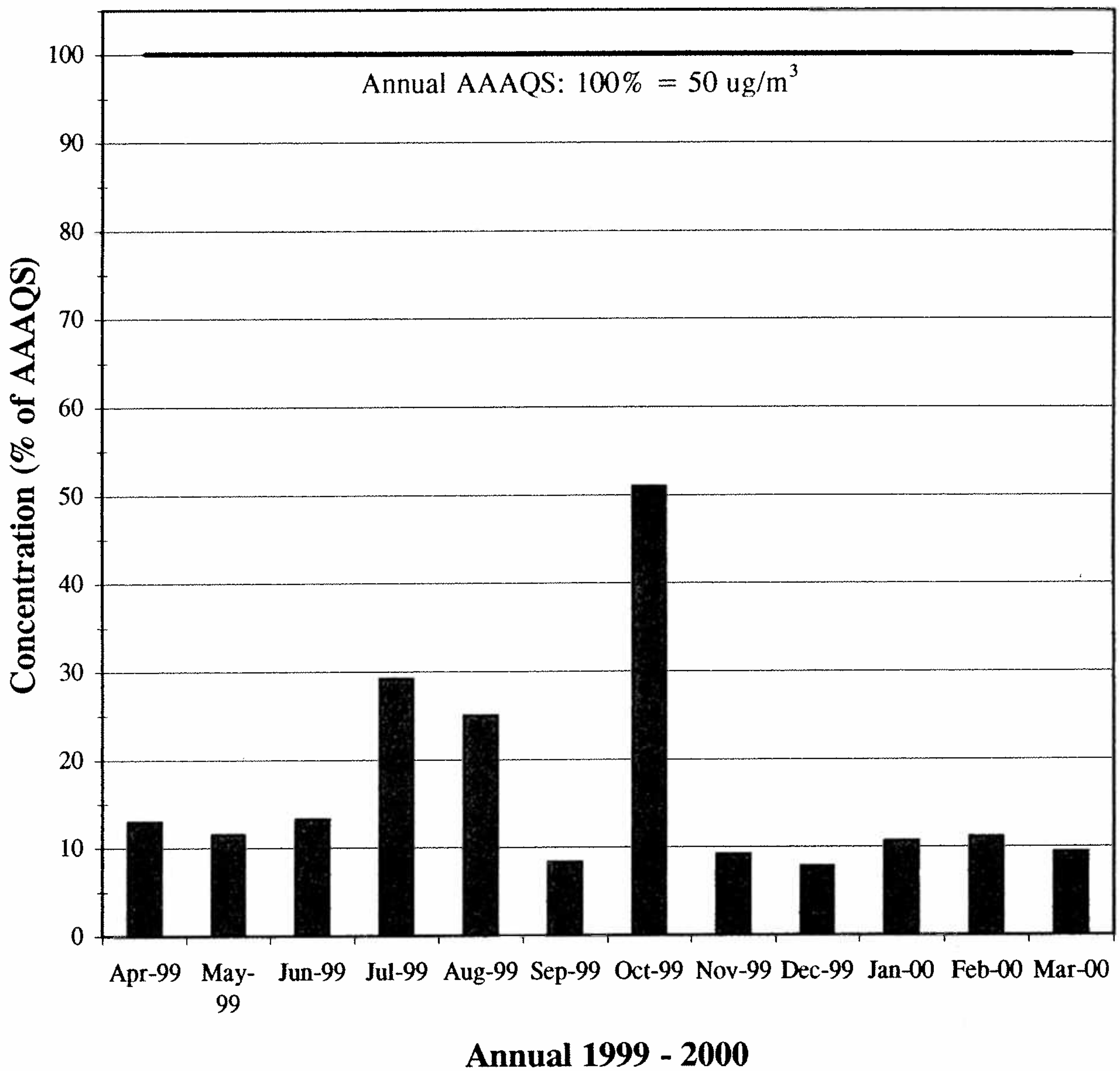


FIGURE 3-8: PM_{10} CONCENTRATION BY MONTH

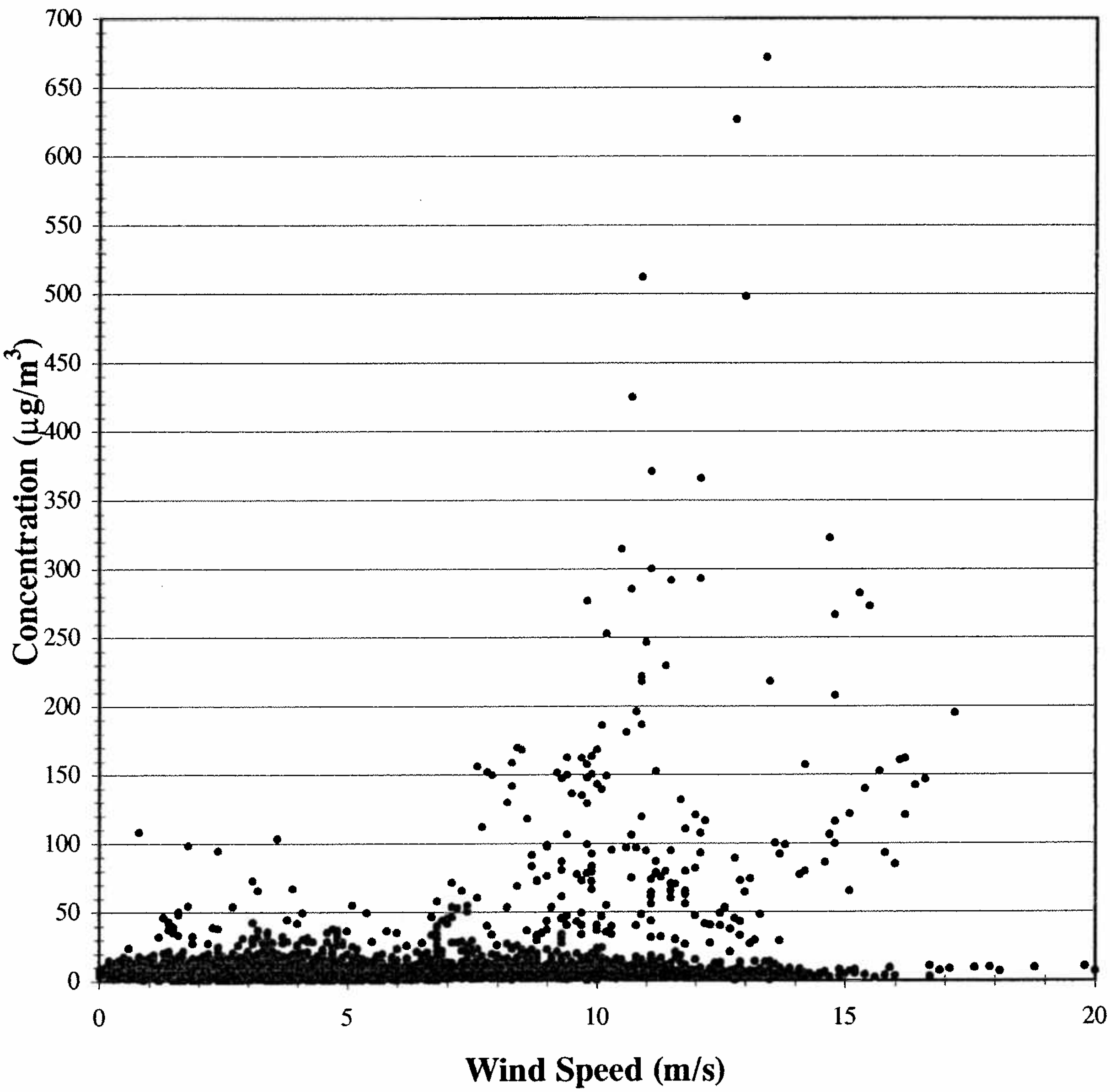


FIGURE 3-9: CORRELATION BETWEEN PM_{10} CONCENTRATION AND WIND SPEED

concentrations were low because for most of the year, the frozen and snow covered ground eliminates fugitive sources of measurable concentrations. In summary, the data shows that PM_{10} impacts are a result of naturally occurring wind blown fugitive dust. The single most identifiable source of wind blown fugitive dust, based on the data collected and discussions with City of Nuiqsut personnel, is the exposed river bank of the Nechelik channel to the east of the monitoring site. When fugitive dust from this source is not present (i.e., during winter), hourly concentrations drop to or below the instrument detection limit.

PM_{10} has a 24-hour (midnight-to-midnight) AAAQS of 150 $\mu g/m^3$, and an annual AAAQS of 50 $\mu g/m^3$, measured at standard temperature and pressure conditions. As listed in Table 3-1, the maximum 24-hour PM_{10} concentration measured during the monitoring period was 222.9 $\mu g/m^3$, which exceeds the 24-hour AAAQS. The second highest 24-hour concentration was 128.4 $\mu g/m^3$, which is below the AAAQS. The annual average PM_{10} concentration compared against the annual PM_{10} AAAQS, was 8.3 $\mu g/m^3$. This is well below the annual AAAQS.

The highest 24-hour PM_{10} concentration occurred on October 4, 1999, a day with east-northeasterly through easterly winds and speeds in excess of 10 m/s. This high impact is consistent with the discussion in the third quarter 1999 report, which concluded that high measured particulate concentrations resulted from high winds transporting dust from the thawed, exposed Nechelik channel bank to the east of the village. This conclusion was supported by discussions with Nuiqsut residences.

A frequency analysis of 1-hour average PM_{10} measurements by wind direction is shown in Figure 3-6. This analysis shows the following characteristics of the ambient PM_{10} measured at Nuiqsut this quarter:

- 54 percent of the measurements were below the instrument detection limit of 5 $\mu g/m^3$, as shown in the center ring of the plot. The high percentage of low measurements is explained by the rural environment of the site combined with the absence of wind blown fugitive dust during a large part of the year when the ground is frozen and or snow covered.

- The highest hourly measurements (reflected in the width of the spokes) were measured during east-northeast through easterly winds which are responsible for transporting particulate from the bank of the Nechelik channel to the monitoring site.

Maximum and average PM_{10} concentrations as a function of wind direction over the monitoring year are shown in Figure 3-7. Average impacts as a function of wind direction indicate that concentrations measured from most directions are at or just above the instrument detection limit. One significant exception to this is average concentrations measured when winds are from east-northeasterly through easterly directions. Based on eyewitness accounts, winds from these directions are responsible for producing fugitive dust from the exposed Nechelik Channel bank which in turn results in high measured concentrations. Slightly elevated concentrations are also experienced when winds are from the south-southeast. Possible sources in this direction include the city power plant, and an un-vegetated quarter-mile-long utility right of way. Properly oriented winds may generate wind blown fugitive dust along the length of the right-of-way when it is thawed and exposed.

Referring again to Figure 3-7, two conclusions can be drawn by examining maximum hourly impacts as a function of wind direction. The highest maximums as a function of wind direction are associated with east-northeasterly through easterly winds. Again, these winds have been discussed as responsible for producing wind blown fugitive dust from the exposed bank of the Nechelik channel. High maximum hourly impacts are also seen from the direction of the village. The high maximums associated with these directions indicate that there are particulate sources in the village; potential sources include utility construction. The low averages show that these sources are neither high enough nor persistent enough to affect yearly averages, or come close to causing violations of the 24-hour AAAQS.

Figure 3-8 shows the average monthly PM_{10} concentrations measured during the monitoring year. Clearly, PM_{10} impacts are correlated to season as indicated by the near doubling of average monthly concentrations from July 1999 through October 1999. This doubling is related to the wind blown fugitive nature of the PM_{10} measured. About one month after the mean temperatures rise above freezing (mid-June), the ground has thawed and starts drying. With the ground exposed and dry, the normally high regional winds are able to produce wind blown fugitive dust through erosion, and to transport particulate to the monitoring site. This results in an increase in measured particulate concentrations. Similarly, about a month after the mean temperatures drop below freezing (mid-October), the ground becomes frozen and snow covered, and average monthly impacts once again drop to around 10 $\mu g/m^3$.

PM_{10} has been shown to be strongly correlated to wind speed in both the third and fourth quarter 1999 data reports. Figure 3-9 revisits this correlation with the full monitoring year data set. This figure plots hourly PM_{10} concentration against wind speed for all valid hours during the monitoring year. Clearly, the highest measured hourly concentrations are associated with wind speeds higher than 6 m/s. This correlation is consistent with the dependence of wind blown fugitive dust on wind speed.

Table 3-2 lists all 24-hour (midnight to midnight) averaged PM_{10} concentrations measured over 20 $\mu g/m^3$, and compares them to the average wind speed and wind direction for the same period. Of the 15 measurements listed, all but one occurred with east-northeasterly through easterly winds, and all but three of the measurements occurred in conjunction with wind speeds over 6 m/s. This is consistent with the conclusion that the highest PM_{10} impacts are associated with fugitive dust sources.

3.2 Meteorological Data

Meteorological data collected at the Nuiqsut monitoring station include temperature, wind speed, and wind direction.

3.2.1 Wind Speed and Direction Climatology

The annual Nuiqsut wind rose is presented in Figure 3-10. This figure shows that winds during the monitoring year were distinctly bi-modal, dominated by northeasterly through easterly winds (53.8 percent), and by south-southwesterly through westerly (22.9 percent) winds. The mean 10-meter wind speed for the period was 5.3 m/s while the maximum was 20.1 m/s. This climatology reflects the persistence of regional seasonal weather patterns which remain uninfluenced by flat terrain as they move through the Alaska North Slope Coastal Plain surrounding Nuiqsut.

Figure 3-11 shows the seasonal differences in the Nuiqsut wind rose between summer and winter. The seasonal wind roses indicate that there is a persistence of northeasterly through easterly winds all year long, with an increase in southwesterly through westerly winds developing during the winter.

Nuiqsut Air Quality Monitoring Program - Nuiqsut, AK
WIND ROSE ANALYSIS (PERCENT)
4/ 1/99 through 3/31/00
All Hours

WIND DIRECTION	WIND SPEED (M/S) <= 1.5	<= 3.1	<= 5.1	<= 8.2	<=10.8	>10.8	TOTAL	AVG SPEED
N	0.32	1.33	1.48	0.15	0.00	0.00	3.29	3.05
NNE	0.35	1.38	2.07	0.40	0.00	0.00	4.20	3.32
NE	0.98	2.14	3.39	3.29	0.93	0.26	11.00	4.83
ENE	0.52	1.91	4.92	8.92	6.18	2.21	24.66	6.92
E	0.31	1.32	3.75	6.53	4.10	2.17	18.18	7.14
ESE	0.19	0.71	1.86	0.65	0.06	0.00	3.46	4.03
SE	0.22	0.27	0.32	0.07	0.00	0.00	0.90	2.85
SSE	0.16	0.37	0.21	0.02	0.00	0.00	0.77	2.53
S	0.29	0.65	0.56	0.12	0.00	0.00	1.62	2.94
SSW	0.39	2.39	2.38	0.45	0.00	0.00	5.61	3.28
SW	0.41	1.36	1.92	0.51	0.01	0.00	4.21	3.45
WSW	0.62	1.17	2.06	2.33	0.75	0.76	7.69	5.61
W	0.56	0.87	1.63	1.37	0.35	0.59	5.37	5.37
WNW	0.42	0.97	1.47	0.65	0.16	0.01	3.69	3.90
NW	0.30	0.87	1.17	0.34	0.05	0.06	2.79	3.59
NNW	0.30	0.77	1.01	0.25	0.04	0.00	2.37	3.41
CALM	0.19						0.19	
TOTAL	6.54	18.50	30.21	26.06	12.64	6.06	100.00	

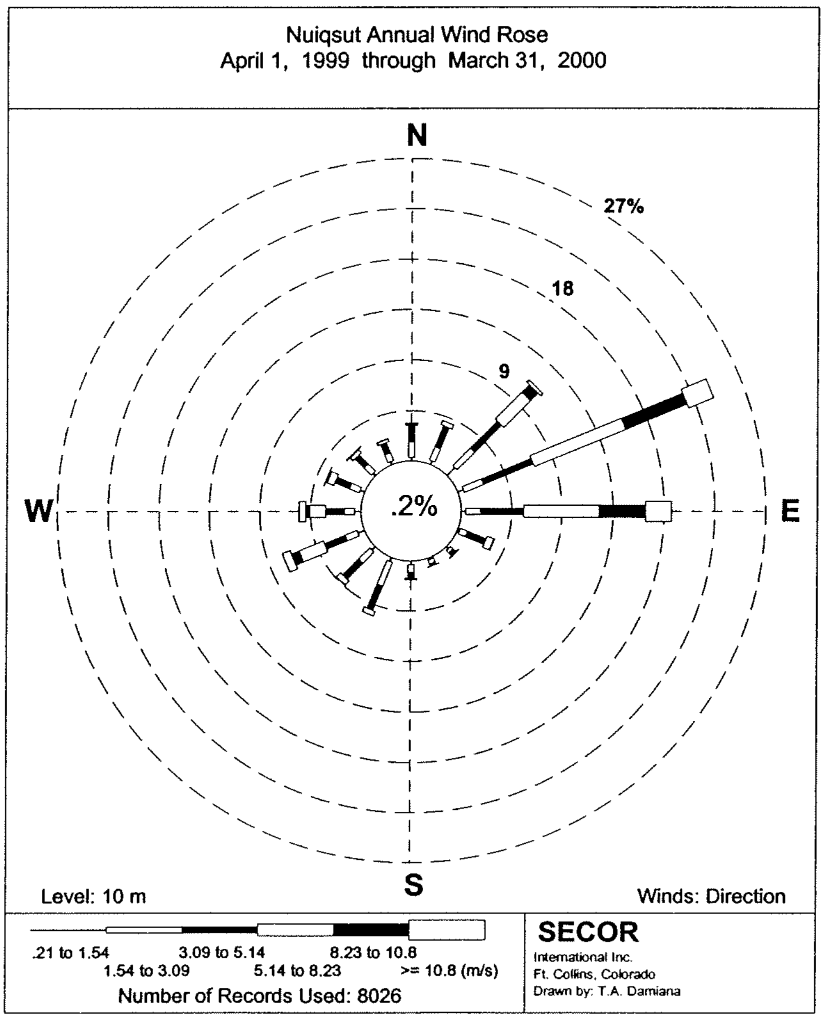
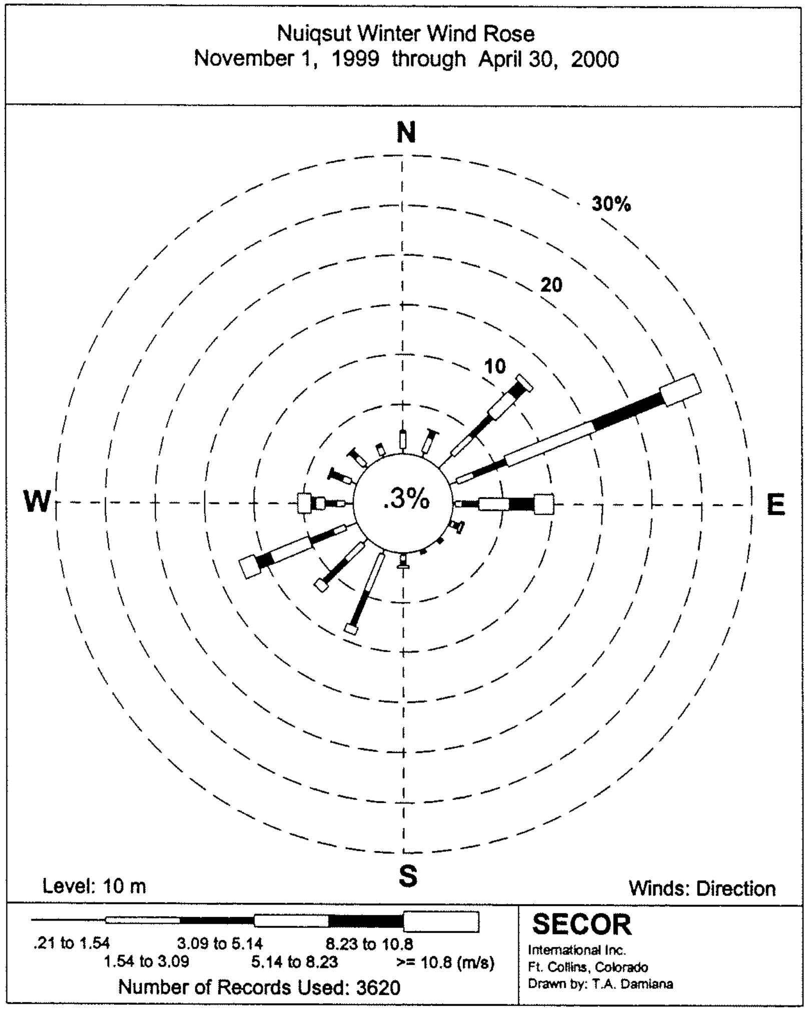


FIGURE 3-10: ANNUAL WIND ROSE



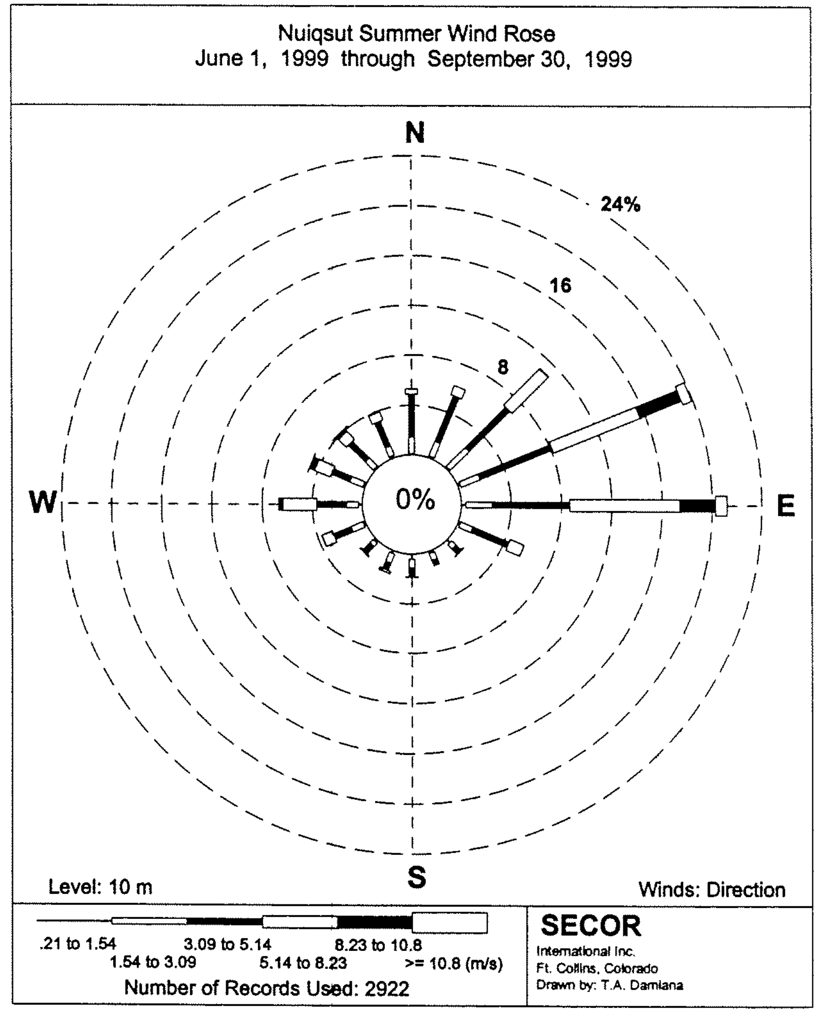


FIGURE 3-11: SEASONAL WIND ROSES

3.2.2 Stability Frequencies

The Pasquill-Gifford stability class distribution derived for the reporting period is presented in Figure 3-12. The stability class was calculated based on the observed wind speed and wind direction standard deviation (sigma-theta, or σ_θ) according to the method presented in Appendix A. Neutral stability conditions occurred approximately 70 percent of the time, with unstable and stable conditions rarely occurring. This is consistent with the regional climatology and is due to typically high wind speeds in the area creating a well-mixed surface layer.

This stability class distribution has been persistent throughout the year, and shows little seasonal variability.

3.2.3 Temperature Climatology

During the monitoring year, the hourly averaged near-surface ambient temperature reached a maximum of 27.8°C (82.0°F) in the afternoon on August 5, 1999 and a minimum of -41.5°C (-42.7°F) in the early morning of February 28. The maximum extreme temperature measured at Nuiqsut was 5.6 degrees C higher than the maximum recorded at the Barrow National Weather Service office in 50 years of data collection. The higher temperatures at Nuiqsut may be explained by the fact that Nuiqsut is further inland where high temperatures are not moderated by the ocean, and that the surrounding land allows for more radiational heating during the day. Temperature data are summarized in Figure 3-13, which displays the developing Nuiqsut temperature climatology compared to historical data collected at Barrow and at the Kuparuk River Unit Drill Site 1F monitoring station operated from 1990 through 1992. The Nuiqsut temperature climatology is also summarized in Table 3-2.

The Nuiqsut temperature climatology shown in Figure 3-13 does not follow the nearby (55 km) Kuparuk River Unit (KRU) temperature climatology as well as it was expected to. In general, Nuiqsut temperatures this monitoring year were two to three degrees C higher than at KRU. The Nuiqsut data set is still too short to say whether the data collected so far is indicative of a long-term average, or represents an anomalously warm year as the KRU data set would indicate.

NUIQSUT AIR QUALITY MONITORING SITE

April 1, 1999 - March 31, 2000

Stability Class	Percent Occurrence
Extremely Unstable	3.6
Unstable	4.1
Slightly Unstable	11.4
Neutral	69.7
Slightly Stable	8.1
Stable	3.1

(Calculated Using the Sigma-Theta Method)

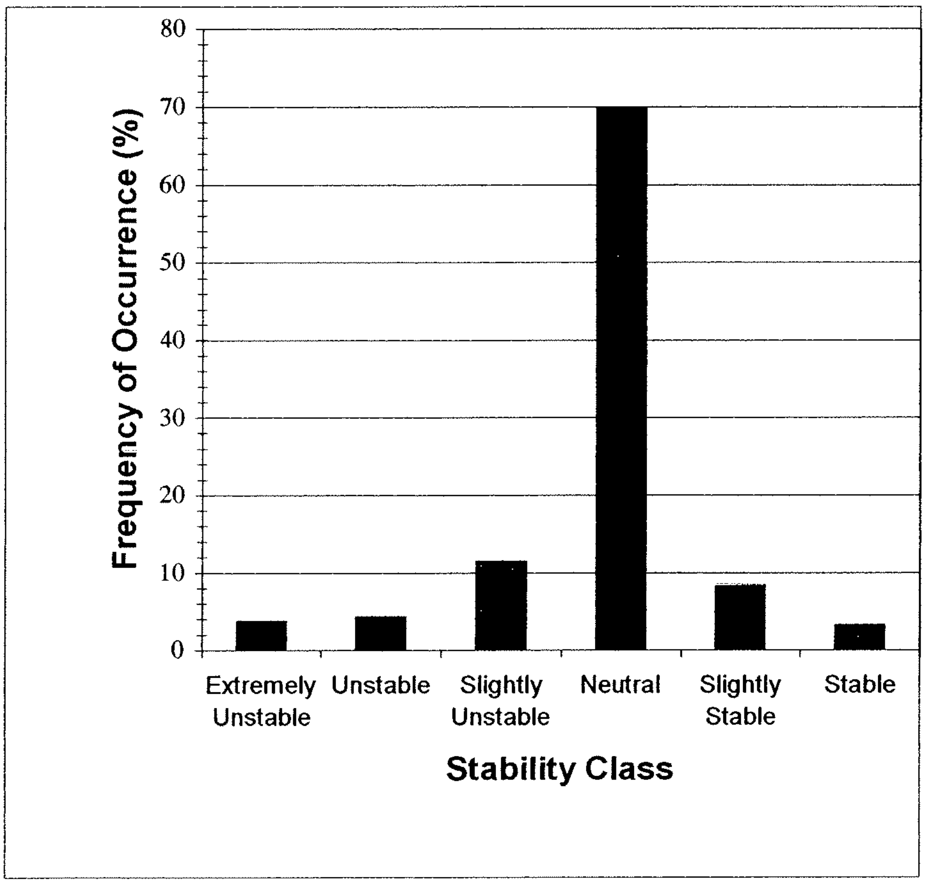


FIGURE 3-12: NUIQSUT STABILITY CLASS FREQUENCY DISTRIBUTIONS

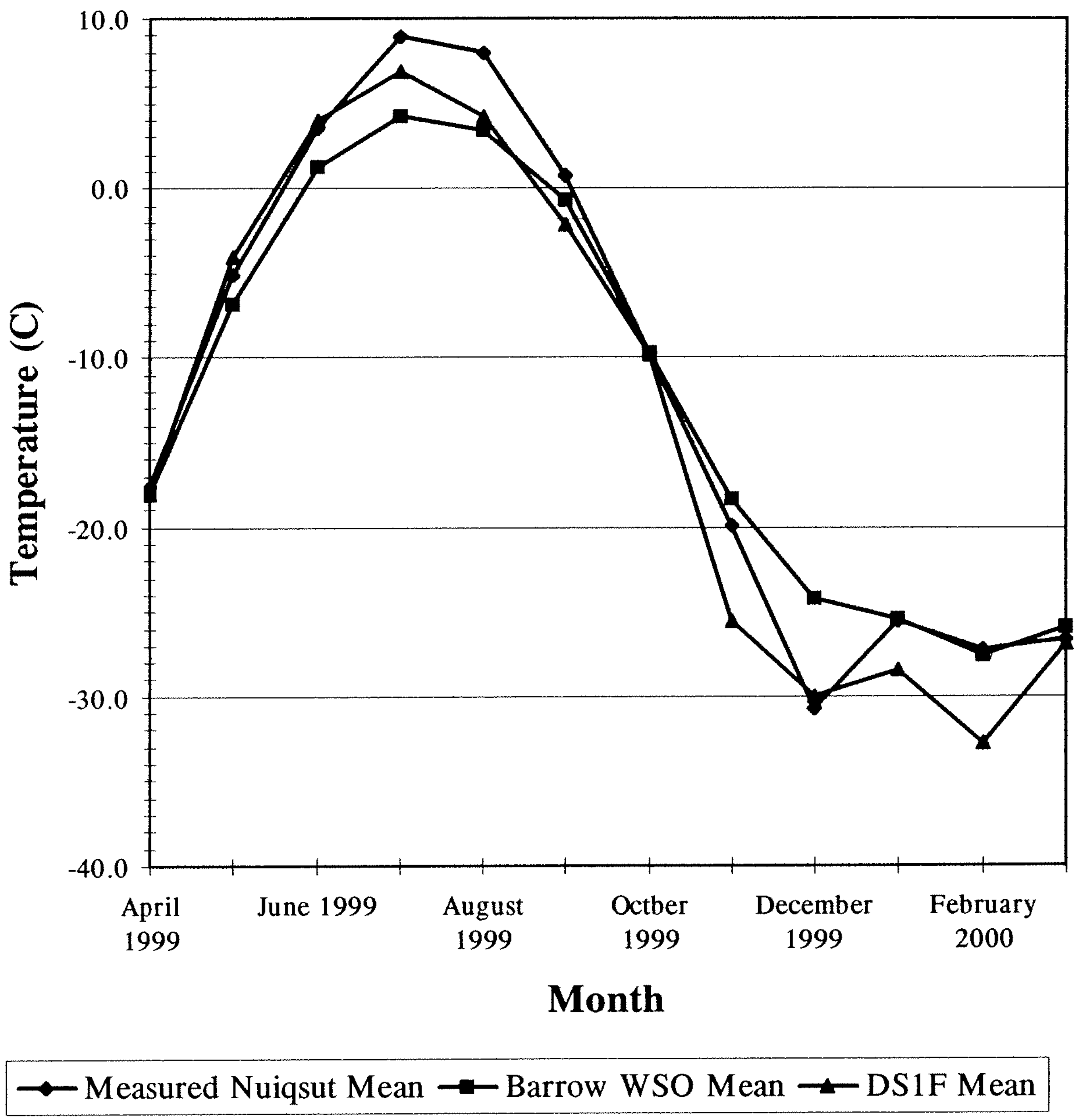


FIGURE 3-13: NUIQSUT TEMPERATURE CLIMATOLOGY

TABLE 3-3
NUIQSUT AIR QUALITY PROGRAM
TEMPERATURE CLIMATE SUMMARY
PERIOD OF RECORD APRIL 9, 1999 THROUGH MARCH 31, 2000

Temperature (°C)									
	Mean			Extremes					
Month	Daily Maximum	Daily Minimum	Monthly	Record Highest	Year	Day	Record Lowest	Year	Day
April 1999	-14.2	-22.2	-17.9	0.8	1999	30	-31.2	1999	13
May 1999	-3.0	-7.7	-5.2	3.7	1999	29	-20.3	1999	4
June 1999	6.8	0.2	3.5	16.8	1999	12	-3.6	1999	21
July 1999	12.8	5.0	8.9	23.7	1999	1	-0.3	1999	27
August 1999	11.6	4.5	7.9	27.8	1999	5	-1.6	1999	29
September 1999	3.8	-1.9	0.8	14.9	1999	2	-13.6	1999	30
October 1999	-8.2	-11.7	-9.7	-1.2	1999	7	-27.2	1999	31
November 1999	-17.1	-23.1	-20.0	-10.3	1999	19	-35.5	1999	5
December 1999	-27.9	-33.7	-30.8	-18.3	1999	4	-42.1	1999	18
January 2000	-22.2	-29.4	-25.6	-9.2	2000	14	-39.4	2000	17
February 2000	-23.9	-31.4	-27.3	-5.8	2000	11	-41.5	2000	28
March 2000	-24.3	-29.3	-26.7	-18.7	2000	31	-39.4	2000	23
Monitoring Year	-8.8	-15.1	-11.8	27.8	1999	5	-42.1	1999	18

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