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**SUSTAINABLE DEVELOPMENT INDICATORS IN THE UK**

Paper submitted by the Department of the Environment, Transport and the Regions  
(DETR), UK<sup>1</sup>

**Abstract**

In the UK, indicators will be central to future monitoring and reporting on progress towards sustainable development. The first pilot set of sustainable development indicators for the UK was published in 1996 and the next set is due to be published this autumn. The indicators will be strongly tied into the framework and objectives of the UK Sustainable Development Strategy, published in May 1999.

The full set of 150 indicators covers a wide range of economic, social and environmental issues. The UK has also identified 14 'headline' indicators to give an overview, and to inform policy decisions and help people understand what sustainable development means.

For air quality, research has been carried out to aggregate the large volume of data available for individual sites in the UK to provide meaningful indicators at the national scale. This paper discusses research carried out in the UK to provide a methodology for presenting indicators of air pollution concentrations for individual air pollutants and for a 'headline' indicator of overall air quality.

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1 Prepared by Dorothy Salathiel.

## I. The UK Sustainable Development Strategy

1. 'Sustainable development' is a phrase that has become widely used in recent years, particularly during and since the Earth Summit in Rio de Janeiro in 1992. Following Rio, the UK was one of the first countries in the world to prepare a national Sustainable Development Strategy<sup>1</sup>, published in 1994, and a pilot set of Sustainable Development Indicators<sup>2</sup>, published in 1996. A revised UK Sustainable Development Strategy<sup>3</sup> was published in May 1999. In the strategy the UK Government identifies 150 sustainable development indicators, which will be central to future monitoring and reporting on progress. A companion booklet<sup>4</sup> lists these indicators together with the key objectives from the Strategy to which they relate. A report presenting and analysing the indicators will be published in autumn 1999.

2. The UK Government's view of sustainable development is based on four objectives:

- **social** progress which recognises the needs of everyone
  - effective protection of the **environment**
  - prudent use of natural **resources**
  - maintenance of high and stable levels of **economic** growth and employment
- In short, it is about ensuring a better quality of life for everyone, now and for generations to come.

## II. Indicators of sustainable development

3. Indicators of sustainable development are not just summary or descriptive statistics. They need to be strongly linked to sustainable development objectives and actions required to achieve those objectives. Furthermore the indicators need to be developed to communicate with and encourage actors, who can have an effect, and to monitor actions. Indicators must therefore be meaningful to and resonant with their intended audience.

4. The UK core set of sustainable development indicators is intended :

- to describe, overall, whether we are achieving sustainable development
- to highlight key national-scale policy initiatives relevant to sustainable development and to monitor whether we are meeting key targets and commitments in those areas
- to educate the public about what sustainable development means
- to raise public and business awareness of particular actions which they need to take in order to achieve more sustainable development
- to report progress to international audiences, as well as citizens of the UK

## III. Headline indicators

5. The Government consulted widely in developing the national Strategy, and during the consultation it proposed that, alongside the more detailed set of indicators which would be needed to measure progress at a national scale, a much more limited set of "headline" indicators should be developed. These would help to inform policy decisions, and would help people to understand what sustainable

development means. They would also help businesses and individuals to understand how their own actions might contribute towards more sustainable development. A set of 14 headline indicators for the UK has been developed covering the following issues:

- **economic** - economic output; investment; employment
- **social** - education; health; housing; crime
- **environment** - climate change; air pollution; transport; water quality; wildlife; land use
- **resources** - waste

Future plans include developing better indicators of resource use and adding headline indicators on poverty and landscape.

#### IV. Framework

6. A framework<sup>4</sup> has been developed, based on the four main objectives given above, for the Strategy and the indicators. Key indicators have been identified building on work done by 6 advisory groups of experts in the UK to develop indicators for various environmental media, and on work by UNCSO, OECD, EEA, Eurostat and other countries. Each indicator is linked to an objective within the strategy. Coverage of indicators within the framework is as follows:

- **assessing overall progress and priorities** - the headline indicators;
- **sending the right signals** - indicators on the mechanisms by which sustainable development can be put into practice within government, through policy instruments like taxes and regulation, through information and campaigns to change people's behaviour;
- **sustainable economy** - covering efficient use of resources; economic stability and competitiveness; education and skills of the population; employment and equal opportunities; ethical trading; action by producers and consumers in priority areas (the home, home appliances, food and drink, personal transport, tourism and leisure);
- **building sustainable communities** - local economic vitality and equity between communities in the UK; health; access to services, culture and sport; housing; planning and design; local environmental quality; crime; institutional arrangements and participation;
- **managing the environment and resources** - indicators covering persistent pollutants; climate change and energy; air quality; fresh water; seas oceans and coasts; soil; landscape and wildlife; forests; minerals extraction and use;
- **international co-operation and development** - measures of global population and global poverty; aid to developing countries; implementation of international agreements; comparison of UK resource consumption with that of other countries.

7. Many indicators are relevant to more than one theme, but they have been allocated to what is felt to be the most relevant. This is not the traditional approach to an indicator framework and leads to indicators, for example on energy and transport, being scattered over different themes, but it does help to facilitate a more integrated assessment of the economic, social and environmental aspects of sustainable development.

8. For some indicators data are available and presentation is straightforward. For others there are problems with data availability. For air quality, many data are available but the best way to aggregate them to provide a meaningful indicator needed to be developed. The rest of this paper discusses research carried out in the UK to provide a methodology for presenting indicators of air pollution concentrations.

#### **V. Indicators of air pollution: Methodological developments**

9. The air quality indicators presented in the first 'Indicators of Sustainable Development' report<sup>2</sup> were in terms of trends in concentrations of ozone, nitrogen dioxide and particulate matter at selected sites in the UK. The trends were in hours of 'accumulated exposures over a threshold X', where X was the pollutant concentration level that was considered to be poor. Whilst presenting information in this way highlighted peak trends in pollutant concentrations, underlying trends were not shown and so there was no general feel about whether air quality was improving. It was recognised at the time that presenting site specific information was not ideal and further work should be carried out to develop appropriate aggregated indicators. The difficulty was to find a valid method of combining information from a wide number of sites, in order to get some idea of what is happening at a national level, without obscuring too much the variability between sites.

10. The Department of the Environment, Transport and the Regions (DETR) in the UK contracted WS Atkins Environment to produce ideas and a range of suggestions for presenting aggregate national indicators by combining data from a large number of sites to generate overall trends. Indicators produced by aggregating data across sites are more reliable, comprehensive and informative than site specific indicators for assessing overall status and trends in pollution. Aggregating data in a rigorous manner to produce representative indicators however presents significant difficulties, particularly with a limited historical dataset. A review of air quality indicators developed by other countries and international organisations concluded few countries have produced aggregate statistics and that no *off-the-shelf* solution was appropriate for the UK situation. The methodology adopted is therefore original, but broadly based upon an approach that had been developed by the contractors for the OECD.

#### **VI. Selection of data**

11. The methodology developed<sup>5</sup> uses primary statistics (for example averages and percentiles) from monitoring data aggregated over sites to demonstrate status and trends in pollution level, rather than exceedences above a threshold or surrogate measurements. The indicators do not therefore determine population exposure to air pollution, but do illustrate the range of monitored concentrations in urban and rural areas. Primary statistics are recommended because they are: most closely derived from the original monitoring

concentration data; independent of the threshold selected; more transparent; and probably more readily interpreted by the public and non experts. Indicators have been elaborated for pollutants for which there are UK National Air Quality Standards and include trends in both annual average and short-term peak concentrations representative of chronic and acute health effects of air pollution (see Table 1).

**Table 1 - Summary of Proposed Objectives**

<b>Pollutant</b>	<b>concentration measured as</b>	<b>Standard</b>	<b>Objective - to be achieved by 2005</b>
Benzene	5 ppb	running annual mean	5 ppb
1,3-Butadiene	1 ppb	running annual mean	1 ppb
Carbon monoxide	10 ppm	running 8-hour mean	10 ppm
Lead	0.5 µg/m <sup>3</sup>	annual mean	0.5 µg/m <sup>3</sup>
Nitrogen dioxide	150 ppb	1 hour mean	150 ppb, hourly mean
Ozone	21 ppb	annual mean	21 ppb, annual mean
	50 ppb	running 8-hour mean	50 ppb measured as the 97th percentile
Fine particles (PM <sub>10</sub> )	50 µg/m <sup>3</sup>	running 24-hour mean	50 µg/m <sup>3</sup> measured as the 99th percentile
Sulphur dioxide	100 ppb	15 minute mean	100 ppb measured as the 99.9th percentile

Source: The United Kingdom National Air Quality Strategy, 1997, DETR (revised draft strategy currently out for consultation)

#### VII. Robustness tests

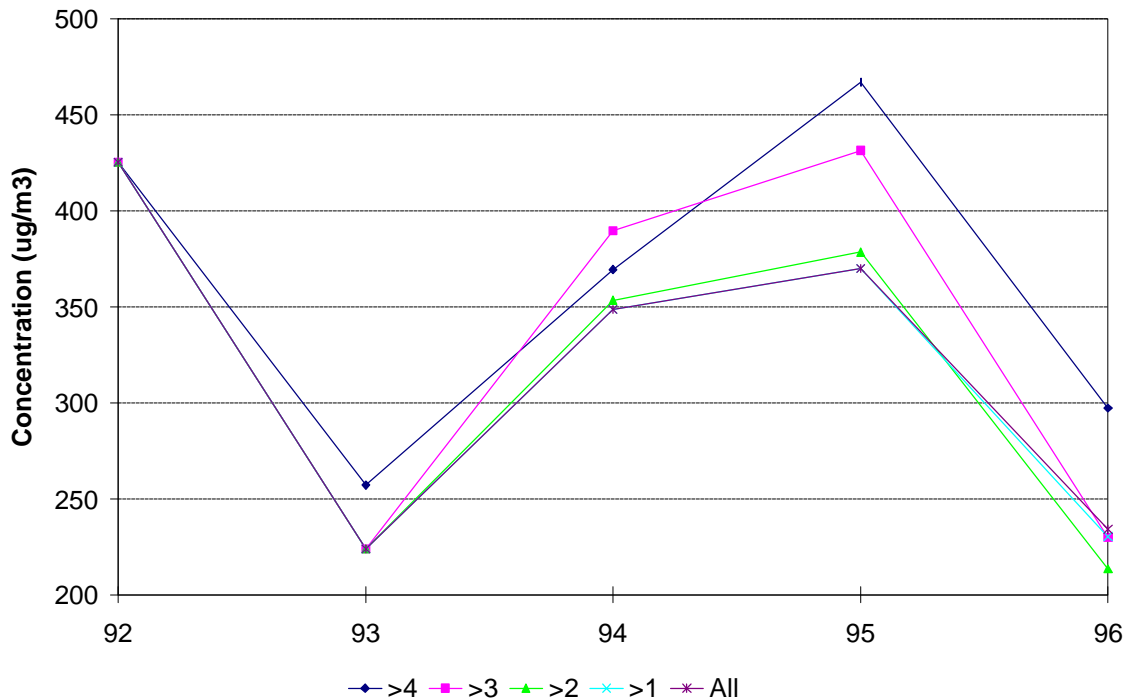
12. Only reliable, quality controlled data have been used. It is not possible to use a statistically representative sample because of the limited number of sites for earlier years, missing data and lack of a long term series at some sites. The available data were therefore combined from different locations within site classes (urban, rural etc) and a series of tests of robustness were performed to establish the effects of including or excluding sites and combining them in different ways. The aim was to assess whether there was a case for excluding certain sites. There were three principal reasons for which data might be excluded:

- inadequate **data capture** in a specified year
- a **discontinuous data record**, the site being unable to contribute data to the aggregate indicator in every year
- **unrepresentative trends**, the site trend being inconsistent with that observed at other sites.

13. The method used was to carry out sensitivity tests by charting different assumptions. For example, to test the effect of discontinuous data records,

aggregate trends from sites which had data for all years were compared to those which had data in fewer years. The trendlines were analysed to see the difference that non-continuous data sets may make to the overall trend. Figure 1 shows the effect of discontinuity for 1-hour maximum PM<sub>10</sub> concentrations. The assessments demonstrated that the effect upon the observed trend, or annual variation, of including sites which are unable to contribute data in every year to an aggregate indicator was minimal.

**Figure 1. Effect of discontinuity in the data for 1-hour maximum PM<sub>10</sub> concentrations**



Number of years for which sites included had data

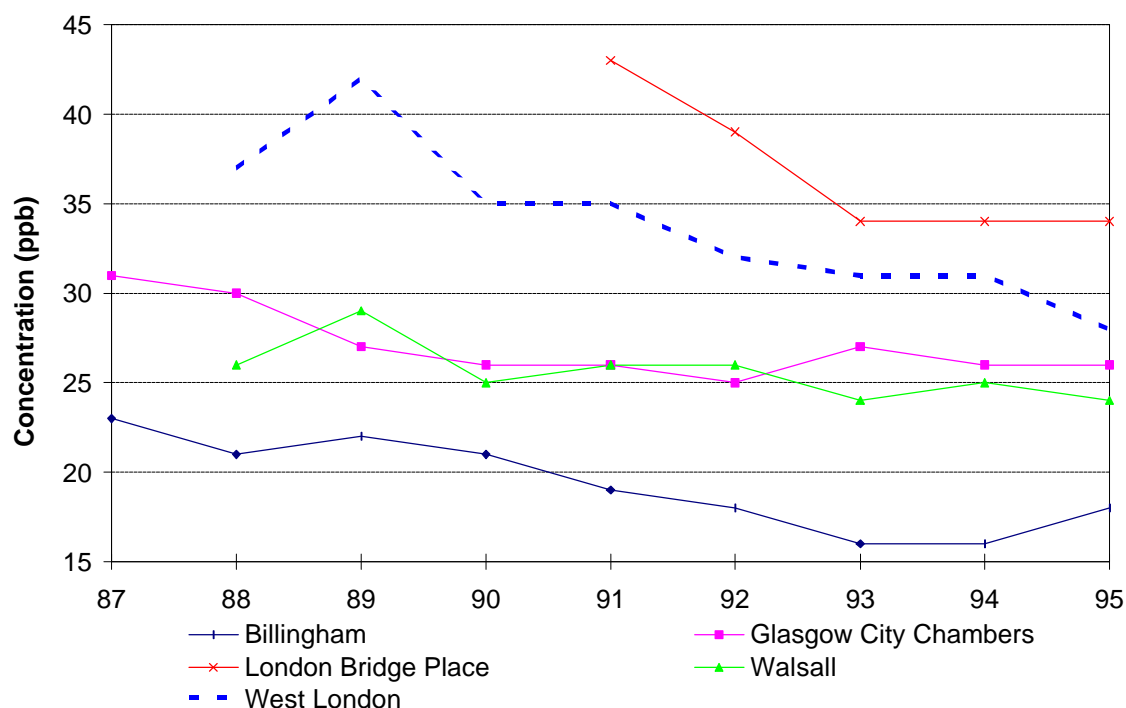
14. To test for consistency in trends, sites with statistically significant trends were examined. Figure 2 shows those for annual mean urban nitrogen dioxide concentrations.

15. The examination of site specific trends showed that in most circumstances monitoring sites in similar locations (urban or rural) in different physical areas generally observe similar pollution trends. This conclusion means that in generating an appropriate aggregate indicator the aggregate trend is generally fairly consistent with that observed at most individual sites. An aggregate indicator does not need to, and will not in most circumstances, demonstrate the same trend as every site from which it is compiled. This is not important since the objective of the indicator is to produce an overall assessment.

16. In general, it was found that the results did not differ greatly between options. As a result of these tests, indicators have been produced on the following basis:

- for a site to be included in a particular year, data capture should be at least 50 per cent
- all sites meeting the above criteria should be included for that year, even though this may lead to different sites being included each year in the aggregate indicator
- for any year, a minimum of four sites are required to produce an aggregate indicator
- data from different site classes can be aggregated to produce overall urban and rural trends
- no individual site should be excluded on the basis that it has a different trend from others

**Figure 2. Statistically significant annual mean nitrogen dioxide concentrations**  
Urban sites



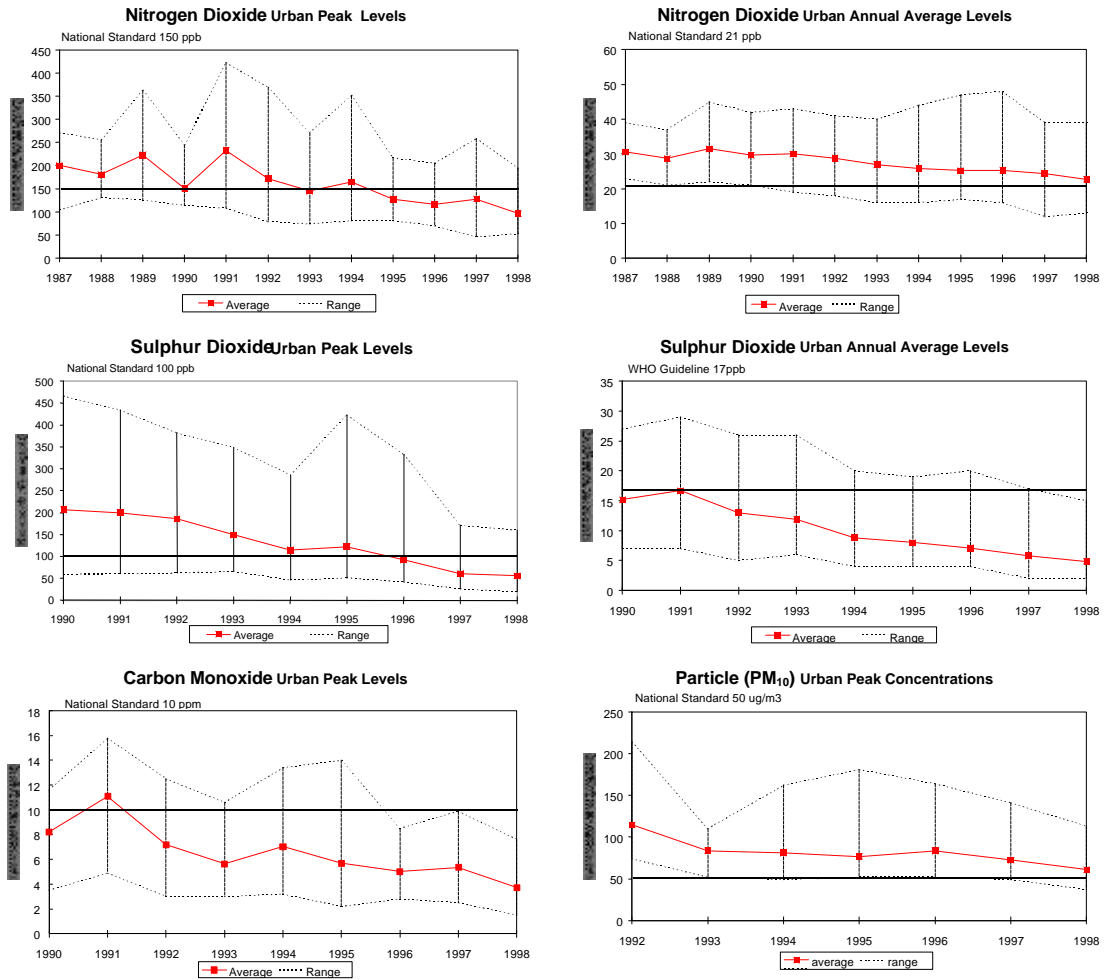
17. The indicators are presented as simple line graphs which show the composite average and range (maximum and minimum) of the aggregate concentrations in each year. These can be readily interpreted by the public and non-expert decision makers to identify trends, compare levels against the National Standards and to assess progress towards meeting the 2005 Objectives. Examples for selected air pollutants are given in Figure 3.

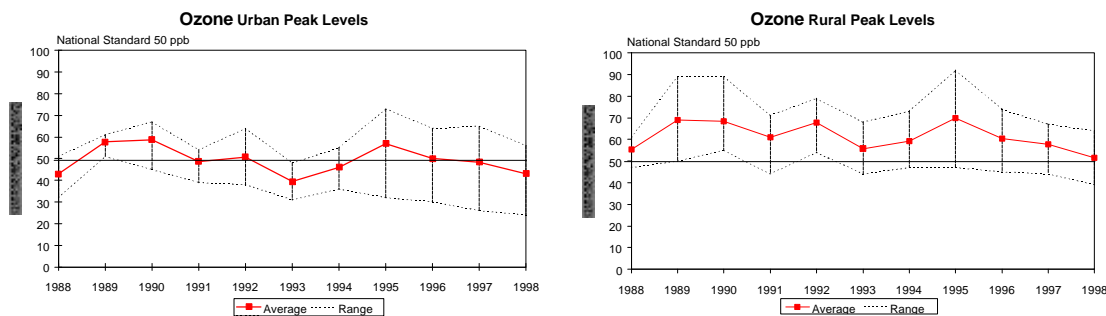
#### VIII. Headline indicator of air pollution concentrations

18. Air quality was identified for inclusion in the set of Headline Indicators. DETR commissioned further research from WS Atkins to develop a single overall indicator of air pollution concentrations<sup>6</sup>.

19. To produce a single air pollution indicator, measured concentrations of different pollutants must be combined. This was achieved by employing the DETR's Air Pollution Public Information System<sup>7</sup> to determine the average number of days, at each site, on which the pollution level exceeded the National Standard. The Public Information System includes the five pollutants within the National Air Quality Strategy<sup>8</sup> which can cause acute health effects: carbon monoxide, nitrogen dioxide, ozone, PM<sub>10</sub> and sulphur dioxide. Pollutants which cause chronic effects are not included within the Indicator.

Figure 3. Concentrations of Selected Air Pollutants.





Peak measurements are as follows:

Nitrogen dioxide: Maximum of 1-hour mean in year.

Sulphur dioxide: 99.9<sup>th</sup> percentile of 15 minute means in year.

Carbon Monoxide: Maximum of running 8 hour means in year.

Particulates (PM<sub>10</sub>): 99<sup>th</sup> percentile of daily maximum running 24-hour means.

Ozone: 97<sup>th</sup> percentile of daily maximum running 8-hour means.

20. The Standard Threshold was used since this represents the concentration below which air pollution is unlikely to have any health effects. The Indicator measures the average number of days in each year on which concentrations of any pollutant were above the Standard. This is consistent with the approach used in the UK Public Information System and is readily understood.

21. To ensure the Indicator is robust and representative, only ratified data from the National Automated Monitoring Network was employed. A data inclusion criterion was also developed to determine which sites should contribute to the data-set. This criterion sought to include within the Indicator a large number of sites, with a wide ranging geographical distribution and classification. It also sought to include only sites which produced reliable data and recorded a representative number of days on which pollution was above the Standard. The data inclusion criterion adopted is a compromise between these conflicting requirements. It is not possible to use a statistically representative sample because of the limited number of sites for earlier years, missing data and the lack of a long-term series at some sites.

22. It is highly desirable that sites contributing data to the Indicator measure all five pollutants. A limited range of pollutants are monitored at most rural, remote, suburban and hotspot sites (those in industrial areas or adjacent to roads). A data inclusion criterion requiring measurements for all five pollutants would therefore unacceptably limit the range of sites available to contribute data to the Indicator. Extensive analysis was undertaken to determine which pollutants it was *essential* to monitor to record a *representative* number of polluted days.

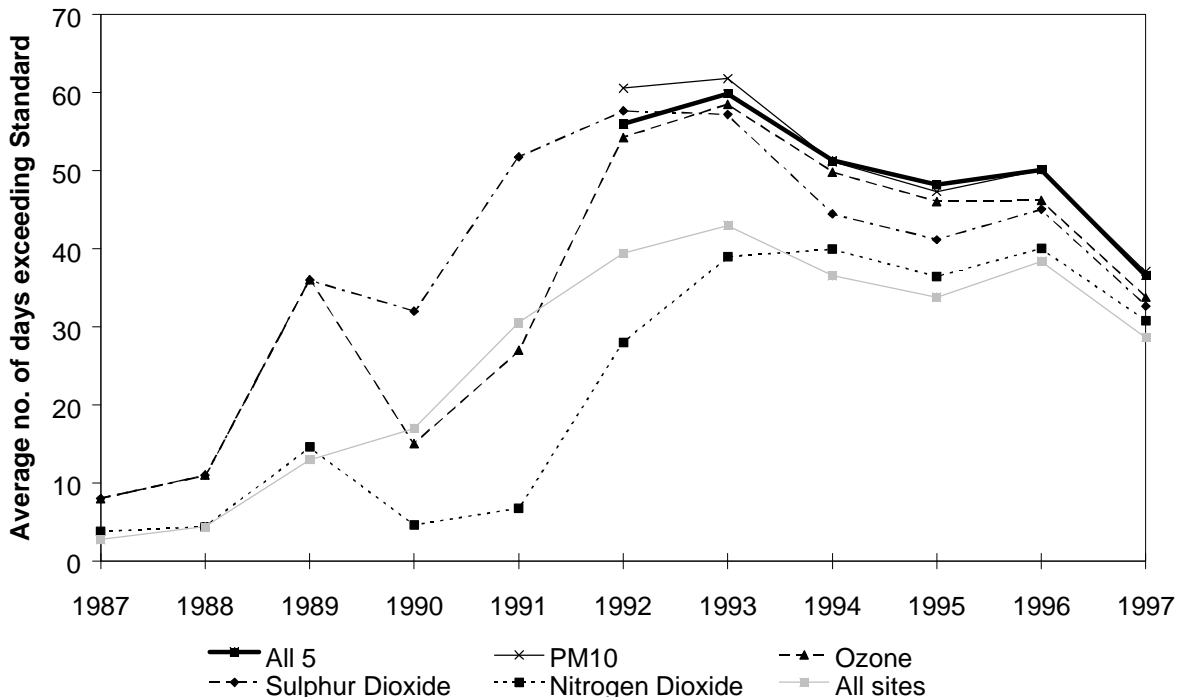
23. Analysis was undertaken to determine the difference that measuring particular pollutants made to the average number of exceedences of the national standard at urban sites. Figure 4 illustrates the impact of monitoring different data inclusion criteria: all five pollutants compared with at least PM<sub>10</sub>, ozone, sulphur dioxide, nitrogen dioxide. The figure illustrates the increase in the number of recorded exceedences after 1992 when PM<sub>10</sub> monitoring

commenced. This suggested that for a representative number of exceedences to be recorded in an urban areas the site must monitor PM<sub>10</sub> as a minimum.

24. Following further analysis, the criteria adopted was that rural and remote sites should monitor at least ozone; urban and suburban sites must monitor PM<sub>10</sub>, ozone and sulphur dioxide; and kerbside and roadside sites must monitor PM<sub>10</sub>.

25. Further analysis demonstrated that any site which monitored each of these pollutants for more than 50 per cent of the year would identify a representative number of days on which the pollution level was above the Standard. Since 1996, the number of monitoring sites has increased substantially. The data capture achieved by sites was also generally much better than 50 per cent. From 1998 onwards, it is proposed a 75 per cent data capture (consistent with the rate employed in other DETR air quality assessments) is utilised. This will produce a more robust measure.

**Figure 4. Impact upon the average number of days of moderate or worse pollution recorded at urban sites monitoring different pollutants**



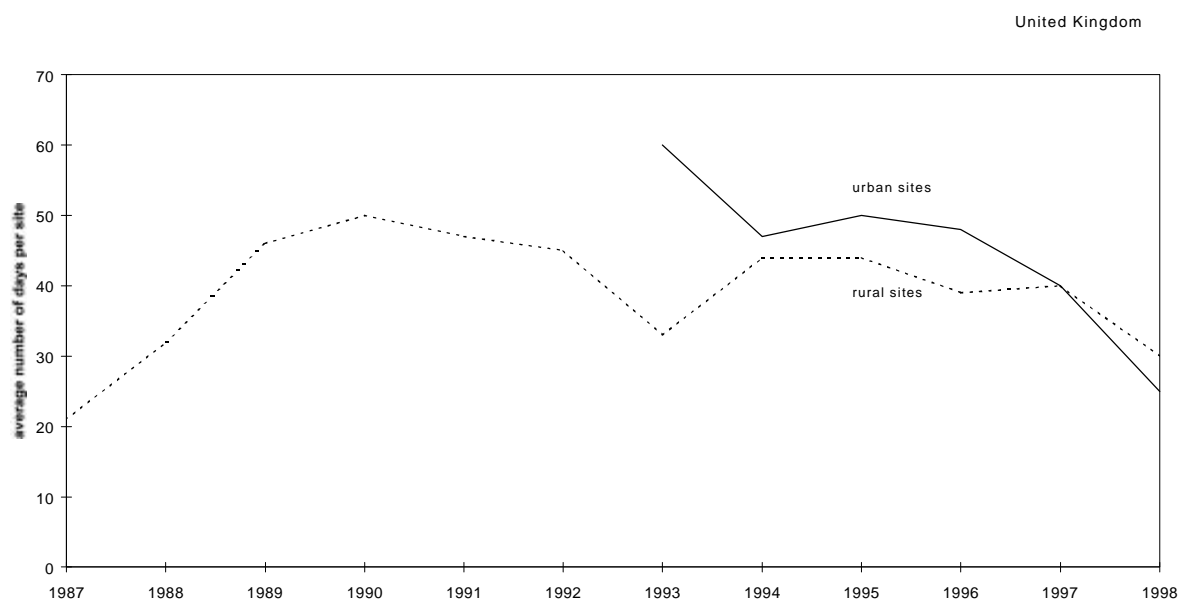
26. Figure 5 illustrates the observed trend in air pollution levels employing the methodology devised for the air quality headline indicator. This illustrates the average number of days in each year on which the pollution level was above the Standard. It demonstrates that in urban areas the average number of days above the Standard have declined from 62 in 1993 to 40 days in 1997, this trend is statistically significant. The improvement has mainly been caused by a reduction in days of sulphur dioxide pollution. In rural areas there has been no significant change in pollution levels. The number of days of pollution above the Standard has varied widely between years and overall rural pollution

levels have remained unchanged over the period analysed. In 1997, on average throughout the UK, there were 40 days on which pollution levels were above the Standard in both urban and rural areas, the type of pollution in each area is, however, very different.

27. The UK National Air Quality Strategy established Objectives for individual pollutants to be achieved by 2005. These allow a small number of exceedences of the Standard for ozone, PM<sub>10</sub> and sulphur dioxide. It is not possible to relate the Objective for individual pollutants to a permissible number of days on which pollution levels are above the Standard and propose a target for the Indicator. The present Strategy however permits a small number of days on which pollution levels are above the Standard by 2005.

28. The EU is developing a set of headline environmental indicators. A similar indicator to the UK air quality headline indicator is a strong candidate for inclusion and is being developed by the EEA's Environmental Topic Centre.

**Figure 5. Air quality headline indicator: Days when air pollution is moderate or high**



Source: NETCEN, DETR

### References

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- <sup>2</sup> *Indicators of Sustainable Development for the United Kingdom*, Department of the Environment, (1996) [<http://www.detr.gov.uk/epsim/indics/index.htm>]
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- <sup>5</sup> *Development of aggregated UK indicators of air quality*, DETR (1998)
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- <sup>7</sup> *Smog information made clear*, DETR (1997)
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