Air pollution

1 Key Findings

Air pollution in Cambridgeshire:

- There are levels of air pollution in Cambridgeshire that impact health, even though most annual average concentrations may not be over Air Quality Thresholds:
    - There were 257 deaths attributable to air pollution in Cambridgeshire in 2010 .
    - Over 5% of Cambridgeshire's population mortality is attributed to air pollution.
    - Air pollution also impacts respiratory and cardiovascular hospital admissions and incidence of respiratory disease.
- Hot spots of pollution include urban areas and arterial and trunk roads such as the A14.
- New developments in Cambridgeshire are often sited near poor air quality areas.
- There are higher levels of nitrogen dioxide in the winter months and peaks of larger particulate matter in the spring, which may lead to seasonal health impact.
- Small particulates from traffic also contribute to indoor air pollution, where people spend most of their time and receive most of their exposure to air pollutants.

Future focus on:

- Switching to a low emission passenger fleet and vehicles.
- Encouraging walking and cycling rather than car use.
- Further assessment of shorter-term measures to reduce person exposure, for example:
    - Text alerts to vulnerable people.
    - Monitoring of building filters.
    - Further use of health impact of air pollution during planning process for new developments.
    - Further understanding around the seasonal impact of air pollution and potential measures that could reduce this.

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2 Introduction: Why is air pollution important?

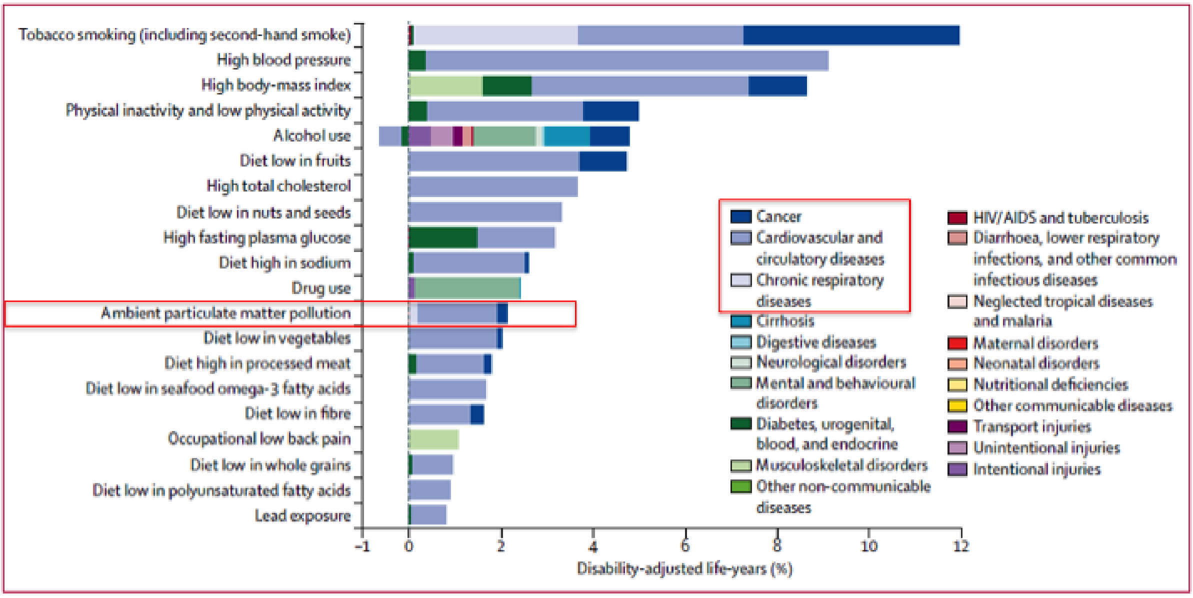
Air pollution is one of the 20 leading risk factors for disease and contributed more than 2% of the annual disability-adjusted life years (DALYs) lost in the UK in the 2010 Global Burden of Disease comparative risk assessment[1]. This study estimated that in the UK over 360,000 disability-adjusted-life-years lost were attributable to ambient (outdoor) air pollution in 2010 although this was a marked improvement from 1990 where the estimate was 996,000. However, air pollution still has a much greater impact on health than risk factors such as second-hand smoke, where only 43,000 attributable DALYs were estimated for 2010 [1].

It is estimated that 360,000 DALYs are lost in the UK due to air pollution.

A DALY or disability-adjusted-life-year is the number of years lost due to ill-health, disability or early death.

This impact is mainly due to air pollutants, especially small particulates ($PM_{2.5}$), increasing the risk of heart and lung conditions, in Section 2.2).

Figure 1 Burden of Disease attributable to 20 leading risk factors for both sexes in 2010, expressed as a percentage of UK disability adjusted life years.



Source: Taken from Living Well for Longer, based on Murray 2013

2.1 What is air pollution?

Air pollutants are generated by a mixture of natural and man-made (anthropogenic) processes and are released into the air, often reacting with other chemicals (chemical transformation). The distribution of these pollutants will depend on the size of the molecule and weather patterns, with some pollutants being mainly deposited locally and some affecting sites in other world regions eg ozone. For example, in spring 2014 there were two peaks of air pollution in the East and South East of England caused by a combination of high levels of air pollution already existing in urban areas and exacerbated by Saharan dusts and easterly winds bringing pollutants from mainland Europe. These periods of poor air quality resulted in a significant increase in respiratory conditions presenting to health care services including NHS111, GP in hours, GP out of hours and emergency departments[2]. It was estimated that the national excess consultations for wheeze or breathlessness issues was an excess of 1,200 GP in hours consultations during the first episode and 2,300 excess consultations in the second air pollution episode[2].

There are many pollutants that impact health and the UK Air Quality Standards Regulations 2000[3] which sets standards for:

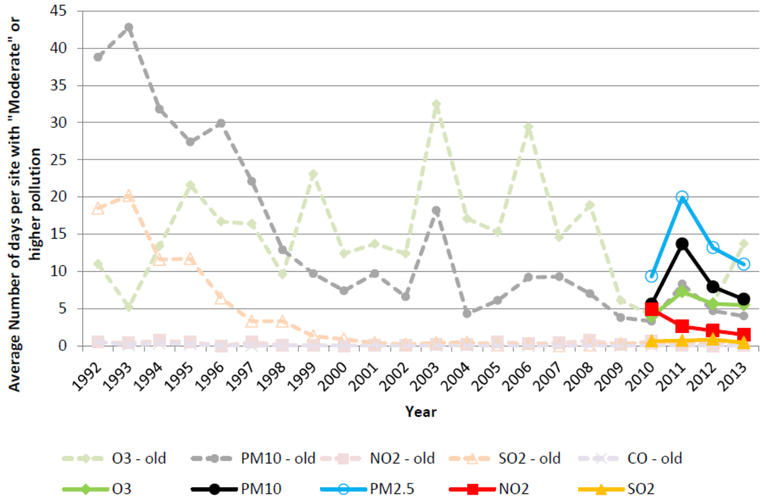
- **Particulate matter (PM_{10} and $PM_{2.5}$)**
- **Nitrogen dioxide (NO_2)**
- Ozone (O_3)
- Sulfur dioxide (SO_2)
- Lead
- Benzene and Benzo(a)pyrene
- Carbon monoxide (CO)

The majority of air pollutants have declined over time in the UK but particulates, nitrogen dioxide and ozone are still at levels that can harm health.

Ozone is not deemed to be a local pollutant, as formation takes place over some time, and may be a result of emissions from thousands of kilometres away. Ozone is not monitored in Cambridgeshire, with the main focus of air quality being on particulates and NO_2, therefore, **the health impacts of ozone will not be assessed in detail.**

Small particulates ($PM_{2.5}$) also have mixed local and non-local sources with some of the more significant components of the total concentration being outside the control of the UK. This is a key problem for local mitigation initiatives.

Figure 2: Average number of days when levels of ozone, particulate matter, nitrogen dioxide and sulphur dioxide were moderate or higher at urban sites in the UK, 1992-2013



Note: for the purposes of this chart, where more than one pollutant exceeds the "moderate" threshold on any given day, it is counted for each pollutant i.e. there is double counting.

Source: Taken from Department for Environment, Food and Rural Affairs (Defra) National Statistics Release: air quality statistics in the UK 1987-2013[4]

Fact sheet on particulate matter: PM_{10} and $PM_{2.5}$

What are PM_{10} and $PM_{2.5}$?
Particulate matter is a mixture of solid particles and liquid droplets in the air. PM_{10} are particles of material that are 10 micrometres across or smaller, $PM_{2.5}$ are particles of material that are 2.5 micrometres across or smaller

Why PM_{10} and $PM_{2.5}$?
These have been chosen as these sizes are likely to be inhaled into the lungs. The smaller the particles the greater the potential impact because of their ability to penetrate deeper into the lung. Particulate matter affects both respiratory and cardiovascular diseases.

Sources of Particulate Matter
Particles in the air arise from a variety of natural and man-made sources and are classed as either primary or secondary sources.

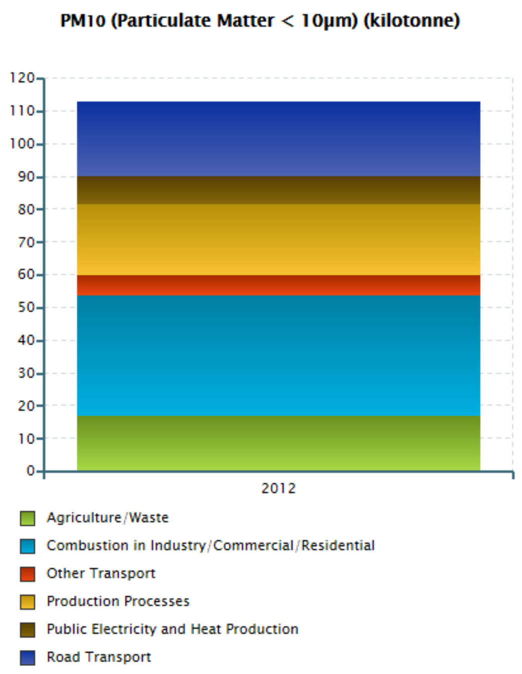
Natural sources
- Sea Spray.
- Erosion of soil and rocks.

Man-made sources
- Combustion processes – both domestic combustion (wood/coal burners) and industrial (power generation).
- Transportation – primarily diesel emissions.
- Transportation – Non-exhaust emissions (attrition of road surfaces and wear and tear of tyres and brakes).
- Industrial sources – construction, waste, aggregates (mining/quarrying), agricultural.

Primary
- Released directly into the air.

Secondary
- Formed in the atmosphere by the chemical reaction of gases, first combining to form less volatile compounds which in turn condense into particles.

For $PM_{2.5}$ not all sources are local as in some weather conditions, air polluted with $PM_{2.5}$ from the continent may circulate over the UK (long range transportation) especially the East and South East of England.



Source: National Atmospheric Emissions Inventory (2013)

Particulate matter in the UK
Emissions of particles have been dropping in the UK for the last 40+ years. It was estimated in 1970 there was 491 kilotonnes of particles emitted into the UK atmosphere whereas in 2012 114 kilotonnes of particulates were emitted into the UK atmosphere.

Air quality standards
PM_{10}: The United Kingdom has a standard of 40 microgrammes (µg) per cubic metre (m^3) of air as an annual average, with a 24 hour average of 50µg/m^3 not to be exceeded more than 35 times a year (to be met by 31 December 2004).

$PM_{2.5}$: The United Kingdom has a target value of 25µg/m^3 of air as an annual average to be reached by 2010, with an additional national exposure reduction target for 2020 based on the levels of $PM_{2.5}$ in 2010. Only areas with initial concentrations equal to or less than 8.5µg/m^3 have no reduction target.

For UK, the average $PM_{2.5}$ level for the base year was 13µg/m^3 resulting in a required 15% reduction necessary by 2020.

Particulate matter monitoring in Cambridgeshire:
Cambridge City:
- Gonville Place (PM_{10} and $PM_{2.5}$)
- Montague Road
- Parker Street
- Newmarket Road ($PM_{2.5}$ only)

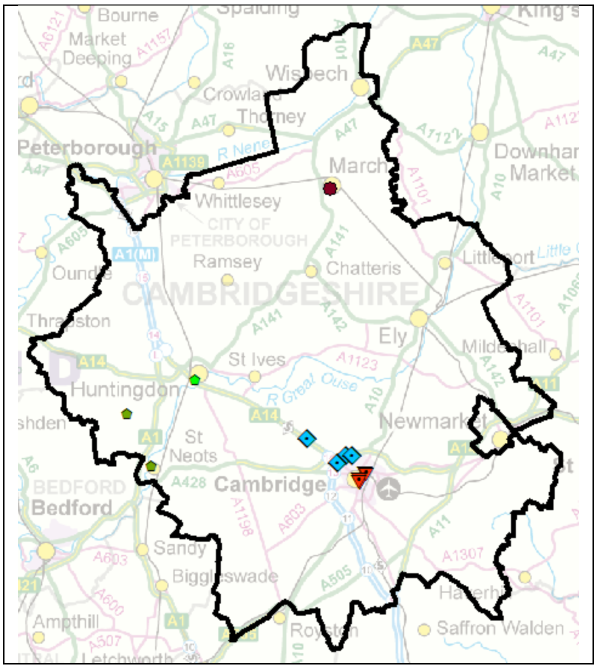
South Cambridgeshire:
- Impington
- Orchard Park, Girton (PM_{10} and $PM_{2.5}$)
- Bar Hill (Decommissioned) (PM_{10} and $PM_{2.5}$)

Huntingdonshire District Council:
- Pathfinder House
- Mobile (Decommissioned)

Fenland District Council:
- None

East Cambridgeshire District Council:
- None

All monitors assess PM_{10} unless stated



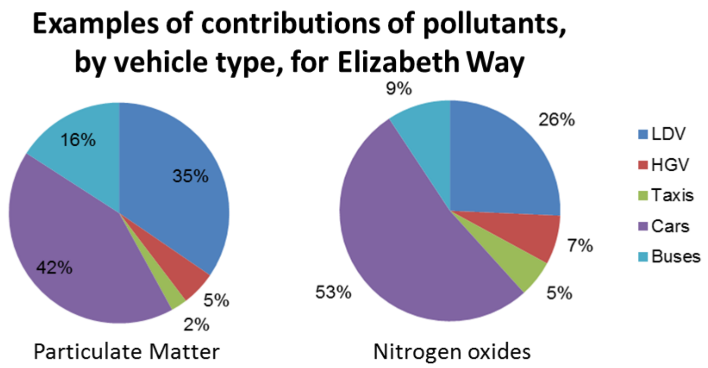
Source: Huntingdonshire County Council

Fact sheet on nitrogen dioxide (NO_2)

Nitrogen dioxide (NO_2) is primarily a secondary pollutant produced by the oxidation of nitric oxide (NO) by ground level ozone. Nitric oxide is produced by the reaction of nitrogen and oxygen in the combustion process. The major source of this pollutant in the UK is the combustion of fossil fuels, particularly by motor transport and non-nuclear power stations. It is estimated that some 75% of oxides of nitrogen are emitted from motor vehicle exhausts in urban areas. Of the transport sources, petrol combustion in cars is currently responsible for a greater proportion than diesel, though this relationship is changing with the progressive introduction of the catalytic converter into petrol vehicles.

Nitrogen dioxide is an irritant gas which has serious and, sometimes, fatal effects on health when inhaled in the very high concentrations associated with accidental exposures. Its properties as an oxidising agent can damage cell membranes and proteins. At relatively high concentrations it causes acute inflammation of the airways.

Air Quality Standards recommend a standard of 40µg/m^3 as an annual average with an hourly mean of 200µg/m^3 not to be exceeded more than 18 times a year (to be met by 31 December 2005). Nitrogen dioxide is measured continuously at the active monitoring sites in Cambridgeshire and monthly at the passive diffusion sites.



Source: Cambridge City Council. LDV- light duty vehicle, HGV – Heavy goods vehicle

2.2 What impact does air pollution have on health?

The World Health Organisation (WHO) has coordinated several key initiatives to summarise the data on air pollution and health:

- REVIHAAP (2013)[5]: a **revi**ew of evidence on **h**ealth **a**spects of **a**ir **p**ollution, which summarises the current literature available on the short and long-term impact of various pollutants.
- HRAPIE (2013)[6]: **h**ealth **r**isks of **a**ir **p**ollution in **E**urope which provides recommendations for values that should be used to assess the risk associated with increasing levels of particulate matter, ozone and nitrogen dioxide. These concentration–response functions can be used to assess the cost–benefit analysis of particular interventions.
- WHO Expert meeting (2014)[7]: on methods and tools for assessing health risks of air pollution.

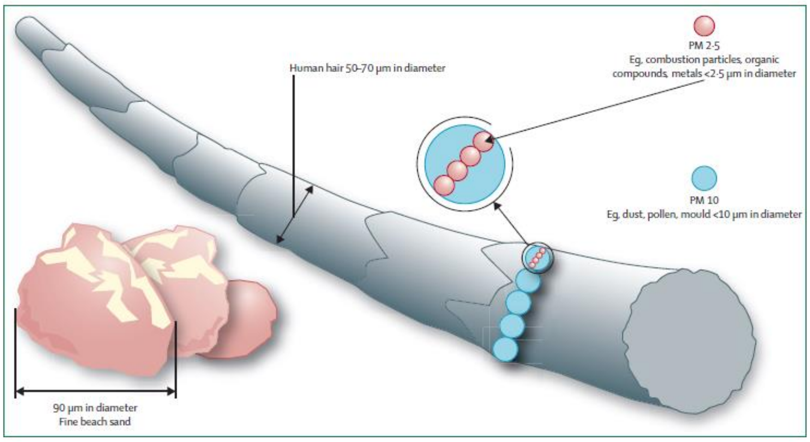
Although the individual increase in risk is small - air pollution affects everyone and so overall impact on the population is high

In addition, the UK Committee for Medical Effects of Air Pollution (COMEAP) provides advice to UK health departments on the effects of indoor and outdoor air pollutants on health, and has been discussing recent evidence around the impact of NO_2 on health.

2.2.1 Health impacts of small particulate matter ($PM_{2.5}$)

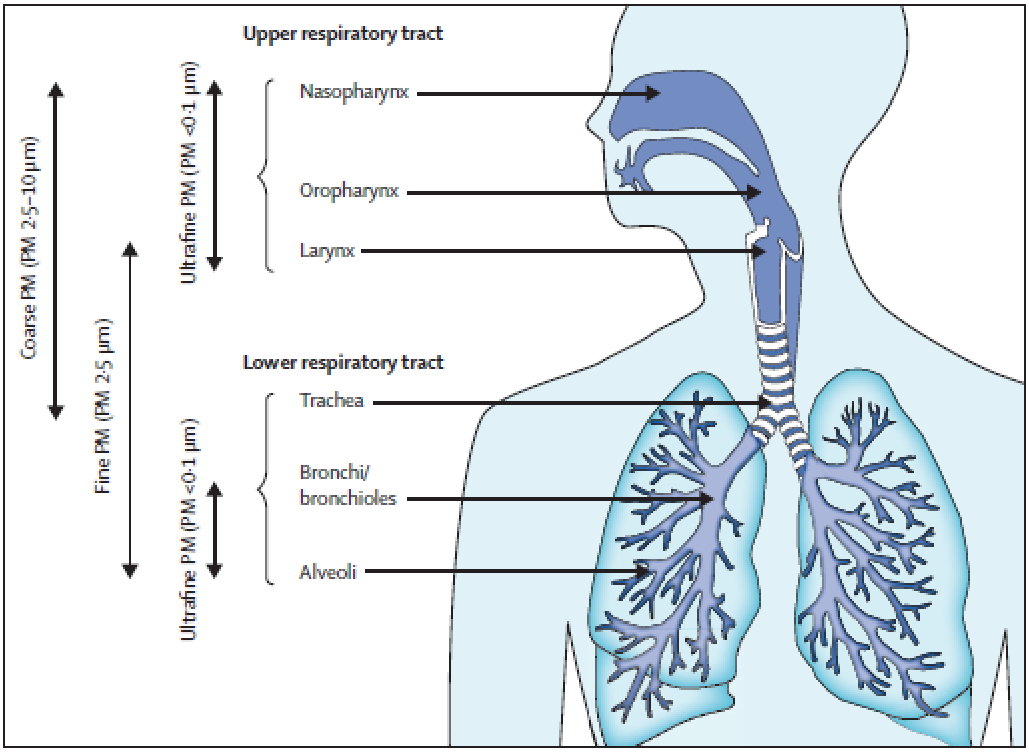
Fine particles of pollution ($PM_{2.5}$) are easily inhaled deep into the lungs (Figure 4) where they may accumulate, react, be cleared or absorbed. There are several mechanisms as to how particulate pollution can impact health including oxidative stress and damage, inflammatory pathways and immunological responses[8]. It is possible that adverse effects are seen in susceptible groups whose pre-existing lung or heart disease make them more likely to be affected by the additional low level inflammation they get from air pollution particles[9].

Figure 3: Particulate matter size



Source: Guarnieri 2014. Image modified with permission from the US Environmental Protection Agency.

Figure 4: Compartmental deposition of particulate matter



Source: Taken from Guarnieri 2014

Long-term exposure to $PM_{2.5}$ is the key air pollution contributor to excess mortality. HRAPIE (2013) estimated that the **relative risk of all-cause mortality increased by 6.2% per 10µg/m^3 increase in $PM_{2.5}$** (Table 1). It increases mortality for cardiovascular and respiratory diseases such as stroke, ischaemic heart disease, chronic obstructive pulmonary disease (COPD) and lung cancer. A recent update of the literature incorporating an additional three studies had little impact on the estimate, only increasing the relative risk by 0.4% (RR 1.066, 95% 1.040-1.093 per 10µg/m^3, WHO Expert Meeting 2014[7]), though they found the estimate for respiratory mortality to be somewhat raised.

It is estimated that small particulates ($PM_{2.5}$) increase the risk of mortality by 6.6% for every 10µg/m^3 increase in pollutant.

Relative risk is calculated by comparing mortality in those exposed at different levels.

Short-term exposure to $PM_{2.5}$ is also associated with small increases in hospital admissions for cardiovascular and respiratory conditions. Any premature deaths caused by short-term exposure to $PM_{2.5}$ are accounted for in the estimates of the effect of long-term exposure.

There is also evidence that short-term $PM_{2.5}$ impacts people's activity levels - resulting in days of missed work, absences from school and other more minor reductions in daily activity.

There is no agreed safe level of exposure or threshold for $PM_{2.5}$, with recent studies showing effects on mortality at concentrations below an annual average of 10µg/m^3 (REVIHAAP 2013, QA5).[5] Therefore EU legislation has adopted a novel approach of 'exposure reduction' for dealing with this pollutant, with a concentration limit value (25µg/m^3 for 2015 and 20µg/m^3 for 2020) and an exposure reduction target dependent on the average level in the county. The target for the UK is a reduction in exposure of 15%.

Much of the ambient (outdoor) $PM_{2.5}$ is from non-local sources. To achieve a reduction of 15% (1.5 - 2µg/m3) of the total urban background concentration, using local measures, would require a very challenging reduction of local sources of 25-67% or a reduction of secondary sources of 25-50% (personal communication, Toby Lewis, formerly Environmental Protection Team Leader, Huntingdonshire District Council).

There is no agreed safe level of exposure to $PM_{2.5}$

The reduction target moves efforts away from reducing named pollutants in particular areas or 'hotspots' to making smaller reductions in concentrations for much larger proportions of the population, potentially having a greater impact on public health.

2.2.2 Health impact of PM_{10}

There is a different deposition pattern of fine ($PM_{2.5}$) and coarse (PM_{10}) particles of pollution with coarse particles having a higher deposition probability in the upper airways and bronchial tree (Figure 4). Larger particles in the upper airways are normally cleared rapidly through mucus and other mechanisms, as long as these methods are not affected by underlying diseases such as asthma. Therefore PM_{10} tends to have a more direct, short-term impact on people's respiratory symptoms and health.

WHO HRAPIE projects summarised that there is evidence that PM_{10} increases the:

- Post neonatal (1- 12 months) all-cause infant mortality (long-term exposure).
- Prevalence of bronchitis in children 6-12 years (long-term exposure).
- Incidence of chronic bronchitis in adults (long-term exposure).
- Incidence of asthma symptoms in children with asthma (short-term exposure).

However, due to variability in the underlying studies, there is uncertainty surrounding the precise estimates to use when estimating the overall costs and benefits of interventions and these issues should only be included when trying to estimate the extended impact of air pollution.

Particulate air pollution (PM_{10} and $PM_{2.5}$) is a complex mixture of many chemical components and it is unclear which components are particularly harmful to health. In March 2015, COMEAP[10] released a statement that "*the evidence is mixed and remains insufficient to draw reliable conclusions about which are the most health-damaging components or sources of ambient particulate matter*".

2.2.3 Health impact of NO_2

Unlike particulates, NO_2 is a gas and therefore disperses differently from traffic sources and can be inhaled deep into the lungs. Although epidemiological evidence associates exposure to NO_2 with adverse effects on health, there is some discussion as to whether NO_2 is just a marker for other toxic elements of vehicle pollution.

Short-term exposure to high NO_2 levels may increase the incidence of asthma in children

Evidence summarised by the WHO HRAPIE project suggests that short-term NO_2 exposure has a small impact (<2%) on hospital admissions for respiratory disease and a smaller impact on mortality. However, a more recent and detailed systematic review has been funded by the Department of Health (DoH) reporting preliminary findings to COMEAP in June 2014. The summary report of the review[11] assessing 204 time-series studies of NO_2, found that a 10μg/m^3 increase in 24 hour NO_2 was associated with increases in:

- Mortality
    - All age, all-cause mortality: 0.71%
    - Cardiovascular mortality: 0.94%
    - Respiratory mortality: 1.09%
- Hospital admissions
    - Respiratory: 0.57%
    - Cardiovascular disease: 0.66%
- Incidence of asthma in children – 6% based on 18 studies.

In March 2015, COMEAP[12] released a statement on the effects of NO_2 on health – "*Evidence associating NO_2 with health effects has strengthened substantially in recent years and we now think that, on the balance of probability, NO_2 itself is responsible for some of the health impact found to be associated with it in epidemiological studies*".

Table 1: Limited set (A*) of concentration response functions recommended by WHO in HRAPIE, based on European data.

Pollutant	Exposure	Health Outcome	Relative Risk per 10µg/m^3 (95% CI)	Percentage increase per 10µg/m^3	Comments
$PM_{2.5}$ annual mean	Long-term	Mortality – all-cause, age 30 year+	1.062 (1.040-1.083)	6.2%	Meta-analysis of 13 cohort studies
$PM_{2.5}$ daily mean	Short -term	Hospital admissions, cardiovascular diseases, all ages	1.0091 (1.0017-1.0166)	0.91%	APED meta-analysis of four single city and one multi city studies
		Hospital admissions respiratory admissions, all ages	1.0190 (0.9982-10402	1.9%	APED meta-analysis of three single city studies
NO_2, daily maximum one hour mean	Short-term	Mortality, all-cause, all ages	1.0027 (1.0016-1.0038)	0.27%	APHEA-2 project of 30 cities, adjusted for PM_{10}
NO_2 24 hour mean	Short term	Hospital admissions, respiratory diseases, all ages	1.0180 (1.0115-0.0245)	1.8%	APED meta-analysis of 15 studies before 2006, single pollutant studies
Ozone, daily max eight hour mean	Short-term	Mortality, all-causes, all ages	1.0029 (1.0014-1.0043)	0.29%	APHENA study of 32 cities, adjusted for PM_{10}
		Hospital admissions, age 65+ CVDs (excluding stroke) Respiratory disease	1.0089 (1.0050-1.0127) 1.0044 (1.0007-1.0083)	0.89% 0.44%	APHENA study of 32 cities, adjusted for PM_{10}

Source: Based on Group A* pollutant-outcome pairs in HRAPIE, which are those that contribute to the total effect (i.e. the effects are additive) and where there is enough data to enable reliable quantification of the effect. Other pairs are listed in the table but either do not contribute to the total effect (no *), or there is more uncertainty in precision of the estimate (Group B). APED, Air Pollution Epidemiology Database.

Table 2: Extended set (B*) of concentration response functions recommended by WHO in HRAPIE, based on European data. There is more uncertainty in the precision of these estimates than the limited set.

Pollutant	Exposure	Health Outcome	Relative Risk per 10µg/m^3 (95% CI) (95% CI) per 10µg/m^3	% increase	Comments
PM_{10} annual mean	Long-term	Post neonatal (1-12months) infant mortality, all-cause	1.04 (1.02-1.07)	4%	US study of 4 million infants in 1997
		Prevalence of bronchitis in children (6-12 years)	1.08 (0.98-1.19)	8%	PATY study from nine countries, a lot of heterogeneity between studies
		Incidence of chronic bronchitis in adults (18+)	1.117 (1.040-1.189)	11.7%	Combination of two longitudinal studies, symptoms reporting rather than clinical diagnosis
PM_{10} daily mean	Short-term	Incidence of asthma symptoms in children (5-19)	1.028 (1.006-1.051)	2.8%	Meta-analysis of 36 studies, but varying definitions of symptom occurrence
$PM_{2.5}$ two weekly average coverted to annual average	Short-term	Restricted activity days, all ages	1.047 (1.042-1.053)	4.7%	Based on a US study (n=12,000) from 1987. No European data
NO_2 annual mean	Long-term	Mortality, all-cause, age 30+	1.055 (1.031-1.080)	5.5%	Meta-analysis of 11 cohort studies, but some effects may overlap with effects of long-term $PM_{2.5}$ exposure
Ozone, daily maximum eight hour mean	Short-term	Minor restricted activity days , all ages	1.0154 (1.0060-1.0249)	1.5%	Based on a US study in 1989

Source: Based on Group B* pollutant-outcome pairs in HRAPIE

A recent meta-analysis of 94 studies found that short-term air pollution was associated with admissions to hospital and mortality from stroke. An increase in risk was seen for most pollutants, although with smaller effects for ozone and PM_{10}[13].

2.3 Who is most impacted by air pollution and when?

2.3.1 Inequalities

In England, the most deprived wards tend to experience the highest concentrations of pollutants, although (except for SO_2) the least deprived wards also experience above average concentrations of pollutants. This distribution can mainly be explained by the higher proportion of deprived communities (and very wealthy communities) in urban areas and the levels of pollution due to road transport sources.

Deprived areas, especially in urban areas, experience higher levels of pollution.

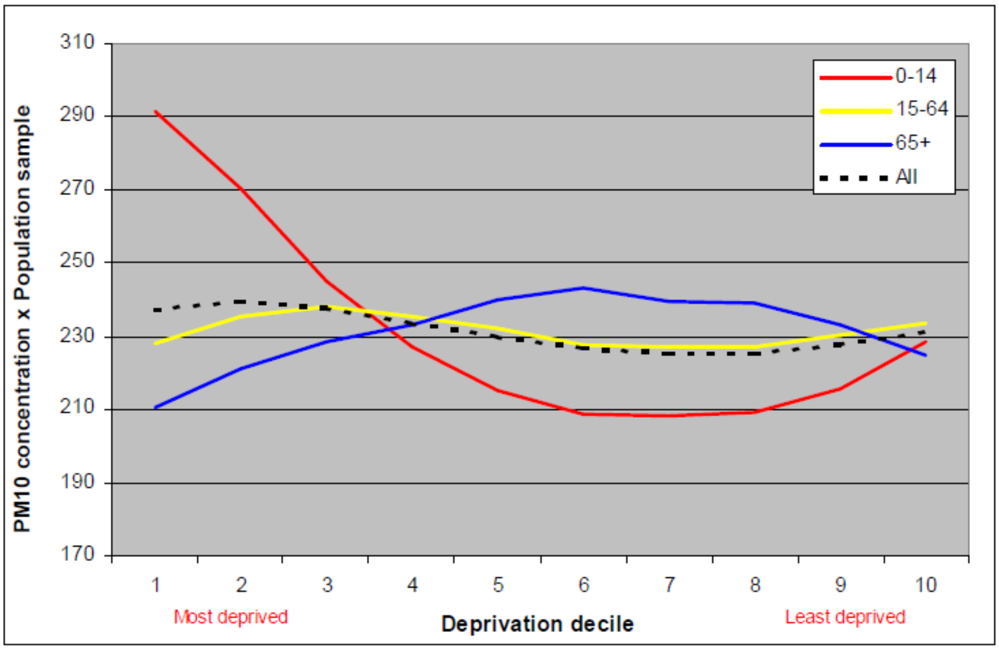
Susceptible populations such as children are also more likely to live in these areas.

The issue is greater though when looked at on a more local level, where proximity to busy roads often results in cheaper housing, leading to a disproportionate effect of air pollution, noise pollution and pedestrian accidents on poorer communities; also reinforcing social exclusion (see Access chapter 2.2.1: social exclusion). Proximity to roads has also shown adverse effects on health even after adjusting for socio-economic status and noise. The precise pollutants responsible are unclear, though may be some combination of ultrafine particles, carbon monoxide, NO_2, black carbon and metals that are more elevated near roads (REVIHAAP, 2013 QC1)[5].

Vulnerable groups to air pollution may include young children and the elderly (REVIHAAP, 2013)[5]. In the Department for Environment, Food and Rural Affairs (Defra) report on Air Quality and Social Deprivation in the UK[14] it was estimated that the young (0-14 years) were disproportionately affected by PM_{10} and NO_2 (Figure 5), experiencing the highest cumulative concentrations as a higher proportion of this age group reside in more deprived deciles where pollutant concentrations are highest. The higher susceptibility of this age group to air pollution implies an extra compounding effect, increasing the inequalities already present.

There have been some recommendations that those with asthma should live at least 300m from major roadways, especially those with heavy truck traffic, as levels of ultrafine particulate matter decrease substantially by 300m[8], although precise distance-decay gradients vary among studies (REVIHAAP, QC1)[5].

Figure 5: Population-weighted concentrations (PM_{10}) by age group in each deprivation decile.



2.3.2 Indoor exposure to pollutants

For $PM_{2.5}$, the particle is so small that 40-70% of it can penetrate into indoor spaces where people are working, and provides much of the exposure to particulate matter (REVIHAAP, QC10)[5].

Indoor exposure accounts for the majority of our exposure to small particulates.

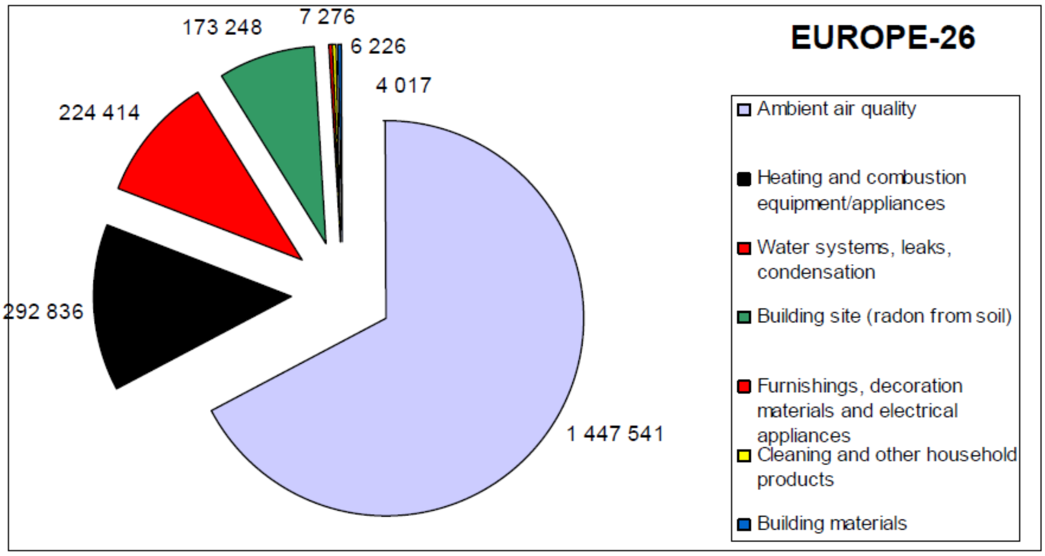
Although the levels are lower, we spend the most of our time indoors

Active urban adults in Europe spend an average of 85-90% of their time indoors, 7-9% in traffic and only 2-5% outdoors, with very vulnerable groups, such as infants and the elderly, spending nearly all their time indoors. Therefore, due to time, exposures indoors dominate overall air pollution exposures (REVIHAAP, QC10)[5].

Therefore, policies that affect ambient (outdoor) $PM_{2.5}$ by 10µg/m^3 will only reduce the urban population exposure by 5-8µg/m^3, as much of their exposure time is indoors (REVIHAAP, QC10)[5]. The average infiltration of $PM_{2.5}$ into buildings depends on location, but also decreases as new, sealed air-conditioned buildings replace older building stock.

A European Commission report[15] estimated that indoor air quality was responsible for approximately 2 million disability adjusted life years (DALYs) lost annually in the EU-26 countries, equivalent to about 3% of the total due to all diseases from all-causes in Europe. The majority of this health impact was due to ambient (outdoor) air quality, mostly fine particulate matter, in indoor settings (Figure 6), though it is worth noting that other household dusts and moulds contribute to indoor air pollution.

Figure 6: The indoor air quality associated burden of disease attributed to the key sources of exposure. Numbers refer to the number of DALYs attributed to each exposure



Source: Taken from Jantunen 2011

2.4 National and local policies to lower emissions

The European Union (EU) air pollution legislation follows two complementary approaches:

- Controlling emissions at source.
- Setting of ambient air quality standards and long-term objectives.

The member states then must transpose the provisions of the EU Directives into their own national laws.

The Air Quality Directive and Fourth Daughter Directive (2008/50/EC)[16] covers the following pollutants; sulphur dioxide, nitrogen oxides, particulate matter (as PM_{10} and $PM_{2.5}$), lead, benzene, carbon monoxide and ozone. This Directive sets 'limit values', 'target values' and 'long-term objectives' for ambient concentrations of pollutants.

Limit values are legally binding and must not be exceeded. They are set for individual pollutants and comprise a concentration value, an averaging period for the concentration value, a number of exceedances allowed (per year) and a date by which it must be achieved. Some pollutants have more than one limit value.

Target values and long-term objectives are set for some pollutants and are configured in the same way as limit values. Member States must take all necessary measures, not entailing disproportionate costs, to meet the target values and long-term objectives.

The UK Air Quality Strategy[17] has established objectives for eight key air pollutants, based on the best available medical and scientific understanding of their effects on health, as well as taking into account relevant developments in Europe and the World Health Organisation. These Air Quality

Objectives are at least as stringent as the limit values of the relevant EU Directives – in some cases, more so. The most recent review of the Strategy was carried out in 2007.

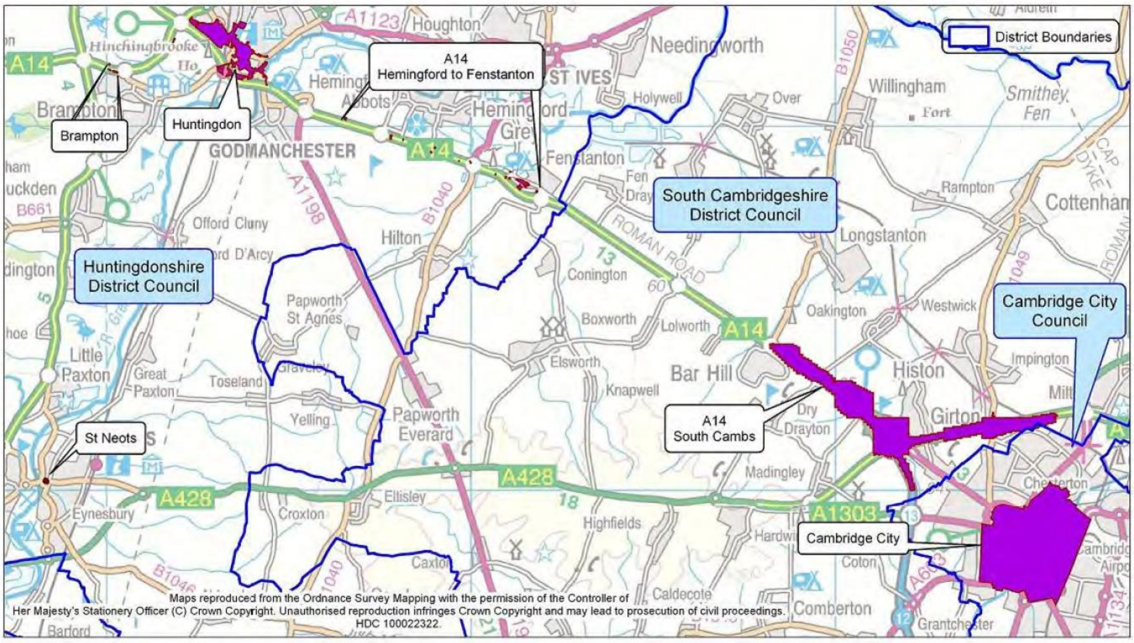
National Air Quality Statistics and Indicators are reported for annual concentrations of particles and ozone and the number of days in the year when air pollution is 'moderate or higher'. In addition, the UK Government's Public Health Outcomes Framework for England (published in 2012)[18] recognises the burden of ill-health resulting from poor air quality as well as other public health concerns. This Framework sets out 60 health outcome indicators for England, and includes as an indicator:

- The fraction of annual all-cause adult mortality attributable to long-term exposure to current levels of anthropogenic particulate air pollution (measured as fine particulate matter, $PM_{2.5}$)

This indicator is intended to enable appropriate prioritisation of action on air quality in local areas. The baseline data for the indicator have been calculated for each upper tier local authority in England based on modelled concentrations of fine particulate air pollution ($PM_{2.5}$) in 2010. Estimates of the percentage of mortality attributable to long-term exposure to particulate air pollution in local authority areas range from around 4% in rural areas to over 8% in cities, where pollution levels are highest.

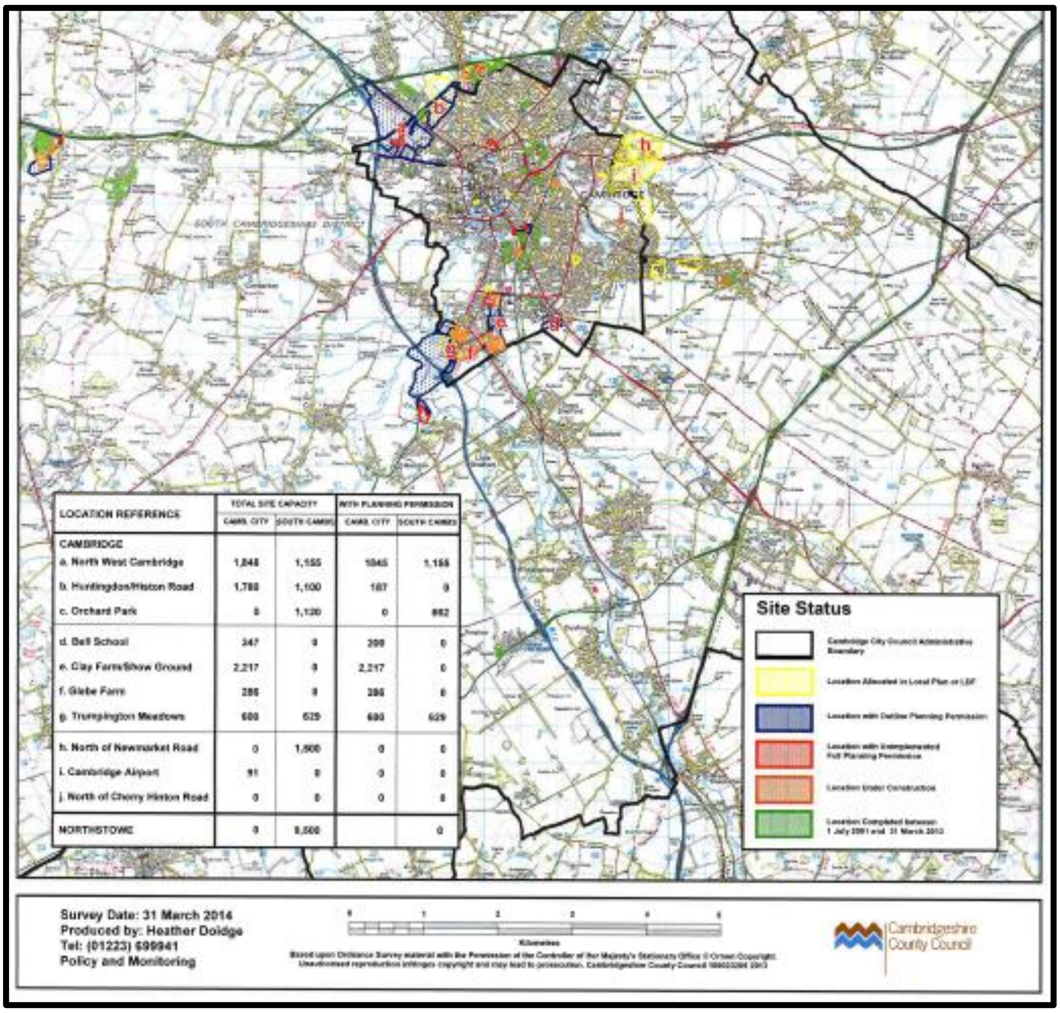
Local Authority Air Quality Management Areas are declared when the local authority review and assessment process identifies an exceedance of an Air Quality Strategy objective. The local authority must declare an 'Air Quality Management Area' (AQMA) and develop an Action Plan to tackle problems in the affected areas. In Cambridgeshire, there are Air Quality Management Areas in Cambridge City, South Cambridgeshire and Huntingdon (Figure 7) mainly linked with urban areas and the A14 with an associated Air Quality Action Plan.[19] With the new growth occurring in Cambridgeshire it is worth noting that many of the new developments are in areas of low air quality (Figure 10).

Figure 7: Air Quality Management Areas in the South of Cambridgeshire



Source: Air Quality Action Plan for the Cambridgeshire Growth Areas, 2009

Figure 8: New development sites in Cambridge City, South Cambridgeshire and Huntingdonshire



LOCATION REFERENCE	TOTAL SITE CAPACITY		WITH PLANNING PERMISSION	
	CAMB. CITY	SOUTH CAMBS	CAMB. CITY	SOUTH CAMBS
CAMBRIDGE				
a. North West Cambridge	1,848	1,155	1845	1,155
b. Huntingdon/Histon Road	1,780	1,100	187	0
c. Orchard Park	0	1,120	0	882
d. Bell School	347	0	399	0
e. Clay Farm/Show Ground	2,217	0	2,217	0
f. Glebe Farm	286	0	286	0
g. Trumpington Meadows	600	629	600	629
h. North of Newmarket Road	0	1,800	0	0
i. Cambridge Airport	91	0	0	0
j. North of Cherry Hinton Road	0	0	0	0
NORTHSTOWE	0	9,500		0

Source: Cambridge County Council

3 Local data: What do we know about air pollution levels in Cambridgeshire?

3.1 Monitors

There are two types of air pollution monitoring.

Active monitoring of key pollutants is carried out by automatic monitors that can measure levels of NO_2, PM_{10} and sometimes $PM_{2.5}$. There are relatively few of these monitors (five or fewer in each district), due to their complexity and expense. Most of these monitors are sited near busy roads or near new developments.

Data can be collected hourly and is summarised as an annual mean or a period where a pollution exceedance has occurred. These provide information on potential hot spots or areas with at risk populations in Cambridgeshire.

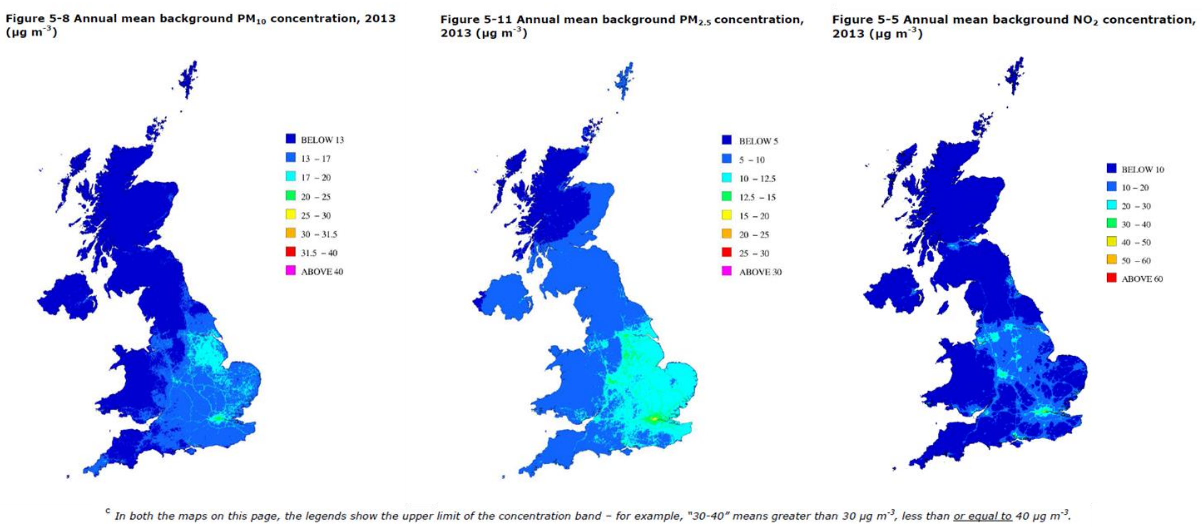
Unlike PM_{10} and other key local air pollutants, $PM_{2.5}$ is not included within the Local Air Quality Management Areas and there is currently no obligation on local authorities to monitor $PM_{2.5.}$ There are currently four sites in Cambridgeshire monitoring $PM_{2.5}$.

Passive monitoring of NO_2 is carried out using diffusion tubes. Data is collected monthly. There are many more of these with over 50 sites in Cambridge City and 20-30 sites in other districts.

3.2 Background levels of pollution in the UK

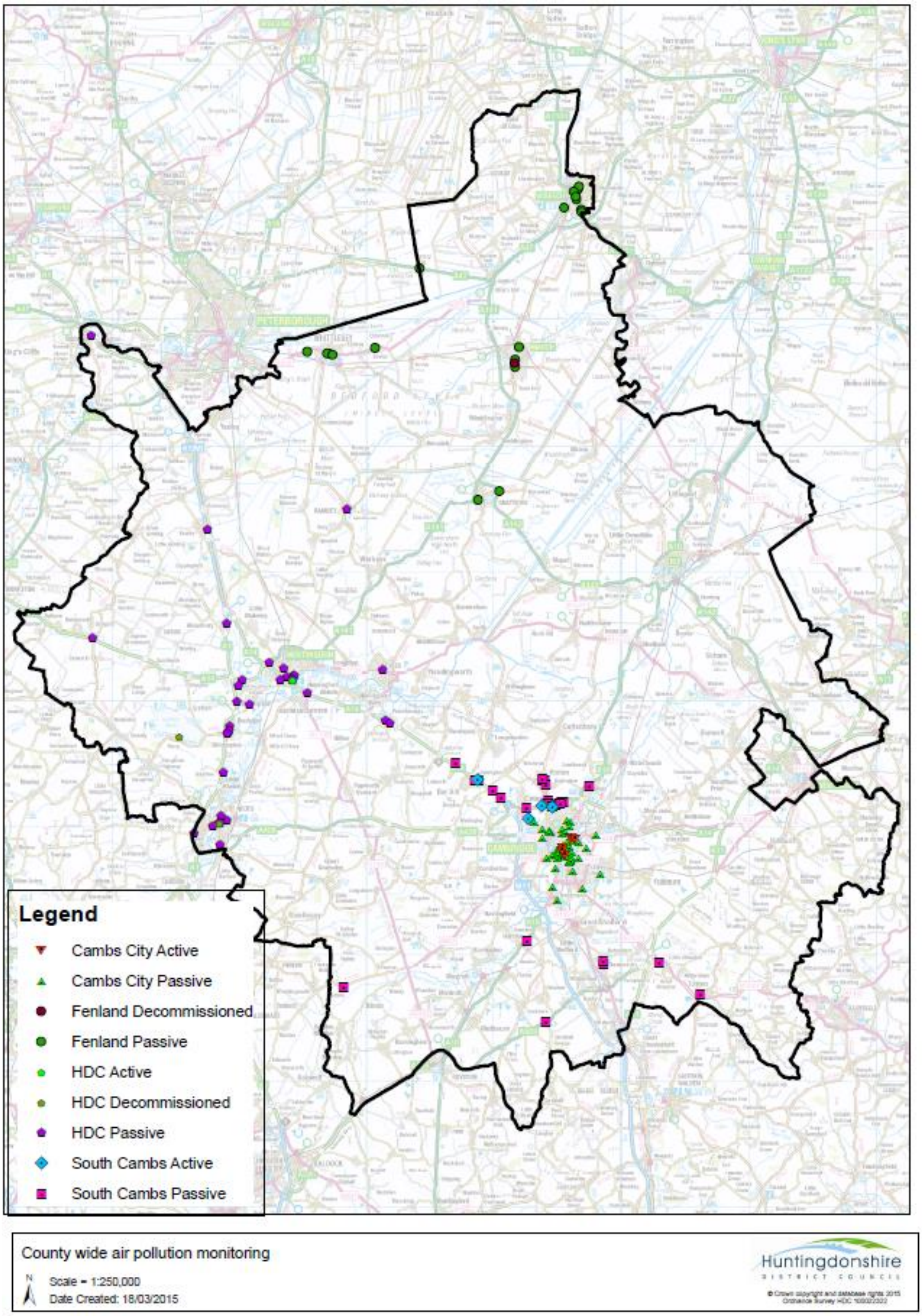
Defra provides maps of modelled background pollutant concentrations (Figure 9). In the UK, high annual NO_2 concentrations are mainly focused around roads, urban and industrial areas, whereas background levels of particulates are higher in the South and East of England, as these regions receive a larger contribution of particulate pollution from mainland Europe.

Figure 9: Maps showing background pollutant concentrations



Source: Air pollution in the UK 2013, Defra

Figure 10: Map showing air pollution monitoring sites in Cambridgeshire



Source: Huntingdonshire District Council

3.3 Hot spots in Cambridgeshire

Cambridge City and South Cambridgeshire pollution levels were modelled for both NO_2 (Figure 11) and PM_{10} (Figure 12). As expected, the major roads and urban centres have the highest levels of pollution with specific issues at congested roads and junctions such as Milton Road, or where there is a lot of standing traffic and buses (Drummer Street). Although average levels of pollution are not necessarily above the threshold, health impacts are seen at levels below threshold (Table 1). There are no models of $PM_{2.5}$ dispersion in Cambridgeshire.

Air pollution in Huntingdon is concentrated around the A14 and the ring road (Figure 13). Slightly different patterns were identified in the various air pollution models mainly due to differences in weather patterns included in each model. Precautionary principles would suggest that areas identified from any of the three modelled years should be included as areas of risk.

Some central sections of St Neots are also affected by high levels of NO_2, with the High Street, which is both canyon-like and congested, being the most significant source of NO_2.

In 2008, modelled NO_2 concentrations were below European Directive limits for most of Wisbech (Figure 14). An assessment of source apportionment showed that HGVs and single occupancy car trips make up a large proportion of the total pollution concentrations (Detailed and Further Assessment of Air Quality in Wisbech). This could be reduced by modal shift of short journeys to walking and cycling, as both walking and cycling levels in Wisbech have been shown to be low (see Active Transport Map 2).

Average annual PM_{10} in Wisbech do not exceed current European Directive annual limits, however the centre of town may have 15-30 days a year with PM_{10} exceedances (Figure 14).

Figure 11: Cambridge City and South Cambridgeshire – NO_2 modelled for 2016

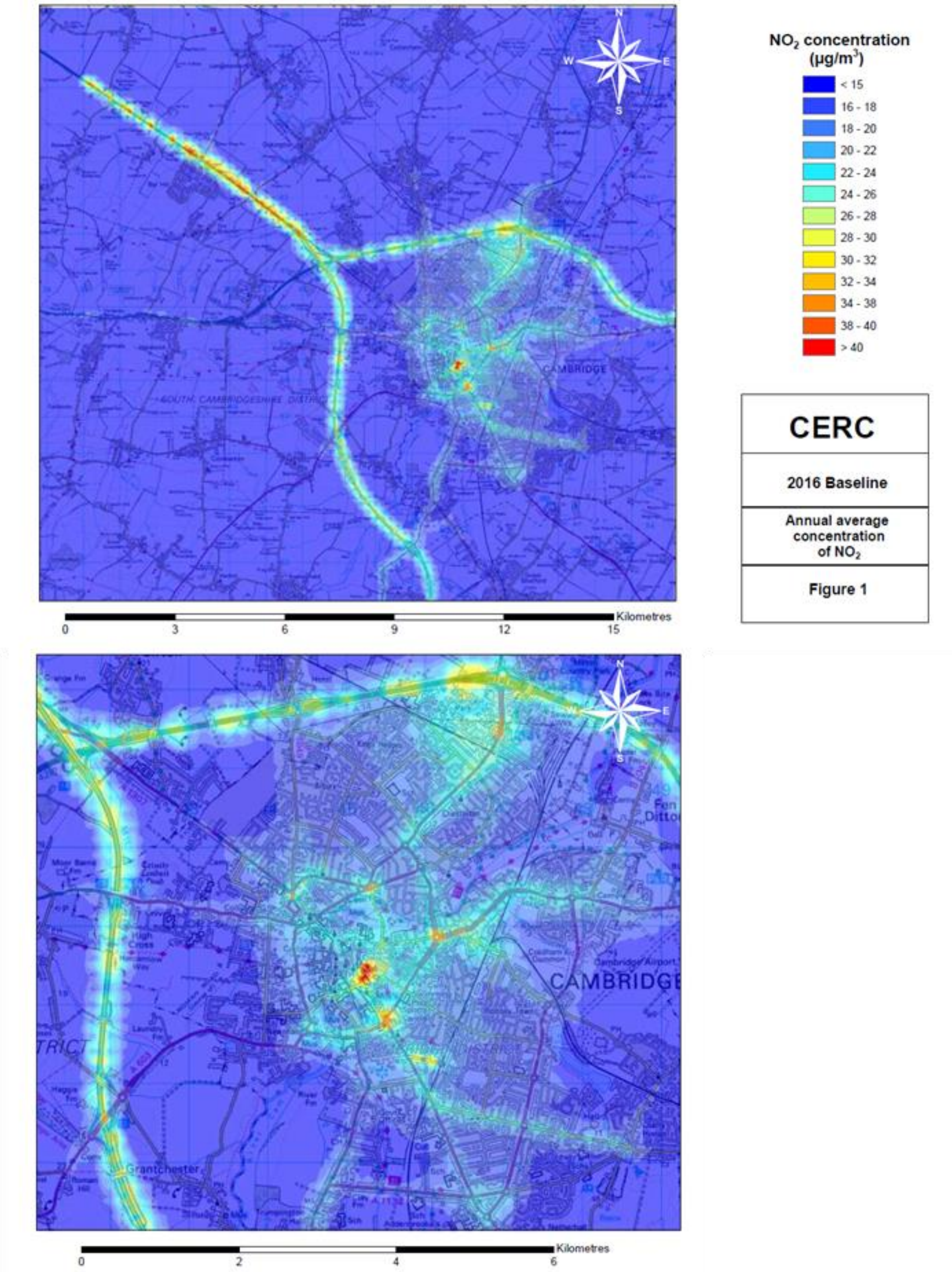


Figure 12: Cambridge City and South Cambridgeshire – PM_{10} modelled for 2016

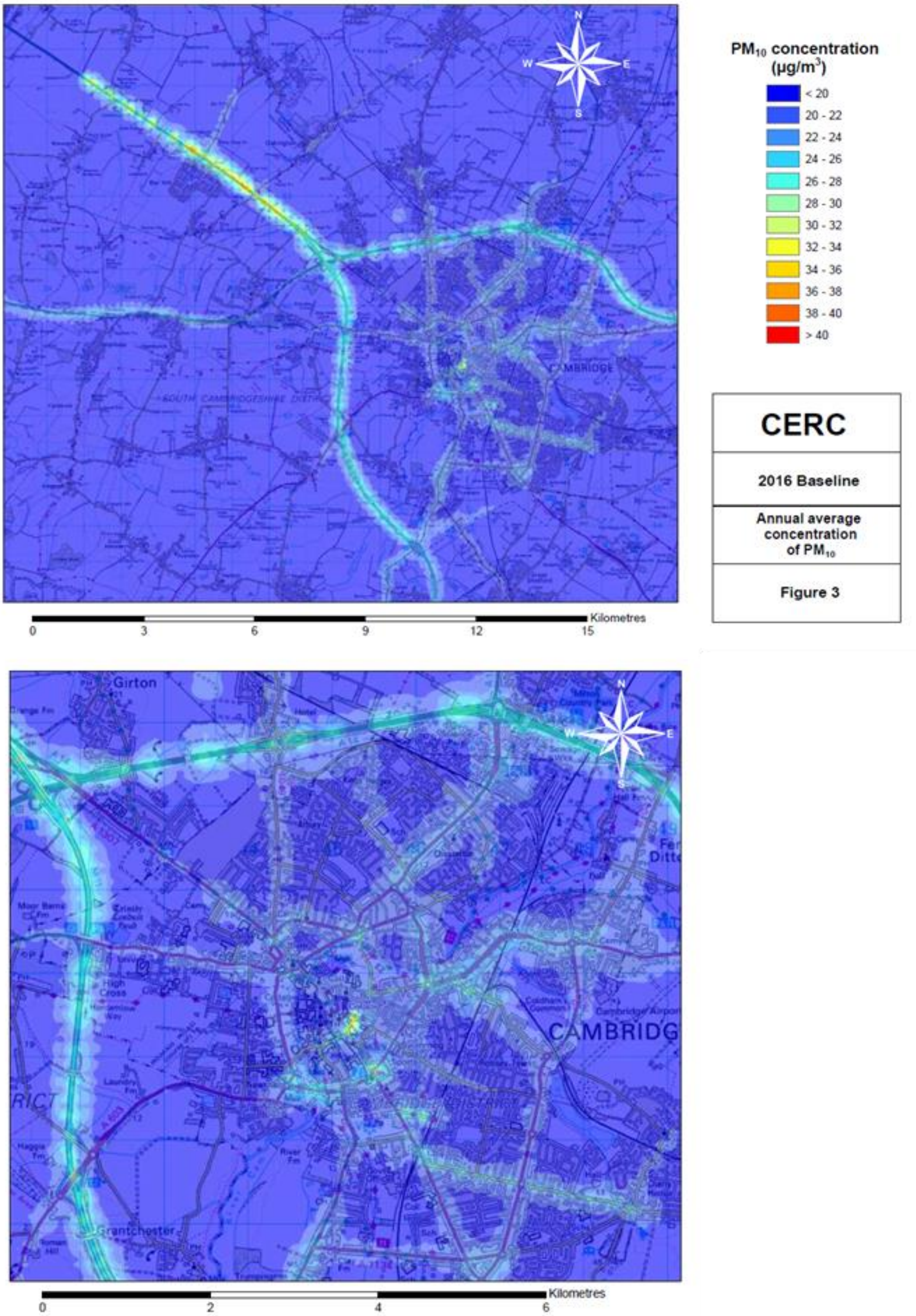
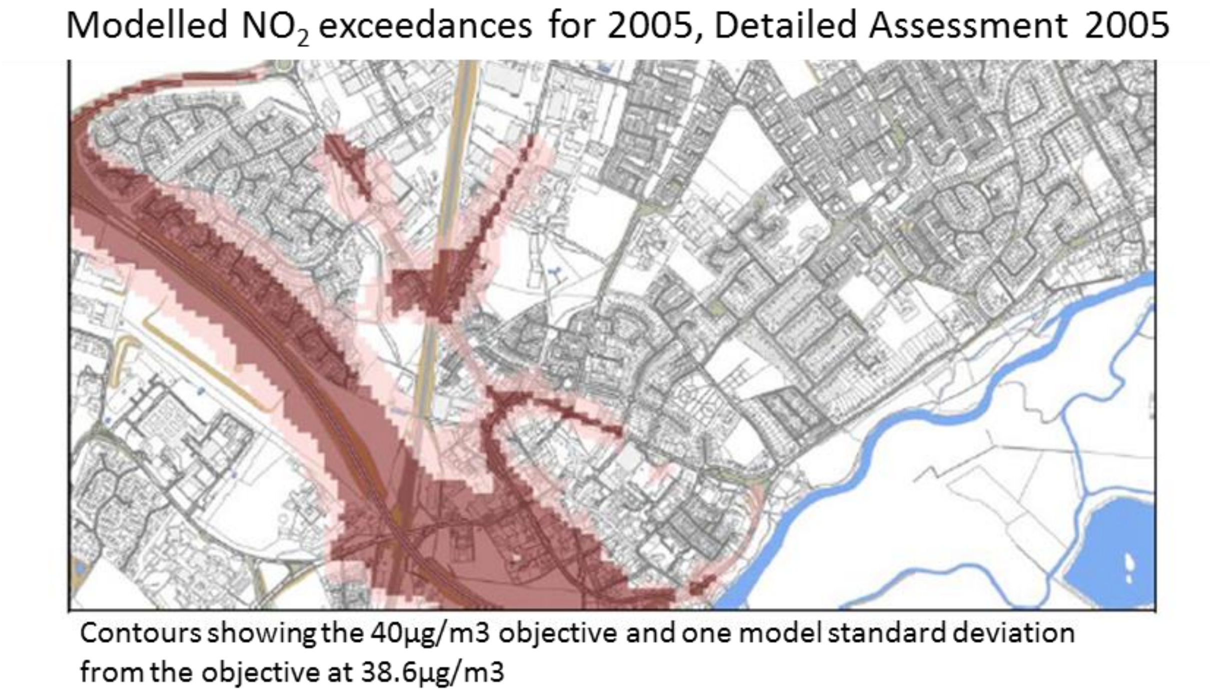


Figure 13 Modelled NO_2 exceedances for Huntingdon



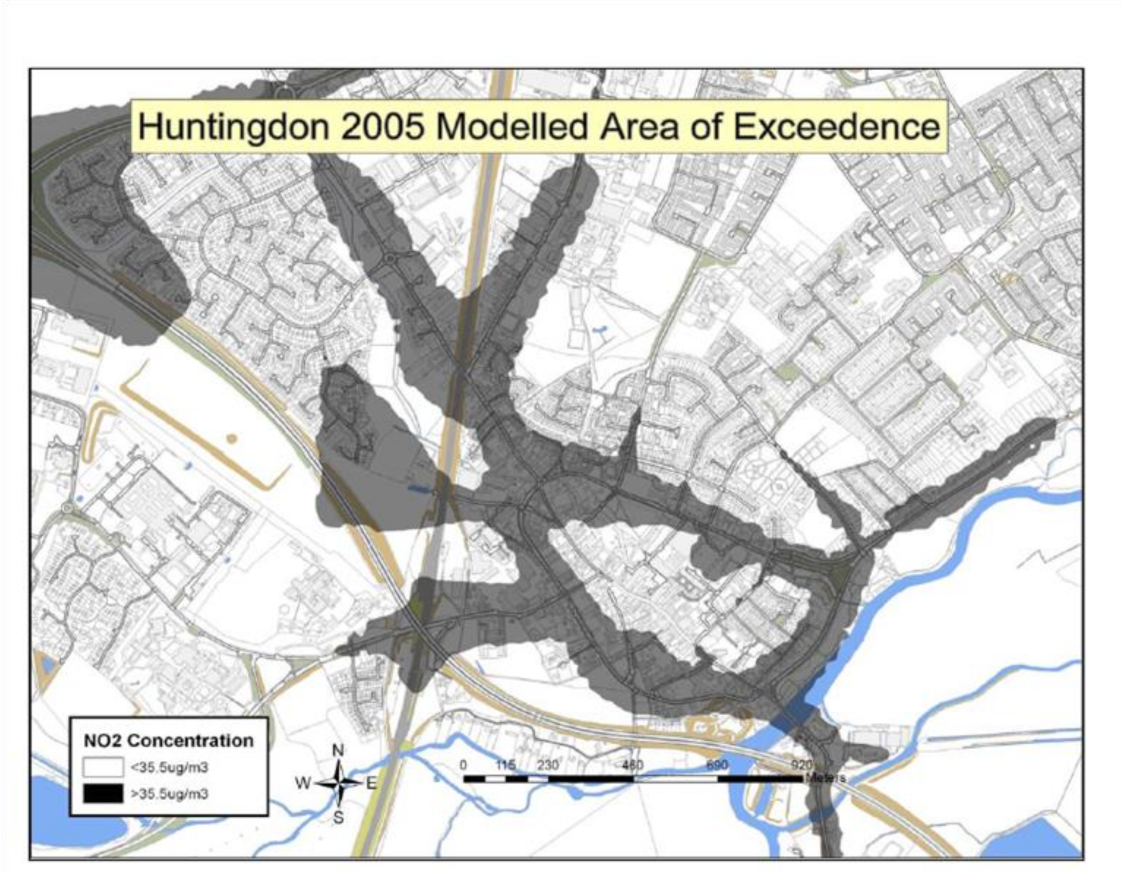
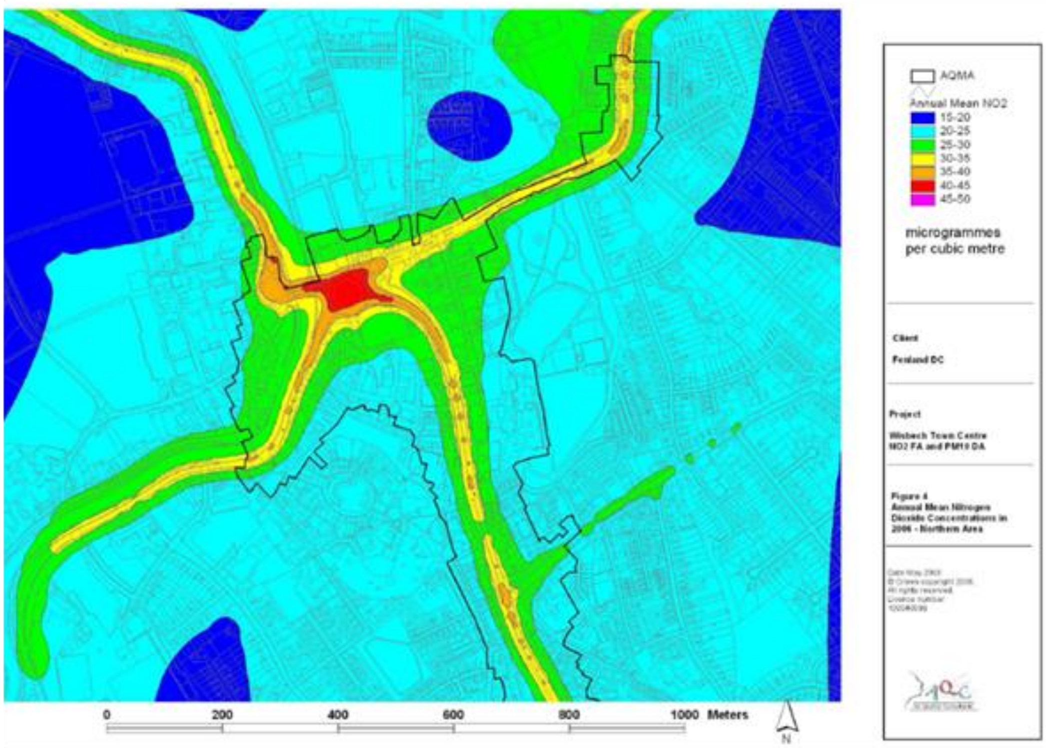
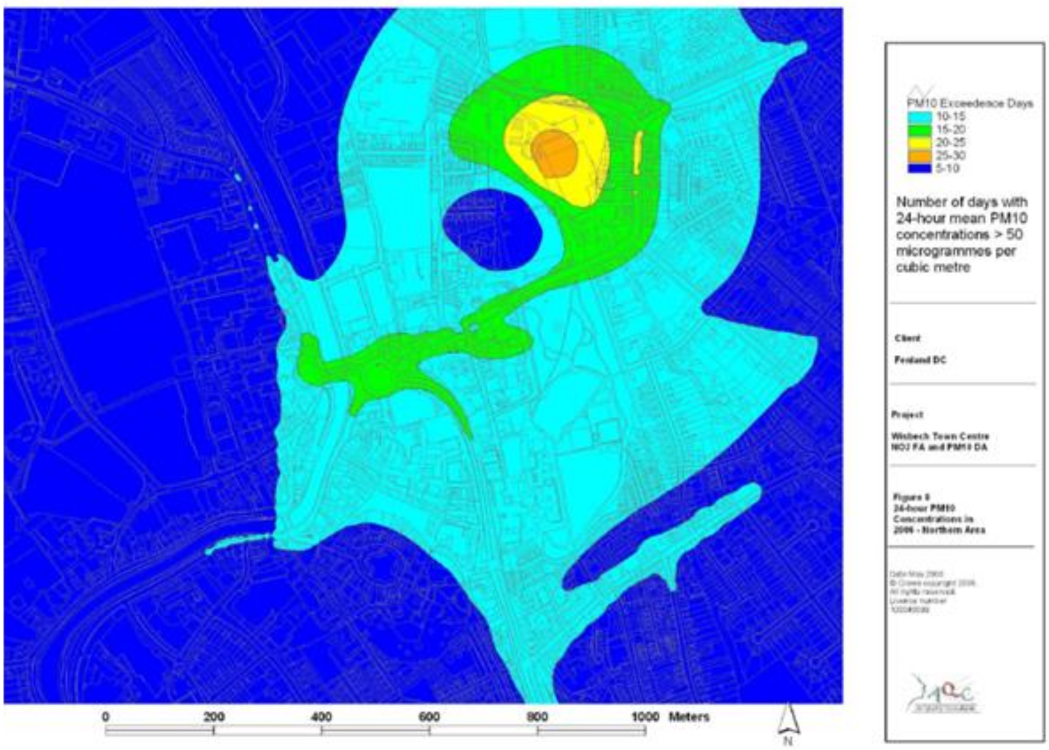


Figure 14 Modelled NO_2 exceedances for Wisbech, 2008

A) NO_2 levels



B) PM_{10}: number of days with exceedances



3.4 Trends in air pollution in Cambridgeshire

The following charts present the annual mean concentrations of PM_{10}, $PM_{2.5}$ and NO_2 for automatic monitors in each district.

3.5 PM_{10} and $PM_{2.5}$

Between 2009 and 2013 there were nine PM_{10} monitoring sites in Cambridgeshire, with some starting and some stopping over the reporting time period. It appears as though the concentrations of PM_{10} in Cambridge City are increasing slightly. Impington, which is sited near the A14, has levels over the EU threshold with large increases between 2010 and 2011, with other sites near the A14 also showing increasing levels in PM_{10}, probably associated with increasing weight of traffic.

Impington has annual mean PM_{10} levels that are above the European Directive limit and there are slight increases at other sites.

Like many areas in the UK, annual mean levels of NO_2 are often above the European Directive limit.

There are relatively few $PM_{2.5}$ automatic monitors in Cambridgeshire compared to other automatic air pollutant monitors. All sites have noticeably lower concentrations than the EU threshold, although the WHO states that there is no safe threshold for $PM_{2.5}$ (REVIHAAP 2013, QA5)[5].

Figure 15: Annual mean concentration for PM_{10}

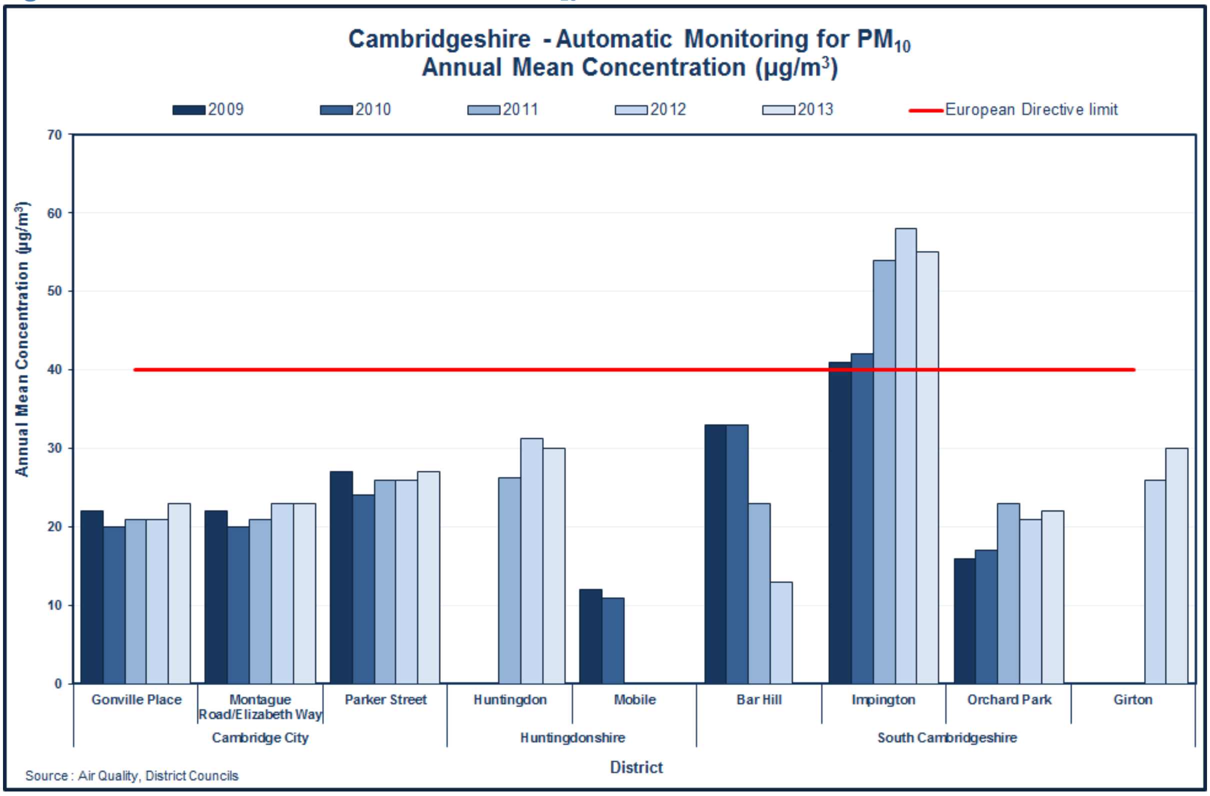
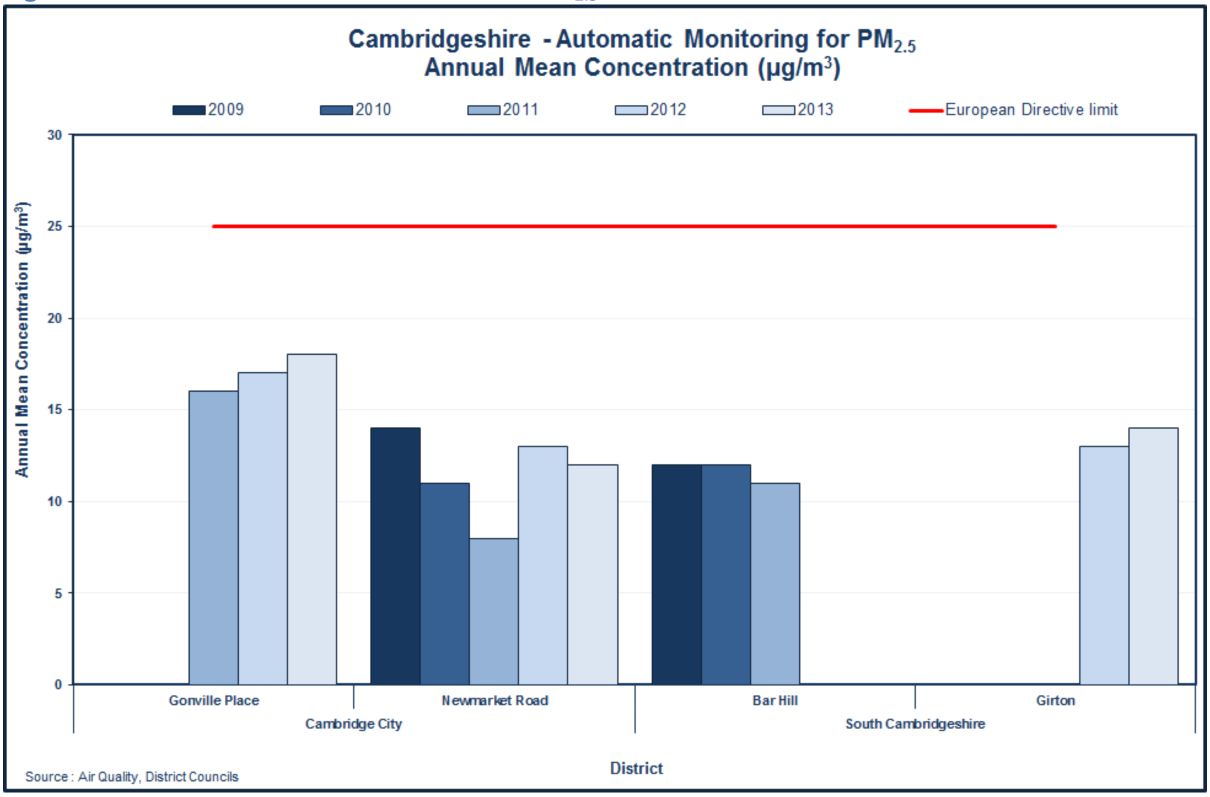


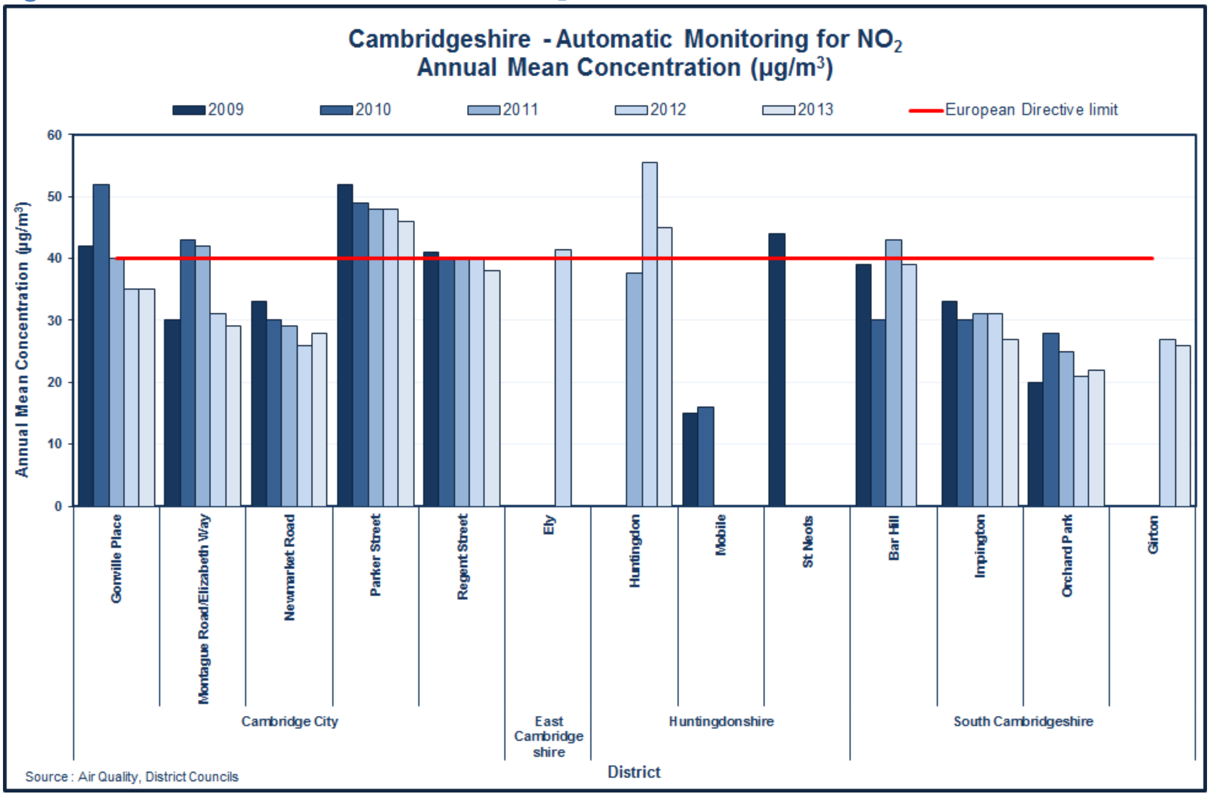
Figure 16: Annual mean concentration for $PM2_{2.5}$



3.6 NO_2

Cambridge City has the highest number of automatic monitors for NO_2. It appears that the concentrations of NO_2 are decreasing year on year at all monitoring sites, although several sites have annual mean concentrations that exceed the threshold.

Figure 17: Annual mean concentration for NO_2



3.7 Seasonality

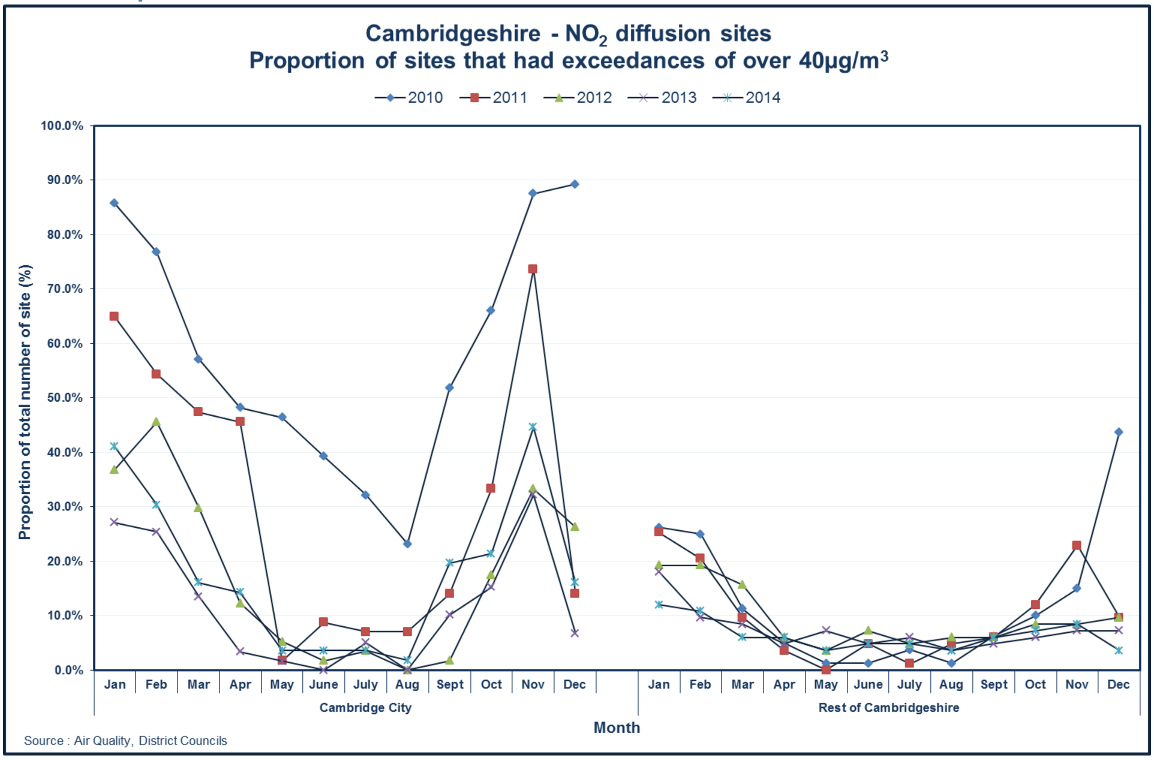
Levels of air pollution are seasonal due to a mix of local weather conditions, such as low wind speeds, low overnight temperatures and fog conditions as well as longer range weather conditions, which can lead to a recirculation of air over northern Europe and influxes of dust. Changes in transport patterns also contribute to pollution levels with more people driving in colder weather. This can lead to peaks in pollution conditions especially in the winter months.

Nitrogen dioxide

In Cambridgeshire, a high proportion of NO_2 diffusion sites show exceedances of over 40µg/m^3 between November and February. Cambridge City has been separated out from the rest of Cambridgeshire due to their higher number of diffusion sites and to remove bias. December does not necessarily fit the pattern but this may be explained by the reduced travel over the Christmas period.

The year 2010 had noticeably high NO_2 exceedances across the country, potentially attributable to the cold winter weather in 2010[20]. Cambridge City also had higher levels of NO_2 in the summer that year when there were also higher ozone levels providing more oxygen to react with the directly emitted from vehicles NO (to make NO_2).

Figure 18: Proportion of sites across Cambridgeshire with NO_2 exceedances over 40µg/m3 showing a seasonal pattern



Note: these data exclude East Cambridgeshire

PM_{10}

Data were also available from the automatic monitoring sites for the dates where there had been exceedances of PM_{10} for Cambridge City (Figure 19) and South Cambridgeshire (Figure 20). Five years of data (2009—2014) were grouped together at a monthly level to be able to examine possible links to seasonality. It is important to note that the numbers of exceedances are relatively small and therefore prone to fluctuation.

There are pollution peaks in winter in Cambridgeshire.

However larger particulates (PM_{10}) tend to be higher in the spring

All sites had noticeably high exceedances in March, especially those in Cambridge City. The Impington monitor shows only a slight increase over the background level, potentially the impact of local weather conditions. The seasonality impact seems to be greater in Cambridge City sites, indicating that some issue beyond local weather conditions may be exacerbating seasonal highs.

Figure 19: Seasonality of Cambridge City, number of PM_{10} exceedances per month, combined data for the five year period between 2009 and 2014

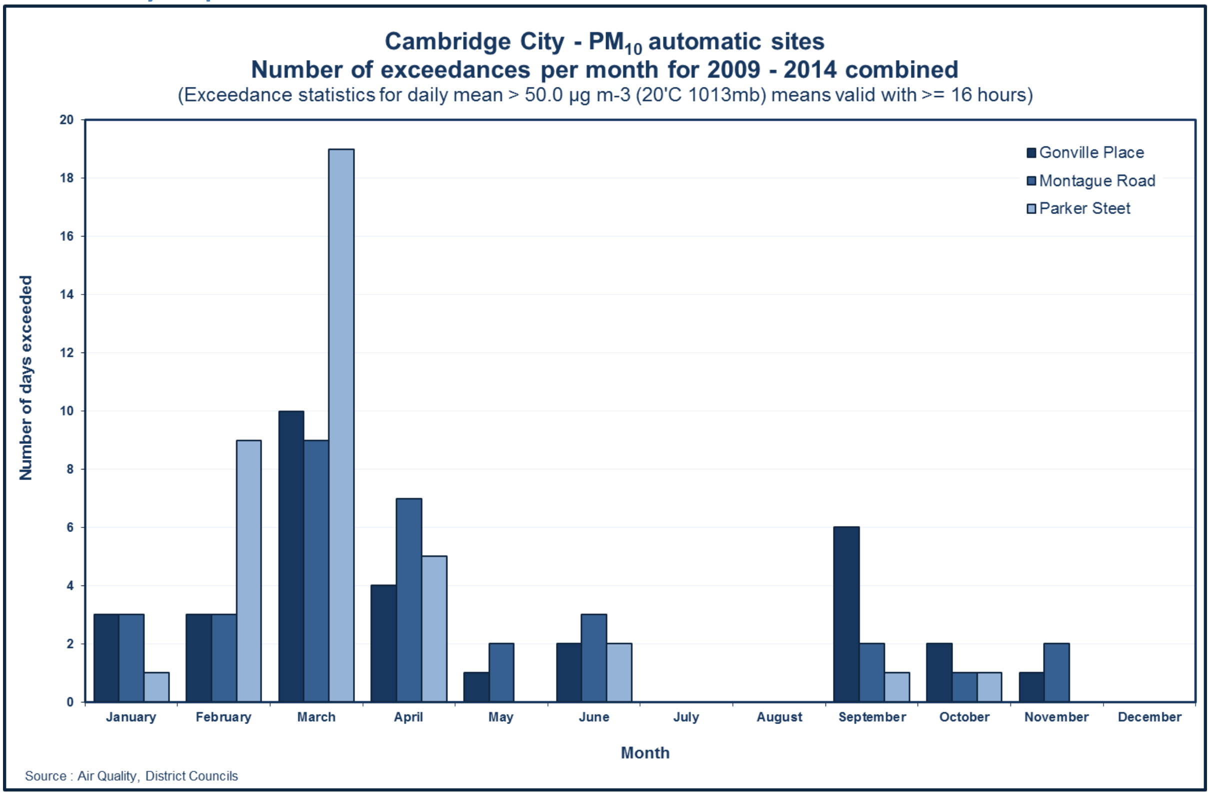
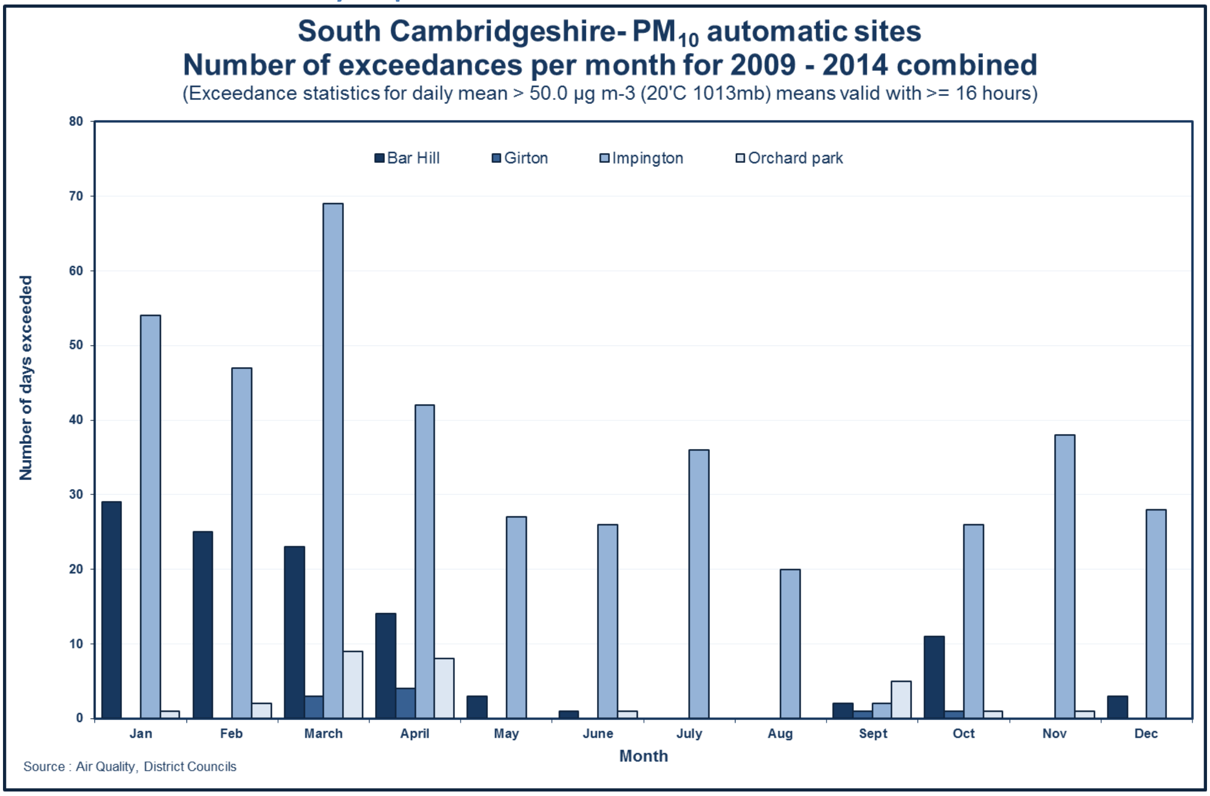


Figure 20: Seasonality of South Cambridgeshire, number of PM_{10} exceedances per month, combined data for the five year period between 2009 and 2014



3.8 Impact on local mortality

Defra create an annual all-cause adult mortality attributable fraction to anthropogenic particulate air pollution (measured as fine particulate matter, $PM_{2.5}$) based on a 1km x 1km grid using an air dispersion model. An increase of 10 µg/m^3 in population-weighted annual average background concentration of $PM_{2.5}$ is assumed to increase all-cause mortality rates by a unit relative risk (RR) factor of 1.06.

In Cambridgeshire 5.2% of all deaths in 2012 could be attributed to air pollution. The impact is highest in Cambridge City and South Cambridgeshire.

In 2012, Cambridge City had the highest particulate air pollution attributable mortality fraction (5.4%) in Cambridgeshire, with all districts except East Cambridgeshire having higher fractions than the national average (5.1%). Cambridge City had a noticeable decrease in these fractions between 2011 and 2012.

Table 3: trend in fraction of all-cause adult mortality attributable to anthropogenic particulate air pollution (measured as fine particulate matter, $PM_{2.5}$)

District	2010	2011	2012
Cambridge City	-	5.7%	5.4%
East Cambrigeshire	-	5.1%	5.1%
Fenland	-	5.2%	5.2%
Huntingdonshire	-	5.4%	5.3%
South Cambridgeshire	-	5.4%	5.3%
Cambridgeshire	5.5%	5.4%	5.2%
England	5.6%	5.4%	5.1%

Data taken from PHOF, Fingertips, PHE

Public Health England used these fractions in 2010 to estimate the number of deaths in people aged 25 years and over where air pollution could have been an attributable factor. In total, it was estimated that there were 257 such deaths in Cambridgeshire in 2010 (Table 4).

Table 4: Estimating local mortality burdens associated with particulate air pollution, 2010

District	Mean anthropogenic PM2.5 (µg/m^{-3})	Attributable Fraction (%)	Attributable deaths aged 25+	Associated life-years lost
Cambridge City	10.2	5.8	47	468
East Cambrigeshire	9.1	5.1	33	378
Fenland	9.4	5.3	54	562
Huntingdonshire	9.7	5.5	67	743
South Cambridgeshire	9.5	5.4	57	611
Cambridgeshire	9.6	5.5	257	2,762
England	9.9	5.6	25,002	264,749

Source : PHE

3.9 Impact on other health outcomes (morbidity)

There are at least 12 modelling tools that combine air quality information, epidemiological derived concentration response functions (similar to Table 5) and demographics to estimate air pollution related health impact[7]. All estimate mortality impact, but only some estimate the broader health impact (morbidity) through additional cases of key diseases and disability adjusted life years.

There is more uncertainty around the model inputs for morbidity especially around the concentrations response function and the extrapolation of data from different populations and different systems. Therefore, the model needs to be appropriate for the context and evaluated individually, with a trade-off between technical refinement and accessibility to the user.

At present, there is no Cambridgeshire-specific estimate for the impact of air pollution on disease prevalence and health care utilisation. Therefore, the health impact on hospital admissions for respiratory and cardiovascular admissions needs to be based on the general estimates provided in Table 1.

Table 5: Broad range of key technical characteristics shown by tools with global scope

Characteristic	AirCounts™	AIRQ2.2	BenMAP-CE	Co-benefits Calculator	EBD	GMAPS	IOMLIFET	SIM-Air	TM5-FASST
Spatial resolution:									
Regional		x	x		x		x	x	x
National		x	x	x	x	x	x		x
City-level	x	x	x			x	x	x	
Any grid		x	x				x		
Pollutants:									
$PM_{2.5}$	x (primary)	x	x	x	x		x	x[1]	x
PM_{10}		x			x	x	x	x	
Ozone		x	x	x			x		x
NO_2		x	x						x
SO_2		x	x						x
CO			x						
Other		Black smoke					*Any affecting mortality*		
Health outcome:									
Mortality (cases)	x	x	x	x	x	x	x	x	x
Disability-adjusted life years (DALY) or years of life lost (YLL)		x	x		x	x	x		x
Morbidity (cases)		x	x		x		x	x	

[1] The SIM-air framework outputs all the criteria pollutants, with linkages for use of all the relevant pollutants in the regional/urban chemical transport models. Only in case of the health impacts, PM is considered as the target pollutant.

Source: Taken from WHO Expert Meeting 2014[7]

3.10 Susceptible populations in Cambridgeshire

The more urban and congested areas have higher levels of pollution, as do areas near arterial and trunk roads. This, therefore, impacts on the health of those that live and work next to these areas. This includes a central section of Cambridge City, sections around the ring road in Huntingdon and the centre of Wisbech.

Deprived areas, especially in urban areas, tend to have a higher level of pollution as well as a higher proportion of young children living there who maybe more susceptible to the health effects of air pollution.

There is also growth in Cambridgeshire, with many new developments sited near to large trunk roads or city arterial roads. The National Planning Framework Guidance on Air Quality[21] states that Local Plans may need to consider ways in which a new development would be appropriate in locations where *air quality is or likely to be* a concern and not give rise to unacceptable risk from air pollution. Local Planning Policies on air quality are mixed in Cambridgeshire districts with few districts having specific policies.

New growth in Cambridgeshire is often near areas of poorer air quality

The health impact of pollution should be considered when planning residential, educational or business properties in or near areas of poor air quality to ensure that appropriate mitigation measures are taken.

There are differences in the seasonal exposure to air pollution. The levels of larger particulates in spring may be sufficient to cause additional symptoms in very vulnerable groups such as those with COPD.

4 Local views

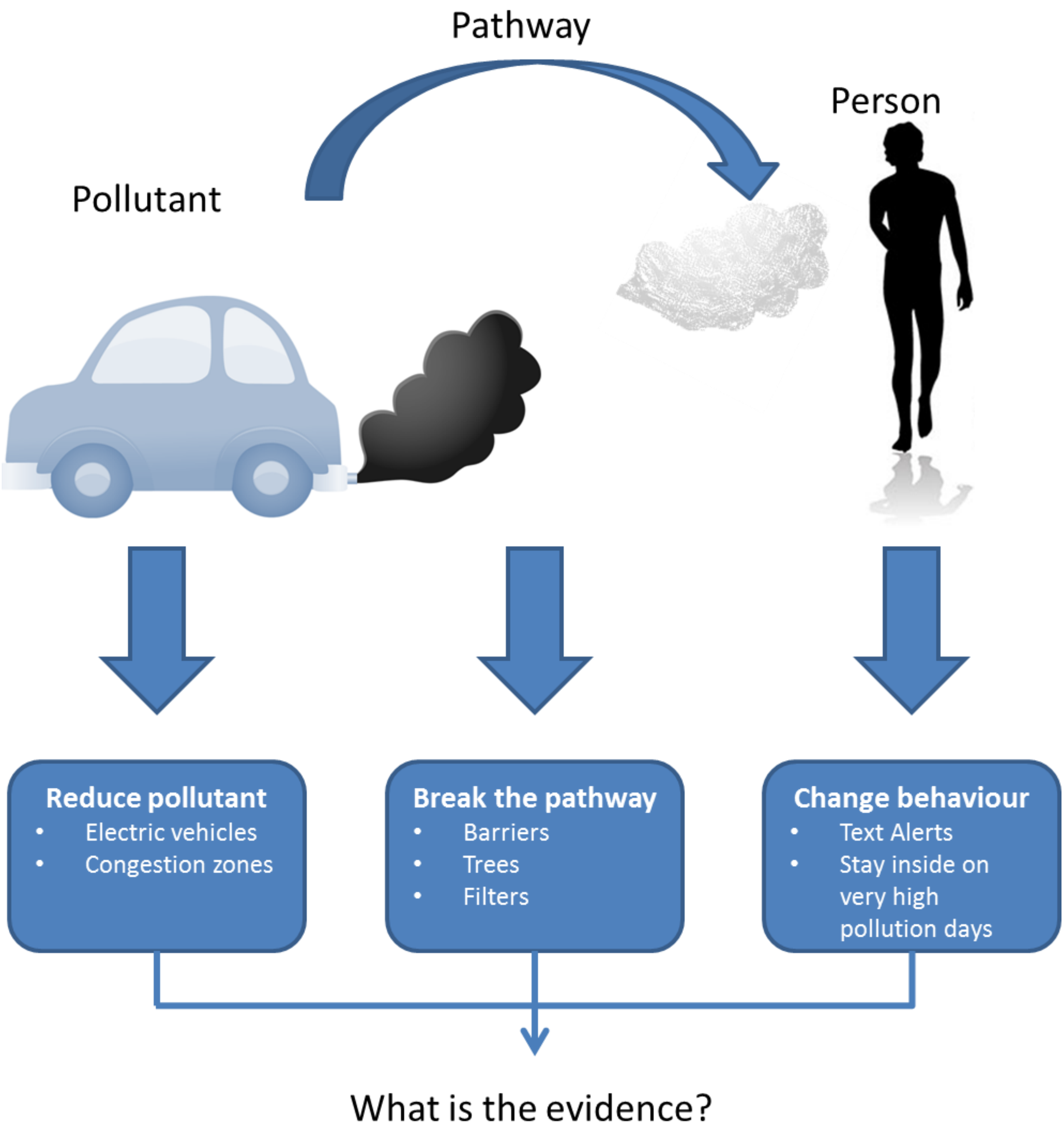
Air pollution remains high on the priority list for those living in Cambridge City. A citizen survey carried out in 2011 asked residents to select three services that the council provide that they think are very important. Preventing air, water, noise and land pollution is ranked sixth out of 20 activities, the same as the 2009 data, with 22% of respondents rating this as very important and only 13% rating it as less important[22].

Similarly in the You Choose Budget Consultation 2014[23] (an online, how shall we cut the budget simulator) preventing land and air contamination was sixth of 22 from the household survey and second of 22 from the self-selecting survey, indicating that these areas remain high on the priority list for local residents.

Other districts did not report any information on local views around air pollution.

5 Addressing local need: What we can do about air pollution in Cambridgeshire?

5.1 Evidence around mitigation measures and cost effectiveness?



5.1.1 Reducing pollutants

Consistent evidence has been reported that links living near major roads and/or traffic-related air pollution to adverse effects on health (REVIHAAP 2013, QD2). In addition, a positive health impact has been observed when moving from areas with high to areas with lower air pollution and traffic[24].

REVIHAAP 2013, (QD2) summarised the evidence regarding several types of traffic-related interventions, below.

Low emission vehicles

Earlier policies relied solely on improvements in diesel vehicle technology via EURO (EU) engine standards. These were incremental and proved ineffective in real operation as the bar for manufacturers could easily be met by designing engine characteristics to meet a standard test cycle. Whilst the gains should have been substantial on paper, up to a 50% cut in emissions between EU2 and EU4 for buses, the reality was a very mixed picture with some in service EU2 buses out performing EU4[25].

Cambridge City Council's long-term field evidence backed-up by the Cambridge Real Emissions Project[26] support this view, with only a 5% improvement in ambient air quality as a result of moving approximately 400 buses up to EURO standards with the majority of buses moving from EU2 to EU4 or EU5.

However, new low emission vehicles are either fully electric with no emissions at the point of use or hybrid vehicles which have significantly reduced emissions for periods of the drive cycle and may be capable of some zero emission running. Therefore, with new low emission vehicle technology there is the potential for substantial real world cuts in emissions.

Low emission zones

Cesaroni et al (2012)[27] examined the effect of the low emission zones in two city areas in Rome, on traffic-related PM_{10} and NO_2 concentrations and on mortality for subjects living near highly trafficked roads from 2001–2005. They reported improvements of air quality and a positive impact on the public health of residents living along busy roads, gaining 3.4 days per person (921 years of life gained per 100 000 population) due to reductions in NO_2 associated with the interventions. The number of years of life gained was higher in higher socioeconomic groups, compared with lower ones. However, similar studies conducted in The Netherlands found that street and urban $PM_{2.5}$ concentrations were reduced more during the study period yet did not find substantial changes in pollutant concentrations associated with the low emission zones two years after they went into effect[28].

Congestion charging zones

Tonne et al. (2010)[29] investigated if there were any health benefits associated with the implementation of the London Congestion Charging |one and reported associations between changes in nitrogen oxides and cardiorespiratory hospital admissions a significant association for bronchiolitis admissions. They estimated the years of life gained per 100,000 population, according to the modelled declines in NO_2, to be 26 years for Greater London, 183 years for congestion charging zone residents (a very small fraction of the London population), and only 18 years for remaining wards. Overall, these findings show a very modest impact of the congestion charging zone on traffic-related air pollution levels and public health. A similar intervention implemented in Stockholm was reported to reduce air pollution levels in the inner city (levels were reduced by 10% for nitrogen oxides, 7.6% for total PM_{10} and 10% for the PM_{10} fraction). It was estimated that, should the decreases be maintained, 206 years of life gained per 100,000 population for the area of Greater Stockholm over a 10-year period could be anticipated[30]. These results are very similar to estimates of Tonne et al for London. A recent study by Börjesson et al (2012)[31] showed that the air quality improvements have persisted since the scheme was made permanent in 2007. Both studies demonstrated reductions in traffic congestion by between 22-30%[32].

Lower traffic exposure
Other traffic measures have also been associated with improved air quality; for example, reductions in traffic speed on highways have been associated with improved air quality in adjacent areas[33] and construction of bypasses to relieve nearby congested streets have been shown to improve PM levels by about 28%.

5.1.2 Breaking the pathway

Use of vegetation and noise barriers
Shelterbelt trees have an influence on pollution levels by a variety of methods. Vegetation can remove some gaseous pollutants by uptake or absorption and particles can physically adhere to the vegetation[34]. Importantly vegetation also alters the dispersion of emissions by changing air-flow patterns, wind speed and surface roughness[35], enhancing turbulence and mixing of pollutants. These elements are may be more important than the general uptake of pollution through absorption.

However, the impact of vegetation is complex, with different results depending on particle size, wind speed and leaf density. In some situations, such as street canyons with close tree spacing, vegetation may restrict dispersion and increase concentrations of pollutants[36].

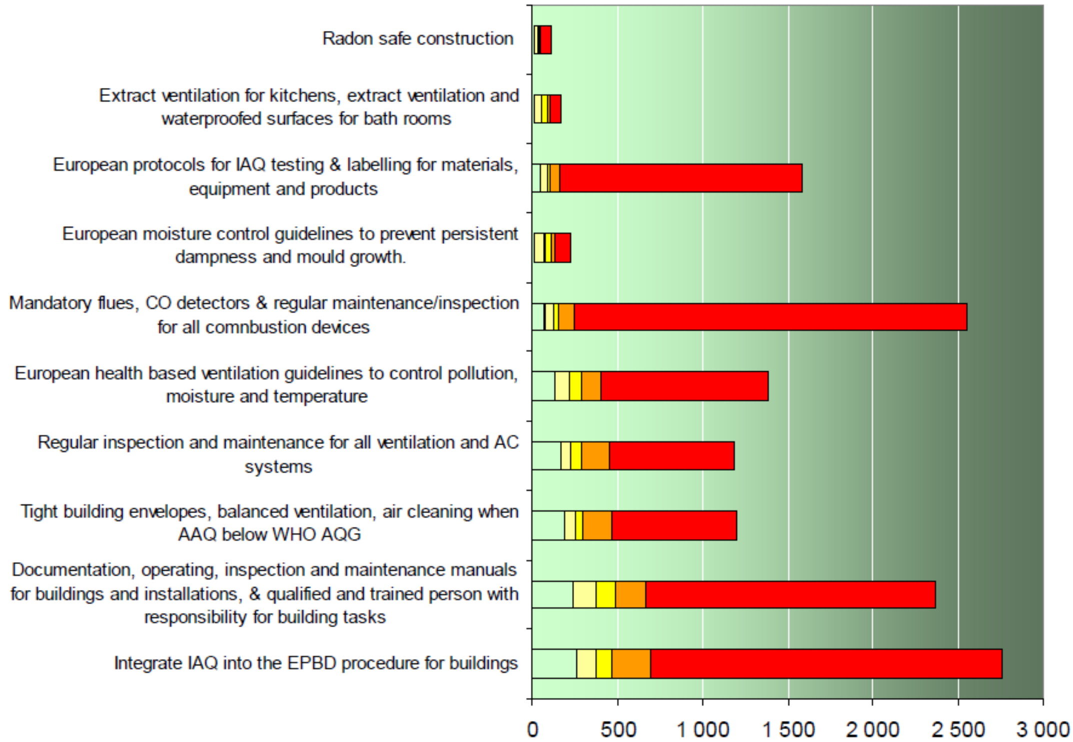
Noise barriers appear to reduce pollutant concentrations near the road way; however the precise benefits a barrier are dependent upon the orientation of the barrier to the prevailing wind direction and the proximity of residential properties to the barrier in the downwind location. Barriers can increase the residence time of the pollution above the road, especially if the road is already in a cutting. This containment effect allows vertical mixing to occur diluting the pollutant with clean air from above the road. There can also be vortex effects downwind of the barrier[36].

However, it is unlikely that barriers as a stand-alone measure will lead to the achievement of air quality objectives.

Indoor Air Quality Improvements
Although the ambient levels of $PM_{2.5}$ are monitored in outdoor air, over 90% of our exposure occurs indoors due to the time spent there. Therefore, much of the health impact of $PM_{2.5}$ is due to indoor air quality. Indoor air exposure can be independently controlled by reducing outdoor levels through emissions reduction and urban planning and by controlling indoor levels through filtration in the building envelope and the ventilation systems.

Tight building envelopes and better air filtration for new or renovated buildings in areas of high pollution does have the potential for benefiting health, but is relatively slow based on the building of new stock. However, a European Commission assessment identified simple documentation and monitoring of **existing building and systems** as having one of the largest potential benefits to health (Figure 21). Although countries with the poorest indoor air quality benefit the most, even countries such as the UK would see health benefits (green and cream section of bar - Figure 21).

Figure 21: Distributions of the national public health benefit potentials of the 10 assessed policies to improve indoor air quality.



In the 10th year of implementation. Health benefits given as DALY per year*million inhabitants within the EU-26 countries. Countries benefit according to current level of indoor air pollution. The UK is in the 1st quartile. Air pollutions levels from left to right: min – 1st quartile – median – third quartile – max. Source: Taken from Jantunen 2011[15].

Planning

The National Planning Framework Guidance on Air Quality states that Local Plans can affect air quality in a number of ways, including through what development is proposed and where, and the encouragement given to sustainable transport. Air Quality Management Areas should be taken into account in plan making but also it is important to take into account other locations where there could be specific requirements or limitations on new development because of air quality.

Drawing on the review of air quality carried out for the local air quality management regime, the Local Plan may need to consider:

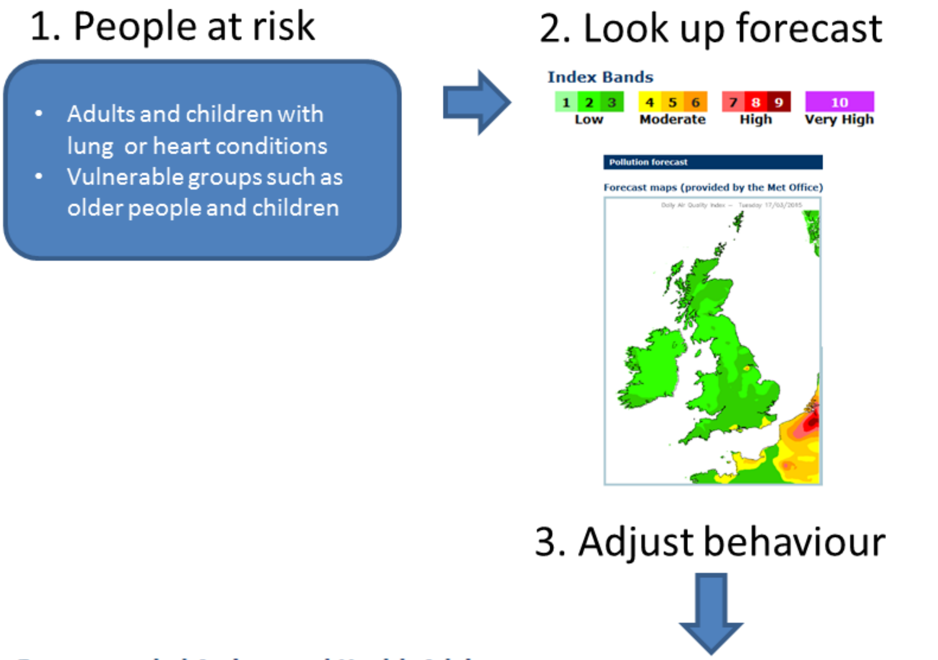
- The potential cumulative impact of a number of smaller developments on air quality as well as the effect of more substantial developments.
- The impact of point sources of air pollution (pollution that originates from one place).
- *Ways in which new development would be appropriate in locations where air quality is or likely to be a concern and not give rise to unacceptable risks from pollution.* This could be through, for example, identifying measures for offsetting the impact on air quality arising from new development including supporting measures in an air quality action plan or low emissions strategy where applicable.

Local planning policies are inconsistent across Cambridgeshire with some districts having specific and detailed policies, while others have much more limited policies.

5.1.3 Reduction of person exposure – eg text alerts

Air pollution warning services can either be active or passive. The UK Daily Air Quality Index (DAQI)[37] is a passive system similar to a UV or pollen forecast, where levels of key pollutants (O_3, NO_2, $PM_{2.5}$, PM_{10} and SO_2) are scored (0-10) and summarised into four bands (low moderate, high and very high). These can then be used, especially by those at risk, to adjust behaviour by potentially reducing activity outdoors or using relieving asthma inhalers more frequently (Figure 22).

Figure 22: Passive warning system for air quality levels (DAQI - Defra)



Recommended Actions and Health Advice

Air Pollution Banding	Value	Accompanying health messages for at-risk individuals*	Accompanying health messages for the general population
Low	1-3	**Enjoy** your usual outdoor activities.	**Enjoy** your usual outdoor activities.
Moderate	4-6	Adults and children with lung problems, and adults with heart problems, **who experience symptoms**, should **consider reducing** strenuous physical activity, particularly outdoors.	**Enjoy** your usual outdoor activities.
High	7-9	Adults and children with lung problems, and adults with heart problems, should **reduce** strenuous physical exertion, particularly outdoors, and particularly if they experience symptoms. People with asthma may find they need to use their reliever inhaler more often. Older people should also **reduce** physical exertion.	Anyone experiencing discomfort such as sore eyes, cough or sore throat should **consider reducing** activity, particularly outdoors.
Very High	10	Adults and children with lung problems, adults with heart problems, and older people, should **avoid** strenuous physical activity. People with asthma may find they need to use their reliever inhaler more often.	**Reduce** physical exertion, particularly outdoors, especially if you experience symptoms such as cough or sore throat.

An active system uses the same information but proactively alerts registered users of forecast pollution events rather than leaving it to the responsibility of the user. In the UK there are several systems

- airALERT: available for Sussex, Surrey, Sevenoaks and Southampton, developed by Sussex Air Quality Partnership (Sussex-air) and ERG, King's College London (http://www.airalert.info/Splash.aspx)

- airTEXT: for London, developed and operated by CERC with other partners in the airTEXT consortium (http://www.airtext.info/)
- London Air iphone App: developed by Environmental Research Group, Kings College. (http://www.londonair.org.uk/london/asp/iPhone/)

The benefits of active air alert system are probably small and best targeted at particular patient groups
However air alerts may still be cost-effective as they are cheap

The intention is that by providing preventative information, this empowers users to reduce exposure or increase medication to lessen or prevent the onset of symptoms, with the knock-on-effect of reducing GP visits and hospital admissions.

A review of air pollution early warning systems found that the evidence of behaviour was mixed with some indication that personal perception of poor air quality drives behaviour change more than validated data, although susceptible groups may be more aware of the official alerts[38].

There has been one quantitative evaluation of the Sussex air Alert system[39], which estimated that there had been **an additional 741.7 respiratory admissions in Sussex in 2006-2011** based on the number of moderate, high and very high air pollution days with at least one raised pollutant. Interestingly, while high and very high pollution days provided the greatest individual risk, the overall public health impact of moderate days was much greater as there were many more of them.

The estimated benefit of the airALERT service was small[39]. Based on 67% of participants taking action that was 100% effective (eg avoided pollution by staying indoors) you would need to provide the service to 837 COPD patients to avoid one admission. The numbers needed to avoid one admission were very much higher for other groups (Table 6). However, the costs of air alert messaging are low, so this may still be a cost effective approach.

In Cambridgeshire, there are 10,929 diagnosed individuals with COPD, with an average hospital admission cost of £2,350 for 2013/14. Assuming the same effectiveness levels for a text alert system approximately 13 admissions per year could be prevented in Cambridgeshire, a saving of £30,684.

Table 6: Estimated numbers of people in various categories to which the service would need to be provided to avoid one hospital admission

Category	Numbers needed to avoid 1 admission[a] by disease group
COPD	837
Children 1-16 with asthma	14,860
Adults 17-60 with asthma	21,760
Children from schools	102,470
Non COPD/children or young adult asthma i.e. elderly 60+ with asthma, other respiratory, heart disease, other, none, non-asthmatic children from schools	3,190

[a] Numbers to which the service needs to be provided if 67% of participants take action and the action is 100% effective

Source: Walton 2014

5.2 What are our current assets and gaps?

A Joint Air Quality Action Plan was prepared in 2009 by the districts with Air Quality Management Areas (Cambridge City Council, Huntingdonshire District Council and South Cambridgeshire District Council). The three districts and County Council in this partnership are linked by transport issues, which are the primary source of pollutants of concern across the sub-region. There are two main themes causing excessive transport related pollution in Cambridgeshire. These are firstly the importance of Cambridge as an employment, education and tourist centre, and secondly the prevalence of long-distance freight on the A14 East-West corridor. These factors lead to high numbers of longer than average commutes to and from Cambridge and a very high proportion of heavy goods vehicles (HGV's) on the trunk roads. The resulting congestion on trunk routes and the centre of Cambridge and the surrounding market towns also exacerbates the problems associated with high traffic flows.

The Joint Air Quality Action Plan 2009 identified the key causes in each management area and provided a series of priority actions for each affected areas for 2009-2015. Cambridge City Council has put forward plans for 2015-2025 (February 2015). The other Air Quality Management Areas are still to update their plans.

The main actions in the Air Quality Action Plan 2009 focused on improving emissions from the vehicles being driven around Cambridge, infrastructure changes throughout the county, public transport improvements, demand management and partnership with freight companies, lowering emissions from buildings, promoting smarter travel choices, as well as strategic planning and development control. The proposed upgrading and re-routing of the A14 away from settlements and as part of the A14 Improvement Scheme is also anticipated to improve air quality in much of the

Air Quality Management Areas for Huntingdonshire and South Cambridgeshire and would potentially result in these areas achieving Air Quality Objectives.

Based on Central Government information, policies to lower vehicle emissions due to newer vehicles should have delivered significant air quality improvements in Cambridgeshire. However, the laboratory improvements have not delivered in the real world, in part because of congestion and stop-start driving conditions and consequently air pollution levels have not fallen as originally predicted. A 2013 study in Cambridge on real emissions from vehicles found that buses are the highest contributors to air pollution, with taxis also contributing significantly more NO_2, and PM_{10} than comparable passenger cars[26].

Reducing vehicle access to particular streets eg Silver Street, can have a large localised impact, reducing air pollution in that street. Similar to findings in larger cities such as London and Stockholm (REVIHAAP 2014, QD2), the benefit is mainly restricted to those living and working in the immediate vicinity.

Planned growth in Cambridgeshire is attracting more residents and will lead to greater transport requirements especially in Cambridge City and along the A14 and associated issues of air pollution. The areas of poorer air quality also often coincide with Cambridgeshire new growth areas and a better understanding is needed of any potential vulnerable groups (eg young children, schools, nursing homes) that may be sited in areas of lower air quality.

5.3 Next steps: How can we address air pollution in Cambridgeshire?

A report on the next Air Quality Action Plan for Cambridge City was submitted to the Environment and Scrutiny Committee, Cambridge City Council in February 2015. The other districts have not yet submitted updated plans.

During the JSNA process, several areas have been highlighted by stakeholders from all districts as important areas of focus to continue the control and potential improvement of air quality in Cambridgeshire.

5.3.1 Lower emissions from vehicles

A significantly lower emission passenger transport fleet will be required to make air quality improvements in central Cambridge and beyond. Future improvement is dependent on accelerating and stimulating the shift to lower emission vehicles with continued traffic restraint.

- Buses are the main source of air pollution from traffic, especially in the City Centre, so a significant reduction in emissions from the buses in operation is required. Buses are a large proportion of the fleet and they make repeat journeys. Renewing a small number of vehicles with cleaner technology will lead to more improvement than with any other category of vehicle.
- Incentives for low emission vehicles for taxis. The District Councils are the Licensing Authority for taxis and can make a difference by tailoring Taxi Licensing Policy to incentivise low emission vehicles.

Although previous improvements to vehicle technology have had limited real world effect, the new low emission vehicles are either fully electric with no emissions at the point of use or hybrid vehicles which have significantly reduced emissions for periods of the drive cycle and may be capable of some zero emission running.

5.3.2 Modal shift from cars to active transport

Switching journeys from cars to walking, cycling and public transport not only has a large beneficial impact on the individual's health, but a wider benefit to the population health as there are corresponding decreases in overall air pollution levels. Mechanisms for doing this are dealt with in more detail in the Active Transport section.

A recent study in Copenhagen found that exposure to high levels of traffic-related air pollution did not appear to modify associations indicating beneficial effects of physical activity on mortality[40]. Therefore, the emphasis of modal shift should be appropriate even in areas with higher levels of pollution.

5.3.3 Further investigation into the potential for reducing person exposure in the short term

While a lower emissions transport fleet and modal shift provide the overall long-term momentum to reduce air pollution, there are measures that may reduce person exposure in the short-term. These include:

- Text alerts to vulnerable patient groups.
- Monitoring measures to improve indoor air quality especially in newer office buildings.
- Better use of health evidence when assessing the populations exposed in new developments.
- Further understanding around the seasonal impact of air pollution and potential measures that could reduce this.

The cost effectiveness and practicality of these options needs further investigation.

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