AEAT/ENV/R/1506 Issue 1

# Air Quality at Sutton Bridge: 2002 Annual Report

S Eaton

June 2003

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AEAT/ENV/R/1506 Issue 1

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| **Title** | Air Quality at Sutton Bridge: 2002 Annual Report |
| **Customer** | South Holland District Council |
| **Customer reference** | |
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| **File reference** | ED45047 |
| **Report number** | AEAT/ENV/R/1506 |
| **Report status** | Issue 1 |

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# Executive Summary

Netcen have measured air pollution levels at Westmere County Primary School, Sutton Bridge on behalf of South Holland District Council, from July 1998. This report summarises the period from January to December 2002. The reporting period has now been changed to calendar years, and part of 2002 has already been reported. The results of previous years are presented in the following reports:

First year of operation: report AEAT/EEQP/00020
Second year of operation: AEAT/ENV/R/0382
Third year of operation: AEAT/ENV/R/0872
Fourth year of operation: AEAT/ENV/R/1205

The pollutants measured at the site are nitrogen oxides ($NO_x$), ozone ($O_3$) and $PM_{10}$ (since 1/10/2000). $NO_x$ is produced in combustion processes and by motor vehicles. $O_3$ at ground level is produced by chemical reactions between pollutants such as organic compounds. These are often emitted in other parts of the UK or Europe, particularly during hot, sunny weather. The monitoring site also records wind speed and direction.

The data collected from the site have been summarised and compared to current air quality standards set by various bodies, which are described in the text of this report. The data are also compared to those from other local air quality monitoring stations in the east of England.

The $NO_2$ results show that the Air Quality Standards and Objectives for $NO_2$ have not been exceeded and levels within Sutton Bridge are low. The highest average concentration of $NO_2$ when the wind was from the south-east; this may be attributed to the power station, road traffic or other sources around the Sutton Bridge area.

The results have been compared with relevant air quality standards and objectives:

- $NO_2$: no air quality standards or objectives have been exceeded
- $O_3$: the AQS objective daily maximum of running 8-hour means on 26 days during the period; the objective permits only 10 days with 8-hour averages over 50ppb.

  The EC Directive Health Protection Threshold for fixed 8-hour means of 55ppb

  The EC Directive Vegetation Protection Threshold for daily means greater than 32ppb

- $PM_{10}$: There were 3 daily average $PM_{10}$ gravimetric concentrations above the AQS objective of 50$\mu$g $m^{-3}$; a maximum of 35 such exceedences are permitted each calendar year.

  The annual average $PM_{10}$ concentration was below the AQS objective

Due to the nature of ground-level ozone formation, sources of ozone and its precursors outside the district may cause the ozone levels to exceed the air quality standards. It is recognised that reduction in ozone concentrations in the UK will require action on a European scale. As a result, the objectives for ozone are not to be included in Local Air Quality Management.

The concentrations of $NO_2$ and $O_3$ measured at the Sutton Bridge site were generally similar to those measured at a rural monitoring site in Cambridgeshire. Concentrations

were generally much lower than were measured in nearby urban areas, such as Norwich. Average $PM_{10}$ concentrations at Sutton Bridge were similar to those at Norwich.

# Contents

# 1 Introduction

Netcen, part of AEA Technology Environment, has been appointed by South Holland District Council as consultants for the purpose of monitoring air quality at Sutton Bridge. The study of air quality in the town has been necessary as part of the planning consent for the construction and commissioning of a 790MW gas fired power station close to the town. An air quality monitoring site was installed in July 1998. The pollutants measured are oxides of nitrogen ($NO_x$ consisting of nitric oxide, NO and nitrogen dioxide, $NO_2$), ozone ($O_3$) and $PM_{10}$ (since 1/10/2000). This report covers the period January-December 2002; part of this period is covered by report NETCEN/R/ENV/1205 (November 2002).

Oxides of nitrogen are produced mainly by combustion sources, particularly motor vehicles. NO is not recognised as harmful to health, but it is readily oxidised in the atmosphere to form $NO_2$. There is evidence that $NO_2$ in high concentrations causes inflammation of the airways in humans, and may affect lung function.

Ozone is produced by a complex set of chemical reactions in the atmosphere, involving volatile organic species and UV light. The chemical pollutants required for ozone formation may be emitted some distance from the UK, and peak ozone concentrations in the UK are observed during periods where air masses from the continent move over the country. The highest concentrations are frequently observed over the south and south-east of England. The background ozone concentration in unpolluted air is approximately 36ppb.

Most anthropogenic particulate matter in the atmosphere is less than 10 micrometres in diameter ($PM_{10}$). Sources of $PM_{10}$ include combustion processes such as power stations (fly ash), motor engines (particularly diesel engines) and soot. Particulate matter from these sources typically contains a large proportion of elemental and organic carbon, which is associated with health effects and haze phenomena. $PM_{10}$ is fine enough to penetrate deeply into the human respiratory system before deposition and has a longer residence time than larger particles. This, combined with the presence of large quantities of organic material, may result in significant long term health effects.

# 2 Monitoring Methods

## 2.1 EQUIPMENT

A continuous automatic monitoring site has been installed at Westmere County Primary School, Sutton Bridge. A map showing its location is shown separately. The site is fully self-contained, and is equipped with the following:

- Continuous automatic analysers for $NO_x$ and $O_3$
- $PM_{10}$ equipment – TEOM analyser for continuous measurement of $PM_{10}$ particles.
- Datalogger, modem and telephone line for collection and transmission of data to netcen
- Air conditioning to ensure reliable analyser performance
- Compressed gas mixtures of NO and $NO_2$ at near-ambient concentrations for calibration of the $NO_x$ analyser
- Sensors for wind speed and direction

The principle of operation and expected accuracy of the analysers are given in Table 1.

**Table 1: Principle of operation and accuracy of analysers used**

| Pollutant | Analyser type | Method of operation | Expected accuracy |
|---|---|---|---|
| Ozone | API M400 | UV absorption | ±11%±2ppb |
| Oxides of nitrogen | APIM200A | Chemiluminescence | ±10%±2.5ppb |
| $PM_{10}$ | TEOM | Tapered element oscillating microbalance | ± 4 $\mu$g $m^{-3}$ (precision) |

Although the use of TEOMs in the UK is commonplace, there is concern expressed by, amongst others, the Airborne Particles Expert Group (APEG) that this monitoring method does result in an under-read of particle concentrations of between 15 and 30 % at typical ambient concentrations. It is thought this occurs as a result of evaporation of volatile species (eg hydrocarbons) in the heated inlet of the analyser. The air quality objectives referred to in Defra's Pollutant Specific Guidance are based on the European reference method, which is a gravimetric method. It is therefore necessary to apply a "correction factor" when comparing TEOM measurements with the objectives. A constant factor of 1.3 is therefore applied to the measurements from this survey when comparing with the objectives. Measurements thus corrected in this report will therefore be referred to as $\mu$g $m^{-3}$, gravimetric.

## 2.2 OPERATION OF SITE

The routine site operations are carried out by SHDC staff, who have received full training by netcen and Enviro Technology Services plc, the suppliers of the monitoring equipment. Data collection, validation and reporting are carried out by netcen. Netcen also supply QA/QC services, consisting of the following:

- Traceable calibrated compressed gas mixtures for the routine calibration of the $NO_x$ analyser
- 6-monthly audits of analyser performance
- Ratified datasets on a six-monthly basis

Netcen have been awarded UKAS accreditation (calibration laboratory no 0401) for the calibration of compressed gas mixtures and ambient air quality monitoring equipment. The site is operated to the same protocols as the Defra automatic urban network, to ensure that the data from the Sutton Bridge site are directly comparable to national network data.

The monitoring equipment is covered by a service contract with the manufacturers UK agent, to ensure reliable operation and prompt repair of faults and breakdowns.

## 2.3 DATA REPORTING

The data are collected daily by netcen, and are inspected for faults or irregularities. The provisional monitoring data are then sent electronically to SHDC on a daily basis. Monthly

reports, including summary statistics are supplied by netcen. The final ratified dataset is reported annually.

## 2.4 DATA CAPTURE

The data capture for the pollutants measured was generally very good, with a data capture of 97% for $O_3$, 96% for PM10 and 98% for $NO_x$. The new, solid-state sensors that were installed to improve reliability of the wind speed and direction measurements have resulted in a data capture of better than 99%.

# 3 Results and Discussion

## 3.1 PRESENTATION OF DATA

The data from the monitoring survey for the 12 months of operation (January-December 2002) are summarised in tabular form, in Appendix 2. The summary also compares the data with relevant Air Quality Strategy (AQS) and EC Directive standards and guidelines. These are detailed in Appendix 3.

## 3.2 COMPARISON WITH AIR QUALITY STANDARDS AND OBJECTIVES

Relevant Air Quality Standards and guidelines are given in Appendix 3. These have been subject to recent revision.

### 3.2.1 Air Quality Standards

**$NO_2$:**
The current AQS[1] contains two objectives for $NO_2$:

- The objective for an hourly mean of 105ppb, to be exceeded not more than 18 times per year, by 31 December 2005. This brings the AQS standard in line with the EC Daughter Directive limit, see below.
- For the annual mean, 21ppb to be achieved by 31 December 2005.
- A new national objective for protection of vegetation, 16ppb (as $NO_x$) has been adopted for 31 December 2000. This is aimed at the protection of vegetation and ecosystems, and is not to be included in Local Air Quality Management.

The maximum 1 hour mean $NO_2$ concentration measured in this survey was 46ppb; well within the current and proposed objectives for this parameter. The overall mean for the whole 12-month period was 8ppb; well within the annual mean limit of 21ppb.

**$O_3$:**
The current AQS contains one provisional objective for $O_3$:

- Daily maximum of running 8-hour mean of 50ppb not to be exceeded more than 10 times per year to be achieved by 31 December 2005.

This remains provisional whilst other European countries set their own commitments for the reduction in emissions of $O_3$ precursors, such as volatile organic compounds (VOCs). This objective is therefore not to be included in Local Air Quality Management.

This value was exceeded on 26 days during the period, with exceedences recorded in March, April (9), May (2), June (3), July (6), August (4) and September.

There were a total of 163 occasions on which the running 8-hour running mean exceeded 50ppb.

**$PM_{10}$:**
The current AQS contains two objectives for $PM_{10}$:
- The objective for a 24-hour mean of 50$\mu$g $m^{-3}$ gravimetric, not to be exceeded more than 35 times per year, to be achieved by December 2004.
- Annual mean not to exceed 40$\mu$g $m^{-3}$ gravimetric, to be achieved by December 2004

In addition, the 2003 addendum to the strategy contains additional objectives for 2010 for England (outside London). These are an annual average $PM_{10}$ gravimetric objective of 20$\mu$g $m^{-3}$ and a daily $PM_{10}$ gravimetric objective of 50$\mu$g $m^{-3}$, not to be exceeded more than 7 times per year. However, as these objectives have not been set into regulation, they are not considered in detail in this report.

There were 3 days during this period when the daily average $PM_{10}$ gravimetric concentration exceeded 50$\mu$g $m^{-3}$ gravimetric. The annual average was 20$\mu$g $m^{-3}$ gravimetric, (16$\mu$g $m^{-3}$ TEOM) and it is therefore unlikely that the $PM_{10}$ objective for 2004 will be breached. This value is equal to the annual average $PM_{10}$ concentration set for 2010.

### 3.2.2 EC Directives

**$NO_2$:**

Under EC Directive 96/62, (the "Framework Directive[2]"), provision is made for setting limit values for a range of pollutant species via subsequent Daughter Directives. New limits for this and other pollutants are contained in the first Daughter Directive[3] on oxides of nitrogen, sulphur dioxide, $PM_{10}$, and lead. This Directive was adopted into UK law via Statutory Instrument 2001 no. 2315 in 1999. The limits for $NO_2$ are as follows:
- Hourly mean limit 105ppb, to be exceeded not more than 18 times per year, by 1 January 2010.
- Annual mean limit 21ppb, to be achieved by 1 January 2010.
- Annual mean limit of 16ppb (as $NO_x$) for the protection of vegetation, to be achieved by July 2001.

From the data collected at Sutton Bridge, neither the maximum hourly mean of 46ppb or the annual mean of 8ppb exceeded these limits. The average $NO_x$ concentration was 10ppb ($NO_x$ as $NO_{2)}$, below the EC vegetation limit of 16ppb.

**$O_3$:**
The EC has set threshold limits relating to population exposure for $O_3$ concentrations[4]:
- Population Information Threshold for hourly averages of 90ppb
- Population Warning Value for hourly averages of 180ppb
- Health Protection Threshold for fixed 8-hour means of 55ppb

Under the EC Directive, Defra must inform the public if a network site exceeds 90ppb as an hourly average $O_3$ concentration, or if it expects a site to exceed 180ppb. This is not applicable to the Sutton Bridge site, but the 90ppb threshold was not exceeded during the year. The Health Protection Threshold for fixed 8-hour means (55ppb) was exceeded on 17 occasions. The Vegetation Protection Threshold for daily means greater than 32ppb was also exceeded, on 110 days during the year. Both these thresholds are widely exceeded at many sites in the UK. This Directive will be repealed in September 2003.

A new ozone Directive[5] will be brought into UK Law in September 2003. This will set a target of 60ppb as an 8-hour average, not to be exceeded on more than 25 days per calendar year, averaged over 3 years. This was not exceeded in 2002 (8 days were recorded with maximum 8-hour means over 60ppb during 2002, 13 in 2001 and 6 in 2000). The Target Value for protection of vegetation (AOT40)* based on daytime hourly averages was not exceeded.

It should be noted that $O_3$ objectives and the new EC Daughter Directive (from September 2003) are not included in UK Regulations, as $O_3$ concentrations are out of the control of individual states or local authorities.

**$PM_{10}$:**

- 24-hour limit value for protection of human health: 24-hour average of 50$\mu$g $m^{-3}$ gravimetric not to be exceeded more than 35 times per calendar year. Annual limit value for protection of human health: annual average of 40$\mu$g $m^{-3}$ not to be exceeded.
-

There were 3 days where daily average $PM_{10}$ concentrations exceeded 50$\mu$g $m^{-3}$ during 2002.

### 3.2.3 Defra Air Quality Bands

On a day-to-day basis UK air quality data are reported to the public by using a health-effects based system of four bands and a 1-10 index. This provides detail about air pollution level in a simple way, similar to the sun index or pollen index. This is described in Table 2

**Table 2: Health Effects Banding System for Air Quality**

| Banding | Index | Health Descriptor |
|---|---|---|
| Low | 1 | Effects are unlikely to be noticed even by individuals who know they are sensitive to air pollutants |
| | 2 | |
| | 3 | |
| Moderate | 4 | Mild effects, unlikely to require action, may be noticed amongst sensitive individuals. |
| | 5 | |
| | 6 | |
| High | 7 | Significant effects may be noticed by sensitive individuals and action to avoid or reduce these effects may be needed (e.g. reducing exposure by spending less time in polluted areas outdoors). Asthmatics will find that their 'reliever' inhaler is likely to reverse the effects on the lung. |
| | 8 | |
| | 9 | |
| Very High | 10 | The effects on sensitive individuals described for 'High' levels of pollution may worsen. |

$NO_2$ concentrations remained in the Defra “low” band throughout the year. $O_3$ hourly average concentrations were in the “moderate” band for 385 hours. $PM_{10}$ concentrations were within the Defra “moderate” band for 3 hours.

## 3.3 METEOROLOGICAL MEASUREMENTS

The wind speed and direction roses are given in Appendix 4, together with time series plots for these parameters. The wind direction rose shows the proportion of time in which the wind blows from each of 16 sectors. The wind speed rose shows the average wind speed in each of these sectors. Similarly, the pollution roses show average concentration of each species measured in each of the direction sectors. Data measured during periods of low wind speed (<0.1$ms^{-1}$) are disregarded in the pollution roses. The power station is

* See note 5 under the O3 Table, Appendix 3 for explanation

situated at a bearing of approximately 155$^o$ from the monitoring site, and the average concentrations of pollutants in the sector 150$^o$-160$^o$ has been calculated in each case. Note, however, that the town of Sutton Bridge itself may contribute to measured concentrations in this direction, and it is not possible to say with certainty what the likely source of pollution may be.

The wind direction rose shows that the wind was most frequently from a south-westerly direction during the year. North-westerly and south-easterly winds were infrequent during the monitoring period. Wind speeds were more evenly distributed throughout the 16 sectors, northerly and southerly winds being slightly stronger on average.

The maximum average NO concentrations for the year were clearly from the south-east. NO concentrations from the north-east were particularly low. Concentrations from the westerly directions were all fairly uniform. The average concentration in the 150$^o$-160$^o$ sector was 3.2ppb. $NO_x$ showed a similar trend but was more evenly distributed. Again, highest concentrations were from the south-east and the lowest concentrations were from the north-east. The 150$^o$-160$^o$ sector average concentration for $NO_x$ was 14.8ppb. NO is a primary pollutant (i.e., produced directly from pollution sources, such as combustion or road traffic), and thus this can be attributed to a local source.

The $NO_2$ plot again shows a significant contribution from the south-east (11.6ppb average in the 150$^o$-160$^o$ sector). $NO_2$ is a secondary pollutant, and may be produced by oxidation of NO in the atmosphere. The higher concentrations of $NO_2$ from this direction may be due to the conversion of NO from a local source including the power station, road traffic or other sources as it moves towards the monitoring site.

Ozone is not emitted directly by sources; ozone is produced by the reaction of various pollutants in the presence of sunlight. Highest levels are always observed in the summer. The background tropospheric $O_3$ concentration in unpolluted air is approximately 36ppb. The ozone plot shows a reasonably even distribution at approximately 25ppb from all directions except the north-east. The north-east shows higher concentrations of ozone, corresponding to the lower concentrations of NO from this direction. This is understandable, as any ozone mixing with the locally produced NO will gradually react, producing $NO_2$. The highest concentrations in the north may reflect the lack of depletion of background ozone, as there are no significant sources of ozone sinks in this direction.

$PM_{10}$ was more evenly distributed than the other measured pollutants. There were very slightly higher concentrations measured from the south-east and the average concentration of $PM_{10}$ in the 150$^o$-160$^o$ sector was 17.6$\mu$g m$^{-3}$ TEOM, compared to a mean of 16$\mu$g m$^{-3}$ for all directions.

# 4 Comparison with Previous Years

The Westmere School monitoring site has been operational since 1998 (2000 for $PM_{10}$ particles), and although this is not sufficiently long to accurately determine trends, it is nevertheless of interest to consider 2002 data with those from previous years. Table 3 shows some key statistics in relation to current air quality standards and objectives.

**Table 3: Comparison with Previous Years' Data: Westmere School**

| Pollutant | Statistic | 1998 | 1999 | 2000 | 2001 | 2002 |
|---|---|---|---|---|---|---|
| $O_3$ (ppb) | Max. hourly mean | 74 | 93 | 85 | 92 | 81 |
| | Max. 8-hourly mean | 62 | 88 | 72 | 84 | 77 |
| | No. running 8-hour mean>50ppb | 31 (on 7 days) | 375 (on 49 days) | 138 (on 19 days) | 292 (on 43 days) | 163 (on 26 days) |
| $NO_2$ (ppb) | Max. hourly mean | 43 | 44 | 43 | 54 | 46 |
| | Annual mean | 9 | 9 | 10 | 9 | 8 |
| $PM_{10}$ ($\mu g\ m^{-3}$) | No. 24-hourly mean>50$\mu g\ m^{-3}$ (grav) | - | - | 0* | 3 | 3 |
| | Annual mean (TEOM) | - | - | 12* | 14 | 16 |

- From October 2000

It can be seen that the number of exceedences of the running 8-hour mean for $O_3$ varies considerably each year, mainly due to variations in the meteorological conditions experienced, although maximum hourly and 8-hourly average concentrations show less variation. Longer-term average concentrations show much less variation.

# 5 Comparison with other Monitoring Sites

The data from Sutton Bridge are compared with data from local Defra automatic network sites - Wicken Fen (rural site close to Newmarket) and Norwich Centre. The data from these sites are given in Tables 4, 5, 6 and 7 for $O_3$, NO, $NO_2$ and $PM_{10}$.

The Norwich Centre monitoring station (left)is within a self-contained, air-conditioned housing located within the south-western corner of a central Norwich public garden. The nearest road is located approximately 12 metres away at St George's Street although traffic flow is free flowing and very light (1 or 2 vehicles per minute observed off peak). The manifold inlet is approximately 3 metres high. The surrounding area is generally open and comprises of residential and light industrial premises.

OS Grid Reference: TG230089
Site Type: Urban Centre
Start Date: 24/07/97
Pollutants Measured: O3,CO,SO2,PM10,NOx

The Wicken Fen monitoring station (right) is within a self-contained, air conditioned housing located within a field in a rural setting. The nearest road is approximately 5 metres from the monitoring station and is a small rural track used access only. The closest dwellings are approximately 150 metres east of the monitoring station. The surrounding area is open with isolated trees in open fields

OS Grid Reference: TL564692
Site Type: Rural
Start Date: 12/08/97
Pollutants Measured: O3,SO2,NOx

**Table 4: Comparison of Ozone Statistics with Defra sites: January-December 2002**

| $O_3$ ppb | Sutton Bridge (Westmere) | Norwich Centre | Wicken Fen |
|---|---|---|---|
| Max 15-min mean | 83 | 101 | 93 |
| Max hourly mean | 81 | 98 | 92 |
| Max 8-hourly mean | 77 | 85 | 82 |
| Max 24-hourly mean | 59 | 60 | 54 |
| Mean | 27 | 22 | 22 |
| Data capture | 97% | 95% | 96% |

The measured concentrations from all three sites are generally similar, but the annual average concentration is highest at Sutton Bridge. This may be due to the influence of the background ozone in unpolluted air, which affects Sutton Bridge for much of the year.

**Table 5: Comparison of Nitric Oxide Statistics with Defra sites: January-December 2002**

| NO ppb | Sutton Bridge (Westmere) | Norwich | Wicken Fen |
|---|---|---|---|
| Max 15-min mean | 84 | 460 | 102 |
| Max hourly mean | 77 | 385 | 101 |
| Max 8-hourly mean | 45 | 173 | 78 |
| Max 24-hourly mean | 31 | 83 | 51 |
| Mean | 2 | 7 | 2 |
| Data capture | 98% | 95% | 85% |

Although NO is not regarded as a significant pollutant (it has no recognised adverse affects on human health), it does provide an indication of influence by combustion processes. Urban sites show higher NO concentrations, often due to road traffic. Rural sites show lower levels, as any NO present is oxidised to $NO_2$ in the atmosphere.

**Table 6: Comparison of Nitrogen Dioxide Statistics with Defra sites: January-December 2002**

| $NO_2$ ppb | Sutton Bridge (Westmere) | Norwich | Wicken Fen |
|---|---|---|---|
| Max 15-min mean | 52 | 89 | 35 |
| Max hourly mean | 46 | 81 | 33 |
| Max 8-hourly mean | 37 | 49 | 27 |
| Max 24-hourly mean | 29 | 44 | 25 |
| Mean | 8 | 13 | 6 |
| Data capture | 98% | 95% | 85% |

The $NO_2$ concentrations measured at Sutton Bridge (Westmere) are similar to those measured at Wicken Fen. Sutton Bridge is a semi-rural site, and is likely to be influenced by local factors, e.g. traffic. Norwich is an urban site and shows higher levels of $NO_2$, probably as a result of heavier traffic.

**Table 7: Comparison of $PM_{10}$ Statistics with Defra sites: January-December 2002**

| $PM_{10}$ TEOM $\mu g\ m^{-3}$ | Sutton Bridge (Westmere) | Norwich |
|---|---|---|
| Max 15-min mean | 270 | 218 |
| Max hourly mean | 198 | 136 |
| Max 8-hourly mean | 67 | 61 |
| Max daily mean | 50 | 38 |
| Mean (TEOM) | 16 | 16 |
| Mean (gravimetric) | 21 | 21 |
| Data capture | 96% | 96% |

There were 3 daily average $PM_{10}$ concentrations above 50$\mu g\ m^{-3}$ gravimetric at Sutton Bridge (Westmere), compared with none at Norwich Centre over the same period. The annual averages at both sites were well below the objective of 40$\mu g\ m^{-3}$ gravimetric.

# 6 Conclusions

1. The maximum hourly mean $NO_2$ concentration measured at Sutton Bridge during the period 1 January-31 December 2002 was 46ppb. This is well within the AQS limit of 105 ppb and the EC Directive limit (also 105ppb).

2. The annual average $NO_2$ concentration measured was 8ppb. This is well within the AQS standard of 21ppb, and the EC Daughter Directive (also 21ppb), to be met by 2010.

3. The $NO_2$ concentrations remained in the Defra "low" band throughout the year. $PM_{10}$ concentrations were "moderate" for 3 hours, and $O_3$ concentrations were "moderate" for 385 hours. All other hourly averages were "low"

4. $O_3$ concentrations exceeded the AQS objective daily maximum of running 8-hour means on 26 days during the period; the objective permits only 10 such exceedences.

5. The EC Population Information Threshold for hourly average $O_3$ concentration was not exceeded (no hourly average of 90ppb or above), with the maximum hourly concentration being 81ppb. This has been exceeded during previous years. The Health Protection Threshold and Vegetation Protection Threshold were exceeded during 2002. This Directive will be repealed in September 2003; the EC 3rd Daughter Directive which replaces it was not exceeded.

6. There were 3 exceedences of the $PM_{10}$ objective for daily average concentrations of 50$\mu$g $m^{-3}$ gravimetric; 35 such exceedences are permitted each year.

7. The annual average $PM_{10}$ objective for $PM_{10}$ (40$\mu$g $m^{-3}$ gravimetric) was not exceeded.

* See note 5 under the O3 Table, Appendix 3 for explanation

# 7 References

1. The Air Quality Strategy.for England, Scotland, Wales and Northern Ireland. January 2000. ISBN 0-10-145482 and Addendum 2003
2. Council Directive 96/62/EC on Ambient Air Quality Assessment and Management.
3. Council Directive 1999/30/EC relating to limit values for $SO_2$, $NO_2$, $NO_x$, particulate matter and lead in ambient air.
4. Council Directive 92/72/EEC on air pollution by ozone
5. EC Directive 2002/3/EC on ozone in ambient air

# Appendices

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# Appendix 1
## Location of Monitoring Site

# Appendix 2

## Summary of Data from Sutton Bridge (Westmere School)

### Period 1 January-31 December 2002

| POLLUTANT | $O_3$ (ppb) | $NO_x$ (ppb) | NO (ppb) | $NO_2$ (ppb) | $PM_{10}$ * ($\mu g\ m^3$) |
|---|---|---|---|---|---|
| | This Period | This Period | This Period | This Period | This Period |
| Number days in 'VERY HIGH' band | 0 | - | - | 0 | 0 |
| Number days in 'HIGH' band | 0 | - | - | 0 | 0 |
| Number days in 'MODERATE' band | 385 | - | - | 0 | 3 |
| Number days in 'LOW' band | 8214 | - | - | 8608 | 8399 |
| Number of exceedences of hourly AQS | - | - | - | 0 | - |
| Number of exceedences of 8-hr AQS | 163 | - | - | - | - |
| Number of days with exceedences of AQS | 26 | - | - | - | - |
| Number of exceedences of daily AQS | - | - | - | - | 3 |
| Number of exceedences of annual AQS | - | - | - | 0 | 0 |
| Max 15 min average | 83 | 133 | 84 | 52 | 270 |
| Max 1 hour average | 81 | 123 | 77 | 46 | 198 |
| Max 8 hour average | 77 | 71 | 45 | 37 | 67 |
| Max 24 hr average | 59 | 60 | 31 | 29 | 50 |
| Max daily average | 58 | 52 | 28 | 27 | 50 |
| Average | 27 | 10 | 2 | 8 | 16 |
| Data capture | 97% | 98% | 98% | 98% | 96% |

* $PM_{10}$ exceedences of AQS objectives are based on gravimetric equivalent figures. All other $PM_{10}$ figures are based on TEOM data.

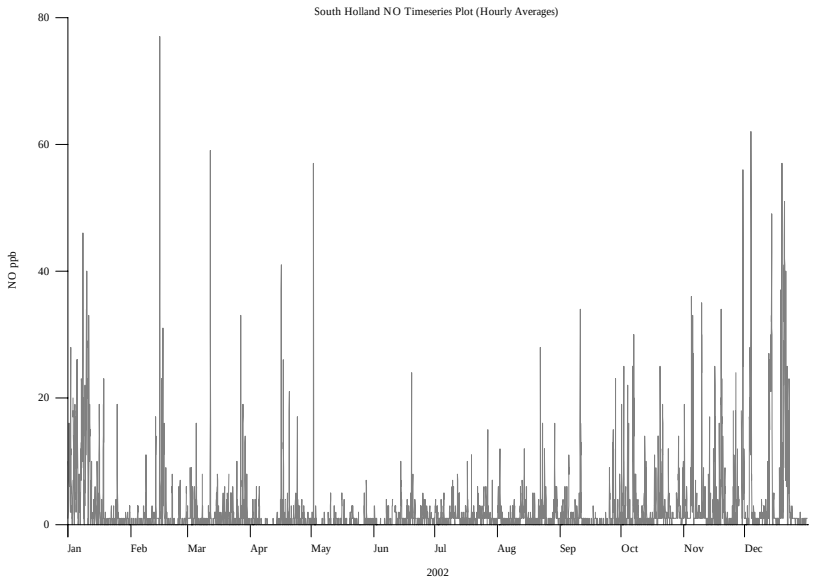



**Figure 1 – Timeseries for NO (hourly averages) 2002**

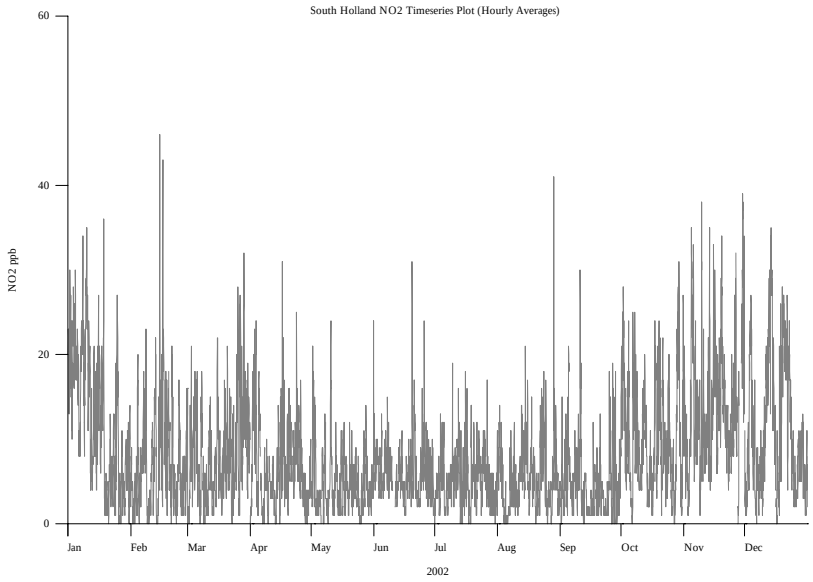



**Figure 2 –Timeseries for $NO_2$ (hourly averages) 2002**

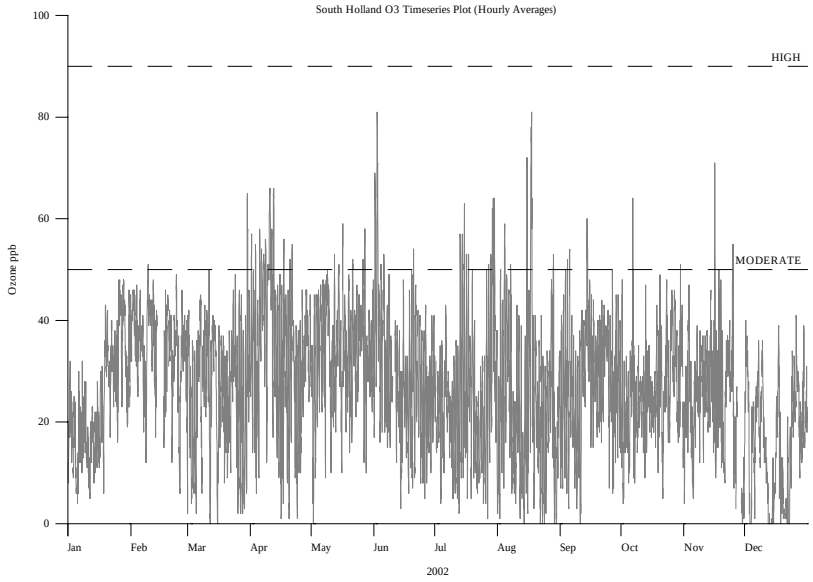



**Figure 3 – Timeseries for $O_3$ (hourly averages) 2002**

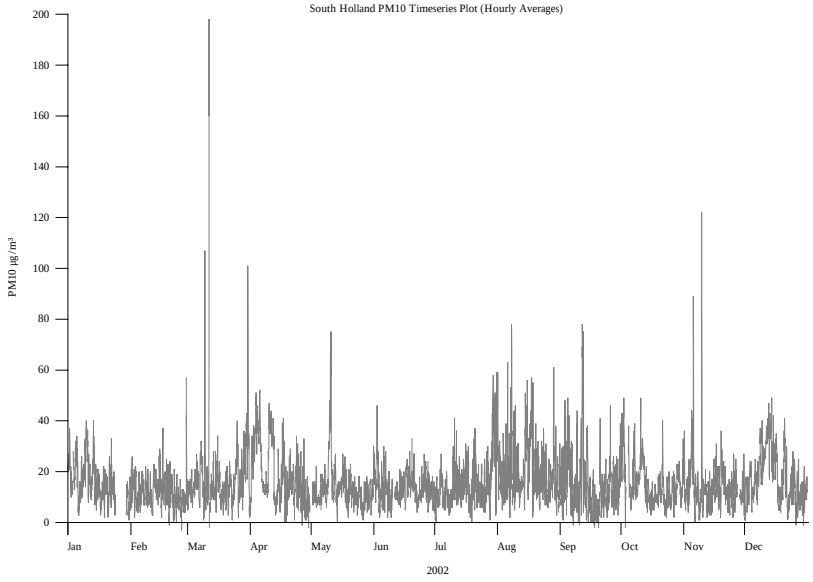



**Figure 4 – Timeseries for $PM_{10}$ (hourly averages, TEOM) 2002**

# Appendix 3
## Relevant Air Quality Standards and Guidelines

Nitrogen Dioxide

| Guideline Set By | Description | | Criteria Based On | Value[1] / µgm$^{-3}$ (ppb) |
|---|---|---|---|---|
| **UK Government Air Pollution Index** | LOW | **1** | 1-hour mean | 0-95 (0-49) |
| | | **2** | | 96-190 (50-99) |
| | | **3** | | 191-286 (100-149) |
| | MODERATE | **4** | 1-hour mean | 287-381 (150-199) |
| | | **5** | | 382-477 (200-249) |
| | | **6** | | 478-572 (250-299) |
| | HIGH | **7** | 1-hour mean | 573-635 (300-332) |
| | | **8** | | 636-700 (333-366) |
| | | **9** | | 701-763 (367-399) |
| | VERY HIGH | **10** | 1-hour mean | ≥ 764 ( ≥ 400) |
| **The Air Quality Strategy[2]** | Objective for Dec. 31st 2005, for protection of human health | | 1-hour mean | 200 (105) Not to be exceeded more than 18 times per calendar year. |
| **Set in regulations[3] for all UK:** | Objective for Dec. 31st 2005, protection of human health | | Annual mean | 40 (21) |
| **Not intended to be set in regulations:** | Objective for Dec. 31st 2000, protection of vegetation. | | Annual mean $NO_x$ ($NO_x$ as $NO_2$) | 30 (16) |
| **European Community 1985 $NO_2$ Directive [4]** Limit remains in force until fully repealed 01/01/2010. | Limit Value | | Calendar year of data: 98%ile of hourly means. | 200 (105) |
| **1st Daughter Directive[5]** | Limit Value for protection of human . To be achieved by Jan. 1st 2010 | | 1 hour mean | 200 (105) not to be exceeded more than 18 times per calendar year |
| | Limit Value for protection of human . To be achieved by Jan. 1st 2010 | | Calendar year mean | 40 (21) |
| | Limit Value ( total $NO_x$) for protection of vegetation. achieved by Jul. 19th 2001 | | Calendar year mean | 30 (16) |
| **World Health Organisation[6]** | Health Guideline | | 1-hour mean | 200 |
| **(Non-Mandatory Guidelines)** | Health Guideline | | Annual mean | 40 |

(1) Conversions between µg m$^{-3}$ and ppb are as used by the EC, i.e. 1ppb $NO_2$ = 1.91 µg m$^{-3}$ at 20°C and 1013 mB.
(2) The Air Quality Strategy for England, Scotland, Wales and Northern Ireland. January 2000. ISBN 0-10-145482-1 & Addendum 2003.
(3) Air Quality (England) Regulations 2000 (SI 2000/928), Air Quality (Scotland) Regulations 2000 (SSI 2000/97), Air Quality (Wales) Regulations 2000 (SI 2000/1940 (W138)).
(4) Council Directive 85/203/EEC.
(5) Council Directive 1999/30/EC. Transposed into UK Air Quality Regulations in England by SI 2001/2315, in Scotland by SSI 2001/224, in Wales by SI 2001/2683 (W224), and by Statutory Rule 2002 (94) in Northern Ireland.
(6) WHO Guidelines for Air Quality WHO/SDE/OEH/00.02 (2000).

Ozone

| Guideline Set By | Description | | Criteria Based On | Value[1] / µgm$^{-3}$ (ppb) |
|---|---|---|---|---|
| **UK Government Air Pollution Index** | LOW | **1** | Max 1-hour and 8-hour mean | 0-32 (0-16) |
| | | **2** | | 33-66 (17-32) |
| | | **3** | | 67-99 (33-49) |
| | MODERATE | **4** | Max 1-hour and 8-hour mean | 100-126 (50-62) |
| | | **5** | | 127-152 (63-76) |
| | | **6** | | 153-179 (77-89) |
| | HIGH | **7** | Max 1-hour and 8-hour mean | 180-239 (90-119) |
| | | **8** | | 240-299 (120-149) |
| | | **9** | | 300-359 (150-179) |
| | VERY HIGH | **10** | Max 1-hour and 8-hour mean | ≥ 360 ( ≥ 180) |
| **The Air Quality Strategy[2] All UK. Not currently set in regulations.** | Objective for Dec. 31st 2005 | | Daily max. running 8-hour mean | 100 (50) Not to be exceeded more than 10 times per calendar year. |
| **European Community EC 1992 Ozone Directive[3] 92/72/EEC** (to be repealed 9 Sep 2003) | Population Information Threshold | | 1-hour mean | 180 (90) |
| | Population Warning Value | | 1-hour mean | 360 (180) |
| | Health Protection Threshold | | Fixed 8-hour means (hours 1-8, 9-16, 17-0, 13-20) | 110 (55) |
| | Vegetation Protection Threshold | | 1-hour mean | 200 (100) |
| | Vegetation Protection Threshold | | 24 hours (daily mean) | 65 (32) |
| **European Community 3rd Daughter Directive[4]** Not yet set in Regulations. | *Target Value* To be achieved by 3-year period beginning 2010. | | Max. daily 8-hour mean. | 120 µg m$^{-3}$ Not to be exceeded on more than 25 days per year, averaged over 3 years. |
| | *Target Value* for protection of vegetation. To be achieved by 5 years, beginning 2010 | | AOT40[5] calculated from 1h values May- July. | 18,000 µg m$^{-3}$ h averaged over 5 years. |
| **World Health Organisation[6] (Non-Mandatory Guidelines)** | Health Guideline | | 8-hour mean | 120 |

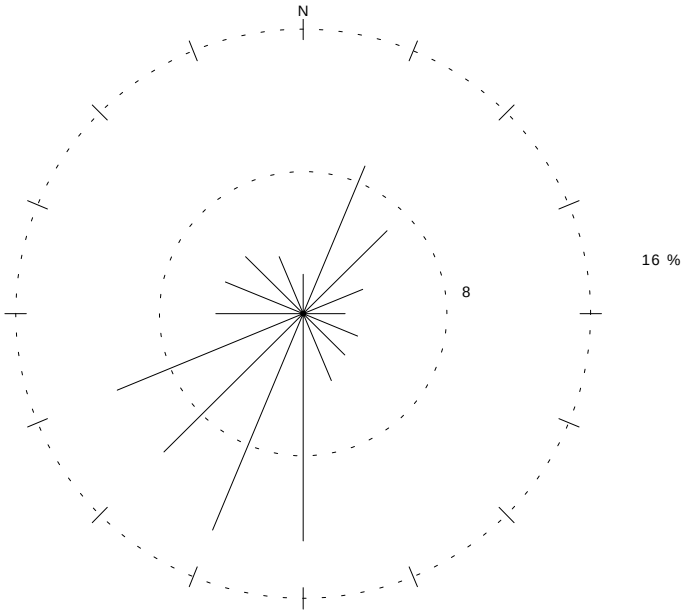
(1) Conversions between µg m$^{-3}$ and ppb are as used by the EC, i.e. 1ppb $O_3$ = 2.00 µg m$^{-3}$ at 20°C and 1013 mB.
(2) The Air Quality Strategy for England, Scotland, Wales and Northern Ireland. January 2000. ISBN 0-10-145482-1 & Addendum 2003.
(3) Directive 92/72/EEC. To be repealed 9 Sep 2003.
(4) Directive (2002/3/EC)
(5) AOT40 statistic is the sum of the differences between hourly concentrations greater than 80 µg m$^{-3}$ (=40ppb) and 80 µg m$^{-3}$, over a given period using only the 1-hour averages measured between 0800 and 2000.
(6) WHO Guidelines for Air Quality WHO/SDE/OEH/00.02 (2000).
(7) Growing season is defined as April to September for WHO guidelines, but is daytime (0900-1500) April to September for UNECE guidelines.

Particulate Matter as $PM_{10}$

| Guideline Set By | Description | | Criteria Based On | Value / $\mu gm^{-3}$ |
|---|---|---|---|---|
| **UK Government Air Pollution Index** | LOW | **1** | 24-hour mean | 0-16 |
| | | **2** | | 17-32 |
| | | **3** | | 33-49 |
| | MODERATE | **4** | 24-hour mean | 50-57 |
| | | **5** | | 58-66 |
| | | **6** | | 67-74 |
| | HIGH | **7** | 24-hour mean | 75-82 |
| | | **8** | | 83-91 |
| | | **9** | | 92-99 |
| | VERY HIGH | **10** | 24-hour mean | ≥ 100 |
| **The Air Quality Strategy(1)**<br><br>**Set in regulations for all UK(2).** | Objective for Dec. 31st 2004 | | 24-hour mean | 50<br>Not to be exceeded more than 35 times per calendar year. |
| | Objective for Dec. 31st 2004 | | Annual mean | 40 |
| **The Air Quality Strategy(1)**<br><br>**Not set in regulations: England (ex. London), Wales, & Northern Ireland.** | Objective for Dec. 31st 2010 | | 24-hour mean | 50<br>Not to be exceeded more than 7 times per calendar year. |
| | Objective for Dec. 31st 2010 | | Annual mean | 20 |
| **1st Daughter Directive(4)**<br><br>**STAGE 1 – Confirmed.** | Limit Value to be achieved by Jan 1st 2005 | | 24-hour mean | 50<br>Not to be exceeded more than 35 times per calendar year. |
| | Limit Value to be achieved by Jan 1st 2005 | | Annual mean | 40 |
| **1st Daughter Directive(4)**<br><br>**STAGE 2 – To be confirmed.** | Limit Value to be achieved by Jan 1st 2010 | | 24-hour mean | 50<br>Not to be exceeded more than 7 times per calendar year. |
| | Limit Value to be achieved by Jan 1st 2010 | | Annual mean | 20 |

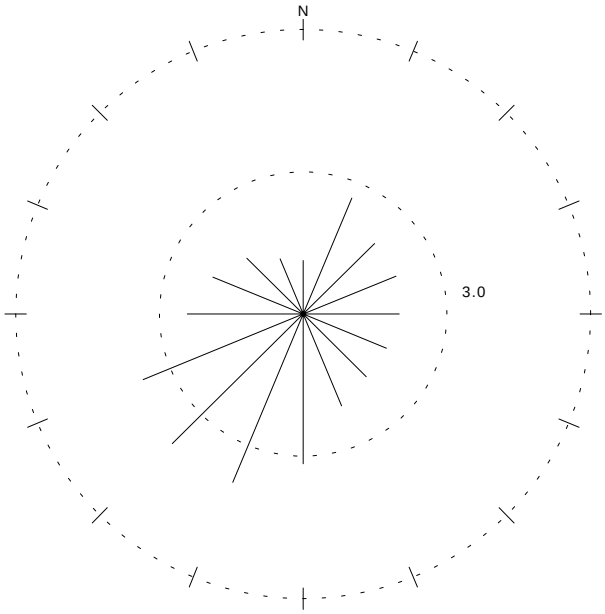
(1) The Air Quality Strategy for England, Scotland, Wales and Northern Ireland. January 2000. ISBN 0-10-145482-1 & Addendum 2003.
(2) Air Quality (England) Regulations 2000 (SI 2000/928), Air Quality (Scotland) Regulations 2000 (SSI 2000/97), Air Quality (Wales) Regulations 2000 (SI 2000/1940 (W138)).
(3) Air Quality (Amendment) (Scotland) Regulations 2002 (SI 2002/297)
(4) Council Directive 1999/30/EC. Transposed into UK Air Quality Regulations in England by SI 2001/2315, in Scotland by SSI 2001/224, in Wales by SI 2001/2683 (W224), and by Statutory Rule 2002 (94) in Northern Ireland.

# Appendix 4
## Wind Speed, Direction and Pollution Roses at Sutton Bridge (Westmere School)



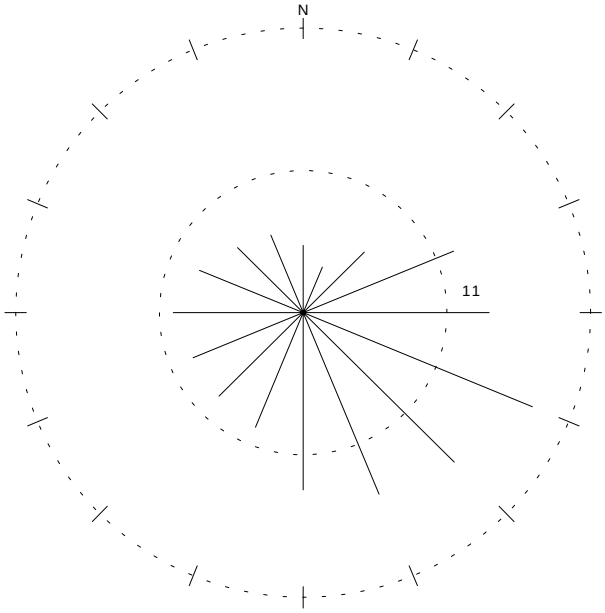

WIND ROSE ANALYSIS

South Holland Wind Direction Rose : 01/01/2002 to 31/12/2002
Frequency of Wind Direction in 150 - 160 degree sector = 1.64 %
Windspeed Threshold set at 0.1 m/s



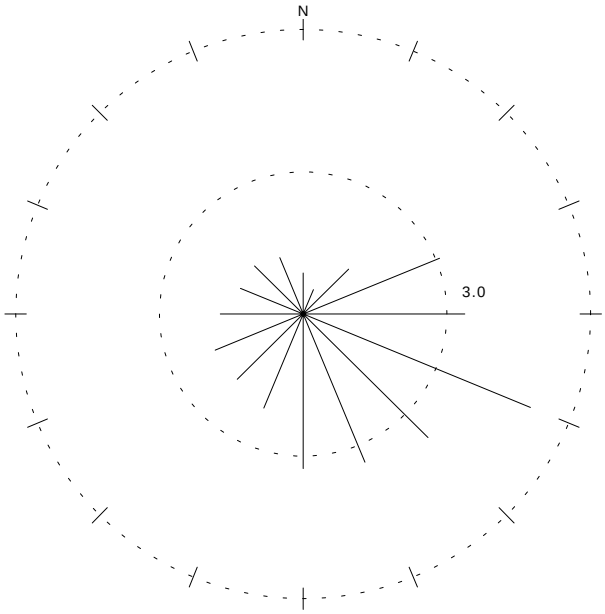

WIND ROSE ANALYSIS

South Holland Wind Speed Rose : 01/01/2002 to 31/12/2002
Average Wind Speed for 150 - 160 degree sector = 2.03 m/sec
Windspeed Threshold set at 0.1 m/s



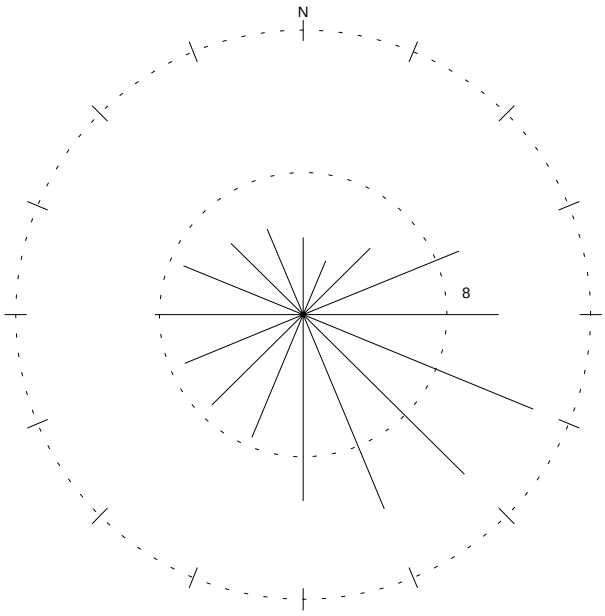

WIND ROSE ANALYSIS

South Holland Nitrogen Oxides Rose : 01/01/2002 to 31/12/2002
Average Nitrogen Oxides for 150 - 160 degree sector = 14.85 ppb
Windspeed Threshold set at 0.1 m/s



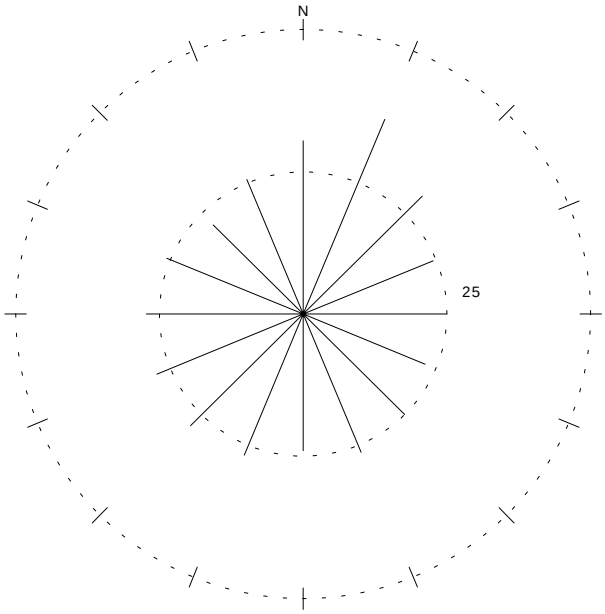

WIND ROSE ANALYSIS

South Holland Nitric Oxide Rose : 01/01/2002 to 31/12/2002
Average Nitric Oxide for 150 - 160 degree sector = 3.25 ppb
Windspeed Threshold set at 0.1 m/s



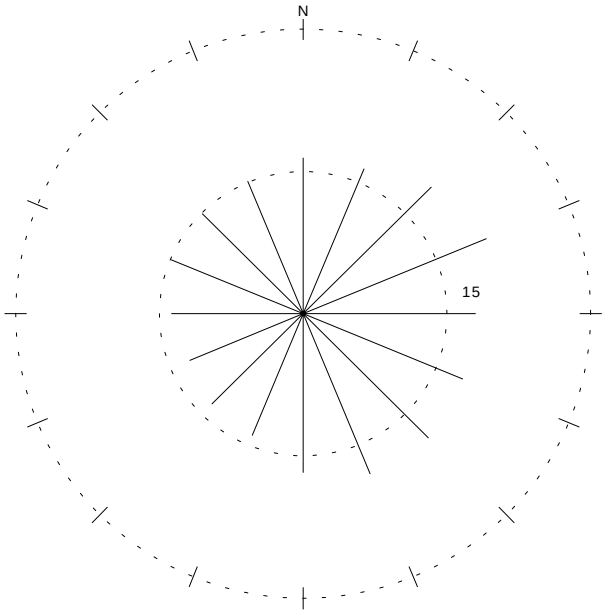

WIND ROSE ANALYSIS

South Holland Nitrogen Dioxide Rose : 01/01/2002 to 31/12/2002
Average Nitrogen Dioxide for 150 - 160 degree sector = 11.60 ppb
Windspeed Threshold set at 0.1 m/s




WIND ROSE ANALYSIS

South Holland Ozone Rose : 01/01/2002 to 31/12/2002
Average Ozone for 150 - 160 degree sector = 27.19 ppb
Windspeed Threshold set at 0.1 m/s




WIND ROSE ANALYSIS

South Holland PM10 Particulate Matter Rose : 01/01/2002 to 31/12/2002
Average PM10 Particulate Matter for 150 - 160 degree sector = 17.60 µg m-3 (20'C 1013mb)
Windspeed Threshold set at 0.1 m/s