Report on Turnkey Osiris Particle Results at the Halkett Place and Howard Davis Park Sites in Jersey for 2013

Environmental Health

Contents

Executive Summary

This report presents the results for the calendar year 2013 of an ongoing program of particulate monitoring in St Helier which is carried out by the Environmental Health Department. This is the 12th consecutive year of monitoring and the results can be directly compared with previous year's results.

At the start of the year, it was decided to take advantage of changes in technology and automate the data collection from the monitoring units by using the 3G mobile phone system. Although relatively simple in concept, the changeover was plagued by technical problems, primarily an incompatibility between the data server and the Jersey Telecom 3G system, which despite best efforts, could not be resolved. Eventually the decision was made to use the Vodafone-Airtel system, which has proved more robust. Further setbacks caused by failure of both monitoring units as well as routine maintenance and repair meant that there are significant gaps in the data for the first half of the year. During the latter half of the year, both units have worked well, although a pump failure caused erroneous measurements to be recorded for part of December.

The data that was gathered showed that PM_{10} concentrations in Jersey once again proved to be generally similar to comparable UK sites and broadly similar to those found in other urban locations. Levels at the Halkett Market site were similar to those that might be expected at a roadside location in the UK.

The UK Air Quality Standards Regulations 2007 set out the standard to which the States of Jersey aspires. The Regulations permit 35 mean daily exceedances of 50µg/m^3 (PM_{10}) which should have been achieved by the end of 2005. There were no exceedances (i.e. average daily figures of greater than 50µg/m^3) at Howard Davis Park and 13 (7.2%) days at the Market ten of which were in April and three in October. Both sites therefore complied with this limit, although it should be noted that there was significant absent data for the year.

The Regulations also set a mean annual limit of PM_{10} of 40µg/m^3. Both sites also complied with this value (Halkett Market 27.5µg/m^3 and Howard Davis Park 16.6µg/m^3).

The exceedances tended to occur outside of the summer months. The weather at these times is characterised by longer nights, clear skies, relatively dry air and conditions which result in temperature inversions (i.e. an increase in temperature with height) which can result in the trapping of moisture and pollutants in the surface air layer. See Appendix 6 for the importance of weather and air quality.

Jersey's local air quality management is reported on in an annual report produced by the UK consultancy Ricardo - AEA Technology. The latest report entitled Air Quality Monitoring in Jersey 2013[26] details the results of an ongoing monitoring program of nitrogen dioxide and hydrocarbon pollutants at a number of locations around the island

Introduction

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 or formed in the atmosphere when gaseous pollutants such as sulphur dioxide and nitrogen oxides react to form fine particles.

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.[18]

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[4]. The impact of road traffic on local air quality is the foremost air quality issue in Jersey.

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.

As part of Environmental Health's Air Quality function, two Turnkey Osiris Particle Monitors (OSIRIS: Optical Scattering Instantaneous Respirable Dust Indication System) were purchased in 1999 and 2002. These were replaced with two new Turnkey Osiris units in October 2008. They are designed to continuously monitor particle levels, in particular Total Suspended Particles (TSP's), PM_{10} (Particles with an aerodynamic diameter of less than 10 microns) $PM_{2.5}$ and $PM_{1.0}$. The Osiris units provide a continuous stream of data in real time which can be analysed and examined in real time as well as being stored on a server for later analysis. The data can also be streamed to a web server for real time display over the internet and it is hoped to get this feature operating in the first half of 2014. The locations of the two monitoring sites are Jersey Market at Halkett Place and Howard Davis Park, both in St. Helier.

Environmental Health leads on Jersey's Air Quality Strategy[6] in conjunction with the Environment Department and Department of Transport and Technical Services (TTS). As part of this process the Jersey Air Quality Action Plan[6] has been produced which details the specific actions required, the Departments responsible and the time limits. Improvements in air quality are generally made through discussion, advice and persuasion as there is no specific air quality legislation in Jersey.

The Turnkey Osiris units are not EU type approved and are designed to provide screening measurements. However, they are reasonably accurate and will indicate whether further type approved (gravimetric) monitoring needs to be carried out.

The European Union reference method for measurement of particulates uses a gravimetric (filter based) system to measure compliance; the UK has suggested that its preferred Tapered Element Oscillating Microbalance (TEOM) measuring devices are adequate if the results are increased by up to 1.3 (30%). Although the Osiris is not as accurate as the TEOM or gravimetric particle measurement methods it provides useful indicative results. No work has been carried out to try and ascertain the precision and accuracy of the Osiris units compared to the TEOM or gravimetric filter based system. See Appendix 3 for the Relationship between the European transfer reference sampler and other PM10 sampling methods [12].

Both monitored sites comply with the EC Directive 2008/50/EC Annual mean objective for fine particles *i.e.* $PM_{2.5}$ (25µg/m^3 by the 31-12-2010). However the measurements were not determined gravimetrically *i.e.* via a weighed filter and are therefore not directly comparable but do give a broadly accurate indication.

Results were obtained for 49% of days in 2012 at Howard Davis Park and 50% of days at the market. These percentages are low because of the problems that were experienced moving towards an automated system. These figures should increase significantly now that the new system is working as it should.

Air Quality and Health

The Air Quality Strategy for England, Scotland, Wales and Northern Ireland[1] states that 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. 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.

The July 2007 UK Air Quality Strategy acknowledged that there will often be co-benefits for air quality and climate change where certain positive measures are taken. Furthermore in the light of current Government policy, it is particularly important that climate change and air quality policies are cohesive. For example, there will be situations where policies to reduce greenhouse gas emissions will have benefits for air quality, and vice-versa. Conversely there may be situations where actions and policies do not necessarily achieve these win-win situations. Technology used to reduce greenhouse gas emissions should always be used in the right circumstances, and not in an area where such technology will impact on the ability of the States of Jersey to pursue the achievement of local air quality objectives.[3] All measures should be given careful consideration to ensure that the benefits for local air quality and climate change are maximised wherever they can be. Where practicable, synergistic policies beneficial to both air quality and climate change should be pursued.[4]

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.

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 1. Some common pollutants and their principle effects on health.

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[3].

The States of Jersey Strategic Plan 2009-2014 contains a commitment to improving air quality with a move towards adopting international air quality standards. UK consultancy AEA Technology first produced an Air Quality Report in 2009 which brings together air pollution data since 1997 and also considers the cumulative impacts of the developments on the Waterfront eg Castle Quay, Esplanade Quarter and the Energy from Waste plant. This report is available on the States website[6]. Subsequent Reports have been produced annually with the latest for data obtained in 2012[13] .

The Transport and Technical Services Department (TTS) produced Jersey's second Sustainable Transport Plan in 2010[24] (updated in 2013) which promotes making greener travel choices. Jersey's 2011 Island Plan aims through better design to provide pedestrian, and cycle ways for new developments. There is also a positive commitment to initiatives aimed at reducing use of the private car and increasing walking and cycling in the Strategic Plan.

The States of Jersey has also signed up to a number of Conventions and Protocols on Air Quality:

1. The convention on Long Range Transboundary Air Pollution- The 1999 Gothenburg Protocol to abate acidification, eutrophication and ground level ozone. The Convention on Long Range Transboundary Air Pollution aims to promote full exchange of information and consultation on long range trans-boundary air pollution and to promote research and monitoring. The Protocol sets emission ceilings for 2010 for four pollutants: sulphur, NOx, VOCs and ammonia.

2. The Convention on Long Range Transboundary Air Pollution – The 1998 Aarus Protocol on Heavy Metals aims to promote full exchange of information and consultation on long range trans-boundary air pollution and to promote research and monitoring. It targets three particularly harmful metals: cadmium, lead and mercury. According to one of the basic obligations, parties will have to reduce their emissions for these three metals below their 1990 levels (or an alternative year between 1985 and 1995). The Protocol aims to cut emissions from a number of industrial sources, such as the iron and steel and non-ferrous metal industries and combustion processes, including power generation, road transport and waste incineration.

Particles: Sources and Health Effects

Particles in the atmosphere originate from a wide variety of sources. They take the form of dust; smoke or very small liquid or solid particles called aerosols. Particles may be either emitted directly into the atmosphere (*i.e.* primary particles) or formed subsequently by chemical reactions (*i.e.* secondary particles). PM_{10} particles are defined as having an average particle size of 10 microns in diameter (10 millionths of a metre), and have well documented effects on human health as they are small enough to be taken deep into lung tissue during respiration. These include effects on the respiratory and cardiovascular systems such as asthma and lead to increased mortality. PM_{10} particles are broadly composed of primary combustion derived carbonaceous particles *e.g.* ultrafines, secondary particles from atmospheric chemistry (*e.g.* ammonium nitrate), wind-blown natural minerals *e.g.* soil and salt or biological *e.g.* spores and bacteria and metals. (See Appendix 4)

Studies have shown that most of the inflammation in the lungs could be explained by the mass of particles inhaled; however mass could not account for all of the variability in the data. It is believed the presence of metals such as iron, zinc, lead and nickel in PM_{10} have the best association with inflammation out of all of the compositional measurements analysed. Primary particulate content of PM_{10} was also positively associated with inflammation.[7]

The Committee on the Medical Effects of Air Pollution (COMEAP), concluded that particle air pollution episodes are responsible for causing excess deaths among those with pre-existing lung and heart disease. Recent research has also associated significantly higher mortality in people recovering from heart attacks if they live in areas with higher $PM_{2.5}$ exposure. European Agency data showed particle pollution causes up to 24,000 premature deaths in the UK each year. COMEAP (formerly EPAQS) also believe 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, for example 20 - 30 years to 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.

There is a wide range of human activities that produce particle emissions, including; motor vehicles (particularly diesel), solid fuel burning, industrial processes, power stations, incinerators and construction activity. The main sources of anthropogenic (*i.e.* man made) particles in Jersey are from transport, the incinerator and domestic fuel burning. The oil fired power station in Jersey is currently running full time while the undersea interlink is being replaced.

Emissions from mainland Europe may also make a significant contribution to secondary particles in Jersey. The UK Airborne Particles Expert Group's findings suggest that in a typical year with typical meteorology, about 15% of the UK's total annual average PM_{10} concentrations (about 50% of secondary particles) are derived from mainland Europe. In years of higher frequency of easterly winds, with large movements of air from mainland Europe, emissions in mainland Europe account for a considerably higher proportion of PM_{10} concentrations, particularly in south and east England. No work has been carried out to try and establish the contribution of secondary particles originating from Europe affecting Jersey.[8]

Research has shown significant associations between $PM_{2.5}$ and elevated risks for cardiopulmonary and lung cancer mortality. A study in California in 2002 found that each 10-

microgram per-cubic-meter increase in long-term average $PM_{2.5}$ concentrations was associated with approximately a 4% increased risk of death from all natural causes, a 6% increased risk of death from cardiopulmonary disease, and an 8% increased risk of death from lung cancer. Associations were also found with sulphur-containing air pollution but not other gaseous pollutants. On the other hand, measures of coarse particles were not consistently associated with mortality.[9]

A UK government Air Quality Strategy Objective and a European Community Directive regulates concentrations of PM_{IO} in the UK (see section 6). The States of Jersey has agreed to work towards the limits set out in the EC Directive 2008/50/EC which deals with benzene, particles PM_{10} & $PM_{2.5}$, sulphur dioxide, nitrogen dioxide, carbon monoxide, ozone and lead. The main issues around air quality in Jersey relate to local air quality and the health impacts associated with high levels monitored mainly at road junctions and along canyon streets[1].

Background

Two Turnkey Osiris Particle Monitors (OSIRIS: Optical Scattering Instantaneous Respirable Dust Indication System) (see photograph 1 below) were purchased in 1999 and 2002[10]. These were replaced with two new units in October 2008.

They are designed to continuously monitor particle levels, in particular Total Suspended Particles (TSPs), PM_{10} (Particles with an aerodynamic diameter of 10 microns) $PM_{2.5}$ and PM $_{1.0}$. The Osiris units sample the various size fractions of particles and provide 15 minute average levels.

This report presents the results of the 11th consecutive year of monitoring and covers the period January 2012 to December 2012. The particle monitoring discussed in this report also forms part of a wider Air Quality monitoring strategy which includes Nitrogen Dioxide passive diffusion tubes, a Nitrogen Dioxide real time chemiluminescent analyser sited at Jersey's market and Volatile Organic compound (VOC) passive diffusion tubes[6].

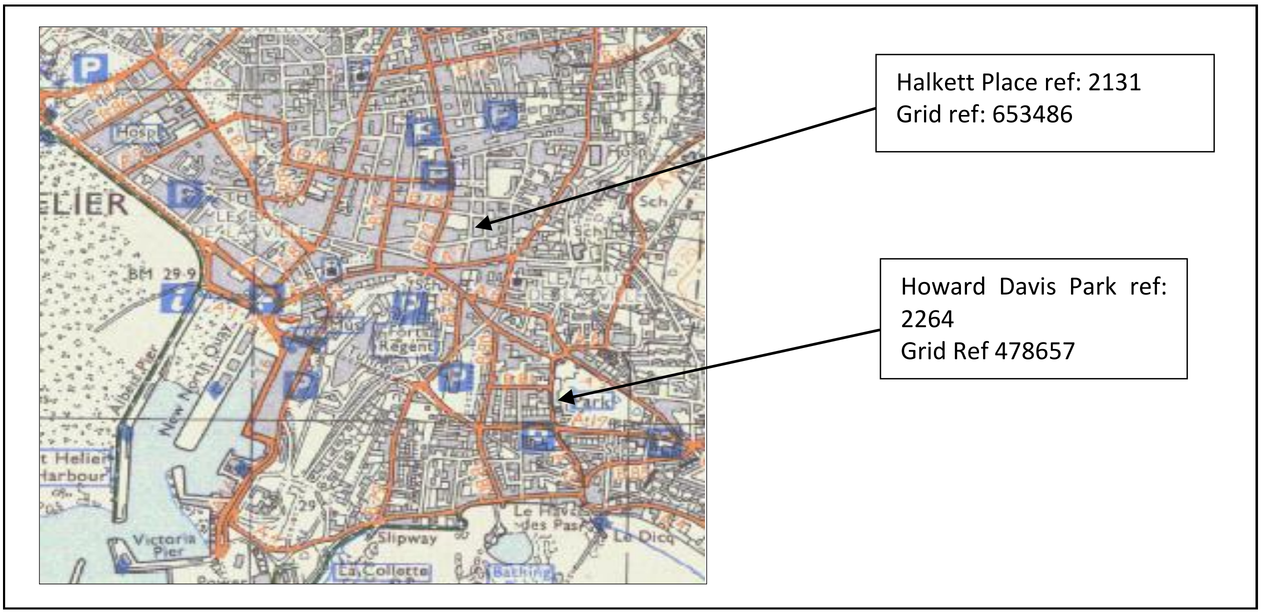


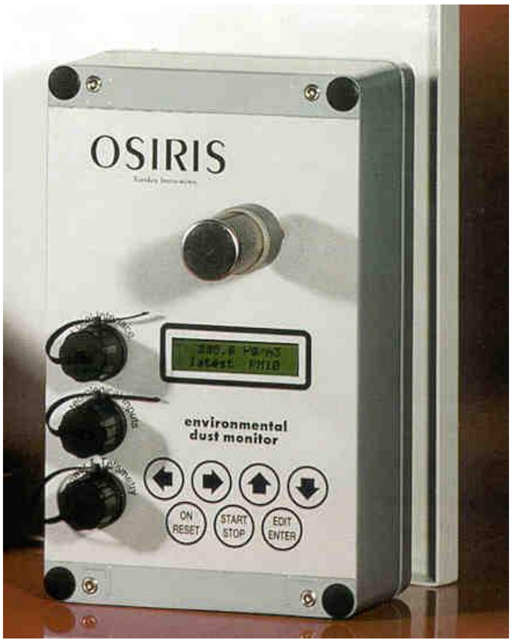
Figure 1: The sampling sites in St Helier town centre[11]

The Turnkey Osiris units are not type approved as per the reference method specified in the the Air Quality Standards Regulations 2007 *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". See Appendix 3 for the relationship between the European transfer reference methods[12].

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 further more detailed measurement is required.

In June 2013, a major upgrade took place to the way that data is collected from the Osiris units. The existing modems were replaced by routers connected to an 'always open' 3G connection which enables the Osiris data to be displayed in real time. Although trials of the system showed that it worked very well, the installation of the units was beset with problems owing to the configuration of the Jersey Telecom 3G SIM cards. These were eventually replaced by Airtel-Vodafone cards which work well. The equipment at Howard Davis Park then failed as a result of wear and tear and was replaced under a maintenance contract. The new router at the Market also failed and was replaced. Some data was lost as a result but the majority has been retrieved and saved. Further problems were experienced with rainwater infiltration of wiring at Howard Davis Park and failure of the photometer in the unit at the Market. At the time of writing, both units are working well.

Data from both of the Osiris units is now published in real time on the States of Jersey website at http://www.gov.je/Environment/ProtectingEnvironment/Air/Pages/AirQuality.aspx.



Photograph 1: The Turnkey Osiris Unit

The Osiris units are also fitted with a GFA Whatman 25mm filter, which traps particles and allows them to be subsequently analysed. The filter analysis allows the weight of particles to be determined and this can help in assessing the accuracy of the Osiris. The analysis is expensive and as it was carried out on the filters in use each year up to 2011, was not repeated for 2013.

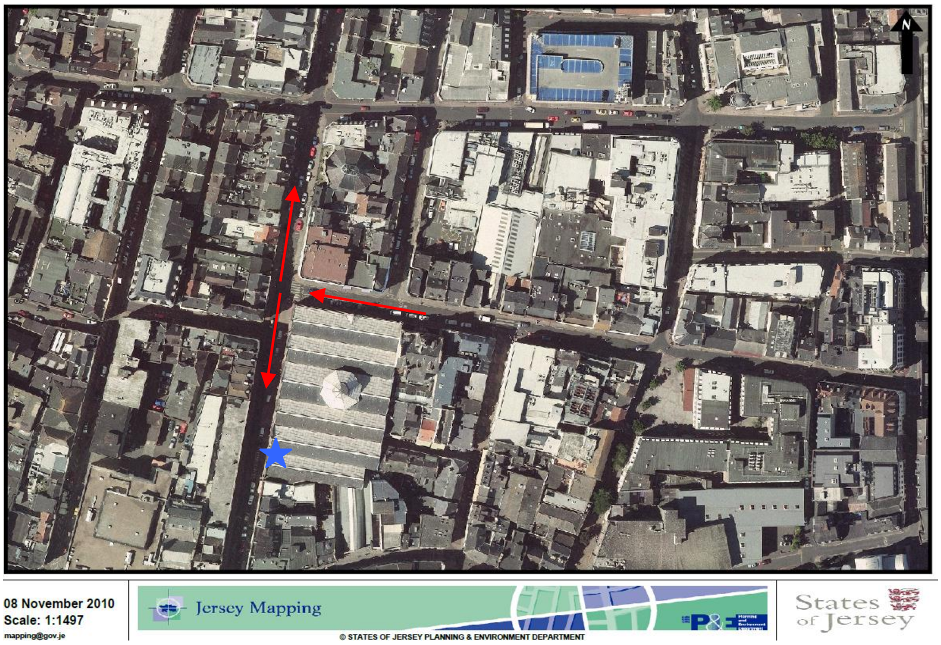
The Osiris unit sited at the central market is approximately 4m above the pavement and approximately 3m from the road of Halkett Place (see the photograph 2 below). This road is used by up to 6,000 vehicles per day with up to 650 per hour at rush hour periods. The peak hours are around 8.00 am and between 12.00 pm and 5.00pm each day. Previous work has shown that particle levels follow traffic numbers, mix and speed closely. The site is also a busy pedestrian area. The unit is co-located with a NOx chemiluminescant analyser and 3 external diffusion tubes. Results from the NOx equipment is the subject of a separate report[26].

Photograph 2: The Position of the Osiris Unit Ref 2131 at the Central Market, Halkett Place, St Helier

Photograph 3: Position of the Osiris unit at Howard Davis Park

This Osiris in Howard Davis Park is specifically located in order to measure particles from a site not directly affected by traffic emissions (see Photograph 4). The nearest road is St Clements Road approx 15 metres away. The site is 300 m from the coast so the particle levels can potentially be affected by sea salt and sand particles which can give elevated readings, though this is less likely to be as significant as it was at Havre des Pas. The site is used by the public so gives an indication of background particle exposure levels.

Particle levels at the market site have reduced generally since the road layout changed in this area. Traffic can now turn right up Halkett Place thereby avoiding the area by the monitor and the provision of two speed bumps/pedestrian crossings on Beresford Street has meant that traffic congestion is now worse on Beresford Street and has improved traffic movement along Halkett Place.



Traffic can turn right or left into Halkett Place from Beresford St. Traffic heading south passes the market and monitoring point.

Direction of traffic:

Location of monitoring site

Photograph 4: Map showing the direction vehicles travel at the market site on Halkett Place[16]

Results

The number of days on which the daily average PM_{10} figure exceeded 50µg/m^3 is shown in Table 1 below. The results are compliant with the UK Air Quality Strategy's target figure of no more than 35 exceedances even when the figures are extrapolated to estimate the figures for a full 365 days or a full year's data.

	Days data obtained	Exceedances >50µg/m^3
Howard Davis Park	180 (49%)	0 (1.8%)
Halkett Market	177 (49%)	13 (7.2%)

Table 1. Number of daily exceedances at both sites

Figures 3 & 4 give a graphical representation of the same data (i.e. daily averages of PM_{10}) for all full days of data collected throughout 2013. Missing data occurred as a result of the difficulties experienced getting the new real time system operational and much improved data collection is expected now that the new system is fully functional.

There are no clear trends throughout the year, but it is clear from the graphs that PM_{10} concentrations are significantly higher at the town centre site than at Howard Davis Park. This is most likely due to traffic emissions in Halkett Place as the principle source of PM_{10} is likely to be from road traffic, rather than other windblown particulates such as sand and salt which tend to be larger in size.

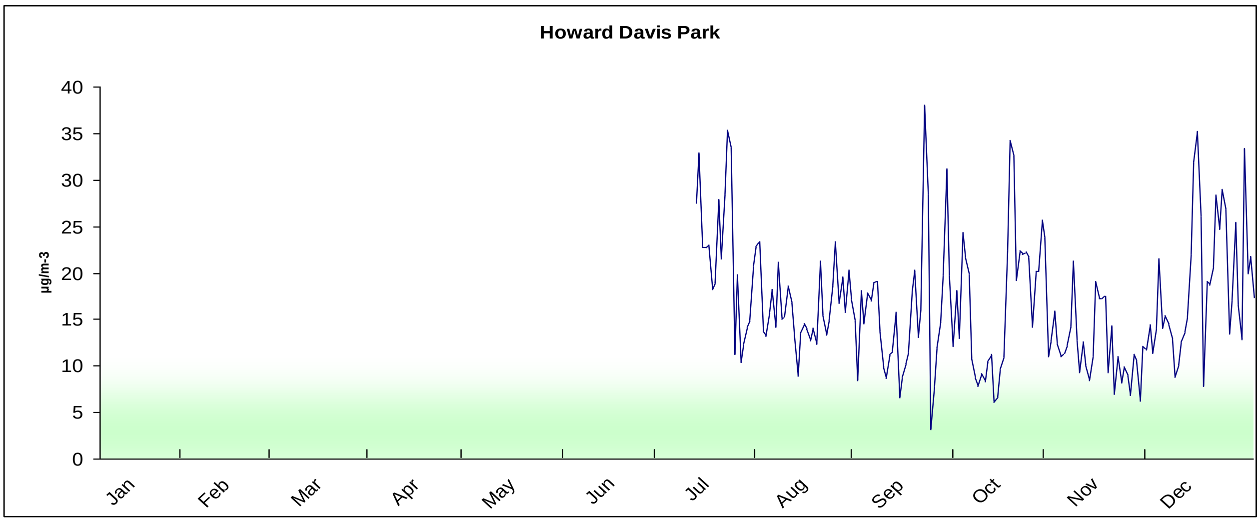


Figure 3. Daily mean PM_{10} levels throughout 2013 at Howard Davis Park.

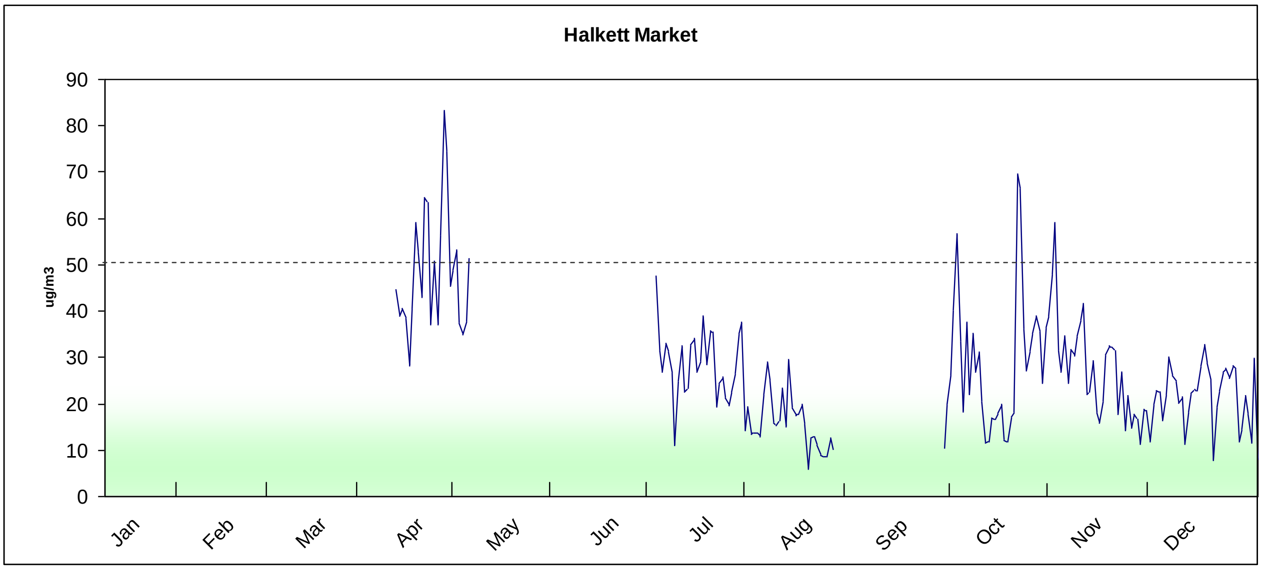


Figure 4. Daily mean PM_{10} levels throughout 2013 at Halkett Place. The horizontal line depicts the 'exceedance' level

The histogram in Figure 5 shows the number of days on which mean 24 hour PM_{10} levels fell into one of a number of categories as shown. At Howard Davis Park, all of the results fell into lower concentration bands, whereas the modal levels at Halkett Place were higher and there were also a number of considerably higher daily averages including all the results that exceeded the indicative level of 50 μg/m^3. It should be noted that the overwhelming majority of daily average PM10 levels were well below the indicative level of 50 μg/m^3.

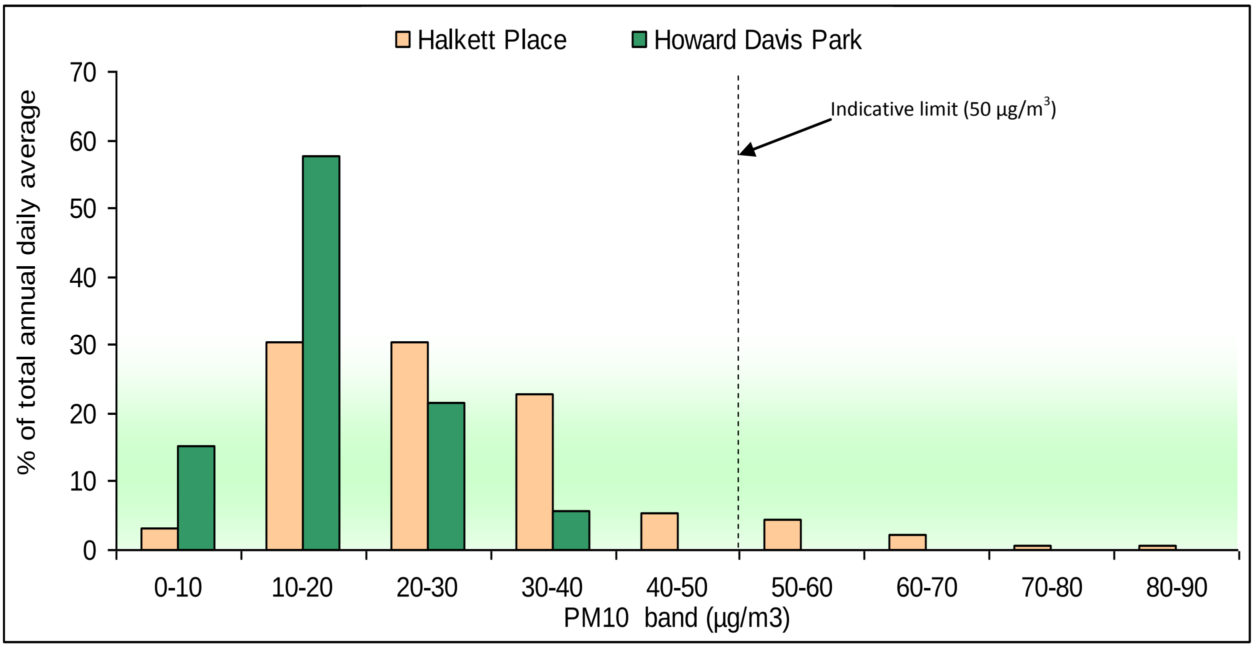


Figure 5. The frequency with which PM10 levels occurred within a series of discreet categories in 2013

In order to examine the link with traffic density further, the 15 minute mean PM_{10} levels for a one week period were taken at random from the entire Halkett Place 2013 data set. Figure 6 shows the plot of this data over the sample period. The weather at the time of the sampling was anti-cyclonic with relatively still air conditions. It can be clearly seen that particulate levels tend to rise during the day and fall back at night, which suggests that it is daytime activities, such as traffic movements that are primarily responsible. However, if traffic density was the sole driver of particulate density, it might be expected that clear peaks would occur during rush hour times and this is not strongly supported by the data.

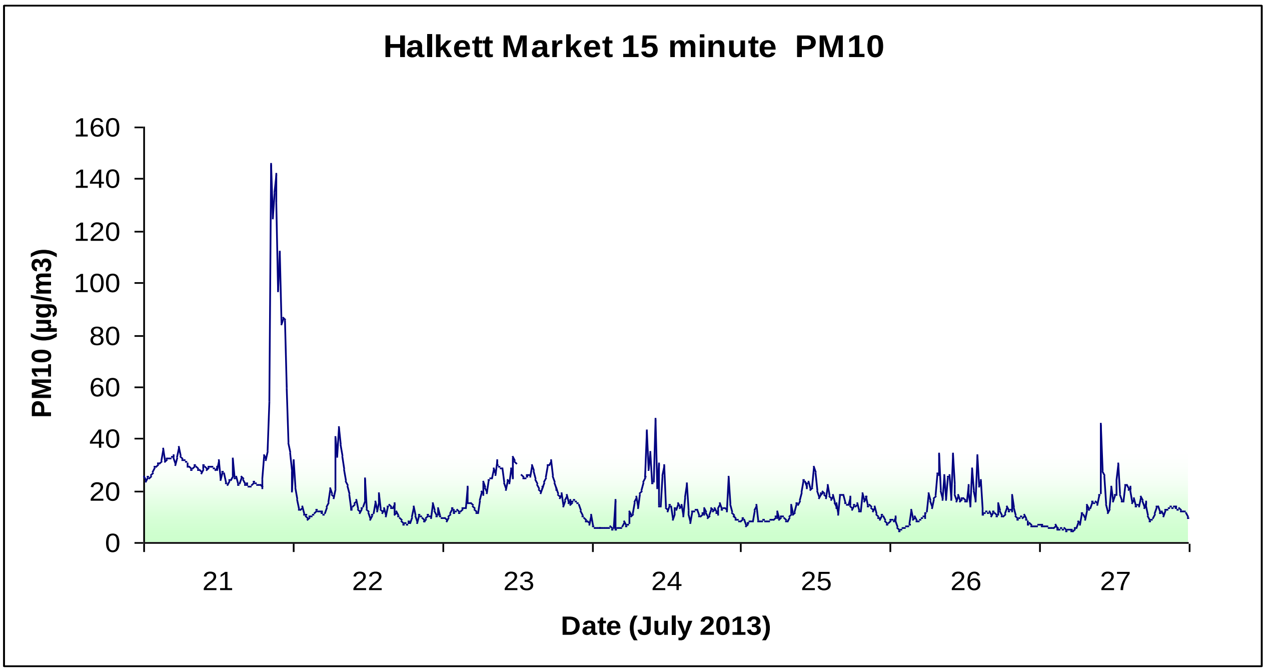


Figure 6. Daily mean PM_{10} levels for a 7 day period in July 2013

Data from previous years also suggests that there is not necessarily a close correlation between traffic volumes and the concentration of particulates[29]. There are other significant factors which influence atmospheric particulate concentrations. The graph in Figure 7 is taken from a UK DEFRA report[30] and shows the estimated reduction in particle emissions from 1970 to 2002. There is a clear downward trend and this continues onto 2012 as shown in Figure 8, but this is not accounted for by any obvious reduction in road transport emissions, which have broadly remained the same over the period. One explanation for this is that despite the improvement in vehicle emissions since 1970, there has been a greatly increased use of diesel vehicles and a significant increase in the number of vehicles on the road.

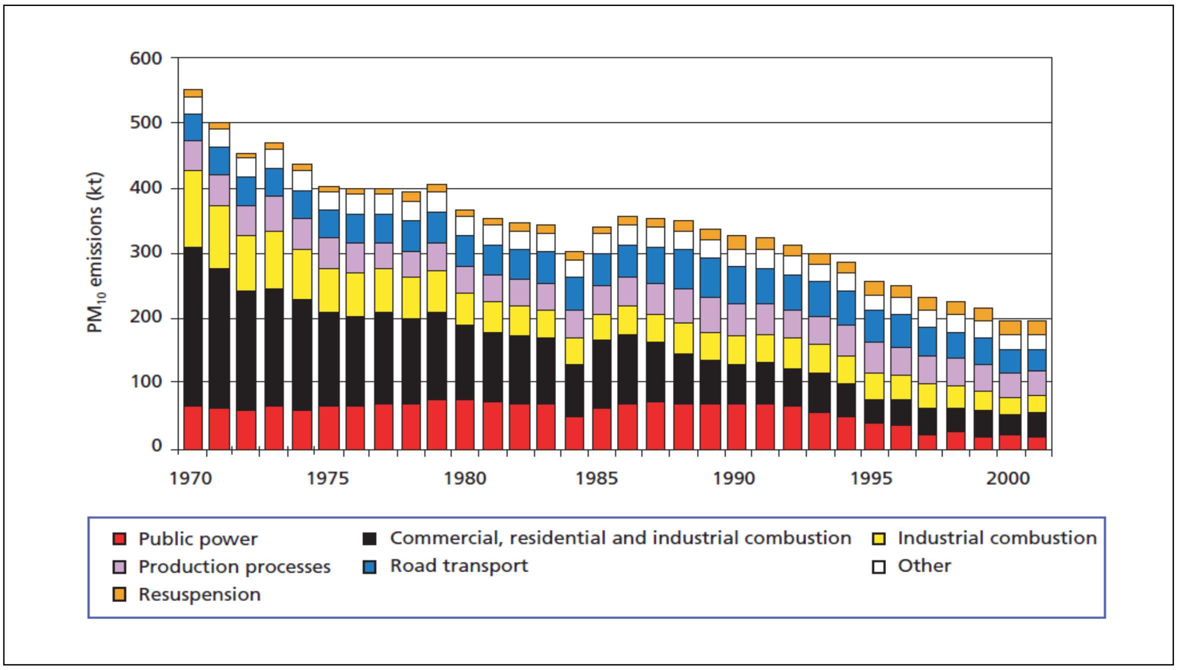


Figure 7. Estimated reduction in particle emissions 1970-2002. (DEFRA Air Quality Expert Group, 2005) Particulate Matter in the United Kingdom. HMSO, Norwich (reproduced with permission)

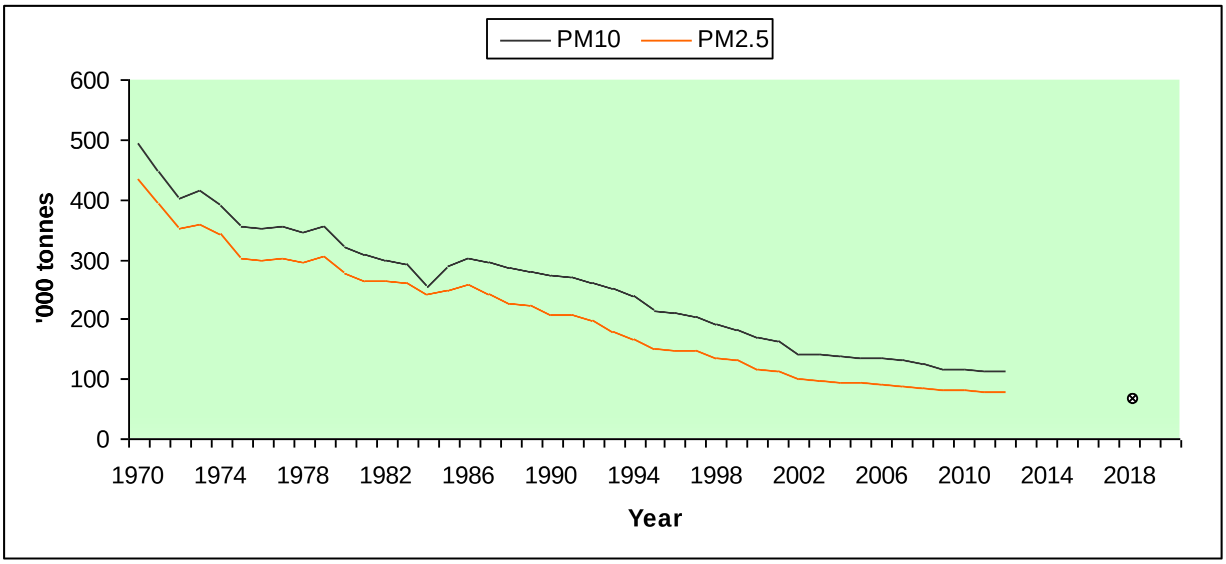


Figure 8. Defra National Statistics Release: Emissions of air pollutants in the UK, 1970 to 2012 and projection for 2020

Another major influence on particle levels is weather with both heavy rain and high winds likely to obscure any relationship between pollutant levels and traffic density.

Interpretation of data can be an imprecise science, but it is often the case that episodes of poor air quality coincide with still days, because dispersion on such days is poor and pollutants are able to accumulate locally, particularly in areas such as Halkett Place, where the narrow street produces a 'canyon' effect.

Table 2 below shows the number of days where average PM_{10} levels met 4 standard categories of pollution level in accordance with the UK Air Quality Index. Particulate levels were generally low at both sites but higher levels were observed, particularly at the Market site. The figures are a slight improvement on those from 2012 with the Market once again having measurably higher levels.

Air Pollution Bandings:	24 Hour mean	Market	Howard Davis Park
Low Air Pollution:	<50 µg/m^3	168 (92.8%)	177 (100%)
Moderate Air Pollution:	50 - 74 µg/m^3	13 (7.2%)	0
High Air Pollution:	75 - 99 µg/m^3	0	0
Very High Air Pollution:	>= 100 µg/m^3	0	0

Table 2. Daily mean readings shown as the number (%) of days where PM10 fell into the four Air Quality Index categories. See Appendix 2 for an explanation of the Index.

The UK Air Quality Strategy allows 35 daily exceedances annually and this limit was again achieved in Jersey in 2013. However, the Environmental Health Service is aware that this limit may soon be under review. Any proposed changes will be discussed as soon as they are known.

Both sites comply with the EC Directive 2008/50/EC Annual mean objective for fine particles *(*$PM_{2.5}$ 25µg/m^3 by the 31 Dec 2010). However the measurements are to be determined gravimetrically *i.e.* via a weighed filter and since the Osiris units use a different method, the results are therefore not directly comparable but do give an indication[12].

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. Data previously published by Environmental Health shows that the prevailing wind comes from a Westerly quadrant, although north-easterlies and southerlies are also not uncommon.

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.

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. Furthermore, increased wind speed can suspend sea salt and sand particles which can be moved inland causing elevated results. More information on the importance of weather on air quality can be found in Appendix 6.

Exceedances of the air quality standard

Figure 9 below shows that the number of exceedances for the historic sites from 2002 – 2007 (ie Southampton Hotel Weighbridge, Bellozanne valley) and the number of exceedances for the Market and Havre Des Pas /Howard Davis Park sites for the years 2006 - 2013.

The number of exceedances for 2013 was very low, with only 13 daily means of over 50µg/m^3 recorded, all of which were at the Market site and all of which fell into the 'moderate' category of the UK Air Quality Index.

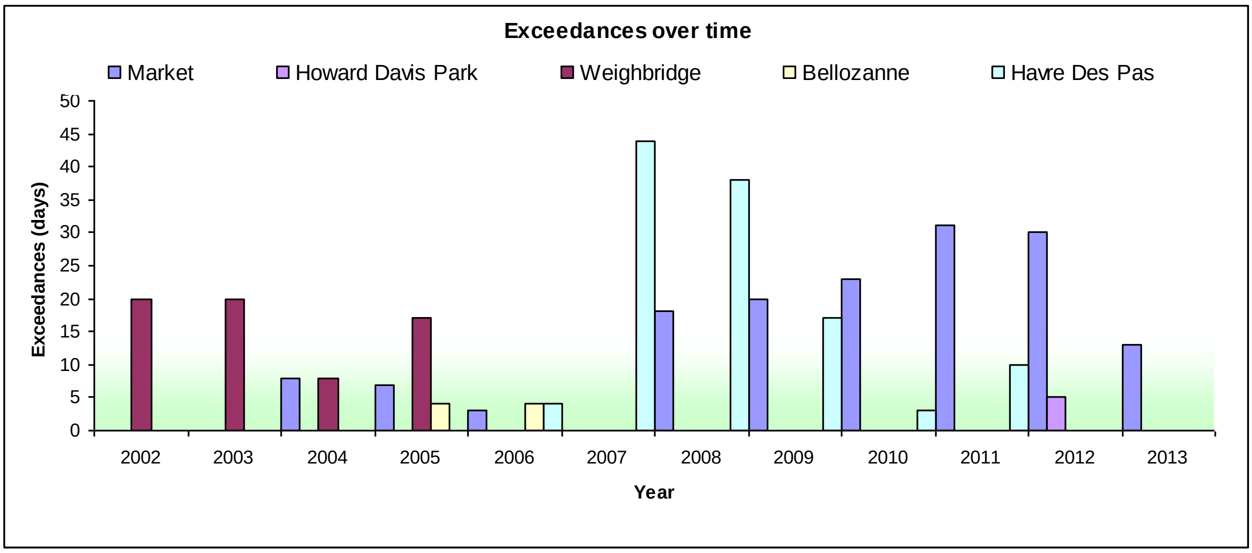


Figure 9. The number of days on which the daily average PM_{10} figure exceeded 50µg/m^3

Because of the low number of exceedances in 2013 (Figure 10), no meaningful conclusions could be drawn from the data. There was no measurable winter increase in particle levels as was observed in 2011 and 1012. It is notable however, that approximately half of the exceedances came from one short period in April 2013.

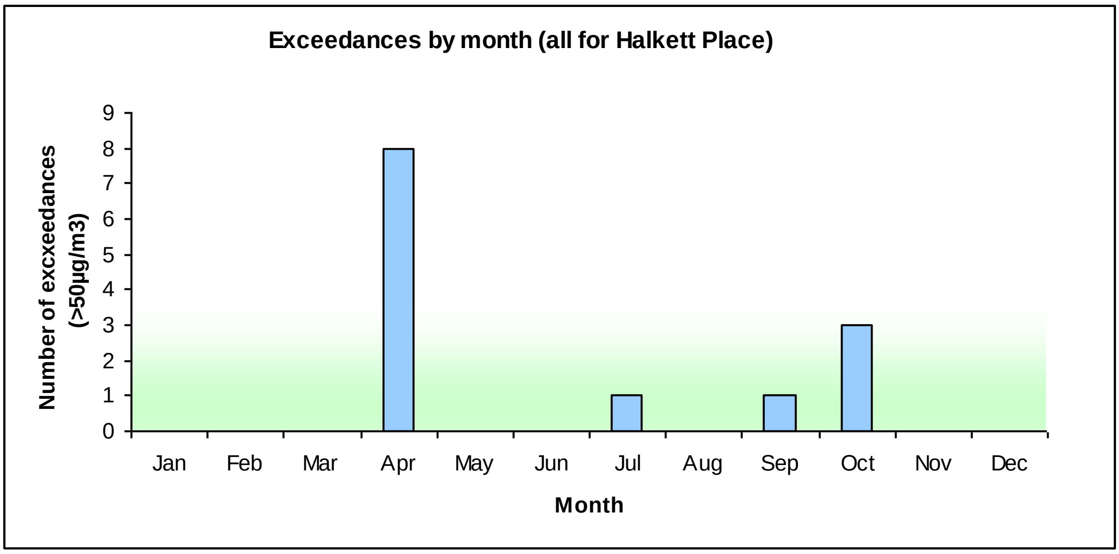


Figure 10. Months in which the exceedances occurred in 2012

EU and UK Guidelines

Although not legally binding in Jersey, the States has agreed to work towards the European Union Directive objectives[20]. 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 legislation. 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.

In the UK, air quality standards and objectives for the major pollutants are described in the Air Quality Strategy for England, Scotland, Wales and Northern Ireland July 2007 (The National Air Quality Strategy, or NAQS)[1]. Appendix 2 provides details of the UK Air Quality Objectives for protection of human health. In a recent UK Government consultation on the air quality strategy, it was noted that the European Commission is developing a new Air Quality Directive and that the Commission has recognised that continuing to pursue the indicative 2010 limit values for particles is unlikely to generate a cost effective improvement in air quality. Therefore, it seems unlikely that the 2010 objectives will ever be enacted in legislation.

Improvements in particle levels in Jersey

Road transport is responsible for up to 70% of air pollutants in UK urban areas. PM_{10} concentrations in Jersey were broadly similar to those found in comparable areas in the UK and levels at both sites are broadly what could be expected at a roadside location[22].

Air quality should improve as the benefits of improved engine design Euro 3/4 are seen. Further road changes as part of the St Helier Life program and general town centre improvements may have assisted in improving air quality. The 2012 States of Jersey Air Quality Report, the Air Quality Strategy and Action Plan 2012 and the TTS Sustainable Traffic and Transport Plan 2011 will raise the profile of Air Pollution and suggests measures needed to reduce it.[23]

The States of Jersey Island Plan 2011 addresses the issue of transport, noting that the level of car ownership on the island is very high and predicted to increase by 5-10% between 2009 and 2014. With this increased ownership will come increased use and increased pollution, particularly in traffic hotspots and during peak periods. It further notes that 'Jersey needs to adopt a cultural change in travel behaviour before significant reductions in car use are apparent and that will take time'.

Jersey Electricity now imports in excess of 90% of its power from EDF (France) compared with just 45% in 1990, the year in which the Kyoto Treaty was signed. This has led to Jersey Electricity being virtually the sole driver of the Island's reduction in carbon emissions - a reduction of one third since 1990 despite a 50% increase in overall energy consumption[23]. The failure of the undersea cable supplies from France has meant that JEC has been generating electricity since June 2012 using heavy fuel oil. This results in emissions of particles, sulphur and nitrogen dioxides. It is expected the new link will be completed in late 2014 / early 2015.

Pollution including particles from the old Bellozanne Incinerator has ceased as the new La Collette Energy from Waste plant is now operational which uses the latest pollution control technology to minimise harmful emissions. The emissions are monitored in real time and are available in report form from the Transport & Technical Services Department. Work is under way to make these reports available on line.

CT Plus (Liberty Bus) took over the running of the island bus service in 2012 and operates a fleet of new buses which operate to high emissions standard as required when they were manufactured. Other options available are to move towards gaseous fuels such as the vehicles operated by Jersey Gas, which emit no particles at all. The availability of bio-diesel in Jersey could also lead to a reduction in pollutant emissions. The States has also leased ten electric cars for use by staff on States business and is committed to the promotion and use of electric vehicles.

Other measures to improve air quality include:

- The installation of two new cremators which comply as far as practicable with the UK Environmental Protection Act 1990 Process Guidance note 5(02)/12
- New Building Byelaw Part L to improve insulation in domestic properties improving reducing fuel consumption by improving the thermal insulation of new build properties.

- The renewal and provision of a new electricity link to France will reduce the need to run the JEC oil fired power station.
- The growth in the use of solar panels, wind generators and ground and air source heat pumps will reduce the reliance on traditional fossil fuels; thereby reducing particle emissions from domestic premises.
- In April 2013, the Transport and Technical Services Department updated the Sustainable Transport policy (STP) which sets out to minimise the environmental impact of our travel and encourage Islanders to make convenient, sustainable and healthy travel choices.
- Liberty Bus have increased the peak hour capacity on routes into St Helier and improved the access to remote areas. The intention is that this should result in a reduction in the use of private cars, however the proposed reduction in road traffic of 15% by 2015 looks unlikely to be achieved, despite an increase in bus usage.
- The draft Island Plan promotes Sustainable Development, Travel & Transport (reducing the need to travel & car dependency) and aims to protect the Environment. These policies should positively impact on air quality.[25]
- Environmental Health is leading on Jersey's Air Quality Strategy in conjunction with the Environment Department and Department of Transport and Technical Services (TTS). As part of this process the Air Quality Strategy and Action Plan have been produced which details the specific actions required, the Departments responsible and the time limits. Improvements in air quality are generally made through discussion, advice and persuasion as there is no specific air quality legislation in Jersey.

Conclusions

1. The Turnkey Osiris particulate monitors currently operate at the Central Market on Halkett Place and at Howard Davis Park, St Helier. 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 ($PM_{1.0}$) as 15 minute averages. Data from the two Osiris units is now displayed in real time on the States of Jersey website.

2. Particles are associated with a range of health effects. These include effects on the respiratory and cardiovascular systems, asthma and mortality. Particles with a small size (PM2.5 and below), which are generally associated with vehicle emissions are capable of inhalation into deep lung tissue and therefore of causing the most significant risk to health. The risk of serious illness is likely to be small but prolonged exposure over many years may lead to chronic health effects. Larger particles will normally be effectively filtered by the respiratory system and are more likely to consist of salt, sand and windblown dust.

3. The Osiris units have glass fibre filters which collect particle material, which was further analysed to determine the sources of the particles and percentage contribution. Examination revealed in 2011 that the collected deposit was varied including sea salt, sand, general dirt and carbonaceous matter with particle size of <10 microns associated with vehicular emissions. Care must be taken interpreting these results as only a very small number of particles (40) were analysed.

4. PM_{10} concentrations in Jersey were generally higher than the UK comparison sites but 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.

5. Particle levels from other sources, such as the power station, have reduced with the use of the cable links to France (ie up to 97% of electricity used in Jersey originates from France). This has not been the case for the latter half of 2012 since the links failed, but there does not appear to have been a significant rise in particle levels as a result of emissions from the island power plant.

6. The main air quality issue in Jersey relates to the impact of traffic on local air quality.

Recommendations

- 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. This forms part of the Air Quality Strategy and Project Plan.

- Monitoring if required could involve the use of EU type approved measurement equipment to be meaningful and allow direct comparison with the UK.

- Traffic data (eg volume, mix and speed) could be obtained to allow more meaningful comparison with particle results.

- Further work is needed to assess the relationships between meteorological data and particle levels.

- Comparison between EU type approved monitoring of PM_{10} and the Osiris units to determine if a factor is needed to account for the loss of volatiles from the heated sampling head.

- Work is carried out to determine the percentage contribution of non toxic particles within monitored particle levels *i.e.* sand and salt

- Work is needed in conjunction with other stakeholders to implement the recommendations in the Jersey's Air Quality Action plan .

- It is recommended that Local Air Quality Management legislation is introduced to formalise the process of management of Air Quality in Jersey.

- It is recommended dose sampling is carried out to assess actual exposure to air pollution whilst driving, cycling and walking.

Appendix 1: 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 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 dependant 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. Details of the Turnkey Osiris Units are provided in Appendix 1.

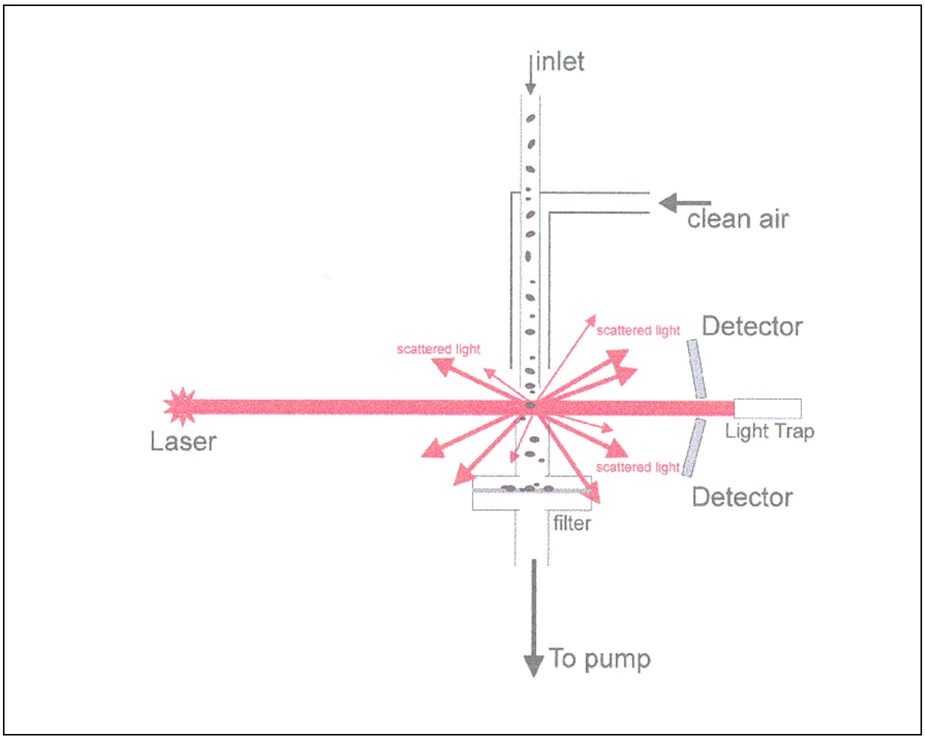


Figure 6: The Osiris particle monitor

Appendix 2: UK Air Quality Objectives for protection of human health, July 2007

UK Air Quality Objectives for protection of human health, July 2007

Pollutant	Air Quality Objective		To be achieved by
	Concentration	Measured as	
Benzene			
All authorities	16.25 µg m^{-3}	Running annual mean	31 December 2003
England and Wales Only	5.00 µg m^{-3}	Annual mean	31 December 2010
Scotland and N. Ireland	3.25 µg m^{-3}	Running annual mean	31 December 2010
1,3-Butadiene	2.25 µg m^{-3}	Running annual mean	31 December 2003
Carbon Monoxide			
England, Wales and N. Ireland	10.0 mg m^{-3}	Maximum daily running 8-hour mean	31 December 2003
Scotland Only	10.0 mg m^{-3}	Running 8-hour mean	31 December 2003
Lead	0.5 µg m^{-3}	Annual mean	31 December 2004
	0.25 µg m^{-3}	Annual mean	31 December 2008
Nitrogen Dioxide	200 µg m^{-3} not to be exceeded more than 18 times a year	1-hour mean	31 December 2005
	40 µg m^{-3}	Annual mean	31 December 2005
Particles (PM10) (gravimetric)			
All authorities	50 µg m^{-3}, not to be exceeded more than 35 times a year	Daily mean	31 December 2004
	40 µg m^{-3}	Annual mean	31 December 2004
Scotland Only	50 µg m^{-3}, not to be exceeded more than 7 times a year	Daily mean	31 December 2010
	18 µg m^{-3}	Annual mean	31 December 2010
Particles (PM2.5) (gravimetric) *	25 µg m^{-3} (target)	Annual mean	2020
All authorities	15% cut in urban background exposure	Annual mean	2010 - 2020
Scotland Only	12 µg m^{-3} (limit)	Annual mean	2010
Sulphur dioxide	350 µg m^{-3}, not to be exceeded more than 24 times a year	1-hour mean	31 December 2004
	125 µg m^{-3}, not to be exceeded more than 3 times a year	24-hour mean	31 December 2004
	266 µg m^{-3}, not to be exceeded more than 35 times a year	15-minute mean	31 December 2005
PAH *	0.25 ng m^{-3}	Annual mean	31 December 2010
Ozone *	100 µg m^{-3} not to be exceeded more than 10 times a year	8 hourly running or hourly mean*	31 December 2005

* not included in regulations at present.   Shaded data shows new objectives

UK Air Quality Objectives for protection of vegetation and ecosystems, July 2007 - New objectives highlighted in shading			
Pollutant	Air Quality Objective		To be achieved by
	Concentration	Measured as	
Nitrogen dioxide (for protection of vegetation & ecosystems) *	30 µg m^{-3}	Annual mean	31 December 2000
Sulphur dioxide (for protection of vegetation & ecosystems) *	20 µg m^{-3} 20 µg m^{-3}	Annual mean Winter Average (Oct - Mar)	31 December 2000
Ozone *	18000 µg m^{-3}.h	AOT40**, calculated from 1h values May-July. Mean of 5 years, starting 2010	01 January 2010

* not included in regulations at present

** AOT 40 is the sum of the differences between hourly concentrations greater than 80 µg m^{-3} (=40ppb) and 80 µg m^{-3}, over a given period using only the 1-hour averages measured between 0800 and 2000. Shaded data shows new objectives

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 a 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 the 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*[28], 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 1. Air Pollution Bandings and Index and the Impact on the health of People who are Sensitive to Air Pollution

Appendix 3: Relationship between the European transfer

Monitoring of PM_{10} in the UK networks has to date, been largely founded on the use of the TEOM analyser. A concern with the TEOM instrument is that the filter is held at a temperature of 50°C in order to minimise errors associated with the evaporation and condensation of water vapour. This can lead to a loss of the more volatile particles, such as ammonium nitrate and a consequent underestimate of particle levels.

The EU limit values and the UK objectives are based upon measurements carried out using the European transfer reference sampler, or equivalent. This is a gravimetric sampler, where the particulate material is collected onto a filter, and subsequently weighed. The filter is therefore held at fluctuating ambient conditions during the period of exposure. Whilst there will inevitably be some losses of volatile species from the filter (dependant upon the ambient temperature), these will be less than from the TEOM.

The Government and the Devolved Administrations have been investigating the relationship between the TEOM and the reference sampler, using co-located instruments at 6 sites in the UK. These studies have shown that the TEOM adjustment factor is site specific, and varies both from season to season, and from year to year. Because of this an interim default adjustment factor of 1.3 has been proposed for the UK. This approach is supported by studies carried out in other EU countries, and appears to also apply to ß-attenuation instruments with a heated manifold.

For the purpose of the next round of review and assessment, authorities should bear in mind the issues set out below:

- Measurements of PM_{10} concentrations carried out using the European transfer reference sampler, or equivalent, are directly comparable with the UK objectives and EU limit values, and no data correction is necessary. There are however, important QA considerations to bear in mind, regarding the handling and weighing of filters.
- Measurements of PM_{10} concentrations carried out using a TEOM or ß-attenuation instrument, operating with a heated manifold, should be adjusted by multiplying the data by 1.3 to estimate gravimetric equivalent concentrations.
- Measurements of PM_{10} concentrations carried out using other sampling methods (e.g. optical analysers, or gravimetric samplers that have not been certified as 'equivalent') will need to be considered carefully, particularly if they are being used in a Detailed Assessment, and the concentrations measured are close to the objectives.
- It is not recommended that authorities carry out local inter-comparison studies between the transfer reference sampler and other samplers for the purpose of review and assessment. Where such studies are carried out, it is essential to carry out the comparison over at least 6 months, including a summer and winter period. Any adjustment factors derived may be both season and site specific, and cannot simply be used to adjust data at other sites, in other years.
- The method of sampling is critical to the result. In all cases, authorities should explicitly state the method of sampling, and report all original and 'adjusted' data.

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

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 [31].

Appendix 5: TES Bretby Ltd Test reports and scanning electron micrographs.

ESG Environmental Scientifics Group

TEST REPORT

1205

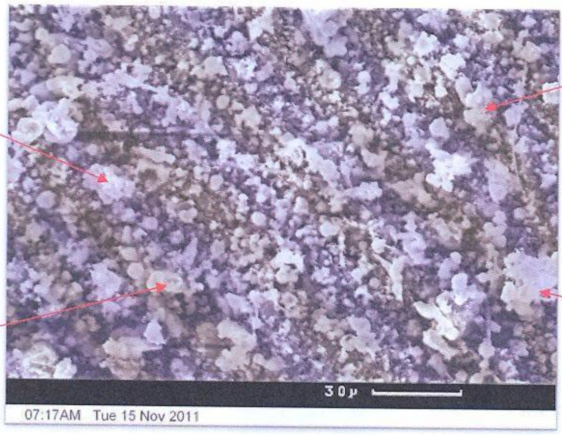
OCCUPATIONAL HYGIENE & ENVIRONMENTAL MONITORING LABORATORY

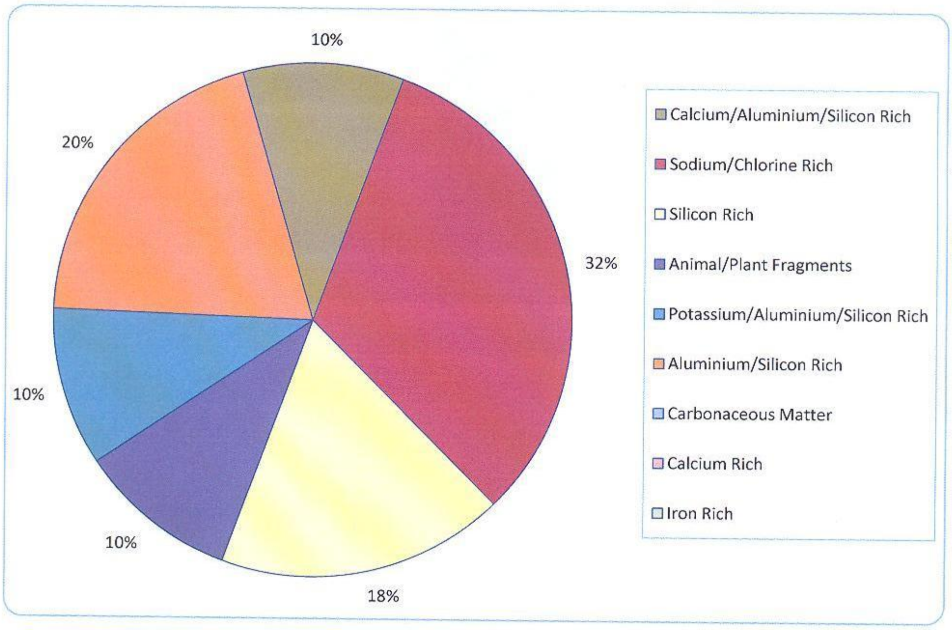
RESULTS OF SEM-EDS EXAMINATION

Report Number: OHEM/06308/SEM/0001

Page 1 of 3

Sample description: Osiris Filter Installed 30/11/2010, Removed 22/06/2011. Mass of deposit 7.95 mg Ref 2264, Sample ID Number: 040210.





Environmental Scientifics Group Limited
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Telephone: 01283 554400 Fax. 01283 554422
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a. Havre Des Pas Site: Filter 1

ESG Environmental Scientifics Group

TEST REPORT

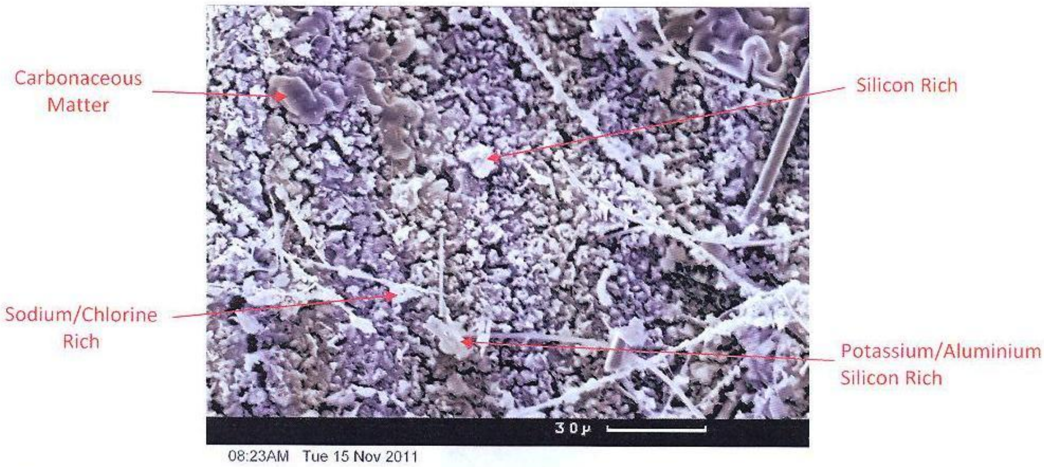
UKAS TESTING 1205

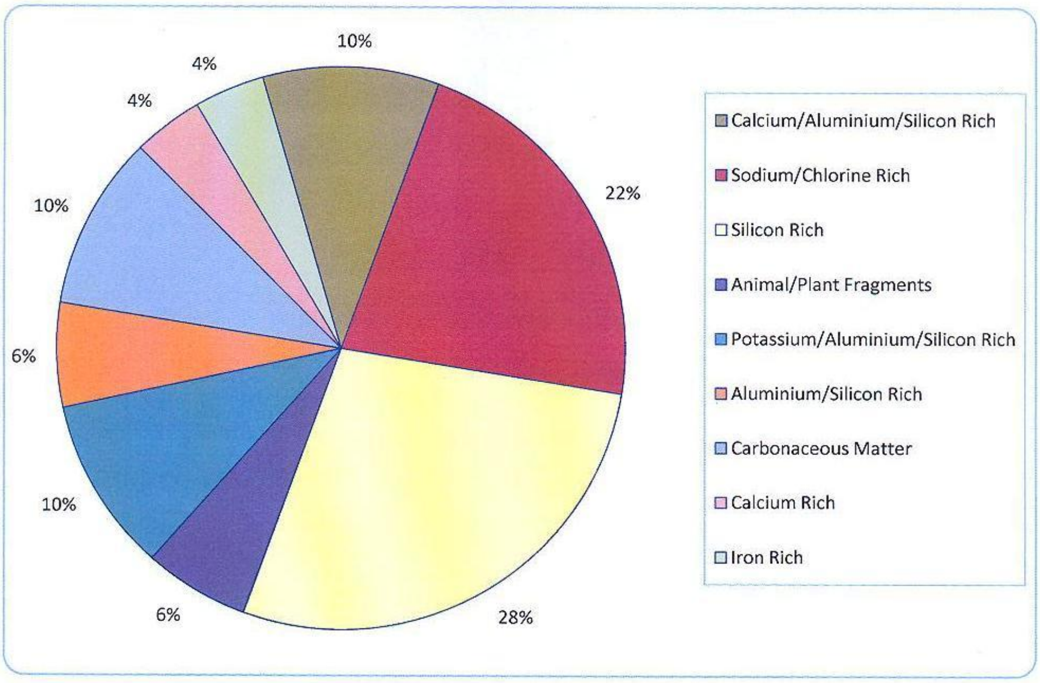
OCCUPATIONAL HYGIENE & ENVIRONMENTAL MONITORING LABORATORY

RESULTS OF SEM-EDS EXAMINATION

Report Number: OHEM/06308/SEM/0001

Sample description: Osiris Filter Installed 22/06/2011, Removed 18/10/2011. Mass of deposit 12.75 mg Ref 2264, Sample ID Number: 040211.





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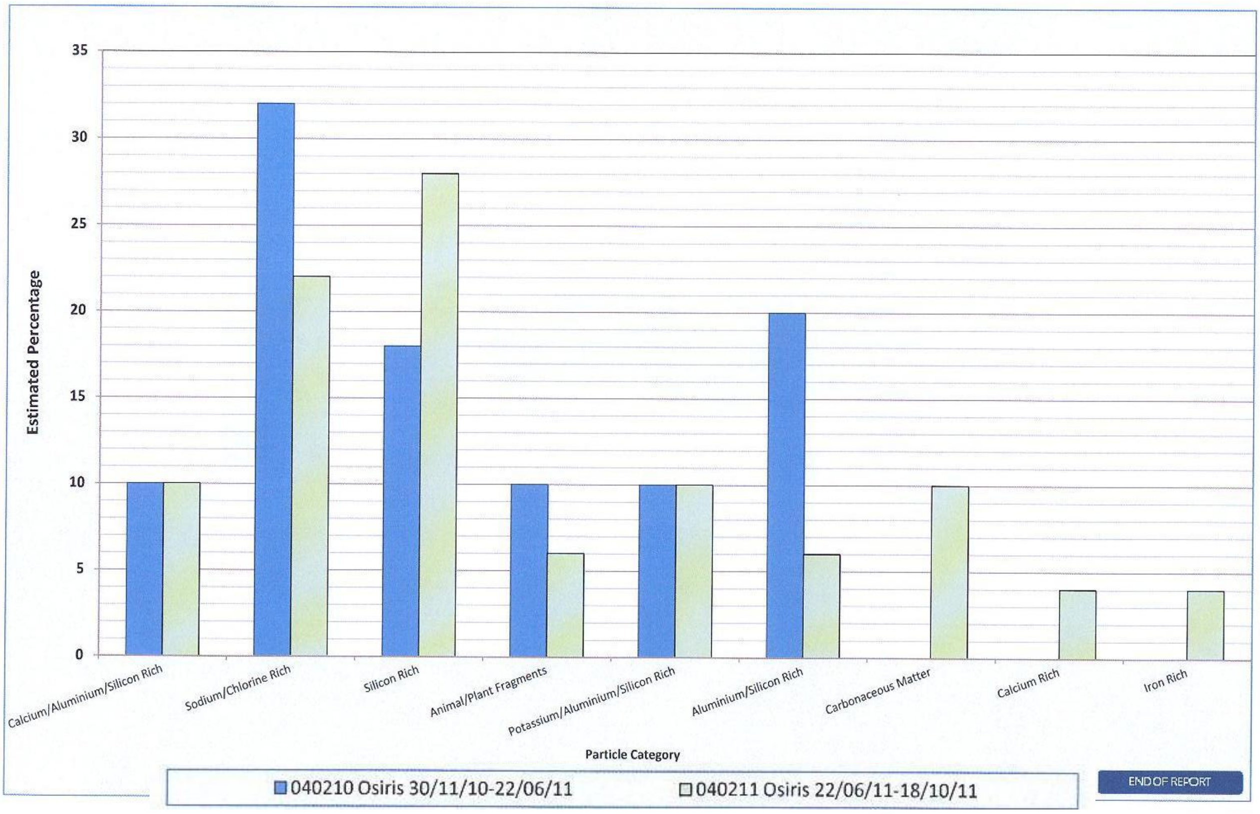
b. Havre Des Pas site: Filter 2:

States of Jersey: SEM-EDS Particle Characterisation
Results Comparison Chart: Job OHEM 06308



END OF REPORT

Page 3 of 3

Appendix 6: The Importance of Weather and Air Quality

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. Examples of the influence of weather conditions on typical air quality include:

- There is a diluting effect of wind speed: at London Hillingdon, an approximate halving of NO_X concentrations with a doubling of wind speed from 5 to10 m.s-1 has been shown.
- $PM_{2.5}$ decreases when wind speed increases due to dilution but PM coarse increases with wind speed due to re-suspension. These effects show the different sources of PM components.
- Daily maximum ozone concentration is highly sensitive to temperature, particularly where this rises above around 24-25^o. At Lullington Heath in Sussex, between 1993 and 1998, a rise from 25-30^o typically produced a rise in ozone peak of around 60 µg.m-3, compared to 13 µg.m-3 for a 10-15^o rise (Anderson *et al*. (2001).

- Precipitation can reduce particulate matter concentrations dramatically, although other weather factors such as wind speed are also correlated with rainfall. Around a 6 ug.m-3 difference in PM_{10} has been observed in Edinburgh between days with no rainfall and those with >20mm rainfall.
- The incidence of certain wind directions can also lead to high pollution concentrations.

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 by-products 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. AEA Technology: AEA is a world leading energy and climate change consultancy delivering outstanding technical advice, policy support and project and programme management services.

5. 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).

6. GSM Modem for sending and receiving data, SMS text messages, GPRS data over the GSM wireless network

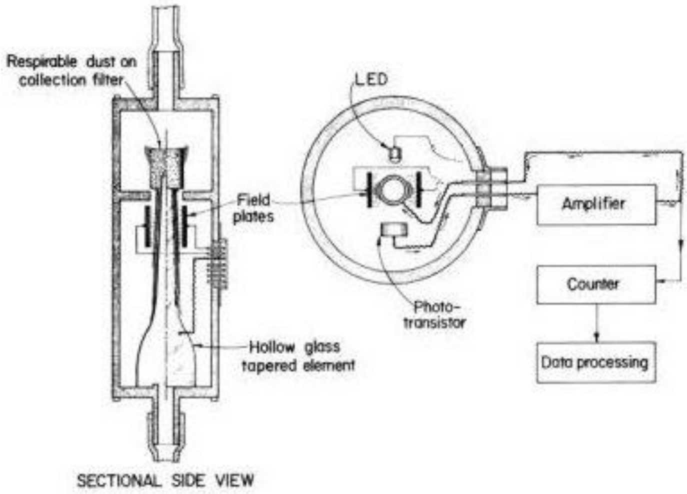
7. Turnkey's Air Q 32 Software: allows officers from Health Protection to use a computer and dial up modem at Le Bas Centre and download data from the two Osiris units remotely. The dial up method has now been replaced by an automated system which uses the 3G telephone network.

8. 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 phosphor screen. This screen will glow and the intensity of the light is measured with a photomultiplier.

9. 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 point the material. The energy of the X-rays emitted depend on the material under examination.

10. 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.



11. Euro 2/3: European emission standards define the acceptable limits for exhaust emissions of new vehicles sold in EU member states. The emission standards are defined in a series of European Union directives staging the progressive introduction of increasingly stringent standards.

12. Bio-diesel: refers to a vegetable oil- or animal fat-based diesel fuel consisting of long-chain alkyl (methyl, propyl or ethyl) esters. Biodiesel is typically made by chemically reacting lipids (e.g., vegetable oil, animal fat (tallow)) with an alcohol. Environmental benefits include reductions in greenhouse gas emissions, deforestation, pollution and the rate of biodegradation

References

1 Air Quality Strategy for England, Scotland, Wales and Northern Ireland. https://www.gov.uk/government/policies/protecting-and-enhancing-our-urban-and-natural-environment-to-improve-public-health-and-wellbeing/supporting-pages/international-european-and-national-standards-for-air-quality

2 Cycling weekly magazine February 2009

3. UK Bio-energy Strategy https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/48337/5142-bioenergy-strategy-.pdf

4

5 Air Quality Expert Group report on air quality and climate change

6 States of Jersey Air Quality Strategy and Action Plan (2013) http://www.statesassembly.gov.je/AssemblyReports/2013/R.049-2013.pdf

7 Adverse Health Effects of Particulate Air Pollution V. Stone, J.H. Lightbody, L. Hibbs, C.L.Tran, M. Heal, and K. Donaldson. Napier University, University of Edinburgh

8 Report: Particles a problem or not in St Helier 2001 - A M Irving

9 http://www.arb.ca.gov/research/health/healthup/may02.pdf

10 Reports on the Turnkey Osiris Particle monitors results for Jersey 2002 – 2010

11 Jersey's Official OS Leisure Map 1:25000 States of Jersey Planning and Environment Department

12 The relationship between the European transfer reference methods

13 Air Quality monitoring in Jersey; Diffusion Tube surveys 2002 - 2012 AEA http://www.gov.je/Environment/ProtectingEnvironment/Air/Pages/AirQuality.aspx

14 The Air Quality Standards Regulations 2007 http://www.opsi.gov.uk/si/si2007/uksi_20070064_en_1

15 EU Daughter Directive 99/30/EC.

16 Jersey Mapping Software: Digimap

17 2008/50/EC (2008) On ambient air quality and cleaner air for Europe

18 AEA Technology report Ref Brian Stacey Analysis of Particulate matter (dust) on filter using SEM and EDX April 2008

19 Air Quality Management issue 170 page 9 National Audit Office Briefing, Rob Bell

20 An Air Quality Strategy for Jersey, April 2003. NETCEN

21 EU Directive 96/62/EC on Ambient Air Quality Assessment and Management (The Air Quality Framework Directive)

22 Air Quality Monitoring St Helier February to March 2000 NETCEN http://

23 www.statesassembly.gov.je/ScrutinyReviewResearches/2008/S-10395-33353-1992008.pdf

24 Transport and Technical Services (2011) Jersey's Sustainable Transport Policy - Making Greener Travel Choices.

[25] Draft (2009) Island Plan White Paper consultation

[26] Ricardo-AEA (2012) Air Quality Monitoring in Jersey 2012.

[27] http://www.gov.je/Environment/ProtectingEnvironment/Air/Pages/AirQuality.aspx

[28] Air pollution – What it means for your health

[29] Report on Turnkey Osiris Particle Results at the Halkett Place and Howard Davis Park Sites in Jersey for 2012

[30] Particulate Matter in the United Kingdom (2005) DEFRA Air Quality Expert Group) HMSO, London

[31] Trends in UK sulphur dioxide, nitrogen oxides, non-methane volatile organic compounds, ammonia and particulate matter (PM10, PM2.5) emissions. DEFRA 2013