# Study of Ambient Air Quality at Hartlepool

## 16 September 2025 to 16 March 2026

Date: May 2026

Version: (AAM/TR/2026/04)

We are the Environment Agency. We protect and improve the environment.

We help people and wildlife adapt to climate change and reduce its impacts, including flooding, drought, sea level rise and coastal erosion.

We improve the quality of our water, land and air by tackling pollution. We work with businesses to help them comply with environmental regulations. A healthy and diverse environment enhances people's lives and contributes to economic growth.

We can't do this alone. We work as part of the Defra group (Department for Environment, Food & Rural Affairs), with the rest of government, local councils, businesses, civil society groups and local communities to create a better place for people and wildlife.

Published by:

Environment Agency
Horizon House, Deanery Road,
Bristol BS1 5AH

www.gov.uk/environment-agency



Further copies of this report are available from our publications catalogue: www.gov.uk/government/publications or our National Customer Contact Centre: 03708 506 506

Email:enquiries@environment-agency.gov.uk

# Executive Summary

This report presents the results from a study of ambient air quality in the vicinity of Seaton Meadow Landfill site, near Hartlepool. The Environment Agency's Ambient Air Monitoring Team (in National Monitoring) conducted the study on behalf of the North East Area. This report considers data collected between the 16 September 2025 and 16 March 2026 (182 days).

A mobile monitoring facility (MMF) containing equipment capable of measuring concentrations of hydrogen sulphide ($H_2S$), methane ($CH_4$) and particulate matter (TSP, $PM_{10}$ and $PM_{2.5}$) was set up. Wind speed, wind direction, temperature and pressure measurements were also collected.

The overall objective of the study was to identify the local sources of air pollution and to quantify the environmental impact of the emissions from these sources on the surrounding area.

The average methane concentration over the monitoring period was 1.51 mg/m$^3$, which is above the northern hemisphere background concentration[2] of ~1.31 mg/m$^3$.

Comparing the collected data with the World Health Organisation (WHO) guidelines showed that $H_2S$ was within the health limits during this reporting period. Comparison with the odour nuisance guideline showed that $H_2S$ concentrations were above the guideline for 0.4% of the monitoring period.

Comparing the collected data with the AQS objectives and the AQSR limit values showed that the monitoring location was subject to concentrations of $PM_{10}$ and $PM_{2.5}$ that were likely to meet their respective standards.

Comparison of $PM_{2.5}$ concentrations with the annual UK Environment Act target and the EIP23 and EIP25 interim targets showed that these targets would not be exceeded at the monitoring location.

Comparison against the Air Quality Index (AQI) banding showed that $PM_{10}$ and $PM_{2.5}$ concentrations were all in the low AQI banding for the duration of the monitoring period.

Directional analysis indicated that the highest average $H_2S$ and $CH_4$ concentrations were measured from the direction of Seaton Meadows landfill site. There were also higher levels of $H_2S$ in the direction of Biopower Ltd.

Percentile rose analysis showed there were relatively continuous sources of $H_2S$ and $CH_4$ in the direction of Seaton Meadows landfill site and additionally in the case of $H_2S$, in the direction of Biopower Ltd.

Diurnal analysis showed that the highest levels of $H_2S$ and $CH_4$ were seen in direction of Seaton Meadows landfill site, with levels generally highest in the early morning and late evening, which suggests that fugitive emissions have been trapped close to the ground during poor dispersion conditions. In the direction of Biopower Ltd the $H_2S$ levels were higher during the morning.

# Contents

# 1 Introduction

This report presents the results from a study of ambient air quality in the vicinity of Seaton Meadow Landfill site, near Hartlepool. The Environment Agency's Ambient Air Monitoring Team (in National Monitoring) conducted the study on behalf of the North East Area. This report considers data collected between the 16 September 2025 and 16 March 2026 (182 days).

A mobile monitoring facility (MMF) containing equipment capable of measuring concentrations of hydrogen sulphide ($H_2S$), methane ($CH_4$) and particulate matter (TSP, $PM_{10}$ and $PM_{2.5}$) was set up. Wind speed, wind direction, temperature and pressure measurements were also collected. Further details about the MMF are included in Appendix A.

The absolute values of the collected data have associated uncertainties in the monitoring process, but these are minimised by the QAQC measures described in Appendix B. These should be considered when assessing the results of any comparisons with the WHO guidelines, The Air Quality Strategy, the Air Quality Standards Regulations 2010 (AQSR), the Environmental Improvement Plans (EIP23 and EIP25), the Environment Act and the DAQI.

A comparison with the AQSR limit values has been made to provide a measure of air quality, to help evaluate compliance and quantify environmental impact in the immediate vicinity of sites that the Environment Agency regulates. The monitoring location must meet several criteria that ensure it is a suitable 'sensitive receptor' in regards AQSR limit values. The monitoring location in this study does not meet these criteria and therefore the data should not be compared with the AQSR limit values for statutory compliance purposes.

The overall objective of the study was to identify the local sources of air pollution and to quantify the environmental impact of the emissions from these sources on the surrounding area. Within this objective, the following individual aims were identified:

- To assess the general air quality of the area relative to the relevant objectives and guidelines.
- To quantify the impact of surrounding pollution sources on local air quality.
- To identify specific sources causing an appreciable impact on air quality.
- To identify and understand the conditions that give rise to episodes of poor air quality.

# 2 Monitoring Location

The Ambient Air Monitoring team deployed a mobile monitoring facility (MMF) in the car park of the Hartlepool Borough Council's fleet workshop at Tofts Farm Industrial Estate. The site of interest, Seaton Meadow landfill site, was at a bearing of approximately 105°- 165° from the monitoring site. Figure 2.1 shows the location of the MMF and Seaton Meadows Landfill Site and Figure 2.2 shows a photograph of the MMF in situ.

**Figure 2.1: Map of monitoring location (★MMF) (Google Maps, March 2026)**


Bearing from MMF:

Seaton Meadows LFS — 105° - 165°

Sewage Treatment Works — 159° – 177°

Biopower Ltd — 190° - 230°

**Figure 2.2: Photograph of MMF at monitoring site.**

# 3 Monitoring Results

## 3.1 Meteorology

Wind speed and direction measurements were collected at the MMF site during the study between 16 September 2025 and 12 March 2026. The sensor was mounted on a mast extending 6m from the top of the MMF trailer giving an overall height above ground of 8m. Where possible MMFs are located over 100m from any buildings of greater or comparable height, to reduce any influence that surrounding buildings may have on the wind distribution. However, in this instance that was not possible and therefore the proximity of certain buildings may have influenced local wind distribution.

When setting up the instrument measuring wind direction at the beginning of the study, the mast was rotated such that the vane pointed in a known direction, and this was used as datum from which other directions were determined by the sensor. An uncertainty of ±5° on the wind direction is introduced which affects all readings by the same amount. For the production of rose plots the wind direction data are resolved into 10° sectors for analysis and interpretation, therefore the uncertainty of each sector is ±5°.

Initial directional analysis suggested that there was a problem with the orientation of the wind vane. On investigation it was discovered that the accuracy of the compass was being affected by something in the carpark at the monitoring site, causing it to not give a true direction for North (used to align the wind vane at the start of the study). The wind direction data was therefore corrected by comparison to a nearby Met Office meteorological station, Loftus, which showed good agreement with the wind direction data from the MMF apart from a slight offset caused by the misalignment of the wind vane at the MMF (see Figures 3.1.1 and 3.1.2).

**Figure 3.1.1: Comparison between the wind direction data from the MMF and from Loftus**

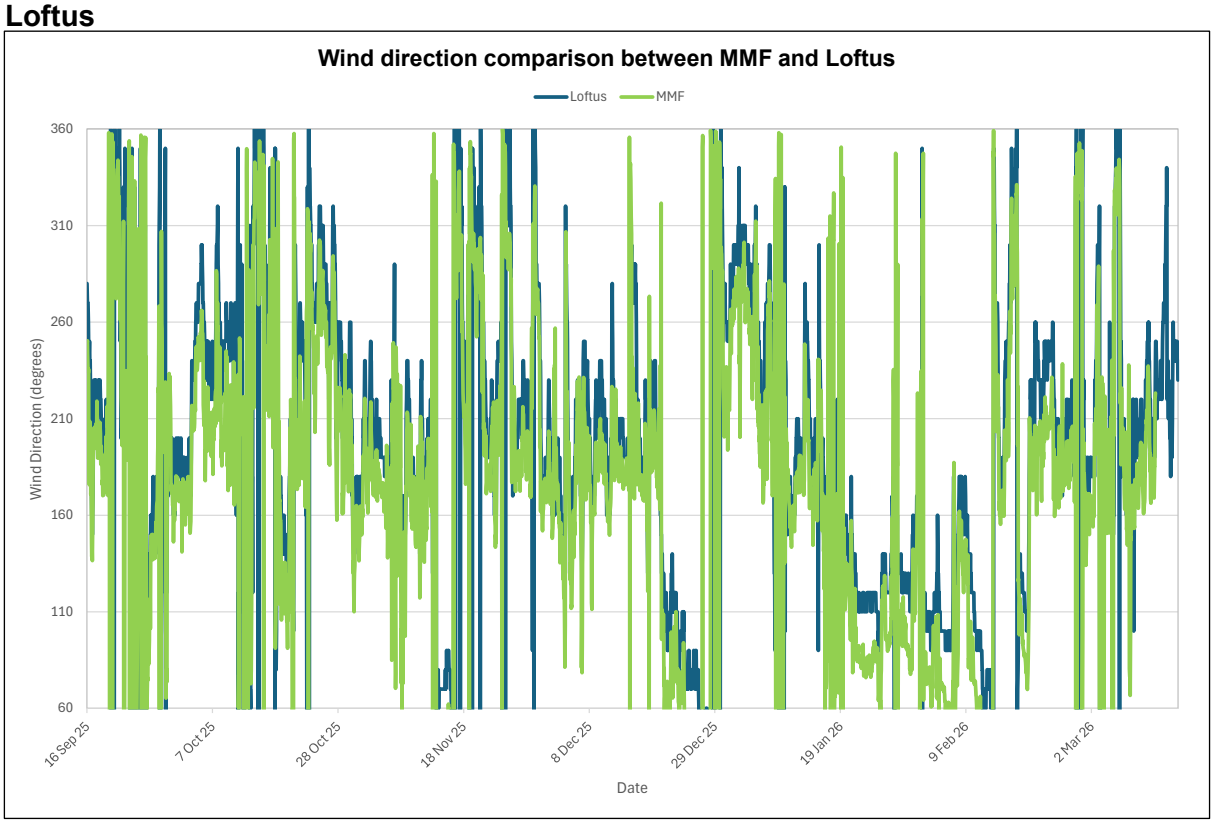
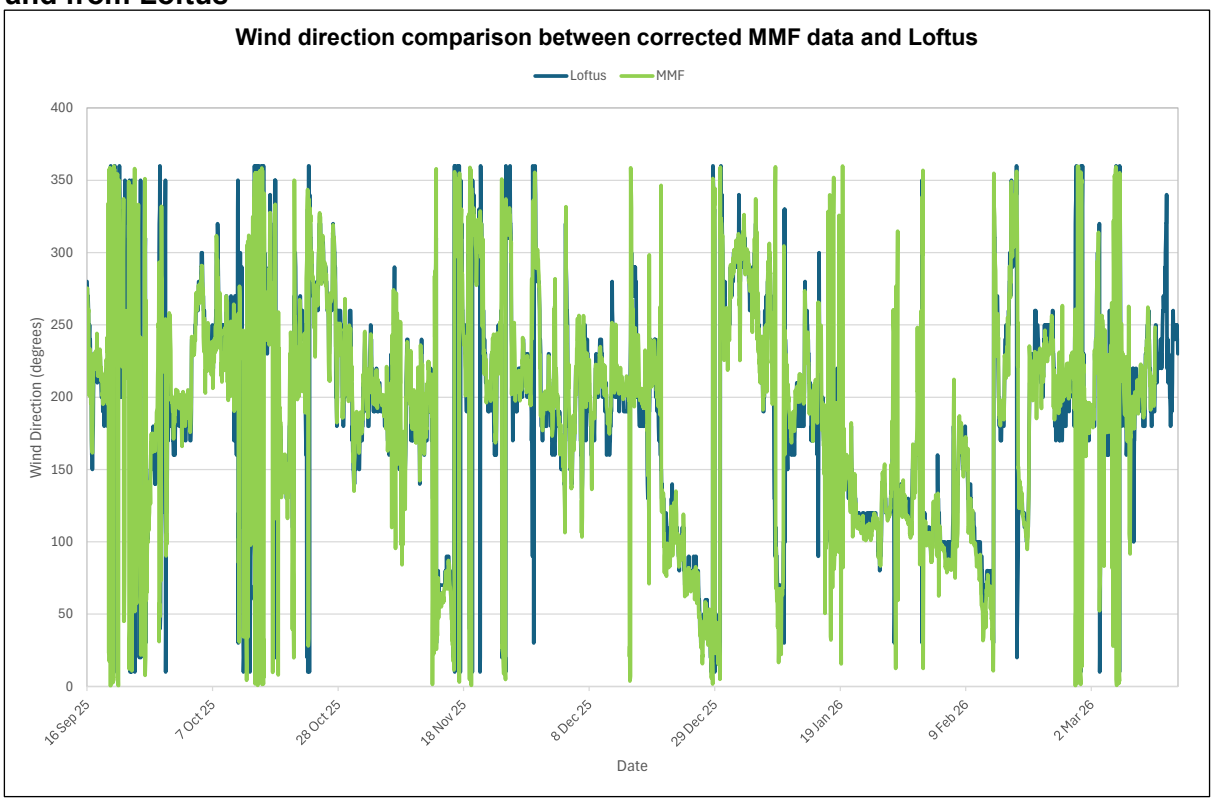


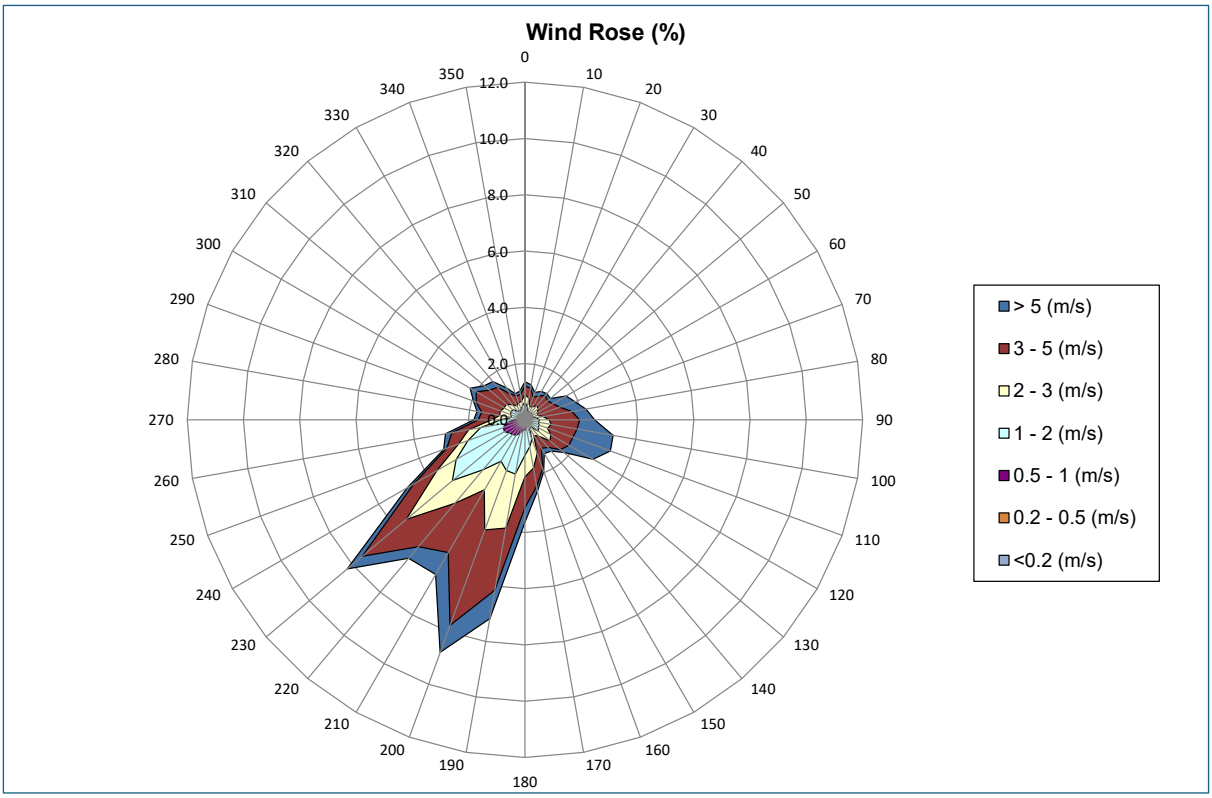
**Figure 3.1.2: Comparison between the corrected wind direction data from the MMF and from Loftus**




Directional plots have been interpreted assuming that the wind was travelling in a straight line, but it is worth noting that real-world conditions are more complex, with topography, buildings and other meteorological conditions influencing movement. This may cause wind direction to vary along a plume's trajectory so that the wind direction will not simply "point" to the source.

The wind direction frequency distribution of the corrected MMF wind direction data at the monitoring location between 16 September 2025 and 12 March 2026 (178 days) is shown in Figure 3.1.3. The plot shows that over the period the dominant wind direction was from 190° - 240°, with wind coming from this sector for 42% of the monitoring period.

**Figure 3.1.3: Wind rose (%).**




The frequency distribution of wind speeds against wind direction at the monitoring location is shown in Figure 3.1.4. The most frequent wind speeds were from sectors 185°-245° at wind speeds of 2-5 m/s.

**Figure 3.1.4: Wind speed frequency rose (m/s)**

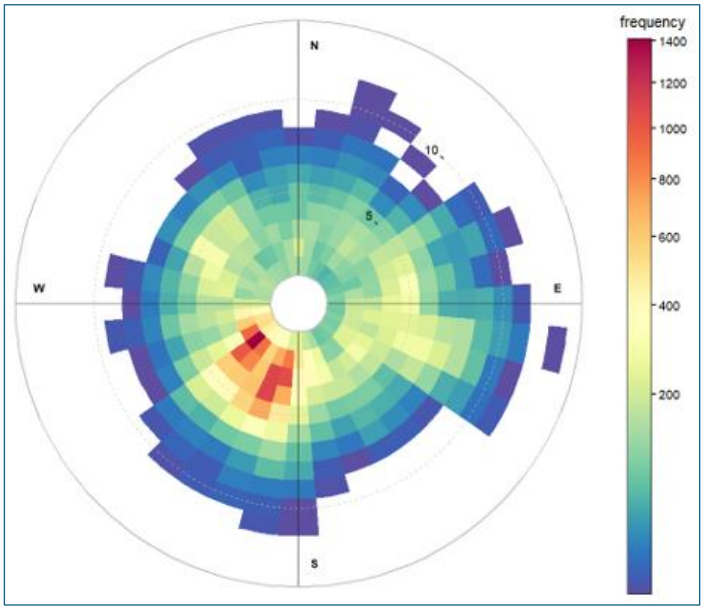



Table 3.1.1 shows a summary of wind speed frequencies at the monitoring location for all directions.

**Table 3.1.1 Summary of wind speed frequencies for the monitoring location.**

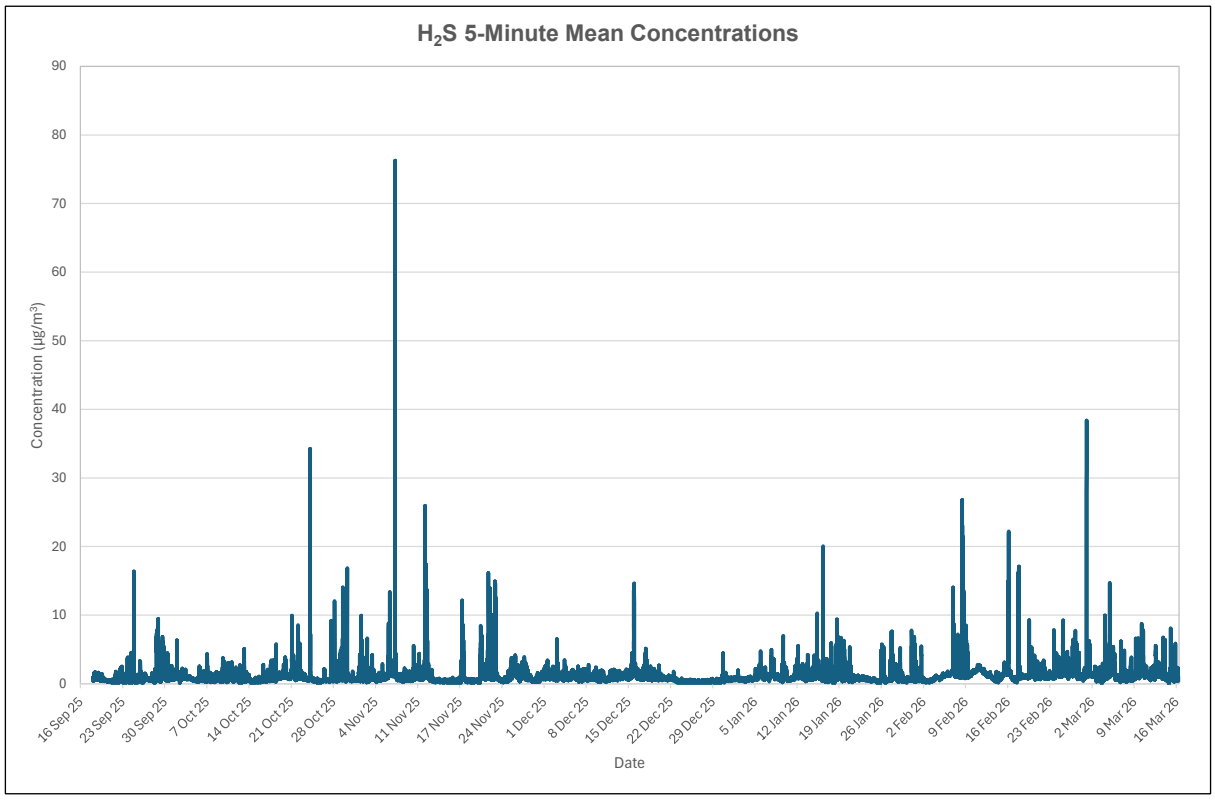
| Wind Speed (m/s) | Frequency of wind speed (%) |
|---|---|
| >5 | 14.5 |
| 3-5 | 32.7 |
| 2-3 | 20.6 |
| 1-2 | 21.4 |
| 0.5-1 | 7.7 |
| 0.2-0.5 | 2.5 |
| < 0.2 | 0.6 |
| **Total** | **100** |

## 3.2 Hydrogen Sulphide

Airborne $H_2S$ concentrations were measured, at a height of 2m above ground, between 18 September 2025 to 16 March 2026 (180 days). Details of the instrumentation and methodology are given in Appendix C. Successful data collection for the monitoring period was 99%.

A time series plot of 5-minute concentrations is shown in Figure 3.2.1. The average concentration over the monitoring period was 1.1 µg/m$^3$. The maximum 5-minute concentration of 76.3 µg/m$^3$ was recorded on 7 November 2025.

**Figure 3.2.1: $H_2S$ 5-minute time series.**




### 3.2.1 Comparison with WHO Guidelines

The World Health Organisation (WHO) guidelines for Europe (2000) have set a 24-hour guidance limit of 150 µg/m$^3$ for $H_2S$ in the context of human health.

A time series plot of 24-hour average $H_2S$ concentrations at the monitoring site is shown in Figure 3.2.2. The highest recorded 24-hour average was 3.4 µg/m$^3$, which is considerably lower than the 150 µg/m$^3$ guideline.

The WHO guidelines have also set a 30-minute average $H_2S$ guide level of 7 µg/m$^3$ above which substantial reports about odour annoyance can be expected. A time series plot of 30-minute average $H_2S$ concentrations measured over the period is shown in Figure 3.2.3. The highest recorded 30-minute average during the monitoring period was 19.7 µg/m$^3$. The WHO guideline level of 7µg/m$^{-3}$ was exceeded at the monitoring site for 0.4% of the monitoring period.

**Figure 3.2.2: $H_2S$ 24-hour average concentrations.**

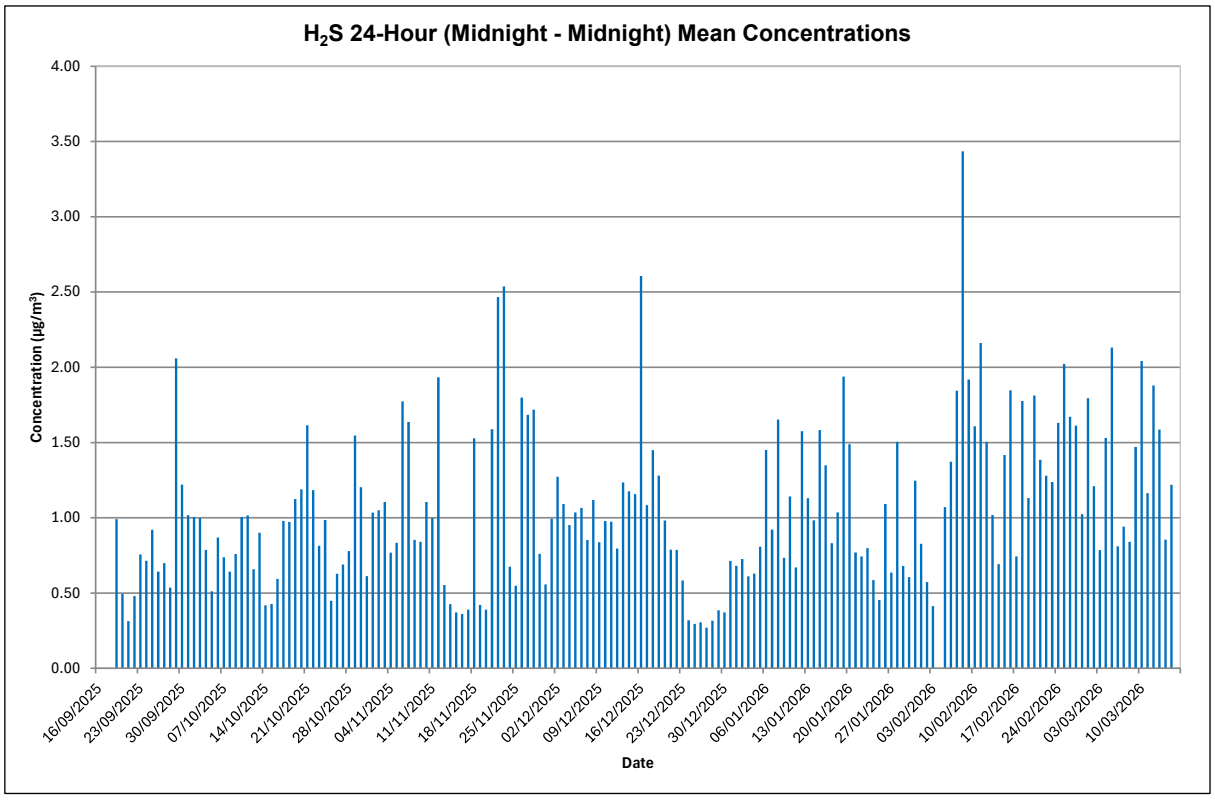
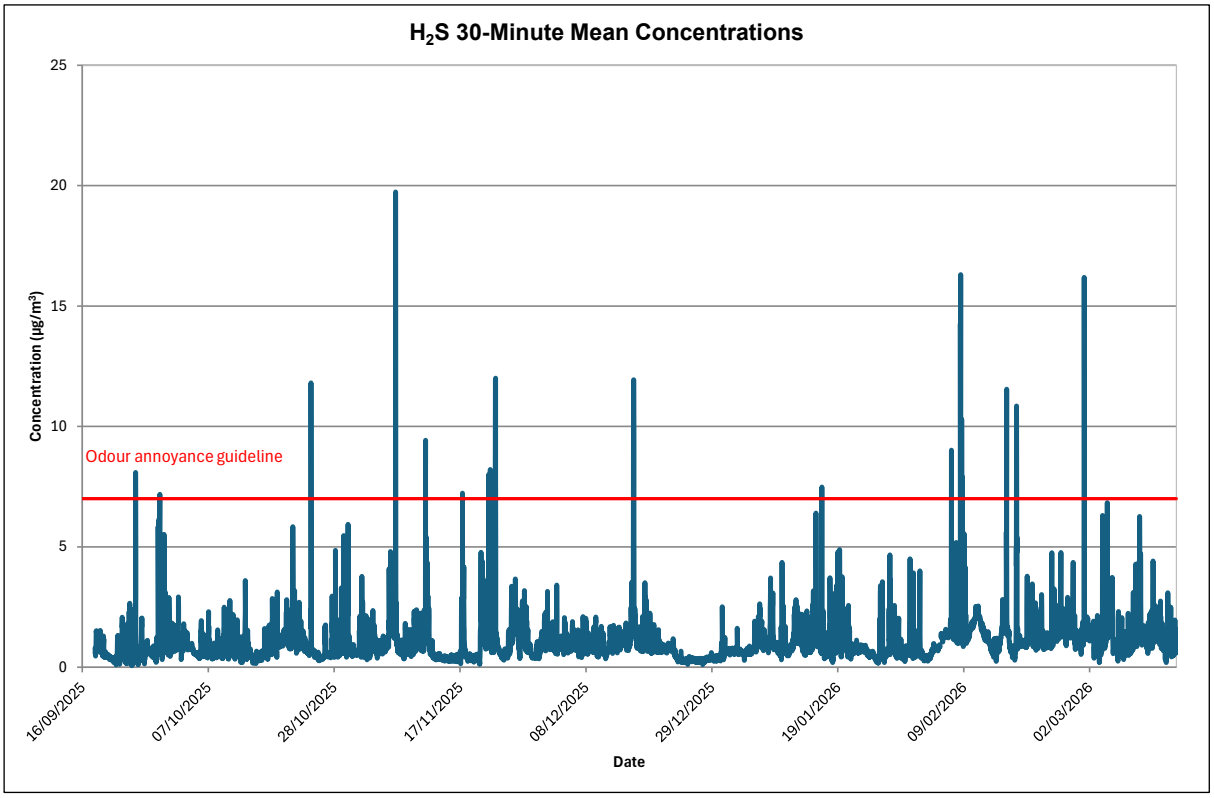



**Figure 3.2.3: $H_2S$ 30-minute average concentrations.**




Substantial complaints due to odour nuisance from $H_2S$ were expected for 0.4% of the monitoring period, based on the WHO guideline alone. However, this does not take in to account the subjective nature of odour complaints and odours from sources other than $H_2S$.

Figure 3.2.4 shows the number of exceedances of the WHO guide level of 7 µg/m$^3$ against average wind direction, for each 10$^o$ sector (based on a 30-min average) over the monitoring period at the monitoring site.

**Figure 3.2.4: $H_2S$ radial exceedance histogram (number of exceedances)**

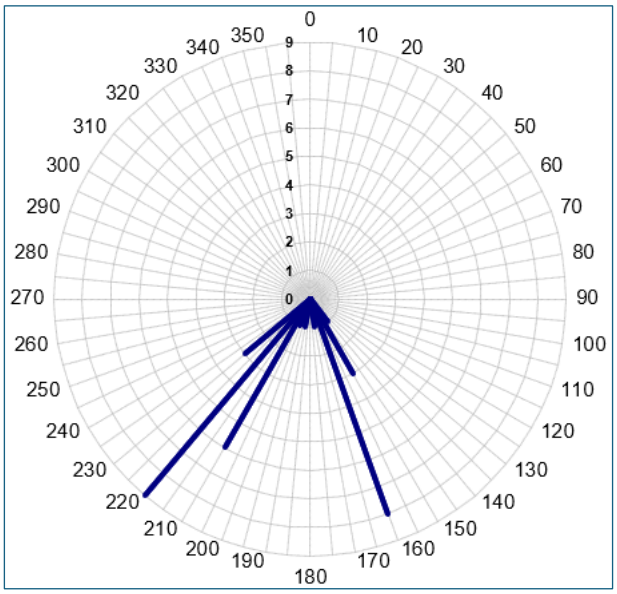



Figure 3.2.4 shows that 11 of the 33 exceedances of the odour guideline came from the sector 150° – 160° (the direction of Seaton Meadows LFS) and 18 exceedances came from the sector 210° – 230° (the direction of Biopower Ltd anaerobic digester).

Table 3.2.1 summarises the percentage of time, for each month of the study, that $H_2S$ concentrations were above the WHO odour annoyance guideline value of 7 µg/m$^3$ and the number of data points above the guideline value. November and February showed the highest number of 30-minute values above the guideline level and the highest $H_2S$ concentrations was in November 2025. However, it should be noted that September and March were not full months.

**Table 3.2.1: summary of the percentage of time and number of data points above the WHO odour annoyance guideline value, for each month.**

| Month | Number of exceedances | % of month above guideline value (7 µg/m$^3$) |
|---|---|---|
| Sep-25 | 2 | 0.3 |
| Oct-25 | 1 | 0.1 |
| Nov-25 | 11 | 0.8 |
| Dec-25 | 4 | 0.3 |
| Jan-26 | 2 | 0.1 |
| Feb-26 | 11 | 0.8 |
| Mar-26 | 2 | 0.3 |

## 3.2.2 Directional Analysis

A radial plot of average $H_2S$ concentrations (µg/m$^3$) against wind direction is shown in Figure 3.2.5.

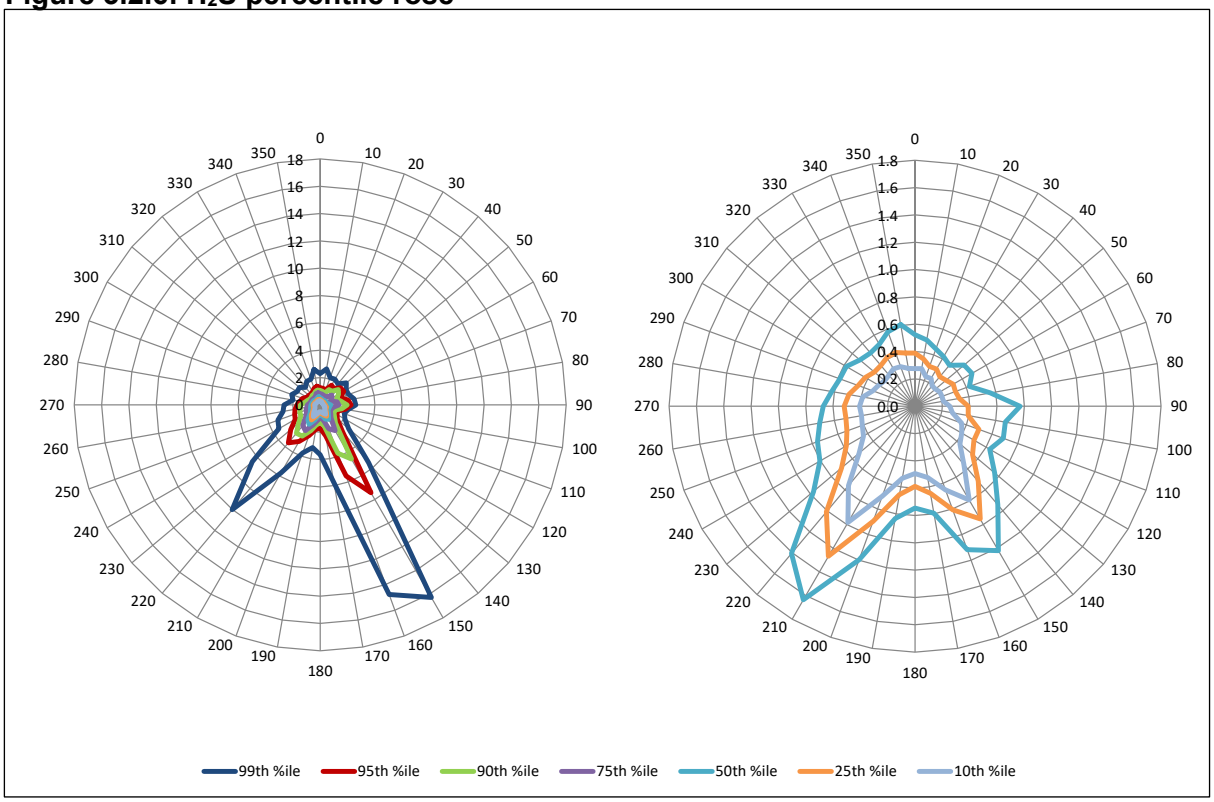
Figure 3.2.5 shows that the highest concentrations came from sectors 150° - 160° (the direction of Seaton Meadows landfill site) and 210° - 220° (the direction of Biopower Ltd anaerobic digester), with average concentrations >1.7 µg/m$^3$.

**Figure 3.2.5: $H_2S$ average pollution rose (scale: 0 – 2.5 µg/m$^3$) (Google Maps, March 2026)**


Plots showing the contribution to $H_2S$ loading (µg/m$^3$) for different percentiles are shown in Figure 3.2.6. An explanation of percentile analysis is given in Appendix F.

Figure 3.2.6 shows that the contribution from the sources in the sectors 150° - 160° and 210° - 220° was seen in all of the percentiles, which suggests that there are relatively continuous sources of $H_2S$ in these sectors.

**Figure 3.2.6: $H_2S$ percentile rose**



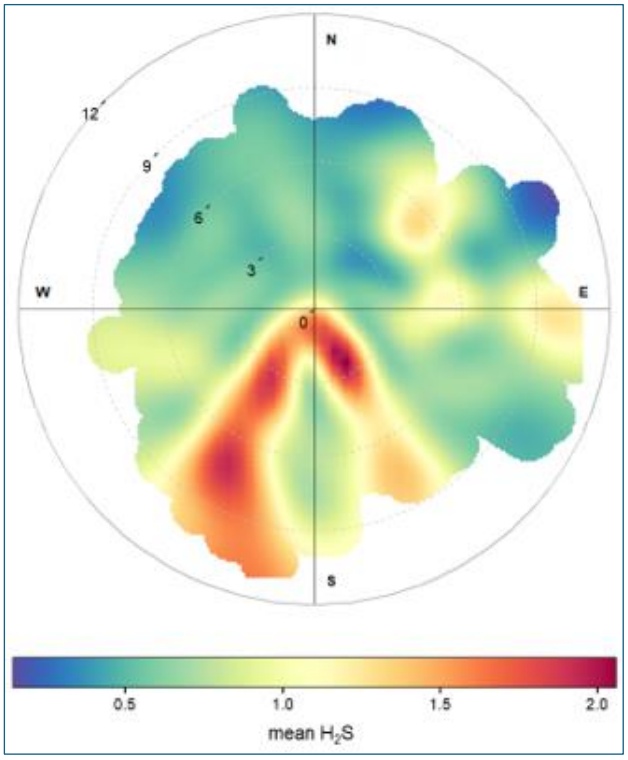

## 3.2.3 Wind Speed Analysis

Wind speed plays an important role in the dispersion of air pollutants. Higher wind speeds generate more mechanical turbulence, which has the effect of distributing emissions more rapidly through the mixed boundary layer of the atmosphere. The relative concentrations measured at different wind speeds can provide insight into the nature of contributing sources.

A polar plot showing the average $H_2S$ concentrations for varying wind speeds and wind directions over the monitoring period is shown in Figure 3.2.7.

Figure 3.2.7 shows that the highest concentrations were seen in the sectors 140° - 170° at wind speeds up to ~5m/s and between 205° - 230°, with increased concentrations seen at all wind speeds.

**Figure 3.2.7: $H_2S$ Wind Speed Dependency Plot (openair 2026)**

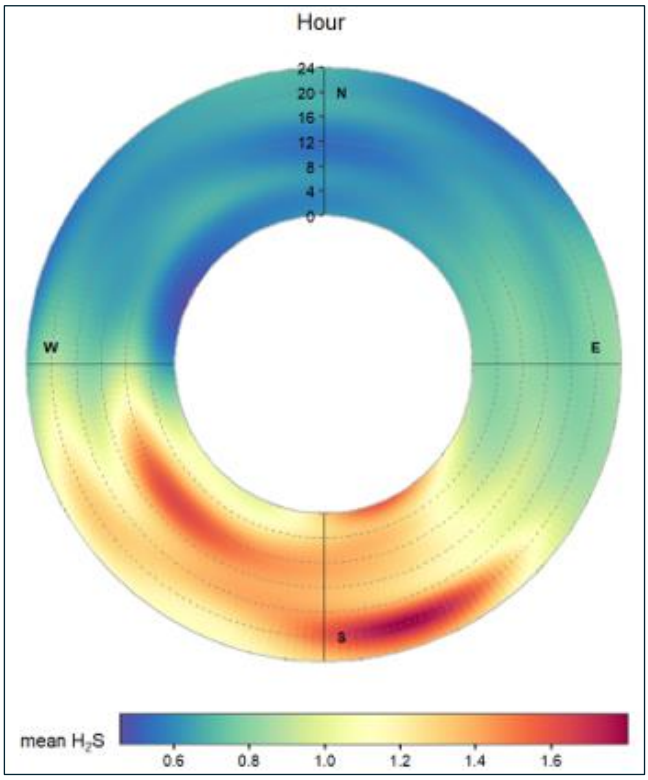



## 3.2.4 Diurnal analysis

Consideration of the diurnal distribution of concentrations can provide further useful information about the sources contributing to the ambient levels in each sector. Polar annulus plots showing the average diurnal $H_2S$ concentrations, for all directions, are shown in Figure 3.2.8.

Figure 3.2.8 shows that $H_2S$ concentrations were elevated in the direction of Seaton Meadows landfill in the late evening and in the early mornings suggesting accumulation under poor dispersion conditions. $H_2S$ concentrations in the direction of Biopower Ltd show levels that are elevated in the morning around 8am.

**Figure 3.2.8: $H_2S$ diurnal plot (openair 2026)**




## 3.2.5 Conclusion

A comparison of the $H_2S$ data with the WHO guidelines for human health of 150 µg/m$^3$, as 24-hour average concentrations, indicated that the air quality at the monitoring site was always below this guideline value.

Comparison of the $H_2S$ data with the WHO guidelines for odour annoyance of 7 µg/m$^3$, as 30-minute average concentrations, indicated that substantial complaints due to odour nuisance from $H_2S$ were expected for 0.4% of the monitoring period, based on the WHO guideline alone. However, this does not take in to account the subjective nature of odour complaints.

Directional analysis indicated that the highest concentrations came from the sectors 150° - 160° (the direction of Seaton Meadows landfill site) and 210° - 220° (the direction of Biopower Ltd anaerobic digester), with average concentrations >1.7 µg/m$^3$.

Percentile rose analysis showed that the contribution from the sources in the sectors 150° - 160° and 210° - 220° was seen in all of the percentiles, which suggests that there are relatively continuous sources of $H_2S$ in these sectors.

Wind speed analysis showed that the highest concentrations were seen in the sectors 140$^o$ - 170$^o$ at wind speeds up to ~5m/s and between 205$^o$ - 230$^o$ at all wind speeds.

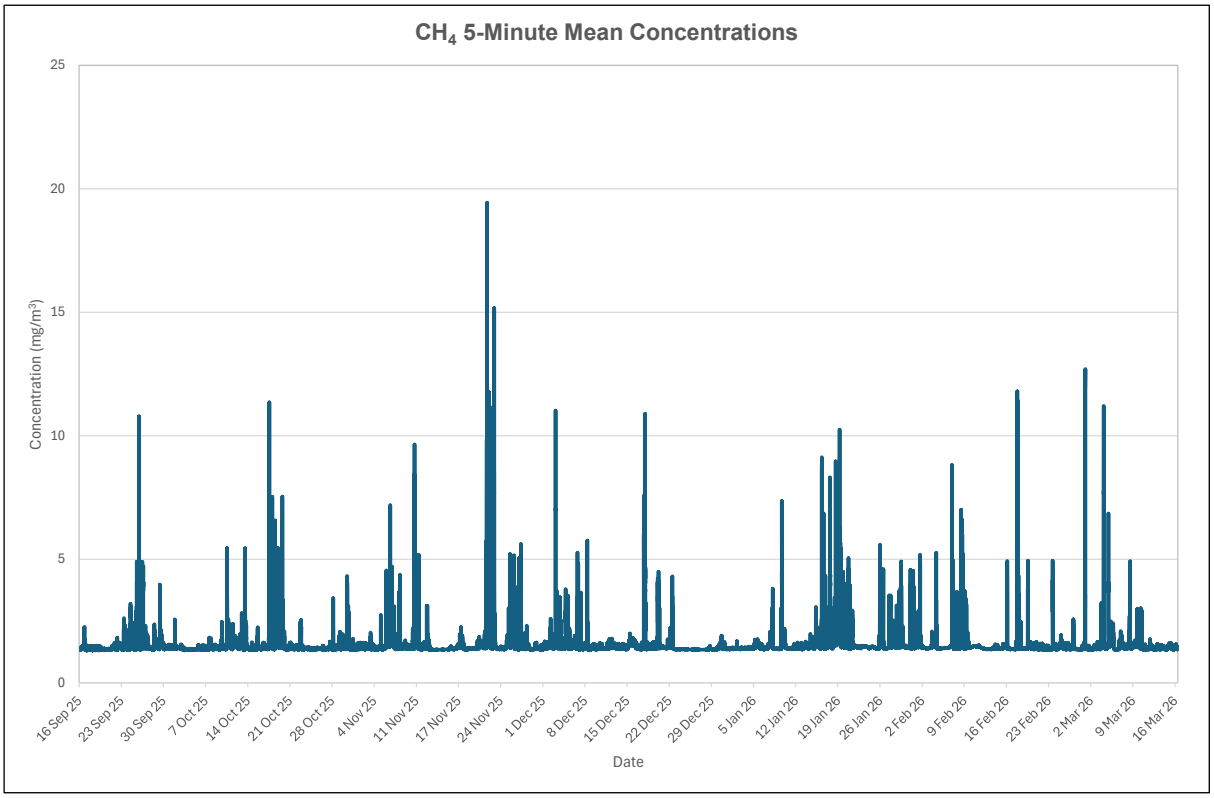
Diurnal analysis showed that $H_2S$ concentrations were elevated in the direction of Seaton Meadows landfill in the late evening and in the early mornings suggesting accumulation under poor dispersion conditions. $H_2S$ concentrations in the direction of Biopower Ltd show levels that are elevated in the morning around 8am.

## 3.3 Methane

Airborne $CH_4$ concentrations were measured at a height of 2m above ground between 16 September 2025 to 16 March 2026 (182 days). Successful data collection for the monitoring period was 99%. Details of the instrumentation and methodology are given in Appendix D.

A time series plot of 5-minute $CH_4$ concentrations ($mg/m^3$) over the monitoring period is shown in Figure 3.3.1.

**Figure 3.3.1: $CH_4$ 5-minute average concentrations.**




Methane does not have any associated impacts on human health, except for the risk of explosion at very high concentrations. The primary environmental impact from methane is the effect on global warming. The average concentration over the period was 1.51 $mg/m^3$, which is higher than the northern hemisphere background concentration of around 1.31 $mg/m^3$, suggesting there was a localised $CH_4$ source.

### 3.3.1 Directional Analysis

A radial plot of average $CH_4$ concentrations ($mg/m^3$) against wind direction is shown in Figure 3.3.2.

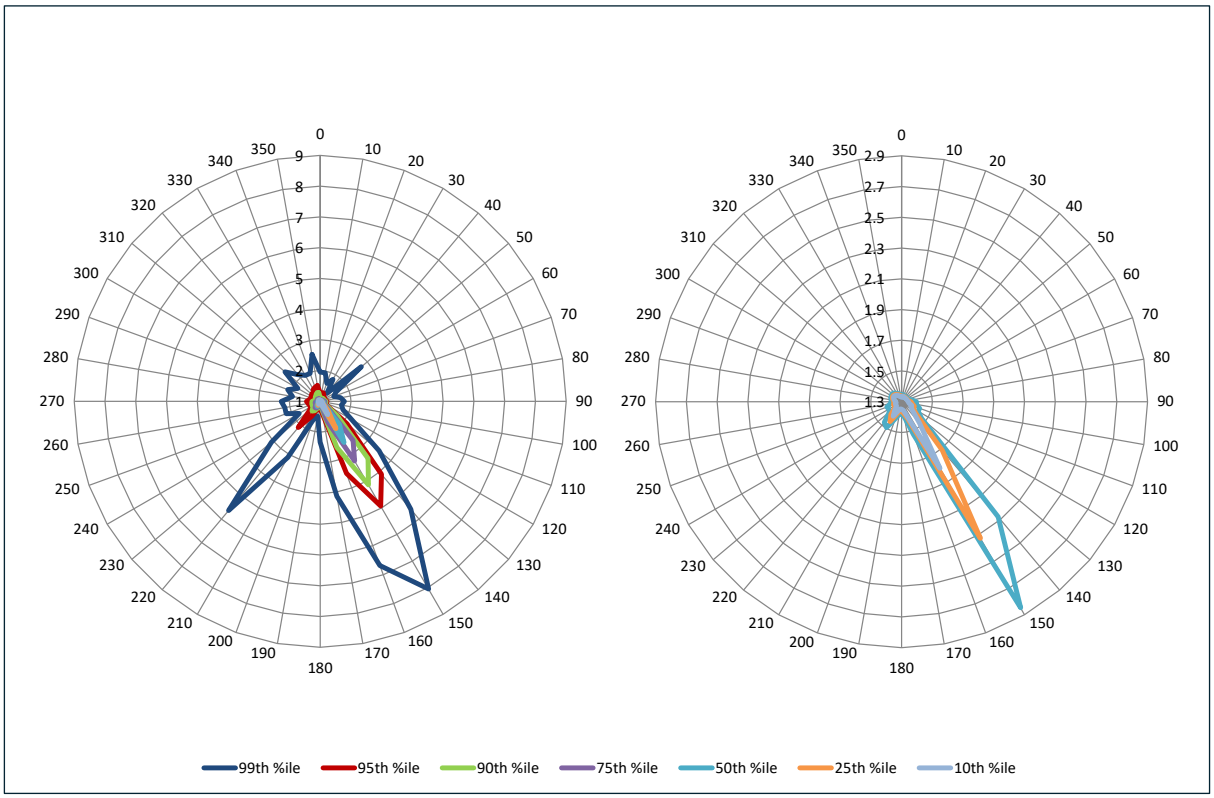
The plot of mean $CH_4$ concentrations shows that the highest average concentrations were seen in the sectors 140° - 150° (the direction of Seaton Meadows landfill site) with concentrations >2.5 $mg/m^3$. Higher levels were also seen in the sector 210° - 220° (the direction of Biopower Ltd anaerobic digester).

**Figure 3.3.2: $CH_4$ Mean Pollution Rose (scale: 1.3– 3.1 mg/m$^3$) (Google Maps, December 2025)**


Percentile plots showing the contribution to $CH_4$ loading (mg/m$^3$) at the monitoring site for different percentiles are shown in Figure 3.3.3.

Figure 3.3.3 shows that the contribution from the source between 140º - 150º (the direction of Seaton Meadows landfill site) affects all the percentiles, which indicates that the source is relatively continuous and commonly affects particulate concentrations at the monitoring site. Contribution from the sources at 50° and 220° was more evident in the higher percentiles, suggesting that there were intermittent sources in these wind directions.

**Figure 3.3.3: $CH_4$ percentile rose**

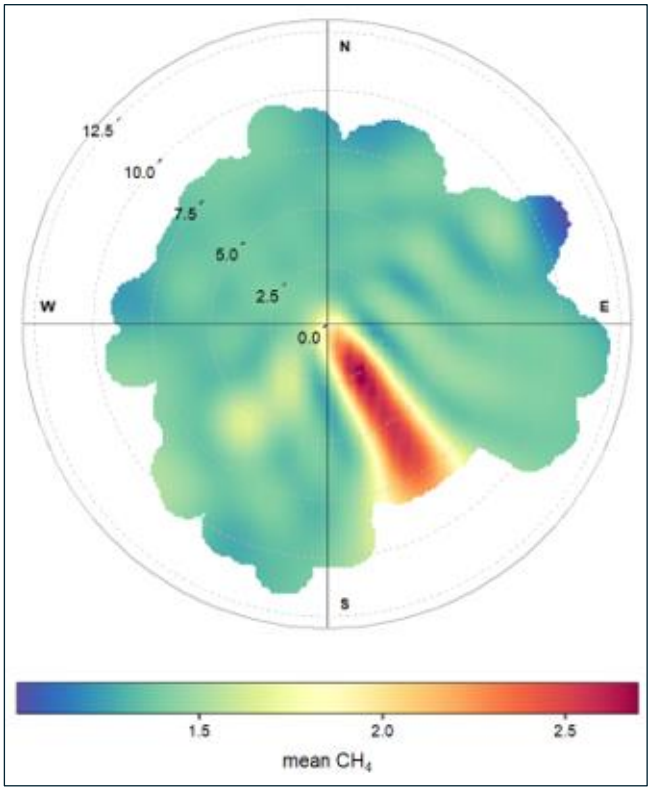



## 3.3.2 Wind Speed Analysis

A polar plot showing the average $CH_4$ concentrations for varying wind speeds and wind directions over the monitoring period is shown in Figure 3.3.4.

Figure 3.3.4 shows that the highest concentrations were seen in the sector 135° - 160° (the direction of Seaton Meadows landfill site) at all wind speeds.

**Figure 3.3.4: $CH_4$ Openair Wind Speed Dependency Plot (Google Maps, December 2025)**

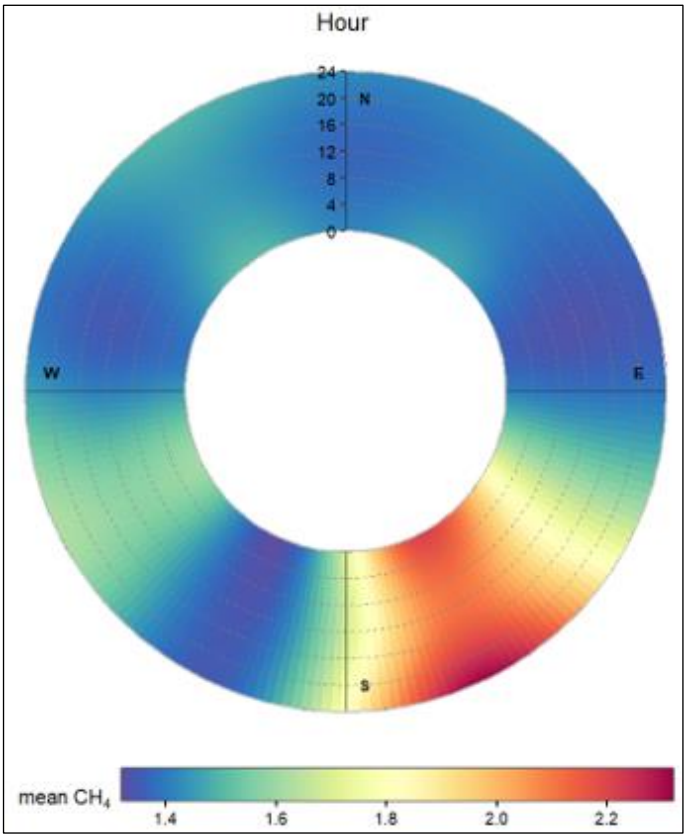



## 3.3.3 Diurnal analysis

Consideration of the diurnal variation of $CH_4$ concentrations can provide further useful information about the conditions contributing to the ambient levels in each sector.

A Polar annulus plot showing the average diurnal $CH_4$ concentrations, for all directions, is shown in Figure 3.3.5. Figure 3.3.5 shows that the highest levels of $CH_4$ are seen in sector 130° – 170°, with levels generally high throughout the day but highest in the early morning and in the late evening (during poor dispersion conditions).

**Figure 3.3.5: $CH_4$ diurnal plot ($mg/m^3$) (Google Maps, December 2025)**




## 3.3.4 Conclusion

The average $CH_4$ concentration over the period was 1.51 $mg/m^3$, which is slightly higher than the northern hemisphere background concentration of around 1.31 $mg/m^3$, suggesting there was a localised source.

Directional analysis indicated that the highest average concentrations were seen in the sectors 140° - 150° (the direction of Seaton Meadows landfill site) with concentrations >2.5 $mg/m^3$. Higher levels were also seen in the sector 210° - 220° (the direction of Biopower Ltd anaerobic digester).

Percentile rose analysis showed that the monitoring site was affected by a relatively continuous $CH_4$ source.

Diurnal analysis showed that the highest levels of $CH_4$ were seen in sector 130° – 170° (the direction of Seaton Meadows landfill site), with levels generally high throughout the day but highest in the early morning and in the late evening (during poor dispersion conditions).

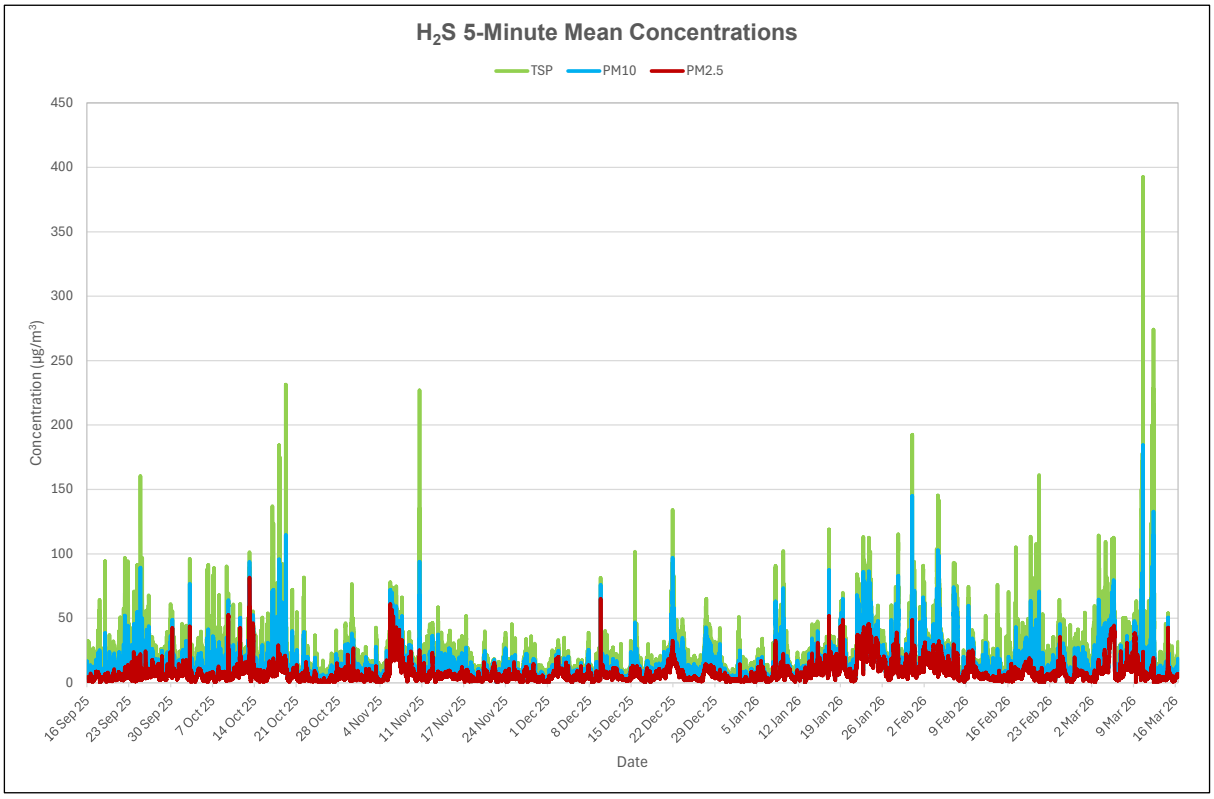
## 3.4 Particulate (TSP, $PM_{10}$ and $PM_{2.5}$)

Between 16 September 2025 and 16 March 2026 (182 days) airborne concentrations of TSP (Total Suspended Particulate matter less than 18 microns in diameter), $PM_{10}$ (particulate matter less than 10 microns in diameter) and $PM_{2.5}$ (particulate matter less than 2.5 microns in diameter) were measured at the MMF (at a height of 2m above ground) using a FIDAS 200 instrument. Details of the instrumentation and methodology are given in Appendix E.

Successful data collection of 5-minute data for TSP, $PM_{10}$ and $PM_{2.5}$ over the period was 99%.

A time series plot of 5-minute TSP, $PM_{10}$ and $PM_{2.5}$ concentrations for the monitoring location is shown in Figure 3.4.1. The average $PM_{10}$ and $PM_{2.5}$ concentrations during the monitoring period were 11.8 µg/m$^3$ and 6.9 µg/m$^3$ respectively. The highest concentrations of TSP and $PM_{10}$ were recorded on 10 March 2026 and the highest concentration of $PM_{2.5}$ was recorded on 13 October 2025.

**Figure 3.4.1: Particulate matter 5-minute average concentrations.**




### 3.4.1 Comparison with standards

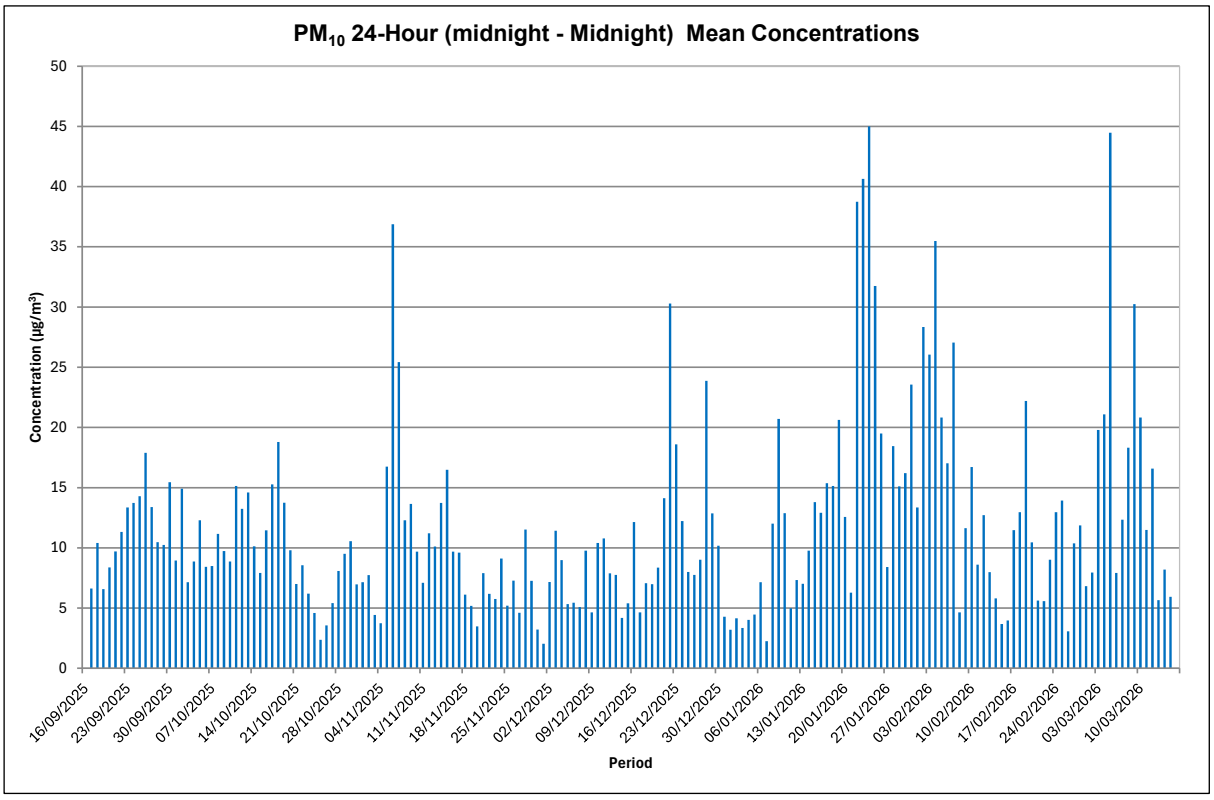
Comparison of $PM_{10}$ and $PM_{2.5}$ concentrations against relevant Air Quality Standards Regulations (AQSR) limit values and the UK Environment Act target for fine particulate matter is made in this chapter.

The AQSR has two limit values for $PM_{10}$, the first is to limit the annual mean concentration to 40 µg/m$^3$ and the second states that the 24-hour mean (midnight-midnight) must not exceed 50 µg/m$^3$ on more than 35 occasions during one year. The AQSR limit value for $PM_{2.5}$ is an annual mean concentration of 20 µg/m$^3$.

The mean $PM_{10}$ concentration over the monitoring period at the monitoring location was 11.8 µg/m$^3$. If the assumption is made that the conditions during the monitoring period were representative of a typical year, then the results would indicate that the AQSR annual mean would not be exceeded at the monitoring location.

Figure 3.4.2 shows that for $PM_{10}$, the 24-hour (midnight-midnight) average concentrations at the monitoring location never exceeded the 50 µg/m$^3$ limit value during the monitoring period, the maximum concentration being 45 µg/m$^3$. If the assumption is made that the conditions during the monitoring period were representative of a typical year, then over a year the AQSR 24-hour (midnight-midnight) mean concentration would not be exceeded at the monitoring site.

**Figure 3.4.2: $PM_{10}$ 24-hour (midnight-midnight) average concentrations.**




The mean $PM_{2.5}$ concentration over the monitoring period at the monitoring location was 6.9 µg/m$^3$. If the assumption is made that the conditions during the monitoring period were representative of a typical year, then the results would indicate that the AQSR annual mean limit value would not be exceeded at the monitoring location.

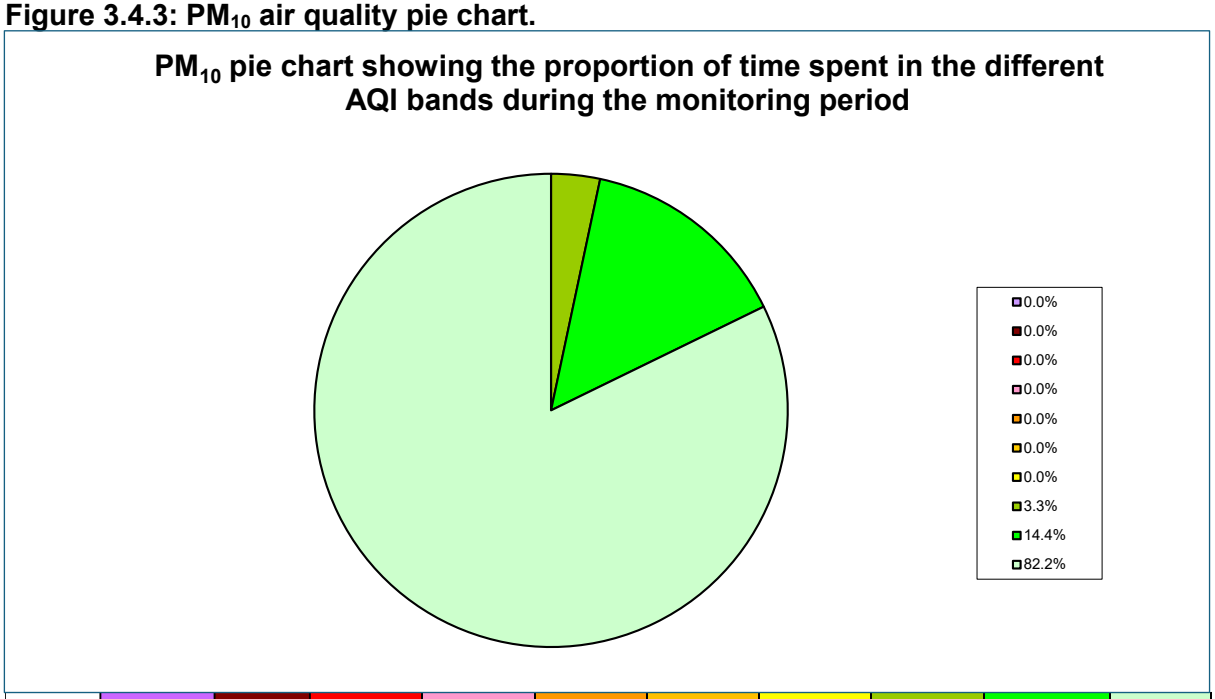
As a requirement of the Environment Act 2021, an environmental target has been set in England for the regulation of fine particulate matter (2023). An annual long-term target for $PM_{2.5}$ of 10 µg/m$^3$ to be met by 2040 at relevant monitoring stations. EIP23 sets out an interim target of 12 µg/m$^3$ to be met by January 2028 to ensure early action. EIP25 has now been published and has set a tougher interim target of 10 µg/m$^3$ to be met by 2030.

The mean $PM_{2.5}$ concentration over the monitoring period was 6.9 µg/m$^3$. If the assumption is made that the conditions during the monitoring period were representative of a typical year, then the results would indicate that levels of $PM_{2.5}$ at the monitoring location were likely to meet the interim and long-term $PM_{2.5}$ target values.

## 3.4.2 Comparison with the Air Quality Index

$PM_{10}$ and $PM_{2.5}$ are two of the five pollutants used to assess the overall air quality index. Figures 3.4.3 and 3.4.4 look retrospectively at the daily $PM_{10}$ and $PM_{2.5}$ concentrations at the monitoring location in relation to the Air Quality Index (AQI) banding.

**Figure 3.4.3: $PM_{10}$ air quality pie chart.**

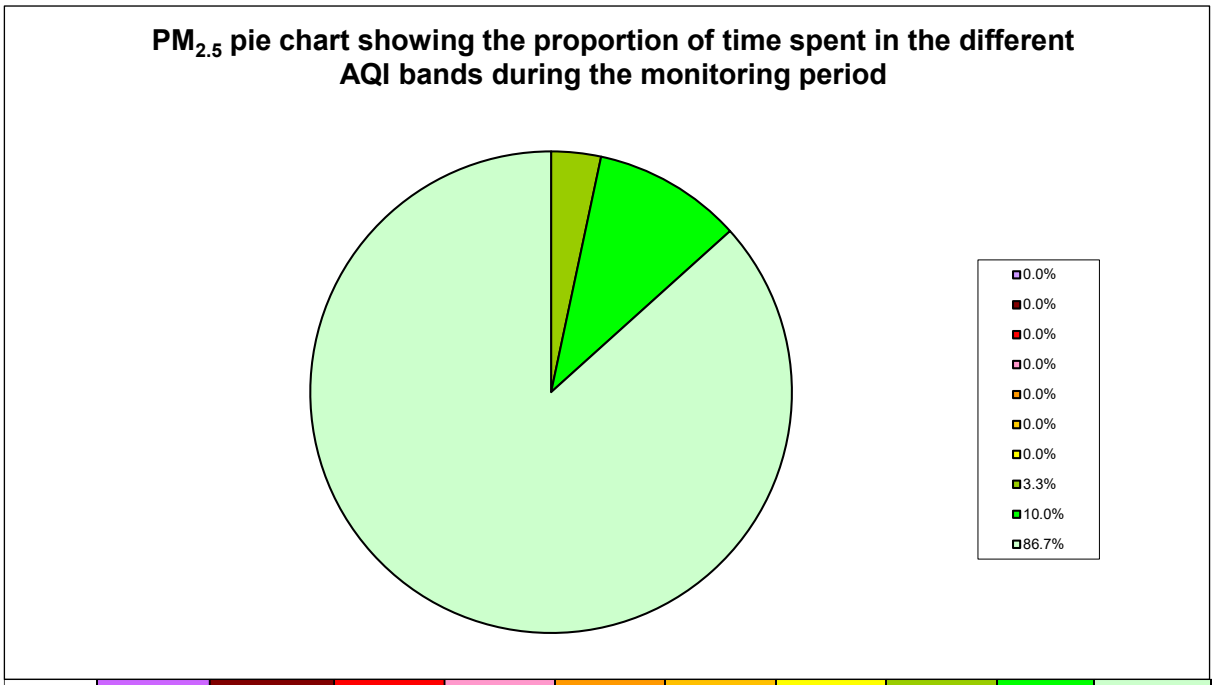



| Index | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 |
|---|---|---|---|---|---|---|---|---|---|---|
| Band | Very High | High | High | High | Moderate | Moderate | Moderate | Low | Low | Low |
| µg/m³ | 101+ | 92 - 100 | 84 - 91 | 76 - 83 | 67 - 75 | 59 - 66 | 51 - 58 | 34 - 50 | 17 - 33 | 0 - 16 |
| | **0.0%** | **0.0%** | **0.0%** | **0.0%** | **0.0%** | **0.0%** | **0.0%** | **3.3%** | **14.4%** | **82.2%** |

Figure 3.4.3 shows that the $PM_{10}$ 24-hour average concentrations at the monitoring site were all in the low banding of the AQI.

Figure 3.4.4 shows that the $PM_{2.5}$ 24-hour average concentrations at the monitoring site were all in the low banding of the AQI.

**Figure 3.4.4: $PM_{2.5}$ air quality pie chart.**




| Index | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 |
|---|---|---|---|---|---|---|---|---|---|---|
| Band | Very High | High | High | High | Moderate | Moderate | Moderate | Low | Low | Low |
| µg/m$^3$ | 71+ | 65 - 70 | 59 - 64 | 54 - 58 | 48 - 53 | 42 - 47 | 36 - 41 | 24 - 35 | 12 - 23 | 0 - 11 |
| | **0.0%** | **0.0%** | **0.0%** | **0.0%** | **0.0%** | **0.0%** | **0.0%** | **3.3%** | **10.0%** | **86.7%** |

## 3.4.3 Directional Analysis

A radial plot of mean TSP, $PM_{10}$ and $PM_{2.5}$ concentrations against wind direction at the MMF site is shown in Figure 3.4.5.

Figure 3.4.5 shows that the highest mean TSP, $PM_{10}$ and $PM_{2.5}$ concentrations were seen in the wind direction 110° with mean concentrations of 36 µg/m$^3$, 31 µg/m$^3$ and 19 µg/m$^3$ respectively.

**Figure 3.4.5: PM pollution rose (scale: 0 - 40 µg/m$^3$) (Google Maps, December 2025)**

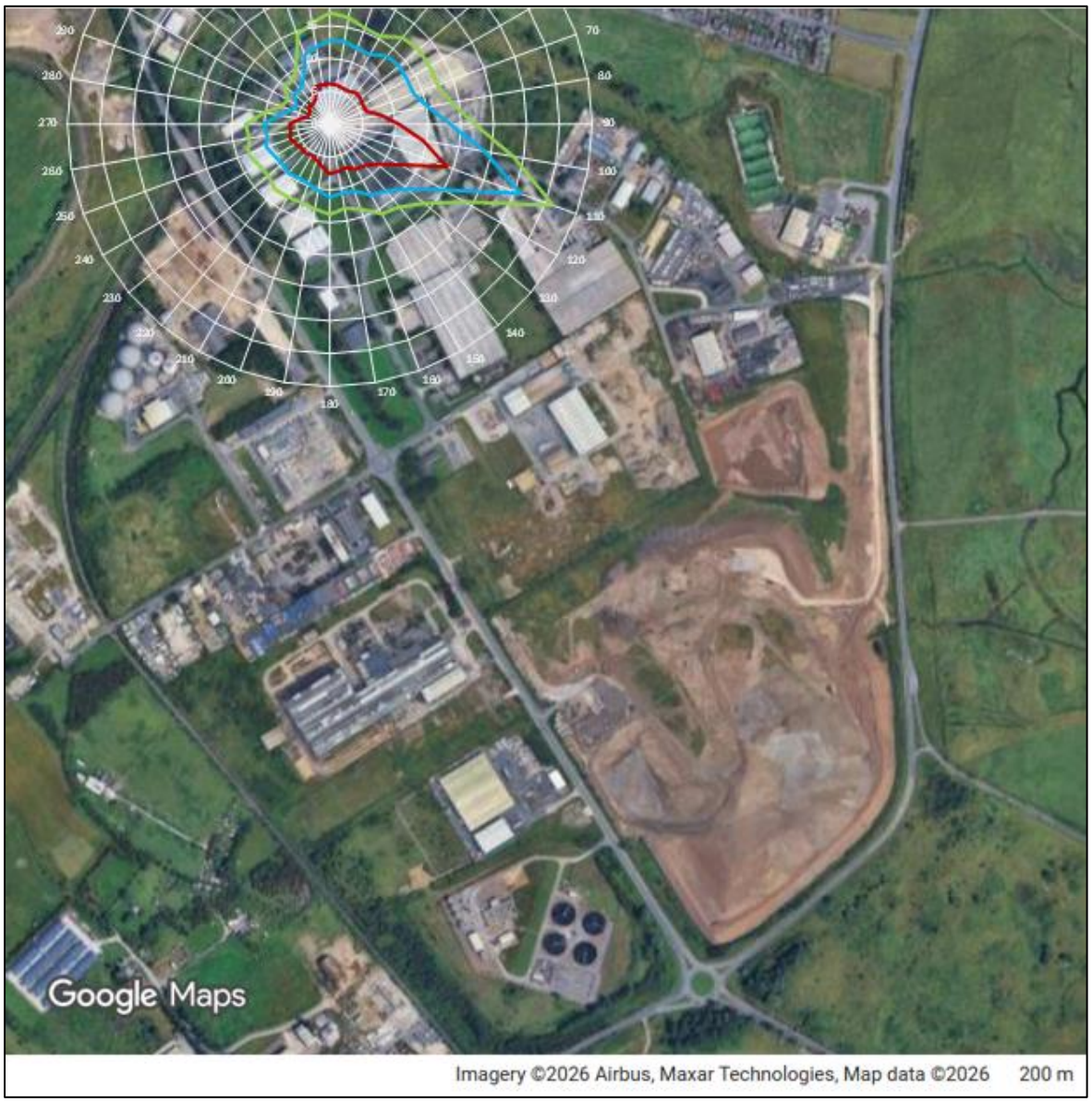
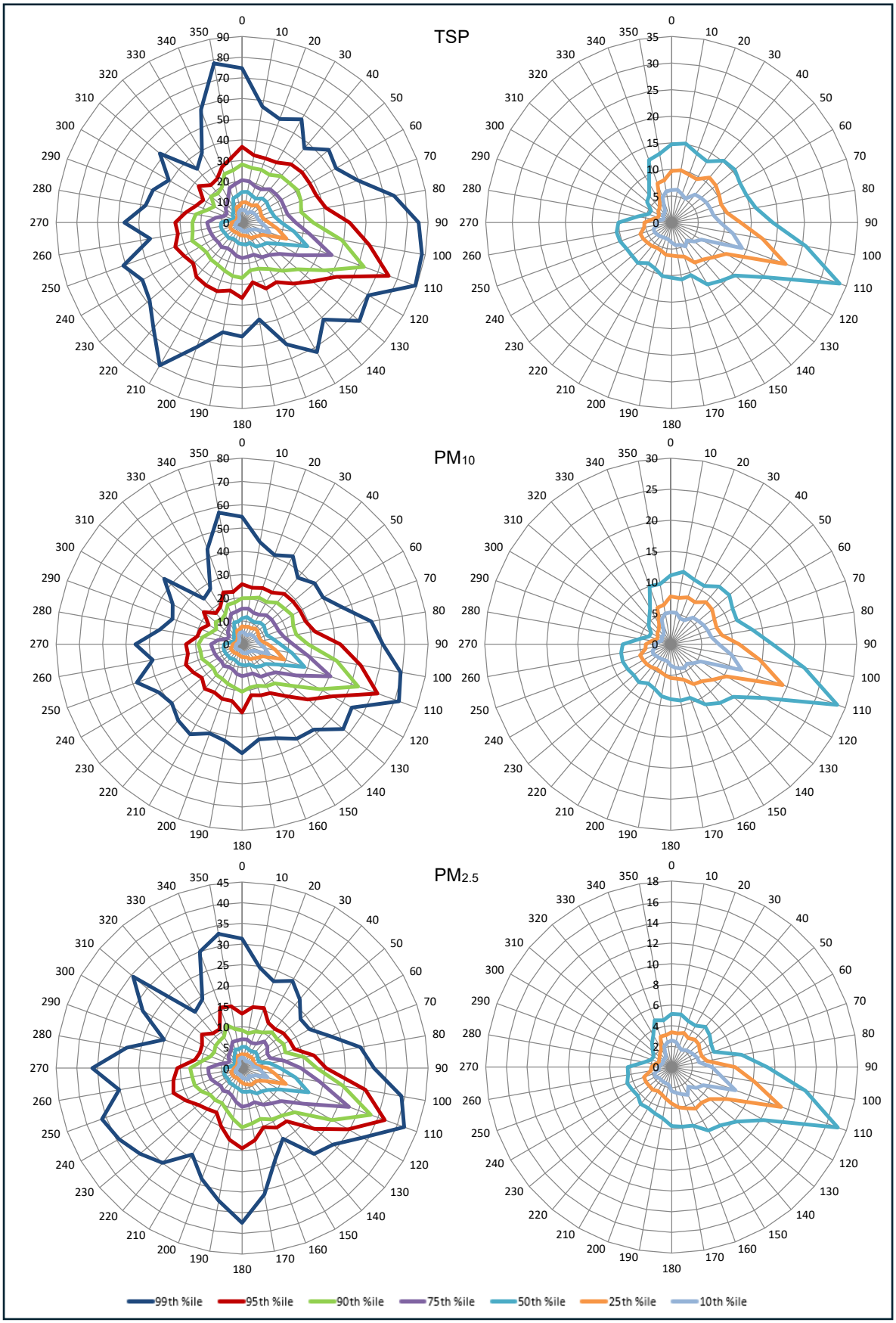



Figure 3.4.6 shows that the contribution from the source at 110º affects all the percentiles, which indicates that the source is relatively continuous and commonly affects particulate concentrations at the monitoring site.

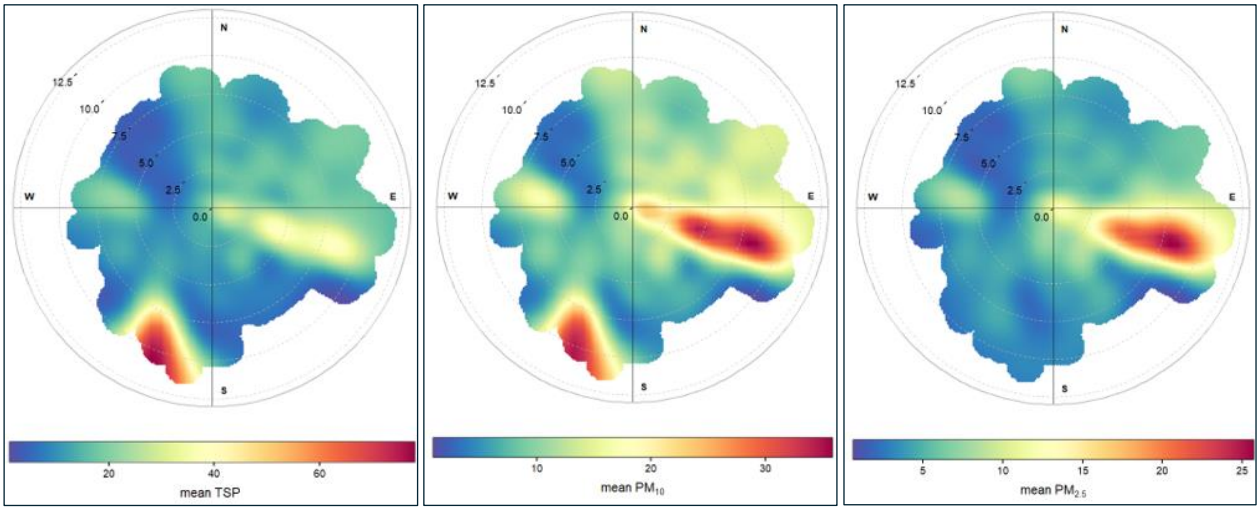
## Figure 3.4.6: PM percentile roses (µg/m³)



## 3.4.4 Wind Speed Analysis

A polar plot showing the average TSP, $PM_{10}$ and $PM_{2.5}$ concentrations for varying wind speeds and wind directions over the monitoring period is shown in Figure 3.4.7. Figure 3.4.7 shows that the highest concentrations of TSP and $PM_{10}$ were seen in the sector 185º - 215º at wind speeds greater than 7.5m/s. As this is not evident in the $PM_{2.5}$ plot it suggests that the source is fugitive emissions such as wind-blown dust and re-suspension. The highest concentrations of $PM_{2.5}$ and $PM_{10}$ are seen in the sector 95º - 115º at wind speeds between 3 - 11 m/s. As this is not as evident in the TSP plot it suggests that this could be the result of an elevated combustion source emission and/or regional emissions. The proximity of the monitoring site to the coast also suggests there will be a contribution from sea salt.

**Figure 3.4.7: TSP, $PM_{10}$ and $PM_{2.5}$ wind speed polar plots.**




## 3.4.5 Diurnal and Weekday Analysis

Consideration of the diurnal distribution of concentrations can provide further useful information about the sources contributing to the ambient levels in each sector. Pollutants generated from everyday traffic on the roads typically take the form of a double peak pattern, where the peaks correspond to the morning and afternoon/evening rush hours. Emissions from activities on an industrial site, meanwhile, are usually characterised by a single peak spanning the hours of the working day or operations on site.

Figure 3.4.8 shows the diurnal variation of mean TSP, $PM_{10}$ and $PM_{2.5}$ concentrations for different wind directions.

Figure 3.4.8 shows the highest levels of TSP, $PM_{10}$ and $PM_{2.5}$ are seen in the sector 70° – 140° during the day, but especially in the morning.

**Figure 3.4.8: TSP, $PM_{10}$ and $PM_{2.5}$ diurnal polar plots.**

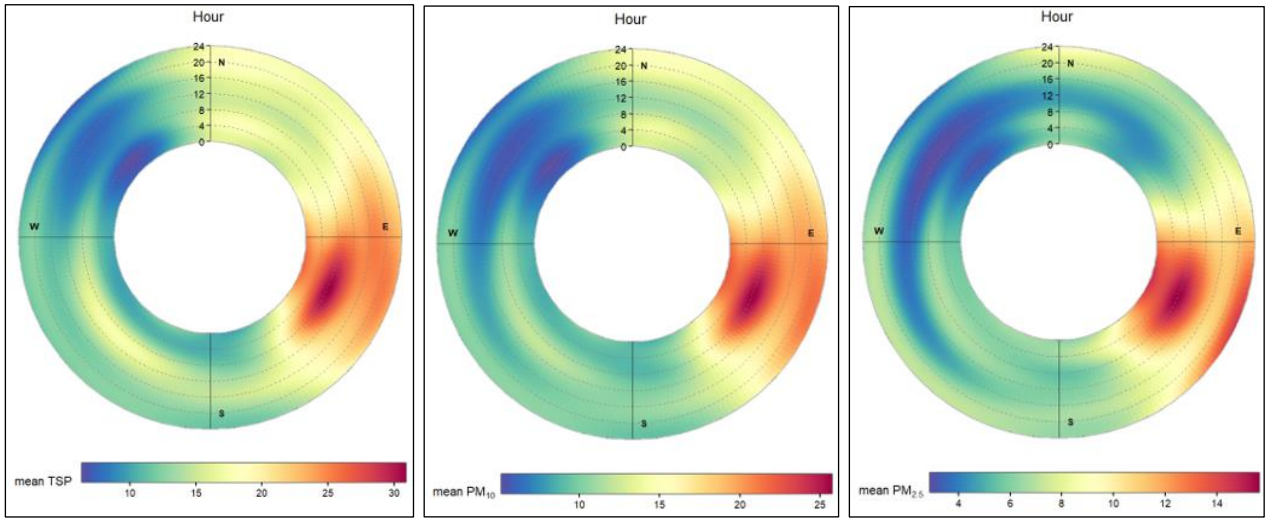



Figure 3.4.9 shows the mean levels of TSP, $PM_{10}$ and $PM_{2.5}$ at the monitoring location for each day of the week shown for each 45° sector.

**Figure 3.4.9: TSP, $PM_{10}$ and $PM_{2.5}$ Weekday plots.**

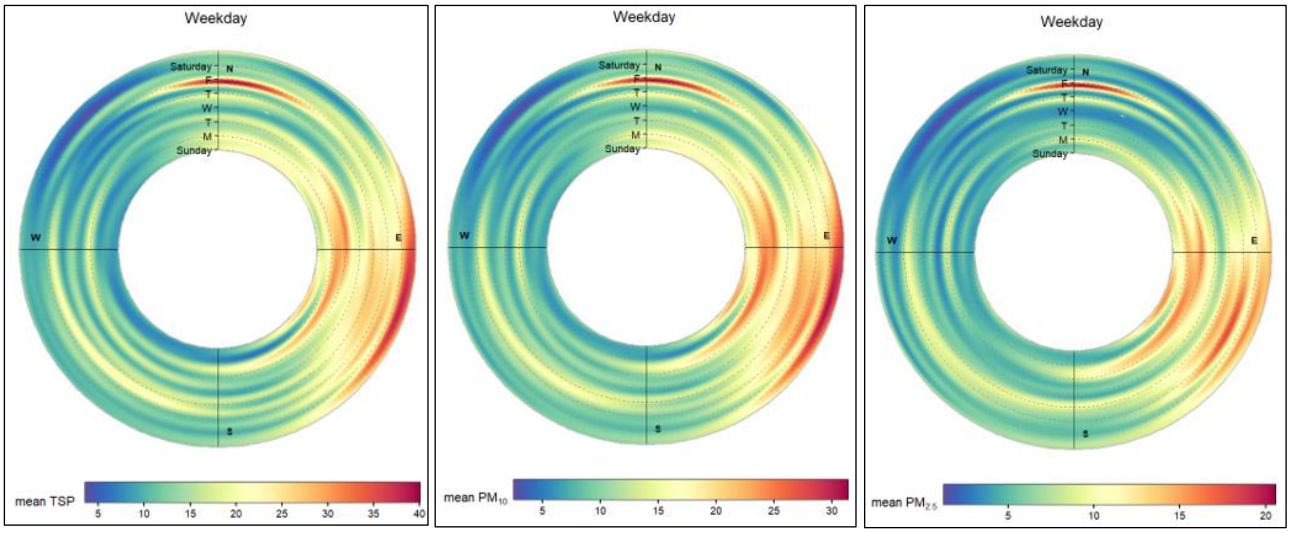



Figure 3.4.9 shows that the highest recorded concentrations of particulate matter (TSP, $PM_{10}$ and $PM_{2.5}$) were from seen in the east south easterly sectors, with levels generally slightly higher on Saturdays for TSP and $PM_{10}$.

## 3.4.6 Conclusions

Comparison of the $PM_{10}$ data with the AQSR limit value for the 24-hour (midnight-midnight) mean indicated that the standard would not be exceeded at the monitoring location.

The mean $PM_{10}$ concentration over the monitoring period at the monitoring location was 11.8 $\mu g/m^3$. If the assumption is made that the conditions during the monitoring period were

representative of a typical year, then the results would indicate that the AQSR limit value for the annual mean of 40 µg/m$^3$ would not be exceeded at the monitoring location.

The mean $PM_{2.5}$ concentration over the monitoring period was 6.9 µg/m$^3$. If the assumption is made that the conditions during the monitoring periods were representative of a typical year, then the results would indicate that the AQSR limit value for the annual mean of 20 µg/m$^3$ would not be exceeded at the monitoring location. Comparison of $PM_{2.5}$ concentrations with the annual UK Environment Act target and the EIP23 and EIP25 interim targets showed that these targets would not be exceeded at the monitoring location.

The $PM_{10}$ and $PM_{2.5}$ 24-hour concentrations were in the low banding of the air quality index at the monitoring location for the duration of the study.

Pollution rose analysis indicated that the highest mean TSP, $PM_{10}$ and $PM_{2.5}$ concentrations were seen in the wind direction 110° with mean concentrations of 36 µg/m$^3$, 31 µg/m$^3$ and 19 µg/m$^3$ respectively.

Percentile rose analysis suggested that the monitoring location was affected by a relatively continuous source of particulate from the wind direction 110°.

Wind speed analysis showed that the highest concentrations of TSP and $PM_{10}$ were seen in the sector 185º - 215º at wind speeds greater than 7.5m/s. As this is not evident in the $PM_{2.5}$ plot it suggests that the source is fugitive emissions such as wind-blown dust and re-suspension. The highest concentrations of $PM_{2.5}$ and $PM_{10}$ are seen in the sector 95º - 115º at wind speeds between 3 - 11 m/s. As this is not as evident in the TSP plot it suggests that this could be the result of an elevated combustion source emission and/or regional emissions. The proximity of the monitoring site to the coast also suggests there will be a contribution from sea salt.

Diurnal analysis showed that the highest levels of TSP, $PM_{10}$ and $PM_{2.5}$ are seen in the sector 70° – 140° during the day, but especially in the morning.

Weekday analysis showed that the highest recorded concentrations of particulate matter (TSP, $PM_{10}$ and $PM_{2.5}$) were from seen in the east south easterly sectors, with levels generally slightly higher on Saturdays for TSP and $PM_{10}$.

# 4 Conclusion

The average methane concentration over the monitoring period was 1.51 mg/m$^3$, which is slightly above the northern hemisphere background concentration[2] of ~1.31 mg/m$^3$.

In the absence of an Air Quality Standards Regulations (AQSR) limit value, the hydrogen sulphide ($H_2S$) data was compared with the World Health Organisation (WHO) guidelines for both human health and odour annoyance (Table 4.1).

**Table 4.1 Impact summary of $H_2S$ compliance with the WHO guidelines for Europe 2000.**

| Pollutant | Averaging Time | Guidance Limit | Percentage of Time Exceeding the Guidance Limit |
|---|---|---|---|
| **$H_2S$** | 24-hr (midnight-midnight) | 150 µg/m$^3$ | 0 |
| | 30-min | 7 µg/m$^3$ | 0.4 |

Comparing the collected data with the World Health Organisation (WHO) guidelines showed that $H_2S$ was within health limits, with a maximum 24-hour average $H_2S$ concentration of 3.4 µg/m$^3$ over the monitoring period. Comparison of the $H_2S$ data with the WHO guideline for odour annoyance of 7 µg/m$^3$ (as 30-minute average concentrations) indicated that the air quality at the monitoring site exceeded this guideline for 0.4% of the monitoring period.

Tables 4.2 and 4.3 summarise the extent of likely compliance/exceedance for AQS objectives, AQSR limit values, and the environmental target and interim targets for $PM_{2.5}$ at the monitoring site.

**Table 4.2 Impact summary for short-term air quality objectives.**

| Pollutant | Averaging Time | AQS | AQSR | Standard (µg/m$^3$) | Maximum Concentration (µg/m$^3$) | Permitted Exceedance (A) | Measured Exceedance | Extrapolated Exceedance* (B) | Projected Compliance Ratio (B/A) |
|---|---|---|---|---|---|---|---|---|---|
| **$PM_{10}$** | 24-hr (midnight-midnight) | 2000 | 2010 | 50 | 45 | 35/year | 0 | 0 | 0.0 |

**Table 4.3 Impact summary for long-term air quality objectives.**

| Pollutant | Averaging Time | AQSR | UK Environment Act* | EIP23** | EIP25*** | Standard (A) (µg/m$^3$) | Measurement (B) (µg/m$^3$) | Projected Compliance Ratio (B/A) |
|---|---|---|---|---|---|---|---|---|
| **$PM_{10}$** | Year | 2010 | - | - | - | 40 | 11.8 | 0.30 |
| **$PM_{2.5}$** | Year | 2010 | - | - | - | 20 | 6.9 | 0.35 |
| **$PM_{2.5}$** | Year | - | 2023 | - | 2025 | 10 | 6.9 | 0.69 |
| **$PM_{2.5}$** | Year | - | - | 2023 | - | 12 | 6.9 | 0.58 |

***** Environmental Targets (Fine Particulate Matter) (England) Regulations 2023, as required by UK Environment Act 2021. To be met by 2040.**

****** Environmental Improvement Plan 2023. To be met by 2028.**

******* Environmental Improvement Plan 2025. To be met by 2030.**

Comparing the collected data with the AQS objectives and the AQSR limit values showed that the monitoring location was subject to concentrations of $PM_{10}$ and $PM_{2.5}$ that were likely to meet their respective standards.

Comparison of $PM_{2.5}$ concentrations with the annual UK Environment Act target and the EIP23 and EIP25 interim targets showed that these targets would not be exceeded at the monitoring location.

It is worth noting that the assumption has been made that the conditions during the monitoring period were representative of a typical year. These calculations do not consider changes in weather conditions or changes to local sources that might occur outside of the monitoring period.

Analysis of the meteorological data collected at the MMF showed the dominant wind direction was from between 190° – 240°, with wind coming from this sector for 42% of the time.

Comparison against the Air Quality Index (AQI) banding showed that $PM_{10}$ and $PM_{2.5}$ concentrations were all in the low AQI banding for the duration of the monitoring period.

Directional analysis indicated that the highest average $H_2S$ and $CH_4$ concentrations were measured from the direction of Seaton Meadows landfill site. There were also higher levels of $H_2S$ in the direction of Biopower Ltd.

Percentile rose analysis showed there were relatively continuous sources of $H_2S$ and $CH_4$ in the direction of Seaton Meadows landfill site and additionally in the case of $H_2S$ in the direction of Biopower Ltd.

Diurnal analysis showed that the highest levels of $H_2S$ and $CH_4$ were seen in direction of Seaton Meadows landfill site, with levels generally highest in the early morning and late evening, which suggests that fugitive emissions have been trapped close to the ground during poor dispersion conditions. In the direction of Biopower Ltd the $H_2S$ levels were higher during the morning.

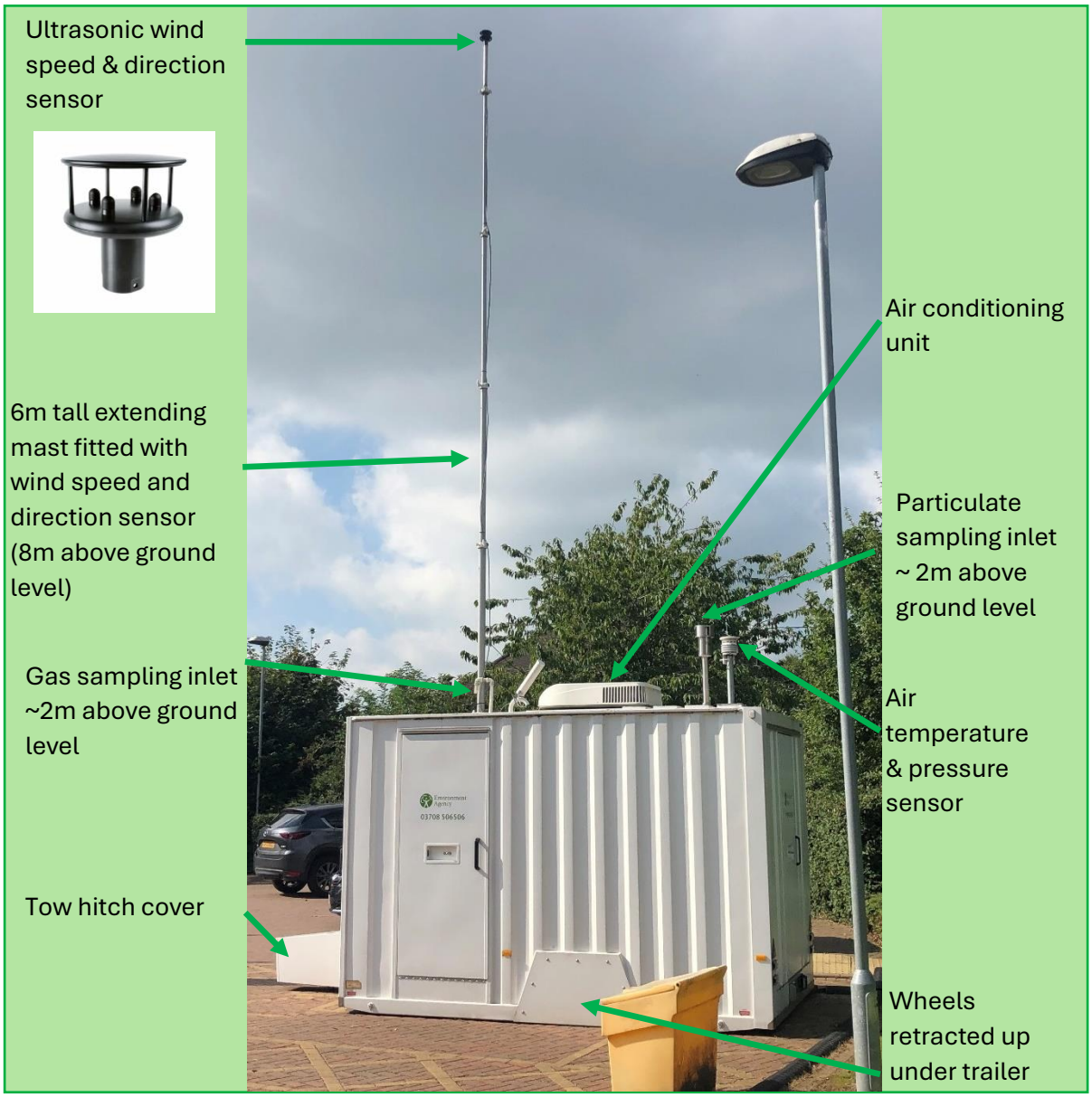
# 5 References

1. Department for Business, Energy and Industrial Strategy. 2021. *Long-Term Atmospheric Measurement and Interpretation of Radiatively Active Trace Gases, Annual Report (Oct 2020 – Sept 2021)*. Retrieved from Long-Term Atmospheric Measurement and Interpretation of Radiatively Active Trace Gases: annual report 2021 (publishing.service.gov.uk) [Accessed 11 December 2023]
2. World Health Organisation (2000), *WHO Air Quality Guidelines for Europe*
3. Department of the Environment (April 2023), The Air Quality Strategy: framework for local authority delivery, (HMSO).
4. The Air Quality Standards Regulations 2010, The Air Quality Standards Regulations 2010
5. Environmental Improvement Plan 2023 for England, Defra 2023, Environmental Improvement Plan
6. Environmental Improvement Plan 2025 for England, Defra 2025, Environmental Improvement Plan (EIP) 2025 - GOV.UK
7. *The Environmental Targets (Fine Particulate Matter) (England) Regulations 2023 The Environmental Targets (Fine Particulate Matter) (England) Regulations 2023*
8. European Commission, Directive 2008/50/EC on ambient air quality and cleaner air for Europe.
9. *Local Air Quality Management Technical Guidance (TG 22), Defra, May 2025*
10. Carslaw, D. C., and K. Ropkins. 2012. “openair — An R package for air quality data analysis.” *Environmental Modelling and Software* 27–28 (0): 5261.
11. Google Maps 2026, Hartlepool, 1:12,500. Available from: Google Maps, [Accessed 25/3/26]

# Appendix A Mobile Monitoring Facility

National Monitoring Services carries out ambient air monitoring on behalf of Environment Agency operational areas using Mobile Monitoring Facilities (MMFs). These facilities allow the Agency to carry out flexible, short-term studies examining the potential impact of Industrial sites regulated by the Environment Agency on local communities. The facilities contain analysers designed to sample the atmosphere for a selection of pollutants commonly associated with industrial emissions. The equipment is contained within a trailer that can conveniently be towed. This allows it to be strategically sited at temporary locations with the intention of quantifying pollution loadings and determining sources. Air is sampled at a height of 2m, slightly above adult head hight and in a location away from the ground, where it is unlikely to be damaged. Figure A1 shows the typical configuration of the MMF's exterior.

**Figure A1: Annotated diagram of MMF exterior**



The pollutants being measured during this study were:

- particles (Total Suspended Particulate (TSP), $PM_{10}$ & $PM_{2.5}$)
- hydrogen sulphide ($H_2S$)
- methane ($CH_4$)

In addition to analysers measuring the concentration of pollutants in the air the facility contains equipment that can measure meteorological conditions. This provides the opportunity to consider measured pollutant levels relative to the prevailing meteorological situation. This can supply important information allowing a more detailed understanding of the pollutants' dispersion in the atmosphere and consequently a more accurate assessment of their origins.

The meteorological parameters being measured are:

- wind direction
- wind speed
- temperature
- pressure

Wind direction and wind speed measurements are taken at an elevation of 8m above the ground (6m mast on top of 2m MMF). The data is recorded as 5-minute averages. Temperature and pressure are measured by the particulate monitor at an elevation of 2m above the ground. The data is recorded as 5-minute averages.

Wind direction is an important consideration as it provides direct information about the orientation of any source relative to the monitoring site. In general, the measured wind direction is considered a reasonable indication of where a pollutant's trajectory has come from locally. However, it is sometimes possible for wind direction to vary along a plume's trajectory so that the wind direction will not simply "point" to the source. Wind speed and temperature both have a strong influence on the amount of mixing within the atmosphere, having profound effects on the vertical distribution of pollutants through the atmospheric boundary layer.

# Appendix B Quality Assurance and Quality Control

Quality assurance covers practices that are undertaken prior to data collection in order to ensure that the sampling arrangements and analysers are capable of providing reliable measurements. Quality Control covers practices applied after data collection in order to ensure that the measurements obtained are repeatable and traceable.
To ensure that data from the MMF and standalone cabinets are representative of pollutant concentrations and meet appropriate standards of quality, a number of QA and QC procedures are routinely implemented in the monitoring facility's execution.

| | | |
|---|---|---|
| Uncertainty | - | The final data set will be subject to uncertainties that are generated during the monitoring process. However, the QAQC measures help to keep these uncertainties to a minimum. For uncertainty budgets please refer to the pollutant appendices. |

**Quality assurance included:**

| | | |
|---|---|---|
| Training | - | All personnel involved with the running of the facility have received training in the execution of the tasks they are expected to undertake. |
| Analyser selection | - | Careful consideration has been given to the choice of analysers, ensuring that they can demonstrate their levels of accuracy and precision. Also, that they can be relied on to be robust and flexible enough to present the data in a suitable format. |
| Trailer Location | - | Attention is given to how representative the location of the facility is when compared against the objectives of the study. |

**Quality control included:**

| | | |
|---|---|---|
| Routine calibration | - | Calibrations are performed at suitable intervals, using traceable gas standards and any adjustments made to the analysers documented. Regular checks using traceable gas standards are also performed in between routine calibrations. |
| Routine maintenance | - | Undertaking and documenting a range of checks on operational equipment derived from best established practice and manufacturer recommendation. |
| Instrument history | - | All invasive work carried out on analysers is documented and recorded. |
| Data review | - | All data is checked to ensure correct scaling, rejecting negative or out-of-range readings, questioning rapid excursions, generally considering the integrity of recorded levels. The data is checked frequently so that measurements affected by instrument fault are recognised quickly. |
| Data comparison | - | Comparing the collected data sets with data sets from other monitoring studies that are carried out in close enough proximity to be relevant. Consideration of the relationship between different pollutants i.e. some pollutant levels will be expected to rise and fall together. |
| Data rectification | - | The adjustment of data to minimise the effects of analyser drift identified through regular checks on the instruments using traceable gas standards. |

# Appendix C Hydrogen Sulphide ($H_2S$)

Hydrogen sulphide ($H_2S$) is a colourless, toxic and flammable gas, with a characteristic odour of 'rotten eggs'.

**Sources**

Hydrogen sulphide is produced naturally in the environment by emissions from volcanoes and geothermal activity, microbial decomposition of organic material in the absence of oxygen (anaerobic digestion) in swamps and saltmarshes and is an important participant in the natural sulphur cycle. Natural sources account for 90% of the global $H_2S$ emissions, whilst the other 10% is emitted from anthropogenic sources such as oil refineries, coke ovens, tanneries, paper mills (using the Kraft process (sulphate process)), wastewater treatment plants, viscose rayon textile production, landfills and farm manure storage facilities, to name but a few.

**Human Health and Standards**

'Although it is unlikely that the general population will be exposed to a level of $H_2S$ high enough to cause adverse health effects' [(1)], levels around some industrial sources can cause a nuisance due to the unpleasant odour associated with the hydrogen sulphide. The odour threshold (point above which an odour can be perceived by 50% of a human panel) for $H_2S$ is between 0.2 – 2ug/$m^3$ depending on the purity. However, at these levels the human nose can only detect that an odour is present, the characteristic 'rotten egg' odour is not perceptible until 3-4 times this threshold level.

The World Health Organisation (WHO) has set two guidelines for $H_2S$, a health standard and an odour threshold above which substantial complaints with regard to odour nuisance should be expected.

Health guideline: 150ug/$m^3$ as a 24-hour average

Odour guideline: 7µg/$m^3$ as a 30-minute average

The health guideline is based on the lowest level of $H_2S$ to cause an adverse effect, which is 15mg/$m^3$ (15,000µg/$m^3$), where it has been shown to cause eye irritation. A high protection (safety) factor of 100 is then applied and the guideline of 0.15mg/$m^3$ (150µg/$m^3$) over a 24-hour averaging time is the result.

The high protection factor applied to create the guideline for health is a result of the marked toxicity of $H_2S$ with increasing concentration above the first observable adverse effect.

**$H_2S$ analyser**

The analyser used to measure hydrogen sulphide is an API T101 analyser. Gas entering the analyser first passes through a selective scrubber to remove sulphur dioxide, then enters a catalytic converter, where hydrogen sulphide is oxidised to form sulphur dioxide. This secondary gas stream of sulphur dioxide is then sampled and analysed.

The operation of the sulphur dioxide analysers is based on the measurement of fluorescence from $SO_2$ due to absorption of UV energy. An ultraviolet (UV) lamp emits radiation that passes through a filter admitting only light with a wavelength of 214nm. This radiation excites $SO_2$ molecules in the sampling air. These excited $SO_2$ molecules quickly return to their ground

state by emitting a photon at a longer wavelength (330nm) and this fluorescence can then be measured by a PMT with a secondary UV filter. The equations describing the reactions are:

$$\textbf{Irradiation} \quad SO_2 + h\nu_{214nm} \longrightarrow SO_2^*$$

$$\textbf{Fluorescence} \quad SO_2^* \longrightarrow SO_2 + h\nu_{330nm}$$

The UV light at any point in the system is given by:

$$I_a = I_o[1 - \exp(-ax(SO_2))]$$

where $I_o$ is the UV light intensity, **a** the absorption coefficient of $SO_2$, **x** the path length, and ($SO_2$) the concentration of $SO_2$. When the $SO_2$ concentration is relatively low and the path length of excited light short, the fluorescence radiation impinging upon the PMT can be considered directly proportional to the concentration of $SO_2$. The PMT transfers the light energy into an electrical signal, which is directly proportional to the light energy in the sample stream being analysed.

An UV detector measures the UV light. Software calculates the ratio of the PMT output and the UV detector in order to compensate for variations in the UV light energy.

As the T101 has not been formally certified, the sources of likely uncertainty in the adjusted data were derived from the factory specification and known uncertainties relating to the T100 Sulphur Dioxide ($SO_2$) instrument, which has been formally certified and with which the T101 shares significant componentry and principles of operation. These are defined under standard EN14212.

There are some aspects of uncertainty that cannot be derived from the certification. These are associated with calibration gas traceability and degradation of the thermal oxidiser. For the uncertainty budget, gas traceability was taken from manufacturer certification. A converter efficiency of 90% has been assumed, although we would expect for efficiency to be higher than this in most cases.

The reported uncertainty is based on a standard uncertainty multiplied by a coverage factor (k = 2), providing a level of confidence of approximately 95%. The reported uncertainty covers the data collected from 1 January 2025.

Data for the uncertainty analysis was taken from the specifications reported by both the instrument and calibration gas manufacturer's and from the TUV and MCERTS product conformity certificates.

| **Assessment of compliance for $H_2S/SO_2$ UV Fluorescent analyser** | | |
|---|---|---|
| Teledyne API T101 | | 1 hour limit value 132ppb |
| Measurement performance related to laboratory and field conditions | | |
| **Performance Characteristic** | **Value** | **Square of Standard Uncertainty** |
| Repeatability at zero | 0.5ppb | 0.0222ppb |
| Lack of fit | 0.2% | 0.0232ppb |
| Sample gas pressure | 0.06ppb/kPa | 2.5613ppb |
| Sample gas temperature | 0.013ppb/K | 0.0105ppb |
| Surrounding temperature | 0.03ppb/K | 0.0559ppb |
| Electrical voltage | 0.02ppb/V | 0.0467ppb |
| Water interference | -1.5ppb | 1.4668ppb |
| Other interference | 7.6ppb | 12.6928ppb |
| Averaging effect | 1.1% | 0.7028ppb |
| Reproducibility under field conditions | 4.8% | 40.1449ppb |
| zero drift | 1.35ppb | 0.6075ppb |
| span drift | 1.56% | 1.4134ppb |
| Converter efficiency (in the field) | 90% | 174.2ppb |
| Uncertainty of gas (used in the field) | 5% | 10.89ppb |
| Combined standard uncertainty (Uc) | | 15.6ppb |
| **Total expanded uncertainty for $H_2S$ 95% confidence)** | | **23.7%** |

## References

1. 'Hydrogen Sulphide: General Information', Public Health England, Toxicology Department, CRCE, PHE 2009 (version 1)
2. World Health Organisation (2000), *WHO Air Quality Guidelines for Europe*
3. 'Model T101 UV Fluorescence $H_2S$ Analyser', User Manual, Teledyne Advanced Pollution Instrumentation, August 2016
4. Sira Certification Service. December 2020. Certificate No: Sira MC050067/08
5. TÜV Rheinland Energy GmbH. March 2023. Certificate No: 0000038501_03

# Appendix D Methane ($CH_4$)

Methane, commonly known as marsh gas, is a colourless, odourless gas with a melting point of -184°C and boiling point -164°C. Its main environmental impact is from its relatively high potential for global warming. It affects the radiation balance of the Earth by absorbing infrared radiation and converting it to heat, therefore increased methane concentrations lead to increased surface temperatures.

**Sources**

Methane is produced by anaerobic bacterial fermentation processes in water that contains substantial organic matter, such as swamps, marshes, rice fields and lakes. This microbial degradation of organic matter may be written:

$$CO_2 + 4H_2 \rightarrow CH_4 + 2H_2O$$

Methane is also produced by enteric fermentation in mammals and other species. The major emitting sources in 2020 were from agriculture (48%), the waste sector (31%), and the UK energy sector (11%) [(2)].

The Northern Hemisphere background concentration is currently around 1.96 ppm (1.31 $mg/m^3$) [(3)]. There has been a small increase in methane background concentrations over the last 30 years, this is mainly due to an increase in the emissions from primary sources. However, the reduction in environmental levels of the hydroxide radical [OH] brought about by the increased levels of carbon monoxide (CO) also plays a part.

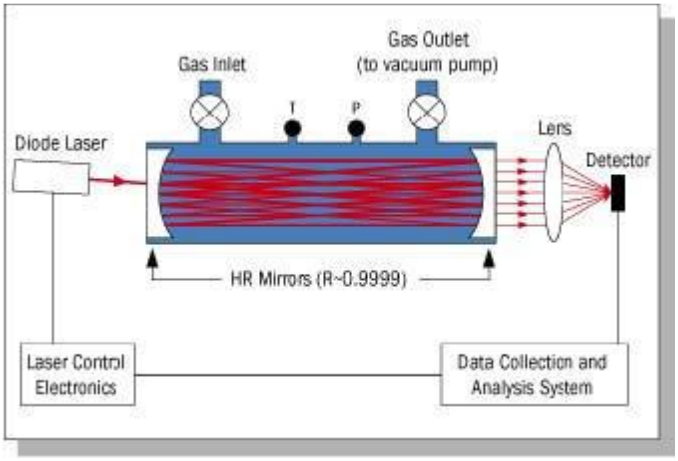
**$CH_4$ Analysers**

The analyser used for the study was a Los Gatos $CH_4$ analyser, which uses Off Axis Integrated Cavity Output Spectroscopy (OA-ICOS).

'Until recently, high-sensitivity trace-gas measurements have been possible only by using expensive lasers (e.g., lead-salt or quantum-cascade) or broadband lamps that operate in the mid-infrared region where absorption features are strong. Los Gatos Research's advances in cavity-enhanced absorption-spectroscopy techniques provide dramatic increases in the optical path length and as a result, enable ultrasensitive trace-gas measurements using robust, reliable, room-temperature diode lasers that operate in the near infrared.

Off-Axis ICOS utilizes a high-finesse optical cavity as an absorption cell as shown in Figure 8. Unlike conventional multi-pass arrangements, which are typically limited to path lengths less than two-hundred meters, an Off-Axis ICOS absorption cell effectively traps the laser photon so that, on average, they make thousands of passes before leaving the cell. As a result, the effective optical path length may be several thousands of meters using high-reflectivity mirrors and thus the measured absorption of light after it passes through the optical cavity is significantly enhanced. For example, for a cell composed of two 99.99% reflectivity mirrors spaced by 25 cm, the effective optical path length is 2500 meters.

***Figure 1: Schematic diagram of an Off-Axis ICOS Instrument***




Because the path length depends only on optical losses in the cavity and not on a unique beam trajectory (like conventional multipass cells or cavity-ring-down systems), the optical alignment is very robust allowing for reliable operation in the field. The effective optical path length is determined routinely by simply switching the laser off and measuring the necessary time for light to leave the cavity (typically tens of microseconds).

As with conventional tunable-laser absorption-spectroscopy methods, the wavelength of the laser is turned over a selected absorption feature of the target species. The measured absorption spectra is recorded and combined with measured gas temperature and pressure in the cell, effective path length, and known line strength, used to determine a quantitative measurement of mixing ratio directly and without external calibration.'

As the Los Gatos $CH_4$ analyser has not been formally certified, the sources of likely uncertainty in the adjusted data were derived from the factory specification and calibration gas traceability.

The reported uncertainty is based on a standard uncertainty multiplied by a coverage factor (k = 2), providing a level of confidence of approximately 95%. The reported uncertainty covers the data collected from 1 January 2025.

| Performance Characteristic | Uncertainty |
|---|---|
| Total uncertainty without calibration | 1% |
| Uncertainty of gas | 5.0% |
| Total expanded uncertainty (95% confidence) | 12.0 % |

**References**

1. ABB. 2014. Ultra-Portable Greenhouse Gas Analyzer User Manual.
2. Department for Business, Energy & Industrial Strategy. 2024. United Kingdom methane memorandum. [online] Available from: United Kingdom methane memorandum - GOV.UK (www.gov.uk) [Accessed 23 September 2024].
3. Department for Business, Energy and Industrial Strategy. 2021. *Long-Term Atmospheric Measurement and Interpretation of Radiatively Active Trace Gases, Annual Report (Oct 2020 – Sept 2021)*. Retrieved from Long-Term Atmospheric Measurement and Interpretation of Radiatively Active Trace Gases: annual report 2021 (publishing.service.gov.uk) [Accessed 11 December 2023]

# Appendix E Particulate Matter (TSP, $PM_{10}$, $PM_{2.5}$)

Airborne particulate matter can be found in a wide range of particle sizes (nm-µm) and chemical constituents. $PM_{10}$ and $PM_{2.5}$ levels have been reported in this study. $PM_{10}$ is defined as particulate matter with an aerodynamic diameter less than 10µm. $PM_{2.5}$ is defined as particulate matter with an aerodynamic diameter less than 2.5 µm. The description of $PM_{10}$ and $PM_{2.5}$ is restricted to its physical characteristic and no particular chemical composition is implied. The size is of importance because it is this that determines where in the human respiratory tract a particle deposits when inhaled. Most concern is given to particles small enough to penetrate into the lungs reaching the alveoli where the delicate tissues involved in the exchange of oxygen and carbon dioxide are to be found. When inhaled almost all particles larger than 7µm are deposited in the nose and throat, and only 20-30% of particles between 1 and 7µm are deposited in the alveoli. However, up to 60% of particles below 0.1µm are deposited in the alveoli. The size of the particles also determines how long they spend in the atmosphere with smaller particles remaining in suspension for longer and can be transported over long distances. The measurement of $PM_{10}$ and $PM_{2.5}$ relies on the use of a size-selective instrument, which collects small particles preferentially.

**Sources**
There are a number of important natural sources of particulate in the air with forest fires and volcanic eruptions being two sources which, can cause extreme pollution episodes and can be very adverse to human health. Sea spray and the erosion of soil and rocks by wind are important sources in many localities. There are also many biological sources with considerable numbers of pollen grains, fungal spores and their fragments contributing to the total loading of airborne particles. Man-made airborne particles result mainly from combustion processes, from the working of soil and rock, from industrial processes and from the attrition of road surfaces by motor vehicles.

The major PM components are sulphate, nitrates, ammonia, sodium chloride, carbon, mineral dust and water. Particles can be classified as being either primary or secondary: the former are released directly into the air, while the latter are formed in the atmosphere by the chemical reaction of gases, first combining to form less volatile compounds which in turn condense into particles. Primary particles have an immediate effect on the particulate loading in the vicinity of the source. The main sources of primary $PM_{10}$ and $PM_{2.5}$ in the UK in 2022 were :

- Domestic combustion; has once more become a major source of airborne particles, accounting for 15% and 29% of primary $PM_{10}$ and $PM_{2.5}$ emissions. Most emissions from this source come from household burning wood stoves and open fires with coal contributing 12% of $PM_{2.5}$ emissions.
- Road transport; nationally, road transport contributed around 16% and 18% of primary $PM_{10}$ and $PM_{2.5}$ emissions, with reductions due to a decrease in exhaust emissions thanks to stricter standards but this has been partially offset by an increase in traffic and non-exhaust emissions (brake, tyre and road wear) since 1996.
- Industrial combustion and processes; nationally, it is estimated that these processes accounted for around 48% of primary $PM_{10}$ emissions and 21% of primary $PM_{2.5}$ emissions. Emissions from this source have decreased in the long term but have remained fairly stable in recent years.

Secondary particles are less easy to ascribe to their original sources. They comprise mainly ammonium sulphate and nitrate, originating from the oxidation of gaseous sulphur and nitrogen oxides to acids, which are then neutralised by atmospheric ammonia, derived from

agricultural sources. The chemical processes involved in the formation of these secondary particles are relatively slow (in the order of days) and their persistence in the atmosphere is similarly prolonged. Thus, while road traffic may be the main source of the original oxides of nitrogen, and coal and oil burning the main sources of sulphur oxides, the secondary particles are distributed more evenly throughout the air with less difference between urban and rural areas. They may also drift for considerable distances. This can result in the transport of pollution across national boundaries.

**Particulate Analyser**
The analyser used to measure PM concentration is a Palas Fidas 200 optical measuring system. It provides measurements of TSP, $PM_{10}$, $PM_4$, $PM_{2.5}$ and $PM_1$ in real time and stores them as 15-minute averages.

The Fidas measures PM using an optical light scattering technique and uses an algorithm to calculate concentrations based upon the number and size distribution of particles.

The Fidas has a flow volume of 0.3 $m^3$/h (flow rate of 4.8 l/m). The inlet is fitted with a Sigma-2 (TSP) sampling head which allows the full range of particle sizes to reach the Intelligent Aerosol Drying System (IADS). The IADS conditions the sampled air, which helps prevent possible measurement inaccuracies due to condensation during periods of high ambient air humidity.

Once the sample has been conditioned the particle size is determined using the Lorenz-Mie scattered light analysis of single particles by an optical aerosol spectrometer. The spectrometer measures the scattered light impulse generated by each particle as it is illuminated by a white LED light at an angle of 90°. The number of scattered light impulses allows the determination of the particle number and the height of the impulse is related to particle size. The scattered light signal is then allocated to a particle size diameter bin using a calibration curve and measurement of the signal number. The bins are then used to form a histogram of the measured particle sizes.

A number of computational steps are required to convert the measured particle sizes into a mass concentration. The measured size distribution is altered to a distribution based on a representative index for environmental aerosol. To account for the variability in the shape of each particle the distribution is altered from optical diameter (spherical shape) to reflect the aerodynamic diameter (variable shape) of the particles. Once the distribution has been altered to account for the refractive index and diameter the EU particle distribution line is used to apply the cut curves for each of the PM fractions.

The data is then converted from particle size to particle mass using a size dependent density algorithm. This system allows for a lower detection limit of 180nm with a sampling range of 0.18 - 18µm.

A calculation of the total expanded uncertainty of the data has been made for the Fidas 200 analyser manufactured by PALAS GmbH. Because performance tests using certified calibration standards are not possible, demonstration of equivalence was conducted based on a series of comparison tests against a reference sampling device as defined under standard EN 16450.

Data for the uncertainty analysis was taken from the specifications reported from the MCERTS product conformity certificate.

For $PM_{10}$ the method 11 algorithm fulfils the relevant Data Quality Objective of EU Directive 2008/50/EC without the need for slope and/or intercept correction. For $PM_{2.5}$ the method does not fulfil the relevant Data Quality Objective of EU Directive 2008/50/EC when used without correction. Slope correction of dividing by 1.06 is required to make the $PM_{2.5}$ Palas Fidas 200 Method 11 equivalent.

| **$PM_{10}$ Palas Fidas 200** | **Calculated slope of all paired data** | **Calculated intercept of all paired data (µg/m$^3$)** | **Range of individual expanded uncertainties** | **Expanded uncertainty of all paired data** |
|---|---|---|---|---|
| Uncorrected data | 1.035 | -1.36 | 5.7% to 19.1 % | 7.5% |

| **$PM_{2.5}$ Palas Fidas 200** | **Calculated slope of all paired data** | **Calculated intercept of all paired data (µg/m$^3$)** | **Range of individual expanded uncertainties** | **Expanded uncertainty of all paired data** |
|---|---|---|---|---|
| Data corrected for slope by dividing by 1.060 | 0.999 | -0.19 | 8.5% to 22.4% | 9.3% |

The expanded uncertainty has been calculated as 7.5% for $PM_{10}$ and 9.3% for $PM_{2.5}$. The reported uncertainty covers the data collected from 1 January 2025.

## References

1. Department for Environment, Food and Rural Affairs. 2022. National Statistics. [online] Available from: Emissions of air pollutants in the UK – Particulate matter (PM10 and PM2.5) - GOV.UK (www.gov.uk) [Accessed 23 September 2024]

2. DETR – May 2000 - Pollutant Specific Guidance

3. Sira Certification Service. April 2021. Certificate No: Sira MC160290/03

# Appendix F Percentile Analysis

Percentile analysis provides a method of looking at the distribution of concentrations within a data set.

Excel calculates percentiles by first sorting the concentrations into ascending order and then ranking each concentration. It then uses the following formula's:

$$r = 1 + \left[\frac{P(n-1)}{100}\right] I + D$$

P = the percentile you want

n = the total number of values

I = the integer part of the ranking

D = the decimal part of the ranking

r = rank

$$p = Y_I + D(Y_{I+1} - Y_I)$$

$Y_I$ = value corresponding to the rank I

p = Value of the required percentile

***BetterSolutions.com***

to interpolate the value of a particular percentile from the calculated ranking. i.e. it calculates the concentration below which a certain percentage of concentrations fall. For example, at the 95$^{th}$ percentile, 95% of the data will lie below this value and 5% of the data will lie above it.

To produce radial percentile roses, the data is first divided into the required wind sectors and then the data in each sector undergoes separate percentile analysis. By calculating the concentration of a pollutant at different percentiles for different wind sectors, you can visually examine the distribution of pollutant concentrations at a particular monitoring site. This in turn will provide information on the source that may be influencing levels at the monitoring site.

By separating the data into various wind sectors, it allows you to assess which wind directions are having the greatest influence on pollutant concentrations at the monitoring site. By calculating the average concentration for every wind sector, you can produce a 'average pollution rose', where the influence on pollutant concentrations from a particular wind sector is seen as a bias on a radial plot. This type of analysis is very effective at visually highlighting the wind sectors where there are significant sources of a given pollutant. By breaking each wind sector down into several different percentiles, it can be seen whether biases are present in all the percentiles or just certain ones, which can tell you whether a source is affecting the monitoring site relatively continuously or just intermittently. For example, a bias that is observed in all percentiles (Figure 1) suggests that the source from that wind sector is emitting relatively continuously as it is influencing a large percentage of the data. Whilst a bias that is only observed in the higher percentiles (Figure 2) suggests that the source is intermittent as it only affects a small percentage of the data, i.e., it doesn't affect concentrations at the monitoring site every time the wind is coming from this direction. Occasionally, a bias is

observed in the lower percentiles that is not evident in the higher percentiles (Figure 3). This suggests that the source is relatively continuous, as it is affecting a large percentage of the data, but it also tells you that the source is not causing appreciably high concentrations at the monitoring site.

**Figure 1: shows a bias between 100° – 140° that is evident in all the percentiles.**

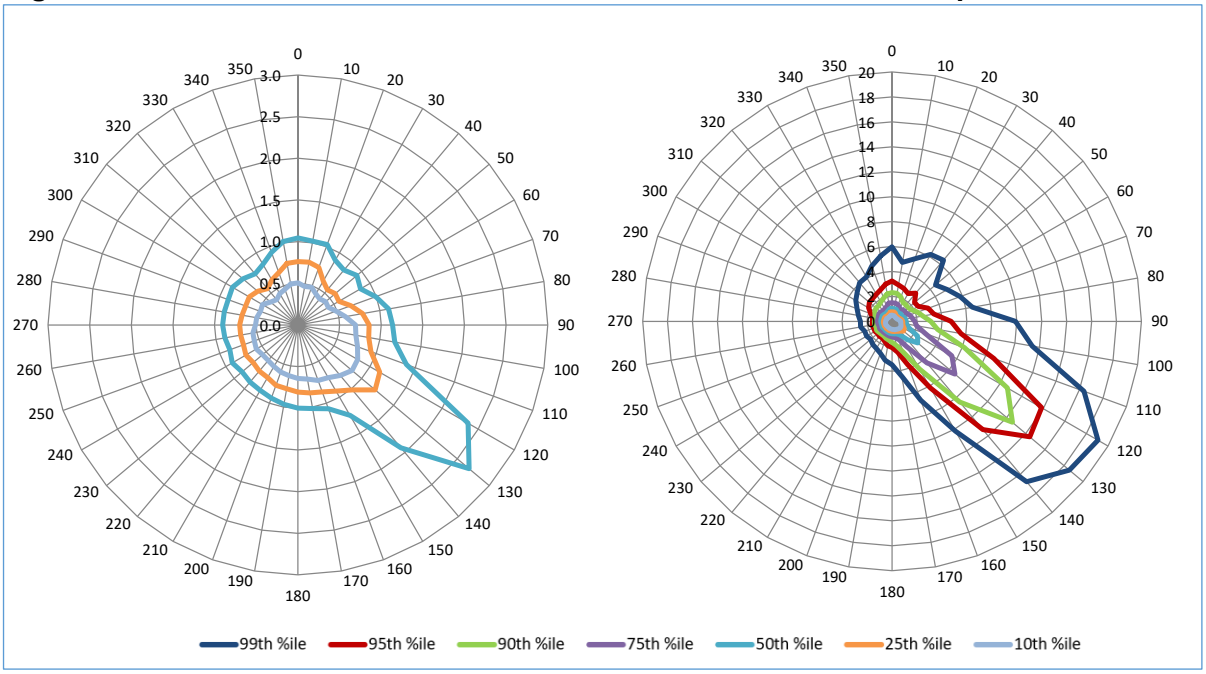



**Figure 2: Shows a bias at 260° - 160° that is only evident in the higher percentiles.**

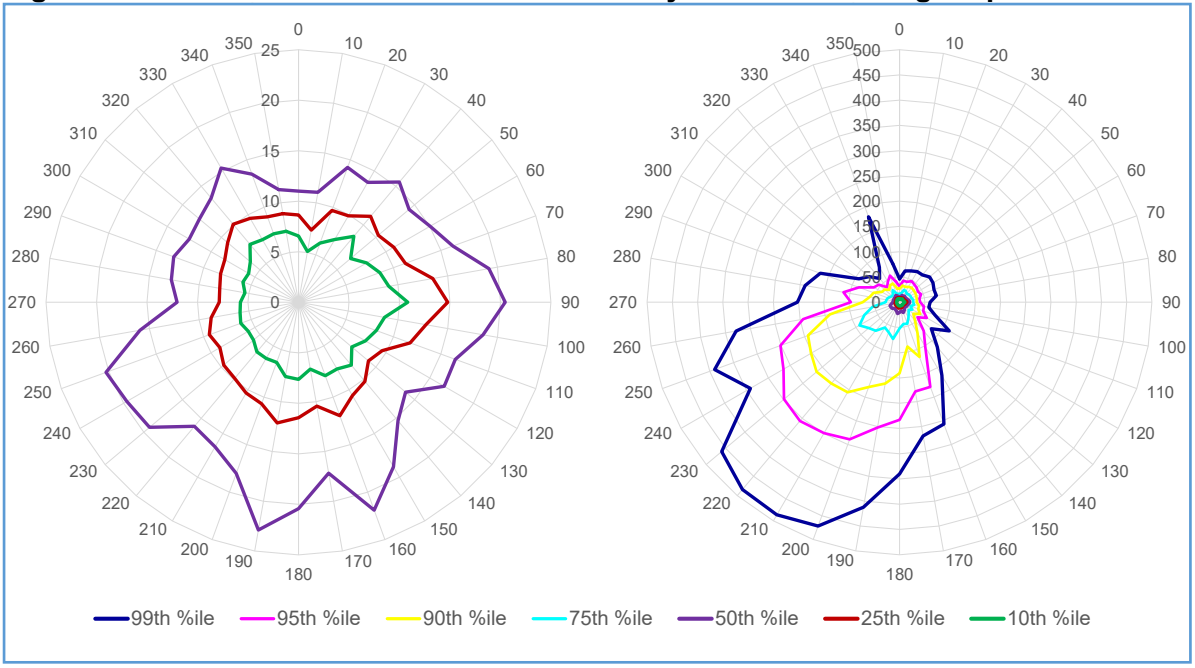
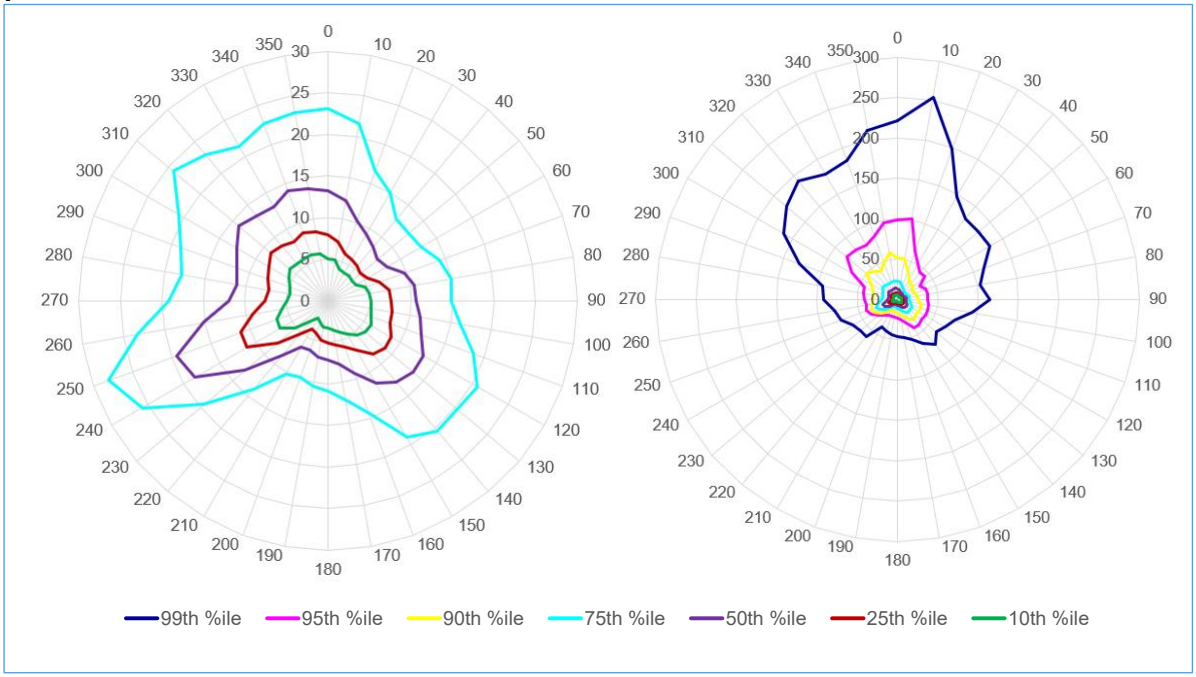


**Figure 3: Shows a bias between 230° – 270° that is only evident in the lower percentiles.**



## Would you like to find out more about us or about your environment?

## Then call us on

**03708 506 506** (Monday to Friday, 8am to 6pm)

## email

**enquiries@environment-agency.gov.uk**

## or visit our website

**www.gov.uk/environment-agency**

**incident hotline 0800 807060** (24 hours)
**floodline 0345 988 1188** (24 hours)

Find out about call charges (www.gov.uk/call-charges)

Environment first: Are you viewing this on screen? Please consider the environment and only print if absolutely necessary. If you are reading a paper copy, please don't forget to reuse and recycle if possible.