Report on Turnkey Osiris Particle Results at the Market/Beresford Street and Howard Davis Park Sites in Jersey for 2021

Executive Summary

This report presents the results for 2021, which is part of an ongoing programme of particle air quality monitoring in Jersey carried out by the Water and Air team part of the Government of Jerseys Natural Environment Department. This is the 20th consecutive year in which an annual particle monitoring programme has been carried out; the first undertaken in 2002. It compares the data from Jersey with relevant European Union (EU), United Kingdom (UK) and World Health Organisation (WHO) air quality limit values, objectives and guidelines as well as data from previous years' monitoring programmes.

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.

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.

The particle analysers known as Osiris units manufactured by Turnkey Instruments Ltd in the UK 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)]

Particle monitoring is undertaken at a roadside site at the Central Market on Halkett Place and at a background site Howard Davis Park, St Helier. The Osiris unit was moved from the market Halkett place to the Beresford Street side of the market in November 2021 to allow easier access and for health and safety reasons. The Osiris is sited close to a busy road in St Helier so the main source of particles is from traffic sources. The Osiris at Howard Davis Park was also moved in June 2021 further into the park to reduce interference from traffic emissions.

The PM_{10} and $PM_{2.5}$ levels met the existing EU and UK limit and guideline values (however these limits are now out of date and need revising) but exceeded the 2021 WHO Air Quality guidelines (these are not legally binding). There were generally low levels of air pollution throughout the year but there were 19 days of moderate pollution and 6 days of high or very high pollution.

These however were not all likely to be due to traffic sources as a for example 2 days of very high pollution were at Howard Davis Park and are therefore likely to be due to natural particles. The analysis of the Osiris filter for Howard Davis park (the market Halkett Place/ Beresford Street filter was discounted due to erroneous results) indicated high levels of silicon (sand), salt, animal fragments and various metals such as barium, zinc and aluminium. This is to be expected as particles can undergo complex reactions in the atmosphere and can originate from France in easterly winds.

Comparison of the data from 2002 has been carried out of the various existing and historic measurement sites. Care needs to be taken in direct comparison as the data capture and measurement periods varied. It also highlights the interference from natural sources and how data levels can be affected.

The effect of the COVID lockdowns resulted in particle levels reducing in the first lock down (March 2020) by up to 30% PM_{10} and up to 13% $PM_{2.5}$ respectively at Halkett Place/Market site however the reduction was greater in the second lock down (October /November) by up to 67% PM_{10} and up to 72% $PM_{2.5}$.

PM_{10} concentrations in Jersey are broadly similar to those found in comparable urban areas in the UK. The level at the Market site is 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.

Increases in particle air pollution tends to occur in the spring, autumn and winter months. The weather at these times is characterised by longer nights, fog, 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.

Levels of particles increase during the morning on Halkett Place due to delivery vehicles keeping their engines running as they park close to the Osiris. Certain vehicles such as the refuse and Ferry speed food delivery vehicles have to run engines to allow bins to be raised and maintaining cold temperatures for food deliveries.

Improvements in air quality are generally made through discussion, advice, and persuasion as there is no specific air quality legislation in Jersey. It is hoped that as part of implementing the Carbon Neutral Road Map measures air quality will improve.

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 2021. This is the 20th 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 EU, UK and WHO 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]

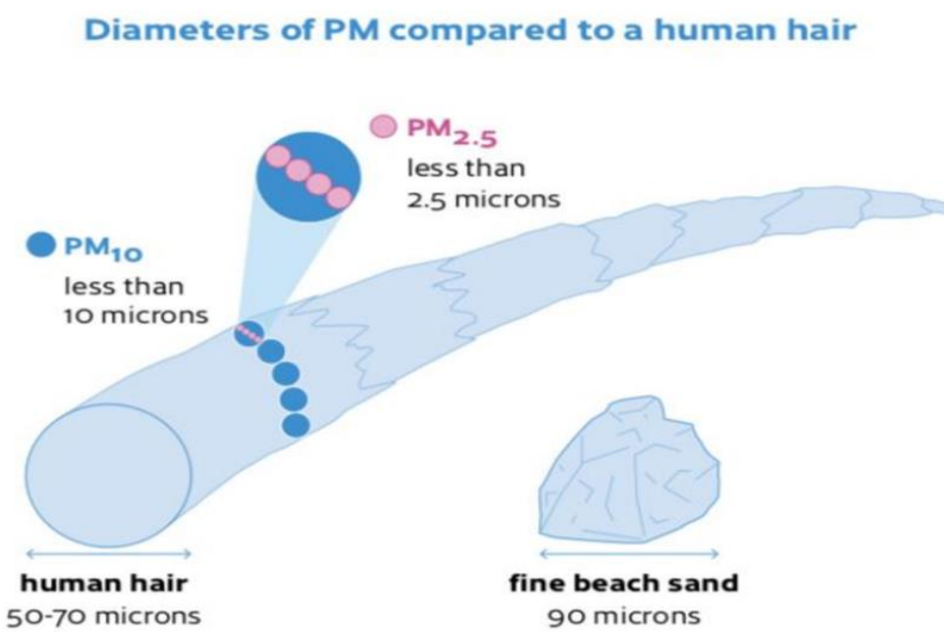


Figure 1: How small is Particulate matter (PM) [1]

Particles can be also differentiated depending on their source:

a. Primary particles: those that are directly emitted from natural and anthropogenic sources such as sea spray, transportation, industry, forest fires, etc.

b. Secondary particles: those formed from chemical reactions of gaseous precursors in air. The latter include both inorganics such as sulphuric acid/sulphate from SO_2 oxidation and nitrate from NO_x oxidation, as well as a host of volatile organics, which make up a major fraction of the particles around the world. Because there are thousands of potential organic precursors in air, and a number of different oxidation reactions involving O_3 and OH, Cl, and NO_3 radicals, the organic component of particles becomes very complex. Further adding to the complexity of this secondary organic aerosol (SOA) are reactions in the condensed phase that can also form new products after the particle has formed[2].

More information on particles, their health effects and how they are differentiated can be found in Appendix 4

The report also compares the number of PM_{10} exceedances of the EU and UK air quality objective (50µg/m^3 as a daily mean which allows 35 exceedances per year) for the monitoring at historic roadside sites since 2002:

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 and background site at Howard Davis Park: 2014 - date.
d. The Market / Beresford Street: November 2021 to date and new background site at Howard Davis Park: June 2021 to date

1.2 Objectives

The 2021 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.

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]

1.4 Impacts of Covid 19

The 2021 monitoring programme was less disrupted by Covid 19 than in 2020. Annual calibration of equipment occurred although there were delays in the UK due to staffing issues. This explains the low data capture rates in 2021. The Natural Environment air quality officers were able to visit the sites every 3 months to change filters and check equipment.

The effect of the COVID lockdowns in March and November 2020 on particle levels can be seen in figure 2 below. The 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 Halkett Place/Market site and the reduction was greater in the second lock down (October /November) by up to 67% PM_{10} and up to 72% $PM_{2.5}$. Some data is missing in 2020 due to the lockdown.

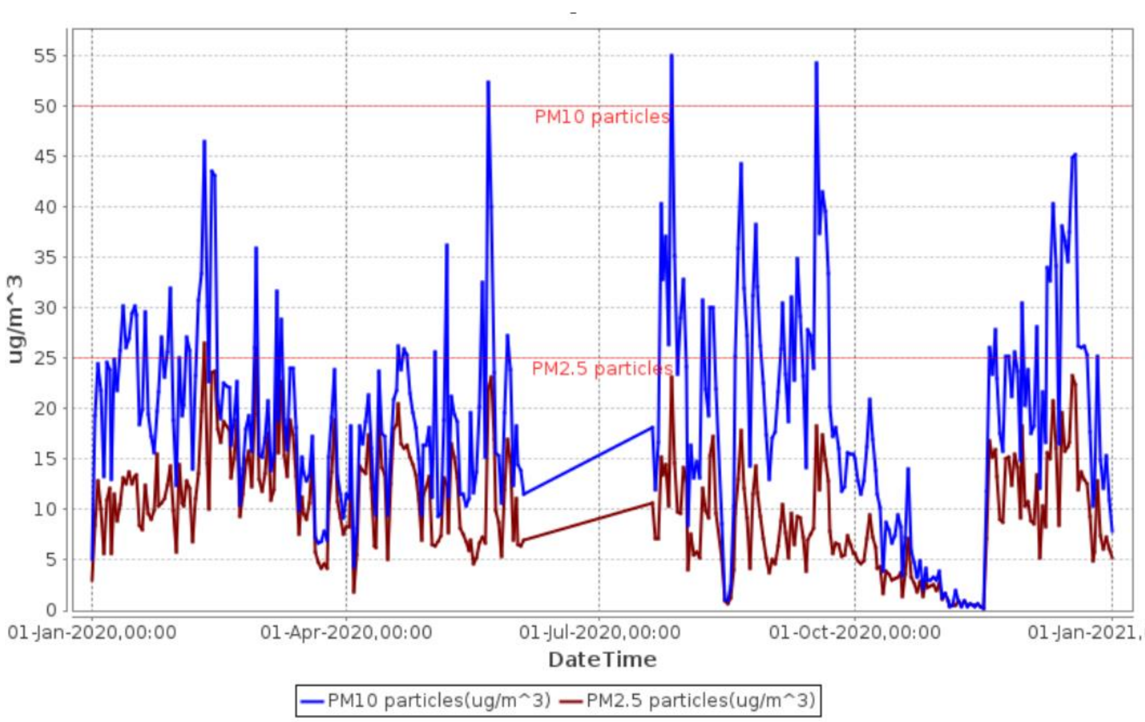


Figure 2: Reduction in PM_{10} and $PM_{2.5}$ during the lockdowns at the Halkett Place / market site

2.0 Details of the Monitoring Programme

2.1 Pollutants monitored

Particles (also known as particulate matter PM) are produced as part of any combustion process such as vehicle emissions, domestic heating, industrial processes, energy generation and from natural sources such as sea salt, spores and silica (sand). More information on particles can be found in Appendix 4[1].

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	
	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	Existing
	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 Act limits[3]

The World Health Organisation (WHO) issued non-mandatory, advisory, guidelines for a variety of pollutants in 2005 using currently available scientific evidence on the effects of air pollution on human health. New, updated, guidelines were introduced in September 2021 and in light of the growing evidence of harm that PM_{10} and $PM_{2.5}$ can cause the Annual mean limits were reduced from 20 µg m^{-3} to 15 µg m^{-3} and 10 µg m^{-3} to 5 µg m^{-3} respectively[3].

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 has updated the requirements of the UK government. It requires the UK government set a new limit for $PM_{2.5}$. Targets will be set out in the 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 will contain tough new goals to cut public exposure to particulate matter pollution, as recommended by the World Health Organization. There will be 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 u 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]

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. Considering the reductions in concentrations and improvements in technology since the AQS, it is recommended it is reviewed and updated[7].

2.2.5 Other air quality monitoring programmes

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

1. Twenty 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 Halkett Place and as of the 11th November 2021 it was moved to measure emissions from traffic on Beresford Street due to health and safety reasons.

These reports are available at Air Quality monitoring in Jersey 2020 (gov.je) Unfortunately the traffic data for Halkett Place was not available in the 2021. This prevented determining any correlation between traffic numbers, speed and air pollution levels[8].

2.3 Monitoring Methodologies

2.3.1 Turnkey Osiris particle monitors

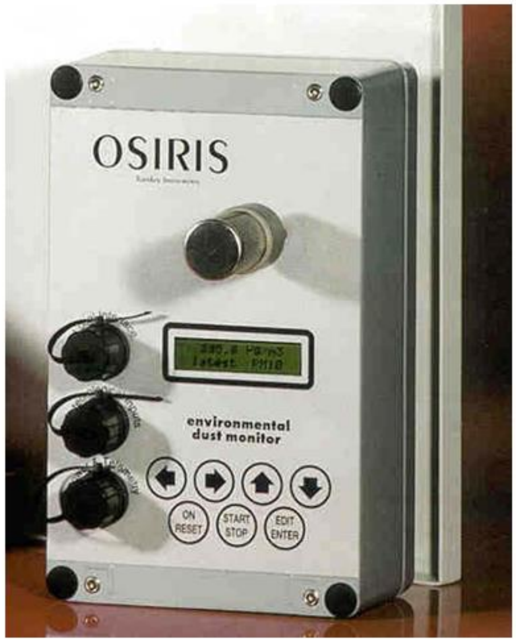
The Osiris units (Optical Scattering Instantaneous Respirable Dust Indication System) are investigational instruments that fulfils the dual role of a portable instrument or permanent installation.

The 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. Air Quality software program AirQWeb allows the data to be analysed, graphed, the settings on the units to be changed remotely[9].

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 accuracy of the units is +/- 10%. They are sent annually to the UK for calibration and service[12]. The Osiris units were purchased in October 2008 costing £6,000 each. They use a heated inlet (50°C) to drive off water vapour particles which would cause erroneous results however this mean they tend to under read. More information on the OSIRIS units can be found in Appendix 2.

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. Analysis of the Howard Davis Park filter was carried out by a UK company Socotec Ltd in 2022 and the results can be found in Section 4.4.



Photograph 1: Turnkey Osiris particle unit[9]

2.3.2 Monitoring sites

The locations of the two sites in St Helier are:

1. an urban roadside site at Jersey Market measuring traffic emissions from Halkett Place approximately 2 m from Halkett Place, GPS coordinates 49.184679 -2.104641. The Osiris was moved in November 2021 to Beresford Street GPS coordinates 49.185226 -2.103917 to measure traffic emissions from vehicles using Beresford Street. The road is one way and gets congested at times of the day. There are two zebra crossings which also reduce traffic flow.

2. a background site at Howard Davis Park, GPS co-ordinates 49.179854 -2.09837 (now 49.179933 -2.09757). The Osiris was moved in June 2021 further into the park to reduce any interference from vehicle emissions, the GPS coordinates 49.179917-2.097401. The analyser is now sited approximately 85m to the nearest road.

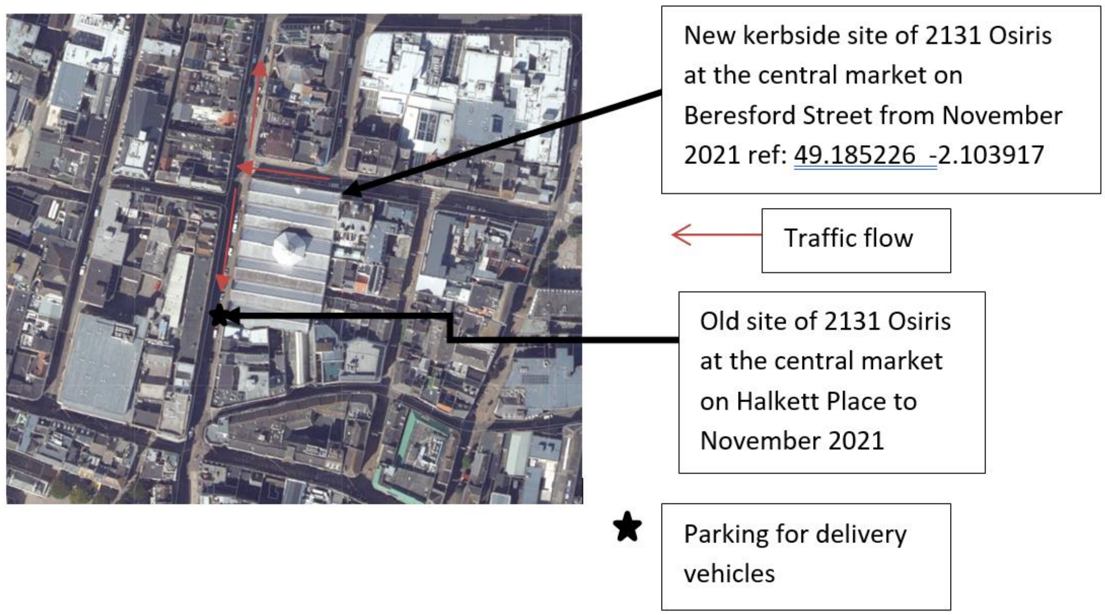


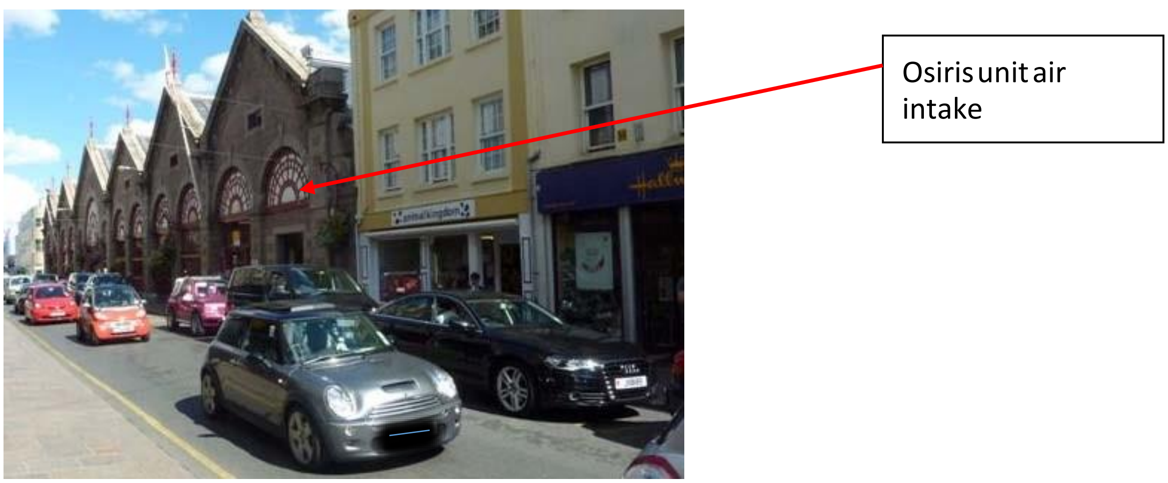
Figure 3: the previous and existing sampling sites at the market in St Helier[10]

The previous site at the central market was approximately 4m above the pavement and 2m from the road of Halkett Place (see the photograph 3 below). This road is used by up to 6,000 vehicles per day with up to 650 vehicles during rush hour periods. The peak hours are around 7.00 - 9.00 am and between 12.00 pm and 5.00pm each day. Halkett place doesn't have a defined afternoon rush hour and is more characterised by shoppers looking for parking, delivery vehicles and drivers cutting through St Helier to head east or west.

Previous work has shown that particle levels follow traffic numbers, vehicle composition and speed closely[11]. There is a definite increase in particles in the morning rush hour up to lunchtimes as delivery vehicles servicing the market leave their engines running outside the market. Some vehicles must leave engines running for example refrigerated lorries and refuse vehicles. Signs are sited in this area to remind drivers to switch engines off when stationary.

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 annual report[9]. (see 2.2.5 above). The new Osiris site is approx. 2 m from Beresford Street but at ground level behind the market access gate. (see photograph 2 below). Particle levels increase up to mid afternoon and then drop during the evening and early hours. Spikes of pollution tend to occur when vehicle drivers parked in the loading bays leave their engines running. The levels are generally lower than the Halkett Place site due to absence of delivery and refuse lorries in this area.

Photograph 2: The new position of the Osiris Unit Ref 2131 at the Central Market, Beresford Street, St Helier (from November 2021)



Photograph 3: The previous position of the Osiris Unit Ref 2131 at the Central Market, Halkett Place, St Helier (to November 2021)

This Osiris unit 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 (see photograph 3 below). The nearest road was St Clements Road, approx. 15 metres away. The site is 350 m from the coast, so the particle levels will be affected by sea salt and sand particles when the wind is from the south, southeast/ west, which can give elevated readings.

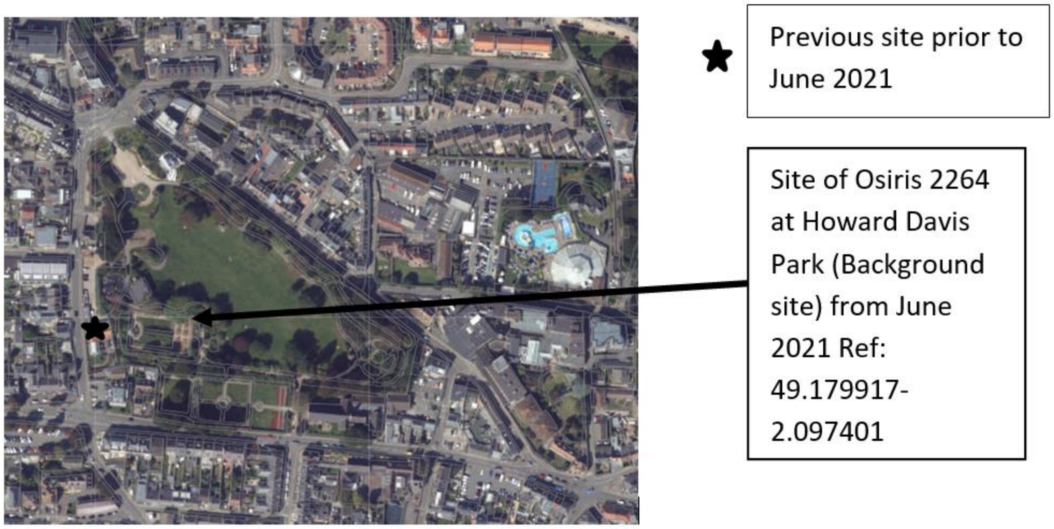


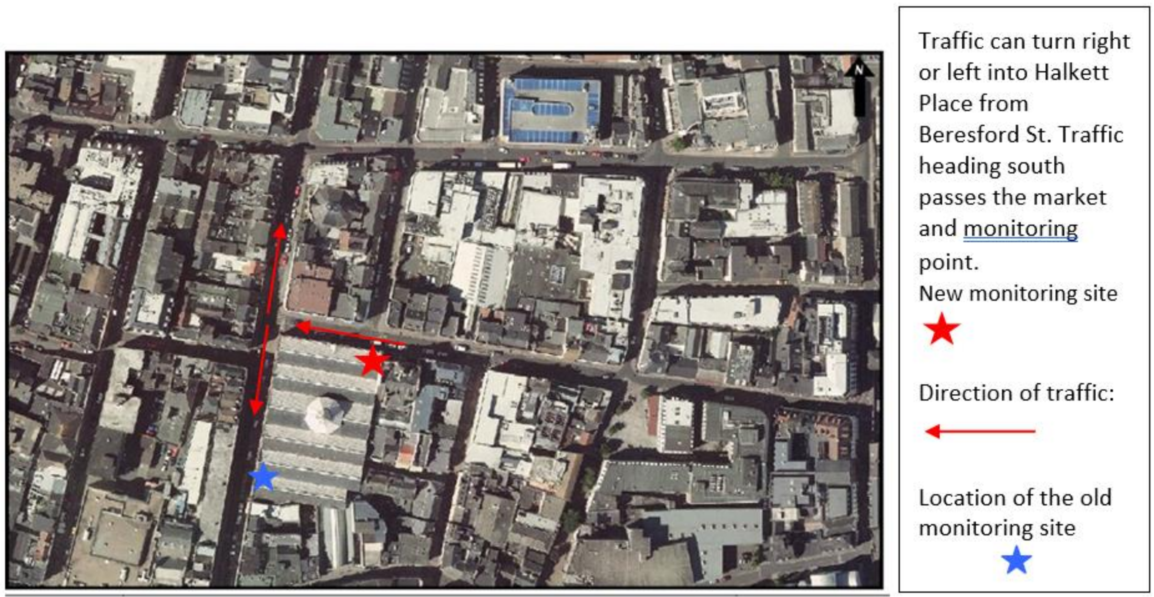
Figure 4: the previous and existing sampling sites at the Howard Davis Park in St Helier[10]

The Howard Davis Park Osiris unit was moved in June 2021 further into the park to the south east of the band stand to allow easier access and to provide more representative background measurements. This new site is 85m from the nearest road.
As the site is within a park used by the public, it gives an indication of background particle exposure levels from non-man made sources such as pollen, sand and sea salt. It is 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 4: The new position of the Osiris unit Ref 2264 at Howard Davis Park from June 2021

2.3.3 Impact of Traffic flow

Particle levels at the market site have reduced since the road layout changed in this area. Traffic can now turn right heading northerly along Halkett Place, thereby avoiding the area by the analyser. The provision of two speed bumps/pedestrian crossings on Beresford Street has led to an increase in traffic congestion on Beresford Street, however it has improved traffic movement along Halkett Place. (See photograph 5 below)



Photograph 5: Map showing the direction of traffic flow in the area and the old and new monitoring sites [10]

2.3.4 Vehicle emissions remote sensing in Jersey (2017)[12]

The plot below shows particulate matter (PM) emissions are low for petrol cars. The measurements show a sharp decline in PM for Euro 5 and 6 vehicles compared to earlier Euro standards. This reflects the tightening of limits on PM emissions from diesel cars from Euro 5 onwards. All diesel vehicles have to be fitted with a Diesel particulate filter (DPF) from Euro 5 onwards. The measurements demonstrate the success of diesel particulate filters (DPF) in reducing PM emissions. Some Euro 4 vehicles are also fitted with DPFs and this is reflected in the measurements. The trend in emissions of PM from diesel cars in Jersey differ from the trends in emissions of PM measured at UK mainland locations. Emissions of PM show a steady decline between Euro 3 to Euro 6. This suggests that DPFs may not work as effectively under standard driving conditions in Jersey which are likely to consist of short journeys at low speed. DPFs require active regeneration every few hundred miles which requires driving at speeds greater than 40 mph for at least 10 minutes which may be difficult to achieve on Jersey.

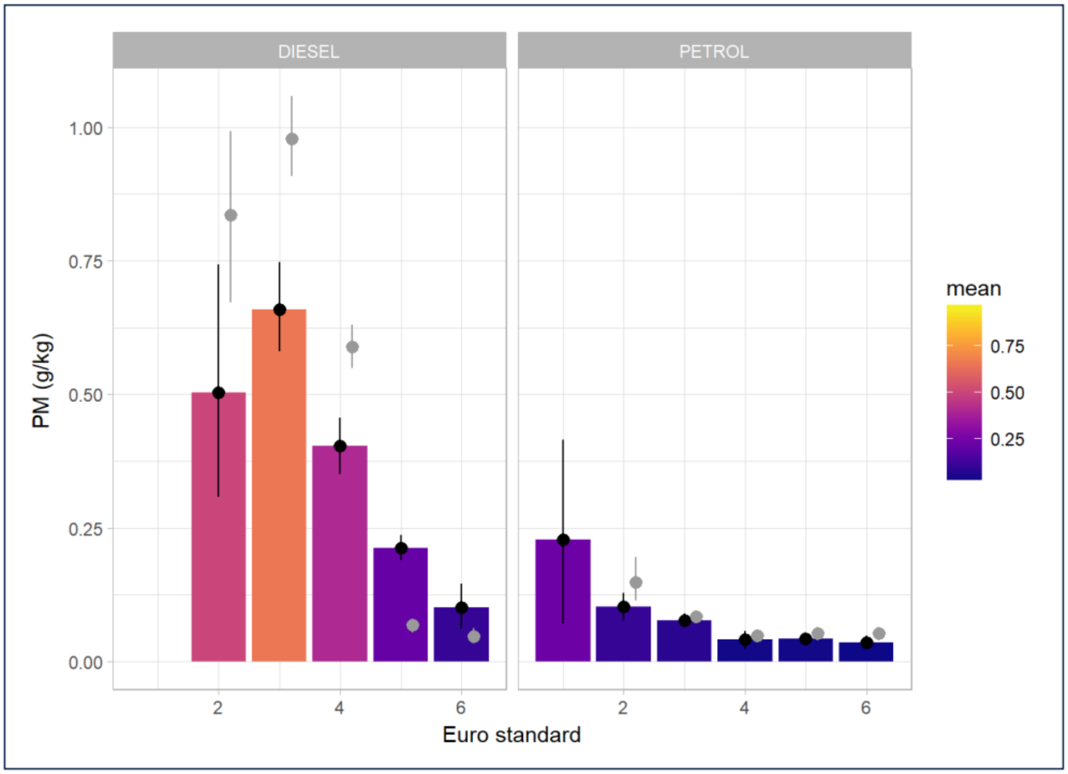


Figure 5. A box plot showing the emissions of particles g/kg when compared to the Euro emission standards 2 – 6[12]

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". [13]

This is relevant because it means the data from the Osiris units provided is indicative only. The Osiris units are less accurate than the gravimetric type units used in monitoring stations throughout the UK and the European Union.

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. The units provide a useful screening tool to determine if more detailed measurement is required.
Ideally an EU type approved particle measurement unit, 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 cost of an EU type approved particle FIDAS analyser would be in the region of £25,000. The More information on the OSIRIS units can be found in Appendix 2.

3.1 Data capture

In 2021 data capture was 70% for the market / Halkett Place and 88% for the Howard Davis Park sites. The data capture was reduced due to delays during calibration in the UK caused by Covid and staffing levels at Turnkey 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) [14] 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 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)[8] , https://www.airqweb.co.uk/ and http://jerseyair.ricardo-aea.com/index.php?site_id=JERS [11]

4.0 Results

Table 3 above shows:

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

Site	Days data obtained %	PM_{10} Exceedances (>50µg/m^3) (max 35 exceedances)	PM_{10} annual mean (limit 40 µg/m^3)	$PM_{2.5}$ annual mean (target 2020 25µg/m^3)
Howard Davis Park *	320 (88%)	8(2)	19.12	8.66
Halkett Place/Market Beresford Street site	254 (70%)	17(4)	23.8	12.18

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

4.1 Exceedances:

There were 17 exceedances at the Market/Halkett place site (of which 4 exceedances were at the new Beresford Street site) and 8 at the Howard Davis Park site (2 of which were at the new position) the EU health limit of 50 µg/m^3 as a 24-hour average. The EU Directive allows 35 exceedances per year so both sites were within this.

The exceedances at the Halkett Place site occurred in January, February, October, November, and December, (the November and December exceedances were at the new Beresford Street site) in 2021 which is to be expected as poor air quality tends to occur in the winter months. At Howard Davis Park exceedances occurred in February, April, September, and October 2021, (the September and October exceedances were at the new site). As a background site this is less affected by traffic emissions however natural sources such as salt and silica are more prevalent. This is shown in figure 3 below.

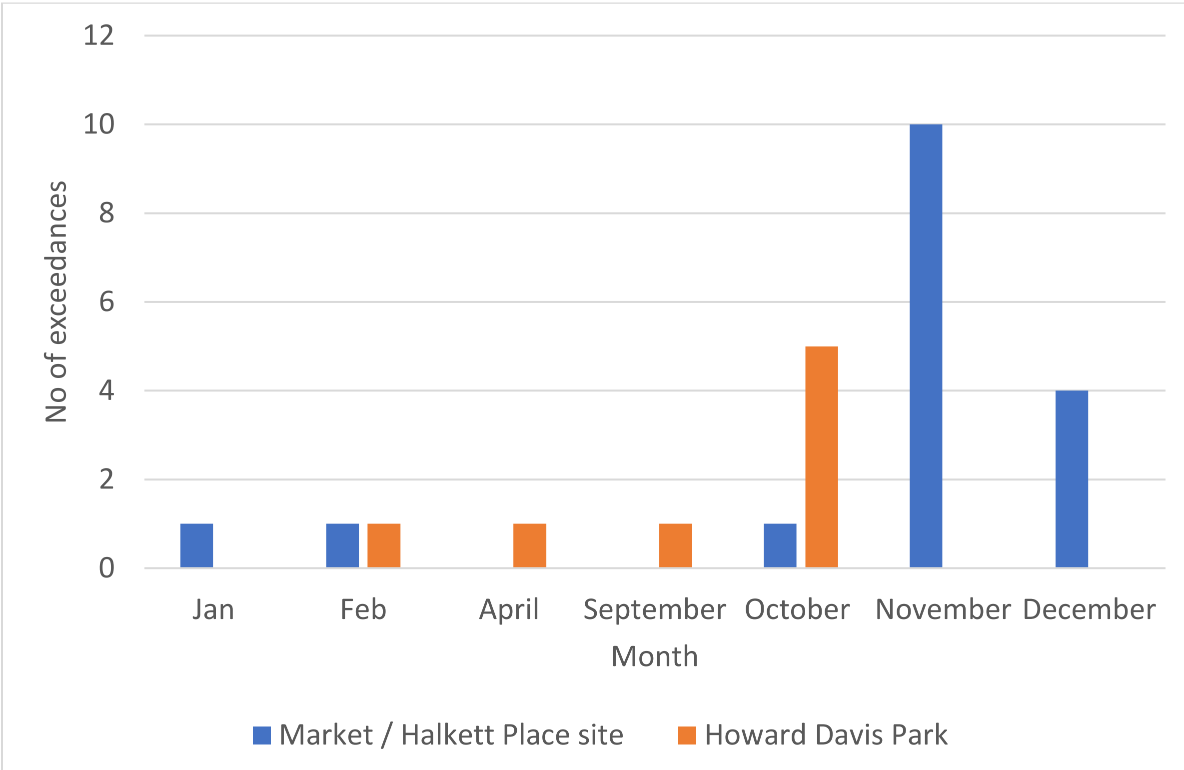


Figure 6. The number of exceedances by month for both sites in 2021

Figures 7 and 8 below show the 24-hour average particle levels for 2021 at the two sites with the exceedances (of which 4 exceedances were at the new Beresford Street site). As expected, the concentrations are greater for Halkett Place due to traffic emissions. Traffic heads south past the market looking for parking or is cutting through St Helier heading east or west and there are delivery vehicles servicing the market each day. Particle levels increase up to mid afternoon and then drop during the evening and early hours. Spikes of pollution tend to occur when vehicle drivers park in the loading bays and leave their engines running.

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. At the previous Market/ Halkett Place site levels increase at certain times in the morning as the refuse lorry parks close to the unit with its engine running to allow the euro-bins to be emptied and ferry speed food delivery lorries keep their engines running to maintain the chilled or frozen temperatures. This has led to complaints from market traders about fumes within the market from delivery vehicles.

Particle levels at the new Market / Beresford Street increase up to mid-afternoon and then drop during the evening and early hours. Spikes of pollution tend to occur when vehicle drivers park in the loading bays and leave their engines running. The levels are generally lower than the Halkett Place site due to absence of delivery and refuse lorries in this area.

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 likely to be due to non-anthropogenic sources such as sea salt and biological sources. Prior to June 2021 there were occasional petrol or diesel emissions as the Osiris unit was sited on the roof above the gardener's office and equipment storage shed. There were six exceedances following the relocation of the Osiris further into the park. A high daily average was recorded on 6th April 2021: 188 µg/m^3. This is an outlier and was not considered.

Figure 7. PM_{10} and $PM_{2.5}$ 24 hour averages for 2021 at Market/ Halkett Place/ Beresford Street sites showing the 50 µg/m^3 limit.

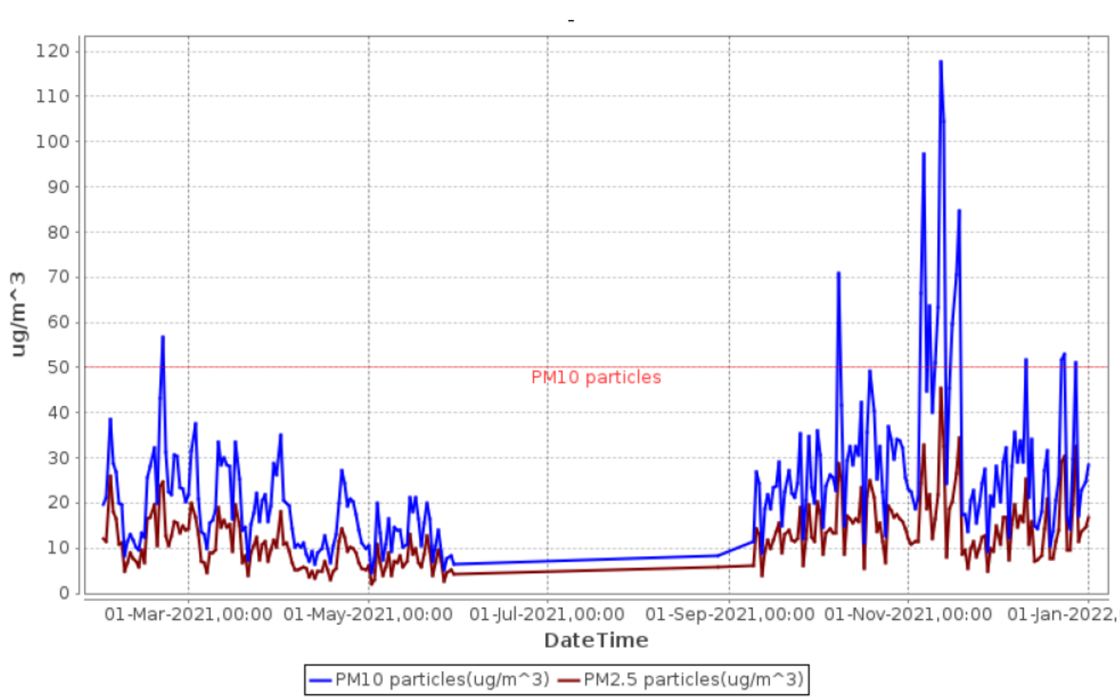
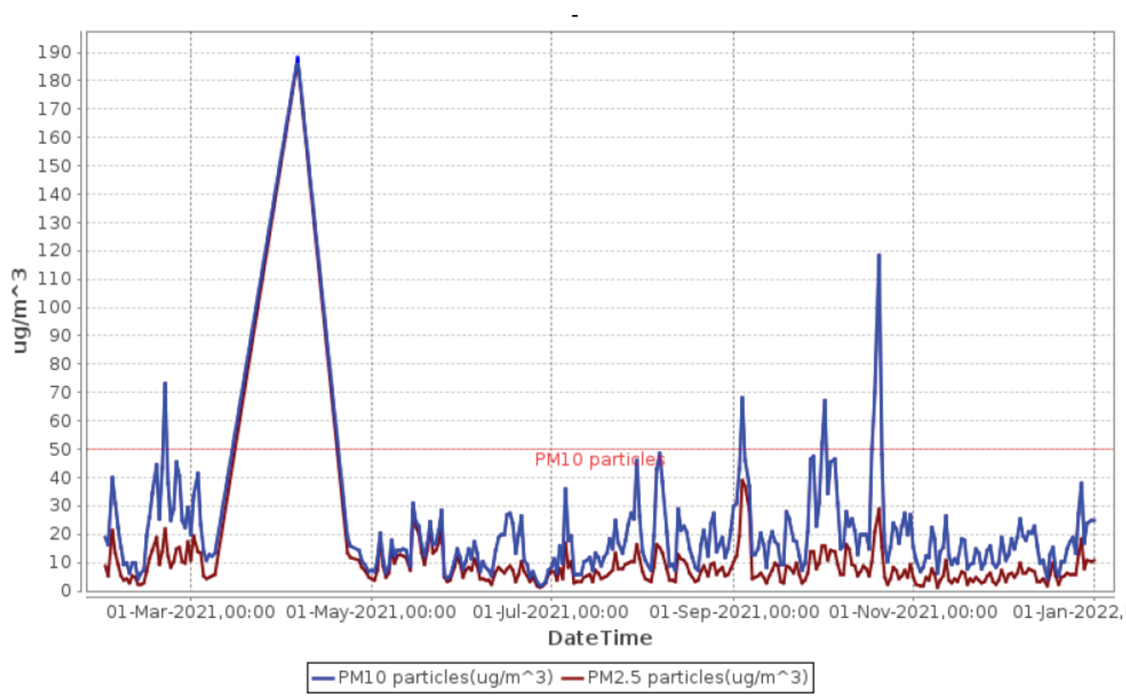


Figure 8. PM_{10} and $PM_{2.5}$ 24-hour averages for 2021 at Howard Davis Park site showing the 50 µg/m³ limit.



4.2 Comparison with WHO, EU, and UK Health limits, guidelines and targets

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 *	320 (88%)	8	19.12	8.66
Halkett Place/Market	254 (70%)	17	23.8	12.18

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

The PM_{10} 24 hour WHO Air Quality Guideline (AQG) of 45 µg/m³was exceeded at both sites and the PM_{10} and $PM_{2.5}$ WHO annual Air Quality guidelines were also exceeded 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} daily average levels did not exceed the 35 allowable exceedances for both sites and the EU annual mean of 40 µg/m^3 was also complied with. The $PM_{2.5}$ EU annual health limits of 25 µg/m3 (to be achieved by 2010) and 20 µg/m^3 (to be achieved by 2015) respectively was complied with. The annual mean $PM_{2.5}$ levels for both sites also met 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]
PM10 µg/m3	Annual mean	40
	24 Hour mean	50 (35 exceedances/yr)
PM2.5 µg/m3	Annual	25
	24 Hour mean	N/A

The PM_{10} 24 hour mean levels did not exceed the 35 allowable exceedances for both sites and the UK PM_{10} annual mean of 40 µg/m^3 was also complied with. The $PM_{2.5}$ UK annual health limit of 25 µg/m3 was complied with. The EU and UK limits need revising as they are out of date.

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 man-made particles. Historical data from the year 2000, demonstrate, as expected, the increase in particle levels as traffic numbers increase.

Research findings indicate that air pollution is influenced 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. Certain wind and terrain conditions, certain times of the day, including rush hours can result in elevated concentrations of air pollution near roads and air pollutants traveling further from the road. 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.

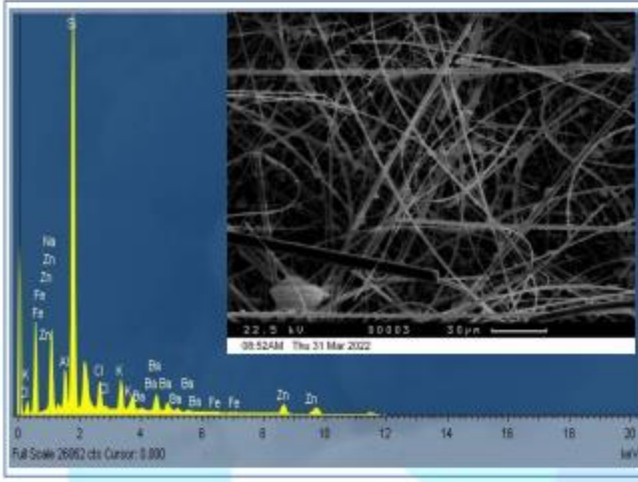
Per vehicle, heavy-duty diesel vehicles can emit more of certain pollutants (e.g., NOx and PM) and contribute disproportionately to the emissions from all motor vehicles. Petrol passenger cars generally emit more of other pollutants (e.g., CO, and benzene, a volatile organic compound (VOC). [14]

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 Howard Davis Park sample. The analysis allows a degree of source apportionment. Unfortunately, the Halkett Place filter was not analysed. The Howard Davis Park sample was 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 is provided detailing the various constituents found. The photomicrograph for Howard Davis Park is provided below in Figure 7.

SAMPLE I.D: 205074 **JOB REF:** 39439 **SAMPLE TAKEN:** 13/09/21

SITE: Howard Davis Park - Background **SAMPLE TYPE:** Osiris Filter



Element	Relative Composition (% m/m) *
Sodium	14
Aluminium	5
Silicon	53
Chlorine	6
Potassium	5
Zinc	7
Barium	10

* 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.

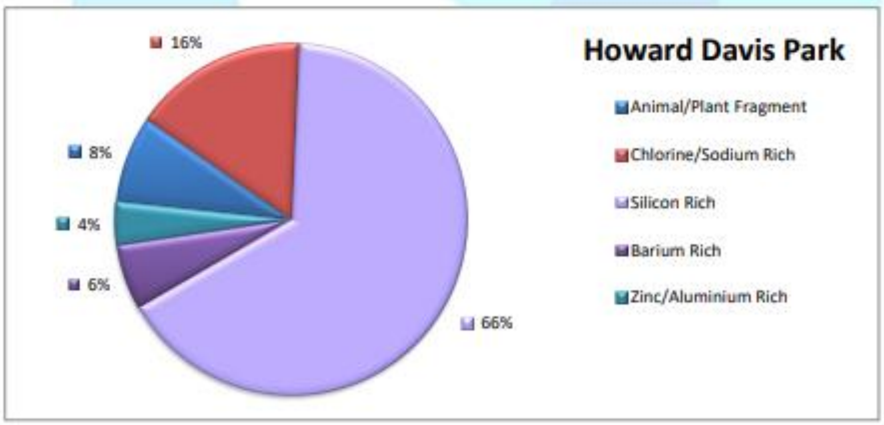


Figure 9: Scanning Electron Microscopy (SEM-EDS) report for the Howard Davis Park filter.

The results indicate high levels of silicon, salt, and animal fragments as expected. 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.

Previous elemental analysis of particles shows the following atoms: Carbon, Hydrogen , Oxygen, Nitrates, Sulphates as well as trace metals are very common components, and it is known that sulphate, nitrate, and ammonium ions as well as organics are ubiquitous in particles. The organic component of primary particles tends to be less oxidized (e.g., polycyclic aromatic hydrocarbons in soot) and can contain unique compounds that serve as tracers of specific sources[15]

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[22]:

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

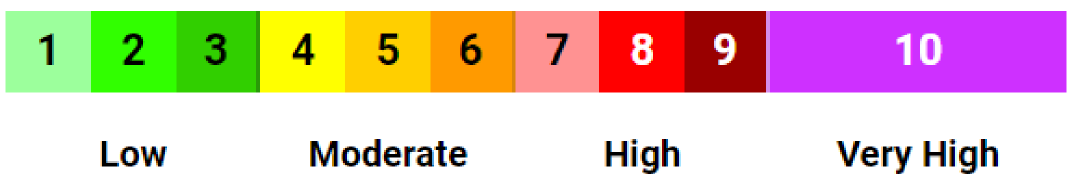


Table 8. below shows the number of days where average PM_{10} levels met 4 standard categories of pollution level in 2021.

Levels were low at both sites for much of the year but higher levels were observed, particularly at the Halkett place site. This included 2 incidents of high air pollution and 2 incidents of very high air pollution. There were 2 incidents of very high air pollution at Howard Davis Park. Incidents of high or very high pollution at the market / Halkett Place site may have been due to vehicle engines not being switched off and deliveries. It is not known why the level was so high on these two days at Howard Davis Park, but it may have been due to meteorological conditions resulting in high levels of salt and sand. Appendix 4 provides explanation of the terms low moderate high and very high air pollution.

Air Pollution Bandings:	24 Hour mean	Market	Howard Davis Park
Low Air Pollution:	<50 µg/m^3	237	312
Moderate Air Pollution:	50 - 74 µg/m^3	13	6
High Air Pollution:	75 - 99 µg/m^3	2	0
Very High Air Pollution:	>= 100 µg/m^3	2	2

Table 8. Daily mean readings shown as the number of days where PM_{10} fell into the four air pollution bandings[16].

4.6 Comparisons with previous years

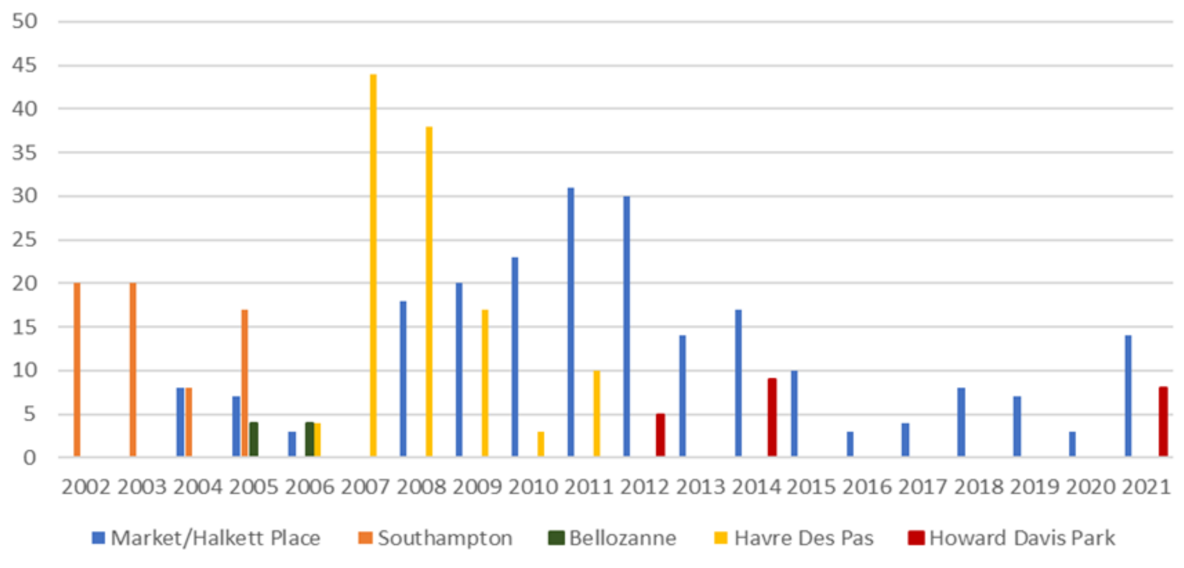
Figure 8 below presents that the number of exceedances of the air quality objective of 50µg/m^3 as daily mean (which allows 35 exceedances per year) for the following historic sites:

- 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/ Beresford Street and Howard Davis Park Sites

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 may be due in part to wind-blown salt and sand particles. This was confirmed by the analysis of the unit's filter. Care needs to be taken 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 has since reduced. This highlights the difficulty in relying on particle data as it can be from non human sources which can skew the results.

Figure 9. 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 Jersey and the European Union (EU)

Although not legally binding in Jersey, the States has agreed to work towards the European Union Directive objectives. The 2008 Ambient Air Quality Directive (2008/50/EC) and four associated Daughter Directives set standards and target dates for reducing concentrations of fine particles, which together with coarser particles known as PM_{10} were already subject to UK legislation[6].

Under the new Directive, Member States are required to reduce exposure to $PM_{2.5}$ in urban areas by an average of 20% by 2020 based on 2010 levels. It obliges them to bring exposure levels below 20 micrograms/m^3 by 2015. Throughout their territory Member States were bound to achieve the $PM_{2.5}$ limit value set at 25 micrograms/m^3. This value must be achieved by 2015 or, where possible, 2010.

The European Union Directive also set an $PM_{2.5}$ exposure reduction target of 18 µg/m^3 based on 3-year average, to be achieved by 2020. Jersey has achieved the PM_{10} and $PM_{2.5}$ limits and exposure reduction target[4].

6.0 Conclusions

1. Particle monitoring is undertaken at two sites in St Helier: an urban roadside site at Jersey Market measuring traffic emissions from Halkett Place approximately 2 m from Halkett Place, (the Osiris was moved in November 2021 to Beresford Street to measure traffic emissions from vehicles using Beresford Street) and a background site at Howard Davis Park, St Clements Road approximately 15m from St Clements Road, (the Osiris was moved in June 2021 further into the park to reduce any interference from vehicle emissions). The analyser is now sited approximately 85m to the nearest road.

2. 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.

3. The Osiris 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)].

4. There were 17 exceedances at the Market site (of which 4 were at the new Beresford Street site) and 8 at Howard Davis Park (2 at the new position) of the 50 ug/m3 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. Exceedances are likely to be due to traffic congestion and delivery vehicles servicing the market on Halkett Place elevating emissions coupled with and/or meteorological conditions.

5. The $PM_{2.5}$ data was also below the EU and UK health limits. 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.

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. PM_{10} concentrations in Jersey are broadly similar to those found in comparable urban areas in the UK. Levels at the Market 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. Levels increase early mornings due to deliveries and refuse collections as vehicle engines are left running. The new site at Beresford Street is approx. 2 m from the road but at ground level behind the market access gate.

8. The levels are generally lower than the 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.

9. The main source of particles in Jersey is from road traffic. Levels of particles are also influenced by sea salt and sand due to the close proximity of the sea.

7.0 Recommendations

1. It is recommended a FIDAS EU type approved PM measurement analyser is purchased to allow meaningful and allow direct comparison with the UK. This could also allow a bias adjustment figure to be determined to increase the accuracy of the Osiris results. It would also allow the Osiris units and low-cost analysers to be calibrated and evaluated. Low cost analysers can be co-located to determine their accuracy and suitability for Jersey.

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 guideline 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 a 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 replacement of the Osiris units in due course with suitable low-cost sensors.

6. 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[6].

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[10].

Poor air quality also impacts on the environment, harming ecosystems and biodiversity. Measures to tackle air quality, such as speed restrictions, may also have a beneficial impact on noise pollution, and vice-versa[6].

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 50ºC) 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.[11]

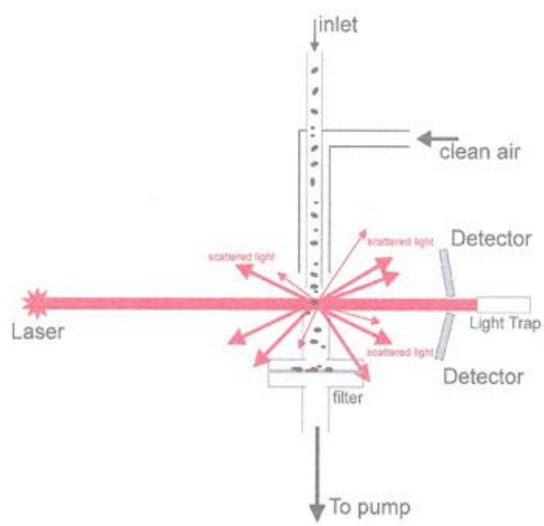
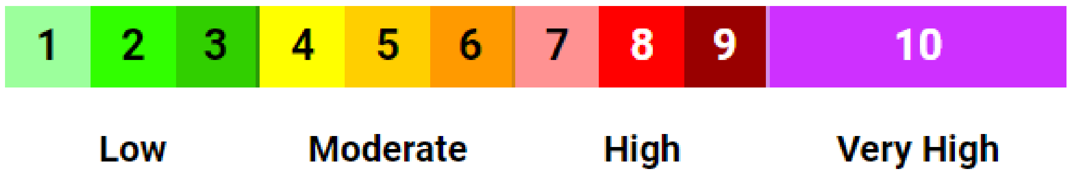


Figure 11: The Osiris particle monitor [11]

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.[16]

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.

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[16]

Appendix 4: Sources of Particles

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[1]

Researchers in New Zealand found that natural sources of PM_{10} accounted for 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 [10]. Particles can be primary or secondary and involve complex chemistry in the atmosphere. (See below)

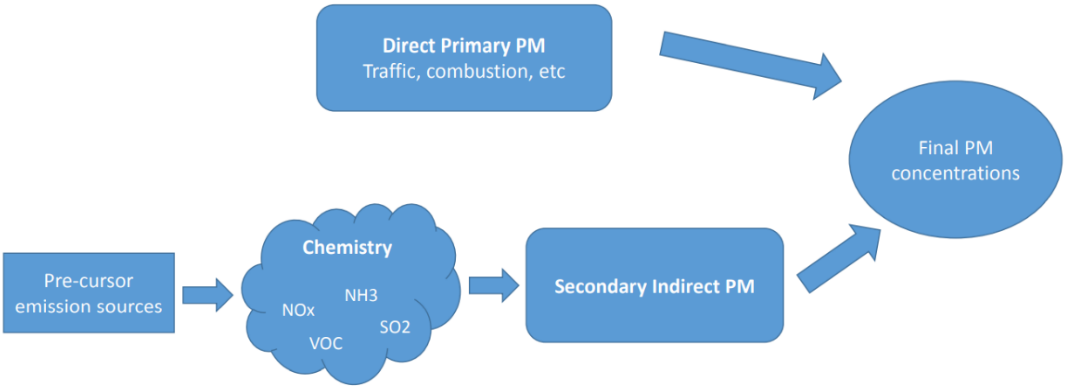


Figure 13: Formation of PM10 through complex chemistry in the atmosphere[2]

Appendix 5: The Importance of Weather and Air Quality

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. 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[17].

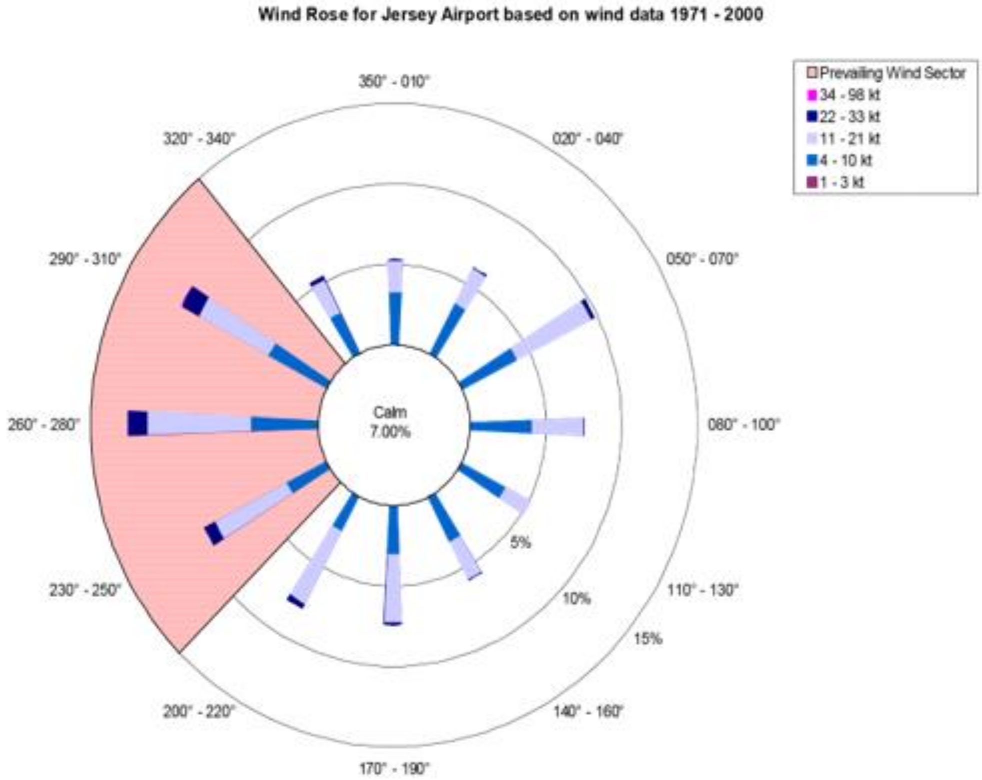
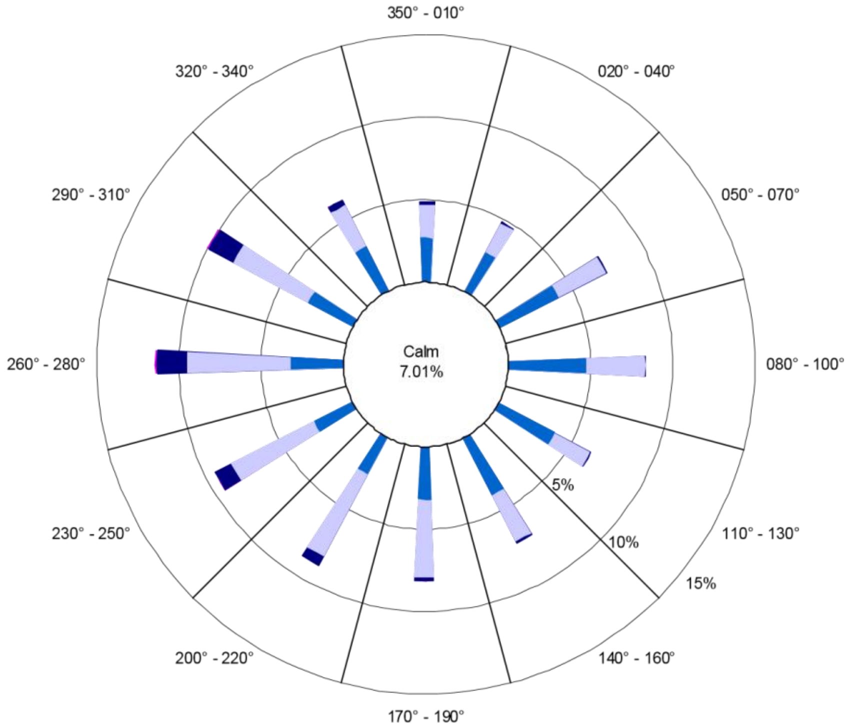
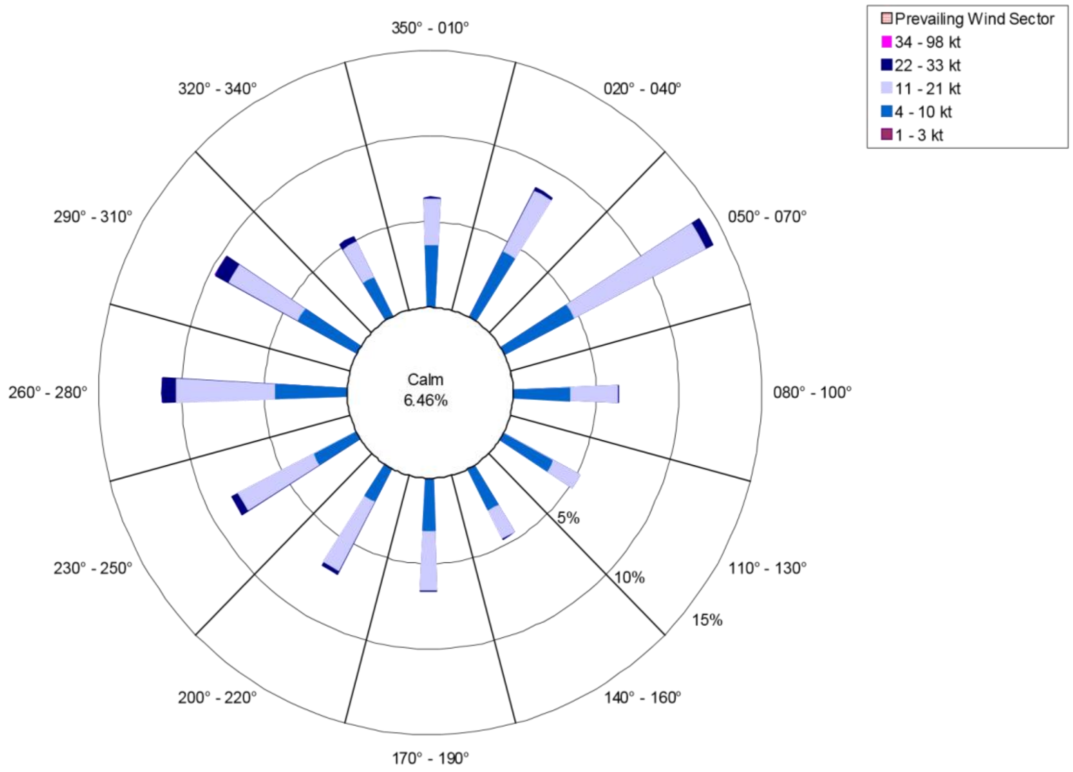


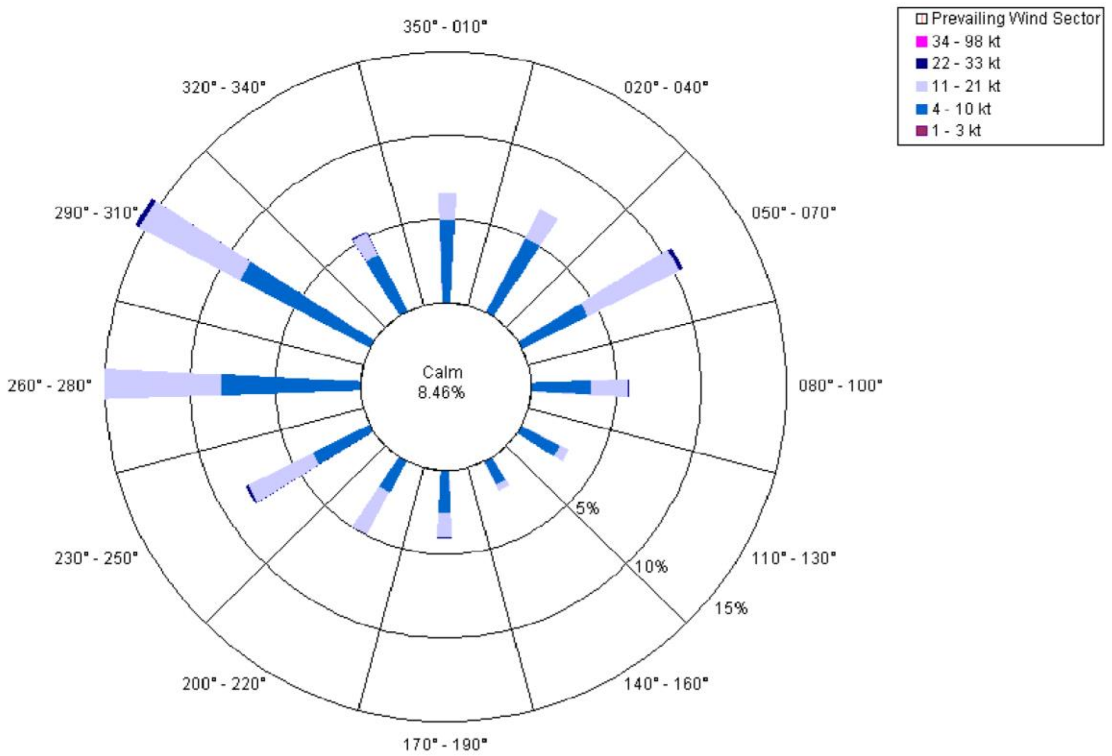
Figure 13: Wind roses for each of the four seasons at the airport. Data taken from 1971 to 2000 inclusive (wind speed in knots). *(Courtesy of Jersey Meteorological Department*[18]

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

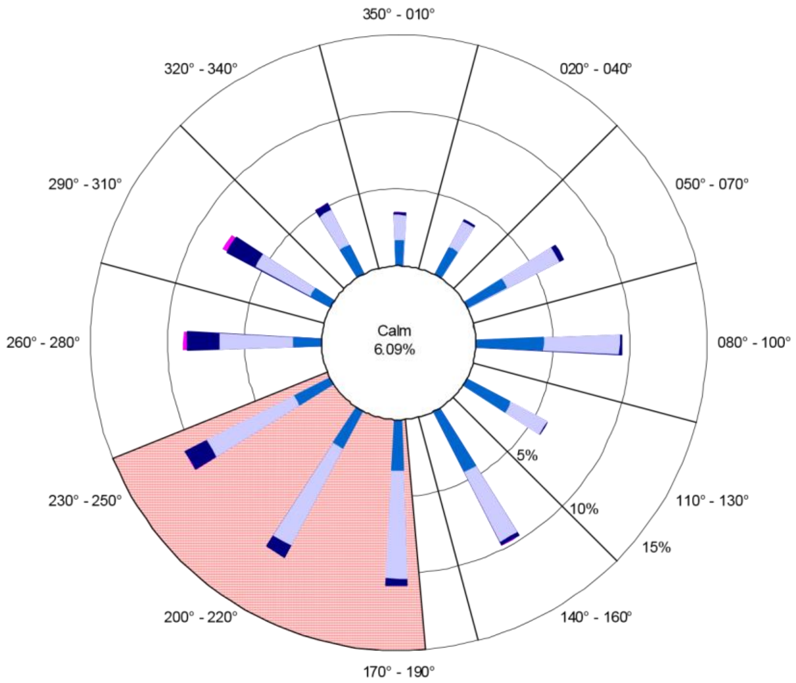




Summer - Wind Rose for Jersey Airport based on wind data 1971 - 2000



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 influences by temperature, humidity, soil moisture, wind speed and so on[17].

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)

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.

10. 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.

11. 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.

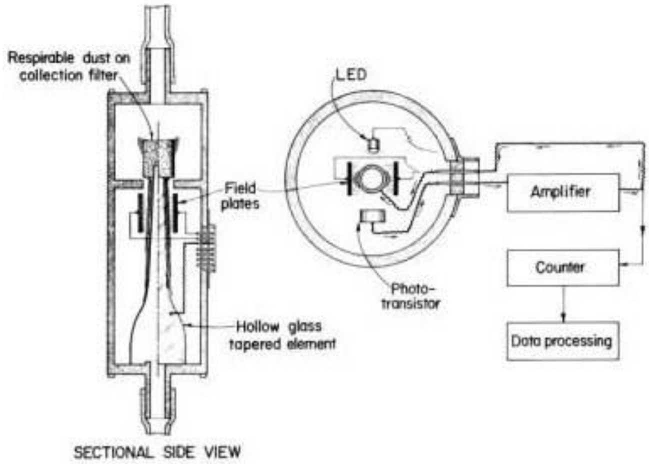


Figure 15: A TEOM sectional view

12. 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

13. 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.

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