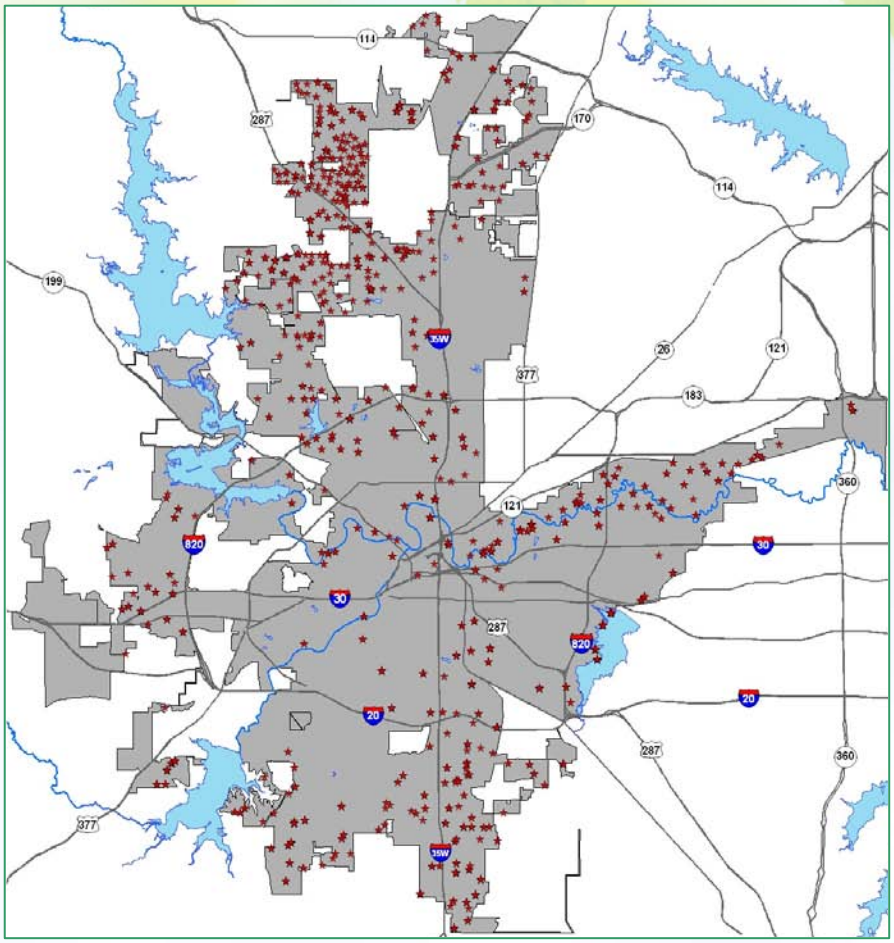
City of Fort Worth Natural Gas Air Quality Study

Final
Ambient Air Monitoring Plan



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September 15, 2010

Table of Contents

Page

1.0 Project Overview 1-1
1.1 Summary 1-1
1.2 Participants in the Ambient Air Monitoring Investigation 1-1

2.0 Introduction 2-1
2.1 Background 2-1
2.2 Reason for the Monitoring Program 2-1

3.0 Project Goals, Objectives, and Requirements 3-1
3.1 Data Quality Objectives 3-1
3.2 Method Quality Objectives 3-2

4.0 Technical Approach 4-1
4.1 Siting 4-1
4.1.1 Network Sites 4-1
4.1.2 Windroses 4-10
4.1.3 Well Information 4-13
4.1.4 City-Owned Buildings 4-13
4.1.5 Emissions Information 4-13
4.1.6 Identifying Potential Sites 4-13
4.1.7 Selecting Final Sites 4-18
4.2 Site Access 4-19
4.3 Sample Collection 4-20
4.3.1 Collection Procedure 4-21
4.3.2 Sample Documentation 4-23
4.3.3 Sample Shipping 4-25
4.3.4 Sample Handling, Tracking, Analysis, and Reporting 4-26
4.3.5 Collection Schedule and Expected Quantities 4-27
4.4 Sample Analysis 4-28
4.4.1 Laboratory Control Samples 4-31
4.5 Security 4-31

5.0 References 5-1

Appendix A – Fort Worth Area Windroses

List of Tables

Page

Table 3-1. Data Quality Objectives 3-1
Table 3-2. Sampling and Analysis MQOs 3-3
Table 4-1. Details for Each Sample Collection Site 4-10
Table 4-2. Predominant Wind Directions by Meteorological Site and Time Period 4-12
Table 4-3. Proposed Approach and Schedule of Collection Events 4-27
Table 4-4. Specific Sample Quantities 4-28
Table 4-5. NGAQS Compendium Method TO-15 Target Compounds and Detection Limits . 4-29
Table 4-6. NGAQS SNMOC Target Compounds and Detection Limits 4-30
Table 4-7. NGAQS Carbonyl Target Compounds and Detection Limits 4-31
Table 4-8. NGAQS TO-14 Target Compounds and Detection Limits 4-31

List of Figures

Page

Figure 4-1. Map of the Investigation Area 4-2
Figure 4-2. Aerial Map of Site 1 – Fire Station 33 4-3
Figure 4-3. Aerial Map of Site 2 – Environmental Collection Center. 4-4
Figure 4-4. Aerial Map of Site 3 –Eastside Landfill. 4-5
Figure 4-5. Aerial Map of Site 4 – Garbage Drop-Off 4-6
Figure 4-6. Aerial Map of Site 5 – Fire Station 34 4-7
Figure 4-7. Aerial Map of Site 6 – Spinks Airport (South) 4-8
Figure 4-8. Aerial Map of Site 7 Spinks Airport (North) 4-9
Figure 4-9. Map of Meterological Stations (refer to Table 4-2 for Station Identifiers) 4-9
Figure 4-10. City of Fort Worth Active and Permitted Wells 4-14
Figure 4-11. City of Fort Worth Natural Gas Wells By 2010 Production 4-15
Figure 4-12. Map of City of Fort Worth City-Owned Buildings[6] 4-16
Figure 4-13. Point Source Emission Locations from the 2005 National Emissions Inventory[7] 4-17

ABBREVIATIONS

API	Air Pollution Index
AQS	Air Quality Subsystem (of the Aerometric Information and Retrieval System)
CBSA	Consolidated Business Statistical Area
COFW	City of Fort Worth
DQOs	Data Quality Objective(s)
ELS	Effects Screening Levels
EMD	Environmental Management Department
EPA	U.S. Environmental Protection Agency
ERG	Eastern Research Group, Inc.
FIDs	Flame Ionization Detector
GC	Gas Chromatograph
GIS	Geographic Information System
HAPs	Hazardous Air Pollutant(s)
Hg	Mercury
IRIS	Integrated Risk Information System
MDL	Method Detection Limit
mm	Millimeter
MQOs	Method Quality Objective
NEI	National Emission Inventory
NWS	National Weather Service
OSHA	Occupational Safety and Health Administration
ppbc	parts per billion by carbon
ppbv	parts per billion by volume
ppmv	parts per million by volume
RSD	Relative Standard Difference
SIM	Selected Ion Monitoring
SOPs	Standard Operating Procedure
TCEQ	Texas Commission on Environmental Quality
TRC	Texas Railroad Commission
VOC	Volatile Organic Compound

1.0 Project Overview

1.1 Summary

This Monitoring Plan details procedures to assess the short-term prevalence and magnitude of concentrations of selected air toxics present in the ambient air in the City of Fort Worth, Texas. The city boundaries are primarily in Tarrant County, but portions of the city are in neighboring Denton County, Parker County, and Wise County. An evaluation of the public health significance will be conducted based on the data generated by this ambient air monitoring program.

1.2 Participants in the Ambient Air Monitoring Investigation

City of Fort Worth (COFW) Department of Environmental Management (DEM)

Michael Gange – Mr. Gange will assist in identifying potential representative sites in the investigation area. He will provide technical direction and logistical support. Mr. Gange and other city staff will also provide the ERG team with information necessary for selecting sites, such as natural gas well locations, compressor stations, city boundaries, city-owned property, etc.

2.0 Introduction

2.1 Background

Over the last several years, natural gas production in the Barnett Shale, located in north-central Texas, has increased. The formation underlies the City of Fort Worth (COFW), which is part of the Fort Worth-Arlington Consolidated Business Statistical Area (CBSA), and the larger Dallas-Fort Worth area. In addition to the formation of the shale being very hard, extraction of natural gas from this area is further complicated by the abundance of urban and suburban areas directly on the shale. New technologies, such as hydraulic fracturing and horizontal drilling, have made extraction and production of natural gas over the last few years commercially viable.

The study is intended to quantify the volume and mass of emissions from natural gas operations during all phases of the natural gas drilling, production process and pipeline operations and to assess air quality impacts to the community. Of particular interest are Hazardous Air Pollutants including benzene, and other ozone precursors. Two questions related to ambient monitoring are:

- What effect do these emissions have on ambient air quality at the fence line?
- Are the City's setbacks for wells, tanks and compressors adequate to protect public health?

The study area is limited to the City of Fort Worth corporate boundaries.

2.2 Reason for the Monitoring Program

Data from the ambient air monitoring program may ultimately be used to:

- Assist in a better understanding of, or correlation to, conclusions drawn from current activity-based sampling and analysis efforts.
- Characterize exposure to selected air toxics in ambient air in areas in the city, along with characterizing certain natural gas activities (drilling, fracturing, well completions, etc.).
- Establish a representative determination of the concentration of air toxics, such as benzene, present in the ambient air in the area.
- Allow for a public health hazard evaluation.

Over the last year, the citizens of the COFW raised questions about the potential health concerns from natural gas activities. In response, the COFW appointed a committee to look at air quality issues and to develop a scope of work for an air emission study.

3.0 Project Goals, Objectives, and Requirements

The overall goal of this monitoring program is to collect quantitative data that representatively determines:

- The potential health hazards associated with estimated short-term and long-term exposures at the determined prevalence and measured concentration levels.

- The impact of natural gas activities on air toxic concentrations at/or near the fenceline.

The potential for health hazards depends upon the intensity and duration of exposure. Any exposure involves some risk; however, the longer that someone is exposed and the more air toxics (such as benzene) that is in the air, the greater the risk. If inhaled, benzene can penetrate body tissues and remain in the lungs and the tissue lining the lungs. Benzene is a known carcinogen, but it also targets the immunological system in the body.

3.1 Data Quality Objectives

Data Quality Objectives (DQOs) are statements that define the type, quality, quantity, purpose, and use of data to be collected. The DQOs provide the answer to the critical question of how good data must be in order to achieve the project goals. The design of a monitoring program is closely tied to the DQOs, which serve as the basis to develop the criteria that the program design should satisfy including where to conduct monitoring, when to conduct monitoring, measurement frequency, program duration, number of sites, and type(s) of data required.

In the case of this ambient air monitoring program, the choice of appropriate DQOs helps ensure that the monitoring program is carefully thought out and that the data collected will provide sufficient information to assess the potential for short-term and long-term exposure of select air toxics in the ambient air in the investigation area and to estimate the potential for health risk. DQOs identified for this investigation are listed in Table 3-1.

Table 3-1. Data Quality Objectives

Step	Objective
1. State the Problem	As specified in “Background” section above.
2. Identify the Decision	Determine the prevalence and concentrations of selected air toxics in ambient air samples collected in the COFW area at multiple sites over a 2-month duration. Determine the associated health risk.
3. Identify Inputs to the decision	Results of analysis of ambient air samples collected in the investigation area. ERG-Concurrent Method (EPA Compendium Methods TO-15[1] and SNMOC), TO-11A[2], and TO-14[3] will be used in the collection and analysis of samples from this monitoring program.

Table 3-1. Data Quality Objectives (Continued)

Step	Objective
4. Define Boundaries	COFW is concerned about elevated air toxics due to natural gas activities occurring in the city. The City currently has over 1,700 active and inactive well sites at over 600 well pad locations. Accordingly, monitoring sites will be placed near high and moderate levels of natural gas activity (as determined by clusters of well locations and production data), fenceline locations, and protected use areas (community centers, schools, parks, etc.). Also, one site will be placed away from the impacted areas as a metric of typical background.
5. Develop a Decision Rule	TCEQ's Effects Screening Levels (ESLs)[4] and EPA's Integrated Risk Information System (IRIS)[5] database will be applied to the ambient air data to determine risk.
6. Specify Limits on Decision Errors	The method detection limits (MDLs) associated with ERG-Concurrent Method (EPA Compendium Methods TO-15[1] and TO-11A[2]) and TO-14[3] have been used in multiple studies to help characterize risk. Thus, the analytical sensitivity is keyed to the MDLs being lower than the risk levels.
7. Optimize the Design	Based on existing information, the following parameters are specified for this investigation: A. Seven fixed-location (including two collocated) sampling sites will be employed to represent the entire city. Sites will be at city-owned and/or public use areas. Sites will be recommended by ERG as representative of the potentially impacted area. Final site selection will be accomplished through concurrence of ERG and COFW DEM program staff. B. Sample collection will be conducted for a two-month duration. Samples will be collected from 00:01 to 23:50 hours (24 Hours +/- 1 hour). C. Sample collection episodes will be conducted at a frequency of once every three days. This schedule ensures that sampling is conducted on all days of the week, multiple times, across the two-month duration of the program. D. Overall completeness must be 75% data capture at each monitoring site or greater.

3.2 Method Quality Objectives

Method Quality Objectives (MQOs) are established to control and assess various critical elements of the specific sampling and analysis procedures that will be used during this monitoring program. Through the implementation and meeting of these MQOs, the assumption can be made that associated DQOs will be met. Considering the target pollutant, site information obtained to date, and specifications associated with the sample collection and analysis methods that will be utilized, MQOs for sampling and analysis are presented in Table 3-2.

Table 3-2. Sampling and Analysis MQOs

Element	MQO
Acceptable Measurement Sensitivity for Methods Analysis	MDLs, as presented in Tables 4-5 through 4-8
Acceptable Measurement Accuracy (based on Performance Evaluation samples)	+/- 20% RSD
Acceptable Measurement Precision (based on collocated samples)	+/- 30% RSD

4.0 Technical Approach

4.1 Siting

All monitoring sites will be located within the COFW corporate boundaries. Figure 4-1 presents a map of the investigation area and identifies the location of each of the seven monitoring sites.

4.1.1 Network Sites

A total of seven fixed-location sampling sites will be utilized (i.e., Sites S-1 through S-7). Table 4-1 presents details for each sample collection site. Each of the seven sites will have a primary sampling system. Criteria applied to select the location for these primary fixed sites are:

- Sites that qualify as most impact must be in close proximity for fenceline monitoring of natural gas activities. City-owned properties, such as those located near or adjacent to well pads, will be reflected.

- Sites that impact citizens must be in close proximity to populated areas. City-owned properties, such as those found in residential areas where gas wells are present, will be reflected.

- Each location must represent typical wind patterns and not be unduly influenced by features that would disturb the wind patterns (i.e., high walls, tree lines/hedges, etc.).

- There must be a high potential for using each site for every collection episode across the 2-month duration of the program so that continuity is achieved and maintained; and Permission for use and access to a site must be obtained prior to the on-set of monitoring.

- 110vAC electrical power must be available for the operation of two fixed sites. The remaining five sites will be using battery-powered field equipment.

There will be two fixed sites for collocated sample collection. Figures 4-2 through 4-8 present individual aerial maps of Sites 1 – 7 respectively.

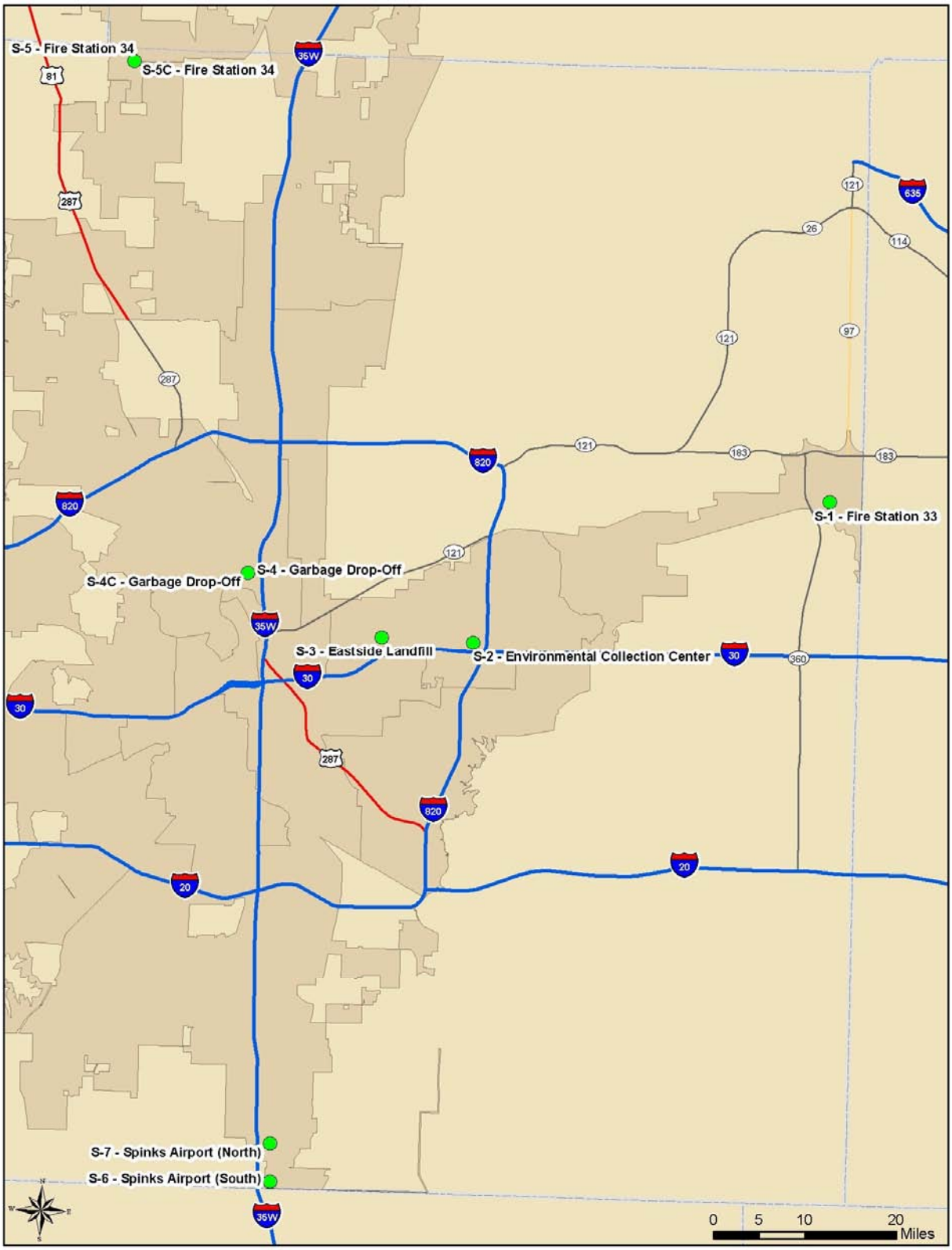

Figure 4-1. Map of the Investigation Area

Figure 4-2. Aerial Map of Site 1 – Fire Station 33

Figure 4-3. Aerial Map of Site 2 – Environmental Collection Center.

Figure 4-4. Aerial Map of Site 3 –Eastside Landfill.

Figure 4-5. Aerial Map of Site 4 – Garbage Drop-Off

Figure 4-6. Aerial Map of Site 5 – Fire Station 34

Figure 4-7. Aerial Map of Site 6 – Spinks Airport (South)

Figure 4-8. Aerial Map of Site 7 Spinks Airport (North)

Table 4-1. Details for Each Sample Collection Site

Site ID	Site Type	Coordinates
S-1	Remote Fire Station 33	32° 49.114'N 97° 02.953'W
S-2	Mobile Sources Environmental Collection Center	32° 33.379'N 97° 13.164'W
S-3	Pre-Production Eastside Landfill	32° 45.897'N 97° 15.763'W
S-4	High-Level Activity Garbage Drop-Off	32° 47.249'N 97° 19.715'W
S-4C	High-Level Activity, Collocated Garbage Drop-Off	32° 47.249'N 97° 19.715'W
S-5	High-Level Activity Fire Station 34	32° 59.044'N 97° 23.131'W
S-5C	High-Level Activity, Collocated Fire Station 34	32° 59.044'N 97° 23.131'W
S-6	Moderate-Level Activity, Fenceline Spinks Airport (South)	32° 33.37'N 97° 18.820'W
S-7	Moderate-Level Activity, Fenceline Spinks Airport (North)	32° 34.223'N 97° 18.815'W

4.1.2 Windroses

Prior to site selection, meteorological data from forty-three meteorological stations in and around the City of Fort Worth were constructed. These stations are presented in Figure 4-9. Twenty-one of these stations are National Weather Service (NWS) stations, while twenty-two are non-NWS meteorological stations that were identified in EPA's Air Quality Subsystem (AQS).

Hourly meteorological wind speed and wind direction data were parsed into five windrose categories: 1) historical; 2) 2009 Annual; 3) August historical; 4) September historical; and 5) October historical. For each one of these site-categories, a windrose was created using LAKES software. The historical time frame for NWS stations went as far back as 2001, while historical time frame at AQS sites went back to 2005. All windroses generated are presented in Appendix A.

Based on the historical, 2009 Annual, and August-October historical monthly windroses, the predominant wind pattern for the study area is from the South to South-Southeast to the North to North-Northwest. A summary of the predominant wind direction at each site is presented in Table 4-2.

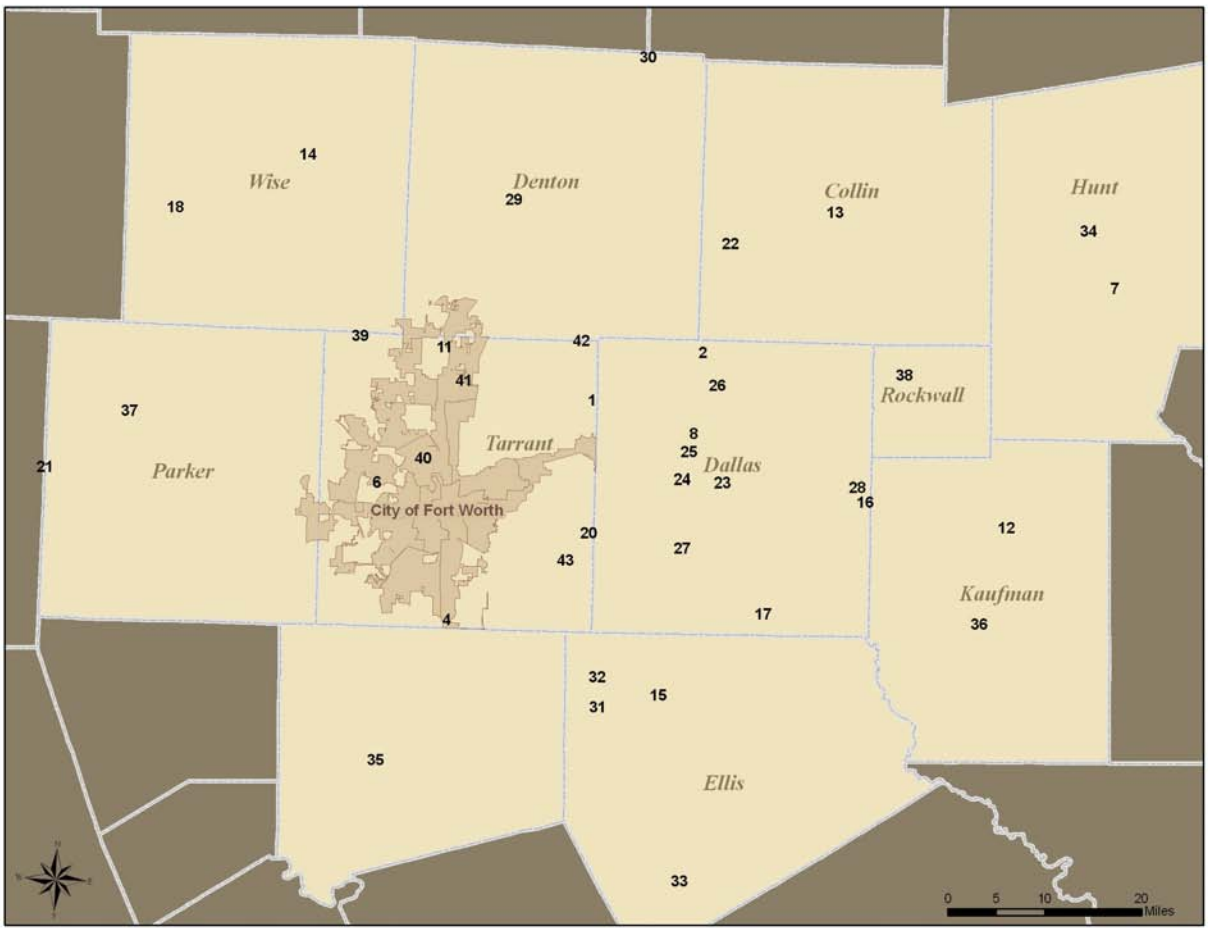

Figure 4-9. Map of Meteorological Stations (refer to Table 4-2 for Station Identifiers)

Table 4-2. Predominant Wind Directions by Meteorological Site and Time Period

Map ID	Site ID	Historical	2009	September	October	November
1	03927	S to SSE	S to SSE	S to ESE, N	S to SSE	S
2	03970	S to SSE	S to SSE	E	S to SSE	S to SSE
3	03971	S to SSE	S to SSE	S to E	S to SSE	S to SSE
4	03985	S to SSE	S to SSE	S to SSE, N	S to SE	S
5	03991	S to SSE	S to SSE	SSE to ESE, N	S to SE	S to SE
6	13911	S	S	S	S to SSE	S
7	13926	S to SSE	S to SSE	E, N	S to SE	S to SE
8	13960	S to SSE	S to SSE	SE to E	S to SE	S to SSE
9	13961	S to SSE	S to SSE	S to SE	S to SE	S
10	53907	S to SSE	S to SSE	S to SSE	S	S
11	53909	S to SSE	S to SSE	S to SSE	S to SSE	S
12	53911	S to SSE	S to SSE	E to N, S	S to SSE	S
13	53914	S to SSE	S to SSE	S to SE, N	S to SSE	S to SSE
14	53964	S to SSE	S to SSE	SSE to E	S to SE	S to SSE
15	53966	S to SSE	S to SSE	S to SSE, E, N	S to SE	S to SSE
16	53970	S to SSE	S to SSE	S to ESE, N	S to SSE	S to SSE
17	53975	S to SSE	S to SSE	S, N	S to SE	S to SSE
18	53976	S to SSE	S to SSE	S to SE	S to SE	S to SSE
19	53981	S to SSE	S to SSE	S to SSE, E	S to SSE	S to SSE
20	53984	S to SSE	S to SSE	S, N	S to SSE	S
21	93985	S to SE	S to SE	S to SE	S to SE	SSE to SE
22	480850005	S to SSE	S to SSE	SE to E	SSE to ESE	S to SE
23	481130050	S to SSE	SSE to SE	ESE to E	SE to E	SSW to E
24	481130057	SSE to ESE	--	SSE to E	ESE to E	SSE to E
25	481130069	S to SSE	S to SSE	S to SSE	S to SSE	S to SSE
26	481130075	S to SE	S to SE	ESE, N	S to ESE	S to SE
27	481130087	S to SSE	S to SSE	S to ESE	S to SE	SSW to SSE
28	481133003	S to SE	--	S to SSE	S to SE, N	SSW to S
29	481210034	S to SE	S to SE	SE	SSE to SE	S to SE
30	481211032	S to SSE	S to SSE	SE	S to SE	S to SSE
31	481390015	SSW to SSE	--	SSW to SSE, N	SSW to SSE	SSW to SSE
32	481390016	SSW to SSE	SSW to SSE	ESE	SSW to ESE	S to SSE
33	481391044	S	S to SSE	NNE to NE	S to SE	SSW to SSE
34	482311006	SSW to SE	S to SE	SE, N to NNE	SSE to ESE	SSW to SE
35	482510003	S to SSE	S to SSE	S to SSE	S to SSE	S to SSE
36	482570005	S to SE	S to SE	SSE to ENE	SSE to ESE	S to SE
37	483670081	S to SSE	S to SSE	S to E	S to SE	S to SSE
38	483970001	SSW to S	SSW to SSE	SSW to ESE	SSE to SE	SSW to S
39	484390075	S to SSE	S to SSE	S to SE	S to SE	S to SSE
40	484391002	S to SE	S to SE	SE to SSE	SSE to SE	SSW to SE
41	484392003	S to SSE	S to SSE	S to SSE	S to SSE	S
42	484393009	S to SSE	S to SSE	S to ESE	S to SE	S to SSE
43	484393011	S	S	S to SE	S to SE	S

SSW: from South-Southwest; S: from South; SSE: from South-Southeast; SE: from Southeast; N: from North; ESE: from East-Southeast; E: from East; ENE: from East-Northeast; NE: from Northeast; NNE: from North-Northeast.

The historical, 2009 annual, and August-October monthly windroses show prevalent wind directions from the south to southeast. Over 95% of the constructed windroses show predominance from one or both of those wind directions. Accordingly, the ambient monitoring sites that will be deployed for this monitoring program need to be positioned to provide upwind and/or downwind data representative of the entire study area.

4.1.3 Well Information

Well location data were provided by the COFW in GIS format.[6] We examined the well information by locations of active wells (density) and by production. Production data was obtained from the Texas Railroad Commission (TRC), and matched back to each well by API ID. Figure 4-10 presents the geographic dispersion of well densities within the COFW and Figure 4-11 presents geographic dispersion by production data. Well densities are primarily in the north and south of the City, while higher levels of production are in the western, northern, and eastern portions of the City.

4.1.4 City-Owned Buildings

Another set of information used to identify potential monitoring sites were the locations of city-owned buildings, such as fire departments, police departments, water towers, libraries, community centers, and other administrative buildings. Figure 4-12 presents this data. This data was provided by the COFW.[6]

4.1.5 Emissions Information

The final set of information used to identify potential monitoring sites were emission inventory data from EPA's National Emission Inventory.[7] Figure 4-13 presents this data.

4.1.6 Identifying Potential Sites

We visually displayed the above data via GIS software, and created various overlays. The following steps were used to identify potential monitoring sites.

1) Began with an overlay of windroses by meteorological site location. Used to determine typical flow in and around the City.
2) Added an overlay of active and permitted well locations. Used to identify high- and moderate-levels of natural gas activity by density and production.
3) Added an overlay of natural gas compressors. Used to identify areas to target to capture the ambient air near these sources.
4) Added an overlay of major highways. Used to identify locations most likely influenced by mobile sources.
5) Added an overlay of emission source locations. Used to identify remote locations where natural gas activity, mobile sources, and other industries are not as prevalent.
6) We identified five geographic areas which fit the monitor purposes described in Table 4-1.

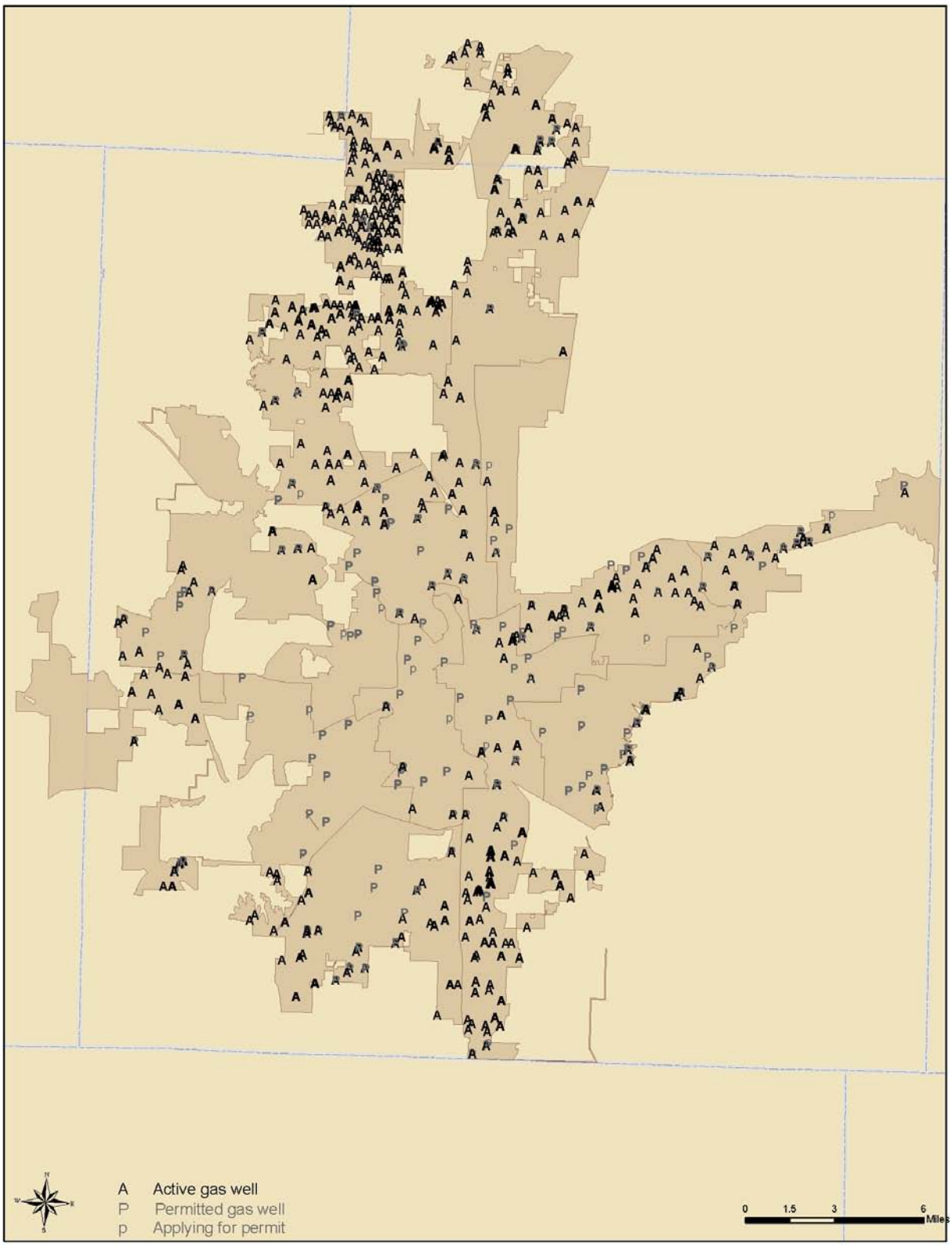

Figure 4-10. City of Fort Worth Active and Permitted Wells

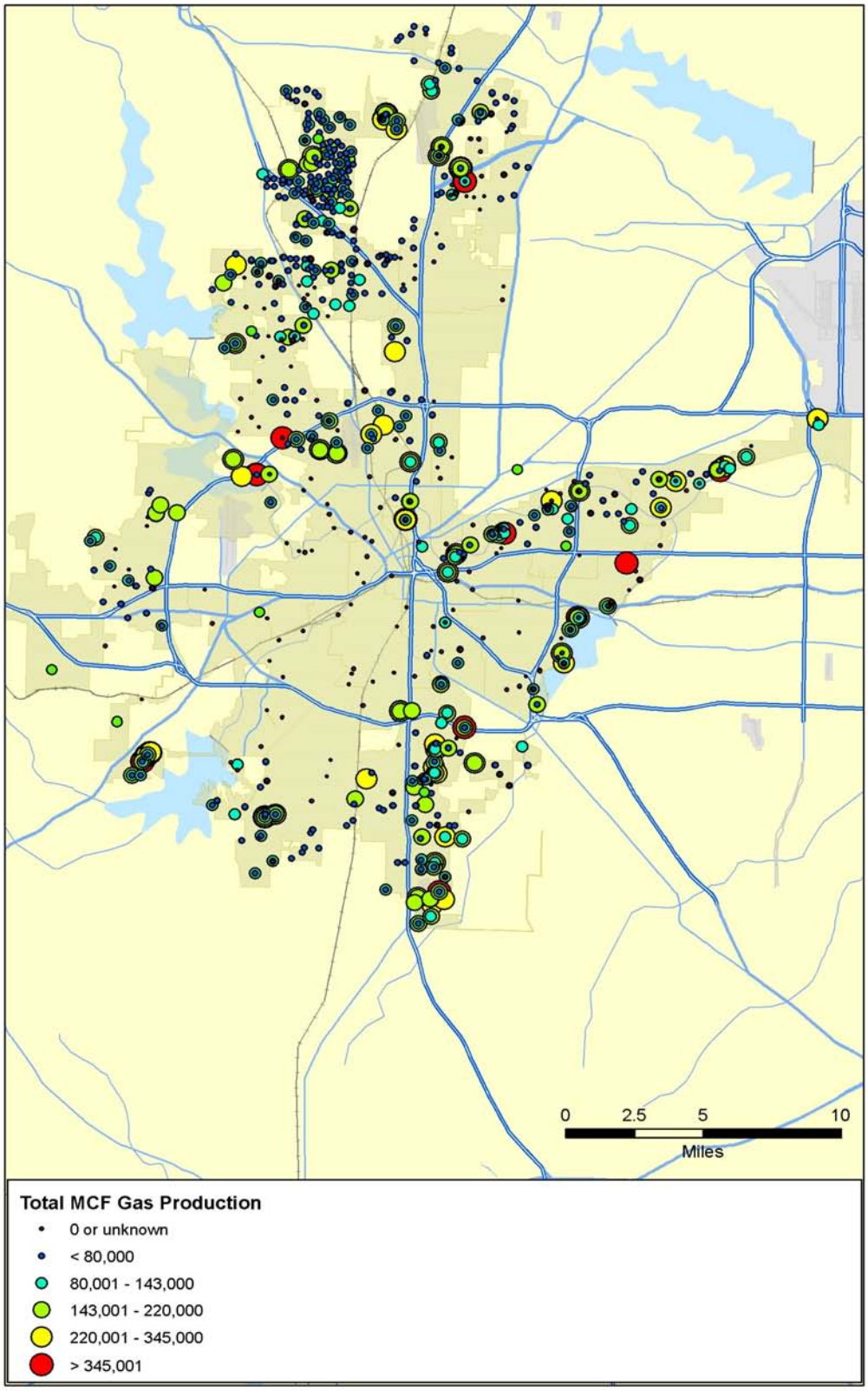

Figure 4-11. City of Fort Worth Natural Gas Wells By 2010 Production

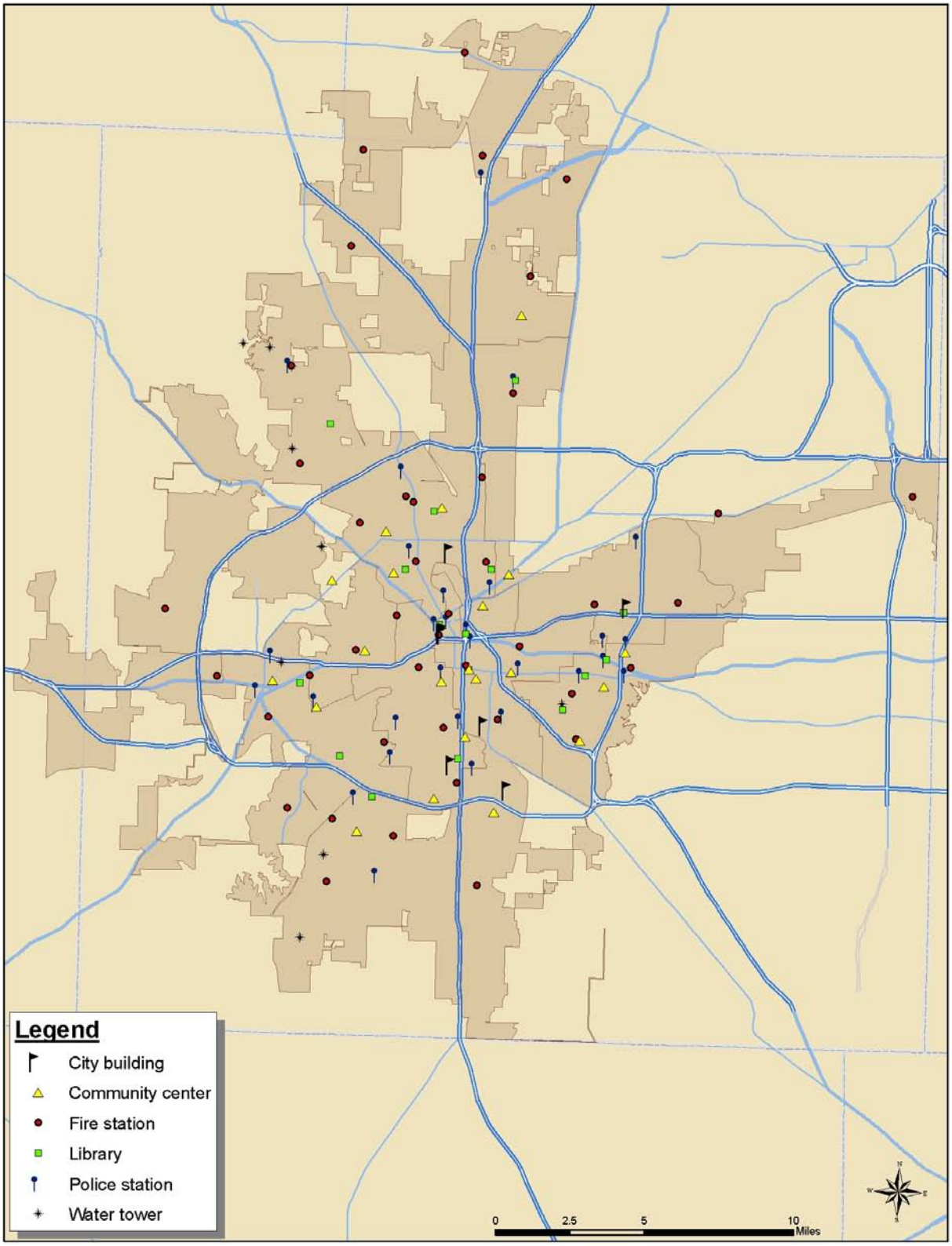

Figure 4-12. Map of City of Fort Worth City-Owned Buildings[6]

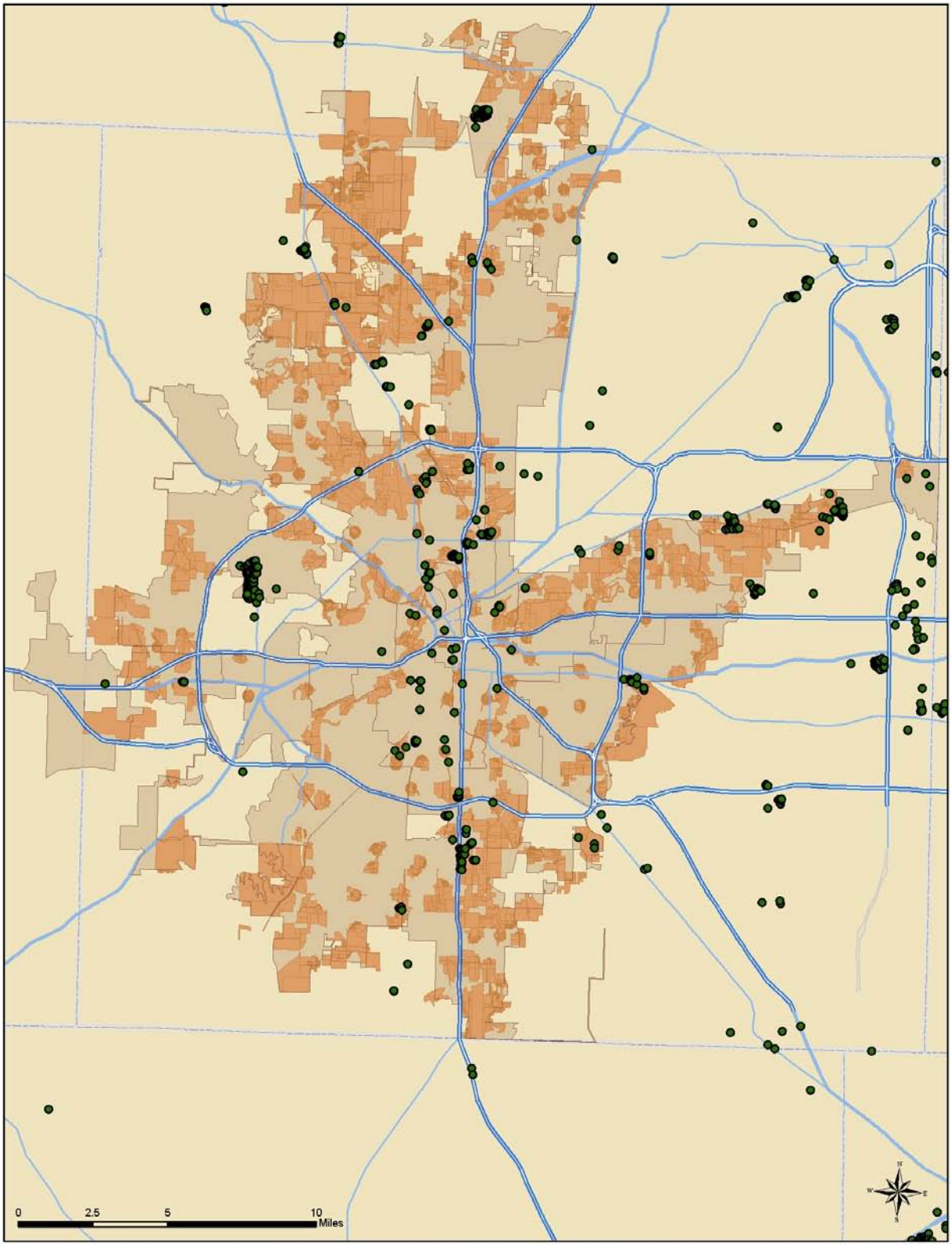

Figure 4-13. Point Source Emission Locations from the 2005 National Emissions Inventory[7]

7) For each of the five geographic regions, we added an overlay of the city-owned properties. It is preferable to place monitoring sites on city-owned property, as these locations will be both accessible and somewhat protected. Using the GIS software and typical wind flow patterns from the windroses, we identified the closest city-owned buildings to active and permitted wells, as well as near the major roadways and in the less active regions of the City.
8) We identified a minimum of:
    a. two monitoring sites that are located in areas of high natural gas production and activity, including compressor stations;
    b. two monitoring sites that are located in areas of moderate natural gas production and activity;
    c. one monitoring site to characterize mobile sources;
    d. one monitoring site to characterize background concentrations; and
    e. one monitoring site, located near permitted wells, to characterize other activities from natural gas, such as from drilling, fracturing, well completions, etc.

4.1.7 Selecting Final Sites

The selection of monitoring sites occurred in two phases. In Phase 1, all GIS information (locations of active and permitted natural gas activities, 2010 production data, compressor stations, city property, nearby roadways, meteorological stations, etc.) were overlaid to provide a snapshot of where the natural gas activities were occurring in relation to city-owned property. For several reasons, including access and security, monitoring on city-owned property is desired.

The City was divided into 5 main areas: north, east, south, west, and city center. By visual inspection, high levels of natural gas activity (number of wells and production) were occurring in the northern portion of the City, and moderate levels were occurring in the south. Additionally, compressor stations were scattered throughout the City, but some were located just north of city center. On the eastern side of the City, low levels of natural gas activity were occurring. Also on the eastern side of the City were major highway intersections which could serve as a site to characterize mobile sources. There were some natural gas activities occurring on the west side of the City. During Phase 1, 20 potential monitoring site locations were identified.

Phase 2 occurred during a site visit by ERG staff. This staff person drove to all potential sites to evaluate the city-owned properties for possible monitoring site location. He conducted interviews and scouted the property, taking particular notice of potential obstructions (trees, buildings, etc.) or limitations (not enough land, no power, etc.) that would not be suitable for a monitoring site. At the end of the trip, after consultation with City staff, seven locations were identified, and are described below:

1) <u>Site 1</u>: Fire Station 33 is located on the east side of the City. Typical wind patterns in that portion of the City are from the south and south-southeast (WBAN 53984 and

WBAN 3927). Very little natural gas activity is occurring upwind of this Fire Station. This site was chosen as the Remote site. VOCs will be collected at this location.

2) Site 2: The City's Environmental Collection Center is located near the intersections of Interstate 820 and Interstate 30. Similar to Site 1, typical wind patterns are from the south and south-southeast (AQS Monitor 484393011, WBAN 53984 and WBAN 3927). The closest natural gas activity south of this site is over two miles away. Thus, mobile sources along these highways (located within 0.50 miles of the Environmental Collection Center) will be characterized. Therefore, this site was chosen as the Mobile Sources site. VOCs will be collected at this location.
3) Site 3: The Eastside Landfill is a capped landfill that is located south of the Brentwood Saltwater Disposal Site, as well as north of pre-production activities. Typical wind patterns are from the south and south-southeast (AQS Monitor 484393011, WBAN 53984 and WBAN 3927). This site was chosen to characterize pre-production activities, and will also characterize emissions from the Brentwood site on days when the direction is predominantly out of a northerly direction. VOCs will be collected.
4) Site 4: The City's Garbage Drop-off location is located along I-35W on Brennan Avenue, just north of city center. Typical wind patterns are from the south and south-southeast (WBAN 13911). This site is located within 0.4 miles northwest of one combined wellpad and compressor station site, 0.8 miles north of another combined wellpad and compressor station site, and 0.2 miles southwest of a wellpad site This site was chosen as a high-level activity site. VOCs and carbonyls will be collected at this site.
5) Site 5: Fire Station 34 is located on the north side of the City. Typical wind patterns are from the south and south-southeast (WBAN 53909). This site is located within one mile of numerous natural gas wells that are upwind of this station. This site was chosen as a high-level activity site. VOCs and carbonyls will be collected at this site.
6) Site 6: Spinks Airport (South) is located at the south end of the City, south of Spinks Airport. Typical wind patterns are south to southeast (WBAN 03985). This site is located within 600 feet of an active wellpad site, and will help characterize fenceline exposure. This site was chosen as a moderate-level activity site. VOCs and methane will be collected at this site.
7) Site 7: Spinks Airport (North) is located at the south end of the City, on the north side of Spinks Airport property. Typical wind patterns are south and southeast (WBAN 03985). This site is located within 400 feet of an active wellpad site, and will help characterize fenceline exposure. This site was chosen as a moderate-level activity site. VOCs and methane will be collected at this site.

4.2 Site Access

COFW will assist in obtaining site access to all City-owned properties before sampling begins. Access to public use areas will be secured from each agency charged with oversight of each location selected. COFW will obtain informed consent from city/county representatives that agree to allow sampling near or on their property. However, emphasis must be placed on selecting and securing access to sites that have a very high likelihood of participating for the entire two months (and possibly 1-year if the City wishes to extend monitoring) duration of

monitoring to ensure that representative trends can be determined with a minimum of convoluting associated factors such as site re-location.

4.3 Sample Collection

The collection of ambient air monitoring samples for this program will be performed in accordance with the guidance provided in ERG's Concurrent Method (EPA Compendium TO-15 and EPA Compendium TO-11A[2]). Sampling will be conducted using ERG mass-flow control systems at two of the sites. These systems are powered and utilize pre-cleaned, evacuated SUMMA® canisters to collect VOC samples and DNPH cartridges to collect carbonyl samples. Sampling will also be conducted using vacuum-regulated systems at five sites. These systems are battery-operated/passive, but also utilize pre-cleaned SUMMA® canisters to collect VOCs. All seven systems incorporate digital timers to ensure that 24-hour integrated samples are achieved (i.e., 00:01 to 23:50).

Sample collection equipment for this study will be deployed and secured at each site prior to initiation of sampling and recovered at the end of the 2-month duration of the program. On each scheduled sampling episode day, each system will be prepared at each of the 7 fixed-location sites. As each system is prepared, it will have a Summa Canister and DNPH-cartridge installed and have the associated sampling flow rate set and checked (i.e., against a transfer flow standard), and all pre-sampling documentation will be completed. The systems will be programmed to initiate and end collection at the same times across the network (i.e., 00:01 through 23:50 local time). At the end of sample collection, the samples will be recovered and properly packaged for shipment and analysis or archiving, and all associated post sampling documentation will be completed.

Sample collection systems for this program will have the following operational characteristics:

- Will be capable of long term deployment (i.e., weather-resistant, substantial in design).
- Will be capable of unattended operation (automated start and stop).
- Will be able to record the elapsed time of a collection event.
- Will be able to achieve and sustain the target sample collection flow rate range (i.e., 5-7 Lpm).
- Will collect a sample at a height between five and seven feet above grade (in the breathing zone); no rooftop sampling is planned.

One collocated sample collection system will be operated during each collection episode across the duration of the program. The collocated sampler pair must have the same start times, end times, and total run times. To the largest extent possible the collocated collection system flow rate should match that of the primary system that it is paired with during a given collection

episode. Comparison of the paired samples results will be used to determine precision and to assess whether the corresponding MQO is being met.

4.3.1 Collection Procedure

Pre-Field Operations

The basic pre-field collection procedures, which will occur prior to sampling initiation, include:

1) ERG will check-out, certify (as required), calibrate (as required), all equipment that will be deployed to the field.
2) ERG will ship the field collection systems to the field for deployment, approximately 9 days prior to the first scheduled sampling event. This shipment will include everything required to assemble and install the 7 sample collection systems. This would include all system components, ancillary materials (i.e., fittings, stainless steel tubing, timers, chargers, etc.), associated Standard Operating Procedures, and tools. The only materials/items envisioned for purchase in the field would be those that are required do to specific site considerations after site inspections have been performed.
3) ERG will travel to study location and install and check-out the sample collection systems at each site approximately 7 days prior to the first scheduled collection event.
4) ERG will train all field staff in the proper operation of the five Timer/Veriflow collection systems and the two Canister/Carbonyl collection systems, and the required procedure for collecting valid representative samples using these systems.
5) ERG will train field staff in the proper procedures for receiving, handling, and shipping samples media.
6) ERG will travel to study location and install and recover the sample collection systems at each site approximately 3 days after the last scheduled collection event, and ship this equipment back to the ERG Laboratory.
7) Upon receipt, ERG will repair/refurbish all field equipment as required.

Field Operations

The basic field collection operations which will occur as part of collecting Air Toxics VOC and Carbonyl Compounds samples on a 1-in-3 day frequency include:

1) Approximately 1 week prior to each scheduled collection event, the field operator will receive via Federal Express a shipment of prepared media (i.e., cleaned evacuated 6-L SUMMA canisters and or DNPH Carbonyl tubes) in quantities consistent with conducting an entire weeks worth of field sample collections. The DNPH Carbonyl tubes will be shipped in a cooler with blue ice. They will be placed in a refrigerator at the common staging area until ready for use collecting field samples. The blue ice will be placed in a freezer until ready for re-use shipping the samples back to the laboratory. Along with the media, specific associated multi-copy Chain-of-Custody (COC) forms will be provided. The COC forms will already have all laboratory origination information completed on them.

2) Two days prior to each scheduled sampling event, for the canister collection systems that are battery powered, the operator will charge the digital control timers using the transformers provided for each system. The charging will occur at the common staging location.
3) One day prior to each collection event, a field operator will visit each site to perform the following:
    a. Carefully transport and deploy each of the battery operated canister collection systems (at locations where fixed systems are not deployed);
    b. Install new collection media (i.e., cleaned evacuated 6-L SUMMA canister for battery operated sites and cleaned evacuated 6-L SUMMA canisters and DNPH Carbonyl tubes for fixed system sites);
    c. Program the digital timer to initiate sampling at 00:01 and terminate sampling at 11:59 on the date of the scheduled event;
    d. Enable collection for each media type (e.g., open canister bellows valve); and
    e. Complete all associated paper work including completion of pre-collection COC information (e.g., document initial canister pressure, document initial DNPH carbonyl tube collection flow rate, etc.) and site log book entries.

Post-collection Field Operations

The basic post-field collection procedures will include:

1) One day after each collection event, a field operator will visit each site to perform the following:
    a. Inspect the site for anything unusual (e.g., damaged/broken equipment, vandalism, evidence of tampering, etc.). If problems are noted, the operator will immediately contact the ERG Project Manager and the pertinent City staff to report the problems. At that time, a corrective action may occur (i.e., resample, relocating the equipment, etc.). If no problems are observed, then proceed to the next step;
    b. Disable collection for each media type (e.g., close canister bellows valve, ensure that each canister inlet valve port is capped);
    c. Complete all associated paper work including completion of post-collection COC information (e.g., document final canister pressure, document final DNPH carbonyl tube collection flow rate, document elapsed time, etc.) and site log book entries. If final canister pressure and/or flow rate do not meet the method criteria, then the operator will notify the ERG Project Manager immediately. If possible, a make-up sample may be taken immediately. If there are no problems with the sample collection, proceed to the next step;
    d. Recover collection media (i.e., whole air canister samples for battery operated sites and whole air canister and DNPH Carbonyl samples for fixed system sites).
2) Carefully transport each of the battery operated canister collection systems (from locations were fixed systems are not deployed) and recovered sample media back to the common staging area.

3) Place the DNPH Carbonyl samples in the refrigerator at the common staging area until they are ready to be shipped back to the laboratory for analysis.

At this point steps the operator is ready to begin the Pre-collection steps in preparation for the next collection event.

4.3.2 Sample Documentation

Each sample specific COC form will be initiated in the field as part of the sample collection process, and continue in the laboratory for all samples collected. Samples will be labeled in a clear and precise way for proper identification in the field and for tracking in the laboratory. The field operator will record site and sample information, details, and observations on the COC form. Figure 4-14 presents the COC form. The COC form is a rainbow page document comprised of the following:

- Sample Traveler (white page) – to accompany the sample to the laboratory for analysis, signed by the appropriate laboratory staff member as analysis is completed, and then returned to the COFW Project Manager.

- Laboratory Copy (canary page) – to accompany the sample to the laboratory for analysis and be retained by the laboratory for their records.

- Field Copy (pink page) – to be retained as field records at the end of each collection episode after all field information has been recorded.

The signed original COC form will be returned to COFW with the final analytical results. The information recorded on the COC form is required for sample identification as well as for asbestos concentration calculations. The minimum information required on the COC form sample record includes the following:

- Sample ID number

- Sampling equipment identification

- Sampling date

- Sampling start time

ERG Lab ID #

TOXICS/SNMOC SAMPLE DATA SHEET

Lab Pre-Sampling

Site Code: _____ Canister Number: _____

City/State: _____ Lab Initial Can. Press. ("Hg): _____

AQS Code: _____ Date Can. Cleaned: _____

Collection Date: _____ Cleaning Batch # : _____

Options

SNMOC (Y/N): _____ Duplicate Event (Y/N): _____

TOXICS (Y/N): _____ Duplicate Can # : _____

Field Setup

Operator: _____ Sys. #: _____ MFC Setting: _____

Setup Date: _____ Elapsed Timer Reset (Y/N): _____

Field Initial Can. Press. ("Hg): _____ Canister Valve Opened (Y/N): _____

Field Recovery

Recovery Date: _____ Sample Duration (3 or 24 hr): _____

Field Final Can. Press. ("Hg): _____ Elapsed Time: _____

Status: Valid Void (Circle one) Canister Valve Closed (Y/N): _____

Lab Recovery

Received by: _____ Date: _____ Lab Final Can. Press. ("Hg): _____

Status: Valid Void (Circle one)

If void, why: _____

SNMOC

Analyst: _____ Date: _____

Batch I.D.: _____

Toxics

Analyst: _____ Date: _____

Batch I.D.: _____

Comments: _____

White: Sample Traveler Canary: Lab Copy Pink: Field Copy

Figure 4-14. Chain of Custody Form

- Sampling end time
- Elapsed time
- Initial flowrate
- End flowrate
- Average flowrate
- Sample volume (total liters)
- Comments (field observations and/or anomalies during sampling)
- Name and signature of field operator releasing samples for shipment
- Condition of custody seal upon receipt by laboratory
- Condition of samples upon receipt by laboratory
- Signature of laboratory representative receiving shipment
- Date of sample receipt at laboratory

Thorough field documentation will help recreate each field event if required. Field staff will record observations of any unusual activities taking place in the vicinity during monitoring that may have impacted sample collection.

4.3.3 Sample Shipping

The basic sample shipping procedure, which will occur as part of normal sample post-collection procedures and operations associated with collecting Air Toxics VOC and Carbonyl Compounds samples on a 1-in-3 day frequency, is as follows:

1) One day after each sample collection, place a canister sample and its associated COC inside of the large bubble bag provided with each canister. Place the bagged canister inside the shipping box provided with each canister. Secure the shipping box with the packing tape provided.
2) Place one events worth of DNPH Carbonyl samples in a zip lock baggie. Place their associated COCs in another zip lock baggie. Place the two baggies in the small cooler as provided. Place blue ice in the cooler as provided.
3) Complete a Federal Express (FedEx) preprinted bill of laden (i.e., over night service) for each canister sample shipping box and each DNPH Carbonyl samples cooler prepared for shipment. Secure the bill of laden to each parcel.
4) Have parcels picked up by FedEx, or deliver the parcels to FedEx, for overnight shipment the same day that they are prepared.

4.3.4 Sample Handling, Tracking, Analysis, and Reporting

The basic laboratory activities, which will occur as part of normal sample handling, tracking, analysis, and reporting Air Toxics VOC and Carbonyl Compounds samples, is as follows:

1) The day after they are shipped from the field, samples will be delivered to the loading dock at ERG's laboratory complex. A dedicated receiving specialist will take custody of the parcels. Each sample will be inspected to ensure that it arrived intact and to establish that the validity of the sample was not compromised in any way during shipment.
2) The receiving specialist will complete all associated paper work including as received COC information (e.g., document as received canister pressure, calculate and document DNPH carbonyl sample total collection volume, etc.) and receiving log book entries.
3) The receiving specialist will then log each sample into ERG's state-of-the-art Laboratory Information Management System (LIMS). During sample login, each sample will receive the following (this information allows the sample to be tracked and status-checked throughout all laboratory process):
    a. A unique sample identification number;
    b. A batching descriptor specifying specifically what analyses the sample is to undergo and data turn-around time requirements.
4) Air Toxics samples will be prepared and analyzed in strict accordance with the guidelines presented in EPA Compendium Method TO-15[1] and the EPA NATTS Technical Assistance Document (TAD).[8] Speciated Nonmethane Organic Compounds analyses will be performed in accordance with the guidelines presented in the EPA Carbon Bond 4 Method[9] and the EPA Ozone Precursors Sampling and Analysis TAD.[10] Carbonyl Compounds will be analyzed in strict accordance with the guidelines presented in EPA Compendium Method TO-11A[2] and the EPA Ozone Precursors Sampling and Analysis TAD.[10] Figures 1 and 2 present ERG's Air Toxics/SNMOC laboratory and ERG's carbonyl laboratory.
5) Raw data is transmitted electronically from each analytical system directly to ERG's LIMS. Within LIMS, the raw analytical data is converted into quantitated measurement values.
6) ERG employs a robust multi-check, multi-level data review process to ensure that all data generated is valid and representative.
7) Data is generated in a form that is easily imported into spreadsheets (e.g. Microsoft Excel®) or database management programs (e.g. Microsoft Access® or SQL).

Collocated Samples

The collocated sampling will be conducted to establish the sampling precision. The collocated sampling system is identical physically and operationally to its primary system counter parts and is run under the same operational parameters. Each pair of collocated samples results will be compared, and the percent difference calculated between each pair and as an average of all pairs to determine if the program specific precision MQO is being met.

4.3.5 Collection Schedule and Expected Quantities

At each of the seven primary fixed-location sample collection sites and two collocated sampling sites, collection episodes will be conducted at a frequency of once every three days. This schedule has been developed to ensure that the next collection episode will occur on the next successive day of the week (including weekend days). This will ensure that a representative population of samples from all days of the week is achieved over the course of the 2-month program duration.

Table 4-3 presents specific information for a sample collection schedule keyed to a start date of September 4, 2010.

Table 4-3. Proposed Approach and Schedule of Collection Events

Date	Concurrent A.T./SNMOC Collection	Carbonyl Collection	A.T./SNMOC Duplicate Samples	Carbonyl Duplicate Samples	Methane and A.T. Samples
9/4/10	From 5 Fixed Sites (Site Numbers 1-5)	From 2 Fixed Sites (Site Numbers 4-5)	--	--	From 2 Fixed Sites (Site Numbers 6-7)
9/7/10			--	--	
9/10/10			--	--	
9/13/10			From 2 Sites	From 2 Sites	
9/16/10			--	--	
9/19/10			--	--	
9/22/10			--	--	
9/25/10			From 2 Sites	From 2 Sites	
9/28/10			--	--	
10/1/10			--	--	
10/4/10			--	--	
10/7/10			From 2 Sites	From 2 Sites	
10/10/10			--	--	
10/13/10			--	--	
10/16/10			--	--	
10/19/10			From 2 Sites	From 2 Sites	
10/22/10			--	--	
10/25/10			--	--	
10/28/10			--	--	
10/31/10			From 2 Sites	From 2 Sites	
	Sub-Total Samples = 100	Sub-Total Samples = 40	Sub-Total Samples = 10	Sub-Total Samples = 10	Subtotal Samples = 40
Overall Total Samples = 200					

If the schedule presented in Table 4-3 is adhered to, over the course of the 2-month duration of the monitoring program, a total of 200 field samples will be collected/obtained and analyzed. Specific sample quantities information is presented in Table 4-4.

Table 4-4. Specific Sample Quantities

Sample Type	Quantity
Primary Samples – 1 per fixed- location site per collection episode for 7 sites and 20 collection episodes. Results in each day of the week represented 2-3 times across the 2-month investigation duration.	180
Collocated Samples – 1 per collocated site per collection episode for 2 site and 20 collection episodes. Results in each primary site having a collocated pair sample 2 -3 times across the 2-month investigation duration.	20
Performance Evaluation Samples – 2 submissions of 2 samples each.	4
Overall Total	204

4.4 Sample Analysis

Air toxics and SNMOC will be collected in accordance with the guidelines presented in U.S. Environmental Protection Agency Compendium of Methods TO-15.[1] Method TO-15[1] provides guidance on sampling and analytical procedures for the measurement of subsets of the 97 VOCs that are included in the 1989 Hazardous Air Pollutants (HAPs) listed in Title III of the Clean Air Act Amendments of 1990.[9] These VOCs are defined as organic compounds having a vapor pressure greater than 10^{-1} Torr at 25°C and 760 mm mercury (Hg).

This method addresses most conditions encountered in the sampling of ambient air into passivated canisters. The atmosphere is sampled by introduction of air into a specially prepared stainless steel canister. A sample of air will be drawn through a calibrated flow limiting orifice assembly that regulates the rate and duration of sampling into the cleaned and pre-evacuated passivated canister. After the air sample is collected, the canister valve will be closed, a COC will be filled out, and both will be shipped to the ERG Laboratory for analysis. Upon receipt, the canister information will be recorded and the sample will be stored until analysis. Storage times of up to 45 days without compound concentration losses have been demonstrated for many of the VOCs (e.g., benzene, toluene, ethylbenzene, and xylenes) found in urban atmospheres. Although official turnaround time under the method guidelines is 45 days, typical turnaround time of approximately 30 days from sample receipt is more representative. ERG has, and will follow, EPA approved Standard of Operating Procedures (SOP) for analysis for air toxics and SNMOC. Target air toxics species, and their corresponding method detection limits (MDL) are presented in Table 4-5. Target SNMOC species and their corresponding MDLs are presented in Table 4-6.

Table 4-5. NGAQS Compendium Method TO-15 Target Compounds and Detection Limits

Target Compounds	ppbv	Target Compounds	ppbv
1,1,1-Trichloroethane	0.020	Dibromochloromethane	0.011
1,1,2,2-Tetrachloroethane	0.011	Dichlorodifluoromethane	0.012
1,1,2-Trichloroethane	0.018	Dichlorotetrafluoroethane	0.012
1,1-Dichloroethane	0.017	Ethyl Acrylate	0.011
1,1-Dichloroethene	0.013	Ethyl tert-Butyl Ether	0.009
1,2,4-Trichlorobenzene	0.018	Ethylbenzene	0.012
1,2,4-Trimethylbenzene	0.011	Hexachloro-1,3-butadiene	0.012
1,2-Dibromoethane	0.012	*m,p*-Xylene	0.014
1,2-Dichloroethane	0.015	m-Dichlorobenzene	0.010
1,2-Dichloropropane	0.025	Methyl Ethyl Ketone	0.026
1,3,5-Trimethylbenzene	0.010	Methyl Isobutyl Ketone	0.010
1,3-Butadiene	0.010	Methyl Methacrylate	0.021
Acetylene	0.025	Methyl *tert*-Butyl Ether	0.009
Acrylonitrile	0.027	Methylene Chloride	0.023
Benzene	0.019	*n*-Octane	0.011
Bromochloromethane	0.018	*o*-Dichlorobenzene	0.012
Bromodichloromethane	0.021	*o*-Xylene	0.010
Bromoform	0.011	p-Dichlorobenzene	0.010
Bromomethane	0.013	Propylene	0.028
Carbon Disulfide	0.011	Styrene	0.010
Carbon Tetrachloride	0.024	*tert*-Amyl Methyl Ether	0.013
Chlorobenzene	0.014	Tetrachloroethylene	0.011
Chloroethane	0.012	Toluene	0.013
Chloroform	0.017	*trans*-1,2-Dichloroethy...	0.014
Chloromethane	0.016	*trans*-1,3-Dichloropropene	0.016
Chloromethylbenzene	0.017	Trichloroethylene	0.017
Chloroprene	0.014	Trichlorofluoromethane	0.012
cis-1,2-Dichloroethylene	0.036	Trichlorotrifluoroethane	0.014
cis-1,3-Dichloropropene	0.015	Vinyl Chloride	0.013

Table 4-6. NGAQS SNMOC Target Compounds and Detection Limits

Target Compound	ppbC	ppbv	Target Compound	ppbC	ppbv
Ethylene	0.38	0.19	2-Methylhexane	0.11	0.02
Ethane	0.12	0.06	2,3-Dimethylpentane	0.37	0.05
Propane	0.20	0.07	3-Methylhexane	0.15	0.02
Propyne	0.20	0.07	1-Heptene	0.37	0.05
Isobutane	0.13	0.03	2,2,4-Trimethylpentane	0.17	0.02
Isobutene/1-Butene	0.15	0.04	*n*-Heptane	0.18	0.03
n-Butane	0.17	0.04	Methylcyclohexane	0.19	0.03
trans-2-Butene	0.14	0.04	2,2,3-Trimethpentane	0.28	0.04
cis-2-Butene	0.18	0.04	2,3,4-Trimethylpentane	0.14	0.02
3-Methyl-1-Butene	0.24	0.05	2-Methylheptane	0.17	0.02
Isopentane	0.19	0.04	3-Methylheptane	0.11	0.01
1-Pentene	0.12	0.02	1-Octene	0.28	0.04
2-Methyl-1-Butene	0.24	0.05	1-Nonene	0.24	0.03
n-Pentane	0.09	0.02	*n*-Nonane	0.18	0.02
Isoprene	0.24	0.05	Isopropylbenzene	0.21	0.02
trans-2-Pentene	0.14	0.03	*alpha*-Pinene	0.24	0.02
cis-2-Pentene	0.19	0.04	*n*-Propylbenzene	0.20	0.02
2-Methyl-2-Butene	0.24	0.05	*m*-Ethyltolune	0.15	0.02
2,2-Dimethylbutane	0.20	0.03	*p*-Ethyltoluene	0.24	0.03
Cyclopentene	0.24	0.05	1,3,5-Trimethylbenzene	0.17	0.02
4-Methyl-1-Pentene	0.36	0.06	*o*-Ethyltoluene	0.18	0.02
Cyclopentane	0.12	0.02	beta-Pinene	0.24	0.02
2,3,-Dimethylbutane	0.20	0.03	1,2,4-Trimethylbenzene	0.24	0.03
2-Methylpentane	0.14	0.02	1-Decene	0.24	0.02
3-Methylpentane	0.20	0.03	*n*-Decane	0.23	0.02
2-Methyl-1-Pentene	0.36	0.06	1,2,3-Trimethylbenzene	0.17	0.02
1-Hexene	0.36	0.06	*m*-Diethylbenzene	0.24	0.02
2-Ethyl-1-butene	0.36	0.06	*p*-Diethylbenzene	0.14	0.01
n-Hexane	0.24	0.04	1-Undecene	0.22	0.02
trans-2-Hexene	0.36	0.06	*n*-Undecane	0.22	0.02
cis-2-Hexene	0.36	0.06	1-Dodecene	0.29	0.02
Methylcyclopentane	0.14	0.02	*n*-Dodecane	0.29	0.02
2,4-Dimethylpentane	0.23	0.03	1-Tridecene	0.29	0.02
Cyclohexane	0.19	0.03	*n*-Tridecane	0.29	0.02

To analyze samples, a known volume of sample gas is directed from the canister through a mass flow controller to a solid multi-sorbent concentrator. After the concentration step is completed, the VOCs are thermally desorbed, entrained in a carrier gas stream, and then focused in a small volume by trapping on a reduced temperature trap or small volume multi-sorbent trap. The sample is then released by thermal desorption and carried onto two gas chromatographic columns housed in a gas chromatograph (GC). Separation of the individual air toxics and SNMOC species is accomplished. Air toxics are then measured using a mass spectrometer operated in the Selected Ion Monitoring (SIM) mode. SNMOC are measured concurrently using a Flame Ionization Detector (FID).

Target carbonyl species from Method TO-11A[2] and their corresponding MDLs are presented in Table 4-7. Methane and ethane using Method TO-14 and their corresponding MDLs are presented in Table 4-8.

Table 4-7. NGAQS Carbonyl Target Compounds and Detection Limits

Compound	ppbv
Formaldehyde	0.004
Acetaldehyde	0.005
Acetone	0.006
Propionaldehyde	0.002
Crotonaldehyde	0.002
Butyr/Isobutyraldehyde	0.002
Benzaldehyde	0.002
Isovaleraldehyde	0.002
Valeraldehyde	0.002
Tolualdehydes	0.003
Hexaldehyde	0.001
2,5-dimethylbenzaldehyde	0.001

Table 4-8. NGAQS TO-14 Target Compounds and Detection Limits

Compound	ppmv
Methane	0.154
Ethane	0.112

4.4.1 Laboratory Control Samples

Performance Evaluation Samples

Performance Evaluations are regularly conducted at ERG's laboratory.

Duplicate Analysis

Duplicate analysis of the same sample will be conducted on one sample out of every collection episode as a measure of reproducibility.

4.5 Security

All air monitoring equipment will be placed at secure locations, either inside a building not accessible to the public, at an outdoor location not readily accessible to the public, or on an outdoor property surrounded by a gated and locked fence. The field technician will immediately notify the ERG Project Manager if the site and/or equipment show signs of tampering or vandalization.

5.0 References

1. Compendium Method TO-15, Determination of Volatile Organic Compounds (VOCs) In Air Collected In Specially-Prepared Canisters And Analyzed by Gas Chromatography/ Mass Spectrometry (GC/MS), 1999. Can be found at *http://www.epa.gov/ttn/amtic/airtox.html*.

2. Compendium Method TO-11A, Determination of Formaldehyde in Ambient Air Using Adsorbent Cartridge Followed by High Performance Liquid Chromatography (HPLC), 1999. Can be found at http://www.epa.gov/ttn/amtic/airtox.html.

3. Compendium Method TO-14, Determination of Volatile Organic Compounds (VOCs) In Air Using Specially Prepared Canisters With Subsequent Analysis By Gas Chromatography. Can be found at http://www.epa.gov/ttnamti1/files/ambient/airtox/to-14ar.pdf

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9. E. R. Morris and T. C. Myers. "User's Guide for the Urban Airshed Model. Volume I: User's Guide for the UAM (CB-IV)."' (EPA-450/4-90-007A), U.S. Environmental Protection Agency, 1990.

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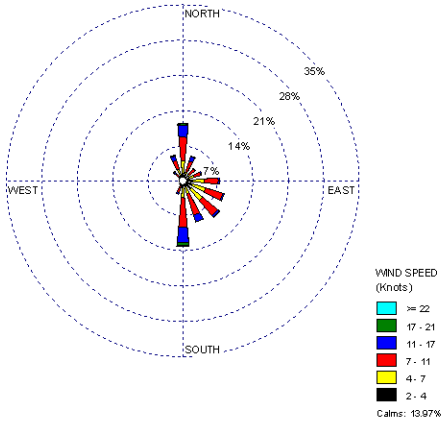
Appendix A

Fort Worth Area Windroses

WBAN 03927 (Map ID = 1)



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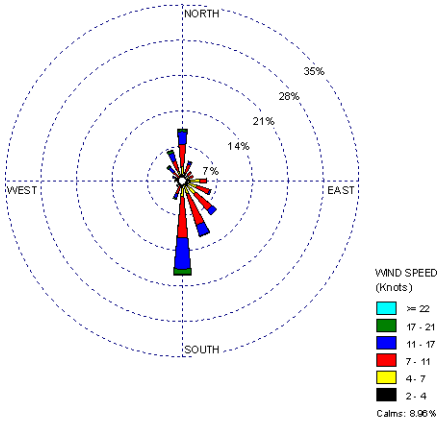

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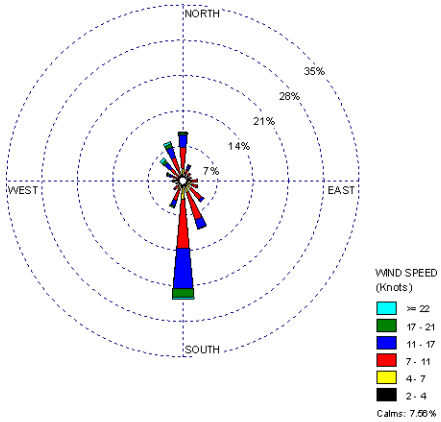

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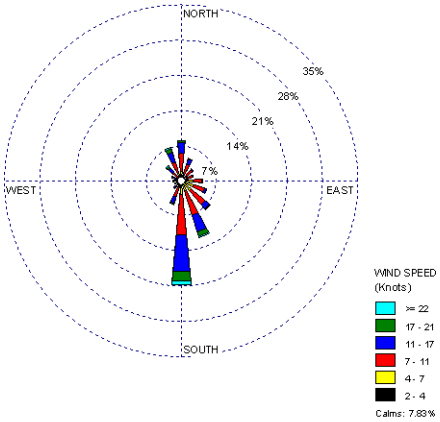

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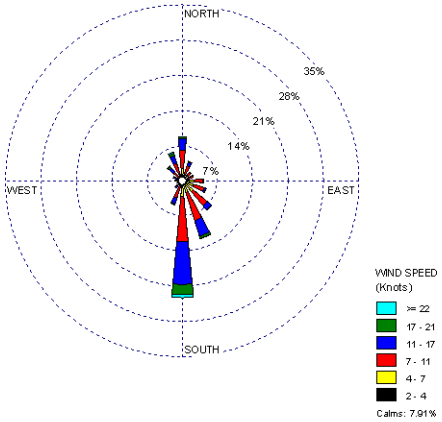

Entire (2001-2009)

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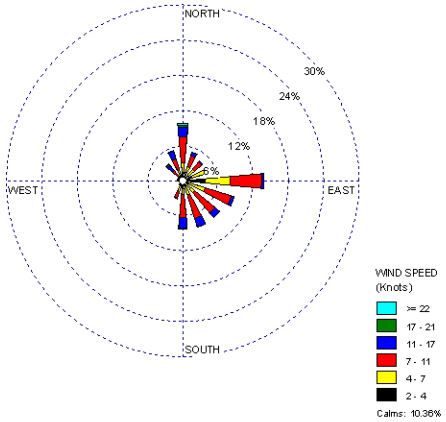

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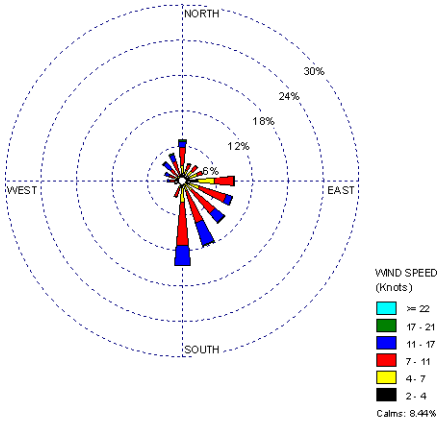

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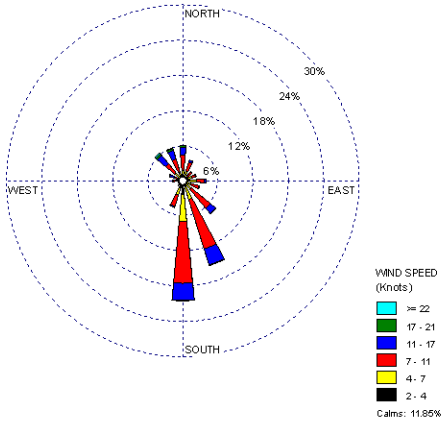

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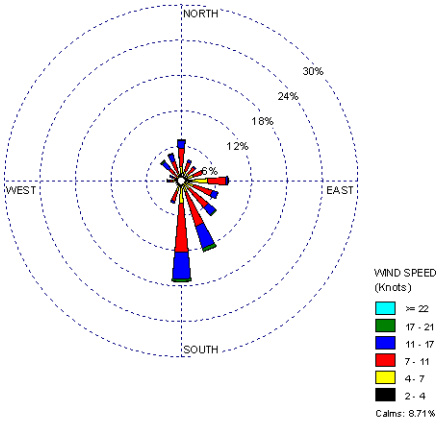

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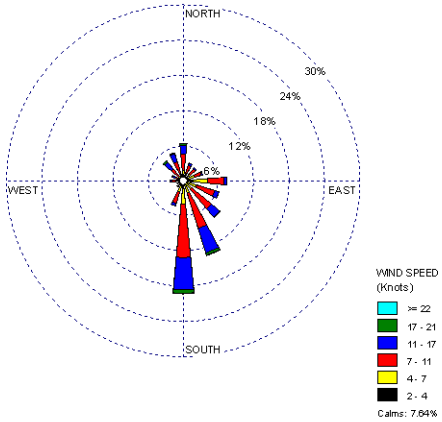

Entire (2006-2009)

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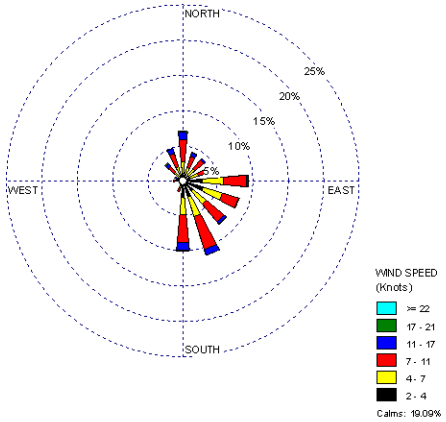

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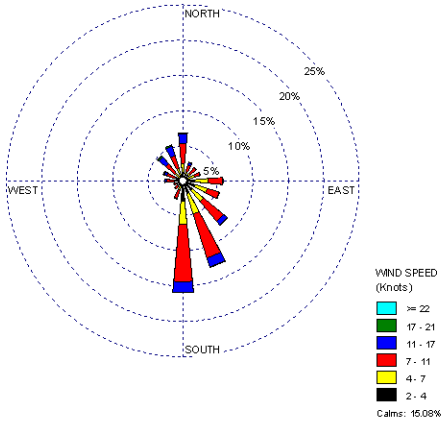

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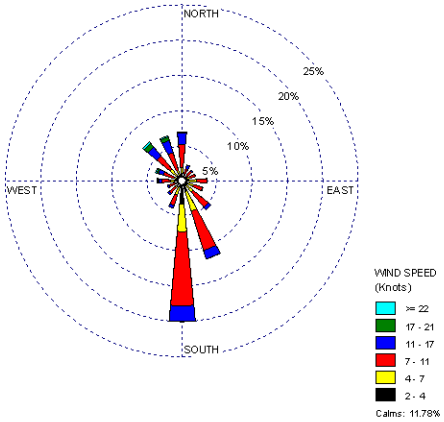

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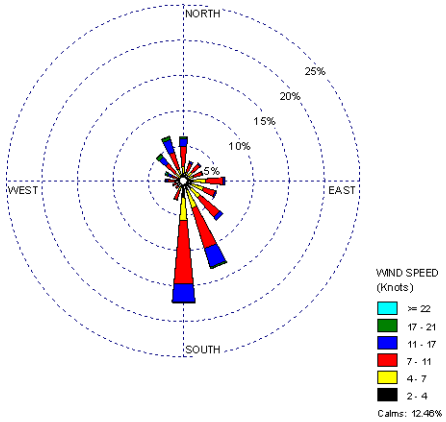

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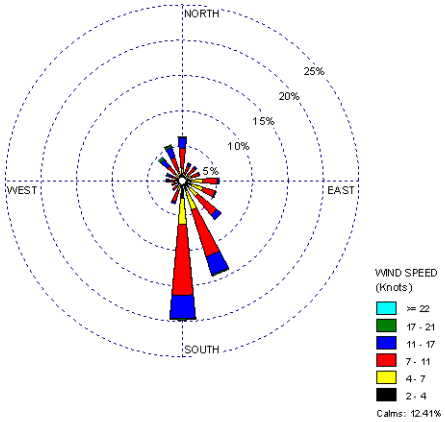

Entire (2001-2009)

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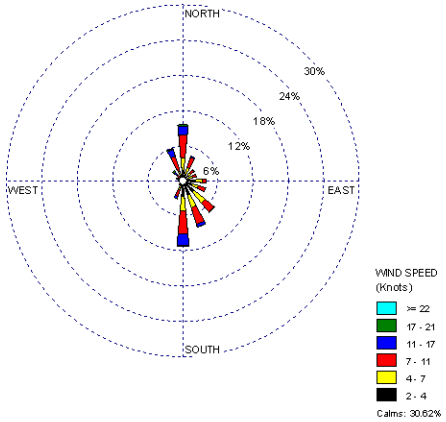

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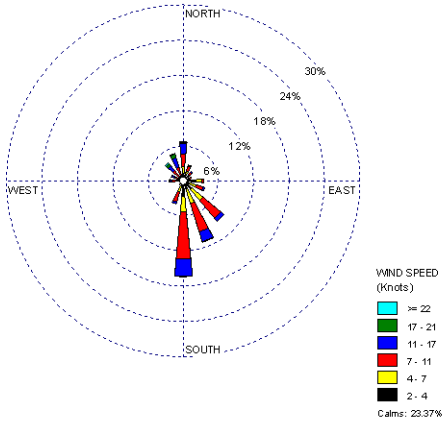

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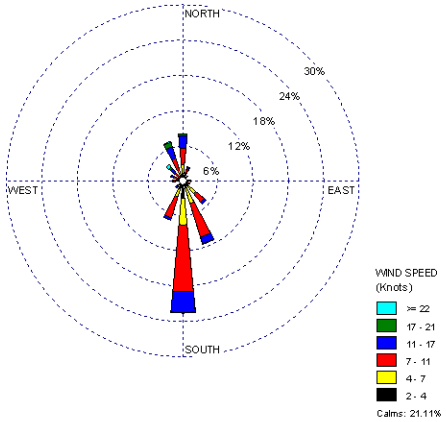

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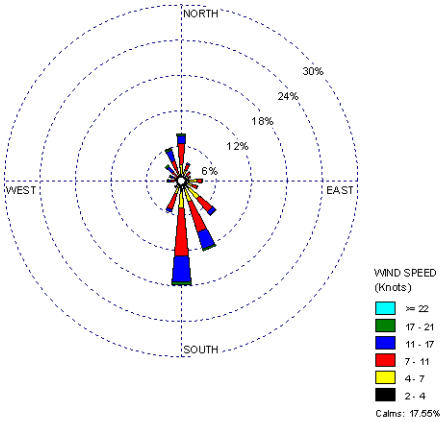

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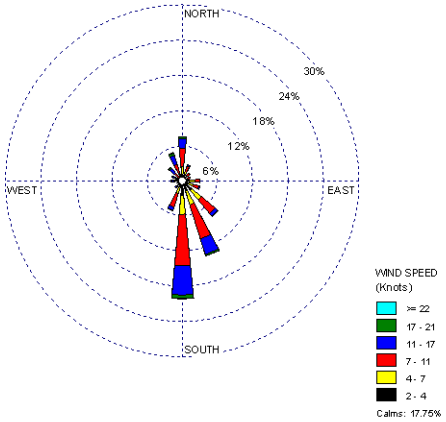

Entire (2006-2009)

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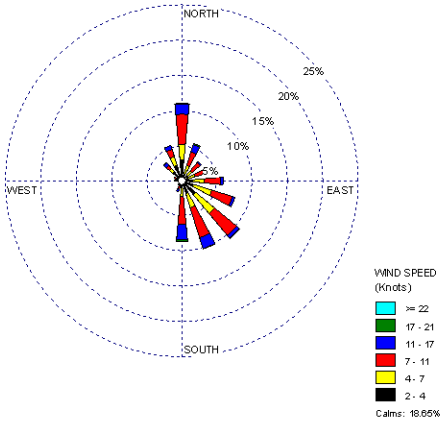

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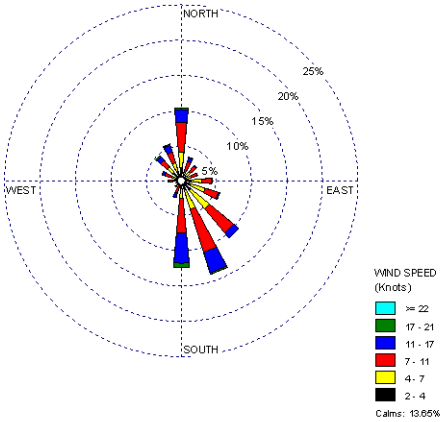

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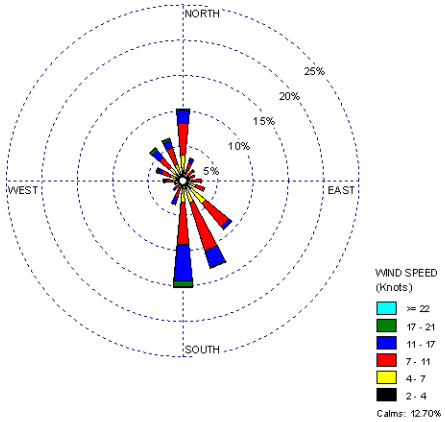

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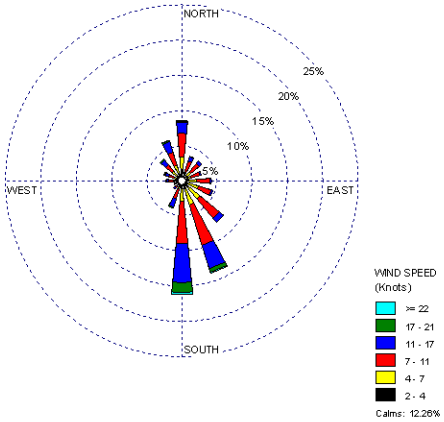

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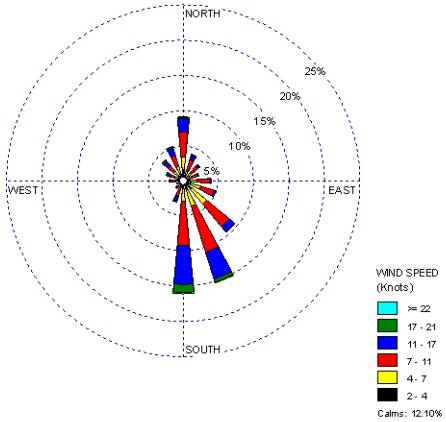

Entire (2001-2009)

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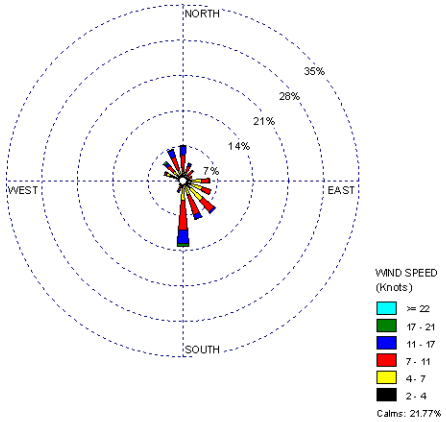

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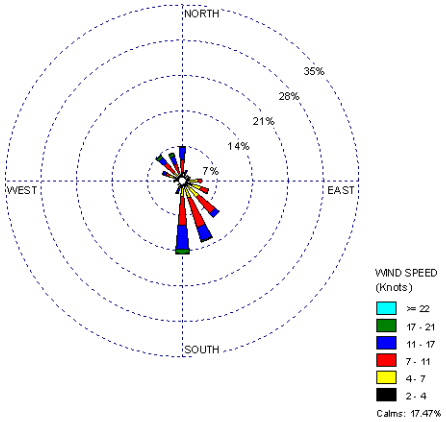

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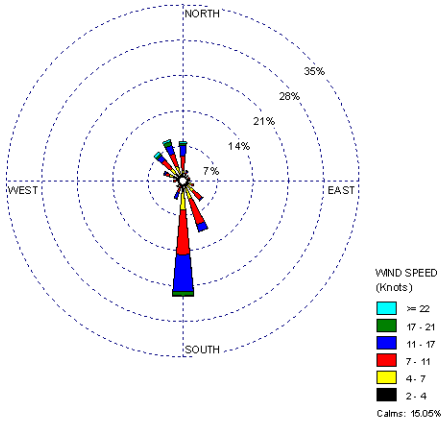

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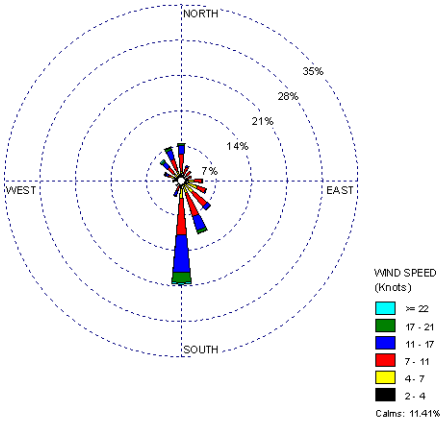

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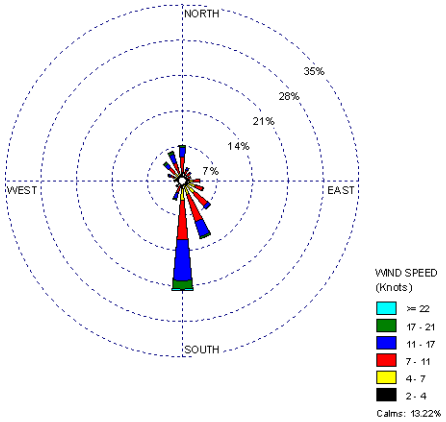

Entire (2005-2009)

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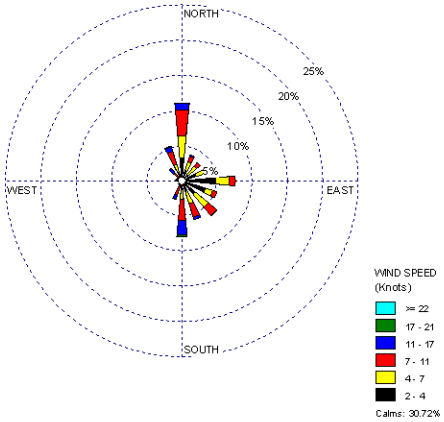

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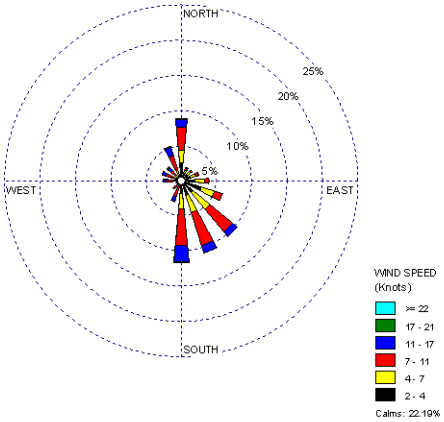

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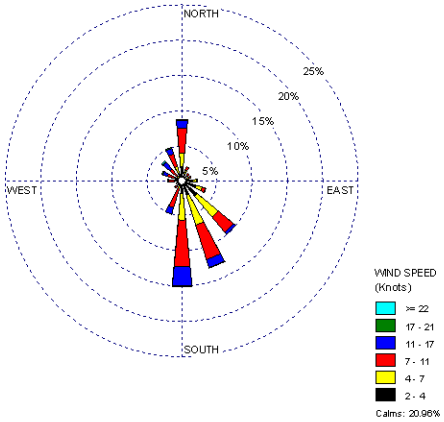

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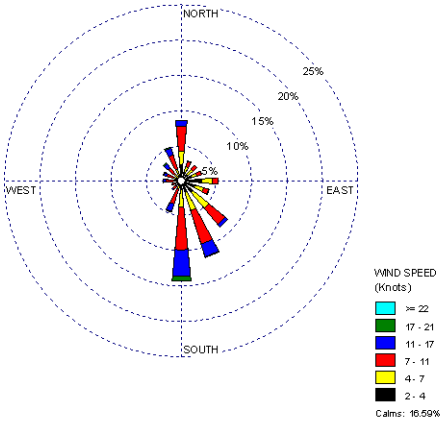

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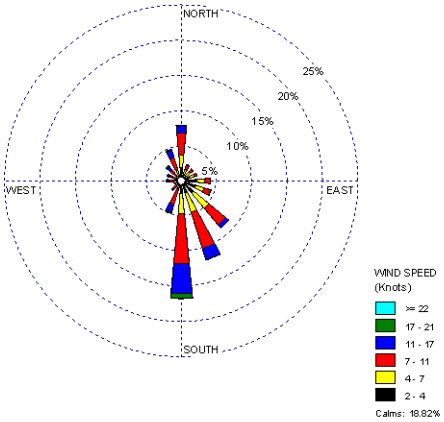

Entire (2006-2009)

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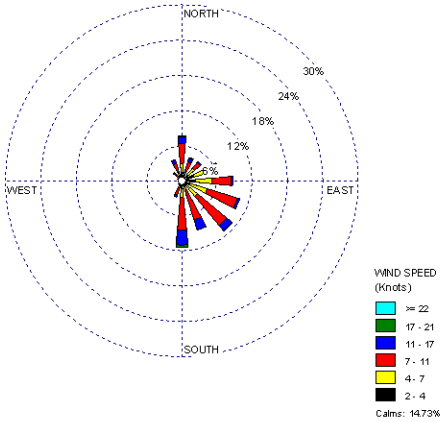

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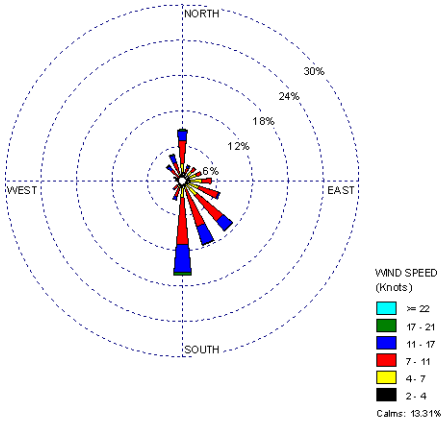

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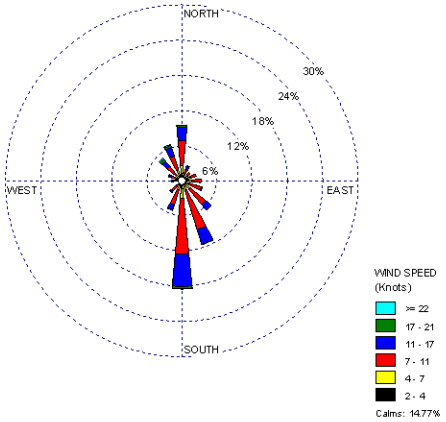

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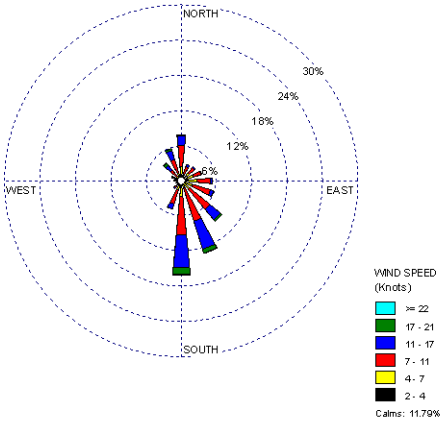

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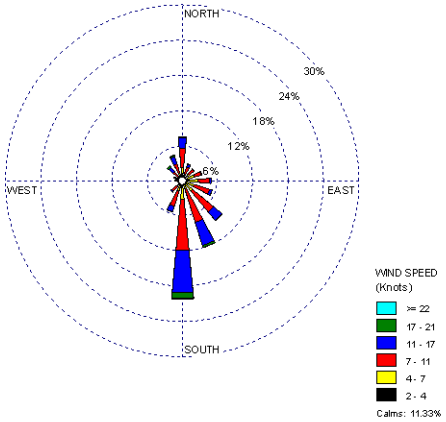

Entire (2001-2009)

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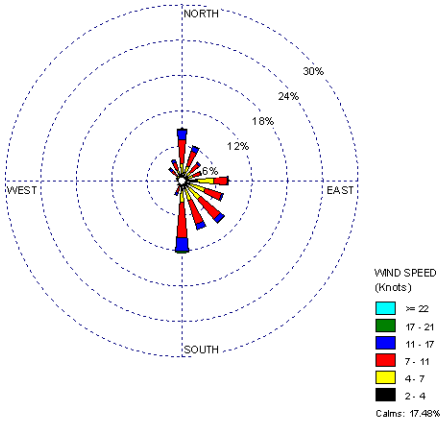

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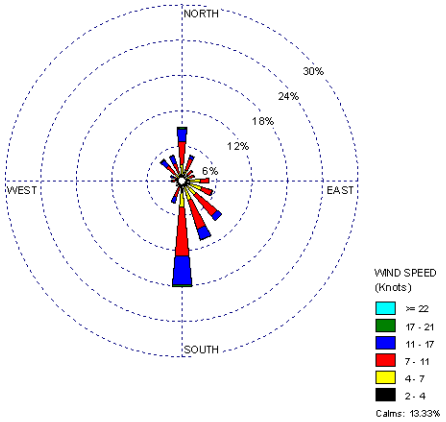

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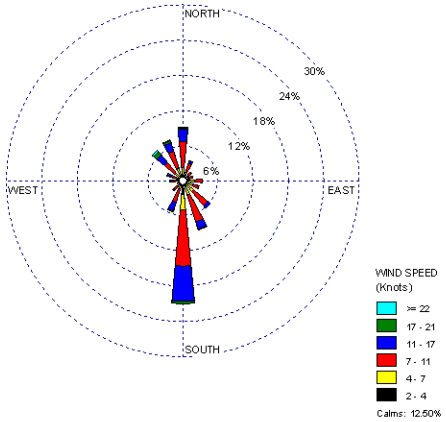

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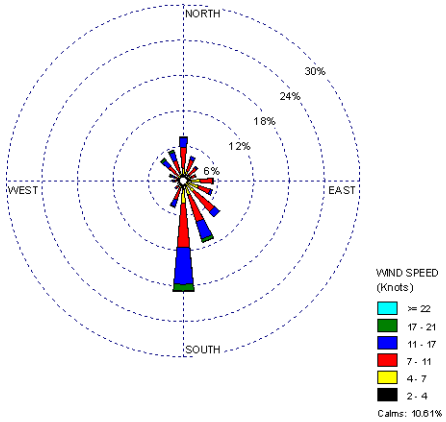

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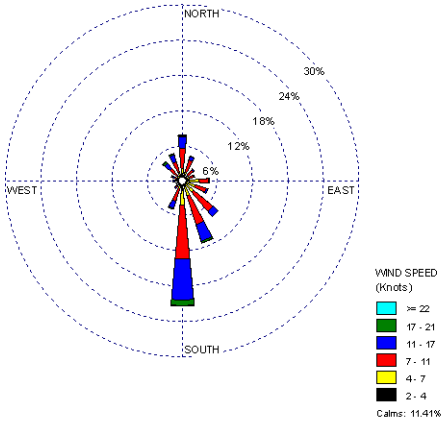

Entire (2001-2009)

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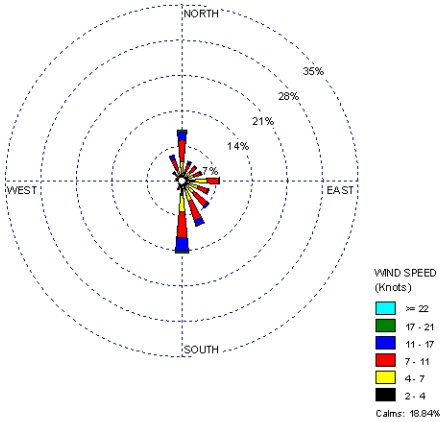

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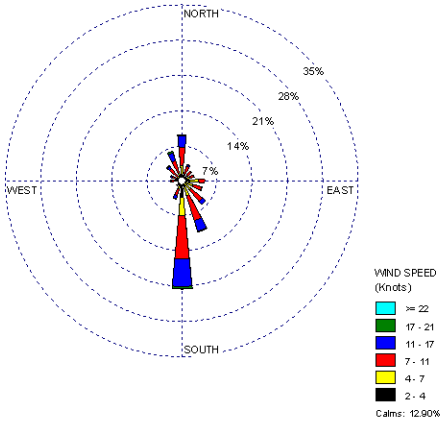

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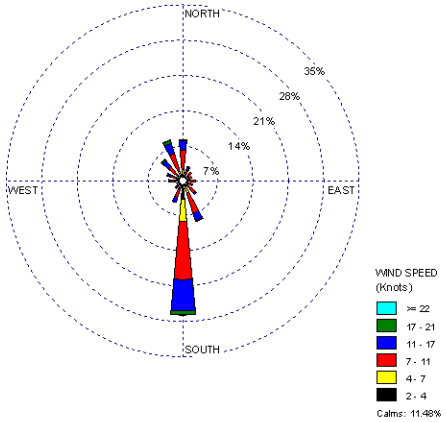

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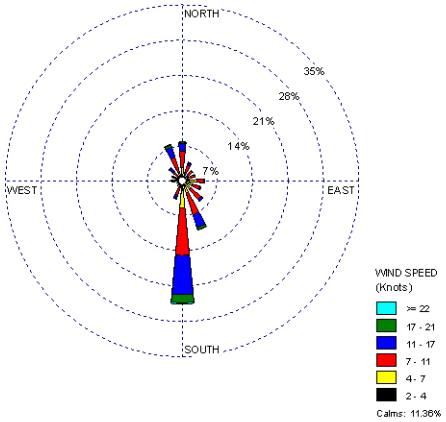

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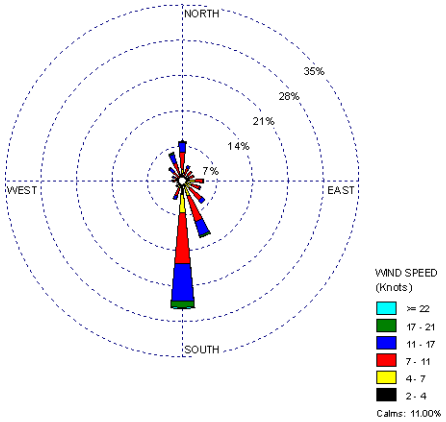
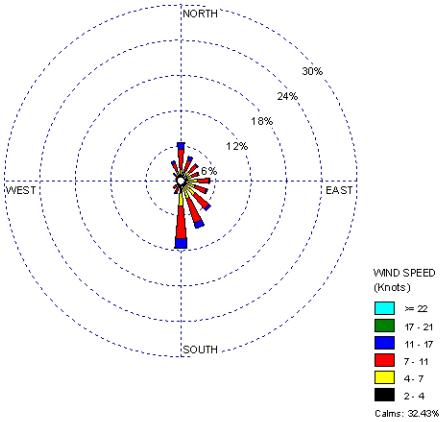


Entire (2001-2009)

WBAN 53909 (Map ID = 11)



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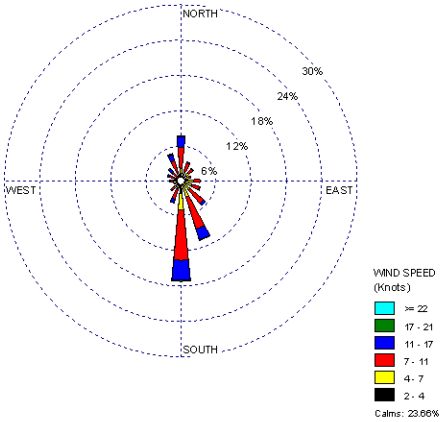

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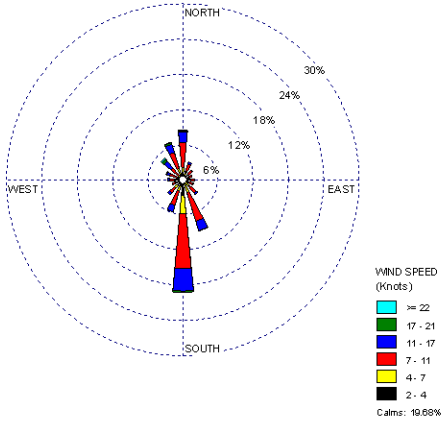

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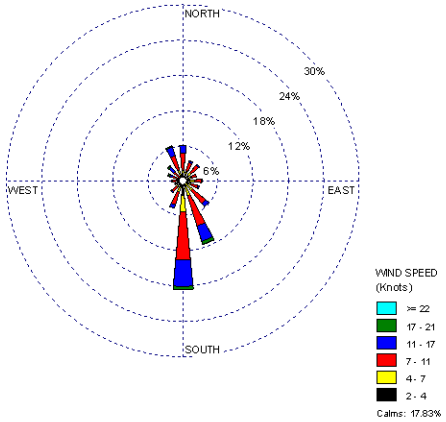

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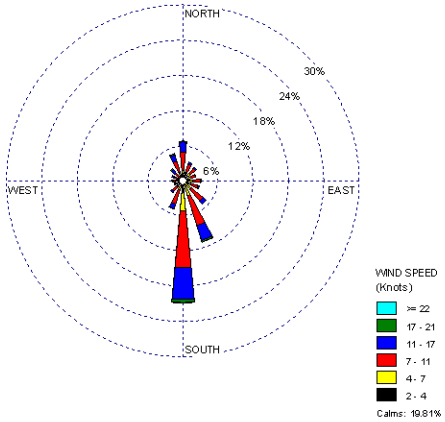

Entire (2001-2009)

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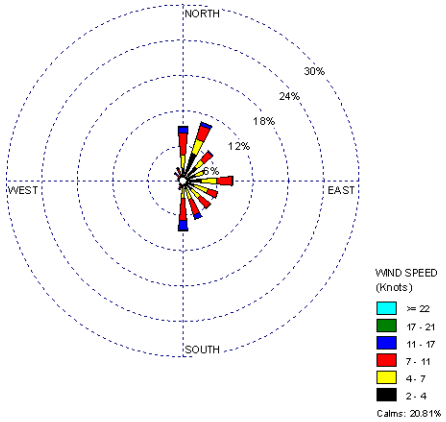

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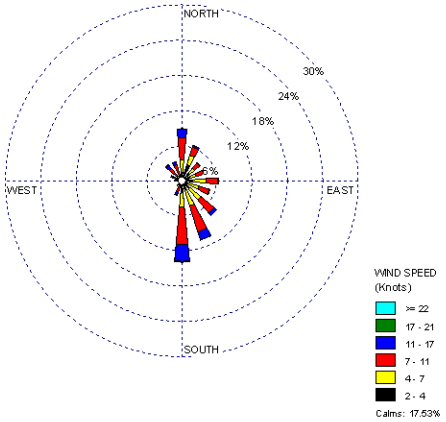

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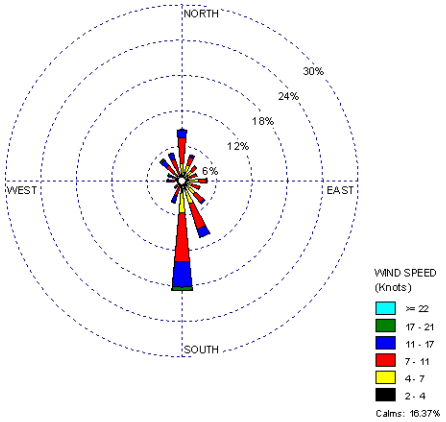

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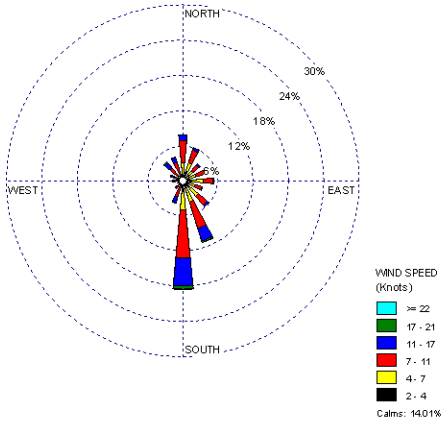

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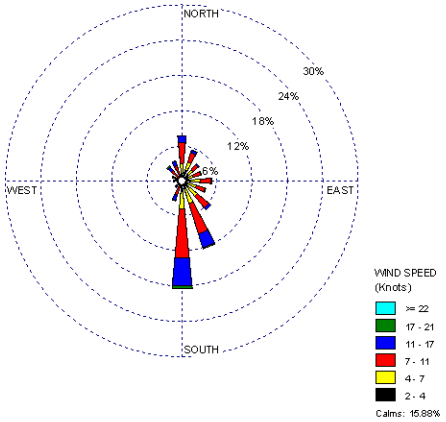
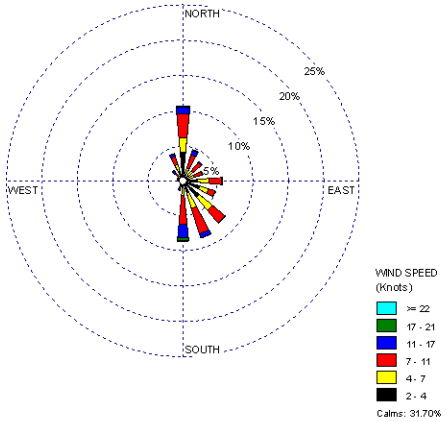


Entire (2001-2009)

WBAN 53914 (Map ID = 13)



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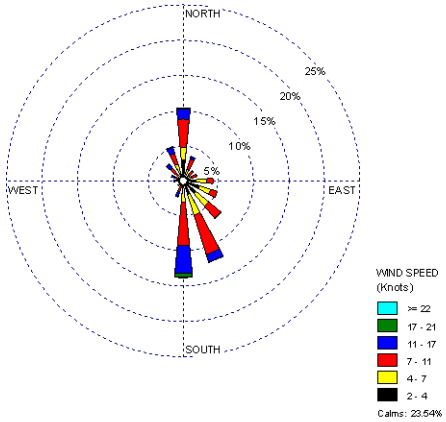

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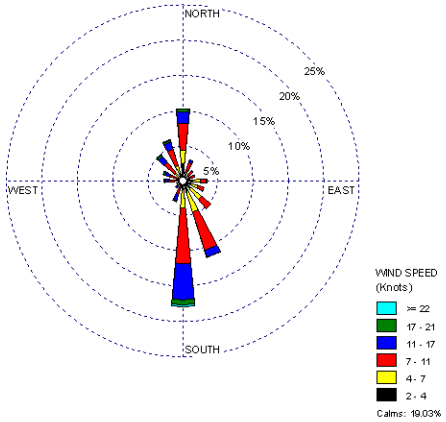

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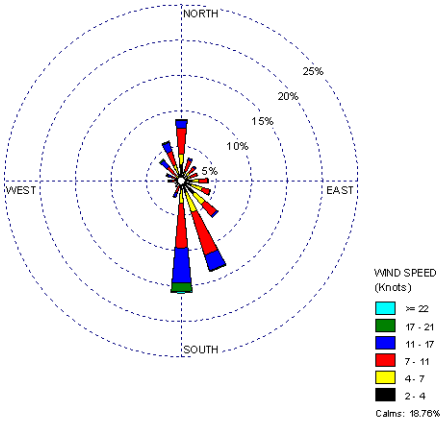

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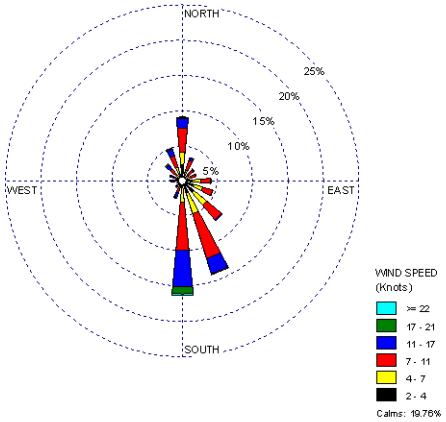
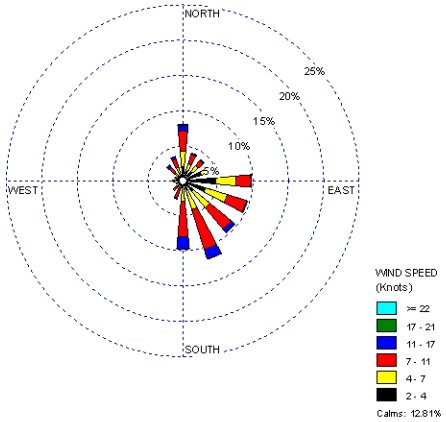


Entire (2001-2009)

WBAN 53964 (Map ID = 14)



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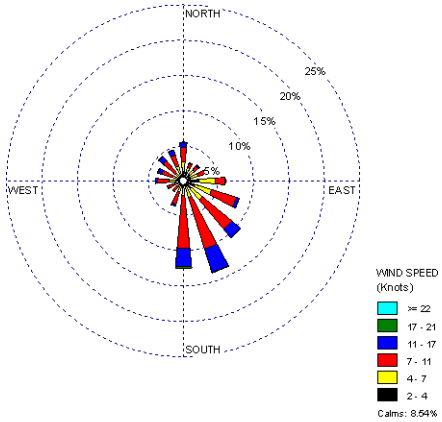

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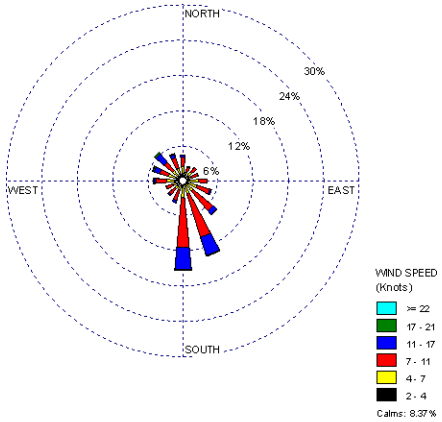

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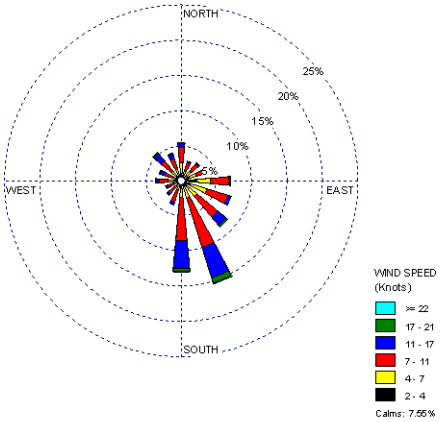

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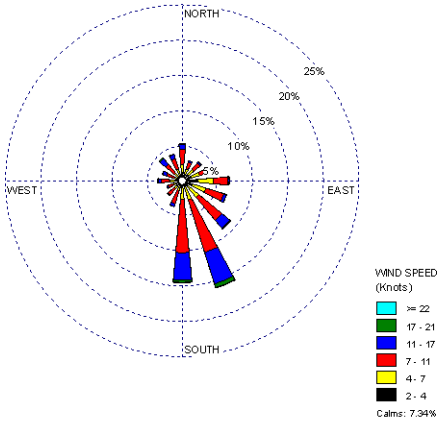
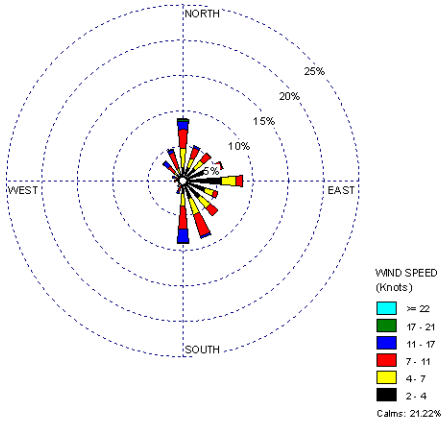


Entire (2004-2009)

WBAN 53966 (Map ID = 15)



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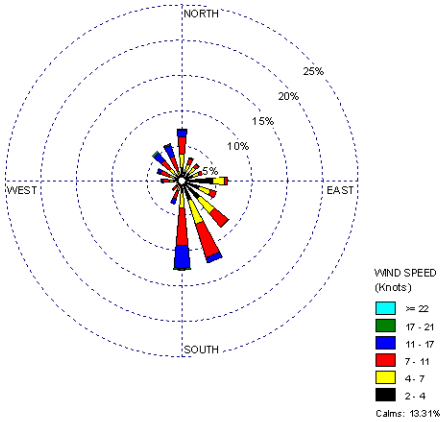

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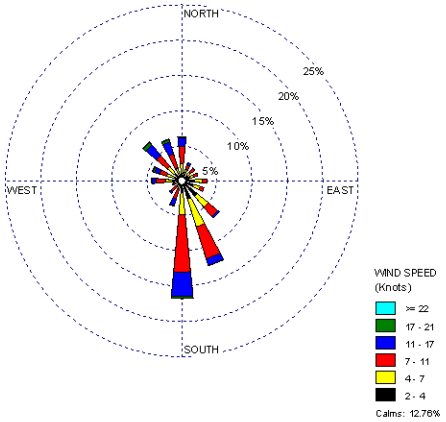

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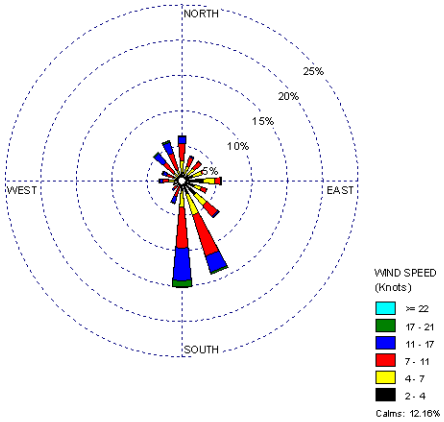

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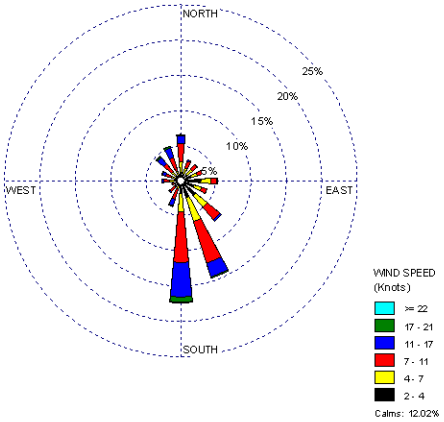
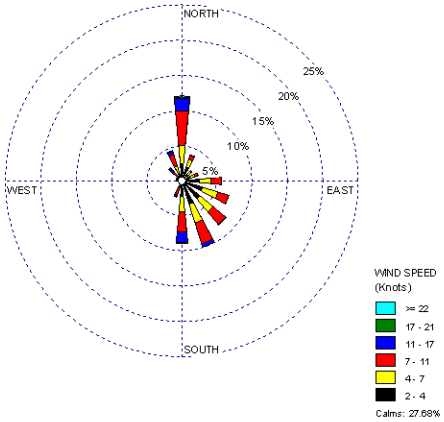


Entire (2004-2009)

WBAN 53970 (Map ID = 16)



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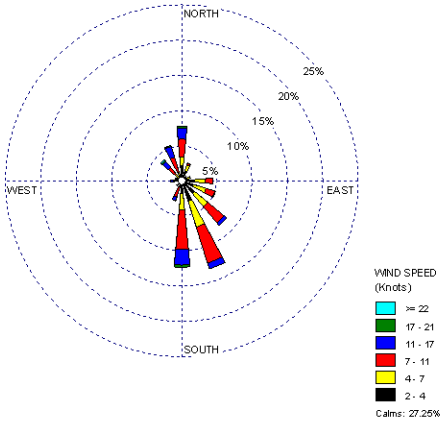

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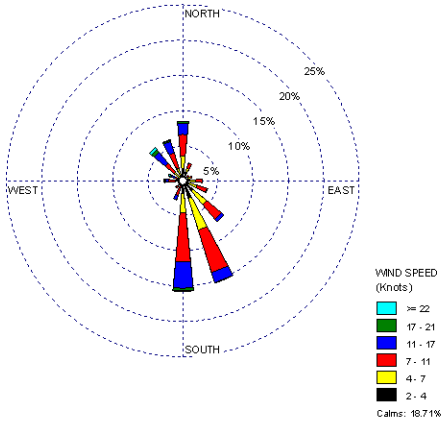

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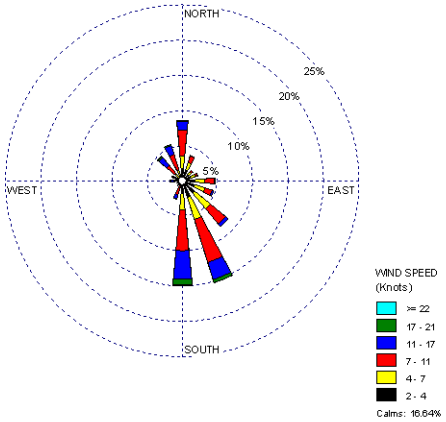

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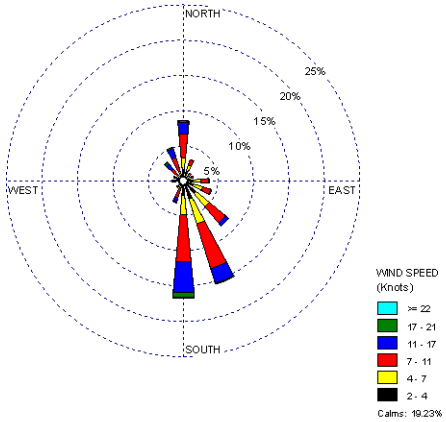
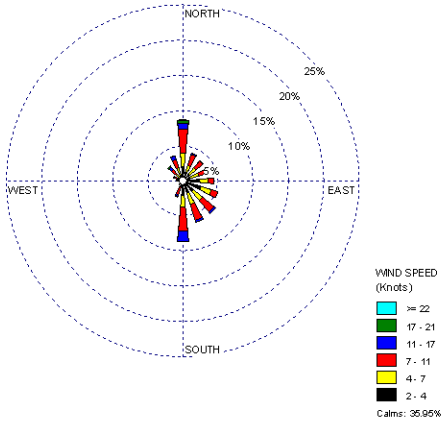


Entire (2004-2009)

WBAN 53975 (Map ID = 17)



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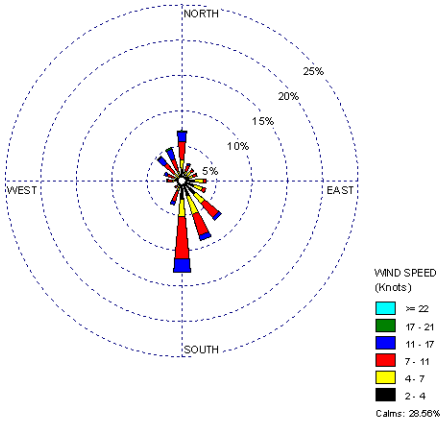

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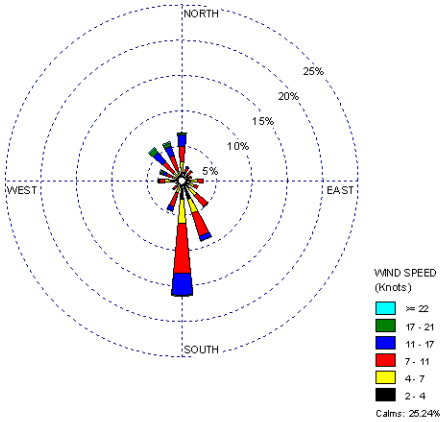

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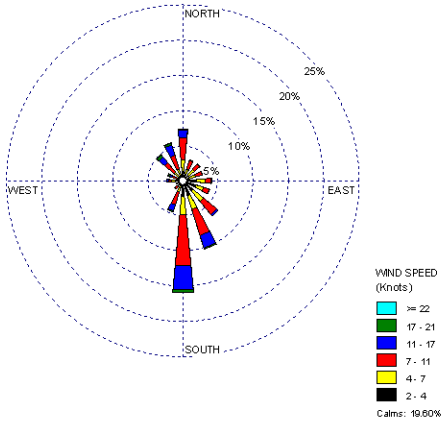

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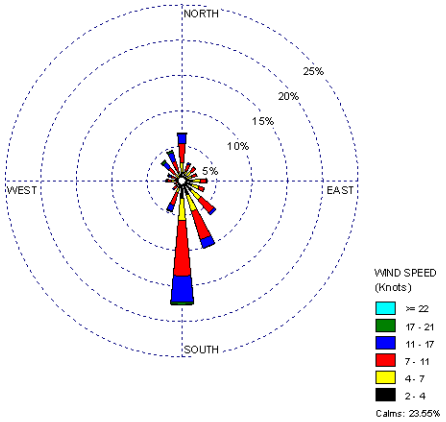
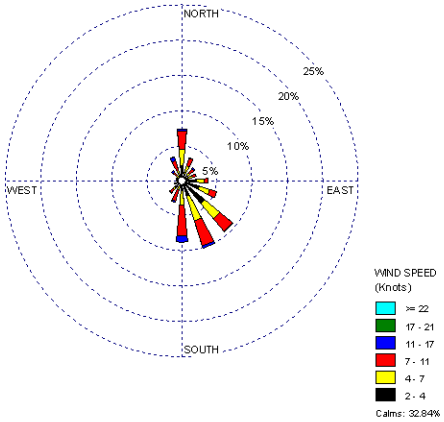


Entire (2004-2009)

WBAN 53976 (Map ID = 18)



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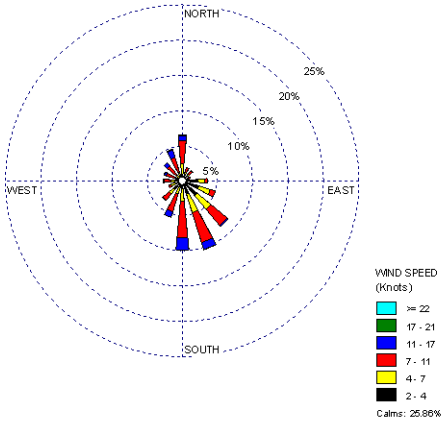

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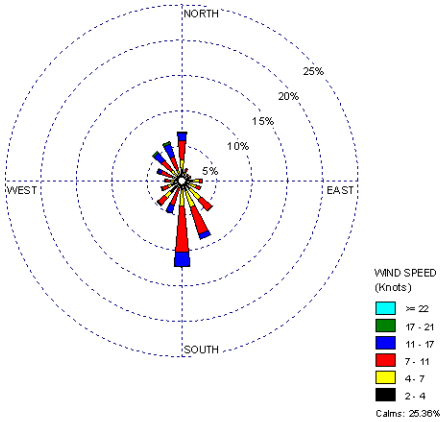

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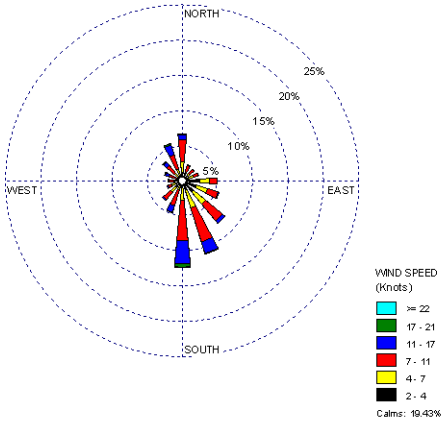

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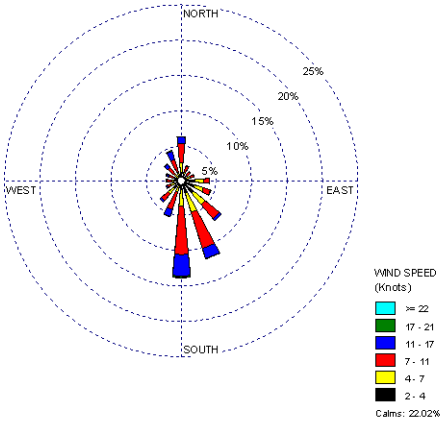
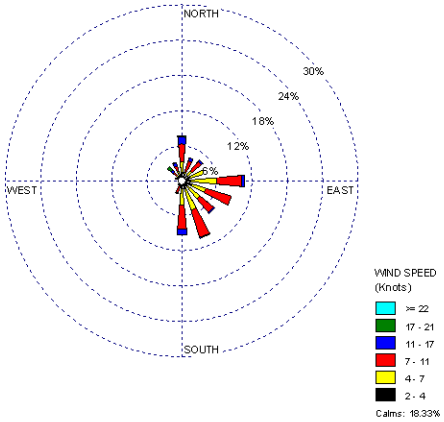


Entire (2004-2009)

WBAN 53981 (Map ID = 19)



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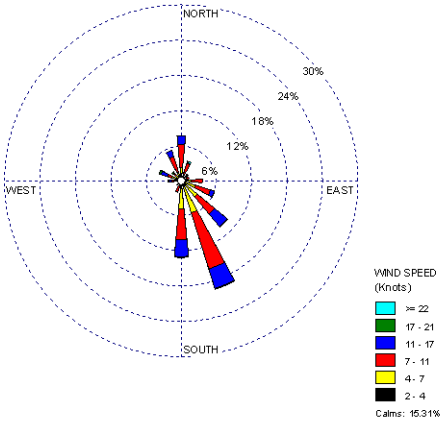

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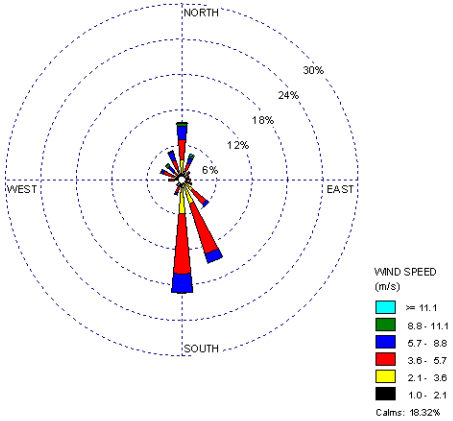

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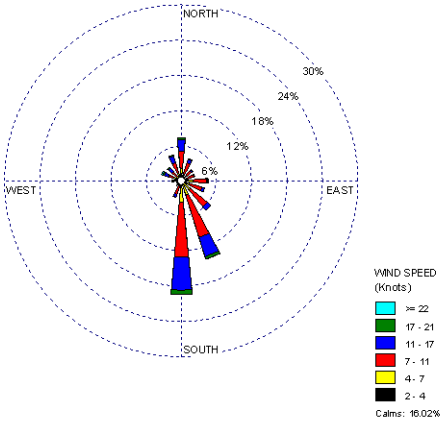

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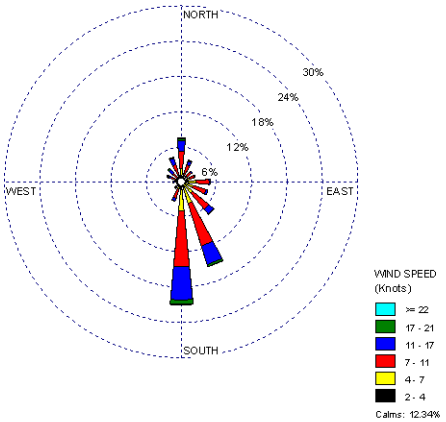
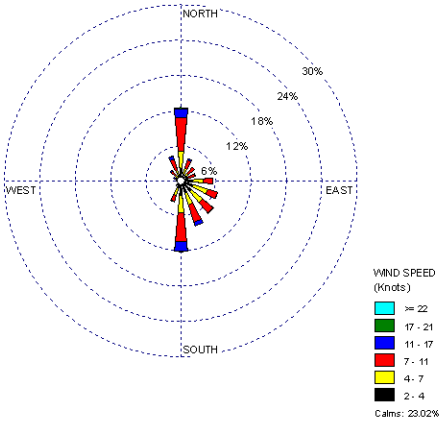


Entire (2007-2009)

WBAN 53984 (Map ID = 20)



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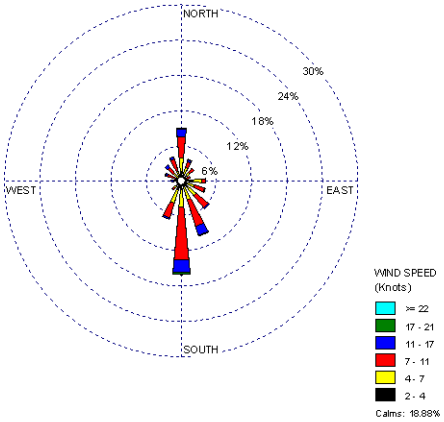

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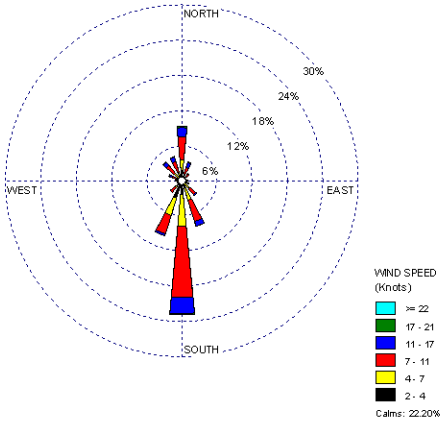

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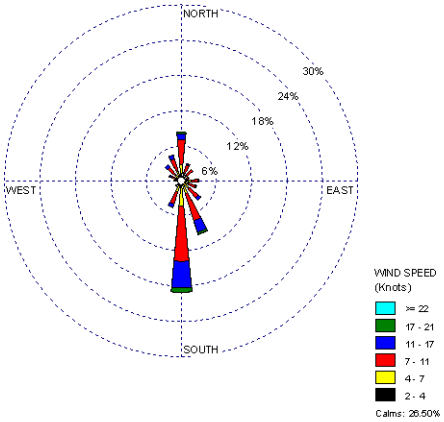

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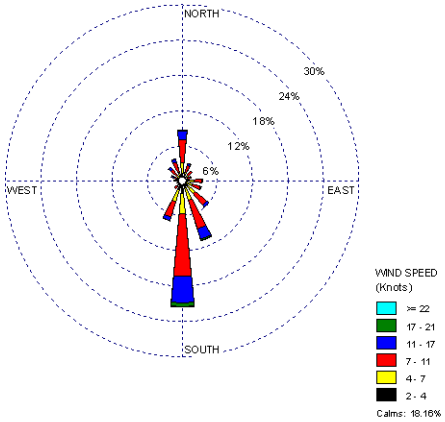
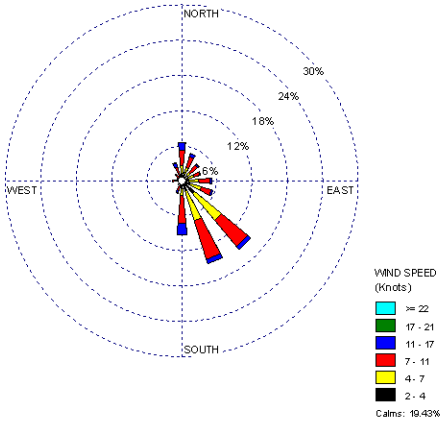


Entire (2006-2009)

WBAN 93985 (Map ID = 21)



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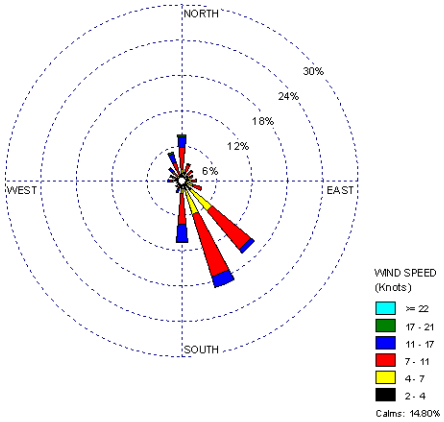

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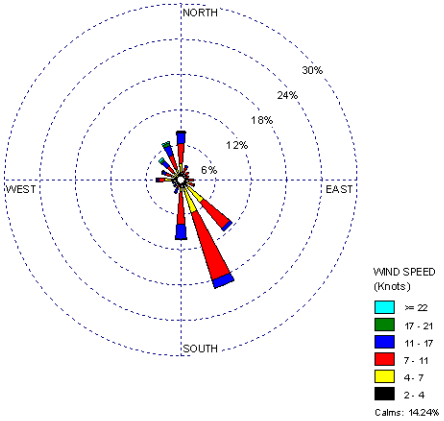

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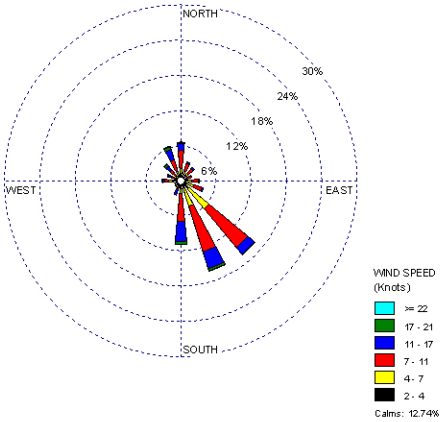

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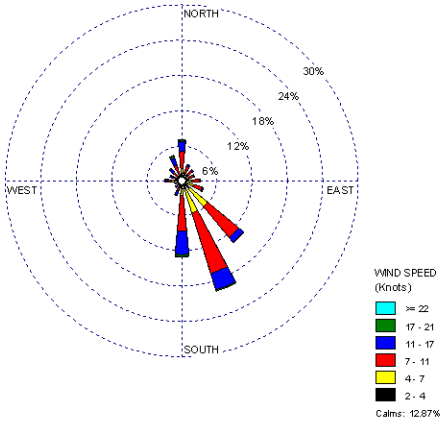
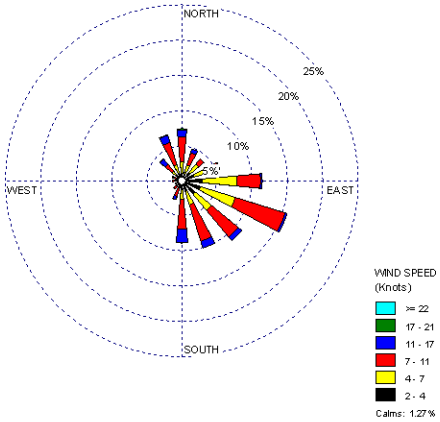


Entire (2001-2009)

AQS 480850005 (Map ID = 22)



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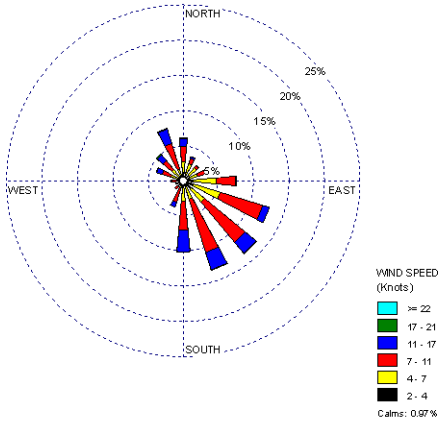

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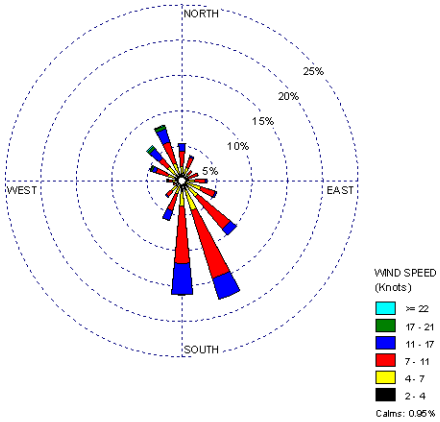

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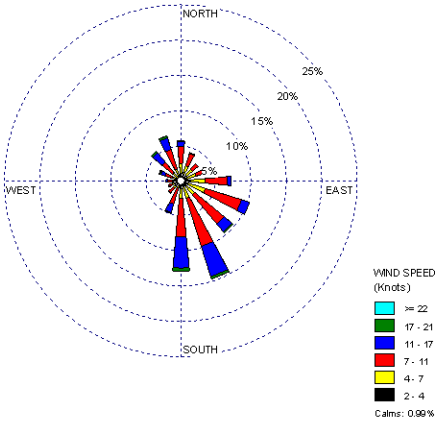

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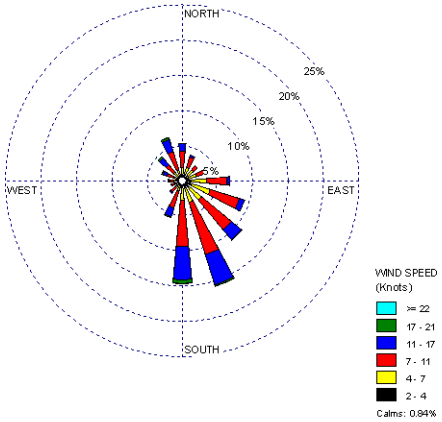
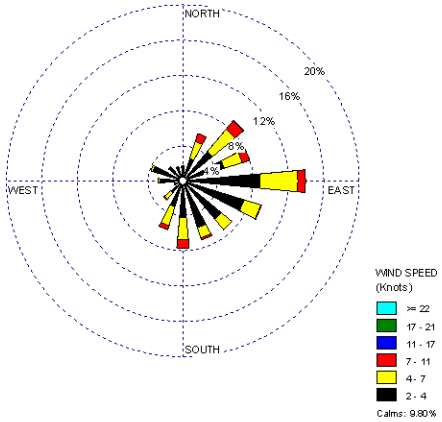


Entire (2005-2009)

AQS 481130050 (Map ID = 23)



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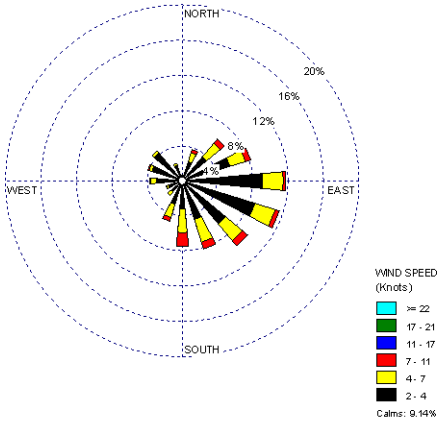

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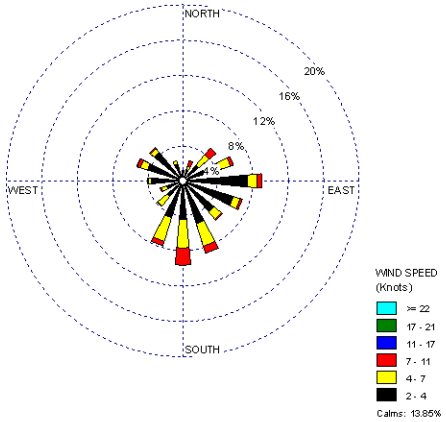

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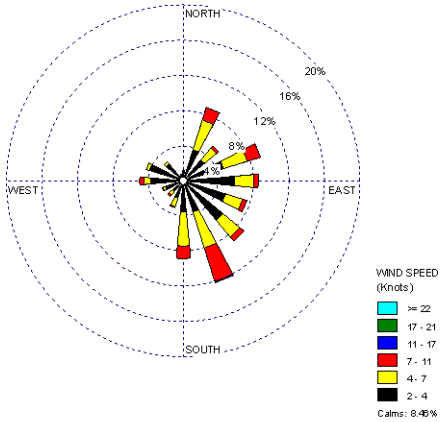

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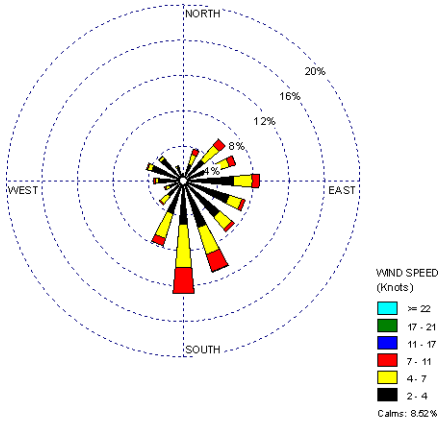
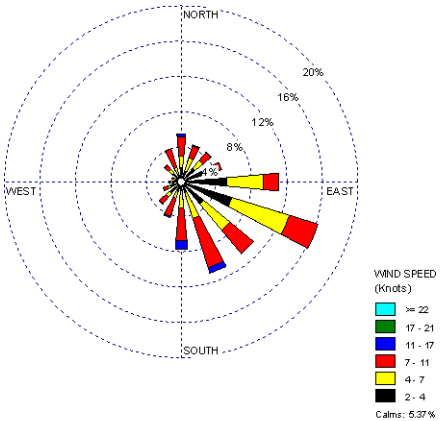


Entire (2005-2009)

AQS 481130057 (Map ID = 24)



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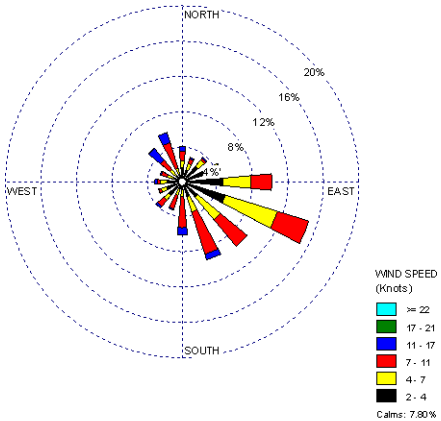
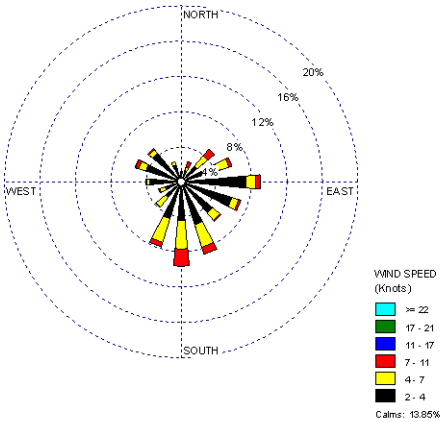


October



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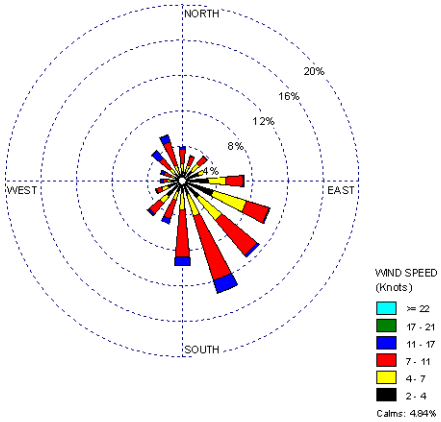
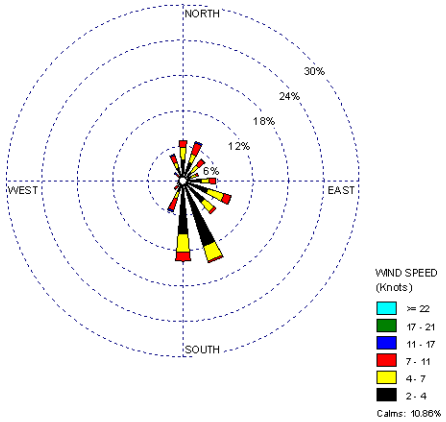


Entire (2005-2007)

AQS 481130069 (Map ID = 25)



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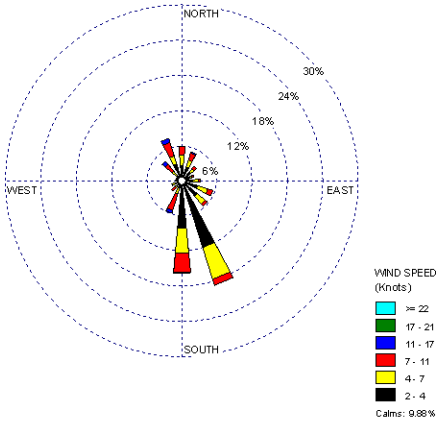

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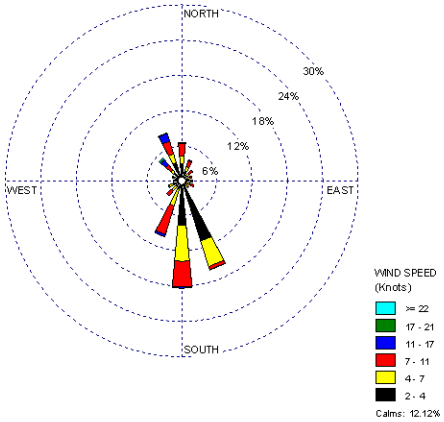

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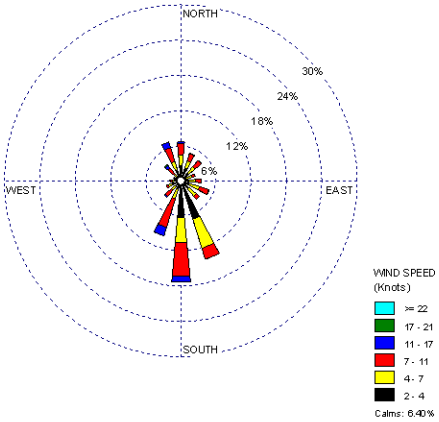

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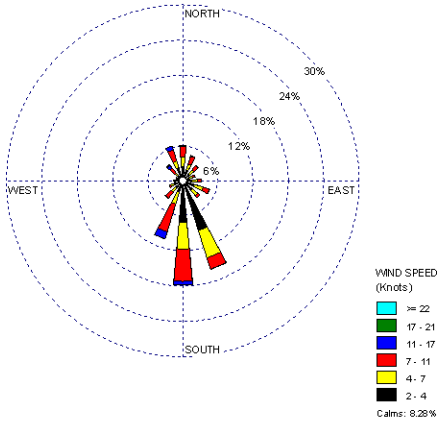
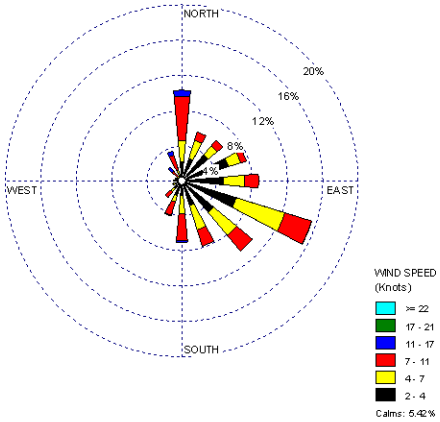


Entire (2005-2009)

AQS 481130075 (Map ID = 26)



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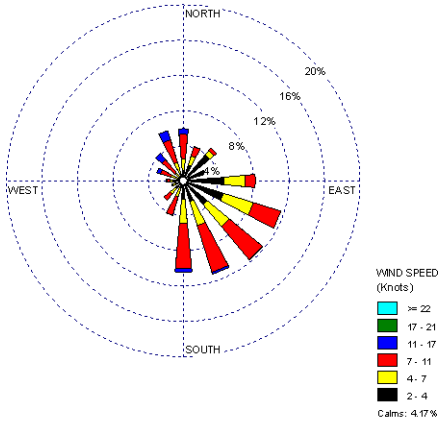

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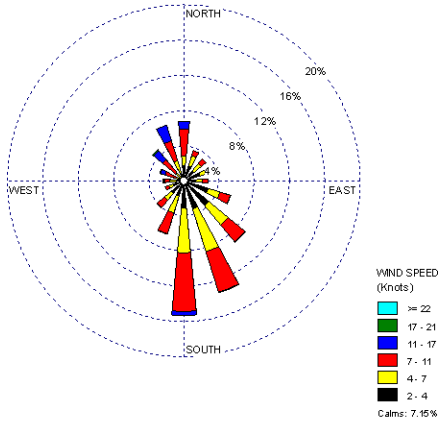

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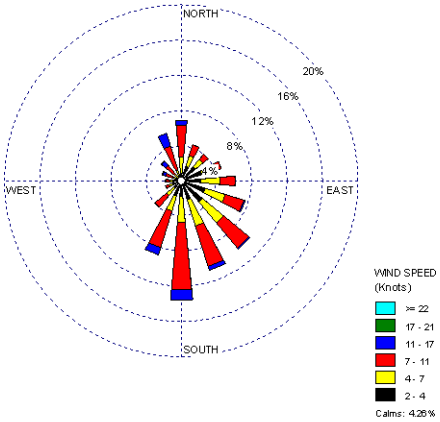

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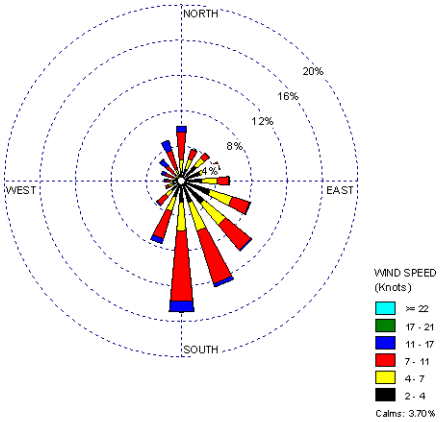

Entire (2005-2009)

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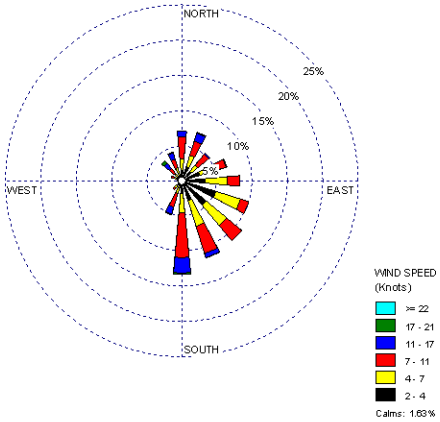

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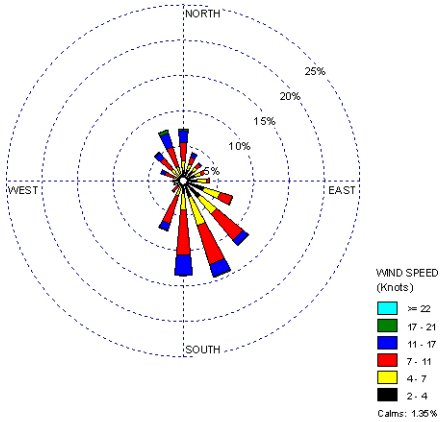

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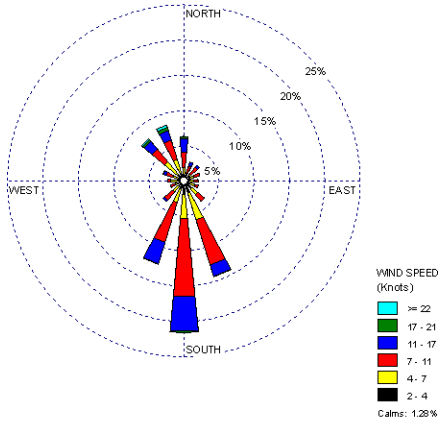

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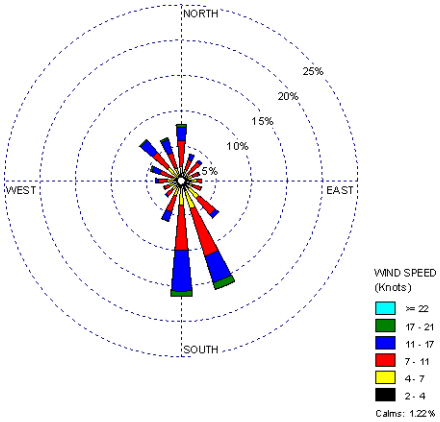

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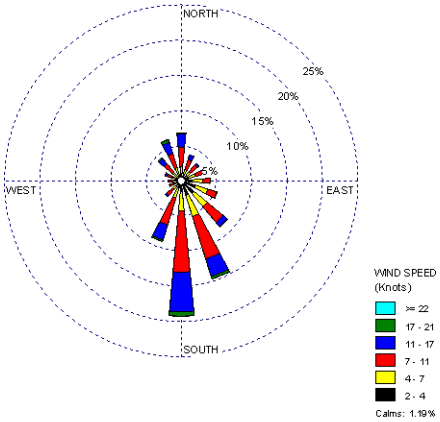
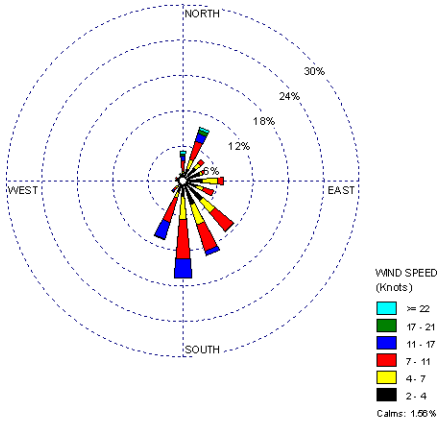


Entire (2005-2009)

AQS 481133003 (Map ID = 28)



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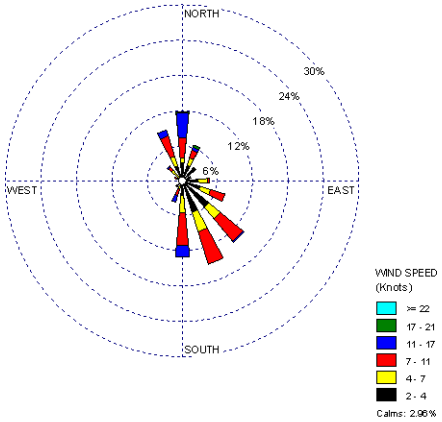

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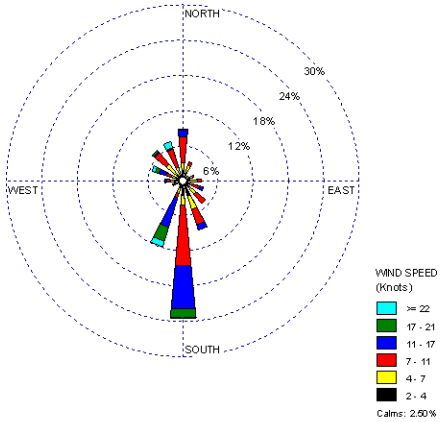

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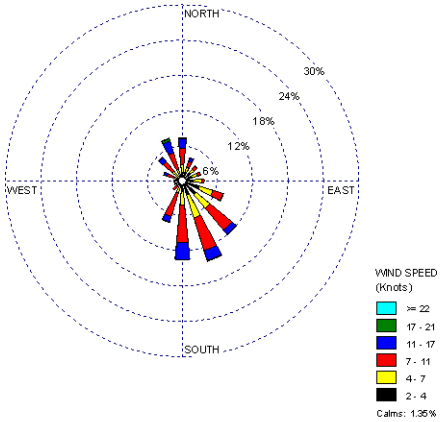
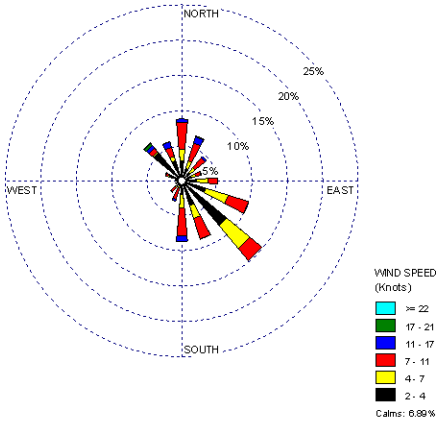


Entire (2005-2006)

AQS 481210034 (Map ID = 29)



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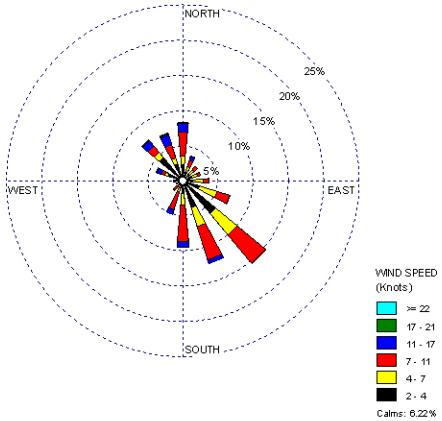

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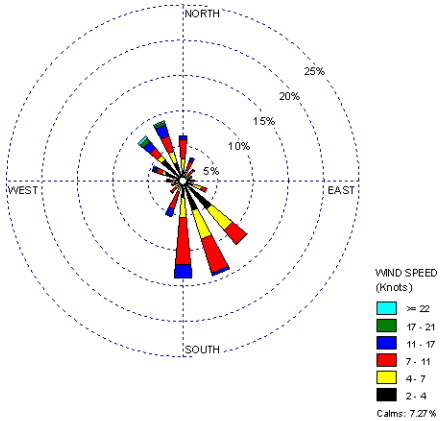

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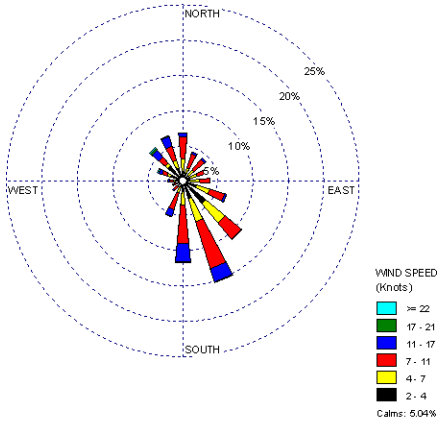

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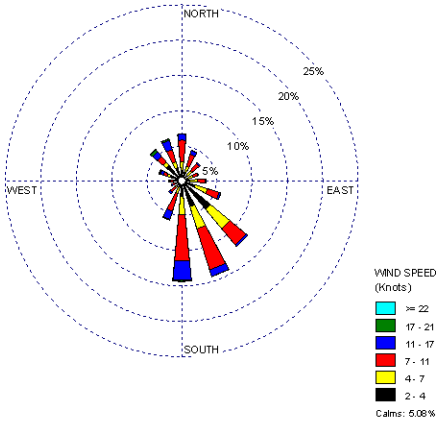
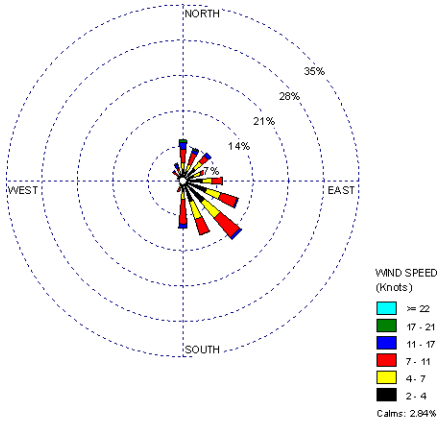


Entire (2005-2009)

AQS 48121032 (Map ID = 30)



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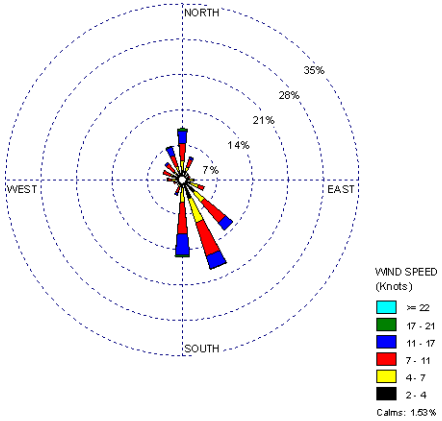

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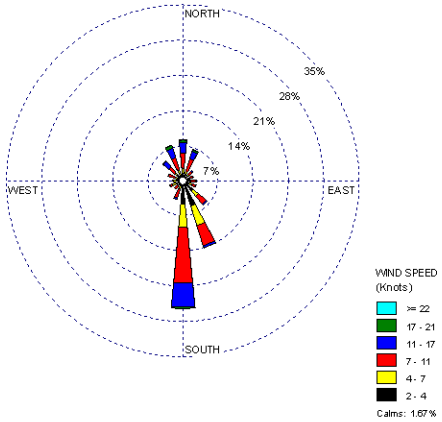

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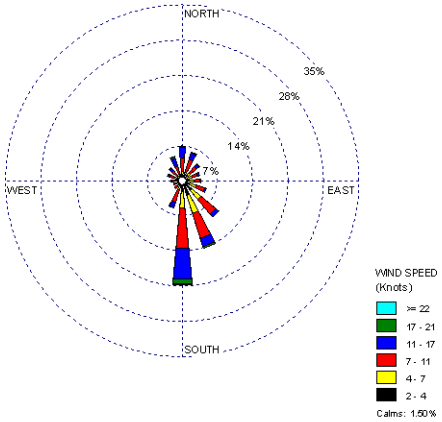

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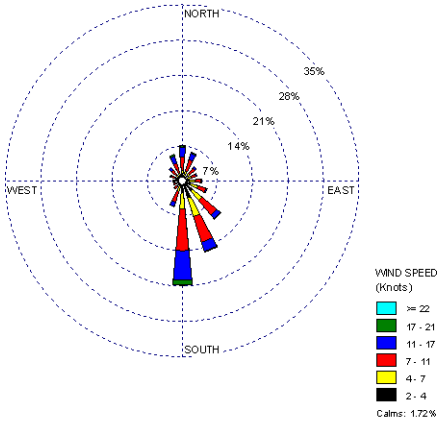
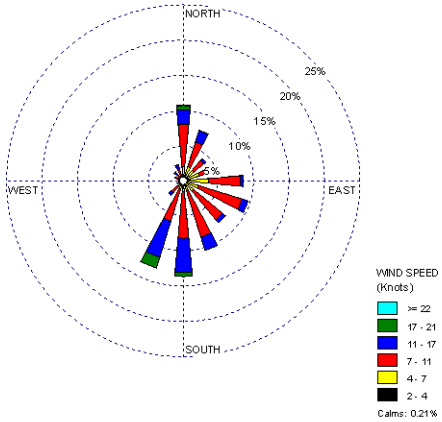


Entire (2007-2009)

AQS 481390015 (Map ID = 31)



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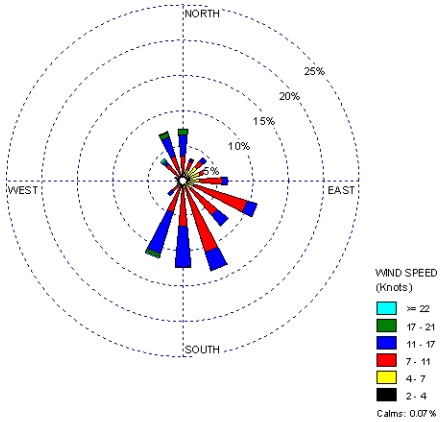

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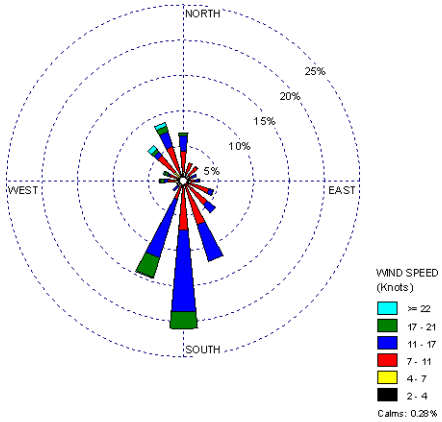

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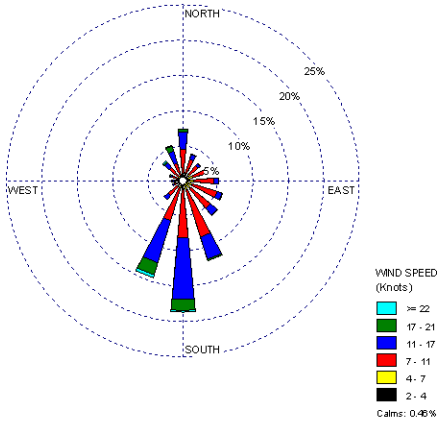

Entire (2005-2006)

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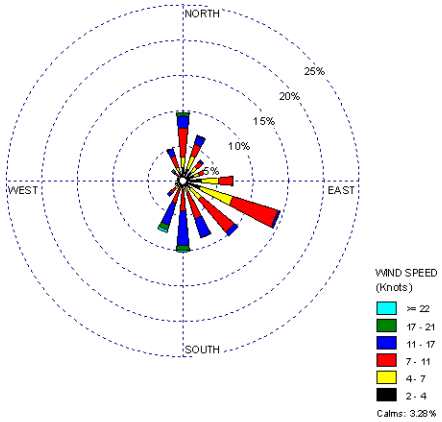

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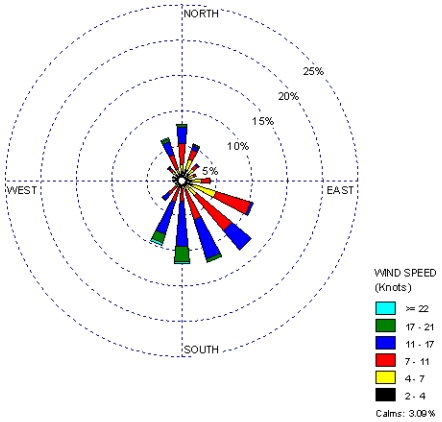

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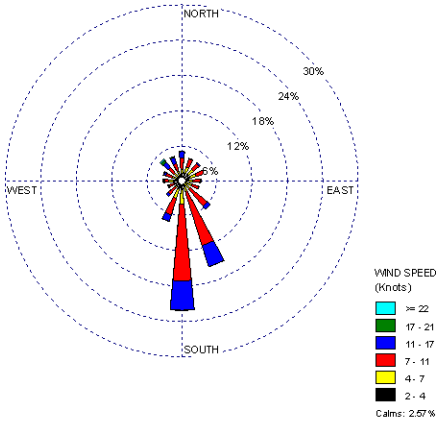

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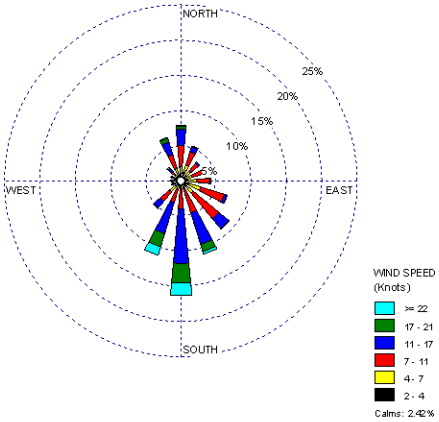

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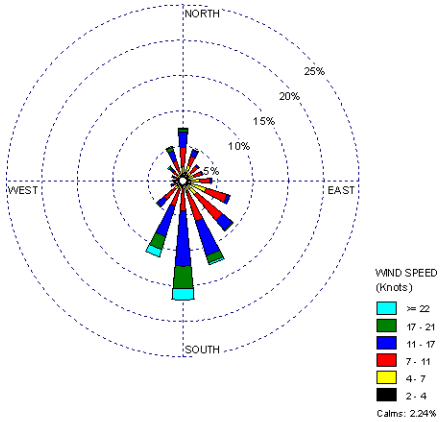

Entire (2005-2009)

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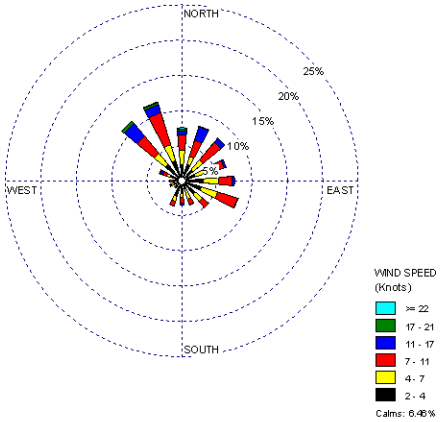

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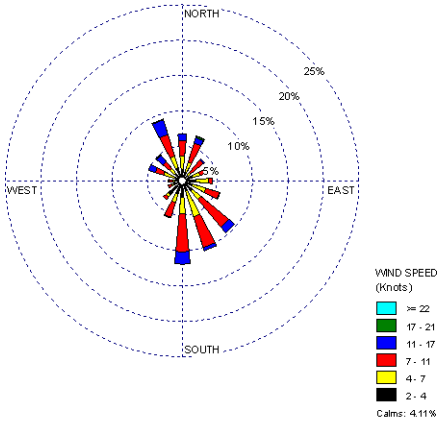

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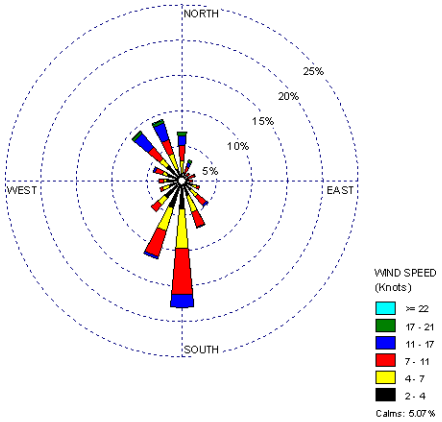

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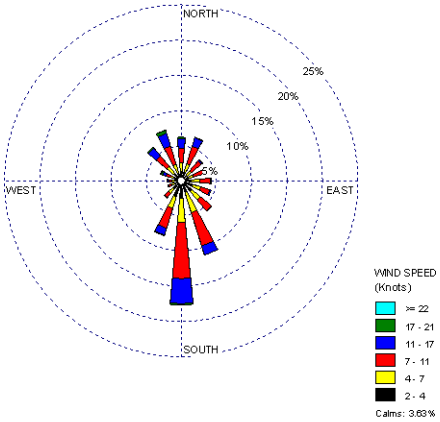

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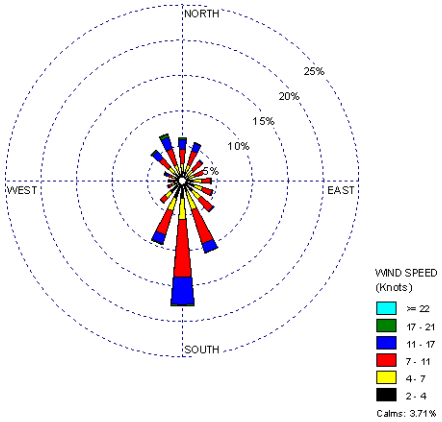
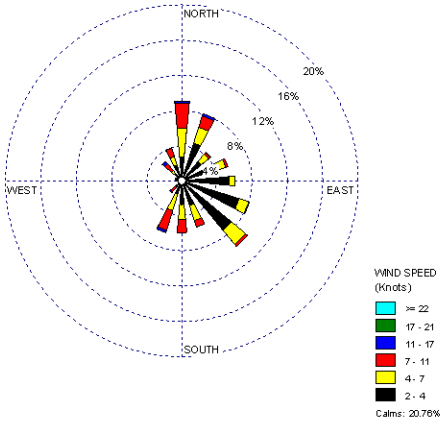


Entire (2008-2009)

AQS 482311006 (Map ID = 34)



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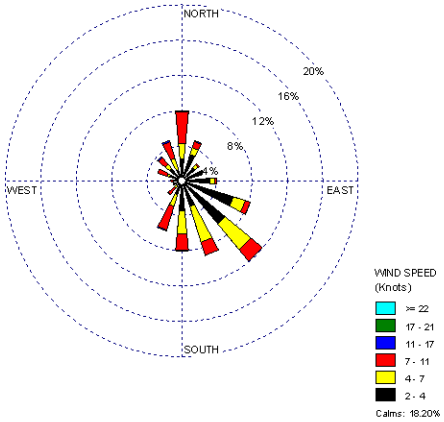

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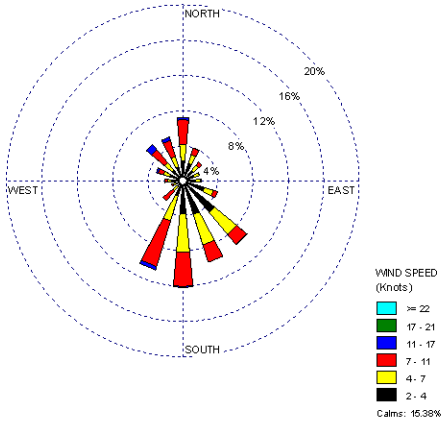

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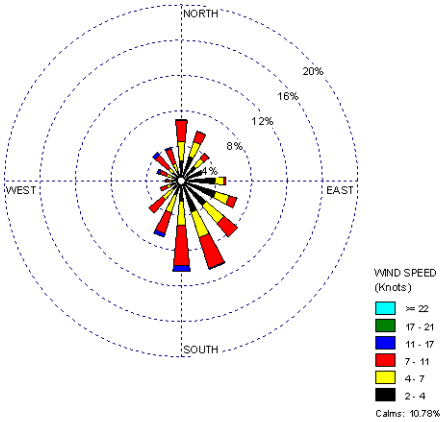

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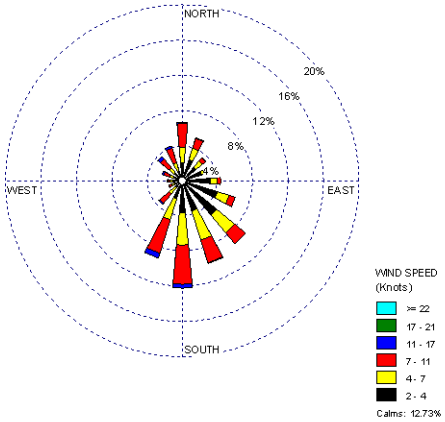
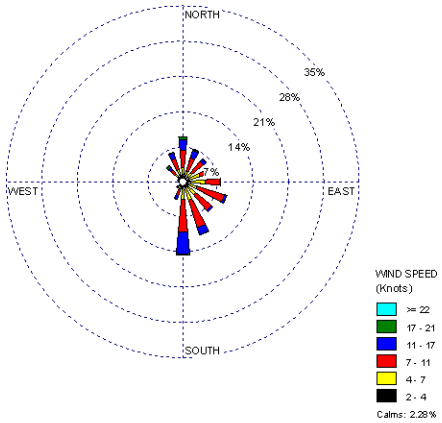


Entire (2005-2009)

AQS 482510003 (Map ID = 35)



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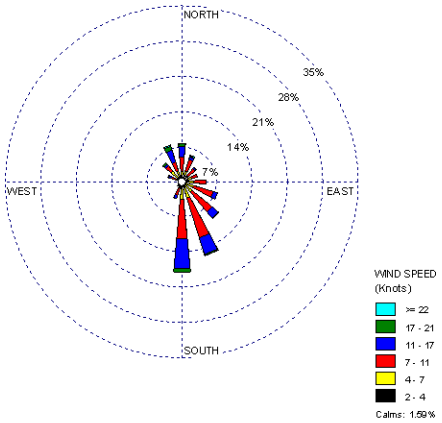

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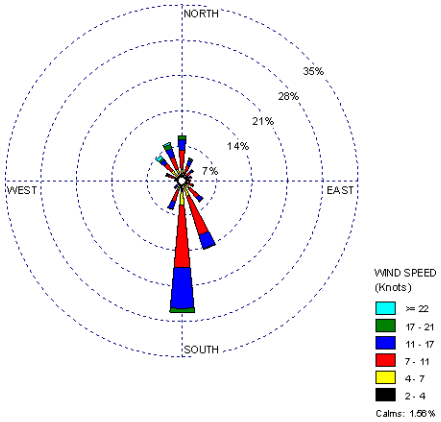

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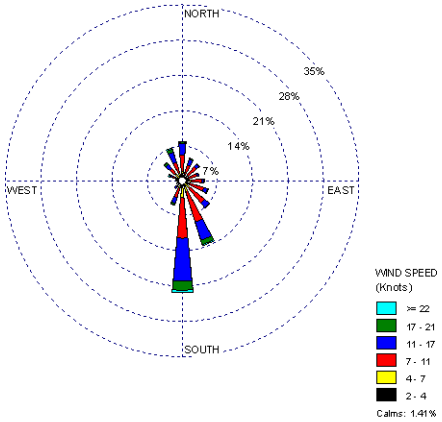

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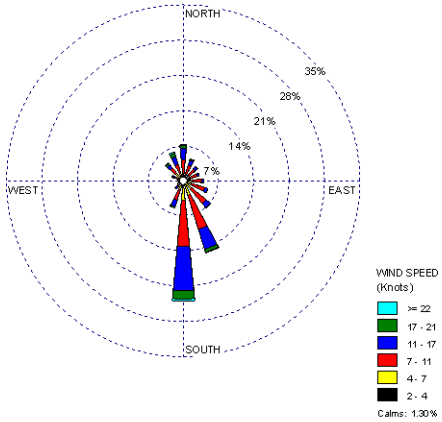
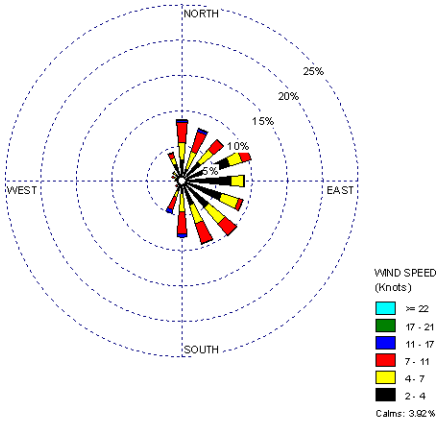


Entire (2005-2009)

AQS 482570005 (Map ID = 36)



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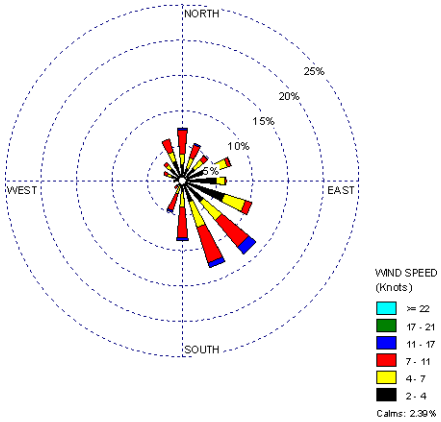

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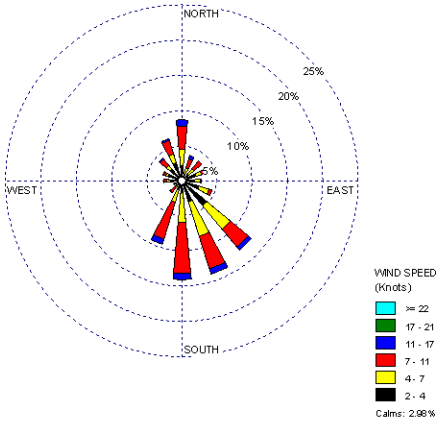

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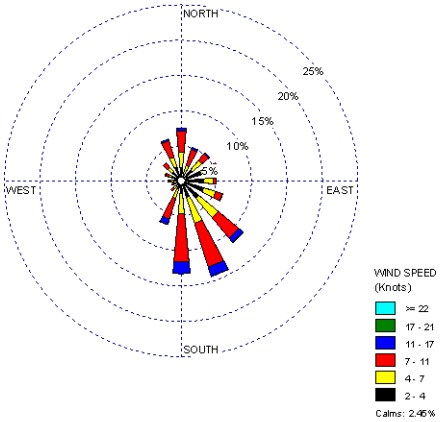
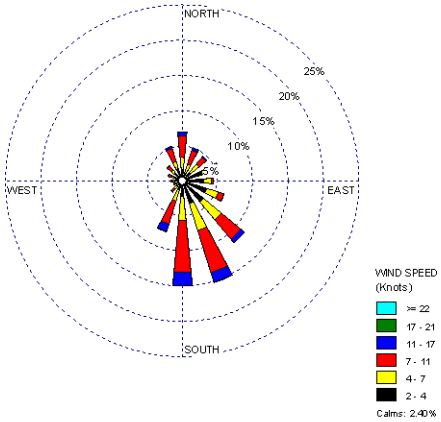
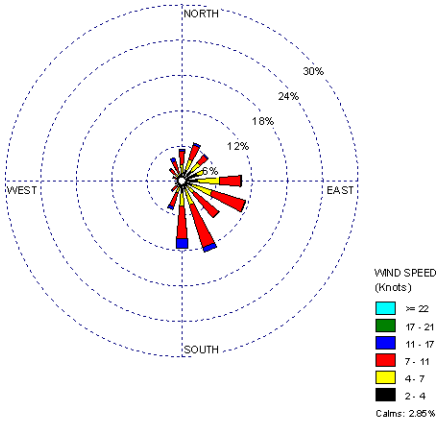


2009



Entire (2005-2009)

AQS 483670081 (Map ID = 37)



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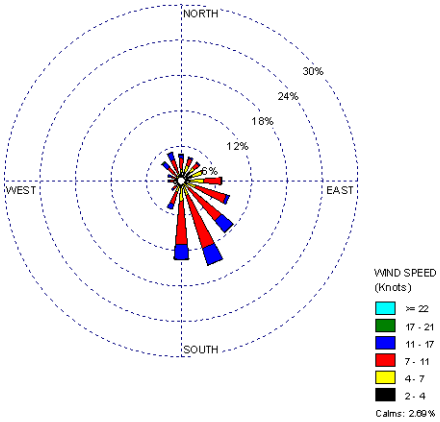

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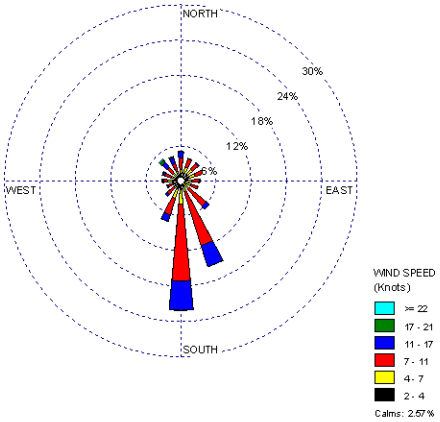

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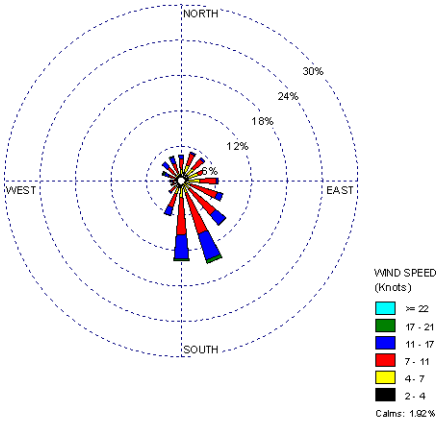

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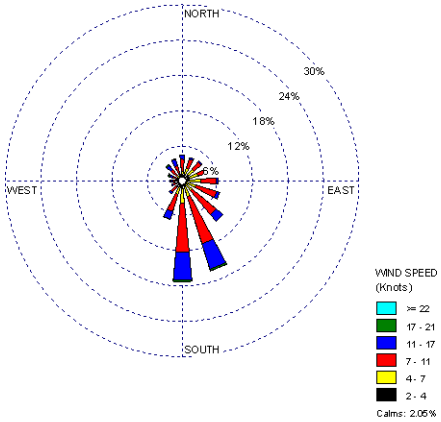
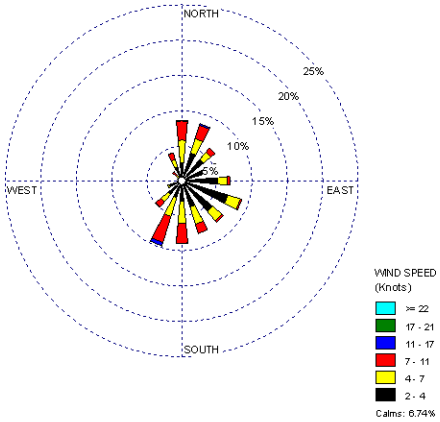


Entire (2005-2009)

AQS 483970001 (Map ID = 38)



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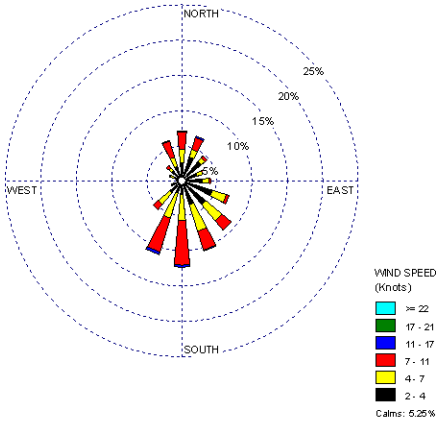

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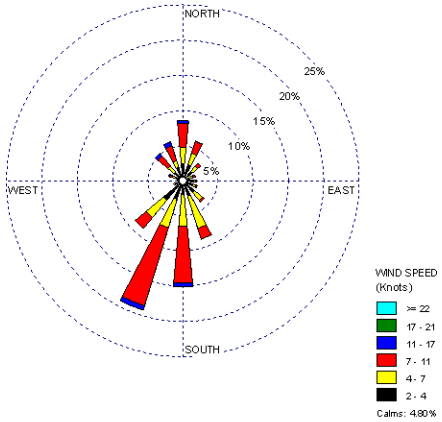

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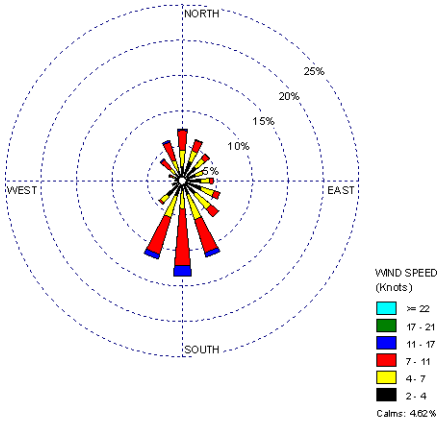

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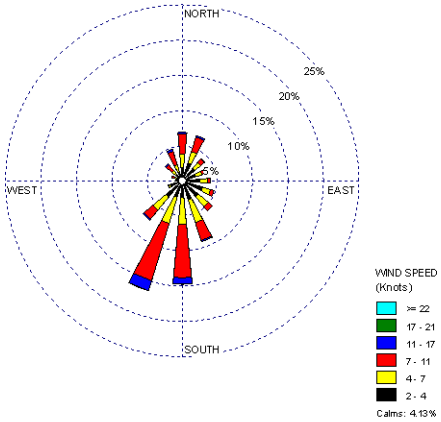
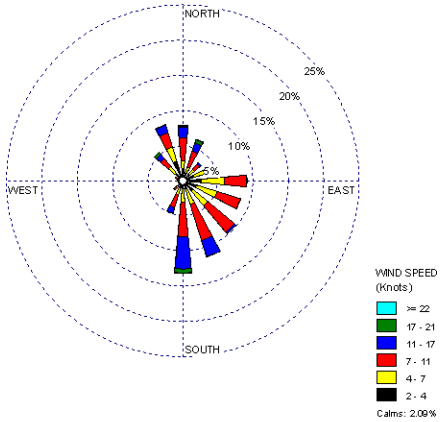


Entire (2005-2009)

AQS 484390075 (Map ID = 39)



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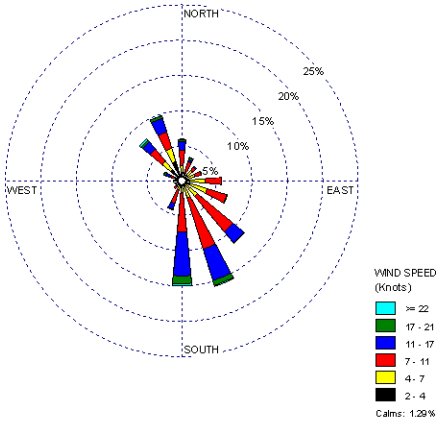

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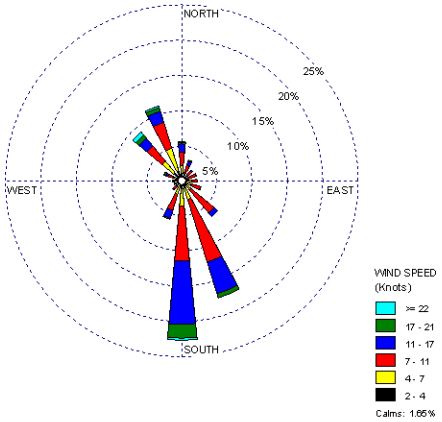

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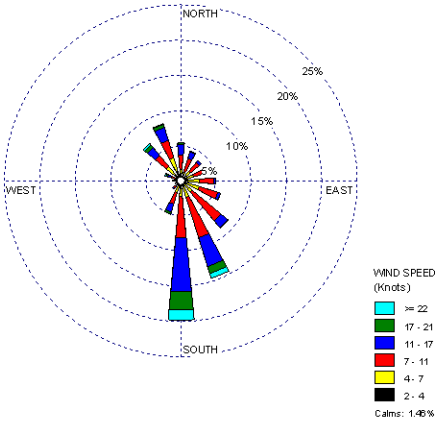

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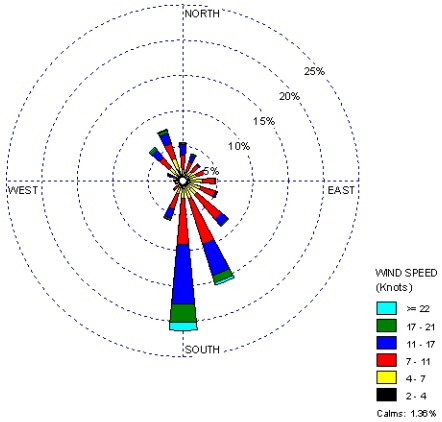
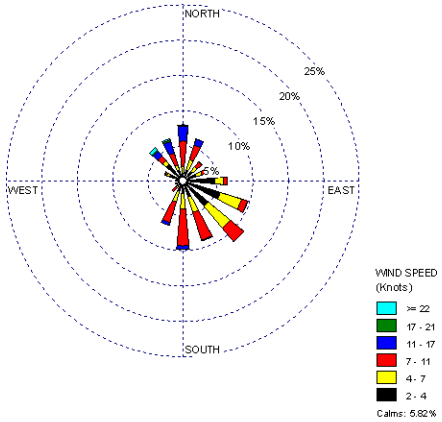


Entire (2005-2009)

AQS 484391002 (Map ID = 40)



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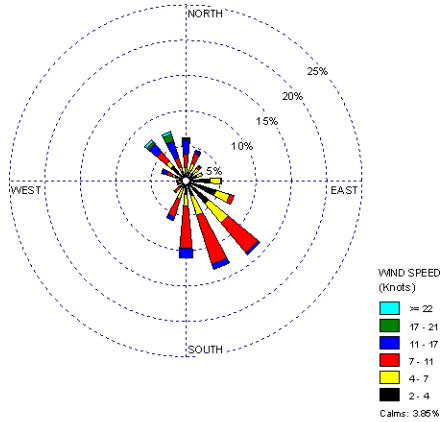

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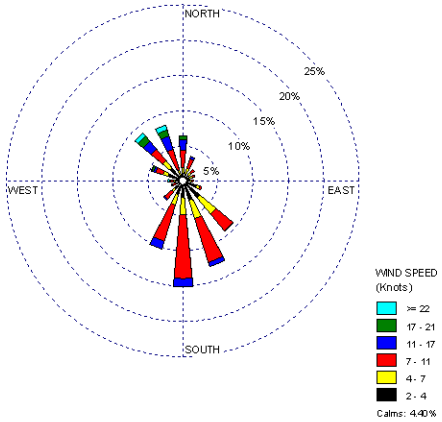

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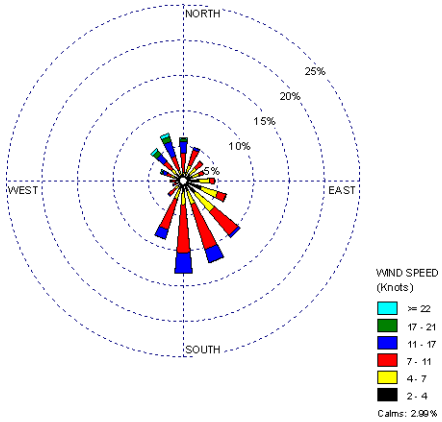

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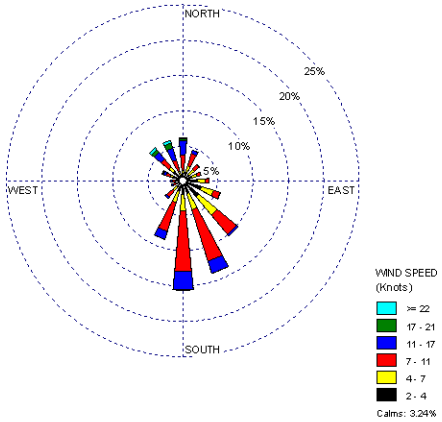
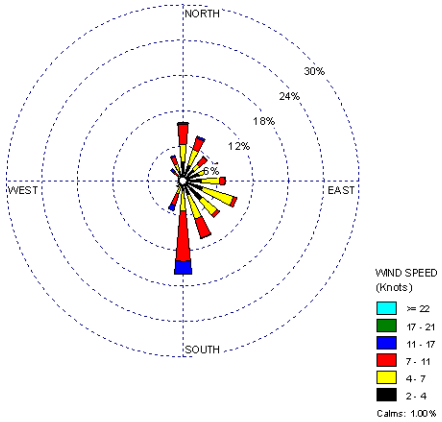


Entire (2005-2009)

AQS 484392003 (Map ID = 41)



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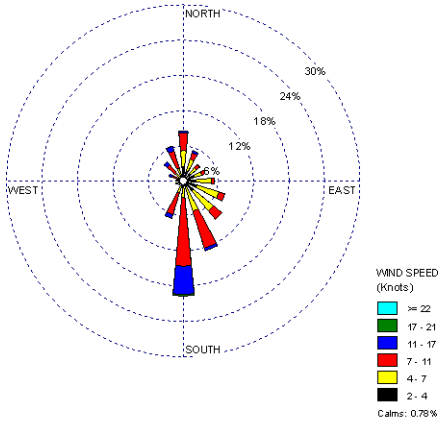

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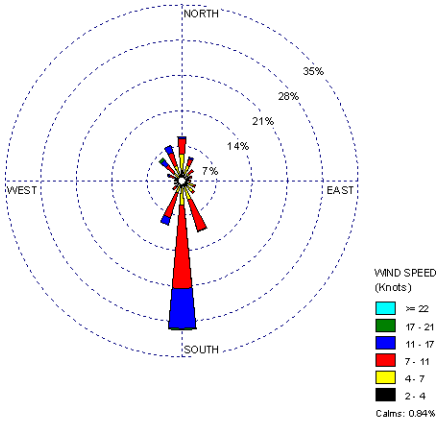

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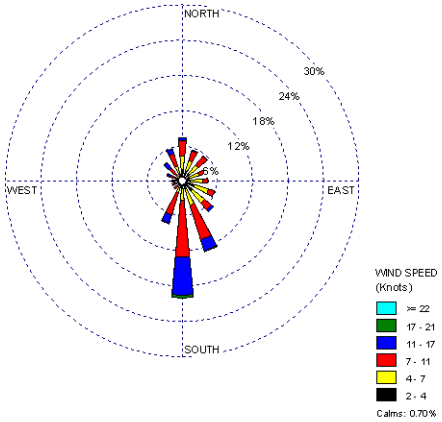

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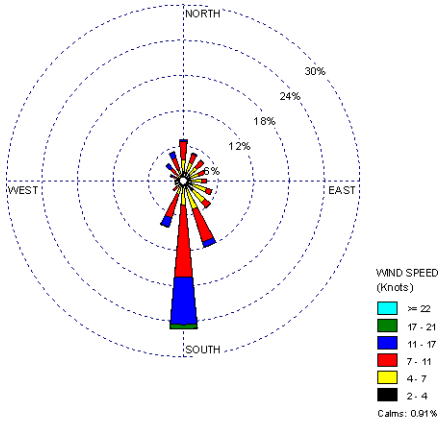
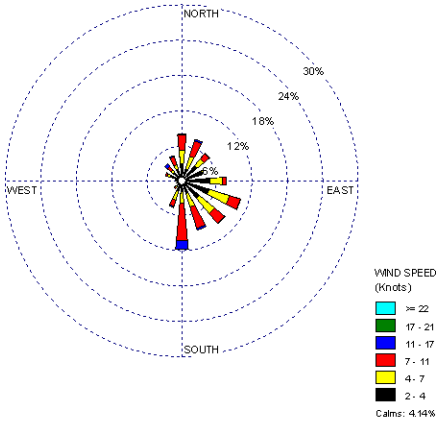


Entire (2005-2009)

AQS 484393009 (Map ID = 42)



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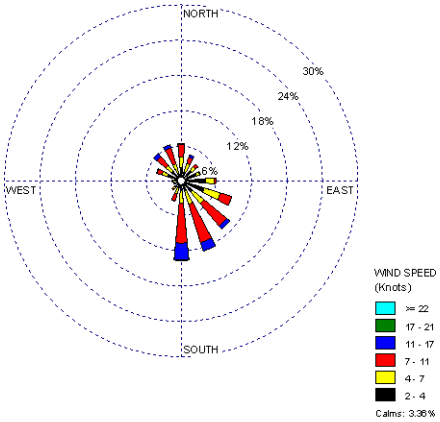

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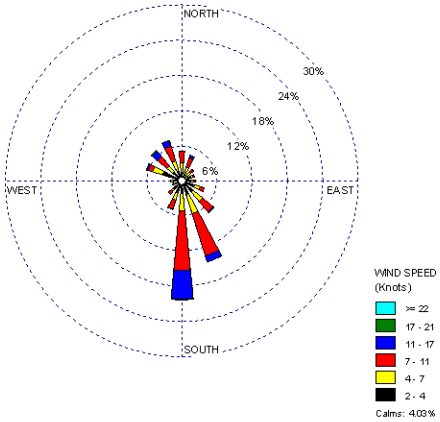

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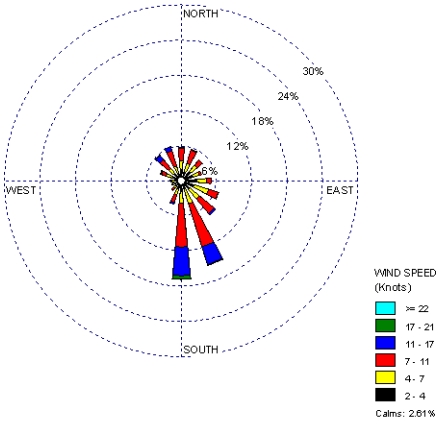

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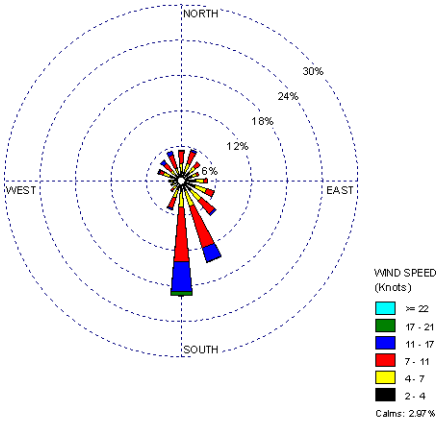
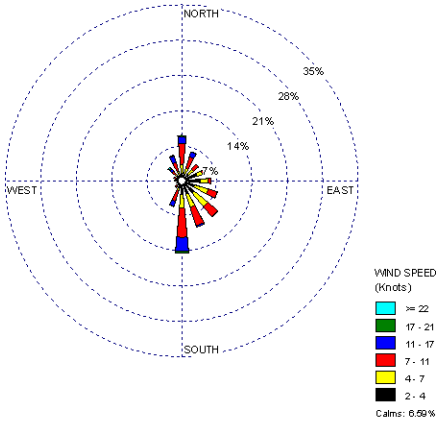


Entire (2005-2009)

AQS 484393011 (Map ID = 43)



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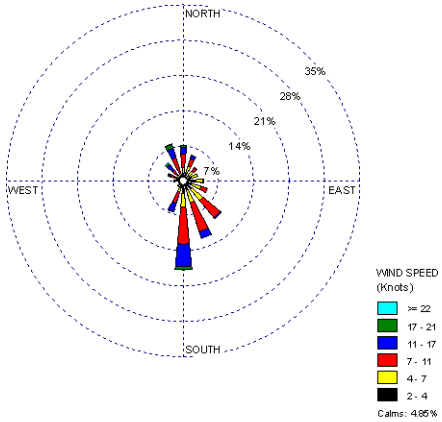

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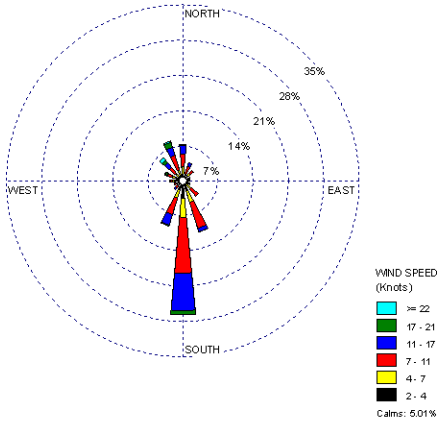

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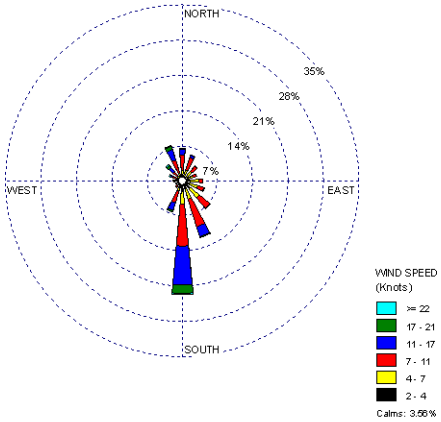

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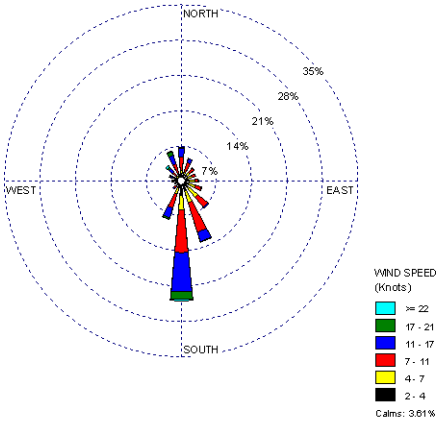

Entire (2005-2009)