Report on Turnkey Osiris Particle Results at the Market/Beresford Street and Howard Davis Park Sites in Jersey for 2022

Executive Summary

This report presents the results for 2022, part of an ongoing programme of particle monitoring in Jersey, carried out by Natural Environment which is part of the Government of Jersey. This is the 21st consecutive year in which an annual monitoring programme has been carried out; the first undertaken in 2002. It compares the particle data from Jersey with relevant World Health Organisation (WHO), European Union (EU) and UK air quality limit values, objectives and guidelines as well as data from previous years' monitoring programmes. Jersey's Air Quality Strategy 2013 limits are based on those in the EU Directive limits and UK Air Quality Standards Regulations 2010.

The COVID-19 pandemic resulted in calibration delays in the UK due to staff shortages which affected data capture rates. Particle levels reduced in the first lock down (March 2020) by up to 30% PM_{10} and up to 13% $PM_{2.5}$ respectively at previous central market / Halkett Place site however the reduction was greater in the second lock down (October /November) by up to 67% PM_{10} and up to 72% $PM_{2.5}$.

The department has two Turnkey particle Osiris analysers which measure particles at an urban roadside site at the Central market on Beresford Street, St Helier and at a background site Howard Davis Park, St Helier. The Osiris unit at the Central market was moved from on Halkett place to the Beresford Street side of the market in November 2021 for health and safety reasons. The Osiris at Howard Davis Park was also moved in June 2021 further into the park to reduce any interference from traffic emissions and is sited approximately 85m to the nearest road which is St Clements Road.

Air quality in Jersey is generally good as it's a windblown island with prevailing north/south westerlies however elevated levels of localised air pollution do occur for example during periods of traffic congestion particularly in canyon type streets and in the tunnel. Jersey has one of the highest car ownership levels with over 175,000 vehicles registered to a population of 100,000. There is no MOT for cars at present so older more polluting vehicles are still being driven.

The Osiris units measure particles in near real time (i.e. Total Suspended Particles (TSP) and particles of a mean aerodynamic diameter of 10 microns (PM_{10}), 2.5 microns ($PM_{2.5}$) and 1 micron ($PM_{1.0}$)) and provide data as 15 minute averages. The data is displayed in near real time on the States of Jersey website [Air quality monitoring (gov.je)]

Although not legally binding in Jersey, the States has agreed to work towards the European Union Directive objectives. The PM_{10} daily and annual levels and the $PM_{2.5}$ annual levels for 2022 from both Osiris analysers did not exceed the EC Directive or UK limit values.

The heated inlet at the Howard Davis analyser failed in November 2022 resulting in water vapour particles being measured. This caused a number of elevated 24 hour averages and false

exceedances. There were 14 exceedances at the Beresford Street site and 15 exceedances at Howard Davis Park. The EU & UK limits allow 35 exceedances of the 50 $\mu g/m^3$ 24 hour limit each year. The limits need updating in line with the 2021 World Health Organisation's air quality guidelines.

The PM_{10} 24 hour WHO Air Quality Guideline (AQG) of 45 $\mu g/m^3$was exceeded at both sites and the PM_{10} and $PM_{2.5}$ annual levels also exceeded the WHO Air Quality guidelines at both sites: 15$\mu g/m^3$ (PM_{10}) and 5$\mu g/m^3$ ($PM_{2.5}$) respectively.

In 2022 the UK government proposed air quality targets for $PM_{2.5}$ as part of the Environment Act 2021:

- Annual Mean Concentration Target ('concentration target') - a maximum concentration of 10$\mu g/m^3$ to be met across England by 2040
- Population Exposure Reduction Target ('exposure target') - a 35% reduction in population exposure by 2040 (compared to a base year of 2018).

The number of exceedances have been decreasing since 2002 but increased in 2021 and 2022. Care is needed interpreting the results as the percentage data capture has varied year on year and levels are influenced by non-anthropogenic particles such as sand and salt which can lead to elevated levels. Data collection was relatively low this year around 68% and 79% respectively due to delays in the UK with calibration.

The diurnal pattern in concentrations of particles at Beresford Street shows there is a clear peak in the early morning between 07:00 and 08:00, with another slight peak in the afternoon rush-hour. Levels of particles spike if there is congestion or vehicles drivers leave their engines running. There is signage at the market requesting vehicle drivers turn off engines off.

PM_{10} concentrations in Jersey are broadly similar to those found in comparable urban areas in the UK. The levels at the Beresford Street site are broadly what would be expected at a roadside location in the UK and the Howard Davis Park site levels are typical of an urban background location.

The exceedances tended to occur in the spring, autumn and winter months. The weather at these times is characterised by longer nights, clear skies, relatively dry air, and conditions which can result in temperature inversions (i.e., an increase in temperature with height), which results in the trapping of moisture and pollutants in the surface air layer.

It is hoped Jersey's air quality will improve over time with the introduction of the proposed MOT for cars, the availability of Renewable diesel (RD100) for diesel vehicles and the Government financial incentives offered for purchase of electric and hybrid vehicles as part of the Carbon Neutral Road Map to achieve net zero by 2050.

Contents

List of figures

List of tables

List of photographs

1.0 Introduction

1.1 Background

This report describes an air quality monitoring programme measuring particles (also known as particulate matter PM) carried out on the Island of Jersey in 2022. This is the 21th consecutive year in which an annual monitoring programme has been carried out; the first undertaken in 2002. It compares the data from Jersey with relevant World Health Organisation WHO, European Union EU and UK air quality limit values, objectives and guidelines as well as data from previous years' monitoring programmes.

This ongoing monitoring programme has provided a long-term dataset of particle pollutant concentrations. Particles which can be differentiated by size:

- TSPs total suspended particles
- PM_{10} particles are defined as having an average particle size of 10 microns in diameter (10 millionths of a metre),
- $PM_{2.5}$ particles are defined as having an average particle size of 2.5 microns in diameter
- $PM_{1.0}$ particles are defined as having an average particle size of 1 micron in diameter[1]

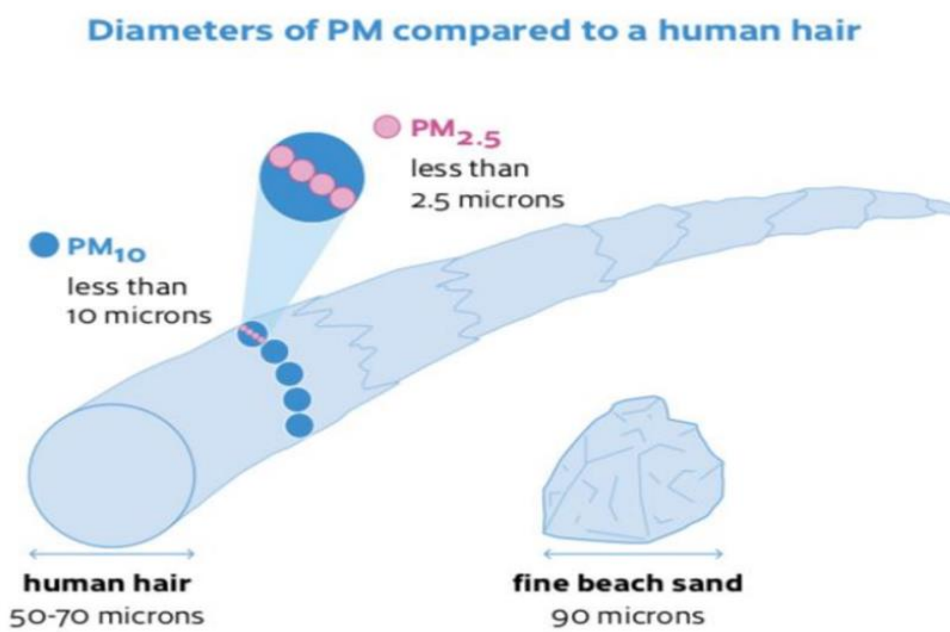


Figure 1: How small is Particulate matter (PM)[1]

The report also compares the number of PM_{10} exceedances of the air quality objective for the period 2002 - 2022 for the following historic roadside sites:

a. The Southampton Hotel, Weighbridge and Bellozanne valley: 2002 - 2007
b. The Market/Halkett Place and Havre Des Pas /Howard Davis Park sites: 2006 - 2014
c. The Market/Halkett Place: 2014 - 2021 and background site at Howard Davis Park: 2014 – date and was moved further into the park in 2021.
d. The Market/Beresford Street site: 2021 – to date

The particle monitoring discussed in this report also forms part of a wider Air Quality monitoring strategy which includes:

1. Twenty five Nitrogen Dioxide (NO_2) passive diffusion tubes measuring Nitrogen Dioxide sited around the island.
2. Five Volatile Organic compound (VOC) passive diffusion tubes measuring, Benzene, Toluene, Ethylene, and Xylene (BTEX) sited around the island.
3. A Nitrogen Dioxide real time chemiluminescent automatic analyser also sited at Jersey's market which measures NO_2 from traffic on Beresford Street. It was moved within the market on the 11th November 2021 due to health and safety reasons.

These reports are available at Air Quality monitoring in Jersey 2021 (gov.je) [2]

1.2 Objectives

The 2022 monitoring is the continuation of a survey that has been carried out since 2002. This report is the latest in a series of annual reports. The objective, as in previous years, was to monitor at a site where particle pollutant concentrations were expected to be relatively high at times, the public are exposed and compare these with a background location. The monitoring sites consist of an urban roadside and a rural background site.

Annual calibration of equipment was carried out in the UK by the manufacturer Turnkey Instruments although there were delays in the UK due to staffing issues. This explains the low data capture rates in 2022. The Natural Environment air quality officers were able to visit the sites every 3 months to change filters and check the equipment.

1.3 Health impacts

Particles are associated with a range of health effects. These include effects on the respiratory and cardiovascular systems, asthma and mortality. The Expert Panel on Air Quality Standards (now part of Department of Health's Committee on the Medical Effects of Air Pollutants) concluded that particulate air pollution episodes are responsible for causing excess deaths among those with pre-existing lung and heart disease. EPAQS also believes that any risk of lung cancer from the concentrations found in the streets of the UK is likely to be exceedingly small. However prolonged exposure (eg 20-30 years) to respirable particles which are likely to be combined with Polycyclic Aromatic Hydrocarbons (PAH's) originating from unburnt or partially burnt fuel, is likely to be carcinogenic[3].

2.0 Details of the Monitoring Programme

2.1 Pollutants monitored

The units measure particles in real time (*i.e.* Total Suspended Particles (TSP) and particles of a mean aerodynamic diameter of 10 microns (PM_{10}), 2.5 microns ($PM_{2.5}$) and 1 micron ($PM_{1.0}$) provide data as 15 minute averages.

2.2 Air Quality limit values and objectives

The report compares the results with air quality limits and objectives applicable worldwide, in Europe and the UK. The comparisons can be found in results and discussion section 4.2.

2.2.1 The World Health Organisation

Pollutant	Averaging period	Concentration			
		Current UK limit	WHO 2021	After Bill	
Nitrogen dioxide (NO_2)	Hourly mean	200 µg/m³	200 µg/m³	200 µg/m³	Existing
	Annual mean	40 µg/m³	10 µg/m³	40 µg/m³	
PM_{10}	24 hour mean	50 µg/m³	45 µg/m³	50 µg/m³	
	Annual mean	40 µg/m³	15 µg/m³	40 µg/m³	
Ozone	Daily 8 hour mean	120 µg/m³	100 µg/m³	120 µg/m³	
$PM_{2.5}$	Annual mean	None	5 µg/m³	*10 µg/m³ ?*	New
	Exposure target*	25 µg/m³		*??*	

Notes:
* $PM_{2.5}$ value is introduced in the new directive and is based on the average exposure index (AEI)
** Scotland has independent value of 10ug/m3

Table 1: WHO Air Quality Guidelines and potential UK Environment Bill limits[4]

The updated WHO Global Air Quality Guidelines (AQGs) provide recommendations on air quality guideline levels as well as interim targets for six key air pollutants. They also offer qualitative statements on good practices for the management of certain types of particulate matter (PM), for example, black carbon/elemental carbon, ultrafine particles, and particles originating from sand and dust storms, for which there is insufficient quantitative evidence to derive AQG levels[4].

2.2.2 The European Community

Throughout Europe, ambient air quality is regulated by the most recent EC Directive on Ambient Air Quality and Cleaner Air for Europe (2008/50/EC). This Directive referred to as the Air Quality Directive sets limit values, which are mandatory and other requirements for the protection of human health and eco systems.

The Air Quality Directive contains 24 hour and annual limit values for PM_{10} and $PM_{2.5}$ as follows:

Table 2: EU standards Directive 2008/50/EU [5]

Pollutant	Concentration µg/m3	Averaging period	Legal nature
PM10	50 40	24 Hour Annual	met by 01/01/05 (35 exceedances / yr) met by 01/01/05
PM2.5	25 20	Annual Annual	met by 01/01/10 met by 01/01/15
PM2.5	20 (AEI) (Average exposure index)	Based on 3 year average	Legally binding in 2015 (Averages 2013 - 15)
PM2.5 Exposure Reduction target	Percentage reduction* + all measures to reach 18 µg/m3 (AEI)	Based on 3 year average	Reduction to be attained where possible by 2020 determined on the basis of the value of the exposure indicator in 2010

*Depending on the value of AEI in 2010, a percentage reduction requirement achieve 18 µg/m3 by 2020.
0,10,15, or 20%) is set in the Directive. If AEI in 2010 is assessed to be over 22 µg/m3, all appropriate measures need to be taken to achieve 18 µg/m3 by 2020

2.2.3 UK Air Quality Strategy and Environment Act 2021

The UK Air Quality Strategy 2011 (AQS)[5] sets out air quality objectives for a range of pollutants including PM_{10} and $PM_{2.5}$. The limits are enshrined in The UK Air Quality Regulations 2010[6]. The AQS or Regulations do not at present have mandatory status in Jersey. The Environment Act 2021 required the UK government to set a new limit for $PM_{2.5}$. Targets will be set out in an Environmental Improvement Plan.

Part IV of the Act imposes a duty on the UK Secretary of State (SoS) to prepare and publish an air quality strategy outlining standards and objectives for air quality, and duties to be undertaken by local authorities and others for the purpose of achieving those objectives.

The new AQS should contain tough new goals to cut public exposure to particulate matter pollution, as recommended by the World Health Organisation. There is particular focus on PM as this is a key health related pollutant[6].

Table 3: UK proposed air quality targets as part of the Environment Act 2021

Pollutant	**Averaging period**	**Concentration**	
		Current UK limit	**Environment Act 2021**
PM_{10}	24 hour mean	50 µg/m^3	50 µg/m^3
	Annual mean	40 µg/m^3	40 µg/m^3
$PM_{2.5}$	Annual mean	None	10ug/m^3
	Exposure target *	25 µg/m^3	Not determined yet

*$PM_{2.5}$ value is introduced in the new directive and is based on the average exposure index (AEI) [6]

In 2022 the UK government proposed air quality targets for $PM_{2.5}$ as part of the Environment Act 2021:

- A legal target to reduce population exposure to $PM_{2.5}$ by 35% in 2040 compared to 2018 levels, with a new interim target to reduce by 22% by the end of January 2028.
- Legal concentration limits for a number of other key pollutants. The UK already meet the majority of these limits including for sulphur dioxide and coarse particulate matter. They are working towards meeting compliance with a 40µg/m^3 limit for nitrogen dioxide.
- A legal target to require a maximum annual mean concentration of 10 micrograms of $PM_{2.5}$ per cubic metre (µg/m^3) by 2040, with a new interim target of 12 µg/m^3 by the end of January 2028.
- Legal emission reduction targets for five damaging pollutants by 2030 relative to 2005 levels:
- Reduce emissions of nitrogen oxides by 73%.
- Reduce emissions of sulphur dioxide by 88%.
- Reduce emission of $PM_{2.5}$ by 46%

Non-government organisations (NGOs) have expressed disappointment suggesting the date of 2040 be brought forward to 2030. The UK government have just published the Environmental Improvement Plan 2023 and have committed to the targets and commitments above.[7]

2.2.4 Jersey's Air Quality Strategy

The most recent Jersey Air Quality Strategy was published in 2013 and is largely based on the WHO, EU and UK policies described above and its limit values are the same. As Jersey is not an EU member state there is no legal requirement to implement the EU Directive however, the Government of Jersey has previously agreed to meet the limit values. The Jersey Air Quality Strategy works within the EU and UK limit values and puts in place a project plan and policies to ensure compliance. JAQS Feb 2013 FINAL (gov.je) Considering the reductions in concentrations and improvements in technology since the AQS was produced in 2013, it is recommended it is reviewed[8].

2.3 Monitoring Methodologies

2.3.1 Turnkey Osiris particle monitors

The Osiris units (Optical Scattering Instantaneous Respirable Dust Indication System) are investigational instruments that fulfils the dual role of a portable instrument or permanent installation. The existing units were replaced with two new Turnkey Osiris units in October 2008 costing £6,000 each.

The instrument is housed in a sturdy die cast metal lamp post box with internal rechargeable battery and requires an external power source for long term monitoring. Data is recorded in respect of PM_{10}, $PM_{2.5}$, $PM_{1.0}$ and Total Suspended Particles (TSP) as 15-minute averages for the monitoring periods. An Air Quality software program AirQWeb allows the data to be analysed, graphed, the settings on the units to be changed remotely[9].

The Osiris units are also fitted with a circular GFA Whatman 25mm filter, which traps particles and allows them to be subsequently analysed. The filters are changed every 3 months and analysis allows the weight of particles to be determined and this can help in assessing the accuracy of the Osiris. The type of filter was changed in 2022 to 25mm Whatman Cellulose Nitrate Membranes to help reduce interference from silica. Analysis of the Beresford Street and Howard Davis Park filters was carried out by a UK company Socotec Ltd in 2023 and the results can be found in Section 4.4. More information on the Osiris units can be found in Appendix 2.

Photograph 1: The Turnkey Osiris unit[9]

2.3.2 Monitoring sites

The locations of the two sites in St Helier are:

1. an urban roadside site at Beresford Street GPS coordinates 49.185226 -2.103917 to measure traffic emissions from vehicles using Beresford Street. The road is one way and runs next to the central market and gets congested through parts of the day. There are two zebra crossings which also limits traffic flow and 20-minute parking next to the market.

2. a background site at Howard Davis Park, St Clements Road, the GPS coordinates 49.179917-2.097401. The analyser is sited near the centre of the park area approximately 85m from the nearest road i.e. St Clements Road.

Figure 2: Market/Beresford Street monitoring site [10]

Figure 3: The Howard Davis Park background monitoring site[10]

The Osiris is sited approx. 2 m from Beresford Street but at ground level behind the market access gate (see the photograph 2 below). This road is used by up to 6,000 vehicles per day with up to 650 vehicles/hour during rush hour periods. The peak hours are around 7.00 - 9.00 am and between 12.00 pm and 5.00pm each day. Beresford Street doesn't have a defined afternoon rush hour and is more characterised by shoppers looking for parking, delivery vehicles parking outside the market and drivers cutting through St Helier to head east or west.

Previous work has shown that particle levels follow wind direction, wind speed, traffic numbers, vehicle composition and speed closely[11]. There is an increase in particles in the morning rush hour up to lunchtimes and pollution spikes occur when vehicles parking outside the market occasionally leave their engines running. Signs are sited in this area to remind drivers to switch engines off when stationary. The levels are generally lower than the previous monitoring site on Halkett Place site due to absence of delivery and refuse lorries in this area.

The site is also a busy pedestrian area in the heart of St Heliers shopping centre. The unit is co-located with a NOx chemiluminescent analyser and three external diffusion tubes. Results from the NOx equipment and diffusion tubes are the subject of a separate report[2]. Air quality monitoring annual report 2022 (gov.je)

Photograph 2: The position of the Osiris Unit Ref 2131 at the Central Market, Beresford Street, St Helier

This Osiris unit sited at Howard Davis Park was relocated from Havre des Pas on the 17th December 2011. It is specifically located to measure particles from a site not directly affected by traffic emissions. The site is 350 m from the coast and 85m from the nearest road (see photograph 3 below). The Howard Davis Park Osiris analyser was moved in June 2021 further into the park to the south of the band stand to allow easier access and to provide more representative background measurements.

Particle levels will be affected by non anthropogenic sources such as sea salt and sand particles when the wind is from the south, southeast/ west, which can give elevated readings and false exceedances.

It is also possible to determine the approximate percentage contribution of natural particles. Studies in New Zealand have determined the concentration of sea salt in certain weather conditions to be as high as 28%.[11]

Photograph 3: The position of the Osiris unit Ref 2264 at Howard Davis Park from June 2021

2.3.3 Impact of Traffic flow

Beresford Street is a one way street and there are two speed bumps/pedestrian crossings. This has led to an increase in traffic congestion. (See photograph 5 below)

Photograph 4: Map showing the direction of traffic flow in the area and the previous and new Osiris monitoring sites [10]

3.0 Quality assurance and quality control

It should be noted that the Turnkey Osiris units are not EU type approved as per the reference method specified in the Air Quality Standards Regulations 2010 *i.e.* EN 12341: 1998 "Air Quality — Field Test Procedure to Demonstrate Reference Equivalence of Sampling Methods for the PM_{10} fraction of particulate matter". [12]

The Osiris units are less accurate than the EU type approved FIDAS / gravimetric type units used in monitoring stations throughout the UK and the European Union. This is relevant because it means the data from the Osiris units provided is indicative only due to the reduced accuracy. The units provide a useful screening tool to determine if more detailed measurement is required.

The EU type approved measurement principle is based on the collection on a glass fibre filter of the PM_{10} fraction of ambient particulate matter and the gravimetric mass determination. The Osiris units use a laser to count and size the particles.

Ideally an EU type approved FIDAS particle measurement analyser, if purchased, would assist in allowing the Osiris units to be co-located for a period to assess their accuracy compared to the more accurate equipment. It would be possible to determine a bias adjustment factor if appropriate. The Osiris analysers tend to under read as they have a heated inlet (50°C) which prevents water vapour particles being measured. More information on the OSIRIS units can be found in Appendix 2

3.1 Data capture

In 2022 data capture was 64% for the Beresford Street and 79% for the Howard Davis Park sites. The data capture was reduced due to equipment issues and delays during calibration in the UK caused by staffing levels at Turnkey Instruments Ltd the manufacturer of the units. An annual data capture rate of 85% or greater for ratified data is recommended in the Defra Technical Guidance LAQM TG(16)[13] in order to assess annual data sets against long term targets.

3.2 Publication of the data

The original modems were replaced in 2013 by routers connected to an 'always open' 3G connection which enables the Osiris data to be displayed in near real time. They use fixed IP address end to end sim cards within the modem with a webserver. The daily PM_{10} results are available at the following three websites Air quality monitoring (gov.je) [2], https://www.airqweb.co.uk/ and http://jerseyair.ricardo-aea.com/index.php?site_id=JERS [12]

4.0 Results

The number of days on which the daily average PM_{10} figure exceeded 50µg/m^3 for both sites is shown in Table 4 below.

Site	Days data obtained %	PM_{10} Exceedances (>50µg/m^3) (max 35 exceedances) 24 hour periods	PM_{10} annual mean (limit 40 µg/m^3)	$PM_{2.5}$ annual mean (target 2020 25µg/m^3)
Howard Davis Park *	290 (79%)	15	21.38	9.53
Market/Beresford Street	236 (64%)	14	21.79	11.27

Table 4. Number of daily PM_{10} exceedances and annual means at both sites (*background site)

Table 3 above shows:

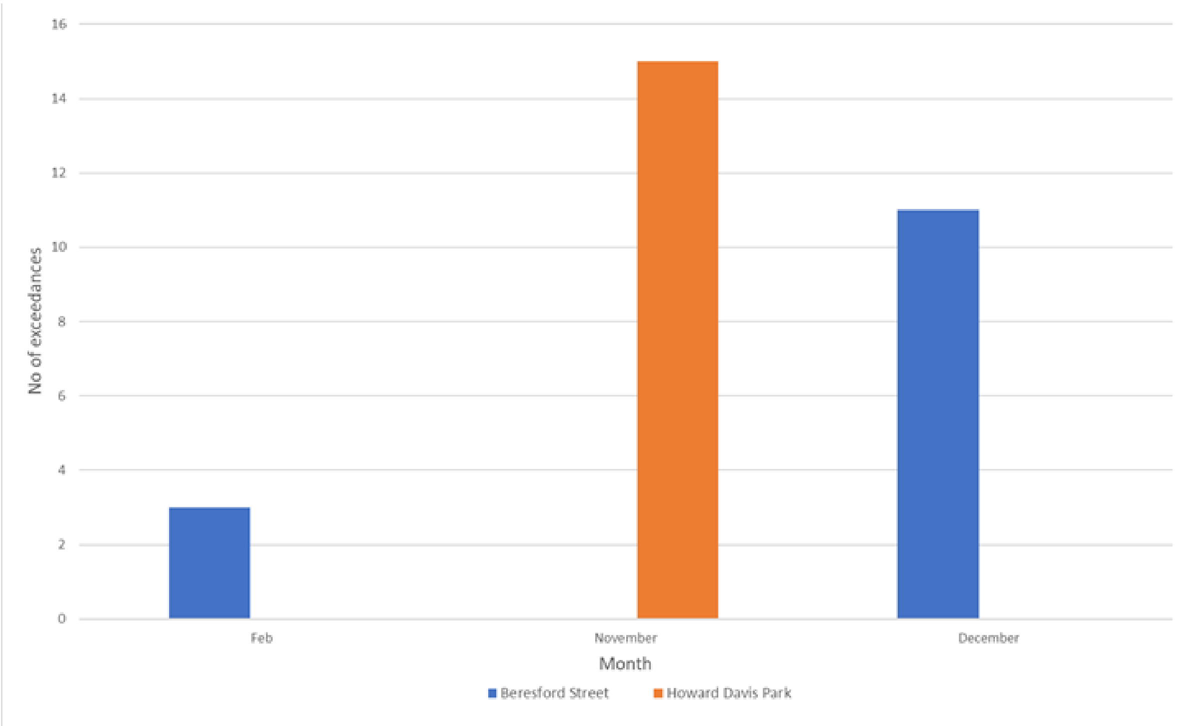
1. the number of days/percentages the units operated.
2. the number of PM_{10} exceedances (24 hour periods).
3. The PM_{10} and $PM_{2.5}$ annual means (µg/m^3)

4.1 Exceedances:

There were 14 exceedances at the Beresford Street site and 15 at the Howard Davis Park site. The heated inlet at the Howard Davis analyser failed in November 2022 resulting in water vapour particles being measured. This caused a number of elevated 24 hour averages and false exceedances. The EU health limit is 50 µg/m^3 as a 24-hour average and the EU Directive allows 35 exceedances per year so both sites were within this limit.

The exceedances at the Beresford Street occurred in February, November and December, which is to be expected as poor air quality tends to occur in the winter and spring months. At Howard Davis Park all the exceedances occurred in November when the heated inlet failed. This is shown in figure 3 below.

Figure 4 The number of exceedances by month for both sites in 2022



Figures 5 and 6 below show the 24-hour average particle levels for 2022 at both sites with the exceedances. As expected, the concentrations are greater for Beresford Street due to traffic emissions. Traffic heads west along Beresford Street past the market and then turns north or south on to Halkett Place. Vehicles are looking for parking or is cutting through St Helier and there are a number of delivery vehicles servicing the market each day.

The peak hours are around 7.00 - 9.00 am and between 12.00 pm and 5.00pm each day. Previous work has shown that particle levels follow traffic numbers, vehicle composition and speed closely.

The levels are lower at Howard Davis Park as expected and indicate background particle levels associated with non-traffic emissions. The exceedances at Howard Davis Park were due in part to the failure of the heated inlet and so water vapour was measured erroneously. There were periods of no measurements in the graphs below when the units were being serviced/calibrated in the UK.

Figure 5. PM_{10} and $PM_{2.5}$ 24 hour averages for 2021 at Beresford Street site showing the 50 µg/m^3 limit.

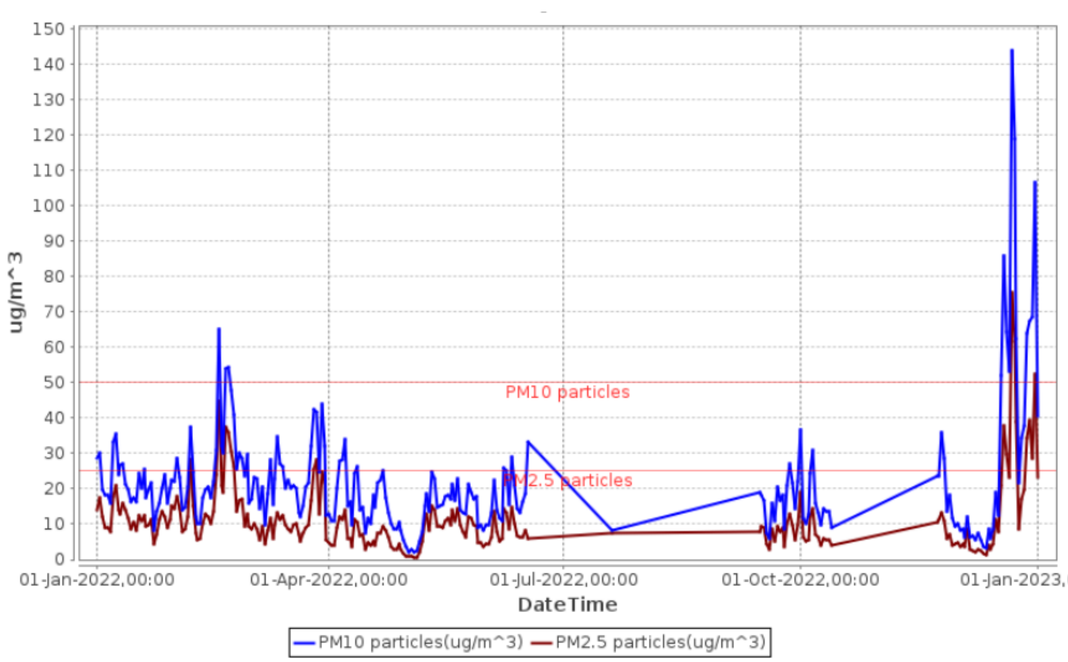
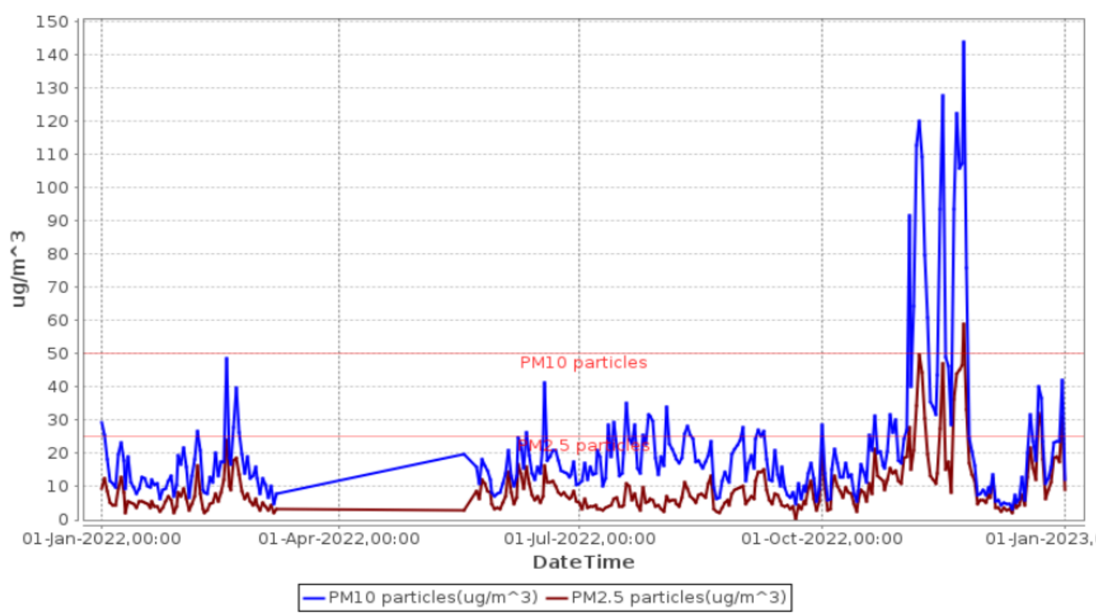


Figure 6. PM_{10} and $PM_{2.5}$ 24-hour averages for 2021 at Howard Davis Park site showing the 50 µg/m^3 limit



4.2 Comparison with WHO, EU, and UK Health limits, guidelines and targets[4,5,6]

Site	Days data obtained	WHO 2021 Air Quality guideline (AQG) 24 hour for PM_{10} (>45µg/m³)	WHO annual mean PM_{10} (AQG) 2021 (15µg/m³)	WHO annual mean (AGQ) $PM_{2.5}$ 2021 (5µg/m³)
Howard Davis Park *	290(79%)	15 exceedances	21.38	9.53
Beresford Street	234 (64%)	14 exceedances	21.79	11.27

Table 5. The 2021 WHO Air quality guidelines and targets[4]

The PM_{10} 24 hour Air Quality Guideline (AQG) of 45 µg/m³was exceeded at both sites (15 and 14 exceedances respectively). The PM_{10} and $PM_{2.5}$ annual levels also exceeded the WHO Air Quality guidelines at both sites: 15µg/m³ (PM_{10}) and 5µg/m³ ($PM_{2.5}$) respectively.

Table 6: EU standards Directive 2008/50/EU[5]

Pollutant	Concentration µg/m3	Averaging period	Legal nature
PM10	50 40	24 Hour Annual	met by 01/01/05 (35 exceedances / yr) met by 01/01/05
PM2.5	25 20	Annual Annual	met by 01/01/10 met by 01/01/15
PM2.5	20 (AEI) (Average exposure index)	Based on 3 year average	Legally binding in 2015 (Averages 2013 - 15)
PM2.5 Exposure Reduction target	Percentage reduction* + all measures to reach 18 µg/m3 (AEI)	Based on 3 year average	Reduction to be attained where possible by 2020 determined on the basis

			of the value of the exposure indicator in 2010

*Depending on the value of AEI in 2010, a percentage reduction requirement achieve 18 µg/m3 by 2020.
0,10,15, or 20%) is set in the Directive. If AEI in 2010 is assessed to be over 22 µg/m3, all appropriate
measures need to be taken to achieve 18 µg/m3 by 2020

The PM_{10} exceedances did not exceed the 24-hour health limit of 50µg/m3 (35 exceedances/yr). The PM_{10} and $PM_{2.5}$ annual levels were both below the annual health limits of 40 µg/m3 and 25 µg/m3 (to be achieved by 2010) and 20 µg/m^3 (to be achieved by 2015) respectively but exceeded the exposure reduction target of 18 µg/m^3.

Table 7: UK Health limits [6]

Particles PM	Limit	UK Air Quality Standards Regulations 2010 [6]
PM_{10} µg/m3	Annual mean	40
	24 Hour mean	50 (35 exceedances/yr)
$PM_{2.5}$ µg/m3	Annual	25
	24 Hour mean	N/A

The PM_{10} exceedances did not exceed the 24-hour health limit of 50µg/m3 (35 exceedances/yr). The PM_{10} and $PM_{2.5}$ annual levels were both below the UK health limit values of 40 and 25µg/m^3 respectively.

4.3 Influences on air quality

A major influence on particle levels is weather conditions. This is discussed in more detail in Appendix 5. There is a correlation between traffic composition, volumes, speed and particulate pollution. Levels increase on still days when dispersion is poor. Also, with fronts coming across the island this can influence the contribution of non anthropogenic (non man made) particles.

Research findings indicate that roads generally influence air quality within a few hundred meters, about 100 – 200m downwind from the vicinity of heavily travelled roads or along pollution corridors with significant traffic. This distance will vary by location and time of day or year, prevailing meteorology, topography, nearby land use, traffic patterns, as well as the individual pollutant.

$PM_{2.5}$ levels can stay relatively consistent, as it is more homogeneous regionally due to its longer atmospheric lifetime and diversity of (urban, rural and regional) sources.

Emissions can be elevated near busy roads and arise from multiple vehicle-related processes, including tailpipe exhaust, evaporation of fuel, brake and tyre wear, and dust resuspended by traffic. The presence of walls, buildings and vegetation also has an impact on pollutant dispersion.

Generally, the more traffic, the higher the emissions; however, certain activities like congestion, stop-and-go movement or high-speed operations can increase emissions of certain pollutants. Both heavy-duty vehicles and light-duty petrol vehicles emit a range of pollutants. However, their contributions to different types of compounds are not the same.

Per vehicle, heavy-duty diesel vehicles can emit more of certain pollutants (e.g., NOx and PM) and contribute disproportionately to the emissions from all motor vehicles. Petrol cars generally emit more of other pollutants (e.g., CO, and benzene, a volatile organic compound VOC). 14

When there are still days dispersion is poor and pollutants can accumulate locally, particularly in areas such as Beresford Street, where the streets have a 'canyon' effect. Wind travelling from the west may assist dispersion and dilution on Beresford Street as it runs east to west. A percentage of PM will be from off island during easterly winds bringing secondary particles from Europe.

Figure 7. Correlation of particle levels (ug/m3) with traffic density (Number of vehicles divided by 10) in the year 2000 historical data). The measurements used a Tapered elliptical oscillating microbalance (TEOM) EU type approved equipment compared to the Osiris unit.[14]

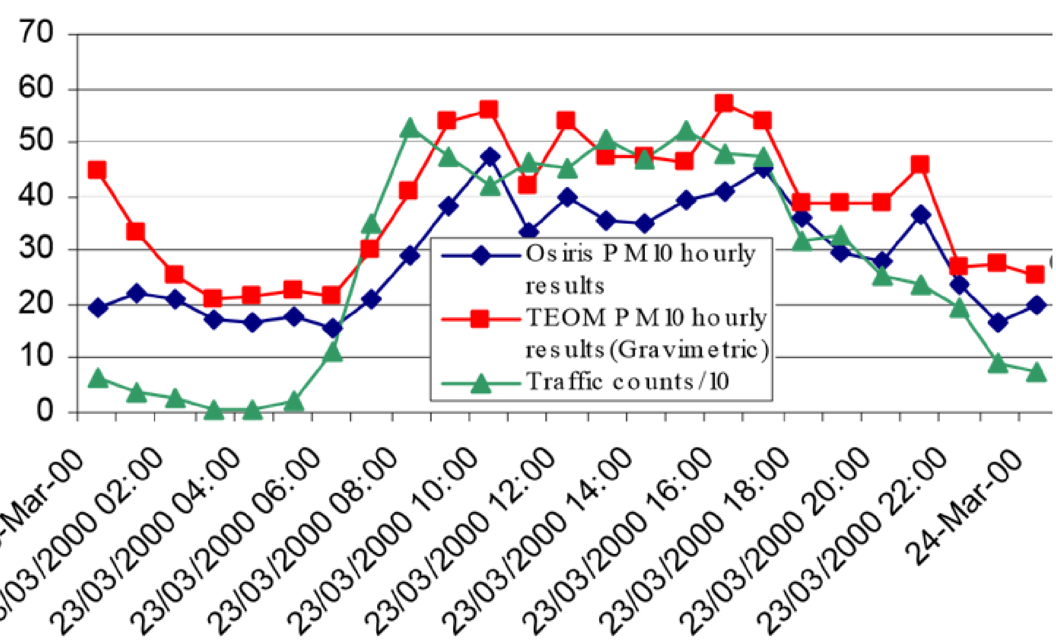


Figure 7 shows how particles increase albeit with a slight delay as traffic numbers increase at around 07.00 and during the afternoon and stay relatively high as traffic hunts for parking and cuts through central St Helier heading west or east[14]

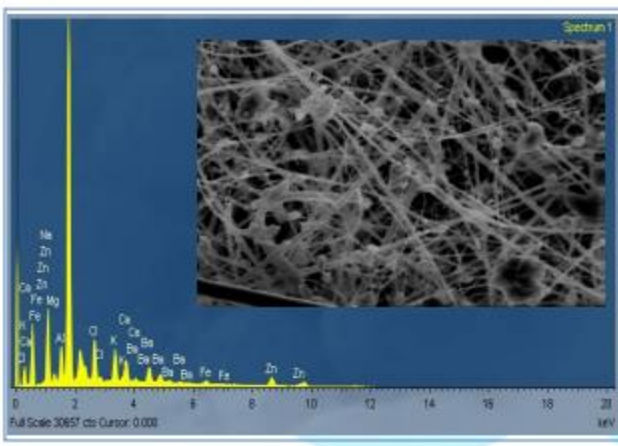
4.4 Glass fibre filter analysis and results

Examination by scanning Electron Microscopy-Energy Dispersive X-Ray Analysis was carried out by Socotek Ltd for the Beresford Street and Howard Davis Park filter samples. The analysis allows a degree of source apportionment.

The samples were systematically analysed looking at 50 particles and the proportions of each are then calculated to give an overall percentage of each category. Usually, only particles greater than 20 microns in size are examined. A pie chart for each filter is provided detailing the various constituents found. The photomicrographs for the Market/Beresford Street and Howard Davis Park sites are provided below in Figures 8 and 9.

Figure 8. Scanning Electron Microscopy (SEM-EDS) report for the Market /Beresford Street filter.

SITE: MARKET SITE - KERBSIDE **SAMPLE TYPE: GFA FILTER**



General Area Analysis

Element	Relative Composition (% w/w) *
Sodium	27
Magnesium	4
Aluminium	16
Chlorine	11
Potassium	8
Calcium	6
Iron	2
Zinc	11
Barium	15

* Relative amount of element present when compared to the other elements listed.
Carbon and oxygen were detected but not quantified.
The relative composition is only indicative and should be confirmed with the appropriate recognised quantitative techniques.
Please note that carbonaceous matter is not accounted for within the general area analysis carried out.

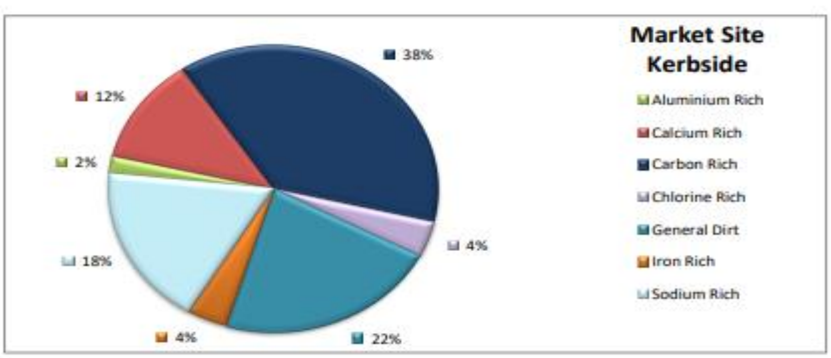
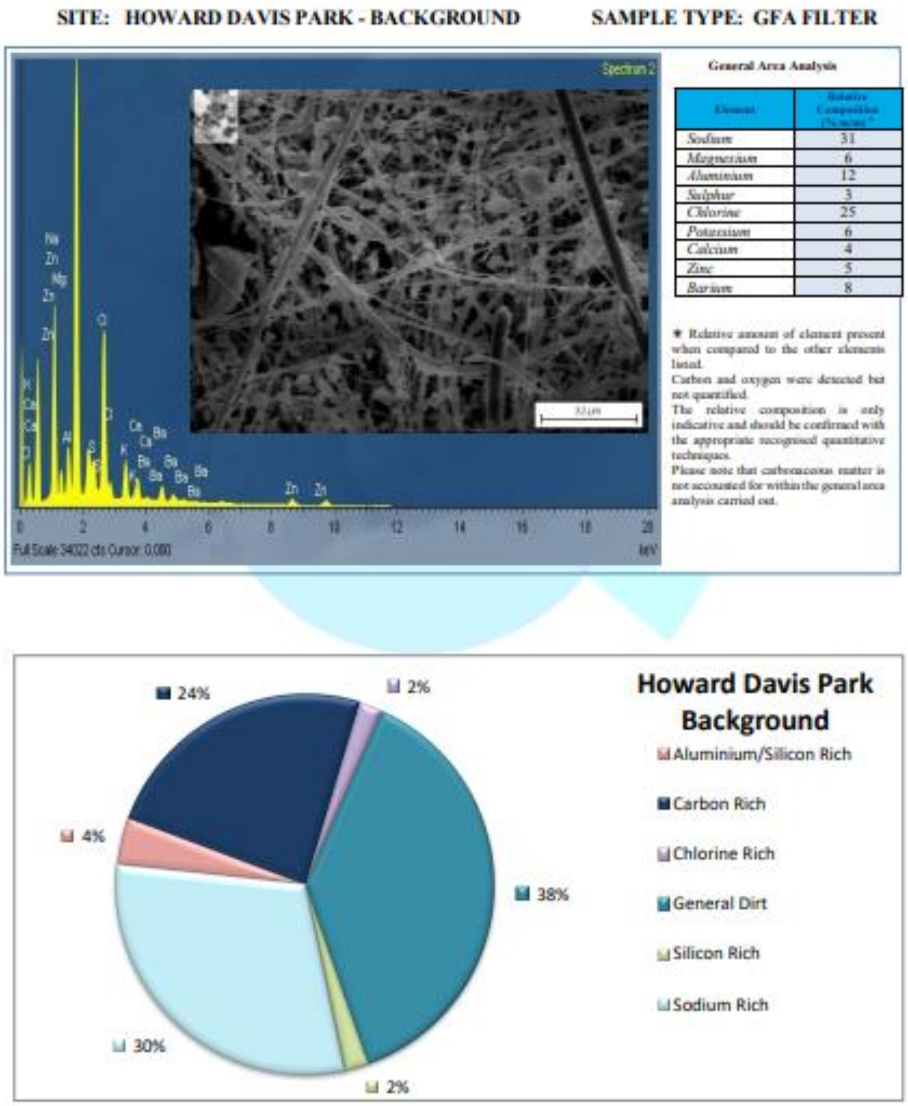


Figure 9. Scanning Electron Microscopy (SEM-EDS) report for the Howard Davis Park filter.



The results indicate:

1. Market/Beresford Street site: as expected the largest proportion of particles analysed are carbon rich which is associated with particle emissions from vehicles. The proportion of general dirt was 22% and this is categorised as irregular particles containing aluminium, silicon, calcium, potassium and iron in varying proportions. Sodium 18% is present as the site is likely to be associated with wind blown sea salt. Iron 4% and chlorine 4% are present in smaller proportions.

2. Howard Davis park site: as this is a background site levels of sodium 30% were present in higher amounts compared to the market/Beresford Street site associated with sea salt. Levels of silicon 2% and aluminium /silicon 4% were present which are likely to be associated with windblown sand.

   Levels of carbon 24% are lower than the Market/Beresford Street kerbside site as expected as the nearest road is 84m away and general dirt 38% is significantly higher than the Market/Beresford street kerbside site.

Previous reports indicate the percentage carbonaceous matter associated with traffic on Halkett Place was:

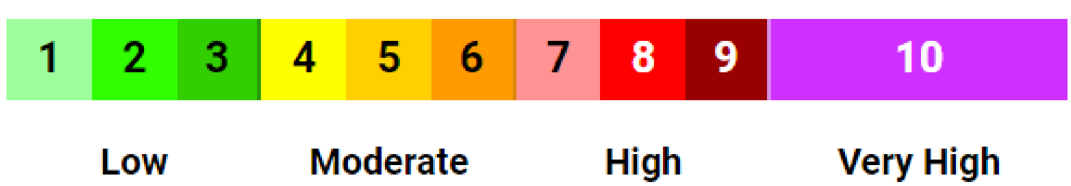
1. 2005: 18%
2. 2006: 28%
3. 2007: 55%
4. 2009: 65%
5. 2010: 28%

Care is needed when drawing conclusions as analysis is of a small proportion of the filter and the percentage of material will vary from day to day depending on traffic volumes, and weather conditions. Further work is recommended on determining a bias adjustment figure to take into account the sources of silica and salt on particle levels in Jersey.

4.5 Pollution categories

In the UK most air pollution information services use the Air Quality index (AQI) and colour coded banding system approved by the *Committee on Medical Effects of Air Pollution Episodes* (COMEAP). The system uses 1-10 index divided into four bands to provide more detail about air pollution levels in a simple way, similar to the sun index or pollen index:

- **1-3** (Low)
- **4-6** (Moderate)
- **7-9** (High)
- **10** (Very High)



Levels were low at both sites for much of the year, but higher levels were observed, particularly at the Beresford Street site. This included 10 incidents of moderate air pollution and 1 incident of high air pollution and 3 incidents of very high pollution. High and very high levels are likely to be associated with traffic congestion, vehicles leaving engines running and particles being resuspended.

There were 275 days of low air pollution. There were 2 days of moderate air pollution. There were 5 and 8 Incidents of high or very high pollution respectively at the Howard Davis Park site.

The high levels at Howard Davis Park were in November and these were due to the heated inlet failing. The Osiris sensor measured water vapour causing levels to be artificially high. Appendix 4 provides explanation of the terms low, moderate, high and very high air pollution[15].

Air Pollution Bandings:	24 Hour mean	Beresford St	Howard Davis Park
Low Air Pollution:	<50 µg/m^3	222	275
Moderate Air Pollution:	50 - 74 µg/m^3	10	2
High Air Pollution:	75 - 99 µg/m^3	1	5
Very High Air Pollution:	>= 100 µg/m^3	3	8

Table 8. Daily mean readings shown as the number of days where PM_{10} fell into the four air pollution bandings[15].

4.6 Comparisons with previous years

As the Osiris units have been in operation since 2002 it allows comparison with previous years data. Figure 7 below presents that the number of exceedances of the air quality objective of 50µg/m^3 as daily mean (which allows 35 exceedances per year) for the following historic sites:

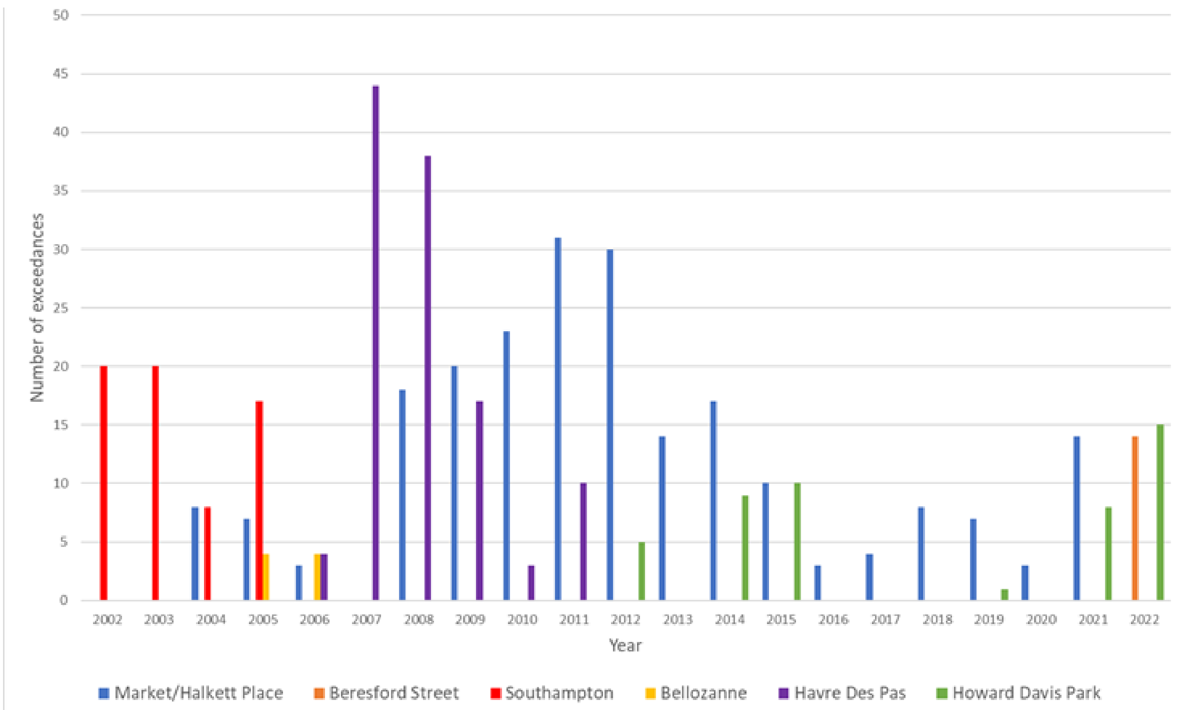
- 2002 – 2007 Southampton Hotel, Weighbridge and Bellozanne valley and
- 2004 – 2011 Market/Halkett Place and Havre Des Pas /Howard Davis Park sites
- 2011 – 2021 Market/Halkett Place and Howard Davis Park Sites
- 2022 – to date Beresford Street and Howard Davis Park Sites

Previously monitoring at the Southampton Hotel site was carried due to the large numbers of traffic movements in this area as it is close to the bus station. The Bellozanne site was chosen to monitor traffic using the incinerator which has now been closed. The Havre Des Pas site was chosen to monitor traffic using the new energy from waste site.

There was a large number of exceedances for the Havre Des Pas site, which was very close to the south coast in 2007 and 2008 (44 and 38) which is likely to be due in part to wind-blown salt and sand particles. Samples analysed on the unit's filter supported the assumption that sea salt was heavily contributing to the PM levels measured.

Care is needed in direct comparison as the data capture and measurement periods varied. The trend at the market was an increasing number of exceedances up to 2011, albeit below the 35 allowable per year. The number of exceedances at both sites reduced at both sites up to 2020 but has increased in 2021 and 2022.

Figure 10. The number of days on which the daily average PM_{10} figure exceeded 50µg/m^3 at the Market and Howard Davis Park and historic sites from 2002 - 2021.



5.0 Conclusions

1. Particle monitoring is undertaken at two sites in St Helier: an urban roadside site in the central market on Beresford Street measuring traffic emissions from Beresford Street and a background site at Howard Davis Park, St Clements Road.

2. The units measure particles in real time (*i.e.* Total Suspended Particles (TSP) and particles of a mean aerodynamic diameter of 10 microns (PM_{10}), 2.5 microns ($PM_{2.5}$) and 1 micron ($PM_{1.0}$) and provide data as 15 minute averages. The data is displayed in real time on the States of Jersey website [Air quality monitoring (gov.je)].

3. Although not legally binding in Jersey, Jersey's parliament has agreed to work towards the European Union Directive objectives. There were 14 exceedances at the Beresford Street site and 15 at Howard Davis Park of the 50µg/m^3 particle levels as a 24-hour average, both sites did not contravene the EU directive limit which allows a maximum of 35 exceedances per year. The exceedances at Howard Davis Park were due in part to the failure of the heated inlet and so water vapour was measured erroneously.

4. The $PM_{2.5}$ data was below the EU and UK health limits. The PM_{10} 24 hour WHO Air Quality Guideline (AQG) of 45 µg/m^{3}was exceeded at both sites. The PM_{10} and $PM_{2.5}$ annual levels also exceeded the WHO Air Quality guidelines at both sites: 15µg/m^3 (PM_{10}) and 5µg/m^3 ($PM_{2.5}$) respectively.

5. The number of exceedances have been decreasing since 2002 but increased in 2021 and 2022. Care is needed interpreting the results as the percentage data capture has varied year on year and levels are influenced by non anthropogenic particles such as sand and salt which can lead to elevated levels. Data collection was relatively low this year around 68% and 79% respectively due to calibration delays in the UK and equipment issues.

6. Particles are associated with a range of health effects. These include effects on the respiratory and cardiovascular systems, asthma, dementia and mortality. The risk of serious illness is likely to be small but prolonged exposure, over many years, may lead to chronic health effects.

7. The main source of particles in Jersey is from road traffic. Levels at the Beresford Street site are broadly what would be expected at a roadside location in the UK. Particle levels increase up to mid afternoon and then drop during the evening and early hours.

8. The PM levels are generally lower at the Beresford Street site are lower than the historic Halkett Place site due to absence of delivery and refuse lorries in this area. Levels at the Howard Davis Park site are typical of an urban background location.

6.0 Recommendations

1. Monitoring should involve the purchase of an FIDAS EU type approved PM measurement analyser to allow increased accuracy of measurement and direct comparison with the UK. It would also allow a bias adjustment figure to be determined to increase the accuracy of the Osiris results. It could also be used for co location/calibration/evaluation of low-cost analysers.

2. Further long-term research should be carried out to assess levels of PM_{10}/$PM_{2.5}$ in Jersey associated with traffic numbers, its mix, and speed and meteorological conditions to establish trends and assess compliance with the European Union Daughter Directive objectives and WHO guidelines.

3. Modelling of particulate matter levels at various locations to highlight particle levels on certain roads to assist with road traffic management and determination of an annual mean $PM_{2.5}$ figure for the Island.

4. Provision of traffic data on Beresford Street to assist in correlating air pollution levels and traffic volume, mix and speed.

5. Consideration of the replacement of the Osiris units in due course with suitable low-cost sensors.

6. Work is needed in conjunction with other stakeholders to update Jersey's Air Quality Strategy and Action plan.

7. It is recommended that source apportionment is assessed to determine the percentage contribution of sea salt. This could allow a bias adjustment to be added to particle results to increase the accuracy of particles associated with traffic emissions.

Appendix 1: Air quality, particles and health

Poor air quality reduces life expectancy in the UK by an average of seven to eight months, with equivalent health costs estimated to be up to £20 billion a year. Improvements between 1990 and 2001 have helped avoid an estimated 4,200 premature deaths a year, and 3,500 hospital admissions a year. A major component of air pollution comes from particles which can be directly emitted (primary) or formed in the atmosphere when gaseous pollutants such as sulphur dioxide and nitrogen oxides react to form fine particles (secondary).

Particles are associated with a range of health effects. These include effects on the respiratory and cardiovascular systems, asthma and mortality. The Expert Panel on Air Quality Standards (now part of Department of Health's Committee on the Medical Effects of Air Pollutants) concluded that particulate air pollution episodes are responsible for causing excess deaths among those with pre-existing lung and heart disease. EPAQS also believes that any risk of lung cancer from the concentrations found in the streets of the UK is likely to be exceedingly small. However prolonged exposure (eg 20-30 years) to respirable particles which are likely to be combined with Polycyclic Aromatic Hydrocarbons (PAH's) originating from unburnt or partially burnt fuel, is likely to be carcinogenic[6]. The impact of road traffic on local air quality is the foremost air quality issue in Jersey.

Particles or particulate matter (PM) are principally the products of combustion from space heating, power generation or from motor vehicle traffic. Pollutants from these sources may not only prove a problem in the immediate vicinity of these sources but can travel long distances. It is estimated that road transport (i.e. combustion of petrol and diesel, brake and tyre wear) is responsible for up to 70% of air pollutants in UK urban areas.[6]

Not all sources of measurable particles are man-made. Wind-blown soils, salt and sand inevitably contribute significantly to the overall figures obtained and it can be difficult to differentiate between these natural sources and the products of combustion which are likely to have more of a negative effect on health. At a previous monitoring site at Havre des Pas, there were a large number of exceedances in 2007 and 2008 (44 and 38) which may be due in part to salt and sand particles. This was confirmed by analysis of the Osiris filters.

The UK Air Quality Strategy aims to reduce the reduced life expectancy impact to five months by 2020. It should be remembered that health effects do not relate solely to the direct impacts of air pollution. By encouraging the use of non-motorised means of transport, such as cycling and walking, as a means of reducing local emissions of pollutants, measures in air quality action plans can help directly improve the health and fitness of local populations. In turn, this may also help individuals to be more resilient to direct ill-effects from air pollution.

Recent research suggests that ultrafine particles associated with sulphur containing diesel emissions are believed to be hazardous to health and there are no international threshold values[5]. (Some combustion processes can lead to discharges of a large amount of very small particles with a diameter less than 100 nm (nanometre = a billionth of a metre). Such particles can be drawn deep into soft lung tissue from where they can transfer directly into the bloodstream[3].

Pollutant	Health effects at very high levels
Nitrogen Dioxide, Sulphur Dioxide, Ozone	These gases irritate the airways of the lungs, increasing the symptoms of those suffering from lung diseases
Particles	Fine particles can be carried deep into the lungs where they can cause inflammation and a worsening of heart and lung diseases
Carbon Monoxide	This gas prevents the uptake of oxygen by the blood. This can lead to a significant reduction in the supply of oxygen to the heart, particularly in people suffering from heart disease

Table 9. Some common pollutants and their principal effects on health[3].

Appendix 2: The Turnkey Osiris Particle Monitor

The Osiris (Optical Scattering Instantaneous Respirable Dust Indication System) is an investigational instrument that fulfils the dual role of a portable instrument or permanent installation. A pump draws in air which is analysed by the unit for particulate content, which is then recorded to internal memory. The accuracy of the units is +/- 10%, and they are sent annually to the UK for calibration and service.

The instrument is housed in a sturdy die cast metal box with internal rechargeable battery and requires an external power source for long term monitoring. Data is recorded in respect of PM_{10}, $PM_{2.5}$, $PM_{1.0}$ and Total Suspended Particles (TSP) as 15-minute averages for the monitoring periods. Up until mid-2013, each 24-hour period was saved in a folder for downloading manually by modem to a computer where further analysis of the data could take place. An Air Quality software program allows the data to be graphed and copied into Microsoft Excel for further analysis.

The instrument measures and records the concentration of airborne particles using a proprietary laser (nephelometer). An internal pump continuously draws an air sample through the nephelometer which analyses the light scattered by individual particles as they pass through a laser beam. These same particles are then collected on the reference filter. The nephelometer's dedicated microprocessor can analyse the individual particles even if there are millions of them per litre. This allows the size fractions to be determined at concentrations up to several milligrams/m^3.

The light scattered by the individual particles is converted into an electrical signal which is proportional to the size of the particle. A unique feature of the Turnkey nephelometer is that only light scattered through very narrow angles 10 degrees or less is measured. At this narrow angle the amount of light scattered is virtually the same for say black diesel or white limestone particles of the same size. That is, it doesn't depend on the material composition of the particle. On the other hand, the easier to measure right angle 90° scatter used by some earlier scattering instruments is highly dependent on material composition with white particles apparently scattering much more light than black ones of the same size.

The light scattered by airborne particles can be thought of as consisting of three components. Light reflected from the surface of the particle, light refracted through the particle and light which is diffracted from its original path by the presence of the particle. The intensity of the light scattered by reflection or refraction strongly depends on the type of particle. Thus a white limestone particle will reflect much more light than a black diesel fume particle of the same size. On the other hand, the diffracted component depends only on the size of the particle and is independent of its material composition.

For irregularly shaped particles, light, which is reflected and refracted, tends to be scattered over all possible directions. The diffracted component, however, tends to be scattered only through very small angles. For example, for a 5 micron diameter particle, 90% of the diffracted light is scattered by less than 10 degrees from the original direction of the light beam.

The intensity of the light pulse is therefore an indicator of particle size, from this the microprocessor is able to calculate the expected mass of the particle. It assumes the material density of the particle is 1.5 grams per cc, which for most airborne dusts is a good approximation but the mass calibration factor can be adjusted to compensate for different material types.

Having evaluated the mass of the particle, the microprocessor then evaluates the likely chance of deposition of the particle according to the sampling convention being used (PM_{10}, thoracic, and so on) as shown in figure 19 below. Thus, for the thoracic convention a 6 micron particle has an 80.5% chance of deposition, hence only this percentage of its evaluated mass is accumulated.

Osiris Particle Monitors use a heated inlet (at 50^{o}C) to evaporate water vapour particles which would otherwise result in inaccurately high readings. However, it is now accepted that evaporation of volatiles/particles also occurs; resulting in lower than expected results. Research has suggested that in the case of the TEOM particle monitor, that such results should be increased by up to 30% to allow for this potential inaccuracy. However, there are uncertainties as to whether 30% is appropriate to the Osiris units in and will vary on the geographical area.[9,14]

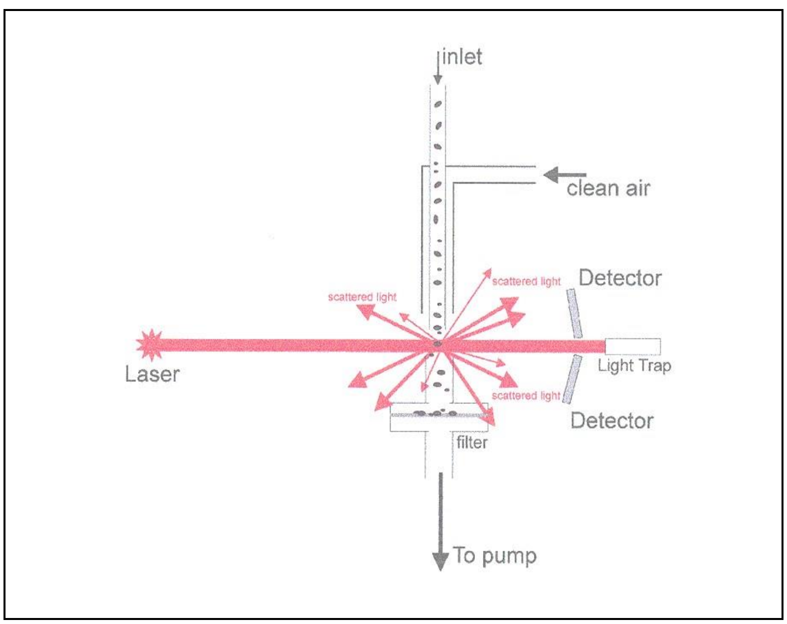
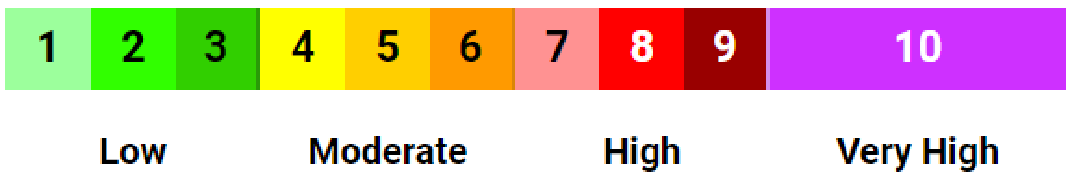


Figure 11: The Osiris particle monitor [9]

Appendix 3: Air Pollution Information Service - Index and Bands

In the UK most air pollution information services use the index and banding system approved by the *Committee on Medical Effects of Air Pollution Episodes* (COMEAP). The system uses 1-10 index divided into four bands to provide more detail about air pollution levels in a simple way, similar to the sun index or pollen index:

- **1-3** (Low)
- **4-6** (Moderate)
- **7-9** (High)
- **10** (Very High)



The overall air pollution index for a site or region is calculated from the highest concentration of five pollutants:

- Nitrogen Dioxide
- Sulphur Dioxide
- Ozone
- Carbon Monoxide
- Particles < 10µm (PM10)

Air Pollution Forecasts

Air Quality Forecasts are issued on a regional basis for three different area types:

- In towns and cities near busy roads
- Elsewhere in towns and cities
- In rural areas

Forecasts are based on the prediction of air pollution index for the worst-case of the five pollutants listed above, for each region.

Health Advice

Latest studies report that:

When air pollution is LOW (1-3) effects are unlikely to be noticed even by those who are sensitive to air pollution.

When air pollution is MODERATE (4-6) sensitive people may notice mild effects but these are unlikely to need action.

When air pollution is HIGH (7-9) sensitive people may notice significant effects and may need to take action.

When air pollution is VERY HIGH (10) effects on sensitive people, described for HIGH pollution, may worsen.

Air pollution can cause short-term health effects to sensitive individuals (people who suffer from heart disease or lung diseases, including asthma). Effects on sensitive people can be reduced by spending less time outdoors. 'Reliever' inhalers should lessen effects on asthma sufferers.

More details on effects, including long-term, are available in a free leaflet *Air Pollution - what it means for your health*, which is available from the gov.uk website[16].

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

Table 10. Air Pollution Bandings and Index and the impact on the health of people sensitive to Air Pollution[15]

Appendix 4: Sources of Particles

People who live, work, or attend school near major roads appear to have an increased incidence and severity of health problems that may be related to air pollution from road traffic.

Furthermore, according to a 2016 study published in *Environmental Science: Processes & Impacts*, air pollution concentrations at the centreline of the road are highest and can be several times higher again than concentrations on the side of the road. It is these centreline concentrations that reflect the air getting into vehicles.[17]

Health effects that have been associated with proximity to roads include asthma onset and aggravation, cardiovascular disease, dementia, reduced lung function, impaired lung development in children, pre-term and low-birthweight infants, childhood leukaemia, and premature death. Further information on the health effects can be found in Appendix 1.

A coroner made legal history in 2013 in the UK by ruling that air pollution was a cause of the death of a 9-year-old girl Ella Kissi- Debrah's. Her death was caused by acute respiratory failure, severe asthma, and air pollution exposure. [1]

Particles can originate from man-made and natural sources. They can be differentiated in a number of ways:

a. Size of particle for example coarse 2.5 microns – 10, fine <2.5 (traffic emissions of concern tend to be PM_{10} and below), see Figure 1 above.
b. Source location for example immediate local, urban background or regional including distant sources.
c. Sources: primary or secondary particles: primary particles from road traffic (exhaust and non - exhaust), domestic, commercial combustion, aircraft, shipping etc and biomass burning; secondary organic aerosols (SOA) and secondary inorganic aerosols (SIA) formed by chemical reactions in the atmosphere.
d. Main source types for example re-suspended dusts, tyre wear, fugitive dusts, traffic exhaust emissions, stockpiles, quarries, and construction.
e. Typical contribution to annual mean concentrations.

Anthropogenic (Man-made):

a. Vehicular transport particularly diesels
b. Domestic heating: coal, wood, oil, and less contribution from gas
c. The energy from waste plant
d. Oil fired power station although a significant amount of power comes from the French undersea link.
e. Construction and quarrying
f. Bonfires

Natural: Non- anthropogenic

a. Sea salt and sand
b. Wind-blown soil
c. Volcanoes
d. Dust storms
e. Water vapour[3]

Box 8.1: Approximate contributions to PM_{10} concentrations (2002)

Type of particle	Source location	Main source categories	Main source types	Typical contribution to annual mean concentration ($\mu g/m^3$ gravi.)
Coarse 2.5-10µm	Immediate local (very close)	Traffic	resuspended dusts tyre wear	1 - 6
		Industry	fugitive dusts stockpiles quarries construction	variable, up to 5
	Urban background	Traffic	resuspended dusts tyre wear	1 - 2
		Industry	fugitive dusts stockpiles quarries construction	variable, up to 2
	Regional (including distant sources)	Natural	resuspended dust/soil sea salt biological	2 - 3 1 - 2 1
Fine <2.5µm	Immediate local (very close)	Traffic	vehicle exhaust	1 - 4
		Industry	combustion industrial processes	variable
		Domestic	coal combustion	variable
	Urban background	Traffic	vehicle exhaust	1 - 4
		Industry	combustion industrial processes	variable, up to 8
		Domestic	coal combustion	variable, up to 8
	Regional (including distant sources)	Secondary	power stations industrial processes vehicles	4 - 8
		Primary (Imported)	power stations vehiclesw industrial processes	1 - 2
		Natural	sea salt	<1

Figure 12: Approximate contributions to PM_{10} concentrations[3]

Researchers in New Zealand found that natural sources of PM_{10} accounted for between 23% and 59% of total PM_{10} respectively at two sites on days when pollution levels were recorded as high. Salt from sea spray contributed approximately 28% of the PM_{10} and a further 31% was from windblown soil [11].
Particles can be primary or secondary and involve complex chemistry in the atmosphere. (See below)

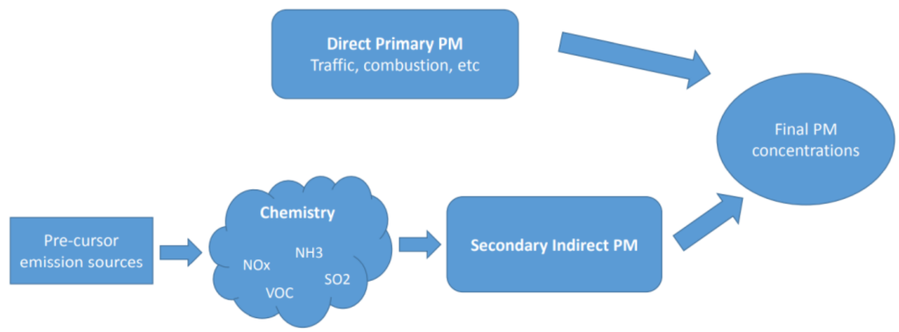


Figure 13: Formation of PM10 through complex chemistry in the atmosphere[1]

Appendix 5: The Importance of Weather and Air Quality

Jersey's meteorological conditions

Jersey's prevailing wind directions are south-westerly, westerly or north-westerly. It is generally accepted that the strength of prevailing winds plays a key role in preventing conditions that allow air pollution to increase. As Jersey is an Island it should be less likely to suffer from chronic air pollution episodes than inland UK towns. The following charts in Figure 11 display graphically the wind directions gathered from 30 years of data from between 1971 and 2000. The prevailing wind can be clearly seen to be from a Westerly quadrant, although north-easterlies and southerlies are also not uncommon particularly in the summer and autumn.

Seasonal variations are quite noticeable, but the influence of westerlies is clear throughout the year. The effect of this is that relatively clean air is most frequently blown in from over the Atlantic rather than from the direction of urban European centres which are more likely to contain a pollutant element. This means generally that air pollution is low in Jersey apart from hotspots areas of car congestion and the tunnel.

Many of the streets in St. Helier are 'canyon' type streets which means that air pollution can take longer to disperse and may be less affected by wind speed and direction than a more open site.

The relationship between meteorological conditions and particle levels is not entirely clear. As wind speed increases particle levels are generally reduced. The monitor at the Market site is in a street canyon which may reduce the dispersion and dilution of particles. As wind passes over the top of the buildings an eddying effect can occur which causes circular dispersion[9]. In dry conditions wind may also re-suspend particles increasing levels. Also increased wind speed suspends sea salt and sand particles which can be moved inland causing elevated results[18].

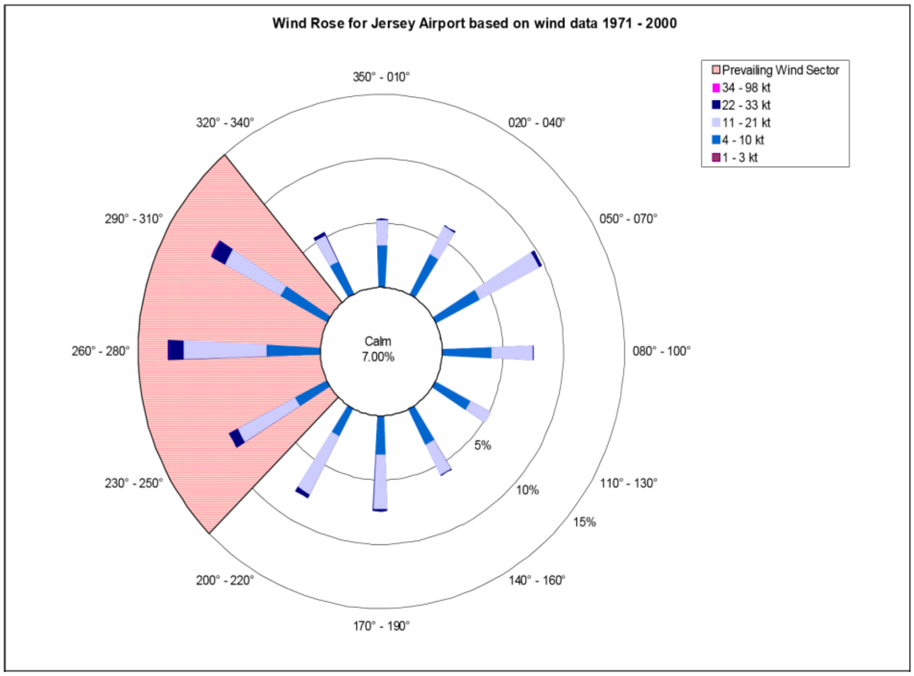
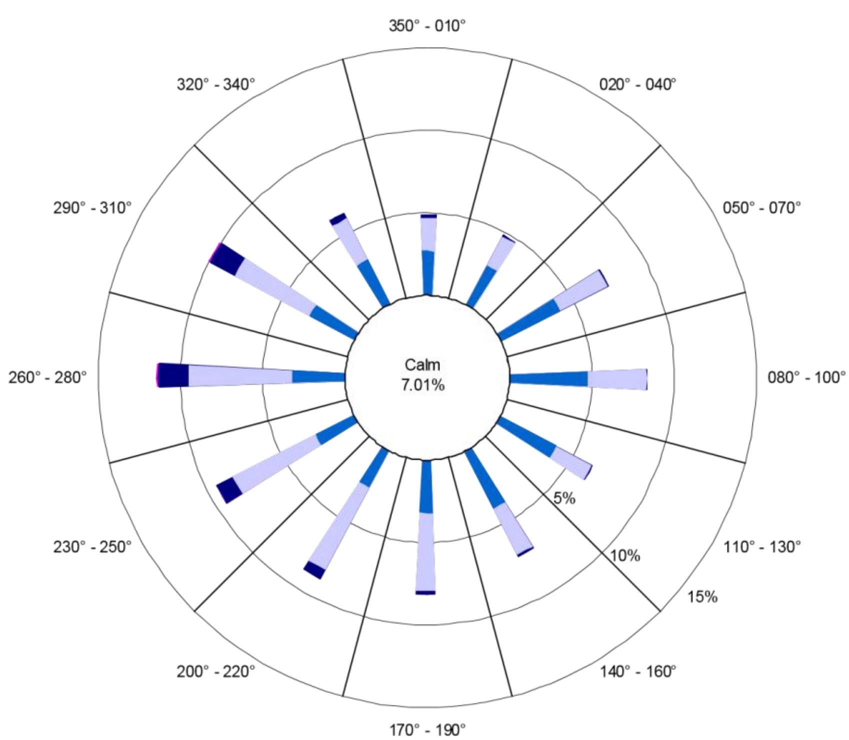
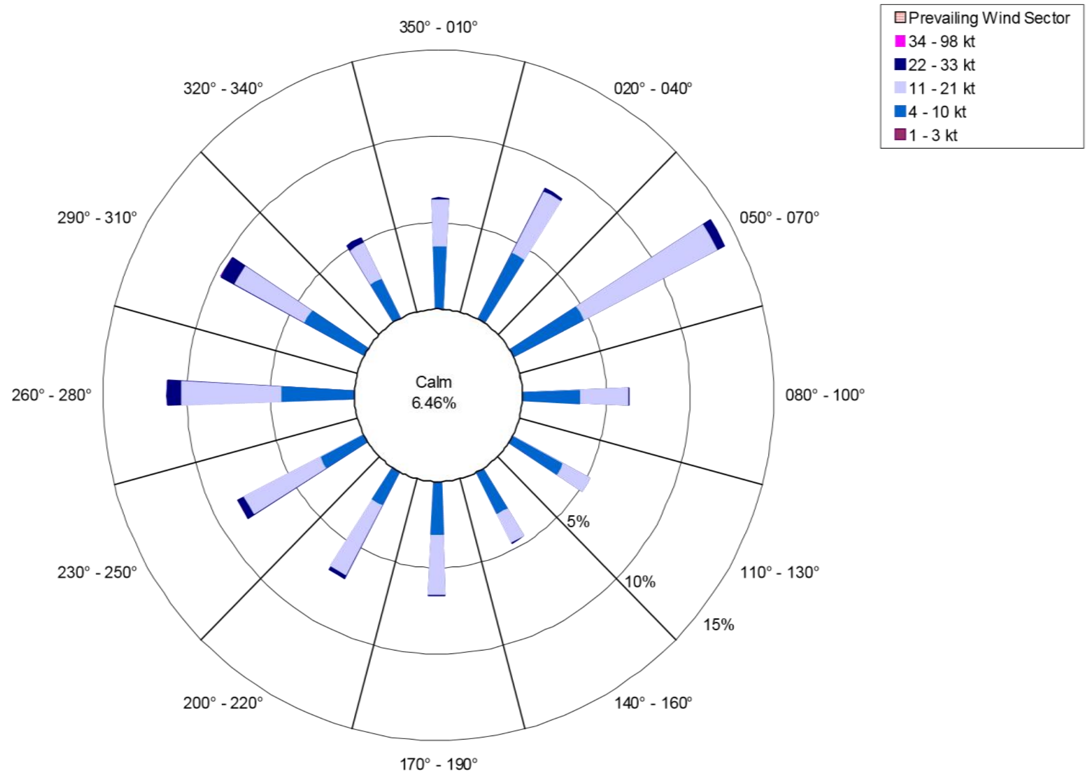


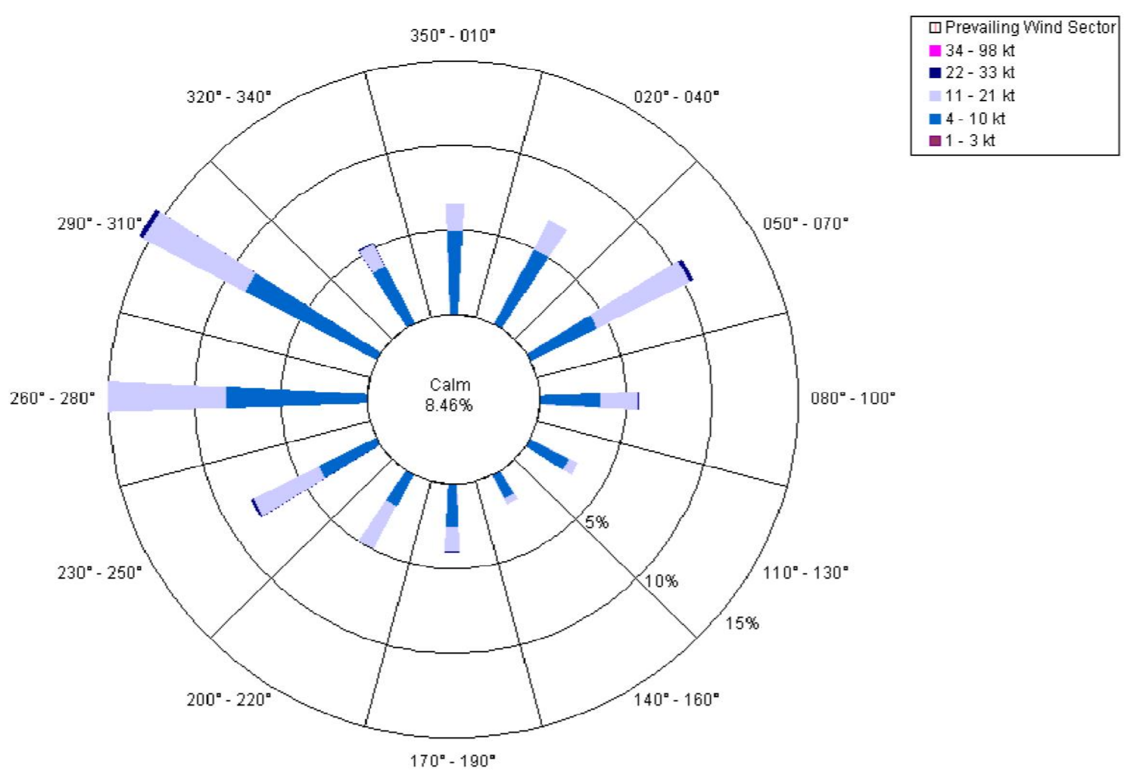
Figure 14: Wind roses for each of the four seasons at the airport. Data taken from 1971 to 2000 inclusive (wind speed in knots). *(Courtesy of Jersey Meteorological Department)*[19]

Spring - Wind Rose for Jersey Airport based on wind data 1971 - 2000

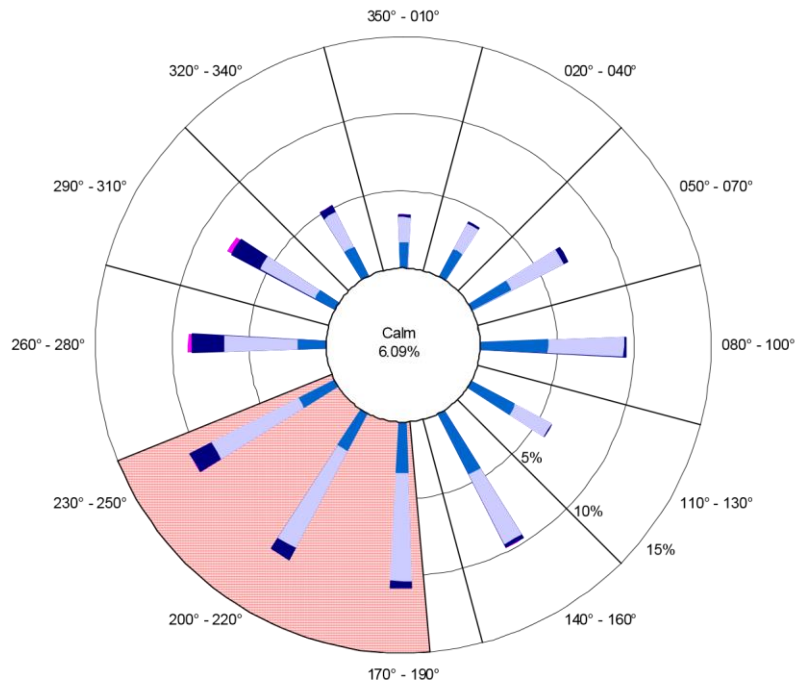




Summer - Wind Rose for Jersey Airport based on wind data 1971 - 2000



Autumn - Wind Rose for Jersey Airport based on wind data 1971 - 2000



Winter - Wind Rose for Jersey Airport based on wind data 1971 - 2000

The eventual fate of most pollutants emitted to atmosphere is chiefly governed by the weather. Wind speed and direction are crucial, as is the stability of the atmosphere as this will govern how well the pollutant mixes in with cleaner air. A further important feature of the lowest levels of the atmosphere is the boundary layer. This effectively 'caps' the atmosphere by impeding the upward movement of pollutants. Therefore, the volume of air available to mix and dilute the pollutant is governed by the height of the boundary layer. When the boundary layer height (BLH) is low there is a less available clean air and so higher pollution concentrations are likely. The BLH varies with climatic conditions, with the lowest BLH typically occurring in still, cold conditions, such as cloudless winter nights, and highest BLH normally occurs at midday in summer. Thus, the BLH can vary on a diurnal as well as an annual cycle.

Once in the atmosphere the released pollutant is free to interact with other pollutants and will sometimes form secondary pollutants (e.g. ozone). These secondary pollutants can be formed through a variety of chemical reactions and/or by the action of incident sunlight.

The speed of these reactions will depend on the temperature, humidity, amount of sunlight, and wind speeds.

Different pollutants stay in the atmosphere for different lengths of time (i.e. they have different atmospheric residence times) depending on a range of factors. Their eventual removal from the atmosphere occurs as a result of quite complex deposition processes.

Some pollutants can be entrained within the processes of cloud formation and then removed from the atmosphere in falling rain. Alternatively, these pollutants may be washed out of the atmosphere by rain falling and literally knocking them out of the atmosphere. Both of these processes are known as "wet deposition".

Those pollutants that are not wet deposited can be dry deposited due to gravitational settling as the pollutant comes into contact with the ground, by reaction on surfaces, or through take up by living organisms. The rate at which this happens is governed by characteristics of the pollutant, the ground surface or organism type and the weather.

For example, plants form an important mechanism for removing ground level ozone from the atmosphere, but the rate at which they do so is influenced by temperature, humidity, soil moisture, wind speed and so on[18].

Glossary

1. $\mu g\ m^{-3}$ Micrograms per cubic metre.

2. Expert Panel on Air Quality Standards (EPAQs): The Expert Panel on Air Quality Standards (EPAQS) was set up in 1991 to provide independent advice on air quality issues, in particular the levels of pollution at which no or minimal health effects are likely to occur. It has now been merged into the Department of Health's Committee on the Medical Effects of Air Pollutants (COMEAP) [20]

3. Polycyclic aromatic hydrocarbons (PAH's) are chemical compounds that consist of fused aromatic rings. PAH's occur in oil, coal, and tar deposits, and are produced as byproducts of fuel burning (whether fossil fuel or biomass). As a pollutant, they are of concern because some compounds have been identified as carcinogenic, mutagenic and teratogenic.

4. The Airborne Particles Expert Group (APEG) studied particles and their source apportionment *i.e.* primary and secondary particles and the proportion of emissions from Europe and UK. They have now merged into the Air Quality Expert Group (AQEG).

5. Scanning Electron Microscopy (SEN)
   A very widely used technique to study surface topography. A high energy (typically 10keV) electron beam is scanned across the surface. The incident electrons cause low energy secondary electrons to be generated, and some escape from the surface. The secondary electrons emitted from the sample are detected by attracting them onto a phosphour screen. This screen will glow and the intensity of the light is measured with a photomultiplier.

6. Energy Dispersive X Ray analysis
   This technique is used in conjunction with SEM and is not a surface science technique. An electron beam strikes the surface of a conducting sample.
   The energy of the beam is typically in the range 10-20keV. This causes X-rays to be emitted from the material. The energy of the X-rays emitted depend on the material under examination.

7. Tapered Element Oscillating Microbalance (TEOM)

   A TEOM detector consists of a substrate (usually a filter cartridge) placed on the end of a hollow tapered tube. The other end of the tube is fixed rigidly to a base. The tube with the filter on the free end is oscillated in a clamped-free mode at its resonant frequency. This frequency depends on the physical characteristics of the tube and the mass on its free end. A particle laden air steam is drawn through the filter where the particles deposit and then through the hollow tube. As particles deposit, the mass of the filter cartridge increases, and the frequency of the system decreases. By accurately measuring the frequency change, the accumulated mass is measured. Combining this accumulated mass with the volume of air drawn through the system during the same time period yields the particle mass concentration.

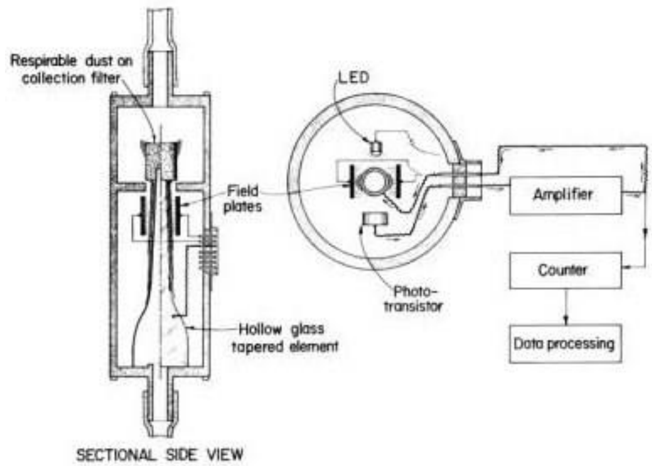


Figure 15. A TEOM sectional view

11. Euro 5/6: The first standard was introduced in 1993 (Euro 1), we are now moving to Euro 6. Every van registered from October 2009 onwards has had to meet the current Euro 5 standard which states the maximum limits of NOx and CO2 that are permissible. Euro 5 engines focused largely on carbon dioxide emissions. September 2014 (September 2015) The Euro 6 standard imposes a further, significant reduction in NOx emissions from diesel engines (a 67% reduction compared to Euro 5) and establishes similar standards for petrol and diesel

12. Renewable diesel (RD) is essentially any diesel fuel produced from a renewable feedstock that is predominantly hydrocarbon (not oxygenates) and meets the requirements for use in a diesel engine. Today almost all renewable diesel is produced from vegetable oil, animal fat, waste cooking oil, and algal oil.

13. FIDAS particle analyser: The Fidas 200 is a fine dust ambient air quality monitoring device, developed specifically for regulatory purposes; providing continuous and simultaneous measurement of PM1, PM2.5, PM4, PM10, TSP.

References

1. CIEH Air Quality Conference 21st April 2021
2. Air quality monitoring (gov.je)
3. AIR QUALITY EXPERT GROUP Particulate Matter in the United Kingdom 2005
4. New WHO Global Air Quality Guidelines aim to save millions of lives from air pollution
5. Air quality standards — European Environment Agency (europa.eu)
6. Air Quality Targets in the Environment Act - Defra, UK
7. Environmental Improvement Plan 2023 - GOV.UK (www.gov.uk)
8. Jerseys Air Quality Strategy 2013
9. Topas-Osiris-Monitor-Training-Manual.pdf (turnkey-instruments.com)
10. Jersey Mapping Jersey digital mapping service (gov.je)
11. EHINZ Environmental Health and Health Intelligence New Zealand
12. EN 12341:1998 - Air quality - Determination of the PM 10 fraction of suspended particulate matter - (iteh.ai)
13. UK Regions (exc. London) Technical Guidance | LAQM (defra.gov.uk)
14. Report: Particles a problem or not in St Helier 2001 - A M Irving
15. What is the Daily Air Quality Index? - Defra, UK
16. Health matters: air pollution - GOV.UK (www.gov.uk)
17. Concentration dynamics of coarse and fine particulate matter at and around signalised traffic intersections (rsc.org)
18. UK Air Quality Strategy 2019 Air Quality Strategy Vol 1 (publishing.service.gov.uk)
19. Jerseys Meteorological Department
20. Committee on the Medical Effects of Air Pollutants - GOV.UK (www.gov.uk)