Greenwich Ship Tier

Results from the PLA's Air Quality Monitoring in 2019

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Introduction

This report sets out the calibrated results of air quality monitoring conducted around Greenwich Ship Tier (GST) during 2019. The monitoring was undertaken as one of the actions set out in the PLA's 2018 Air Quality Strategy for the Tidal Thames.

Highlights

Analysis of the calibrated results of the monitoring shows that there was:

- no exceedance in the National Standard for the daily (24 hour) PM_{10} mean for 97.6% of the time (40 out of 41 days) – this is a statistically insignificant difference compared to the two exceedances of the PM_{10} National Standard (24 hours) over this period when there was no cruise ship berthed at GST.
- no exceedances in the National Standard for the hourly NO_2 mean at any monitoring sites, except at Greenwich Pier; it is considered that, rather than cruise vessels, the strong influence of other river activities at Greenwich Pier was the reason for the hourly NO_2 mean exceeding the National Standard for approximately 1.5% of the entire monitoring period; of this, 0.17% occurred when a cruise vessel was mooring at GST.

Background

The current Air Quality Strategy for the Tidal Thames, prepared by the Port of London Authority (PLA) and published in 2018, includes a number of actions that seek to improve air quality affected by maritime emissions on the tidal River Thames. The strategy is based on a baseline inventory, prepared in conjunction with Transport for London, of emissions from 2016 to which the PLA has set a number of targets to reduce emissions over the next 30 years. Actions include discount schemes to reward good environmental vessel performance, modelling the dispersion of the marine emissions, monitoring levels river wide and investigations into the feasibility and trials of use of alternative fuels and retrofitting fleets with new technology. The PLA is currently reviewing the strategy, in accordance with Department for Transport guidelines and with major cargo-handling operators in the Port of London,

for submission to Government in Summer 2020[1].

The 2016 London Atmospheric Emission Inventory study shows the overall contribution of emissions from river activity is not significant, with 2.1 % of Greater London's total NO_x, and 0.3 % for PM_{10} emissions. However, as the emission legislation for road vehicles tightens and the use of river grows, the proportionate contribution from the river is likely to increase in the future, unless further mitigation action is taken. As part of the strategy, real time monitoring had been planned for 2020 in hotspots across the river. Due to local concerns on the impact on air quality of visiting cruise vessels at Greenwich Ship Tier, the PLA accelerated this timetable and installed an air quality monitoring network around the mooring to access the impacts of cruise vessels berthing on local air quality in 2019. The results have subsequently been collected and calibrated for the period during which all the cruise visits occurred. It has now been analysed and results are published here, including actions that the PLA is taking forward following the analysis. These actions will be incorporated in the revised Air Quality Strategy that the PLA will submit to the Department for Transport in Summer 2020.

Methodology

Following a commitment from the PLA's chief executive to investigate air quality in the vicinity of Greenwich Ship Tier (GST), monitoring results for the period between May and September 2019 from locations surrounding the moorings on both banks of the river, in the Royal Borough of Greenwich and Tower Hamlets (Figure 1) were analysed for this report. Most cruise ship visits to Greenwich occur from May to September, which is based on the tourism market to London; other cruise terminals in the Thames have a more extended season.

In this period in 2019 there were a total of 13 calls to GST which was equivalent to 41 days, or 729 hours, in total. The analysis within this report assesses the impacts of visiting cruise vessels on several air pollutants that are directly emitted from fuel burning, including particulate matter (PM_{10} and $PM_{2.5}$, which refers to a particle size

Figure 1 – Locations of air quality monitors around Greenwich Ship Tier

[1] *Subject to any revised DfT guidance in the light of the current Coronavirus crisis.*

smaller than 10 and 2.5 µm respectively) and nitrogen dioxide (NO_2). A network of seven air quality monitors – acquired from AQMesh a recognised worldwide multi-parameter sensor system for outdoor quality monitoring – was installed around Greenwich Ship Tier, with three situated on the north and four on the south side of the river in order to provide maximum coverage whatever the wind direction.

As promised, the real-time raw data produced by the monitors has been made publicly available on the PLA website. However, as sensor responses are known to vary widely, even across the same make and model, the raw data should only be considered as indicative measurements. The absolute concentration, which is the vital measurement, can only be achieved by calibrating the monitor against reference monitoring stations that have an Environment Agency Monitoring Certification Scheme (MCERTs) approval. As such, all data used for this analysis was calibrated and ratified by an independent third party[2] following these standard procedures.

Local air quality is also strongly influenced by meteorological conditions, particularly wind speed and direction, vertical temperature difference and humidity as these factors affect the dispersion and deposition of pollutants. Wind determines the horizontal movement of the pollutants once they are emitted from the source and in particular wind speed establishes the rate of dispersion and wind direction sets the path followed by the pollutants. Vertical temperature difference controls the stability of boundary layer air which determines the vertical movement of the pollutants. The humidity of the atmosphere affects the removal of pollutants from the air by rain or water droplets. As such, even relatively low emissions can result in a hazardous level of pollution on a day with low wind or a stable boundary layer or dry conditions. The PLA records meteorological data locally at the Thames Barrier for its navigational duties and this has also been used as part of the analysis.

Comparative analysis was made against data recorded at an urban background (Millwall Park) and roadside monitor (Hoskins Street) through the Automatic Urban and Rural national network (AURN) operated by local government. By definition, an urban background site is chosen for the AURN as it is not influenced significantly by any single source, but rather by the integrated contribution from all sources upwind of the station and is generally representative for several square kilometres. In contrast, for a roadside station in the same network, emissions from nearby traffic represent the predominant source.

The calibrated data has been analysed in terms of the values of UK Air Quality Standards and Objectives issued by the Department for Environment Food & Rural Affairs (Defra) to assess whether any legal exceedances have occurred over the specified defined time periods. The Daily Air Quality Index (DAQI) has also been used as it is recommended by the Committee on Medical Effects of Air Pollutants (COMEAP), an UK independent expert committee, on assessing short-term health impacts and is furthermore applied by Defra for air quality forecasts.

National Air Quality Standards and Objectives

The National Air Quality Standards are based on concentrations of pollutants recorded over a given period of time, which are considered to represent an acceptable level on health and the environment, based on scientific evidence.

A National Objective is the target number of times that a standard should be exceeded

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within a year. The National Standards and Objectives for PM and NO_2 are summarised in Table 1. The Annual Mean Objective is not applicable to this analysis due to limited data availability, although this will be reassessed once a larger dataset is available.

Daily Air Quality Index

The Daily Air Quality Index (DAQI) is numbered from 1 to 10 and is divided into four bands as shown in Table 2. It is designed to provide advice on the short-term impacts of air pollution and recommendations on actions for susceptible individuals (see metoffice.gov.uk for further details). The DAQI is dependent on the pollution indices of $PM_{2.5}$, PM_{10}, NO_2, SO_2, and O_3, which are calculated based on concentrations over a specific period of time (See Appendix 1 for calculation details). The highest of the individual pollutant indices is taken as the DAQI index for the site.

Air Quality Results

National Air Quality Standards and Objectives

Over the five months of the cruise season at GST, a number of exceedance events for the daily PM_{10} standard were detected from the network of monitors (Table 3). The exceedance events occurred on three separate days, one of which concurred with the mooring of cruise vessel at GST, with the other two on days when no vessels were at the moorings. For the day when a cruise vessel was at GST, the major contributing factor for the exceedance, besides the emissions from the moored cruise vessel and all other river activities, is the pattern of consecutive days of calm and hence low windspeed conditions. The average daily windspeed was less than 4 m/s for three days successively (half of the annual average wind speed) which limited dispersion and resulted in an accumulation of pollutants. For the other non-cruise vessel related PM_{10} exceedance events, the humidity was relatively low at 55% or below, which has an impact on the settling of pollutants from air to ground.

In comparison, three exceedance events for the daily PM_{10} standard were detected at the Hoskins Street roadside monitor. These occurred on different days than the exceedances recorded around GST. It might be expected that the consecutive days of calm conditions that contributed to the PM_{10} exceedance around GST would also lead to a high level of PM_{10} at Hoskins Street However, this was not the case as those calm days occurred over the weekend when road emissions were lower than during the working week. The emissions on the river have a minimal influence on the roadside monitor at Hoskins Street, as demonstrated by the emission dispersion modelling previously undertaken by King's College London[3] for the PLA, which uses numerical models to estimate how the pollutants move once they are produced. Therefore, regardless of whether any of these exceedances occurred when a vessel was mooring at GST, it is extremely unlikely that these exceedances at the roadside monitor occurred as a result of that vessel.

In relation to NO_2, the hourly standard was met throughout the entire period for all monitoring sites, except at Greenwich Pier (Table 4). Greenwich Pier is intensively used by various river operators to run public cruise and commuter services to and from Central London and it is subject to a far greater influence from all river activities and hence is of limited validity for the consideration of cruise specific emissions. In total, 54 exceedances of the hourly NO_2 mean have been recorded, equivalent to 1.5% of the entire monitoring period. Six of those exceedance events occurred when a cruise vessel was mooring, which is equivalent to 0.17% of the entire monitoring period and 0.8% of the total number of cruise mooring hours. The proportionate occurrence of hourly NO_2 exceedance was lower for the period with mooring, relative to the period without mooring, and it is therefore considered that the high level of NO_2 is predominantly caused by emissions from river traffic rather than cruise vessels. This is an issue that the PLA will be considering and looking to mitigate through its work on inland vessels and the review of the Air Quality Strategy.

One of the PM_{10} exceedances coincided with a cruise ship being berthed at Greenwich Ship Tier. Given that there are occasional PM_{10} exceedances at this site at other times, it is not possible to conclude whether or not this was linked to the cruise ship. The exceedances of hourly NO_2 mean in the national health standard at Greenwich Pier was primarily linked to the emissions from all kinds of river traffic. No exceedance events of hourly NO_2 were recorded at any other monitoring sites, with or without berthing.

Table 1 - National Air Quality Standards and Objectives for PM and NO2

PM	Period	Limit	Objective
PM_{10}	24 hour mean	50 ug/m^3	Not to be exceeded more than 35 times a year
PM_{10}	Annual mean	40 ug/m^3	N/A
$PM_{2.5}$	Annual Mean	250 ug/m^3	N/A
NO_2	1 hour mean	200 ug/m^3	Not to be exceeded more than 18 times a year
NO_2	Annual mean	40 ug/m^3	N/A

Table 2 - Daily Air Quality Index and Bands by the Department for Environment Food & Rural Affairs

Index	1	2	3	4	5	6	7	8	9	10
BAND	LOW			MODERATE			HIGH			VERY HIGH

Table 3 - Number of Days Exceedance of the PM10 Daily Standard Between May and September 2019. Top Row is the Exceedance for the Entire Monitoring Period. Bottom row is Exceedances When There was a Vessel Moored at GST. Note: The Urban Background Data was Missing Between 19/8 and 27/8 When the Exceedance Occurred at Four of the GST Monitoring Sites.

PM_{10} exceedance	AHOY	Deptford	Greenwich	Meridian	Napier	Polar Rowing Club	St David Square	Urban background	Roadside
1/5 - 30/9	1	3	1	0	0	3	2	0	3
Days with berthing	0	1	1	0	0	1	1	0	N/A

Table 4 - Number of Hours Exceedance of the NO2 Hourly Standard Between May and September 2019. Top row is Exceedances for the Entire Monitoring Period. Bottom Row is Exceedances When There was a Vessel Mooring at GST.

NO_2 exceedance	AHOY	Deptford	Greenwich	Meridian	Napier	Polar Rowing C	St David Square	Urban background	Roadside
1/5 - 30/9	0	0	54	0	0	0	0	0	0
Days with berthing	0	0	6	0	0	0	0	0	0

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Daily Air Quality Index

For all seven sites, the concentrations of NO_2, PM_{10}, and $PM_{2.5}$ remained in the Low Band for the vast majority of the time (94% or above), although occasionally fell into the Moderate Band (less than 5% of the time), High Band (less than 2% of the time), or Very High Band (1% or less) during the five months of monitoring (Figures 2 to 8). The level of PM_{10} remained in the Low Band for the entire period at three of the monitoring sites (AHOY Centre, Meridian Estate, and Napier Avenue). For other monitoring sites on a very occasional basis (once or twice), the PM_{10} level reached the Moderate or High Band.

For $PM_{2.5}$, the level was classified in the Low Band for the five month period at three of the monitoring sites (Meridian Estate, Napier Avenue, and Greenwich Pier). A relatively high occurrence in the Moderate to Very High Band was reported at Poplar Rowing Club and AHOY Centre, which equates to 6% and 5% of the total monitoring period respectively. The proportionate occurrence in the Moderate to High Band was comparable between the periods with and without mooring at AHOY Centre, suggesting the exceedances were impacted by other inputs. However, at Poplar Rowing Club 10% of the total period with cruise vessel at GST was in the Moderate to High Band, whilst 4% of the total period without a vessel mooring was in those Bands. However, this must be seen in the context of episodes of Very High Band in $PM_{2.5}$ occurring at Poplar Rowing Club on days without any vessel mooring at GST, while none was recorded when a vessel was at the mooring. For the rest of the monitoring sites, about 2% of the total monitoring period were within the Moderate and High Band.

For NO_2, the pollutant level fell under the Low Band for the entire period at all sites except at Greenwich Pier, where about 2% of the total monitoring period was classified within the Moderate Band. The difference in the occurrence of each pollutant index between days when vessels were mooring at GST or not was minimal and statistically insignificant. The difference in the occurrence of each pollutant index between the downwind monitor and other monitors - when vessels were at the berth - was also statistically insignificant.

The pollution indices of NO_2 and PM_{10} during the five months of monitoring were comparable to the urban background monitor at Millwall Park (see Figure 9) most of the time, with a slightly higher occurrence in the Moderate Band at Greenwich Pier for NO_2, which as noted previously is predominantly influenced by its intensive use by various river services and in the Moderate and High Band at four of the sites for PM_{10}. The indices around GST were similar to those recorded at the roadside monitor at Hoskins Street (see Figure 10), with slightly higher occurrence in the Moderate and High Band at Poplar Rowing Club for PM_{10} and $PM_{2.5}$.

In general, days in the DAQI Very High Band were not concurrent with the days when a cruise vessel was at Greenwich (Figure 2 to Figure 8). For days with a vessel berthing at GST and with a DAQI in the High Band, the data shows it was not caused by direct emission of NO_2, PM_{10}, and $PM_{2.5}$, but rather high concentrations of O_3 on that day.

The data analysis indicates berthing at GST has a modest impact on the daily pollutant indices for NO_2, PM_{10}, and $PM_{2.5}$, which remained in the Low Band for the majority of the monitoring period. However, a slight increase in the occurrence of higher PM indices, that is likely to be linked to the berthing of vessels at GST, can be seen from the data.

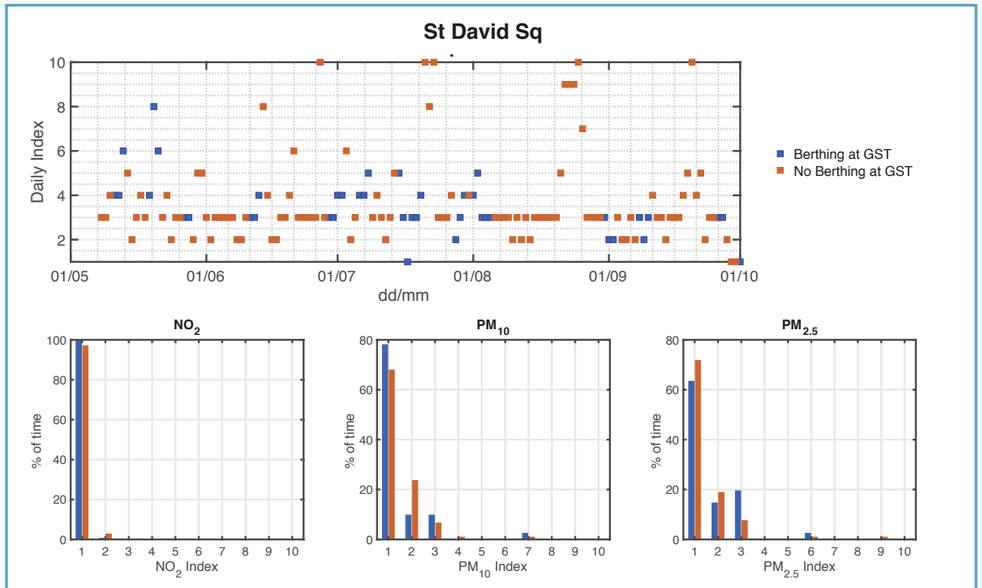

Figure 2 – The Daily Air Quality Indices from May – September 2019 at St David Square; percentage of time in each Pollution Index for NO_2, PM_{10} and $PM_{2.5}$.

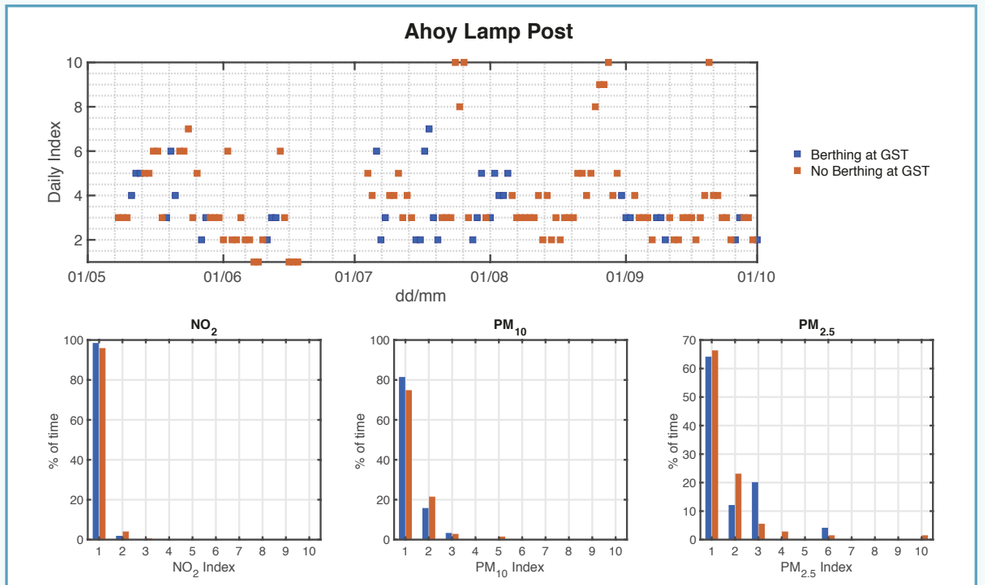

Figure 3 – The Daily Air Quality Indices from May – September 2019 at AHOY Lamp Post; percentage of time in each Pollution Index for NO_2, PM_{10} and $PM_{2.5}$.

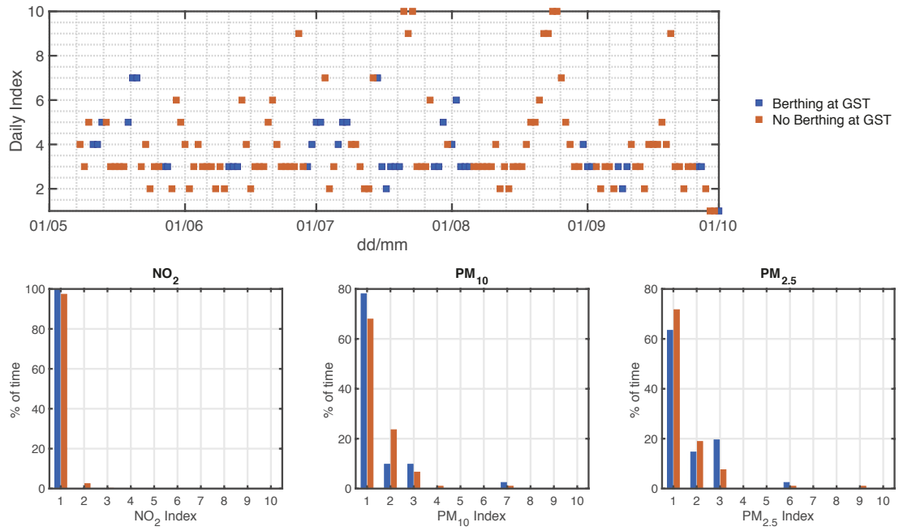

Figure 4 – The Daily Air Quality indices from May – September 2019 at Deptford Creek; percentage of time in each Pollution Index for NO_2, PM_{10} and $PM_{2.5}$.

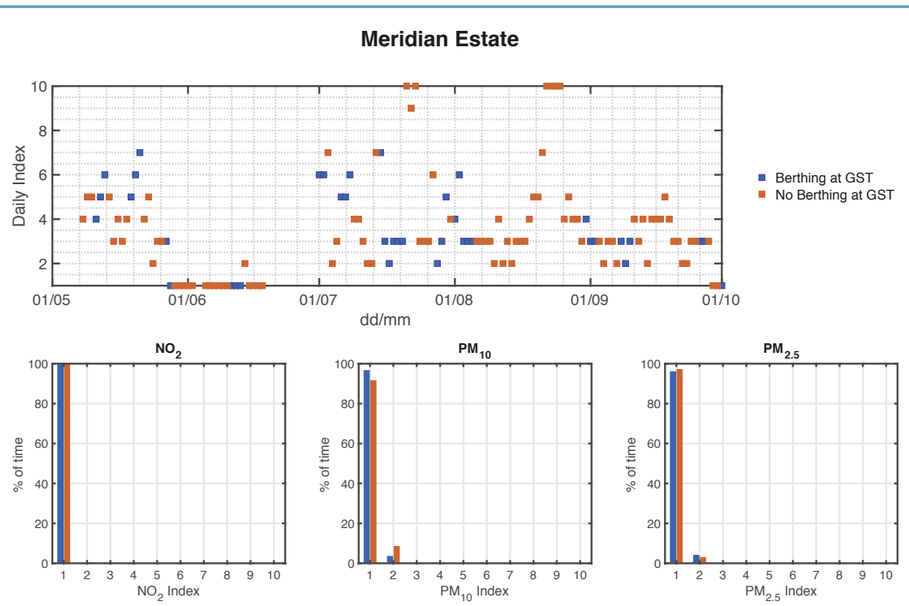

Figure 5 – The Daily Air Quality Indices from May – September 2019 at Meridian Estate; Percentage of Time in Each Pollution Index for NO_2, PM_{10} and $PM_{2.5}$.

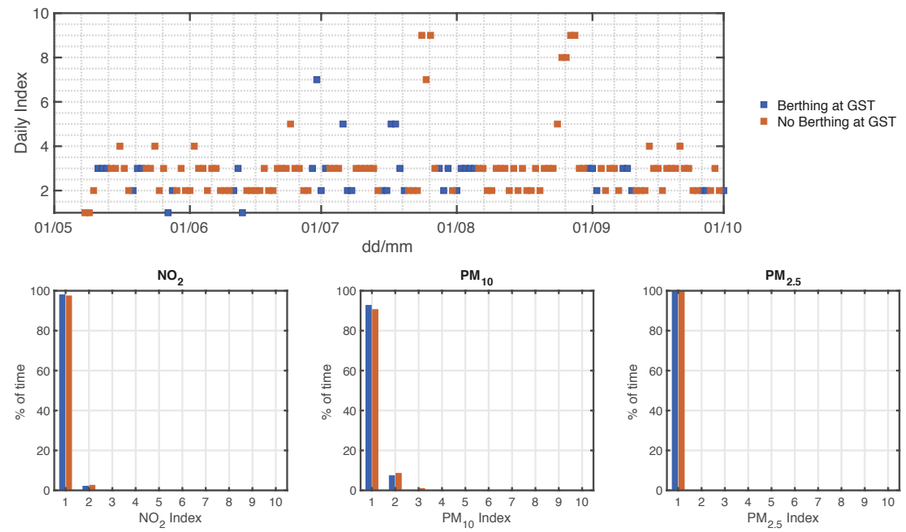

Figure 6 – The Daily Air Quality Indices from May – September 2019 at Napier Avenue; percentage of time in each Pollution Index for NO_2, PM_{10} and $PM_{2.5}$.

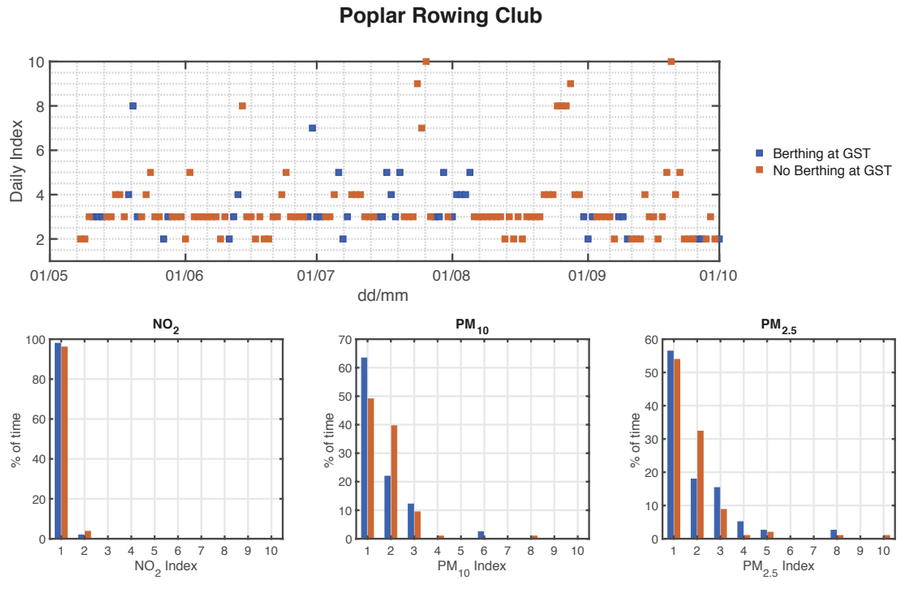

Figure 7 – The Daily Air Quality Indices from May – September 2019 at Poplar Rowing Club; percentage of time in each Pollution Index for NO_2, PM_{10} and $PM_{2.5}$.

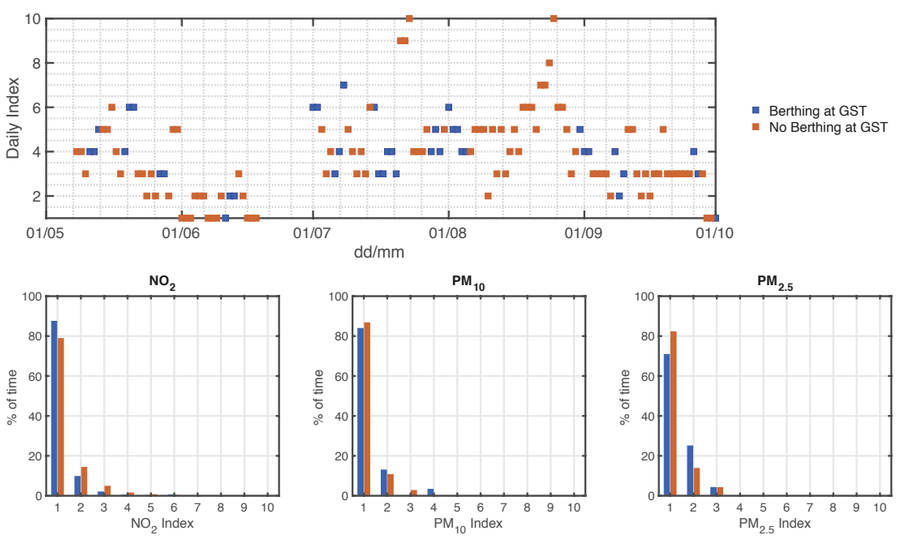

Figure 8 – The Daily Air Quality Indices from May –September 2019 at Greenwich Pier; percentage of time in each Pollution Index for NO_2, PM_{10} and PM .

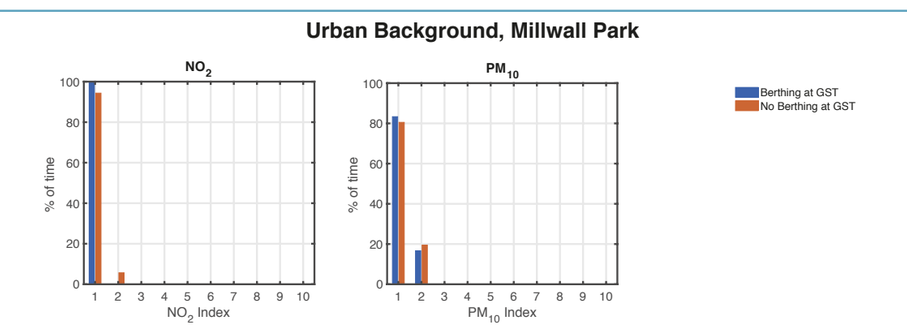

Figure 9 – The percentage of time in each Pollution Index for NO_2 and PM_{10} at an Urban Background site Located at Millwall Park. Note: Level of $PM_{2.5}$ is unavailable at this monitoring site.

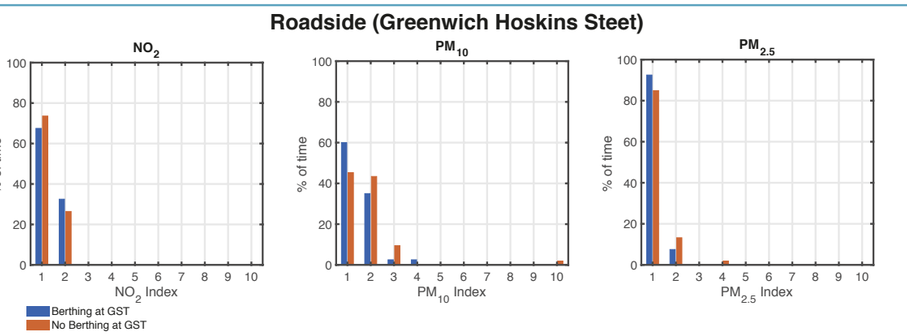

Figure 10 – The percentage of tme in each Pollution Index for NO_2, PM_{10}, and $PM_{2.5}$ at a roadside monitoring site at Hoskins Street.

Conclusions

The analysis of the monitoring and meteorological data undertaken for this report demonstrates that the berthing of cruise vessels at GST resulted in a slight elevation in pollutants resulting from additional emissions. There was an exceedance of the National Standards for the daily PM_{10} mean on one of the days with a vessel mooring when the wind had been calm for several consecutive days, but given there are occasional exceedances at this site, this may or may not have been linked to the cruise ship. The analysis also demonstrates that berthing of cruise vessel is not related to exceedances in the National Standard for hourly NO_2 mean, despite exceedance events being detected at Greenwich Pier where emissions by all other kind of river vessel activities are dominant. This is separate to the mooring of cruise vessels at GST and will be considered separately by the PLA and others.

Next steps

The PLA is committed to reducing the level of maritime emissions related to use of the River Thames, as set out in the 2018 Air Quality Strategy. As part of this, and to follow up this initial year of monitoring and evidence gathering, the PLA will take forward a number of measures in relation to cruise vessels mooring at GST including: -

Further Monitoring

The PLA will keep in place and maintain the network of air quality monitors around Greenwich to continue monitoring until February 2021, at which point the extent of monitoring and the results will be further analysed and reviewed. The Annual Mean National Standards and Objectives will be assessed once a year-long dataset is available.

Use of the Greenwich Ship Tier Mooring

The PLA will continue to encourage the use of Environment Ship Index (ESI) by the operators of visiting cruise vessels to facilitate discounts for greener ships. This is a scheme that rewards environmental performance of vessels above the legal standard through reduced PLA charges. Ongoing work to discuss the source of the results and the performance of the vessels, the PLA will continue to encourage cruise lines to work closely with the PLA and ensuring best practice.

Port Air Quality Strategy

The PLA will continue to implement and revise the its Air Quality Strategy (link here) to monitor changes in emission trends, updating relevant targets and necessary actions to reflect those within the Department for Transport's Clean Maritime Plan, the Climate Change Act 2008, and Net Zero commitments (as amended). Building on the existing evidence provided by the real time monitoring analysed within this report, the updated Strategy will include actions to lead innovation in the wider river use for inland vessels in the vicinity of the mooring, and in London generally to reduce emissions from all maritime sources in London.

Zero Emission Berth

As part of its commitment to Net Zero, the PLA is actively exploring options for cleaner berth operations when vessels are in the Port of London. We are seeking technical, operational and investment business partners to work with to establish the port's first zero emission berth. Our target date for the berth to be operational is 2025, subject to availability of suitable technology and finance, in light of the COVID-19 pandemic impact on port trade.

Air Quality Monitoring – Greenwich Ship Tier

Index	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
BAND	LOW			MODERATE			HIGH			VERY HIGH

PLA Monitor Local Authority Monitor

Appendix I - Daily Air Quality Index

Daily Air Quality Index according to the Department for Environment Food & Rural Affairs

Band	Accompanying health message		Index	Ozone, 0_3	Nitrogen Dioxide, NO_2	Sulphur Dioxide, SO_2	PM_{25}	PM_{10}
	General population	At risk individuals		Running 8 hourly mean	Hourly mean	15 minute mean	24 hour mean	24 hour mean
				µg m^{-3}	µg m^{-3}	µg m^{-3}	µg m^{-3}	µg m^{-3}
Low	Enjoy usual activities	Enjoy usual outdoor activities	1	0-33	0-67	0-88	0-11	0-16
			2	34-66	68-134	894-177	12-23	17-33
			3	67-100	135-200	178-266	24-35	34-50
Moderate	Enjoy usual outdoor activities	Adults and children with lung problems, and adults with heart problems, who experience symptoms, should consider reducing strenuous physical activity, particularly outdoors. with heart problems, who experience symptoms, should consider reducing strenuous physical activity, particularly outdoors.	4	101-120	201-267	267-354	36-41	51-58
			5	121-140	268-334	355-443	42-47	59-66
			6	141-160	335-400	444-532	484-53	67-75
High	Anyone experiencing discomfort such as sore eyes, cough or sore throat should consider reducing activity, particularly outdoors.	Adults and children with lung problems, and adults with heart problems, should reduce strenuous physical exertion, particularly if they experience symptoms. People with asthma may find they need to use their reliever inhaler more often. Older people should also reduce physical exertion.	7	161-187	401-467	533-710	54-58	76-83
			8	188-213	468-534	711-887	59-64	84-91
			9	214-240	535-600	888-1064	65-70	92-100
Very high	Reduce physical exertion, particularly outdoors, especially if you experience symptoms such as cough or sore throat.	Adults and children with lung problems, adults with heart problems, and older people, should avoid strenuous physical activity. People with asthma may find they need to use their reliever inhaler more often.	10	241 or more	600 or more	1065 or more	71 or more	100 or more

SUSTAINABLE DEVELOPMENT GOALS

The PLA's work in this area contributes to the following UN Sustainable Development Goals:

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