# Flying J Study

## Sioux Falls, South Dakota

## PM2.5 Saturation
## Monitoring Project Report
## July/August of 2003

South Dakota Department of Environment and
Natural Resources

Air Quality Program

# TABLE OF CONTENTS

## FIGURES



## TABLES



## APPENDIX

# 1.0 Introduction

On May 19, 2003, Mayor Dave Munson sent a letter to the Department of Environment and Natural Resources (DENR) requesting an air monitoring study around the Flying J Travel Plaza (Plaza) in the city of Sioux Falls. Mayor Munson stated in the letter that the Mayor's office was receiving complaints from residents in a housing development northeast of the Plaza claiming truck exhaust was causing air quality problems. DENR sent a response letter to the Mayor on June 20, 2003, stating that DENR would conduct a short term air quality sampling study in the Plaza area.

The Plaza is located along Interstate Highway 29 on the northeast side of exit 83. Numerous truckers park at the Plaza and use the area for their required rest periods. During these rest periods some of the truckers continue to run their trucks. See the map in Appendix A for more details.

DENR began the study by investigating the sources of air emissions in the study area around the Plaza. The emission sources found included:

- Diesel engine emissions from trucks idling at the Plaza;
- Vehicle emissions from the interstate highways on the west and north sides of the study area;
- Traffic emissions from Highway 38A along the south side of the study area (a busy road used by Sioux Falls commuters);
- Emissions from the re-construction project for the Interstate 29 along the west and south west part of the study area; and
- Local traffic emissions from vehicles in the housing development.

Air emissions from diesel engine exhaust and other vehicle emissions are measured in the ambient air by collecting samples of fine particulate matter. Most of the sources found during the investigation are sources of fine particulate. From this information DENR determined the sampling study would consist of monitoring for particulate matter equal to or less than 2.5 microns in size (PM2.5) or fine particulate matter.

The air monitoring part of the project began on July 17, 2003, and ended on August 10, 2003. The monitoring project included collecting samples every day for a 25 day period at two sites located on the west and south sides of the housing development. In addition one site was also operated every third day at the Hilltop Site, which is one of the state's permanent air quality monitoring sites in Sioux Falls.

# 2.0 Description of the Study Area

The geography of the study area around the Plaza and the housing development is gently rolling hills located on the west edge of the Big Sioux River valley. The Plaza and housing

development are located at the legal description of West 1/2, Section 30, Township 102 N, Range 49 W. See the map in Appendix B for more details.

Land use within two kilometers of the facility includes:

- Farm land that extends around all four sides of the housing development;
- Light industry and commercial businesses are located about ¼ mile south of the housing development along Highway 38A;
- Interstate 90 runs along the north side of the project area;
- Interstate 29 runs along the west side of the project area; and
- Road construction work to the southwest of the study area was occurring along Interstate 29 during the sampling period.

# 3.0 Description of PM2.5 Monitoring Methods

## 3.1 Saturation PM2.5 Monitor

To complete the study for levels of PM2.5 sized particles, an AIR Metrics saturation monitor was selected and equipped with a size selection impactor to collect PM2.5 samples. See Figure 1 for an example of a saturation PM2.5 monitor and site setup. The saturation PM2.5 monitor is a self contained sampling device developed in conjunction with the EPA and the Lane Regional Air Pollution Authority in Eugene, Oregon. The saturation PM2.5 monitor is a low flow, five liter per minute, portable monitor. The monitors were located on poles about three to four meters above the ground. The monitors were powered by a 12 volt battery and ran for a 24-hour period.

Teflon membrane filters were used to collect the PM2.5 samples. The filters were pre-weighed and post weighed by the State Health Lab in Pierre. The lab followed the same filter handling procedures outline in DENR's standard operating procedures for PM2.5 sampling in Section 2.6.0 with the exception that all filters were shipped to the field in Petri dishes instead of filter cassettes.

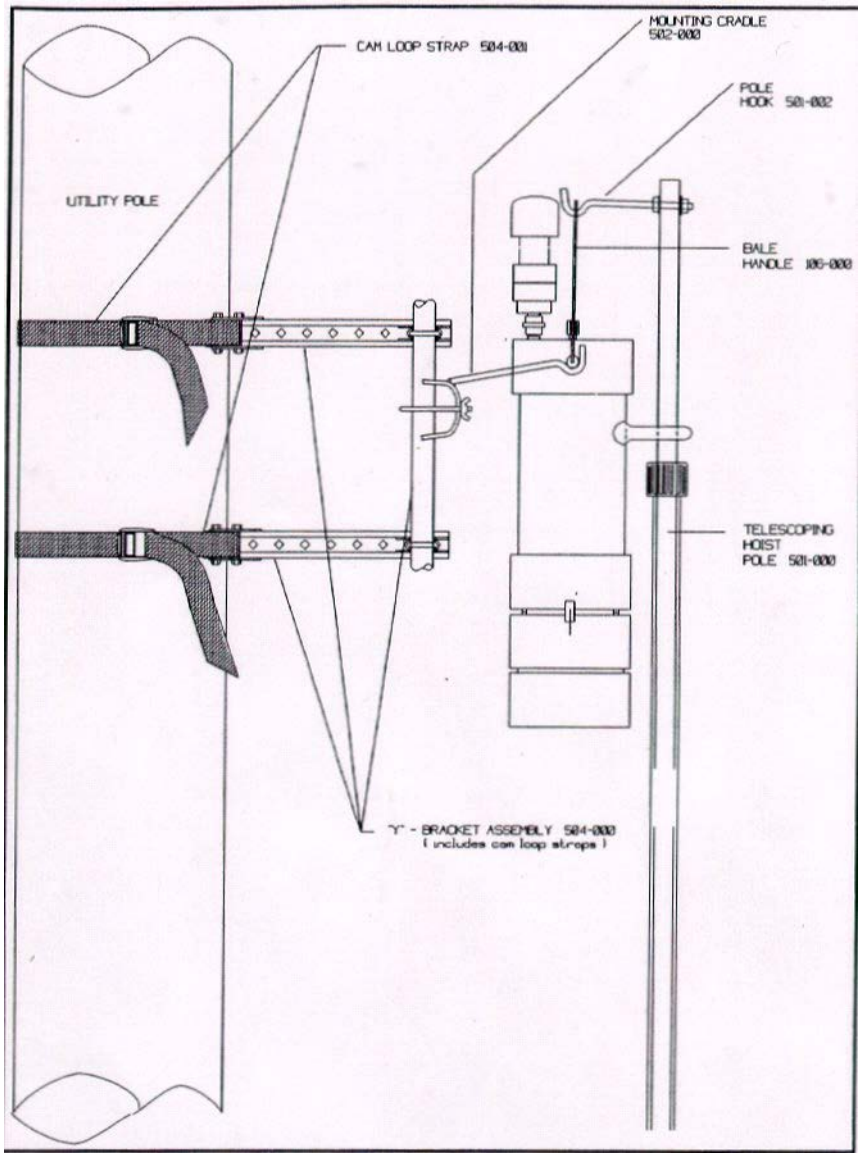
## 3.2 Comparison to Andersen PM2.5 Monitor

EPA has established air quality standards using an approved monitor design. The saturation PM2.5 monitor is not an EPA approved sampling method. Therefore, there may be a difference in sampling results between the saturation PM2.5 monitor and the EPA approved method located at the Sioux Falls sites.

To improve the data quality, a saturation PM2.5 monitor was co-located next to an Andersen PM2.5 monitor to determine the differences in concentrations between the two methods. Data from the saturation PM2.5 monitors was adjusted according to the average difference in concentrations. The adjustment made the comparison between the saturation PM2.5 monitoring data to the EPA 24-hour standard for PM2.5 more reliable.

DENR operates two air monitoring sites in Sioux Falls (Hilltop and KELO). DENR selected the Hilltop Site as the co-located site because it is located in a residential area and the setup and operation of the saturation PM2.5 monitors was more convenient at this location. See Appendix C for a map showing the location of DENR's Sioux Falls monitoring sites and the Plaza area.

**Figure 1. Example of a Saturation PM2.5 Monitor Site Setup**



## 4.0 Monitoring Site Description

Monitors were operated at three sampling locations. The site names are JF1, JF2 and JF3. See the map in Appendix C for more information on the monitoring site locations.

Monitoring site JF3 was located on the west edge of the housing development. The site was located between the Plaza and the housing development. The location will show impacts from the Plaza when the winds are from the South direction. Poles were attached to the boundary fence and monitors attached to the poles. Figure 2 shows a picture of the JF3 monitoring site. The Plaza is shown in the background of this picture. The photo is looking to the south southwest.

**Figure 2. Picture of JF3 Monitors Site**

Monitoring site JF2 was located on the south central edge of the housing development. This site is also located between the Plaza and the housing development. The location will show impacts from the Plaza when the winds are from the southwest direction. The saturation monitors were attached to an existing pole. See Figure 3 to view a picture of the JF2 monitoring site. The photo is looking north into the housing development.

**Figure 3. Picture of JF2 Monitors Site**

Monitoring site JF1 was located at the Hilltop Site in the eastern part of the city of Sioux Falls. The collection of samples at this site will allow a comparison of the saturation sampling results to the EPA reference method monitor, which is used to determine compliance with the national ambient air monitoring standards. The saturation monitors were attached to a pole that was attached to a corner post for the chain link fence around the Hilltop monitoring equipment. Figure 4 shows a picture of the JF1 monitoring site. The photo is looking to the southeast.

**Figure 4. Picture of JF1/Hilltop Monitoring Site**

## 5.0 Monitoring Data

The United States Environmental Protection Agency has set ambient concentrations for PM2.5 levels that if exceeded will cause an un-acceptable threat to public health. The standard includes a short term level (24-hour average concentration at 65 micrograms per cubic meter of air) and a long term level (annual average concentration at 15.0 micrograms per cubic meter of air). The results of the study were compared to the 24-hour national ambient air quality standard for PM2.5 to determine if a health risk exists at the housing development north of the Plaza. The saturation monitoring data was also compared with meteorological data and the existing monitoring sites to determine if the Plaza is impacting the housing development.

The results of the saturation study were not compared to the PM2.5 annual national ambient air quality standard because of the short duration of the sampling study. The annual PM2.5 standard is an average that takes into account the seasonal variation of concentration levels. Therefore, samples collected over a 25 day period would not be a true representation of annual concentrations in the study area.

Before comparisons were made the daily sample concentrations for both JF2 and JF3 were adjusted by 3.3 micrograms to offset the differences in sampling method. The adjustment was determined by calculating the average difference between the saturation PM2.5 monitor and the Andersen PM2.5 monitor. See Section 5.5.2 for details on the concentration differences and the adjustments to the saturation PM2.5 concentrations.

## 5.1 Comparison of Saturation Data to the PM2.5 24-hour Standard

A total of twenty-five 24-hour sampling days were completed. Both JF2 and JF3 monitoring sites had only one voided sample with a valid sample recovery rate of 96%. Table 1 lists the adjusted PM2.5 concentrations for each sampling day and meteorological data from the Sioux Falls Airport.

**Table 1. Saturation and Meteorological Data**

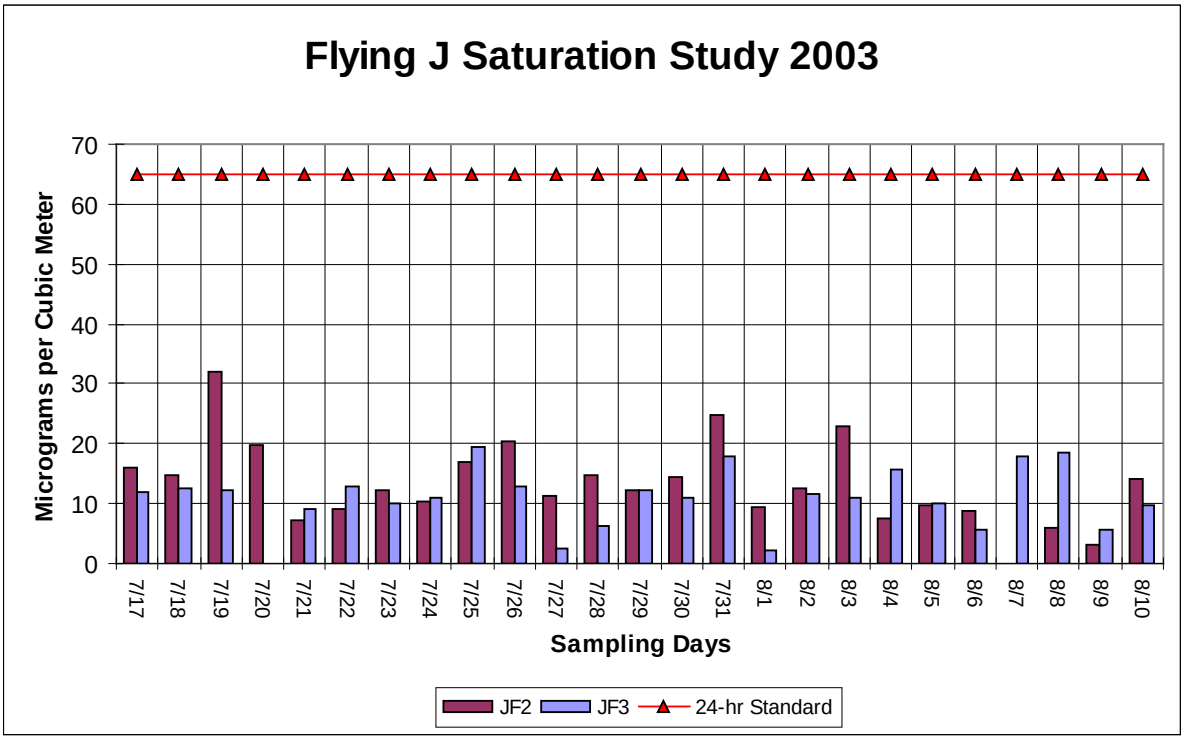
| Date | JF2 Site ug/m3 | JF3 Site ug/m3 | EPA 24-hour Standard ug/m3 | Resultant Wind Speed mph | Resultant Wind Direction | Maximum Wind Speed 1-hour mph | Maximum Wind Speed Gust mph | Rainfall inches |
|---|---|---|---|---|---|---|---|---|
| 07/17/03 | 15.9 | 11.8 | 65 | 10.9 | E | 9.8 | 30 | 0.00 |
| 07/18/03 | 14.6 | 12.7 | 65 | 7.4 | E | 7.6 | 17 | 0.00 |
| 07/19/03 | 32.0 | 12.4 | 65 | 5.8 | S | 8.4 | 16 | 0.00 |
| 07/20/03 | 19.8 | SV | 65 | 2.1 | NE | 10.7 | 22 | Trace |
| 07/21/03 | 7.3 | 9.0 | 65 | 7.4 | N | 7.5 | 14 | Trace |
| 07/22/03 | 9.1 | 12.8 | 65 | 5.1 | N | 7.0 | 16 | Trace |
| 07/23/03 | 12.3 | 10.2 | 65 | 5.1 | SE | 5.2 | 15 | 0.00 |
| 07/24/03 | 10.3 | 11.0 | 65 | 16.1 | S | 10.3 | 25 | 0.00 |
| 07/25/03 | 16.9 | 19.3 | 65 | 18.1 | S | 13.9 | 31 | 0.00 |
| 07/26/03 | 20.5 | 12.8 | 65 | 2.8 | NW | 11.5 | 21 | 0.00 |
| 07/27/03 | 11.2 | 2.6 | 65 | 5.6 | N | 7.0 | 15 | Trace |
| 07/28/03 | 14.6 | 6.3 | 65 | 2.2 | NW | 4.9 | 12 | 0.00 |
| 07/29/03 | 12.3 | 12.2 | 65 | 5.9 | S | 10.1 | 37 | 0.29 |
| 07/30/03 | 14.4 | 10.9 | 65 | 4.2 | SW | 6.4 | 14 | 0.00 |
| 07/31/03 | 24.8 | 17.9 | 65 | 2 | W | 6.2 | 13 | 0.00 |
| 08/01/03 | 9.5 | 2.1 | 65 | 4.6 | NW | 7.7 | 17 | 0.00 |
| 08/02/03 | 12.4 | 11.7 | 65 | 5.8 | NW | 7.8 | 18 | 0.00 |
| 08/03/03 | 23.0 | 11.0 | 65 | 4.7 | N | 7.3 | 15 | 0.00 |
| 08/04/03 | 7.6 | 15.7 | 65 | 7.3 | SE | 5.6 | 15 | Trace |
| 08/05/03 | 9.7 | 10.0 | 65 | 4.1 | E | 4.5 | 31 | 0.41 |

| Date | JF2 Site ug/m3 | JF3 Site ug/m3 | EPA 24-hour Standard ug/m3 | Resultant Wind Speed mph | Resultant Wind Direction | Maximum Wind Speed 1-hour mph | Maximum Wind Speed Gust mph | Rainfall inches |
|---|---|---|---|---|---|---|---|---|
| 08/06/03 | 8.7 | 5.6 | 65 | 5.8 | N | 5.4 | 13 | Trace |
| 08/07/03 | SV | 17.8 | 65 | 4.7 | E | 4.1 | 14 | 0.00 |
| 08/08/03 | 6.0 | 18.4 | 65 | 6.3 | SE | 4.8 | 15 | Trace |
| 08/09/03 | 3.1 | 5.7 | 65 | 6.6 | SE | 8.9 | 31 | 0.03 |
| 08/10/03 | 14.2 | 9.6 | 65 | 3.7 | N | 7.7 | 17 | Trace |
| Average | 13.8 | 11.2 | | | | | | |

Concentrations collected at both JF2 and JF3 monitoring sites were all less than the 24-hour standard for PM2.5. Therefore, based on the 24-hour national ambient air quality standard, the housing development north of the Plaza was not experiencing unhealthy air during the study period.

The highest 24-hour average concentration at the JF2 monitoring site was 32.0 micrograms per cubic meter or 49% of the standard. The highest 24-hour concentration at JF3 was 19.3 micrograms per cubic meter or 30% of the standard. Figure 5 shows a graph representation of each sampling day concentration compared to the 24-hour standard for PM2.5.

**Figure 5. Saturation Data Compared to the PM2.5 24-Hour Standard**

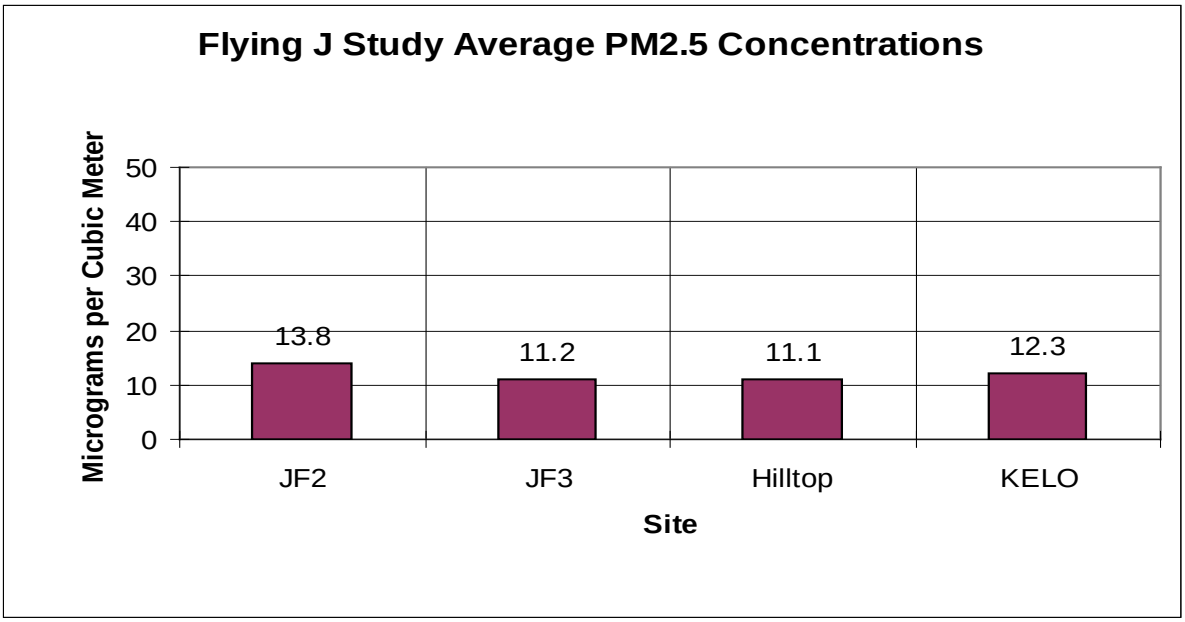


## 5.2 Comparison of Average PM2.5 Concentrations

The average concentration from JF2 and JF3 monitoring sites were compared to the average concentration from the Sioux Falls sites to determine if the housing development was affected by a local source or if the ambient air at the housing development represents a regional concentration. The average concentration was calculated for each of the sites during the study period and plotted on a graph.

The average PM2.5 concentration at the JF2 monitoring site was higher than DENR's Hilltop and KELO Sites by 2.7 and 1.5 micrograms per cubic meter, respectively. The average PM2.5 concentration during the study period at the JF3 monitoring site was similar to the Hilltop Site but less than the KELO Site by 1.1 microgram per cubic meter. The difference between the saturation monitoring sites and DENR's Sioux Falls Sites is generally small and indicates the ambient air at the housing development represents a regional concentration level. The graph in Figure 6 shows the comparison results.

**Figure 6. Comparison of Average PM2.5 Concentrations**




## 5.3 Comparison of Site Data to Wind Direction

The PM2.5 concentrations at the JF2 and JF3 monitoring sites were compared to the wind direction to determine if PM2.5 concentrations were dependent on the wind direction and would indicate a trend. This comparison would help identify if a local source is impacting the housing development or if the housing development was impacted by regional concentrations. Figure 7 and 8 show the evaluation of the data from both saturation sites

plotted on a pollution rose graph. The average wind direction for each sampling day was plotted with the 24-hour average PM2.5 concentration for that day at each site.

A pollution rose is a circler graph that has direction indicators like a compass with bars extending out from the center. The top of the graph represents north. The bars indicate two different measurements. The length of the bar from the center out represents the percent of the days that had winds in eight directions of the compass. The color of the bar represents the PM2.5 concentration ranges that are represented in the legend on the graph.

The wind directions were obtained from the Sioux Falls Airport meteorological station and are displayed in Table 1. The wind direction most common during the study was from the north at approximately 26% of the sampling days. This was followed by northwest, south and southeast with equal number of sampling days at 17%.

The JF2 monitoring site had the highest 24-hour average concentration during the study at 32.0 micrograms per cubic meter when the wind was out of the south on July 19, 2003. If the Plaza was the source of this concentration, the wind direction should have been out of the southwest. With a south wind, the Plaza should have impacted the JF3 monitoring site. But the JF3 monitoring site recorded a concentration of 12.4 micrograms per cubic meter, which is less than 39% of the concentration level at JF2 monitoring site. Therefore, another source or sources south of the JF2 monitoring site could have caused this concentration.

The JF2 monitoring site had three 24-hour average concentrations greater than 20.0 micrograms per cubic meter and three concentrations greater than 15.0 micrograms per cubic meter. The pollution rose graph in Figure 7 shows the highest PM2.5 concentrations days did not occur during any one compass direction but are spread over five compass directions. This indicates that PM2.5 concentrations were more regionally distributed and concentrations were not from one localized source.

The JF3 monitoring site had five 24-hour concentrations greater than 15 micrograms per cubic meter with no concentrations greater than 20.0 micrograms per cubic meter. The highest 24-hour concentration for this site was 19.3 micrograms per cubic meter recorded on July 25, 2003 when the wind was out of the south. This concentration is very low, 30% of the standard, and does not indicate any wind direction dominance or single pollution source. The pollution rose in Figure 8 shows a distribution of highest concentrations for the JF3 monitoring site that are spread in three compass directions and do not indicate any single source of PM2.5 emissions.

### 5.4 Meteorological Data

Meteorological data was obtained from the Sioux Falls Airport meteorological station. The meteorological data was used to evaluate PM2.5 concentrations based on wind direction. See the wind rose graphs in Figures 7 and 8.

**Figure 7. Comparison of Concentrations to Wind Direction Site JF2**

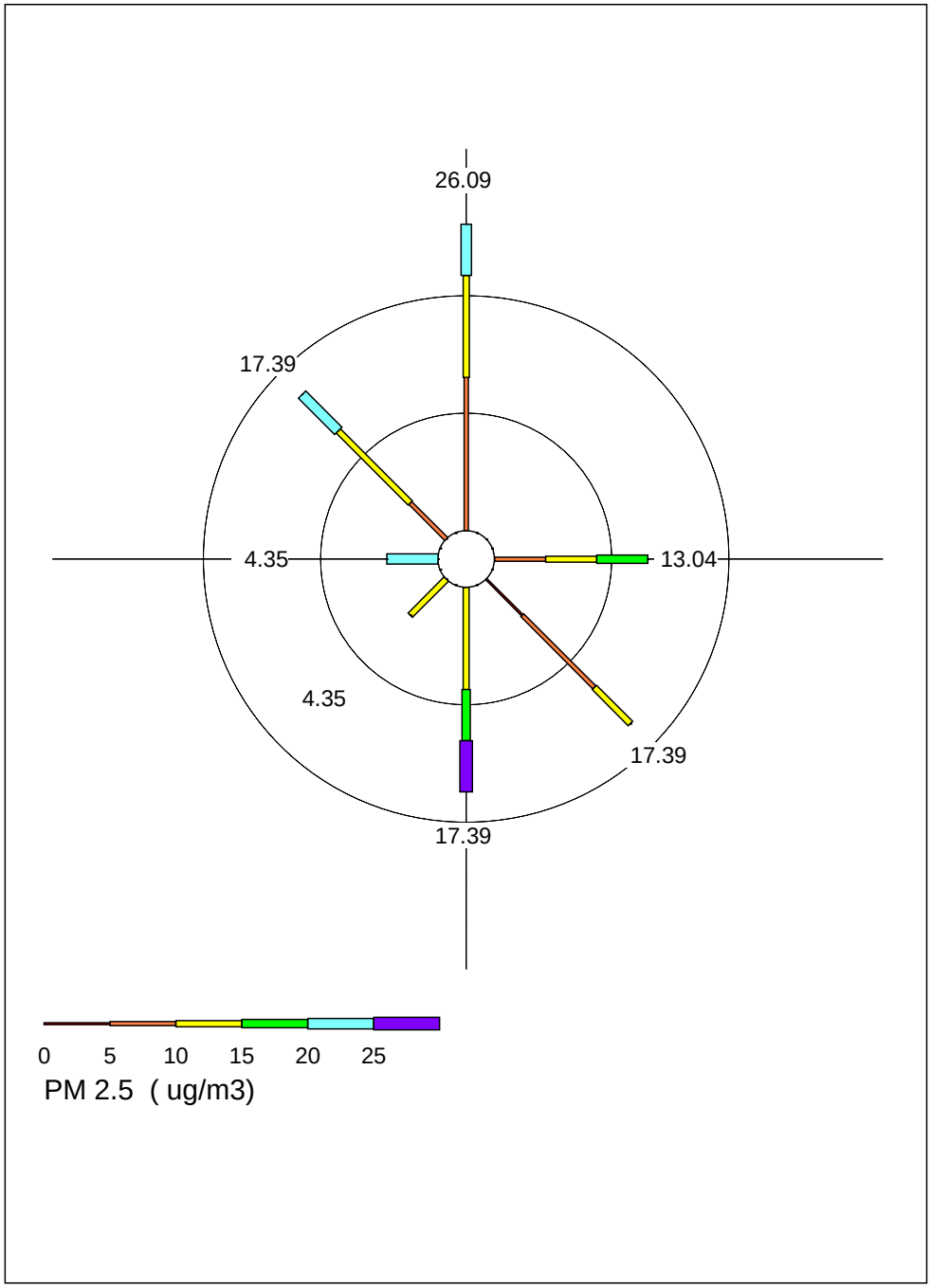
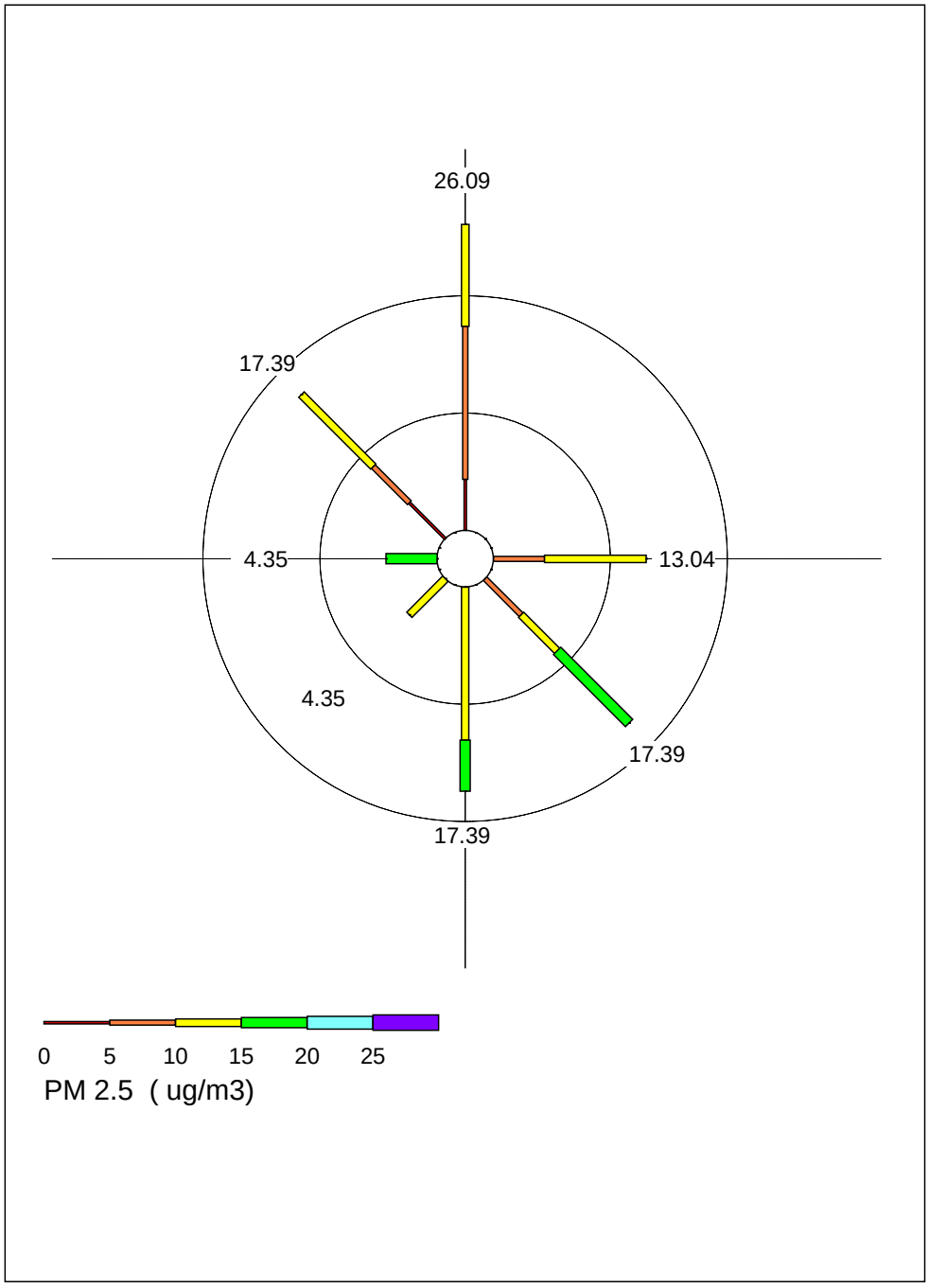


**Figure 8. Comparison of Concentration to Wind Direction at JF3 Site.**



The average annual precipitation for the Sioux Falls area is 21 inches, of which 16 inches or 80% falls during the months between April and September. The amount of rainfall impacts concentration levels as the rain washes PM2.5 particles out of the air. During the study period, six days had trace amounts and three days had measurable amounts of precipitation. On the nine days with rainfall there was no noticeable impact on PM2.5 concentration levels recorded by the monitors. Low precipitation levels may be the reason PM2.5 concentrations were not impacted by the rainfall.

## 5.5 Quality Assurance Program

### 5.5.1 Saturation PM2.5 Monitors

A total of 10 saturation PM2.5 monitors were used for the study. Four monitors were located at each of the sites by the housing development. Two were located at the Hilltop Site. The sample flows were calibrated at the beginning and checked at the end of the study period. Each monitor ran about five times during the study so no further flow audits or calibrations were completed during the study period.

### 5.5.2 Andersen PM2.5 Monitors

The Andersen PM2.5 monitors designated by EPA as a federal reference method are located at the Hilltop Site in the east central part of Sioux Falls and at the KELO Site in the downtown part of the city. The monitors are operated on an every third day sampling schedule. The filters from the Andersen PM2.5 monitors were analyzed in the same manner as the saturation PM2.5 monitors.

Saturation PM2.5 monitors were located next to the Andersen federal reference method monitors at the Hilltop Site. A total of 10 comparison sampling days were attempted. Due to equipment problems, only six of the comparison days were valid. The results indicated the saturation PM2.5 monitors collect about 3.3 micrograms per cubic meter of air higher than the Anderson PM2.5 monitor (see Table 2). This number will be used to adjust the saturation PM2.5 monitor data from the JF2 and JF3 monitoring sites.

**Table 2. Comparison of Co-located Data at Hilltop Site**

| Date | JF1 | Andersen Monitor | Difference |
|---|---|---|---|
| 7/17/03 | 14.3 ug/$m^3$ | 13.7 ug/$m^3$ | 0.7 ug/$m^3$ |
| 7/20/03 | 20.6 ug/$m^3$ | 13.5 ug/$m^3$ | 7.1 ug/$m^3$ |
| 7/23/03 | 13.5 ug/$m^3$ | 7.6 ug/$m^3$ | 5.9 ug/$m^3$ |
| 7/26/03 | 22.7 ug/$m^3$ | 17.5 ug/$m^3$ | 5.3 ug/$m^3$ |
| 7/29/03 | 4.7 ug/$m^3$ | 6.7 ug/$m^3$ | -1.9 ug/$m^3$ |
| 8/1/03 | 10.8 ug/$m^3$ | 7.9 ug/$m^3$ | 2.9 ug/$m^3$ |
| | | **Average** | **3.3 ug/$m^3$** |

## 6.0 Conclusions

The ambient air monitoring concentrations during the study period were less than half of the 24-hour national ambient air standard for PM2.5 of 65 micrograms per cubic meter. Therefore, the ambient air by the housing development is meeting EPA's national ambient air quality standards that are based on health concerns. The recorded levels are similar to the concentrations typically collected at the two state air monitoring sites in the city of Sioux Falls.

The distribution of the higher PM2.5 concentrations in the study area from six different directions and the PM2.5 concentrations from the housing development being comparable to the permanent Sioux Falls monitoring sites indicates that there is no local problem. The ambient air is representative of regional concentration. Sources contributing to the regional levels would be the traffic emissions from the Interstate highways, traffic emissions throughout Sioux Falls, and other combustion sources in the Sioux Falls area.

In conclusion, the data shows that the Flying J Travel Plaza is not causing an increase in PM2.5 concentrations in the study area and PM2.5 concentration levels are not exceeding the national health based standard.

# APPENDIX A

# GIS MAP OF STUDY AREA

# APPENDIX B

# QUADRANGLE MAP OF STUDY AREA

# APPENDIX C

# MAP OF CITY OF SIOUX FALLS