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6. Air Quality: National and Local Assessment

Prepared for the Airports Commission

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Executive Summary

This report considers the change in air quality conditions for the shortlisted airport expansion schemes listed below against the air quality conditions established in the Air Quality: Baseline report (Jacobs, 2014), in accordance with the Airports Commission Appraisal Framework (April 2014):

- Gatwick Airport Second Runway (Gatwick 2R) promoted by Gatwick Airport Limited (GAL);
- Heathrow Airport Northwest Runway (Heathrow NWR) promoted by Heathrow Airport Limited (HAL); and,
- Heathrow Airport Extended Northern Runway (Heathrow ENR) promoted by Heathrow Hub Limited (HH).

The emissions that are the main concern for air quality are emitted from various sources including cars, goods vehicles, aircraft, biomass boilers, incinerators and many more. The total emissions from different sources, combined with the distance to the receptor, will influence air pollution concentrations and determine the air quality impacts on receptors. The most common source of emissions within close proximity to sensitive receptors is road traffic. Consequently, road traffic is the dominant emission source causing poor air quality at sensitive receptors (human health and ecosystems) and is one of the most important sources when considering the impact upon baseline air quality conditions.

A two stage approach is being taken to meet the Appraisal Framework requirements to assess air quality impacts.

The first stage of assessment is covered in this report, and makes use of available surface access modelling information but as this is a static model, it is not suitable as a basis for determining the dispersion of pollutants, their concentrations in the air, or for assessing the impacts of these on sensitive receptors.

The Appraisal Framework sets out recommended methods, guidance documents and datasets to facilitate the assessment. The Appraisal Framework identifies Local and National aspects to the assessment:

- Local air quality assessment, including an assessment of the risk of exceeding limit values; and
- National assessment of pollution at a national scale, including performance in relation to emissions ceilings.

This first stage assessment has, therefore, focused on:

- Capturing the emission sources identified within the Appraisal Framework;
- Calculation of the change in emissions as a result of each scheme;
- National assessment of pollution at a national scale, including performance in relation to emissions ceilings:
- Local air quality assessment, including an assessment of the risk of 2030 baseline air quality concentrations exceeding limit values with the airport expansion schemes in place;
- Assessing the schemes' impact on the UK's ability to meet the National emission ceilings targets and potential for mitigation; and

- Monetisation of the change in mass emissions associated with the shortlisted schemes.

The National and Local assessments use the predicted baseline to allow a comparative assessment between the 'do minimum' (without airport expansion) and 'do something' (with airport expansion) scenarios for the 2030, 2040 and 2050 baseline years.

At the National scale, the first stage assessment considers the total mass emissions of key pollutants associated with airport activity. These are nitrogen oxide (NO_x), and Particulate Matter (PM_{10} and $PM_{2.5}$) which are particles with aerodynamic diameters of less than 10 and 2.5 microns respectively. The predicted level of mass emissions have then been evaluated to compare with the national emissions ceilings.

At the Local scale, the first stage assessment considers the proportions of mass emissions of these same key pollutants but limited to emissions associated directly with airport activity.

In addition, likely future local pollutant concentrations were established for the baseline using results from an existing Department for Environment and Rural Affairs (Defra) National compliance model (the Pollution Climate Mapping (PCM) model) for 2030 and also projecting locally monitored pollution concentrations for 2030. These concentrations included adjustment for expected improvements to vehicle emission technology but not for other potential government policy measures or scheme promoter mitigation measures to reduce local concentrations. The baseline concentrations have been compared to relevant EU Limit Values (EULVs) or Air Quality Objectives (AQOs) and the monitoring locations have been categorised in terms of the (unmitigated) risk of exceeding AQOs and EU Limit Values should the airport schemes cause increases in pollutant concentrations at those locations.

The second stage of assessment to be undertaken, following the publication of this report, will consider pollutant dispersion modelling including the effects of potential government and scheme promoter mitigation measures, and will report on an assessment of receptor impacts and risks to limits and targets..

The main first stage results for each scheme are summarised below.

Gatwick Airport Second Runway Scheme

National

The National Atmospheric Emissions Inventory (NAEI) projects UK total emissions of NO_x and $PM_{2.5}$ up to and including the year 2030. These projections include emissions from Gatwick airport.

UK emissions of NO_x are expected to meet current 2020 Gothenburg Protocol[1] targets in both 2025 and 2030. The baseline NAEI 2030 projections are 86.07% of

[1] The Gothenburg Protocol to Abate Acidification, Eutrophication and Ground-level Ozone was first agreed in 1999 (through the UN Economic Commission for Europe), setting mandatory emission reductions for four major air pollutants (sulphur dioxide, nitrogen oxides, volatile organic compounds and ammonia), to be achieved by 2010. A revised protocol agreed in 2012 specifies further emission reduction commitments in terms of percentage reductions from base 2005 to 2020, and has been extended to cover one additional air pollutant, namely particulate matter (PM2.5).

the current 2020 Gothenburg NO_x targets with the proportion of national emissions increasing to 86.12% with the second runway. While such contributions are likely to be accommodated in the context of the current Protocol targets, there remains a risk that the Protocol targets themselves may become tighter making any accommodation a greater challenge.

UK national emissions could exceed $PM_{2.5}$ emissions targets in 2025 and remain in exceedance in 2030. Although this is only by a small proportion, Gatwick 2R without mitigation measures, could cause exceedance of the Gothenburg targets to increase 0.03% by 2030.

Emissions of $PM_{2.5}$ attributed to associated airport activities with Gatwick 2R in 2030, represent just over 4% of the projected exceedance of the 2020 Gothenburg Protocol target. The principal sources of $PM_{2.5}$ are airport only road traffic and APUs; these are two emission sources which have potential to yield reductions.

Local

Defra's national compliance PCM model and Jacobs' projected NO_2 monitoring data concentrations, were established for the 2030 without scheme baseline. These concentrations take account of expected vehicle technological improvements, although they do not reflect governmental policy or scheme promoter's mitigation measures with the potential to change air quality. A risk category has been applied which rates the monitoring and PCM locations in terms of risk of exceeding AQOs and EU Limit Values should Gatwick R2 cause increases in NO_2 concentrations.

No locations in the Gatwick 2R study area are predicted to exceed NO_2 AQOs or EU Limit Values, however, without mitigation measures, the 2030 projected annual mean NO_2 concentrations are predicted to pose a high risk of exceeding AQOs in locations along the A2011/Hazelwick Roundabout (Craw15). With sufficiently detailed data for dispersion modelling in the second stage assessment, the evaluation will move from rating the risk of exceedance, to quantifying whether the impact is sufficient to result in exceedence of AQOs/EULVs and the impact on sensitive receptors, taking account of potential mitigation.

Based on the information available, there is unlikely to be any risk of PM_{10} and $PM_{2.5}$ AQOs being exceeded in the assessment years within the Gatwick 2R study area. Both the with and without mitigation scenarios for Gatwick R2 will be assessed in the second stage assessment.

Monetisation

The total cost of NO_x and PM_{10} over the 60 year appraisal period based on the unmitigated change in mass emissions with the scheme in place, is £76.8m and £92.4m, respectively.

At the second stage assessment, the change in local air quality concentrations modelled for sensitive receptors (human health and ecosysems) associated with airport expansion will be used to determine the cost of local air quality impacts.

Heathrow Airport Northwest Runway Scheme

National

The NAEI projects UK total emissions of NO_x and $PM_{2.5}$ up to and including the year 2030. These projections include emissions from Heathrow Airport.

UK emissions of NO_x are expected to meet current 2020 Gothenburg Protocol targets in both 2025 and 2030. The baseline NAEI 2030 projections are 82.8% of the 2020 Gothenburg NO_x targets with the proportion of national emissions increasing to 83.20% with the third runway. While such contributions are likely to be accommodated in the context of the current Protocol targets; there remains a risk that the Protocol targets themselves may become tighter making any accommodation a greater challenge.

UK National emissions are projected to exceed the Gothenburg targets for $PM_{2.5}$ emissions in 2025 and remain in exceedence in 2030. Although this is only by a small proportion, without mitigation Heathrow NWR could cause exceedance of the Gothenburg targets to increase 0.12% by 2030.

Emissions of $PM_{2.5}$ attributed to associated airport activities in the Heathrow NWR baseline in 2030 represent almost 9% of the projected exceedance of the current 2020 Gothenburg Protocol target without mitigation considered.

The principal source of $PM_{2.5}$ is aircraft fugitive brake and tyre wear and APUs; these are two emission sources that have potential for reductions.

Local

Defra's national compliance PCM model and Jacobs' projected NO_2 monitoring data concentrations were established for the 2030 baseline. These concentrations take account of expected vehicle technological improvements, although they do not reflect governmental policy or scheme promoter's mitigation measures with the potential to change air quality. A risk category has been applied which rates monitoring and PCM locations in terms of risk of exceeding AQOs and EU Limit Values should Heathrow NWR cause increases in NO_2 concentrations.

The PCM modelling indicates there to be a low to likely risk of exceeding annual mean NO_2 EULVs within the Heathrow NWR study area in 2030. The likely risk is identified along the A4 at sections of Bath Road Colnbrook-by-pass. Projected local monitoring also indicates there to be a low to high risk of exceeding annual mean NO_2 AQOs within the same study area. The high risk locations have been identified along the M4, Hillingdon. With sufficiently detailed data for dispersion modelling in the second stage assessment, the evaluation will move from rating the risk of exceedance, to quantifying whether the impact is sufficient to result in exceedence of AQOs/EULVs and the impact on sensitive receptors taking account of potential mitigation.

Based on the information available, there is unlikely to be any risk of PM_{10} and $PM_{2.5}$ AQOs being exceeded in the assessment years within the Heathrow NWR study area.

Mitigation of road traffic emissions may be required along Bath Road, A4 and the M4, Hillingdon. Such mitigation will be dependent the magnitude of any potential impacts at these locations and the viability of its implementation, but may include traffic management and/or rerouting. Both the with and without mitigation scenarios for Heathrow NWR will be assessed in the second stage assessment.

Monetisation

The total cost of NOx and PM10 over the 60 year appraisal period is £121.2m and £373.1m, respectively.

At the second stage assessment, the change in local air quality concentrations modelled for sensitive receptors (human health and ecosysems) associated with airport expansion will be used to determine the cost of local air quality impacts.

Heathrow Airport Extended Northern Runway Scheme

National

The National Atmospheric Emissions Inventory projects UK total emissions of NO_x and $PM_{2.5}$ up to and including the year 2030. These projections include emissions from Heathrow Airport.

UK emissions of NO_x are expected to meet current 2020 Gothenburg Protocol targets in both 2025 and 2030. The baseline NAEI 2030 projections are 82.8% of the 2020 Gothenburg NO_x targets with the proportion of national emissions increasing to 83.20% with the third runway. While such contributions are likely to be accommodated in the context of the current Protocol targets; there remains a risk that the Protocol targets themselves may become tighter making any accommodation a greater challenge.

UK national emissions are projected to exceed the Gothenburg targets for $PM_{2.5}$ emissions in 2025 and remain in exceedence in 2030. Although this is only by a small proportion, without mitigation Heathrow ENR could cause exceedance of the Gothenburg targets to increase 0.12% by 2030.

Emission of $PM_{2.5}$ attributed to associated airport activities in the Heathrow ENR baseline in 2030 represent almost 9% of the projected exceedance of the current 2020 Gothenburg Protocol target without mitigation considered.

The principal source of $PM_{2.5}$ is aircraft fugitive brake and tyre wear and APUs; these are two emission sources that have potential for reductions.

Local

Defra's National compliance model and Jacobs' projected NO_2 monitoring data concentrations were established for the 2030 baseline. These concentrations take account of expected vehicle technological improvements. although they do not reflect governmental policy or scheme promoter's mitigation measures with the potential to change air quality. Risk categories have been applied to rate monitoring and PCM locations in terms of the risk of exceeding AQOs and EU Limit Values should Heathrow ENR cause increases in NO_2 concentrations.

PCM modelling indicates there to be a low to likely risk of exceeding annual mean NO_2 EULVs within the Heathrow ENR study area. The likely risk is identified along the A4 (Bath Road Colnbrook-by-pass). Projected local monitoring also indicates there to be a low to high risk of exceeding annual mean NO_2 AQOs within the same study area. The high risk locations have been identified along the M4, Hillingdon.

With sufficiently detailed data for dispersion modelling in the second stage assessment, the evaluation will move from rating the risk of exceedance, to quantifying whether the impact is sufficient to result in exceedence of AQOs/EULVs at sensitive receptors and the significance of this impact

Based on the information available, there is unlikely to be any risk of PM_{10} and $PM_{2.5}$ AQOs being exceeded in the assessment years within the Heathrow ENR study area.

Mitigation of road traffic emissions may be required along Bath Road, A4 and the M4, Hillingdon. Such mitigation will be dependent the magnitude of any potential impacts at this location and the viability of its implementation, but may include traffic management and/or rerouting. Both the with and without mitigation scenarios for Heathrow NWR will be assessed in the second stage assessment.

Monetisation

The total cost of NO_x and PM_{10} over the 60 year appraisal period is £107.9m and and £341.5m, respectively.

At the second stage assessment, the change in local air quality concentrations modelled for sensitive receptors (human health and ecosysems) associated with airport expansion will be used to determine the cost of local air quality impacts.

1 Introduction

This Section covers:

- The Airports Commission's Appraisal Framework requirements for air quality assessment;
- The purpose of the report - as the first stage of a two stage assessment of the potential air quality impacts of the airport expansion schemes;
- Context for air quality issues in terms of why air pollution is of concern, the relevant sources of pollution from the airport and surrounding areas and how they can affect air quality; andAn outline of the approach taken and how the report is structured.

1.1 Purpose of Report

This report builds on the Do Minimum scenarios, for air quality around Gatwick and Heathrow airports as identified in the Air Quality: Baseline (Jacobs 2014) report and assesses the following three shortlisted airport expansion scheme options against the baseline:

- Gatwick Airport Second Runway (Gatwick R2) promoted by Gatwick Airport Limited (GAL);
- Heathrow Airport Northwest Runway (Heathrow NWR) promoted by Heathrow Airport Limited (HAL); and
- Heathrow Airport Extended Northern Runway (Heathrow ENR) promoted by Heathrow Hub Limited (HH).

The Do Something scenarios take account of proposed changes to the airports as indicated in their respective expansion plans and forecast changes to air traffic based and related potential sources of airport pollution emissions and airport related road traffic. In establishing the scheme's impacts, the years 2030, 2040 and 2050 have been used.

1.2 Appraisal Framework Requirements

The Airports Commission's Appraisal Framework (April 2014) sets out requirements for 'National' and 'Local' air quality impact assessments. The same National and Local requirements are applied to the baseline and the scheme assessment to allow a comparative assessment between the Do Minimum and Do Something scenarios. Where possible the approach to define scheme impacts has followed the Airports Commission Appraisal Framework recommended guidance documents. This comparison with the baseline is presented in this report. A separate report; Air Quality: Baseline, (Jacobs 2014a) explains the baseline assessment in more detail.

Currently available surface access modelling information is based on a static traffic model which is not suitable as a basis for determining the dispersion of pollutants, their concentrations in the air, or for assessing the impacts of these on sensitive receptors. As such, a two stage approach will be taken to meet the Appraisal Framework requirements to assess air quality impacts.

The first stage of assessment is covered in this report, and has focused on the baseline related to:

- Capturing the emission sources identified within the Appraisal Framework;
- Calculating of the change in emissions as a result of the scheme;
- National assessment of pollution at a national scale, including performance in relation to emissions ceilings;
- Local air quality assessment, including an assessment of the risk of exceeding limit values; and
- Monetisation of the change in mass emissions, relative to mass emissions set out in the baseline report.

To enable the second stage of assessment, a dynamic traffic model is being developed which will provide the basis for pollutant dispersion modelling and the assessment of resultant receptor impacts. The scope of this second stage is set out in more detail in Chapter 6 Further Work.

(a) Scope of Air Quality Impact Assessment

The air quality impact assessment covers National and Local scales.

At the National scale the assessment considers the total mass emission of key pollutants associated with airport activity. These are nitrogen oxide (NO_x), and Particulate Matter (PM_{10} and $PM_{2.5}$) – particles with aerodynamic diameters of less than 10 and 2.5 microns respectively. Background information on these pollutants and why they are of concern is summarised in section 1.2.2 'Context for the air quality assessment' below and provided in more detail in Appendix A.

At the Local scale the assessment considers the proportions of mass emissions of the same key pollutants associated with airport activity.

In addition, the Local scale assessment also considers local ambient air quality monitoring of nitrogen dioxide (NO_2), and Particulate Matter (PM_{10} and $PM_{2.5}$). The baseline concentrations are based on current data projected to 2030 and Defra's national compliance (pollution climate mapping (PCM)) modelled concentrations in 2030 have been reviewed. The 2030 baseline concentrations are assessment in terms of risk of exceeding their respective European Union Limit Values (EULVs) or National Air Quality Objectives (AQOs).

Defra's national compliance model (PCM) concentrations and the projected local air quality monitoring concentrations provide the 2030 baseline and do not take into account any mitigation measures suggested by the scheme promoters. The scheme promoters mitigation will be considered in the second stage dispersion modelling.

The National and Local air quality impact assessments are presented together as they share a common mass emission methodology.

1.2.2 Context for the Air quality assessment

Clean air is essential to human health and ecosystems. The pollutants within the UK which are the greatest threat to these are NO_2, PM_{10} and $PM_{2.5}$ for human health and NOx to ecosystems. NOx is a term for all nitrogen oxides, which include NO_2 (nitrogen dioxide) and NO (Nitric Oxide).

NO_2 is shown to be hazardous to those particularly susceptible to changes in air quality such as asthmatics. NO2 is usually also seen as a precursor to more harmful particulates, such as PM10 and PM2.5, as these are more harmful because these pollutants can penetrate deep into the lungs causing cardiovascular problems.

NO_x is a pollutant that impacts on sensitive habitats and vegetation as it has the potential to alter nutrient availability and cause acid rain. As a result NO_x is a catalyst for change in composition of species, which could materially alter the original habitat type and species which depend on it. NO_x is a primary pollutant, but through photochemical reactions with other pollutants can form secondary pollutants such as ozone. The key chemical reaction of concern for NO_x is the oxidation of NO into NO_2, as this increases the conversion ratio between NO_x and NO_2 and subsequently increases NO_2 concentrations.

The issue of these pollutants is particularly pertinent in areas sensitive to change, often referred to as ‘sensitive receptors’. For human health, it is areas of long term exposure which are more susceptible such as dwellings, hospitals and schools. For ecosystems, the focus is on designated sites e.g. Special Protection Areas (SPA), Special Areas of Conservation (SAC) or Sites of Special Scientific Interest (SSSIs), which contain habitat types that are also sensitive to changes in nitrogen oxides.

Close proximity of the emission source to the ‘sensitive receptor’ causes poor air quality because there is less opportunity for dispersion of emissions between the source and receptor resulting in greater concentrations of pollutants. Local air quality is evaluated by comparing concentrations of pollutants against EU ambient air quality directive limit values (EULVs) or air quality objectives (AQOs) set at locations where exposure harm to human health and ecosystems is thought to occur.

The anthropogenic emission sources directly associated with the airport are the main concern of the appraisal framework and are emitted from various including sources such as road traffic (cars and heavy goods vehicles), aircraft, biomass boilers, incinerators and onsite power sources. However, exposure locations are also influenced by non-airport related sources again including road traffic and power generation, but also other sources such as industry, waste plants and domestic heating. Put simply, it is a combination of the total emissions from the sources and the distance to the receptor which influences the concentrations of pollutants in the air and impacts air quality. As such, the most common emission source within close proximity to sensitive receptors is road traffic. Consequently, based upon studies of source apportionment at monitoring locations along major roads close to airports (Colvile et al, 2000; Airports Council International, 2010), road traffic will tend to be the dominant emission source causing poor air quality.

The calculation of cumulative emissions of pollutants from all sources will give the total National emissions. A country’s National emissions can be carried long distances by winds and can have trans-boundary effects. The National Emission Ceilings Directive[2] (NECD) sets national emissions ceilings to reduce the likelihood and effect of trans-boundary pollution. The cumulative mass emission increase from airport expansion will be compared against the National Atmospheric Emissions Inventory projections to determine whether the scheme could change the date of compliance.

[2] Directive 2001/81/EC of the European Parliament and of the Council of 23 October 2001 on national emission ceilings for certain atmospheric pollutants, Official Journal of the European Communities L309, pp 22-30

The emission sources contributing to the total concentration at a specific receptor are broadly comprised of four main groups:

- Airport related road transport (vehicle access including car parking);
- Airport activities (such as aircraft movements, heat & power generation);
- Non-Airport related road transport (vehicles on the surrounding roads); and
- Other emissions (such as industry andenergy production).

The relative proportion from each source will be dependent on the specific location of a given receptor, particularly in relation to the distance and direction from local sources.

At locations very close to the airport activities, i.e. properties at the boundary and adjacent to airport activities, then the airport itself is likely to comprise a significant proportion of total concentrations. However, because residential locations are more likely to be in close proximity to roads than the airport boundary, then road transport (including airport related traffic) across the wider road network is typically the greatest contributor to overall exposure. As receptors are located further from the airport then the influence of vehicles accessing the airport would also tend to diminish with distance. Analysis of the impacts of the Icelandic volcanic eruption during 2010, which prevented air traffic in Europe for several days, allowed analysis of sources of air pollution which is not normally practicable. This indicated that at locations outside of airport boundaries changes in air concentrations appeared more attributable to the reduction of vehicle traffic than airport activities (Airports Council International, 2010).

Assessment of exposure to air quality pollution involves representation of a large number of emission sources and their impact at specific locations, and also needs to consider how emissions change over time. Calculation of concentrations in future years requires predictions of how emission sources may change, such as the level of aircraft activity or road traffic movements, and the air quality impact per given unit of activity, such as fleet type or engine technology. There are various regulations and policies that will drive predicted reductions in emissions from road traffic and industry, particularly the tightening road vehicle emission limits implemented by the Euro 6/VI standards which started to come into effect in 2013. These emissions reductions are expected to lead to reductions in ambient concentrations of air quality pollutants into the future. Therefore, locations with existing poor air quality, and current exceedences of EULVs or AQOs, are expected to improve and may no longer exceed in the opening year of a scheme. Whilst there is uncertainty in all future predictions, this report takes into account changes to vehicle technology and fleet mix, based on published best practice tools and guidance.

.Mass emission calculations will be used as inputs into dispersion modelling in the second stage of this work, to determine how all emission sources impact (through the pollutant pathway of measured meteorological conditions) to predict pollutant concentrations at relevant receptors (human health and vegetation).

1.2.3 Impact Air Quality Assessment Process

The National and Local impact assessments have been undertaken following the processes shown in Figure 1 and
Figure **2** below.

Figure 1 – National Impact Assessment Process

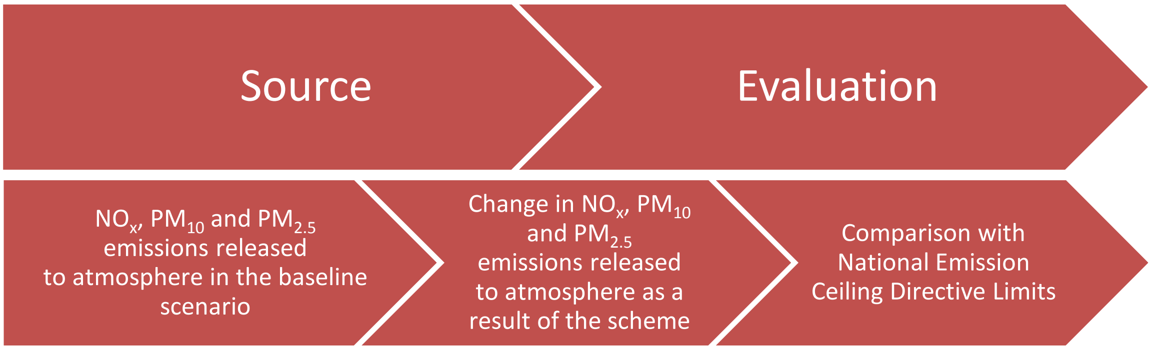
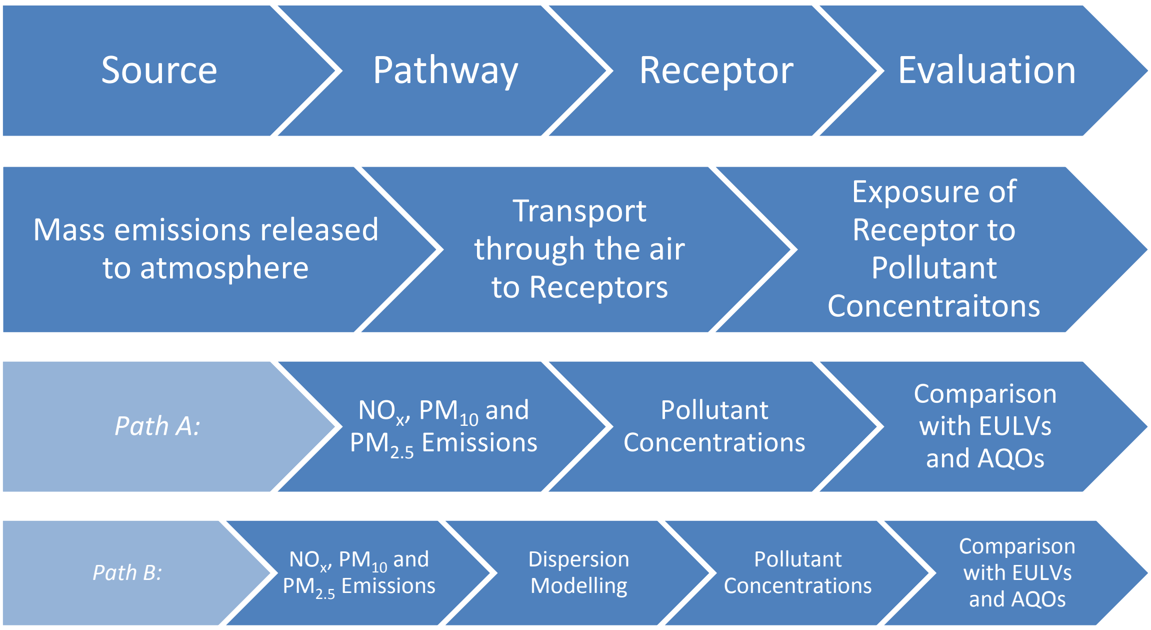


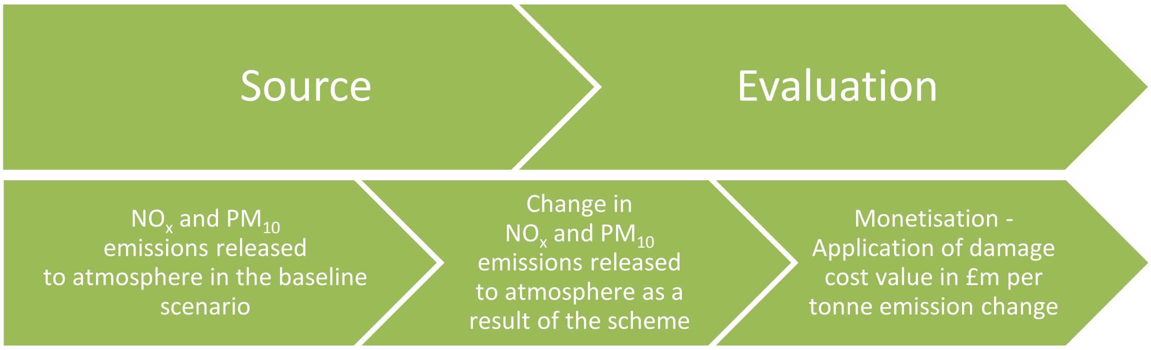
Figure 2 – Local Impact Assessment Process



The local baseline assessment has been undertaken following Process Path A for the first stage assessment. This will be enhanced by also undertaking Process Path B for a second stage assessment on the release of the dynamic traffic models currently in development for the schemes.

Figure 3 illustrates the process for the monetisation of pollution damages (including effects on health and buildings), undertaken on a mass emissions basis. The damage costs are based on the change to PM_{10} and NO_x emissions as a result of the schemes compared to the baseline (without taking account of scheme or policy mitigation).

Figure 3 – Monetisation Process



1.3 Report Structure

This report is structured to address each of the core components in turn for each shortlisted scheme (Gatwick 2R, Heathrow NWR and Heathrow ENR) as follows:

- Methodology and Legislation
  - An outline of the methodology used to inform the baseline, local and national assessments; and
  - Key legislation and relevant guidance applicable to inform the baseline conditions and impact assessment.

- Scheme Impact Assessments
  - Study Area
  - National Assessment
    - Total mass emissions of key pollutants associated with airport activity
  - Local Assessment
    - Proportions of mass emissions of key pollutants associated with airport activity
  - Monetisation
  - Mitigation
  - Commentary on Scheme Promoter's Submission
  - Conclusion/New Risk Evaluation

- Further Work
- Appendices
  - Background information on pollutants
  - Supporting information for the Methodology
  - Monitoring site locations
  - Demand forecast scenarios and emissions
  - Figures

2 Methodology and Legislation

This Section covers:

- An outline of the methodology used to inform the national and local impact assessments; and
- Key legislation and relevant guidance applicable to inform the impact assessments.

2.1 Methodology

2.1.1 Impact Assessment Study Areas

The geographical scope of the impact assessment is currently defined as the proposed airport boundaries and environs, including potentially high risk zones along the routes of any existing surface access. High risk zones include locations with the potential for exceedance of regulatory Standards for the protection of human health and/or sensitive habitats in the initial and/or mature operations years.

Locations for the protection of human health include residential properties, care homes, hospitals and schools; whereas locations for the protection of sensitive habitats include statutory designated sites (such as sites of special scientific interest (SSSIs), special areas of conservation (SACs), special protection areas (SPAs), and Ramsar sites.

Surface access mass emissions for both National and Local assessment are captured across the entire extent of the current traffic data network for each scheme (see Appendix F: Figures 1 to 3). This is a conservative approach as it includes all major roads and all emission changes on the road network as a result of the proposed schemes. Selecting the study area in this way avoids exclusion of 'local roads' which may experience poor air quality.

Note: It is not just the total mass of emissions, but also the distance from the source to the receptor which causes poor air quality. This is why air quality surrounding roads are currently the focal point for air quality studies. Consequently, as sensitive receptors (human health and ecosystems) within close proximity to heavily polluting roads will experience poor air quality (NO_2, NO_x and PM concentrations).

2.1.1 Sensitive habitats

Statutory designated sites of nature conservation importance, as identified within DMRB HA207/07 (SSSIs, SACs, SPAs and Ramsars), have been identified within the scheme study areas. These sites have been reviewed to identify whether they are sensitive to changes in air quality using the Air Pollution Information System (APIS) which provides information on current sensitivity to atmospheric pollutants. In addition, Natural England's Aviation Sensitivity Maps (provided in Jacobs' Biodiversity: Assessment (Jacobs, 2014b) have also been reviewed and additional potentially sensitive sites are taken into account.

2.1.2 Mass Emissions

(i) National

Do Something mass emissions have been calculated to enable National scale air quality impacts for each scheme option to be assessed. These have then been compared with mass emissions calculated for the baseline.

Mass emissions have been calculated without any mitigation proposed within the scheme promoters reports. During the second stage assessment the effect of the scheme promoters mitigation measures on Jacobs' mass emission calculations will be reviewed.

UK emissions of NO_x and PM_{10} have been obtained from the National Atmospheric Emissions Inventory (NAEI) which compiles estimates of emissions to the atmosphere from UK sources such as power stations, traffic, household heating, agriculture and industrial processes.

Total mass emissions of key pollutants, namely NO_x, PM_{10} and $PM_{2.5,}$ have been calculated for the following associated airport activities:

- Aircraft Engine Emissions from landing and take-off (LTO) cycle;
- Aircraft brake and tyre wear
  - Fugitive Particulate Patter (PM) only;
- Surface access brake and tyre wear
  - Fugitive PM only;
- Surface access emissions from airport associated traffic only (this includes passenger and employee traffic and derived contributions from freight traffic)
- Auxiliary Power Unit (APU) emissions; and
- Ground Support Equipment (GSE).

For a summary of the methodology behind the mass emission calculations, the process has been disaggregated into three tables:

- Table 2.1 provides an overview of the International Civil Aviation Organization (ICAO) approach adopted for the calculation of mass emissions from each source assessed;
- Table 2.2 shows the inputs and data sources used whilst following the ICAO approach; and
- Table 2.5 provides information on the assumptions used to fulfil the data input requirements and the limitations upon the conclusions.

The tables are not an exhaustive step-by-step approach through the methodology and greater detail behind the mass emission calculations is provided in Appendix B.

Table 2.1 - ICAO approach adopted for mass emissions calculations

Source Activity	Guidance Level
Aircraft Engine Emissions from landing and take-off (LTO) cycle	ICAO Simple – Approach 'A' Basic knowledge required; necessary data are easy, standardized and available; straightforward methodology (ICAO, 2011). Includes engine exhaust emissions in the landing and take-off (LTO) cycle below 915m (3000 feet) including take off, landing, approach and idling. Uses ICAO reference emission rates and times in mode rather than Approach 'B' which used airport specific emission rates and times in mode.
Fugitive Particulate Matter (PM) emissions from surface access brake and tyre wear	ICAO Simple Basic knowledge required; necessary data are easy, standardized and available; straightforward methodology (ICAO, 2011).
Surface access emissions from airport associated traffic only	ICAO Simple - major road networks and railways, including engine exhaust Basic knowledge required; necessary data are easy, standardized and available; straightforward methodology (ICAO, 2011).
Auxiliary Power Unit (APU) emissions	ICAO Simple Basic knowledge required; necessary data are easy, standardized and available; straightforward methodology (ICAO, 2011).
Ground Support Equipment (GSE) Emissions	Screened out as not being significant. ICAO Simple complete as evidence. Basic knowledge required; necessary data are easy, standardized and available; straightforward methodology (ICAO, 2011).

Table 2.2 – Do Something mass emissions inputs and data sources

Airport Associated Activity	Inputs/Data Source
Aircraft Engine Emissions from LTO cycle	• Forecast aircraft fleet mix and ATMs from Airports Commission Assessment of Need carbon capped scenario 2014 • Engine emissions data from European aviation safety agency ICAO certification databank 2014
Fugitive PM emission from aircraft brake and tyre wear	• Forecast aircraft fleet mix and ATMs from Airports Commission Assessment of Need carbon capped scenario 2014 • National environmental technology centre (NETCEN) method to determine PM emissions from brake and tyre wear (Curran, 2006)
Fugitive PM emission from surface access brake and tyre wear	• Assessment of Need carbon capped scenario Airports Commission 2014 • Annual average daily traffic (AADT) Jacobs 2014 static traffic model forecasts • Speed data from roads current speed limits • Heavy goods vehicles (HGVs) from the Department for Transport's (DfT's) national transport model regional HGVs forecast (DfTa, 2014)
Surface access emissions from airport associated traffic only	• Scheme promoters' passenger demand forecasts (these were used as the basis for the traffic model forecasts) • Assessment of Need carbon capped scenario passenger demand forecast Airports Commission 2014 (these were used in the traffic model forecasts for sensitivity testing the scheme promoter passenger forecast based traffic) • AADT Jacobs 2014 static traffic model forecasts • Speed data from roads current speed limits • HGVs from DfT's national transport model regional HGVs forecast (DfTa, 2014)
APU emissions	• Scheme promoters APU run times 2014 • Forecasted aircraft fleet mix and ATMs from Airports Commission Assessment of Need carbon capped scenario 2014 • Emission rates of APU models commonly fitted to aircraft (NETCEN, 2004)APU efficiency improvements (Hamilton Sundstrand, 2014)
GSE emissions	• Forecast aircraft fleet mix and ATMs from Airports Commission Assessment of Need carbon capped scenario 2014

(ii) Local

Do something mass emissions have also been calculated at the local scale to enable air quality impacts for each scheme option to be assessed.

Proportions of mass emissions of the same key pollutants, NO_x, PM_{10} and $PM_{2.5}$ have been calculated for the same associated airport activities:

- Aircraft Engine Emissions from landing and take-off (LTO) cycle;
- Aircraft brake and tyre wear
  - Fugitive PM only;
- Surface access brake and tyre wear
  - Fugitive PM only;
- Surface access emissions from airport associated traffic only;
- Auxiliary Power Unit (APU) emissions; and
- Ground Support Equipment (GSE).

The ICAO approach adopted for the calculation of mass emission proportions from each source assessed is the same as those presented in Table 2.1. The inputs and data sources used when making the do something mass emission calculations at the Local scale are also the same as those presented in Table 2.2.

Note: Mass emissions from airport associated activities are broadly dispersed within the airport confines. Despite their relative total size compared to other airport associated emission sources, those that contribute most to local air quality issues are predominantly related to road traffic at locations outside the airport boundary.

2.1.3 Modelling/Monitoring

Likely future local pollutant concentrations were established in the baseline report using results from an existing Department for Environment and Rural Affairs (Defra) National Compliance model (the Pollution Climate Mapping (PCM) model) for 2030 and also by projecting locally monitored pollution concentrations to 2030. These 2030 baseline concentrations include adjustment for expected improvements to vehicle emission technology and fleet mix but not for other potential government policy measures or airport mitigation measures to reduce local concentrations.

The Defra National compliance model and Design Manual for Roads and Bridges (DMRB) Interim Advisory Notes (IAN)/170/12v3 projection factors are based on a series of models of future conditions, each subject to its own inherent degree of uncertainty. These include monitoring data used for verification, the future predicted road traffic and aircraft movements and fleet mixes, and the emissions from aircraft and road traffic. These methods to determine likely baseline air quality have been followed in the absence of sufficiently detailed model inputs for dispersion modelling. This will be undertaken in the second stage assessment, for more information refer to the further work section.

Note: Department for Environment and Rural Affairs (Defra) currently published PCM projections have been undertaken with the Emission Factor Toolkit (EFT) V5.2c, which was superseded in June 2014 by EFT V6.01. The latest EFT revises overly optimistic uptake rates of Euro 6/VI vehicles in the future fleet mix, which is likely to increase projected emissions and predict higher pollution concentrations. This has been accounted for in Jacobs' classification of Risk by including NO_2 concentrations between 30-36$\mu g/m^3$ within the low risk category.

This assessment does not incorporate scheme promoter mitigation measures, as sufficient data was not available at the time of assessment. The influence of mitigation measures would need to be determined during second stage assessment (see Further Work Section 6).

The risk to Local air quality has been considered by comparing the 2030 baseline concentrations with the relevant EU Limit Values (EULVs) or Air Quality Objectives (AQOs) to determine their sensitivity to change. Further details on modelling/monitoring are provided in Appendix B.

(a) National Modelling and EU Limit Values

The PCM model, operated by Defra, is the air quality model used to report the UK's status on compliance with EU Ambient Air Quality directive (2008/50/EC[3]). Highways Agency's Interim Advice Note (IAN) 175/13 is the only published methodology for assessing the potential impact of a scheme or development on Defra's reported position with respect to compliance.

IAN 175/13 specifies that two air quality models are required to assess the risk of significant impacts on compliance with the 2008/50/EC[3]:

- The PCM model outputs issued by Defra (Version: ukmjrrds09); and
- An air quality model assessment predicting the concentrations of pollutants with and without development to establish the change in a receptors ambient air quality.

The risk of a scheme affecting Defra's reported position on compliance with the EU Ambient Air Quality directive has been assessed by categorising predicted concentrations into range bands around the EU Limit Value threshold (see risk evaluation in section 2.1.4).

PCM model predictions from Defra are only available up to and including 2030 and it is not currently possible to project PCM concentrations to 2040 and 2050. Consequently 2030 predicted PCM concentrations have been used as the baseline for 2040 and 2050, as this is a conservative approach given the forecast reduction in concentrations in future years.

PCM model predictions relate to locations within 4m of the kerbside of the National road network within each scheme's baseline study area. These have been used to evaluate the potential risk of exceeding EULVs. The 4m distance is the distance at which EULV compliance is determined by Defra.

In accordance with relevant air quality guidance, PCM road links have been selected that are within 200 metres from Jacobs' traffic network (for which 4m pollutant concentrations were predicted), with an additional selection of PCM links that intersect routes used for surface access to the airport. This approach was only applied to PCM links within the study area.

EU Limit Values are legally binding EU parameters that must not be exceeded by Member States. Limit values are set for individual pollutants and are made up of a concentration value, an averaging time over which it is to be measured, the number of exceedences allowed per year, if any, and a date by which it must be achieved. Some pollutants have more than one limit value covering different endpoints or averaging times.

Recently consolidated into Directive 2008/50/EC on Ambient Air Quality and Cleaner Air for Europe (CAFE) and transposed into national legislation in England by the Air Quality Standards Regulations 2010, the responsibility for ensuring air quality limit values are complied with lies solely with the Secretary of State (SoS) for the Environment.

(b) Local Monitoring and National Air Quality Objectives

It is a statutory requirement (Environment Act 1995) for local authorities to Review and Assess air quality within their jurisdiction. Air quality monitoring data has been collated from quality controlled local authorities' monitoring campaigns to establish existing air quality concentrations. Should the local authority identify exceedences of AQOs, Air Quality Management Areas (AQMAs) are established with the aim of reducing concentrations. The baseline study areas relevant to the assessment of local air quality impacts are consistent with those used by the scheme promoters.

In July 2011, Defra published a report examining the long term air quality trends in NO_x and NO_2 concentrations, which identified that there has been a clear decrease in NO_2 concentrations between 1996 and 2002, and that NO_2 concentrations have stabilised with little to no reduction between 2004 and 2012. It concluded that for long term trends, there is now a gap between current projected vehicle emission reductions and measurements on the annual rate of improvements in ambient air quality. The Highways Agency developed the Gap Analysis methodology to adjust model predictions based on the method in Local Air Quality Management (LAQM) TG(09) to account for the long term NO_x and NO_2 profiles. The current trends in air quality are based on measurements of emissions from the existing vehicle fleet. New vehicles will need to comply with the more stringent Euro 6/VI emissions standards from September 2014 onwards. However, vehicles complying with the Euro 6/VI emissions standard have not been on the road network long enough for their performance to be capture in the long term air quality monitoring trends. If the Euro 6/VI fleet emissions perform as predicted, it should result in substantial reductions in predicted future roadside air quality concentrations.

The Gap Analysis methodology (IAN 170/12v3) factors assume that the measured air quality trends continue to occur for all pre-Euro6/VI fleet. They also take a precautionary approach to account for uncertainty associated with Euro 6/VI performance and fleet mix in the future, rather than assuming full reductions in emissions occur as predicted by Euro 6/VI, which has not been observed by air quality monitoring trends associated with recent Euro standards. This is implemented into LTT by taking the mid-point between the measured air quality monitoring trends (which assume no improvement in emissions associated with Euro 6/VI) and predicted Euro 6/VI uptake and vehicle emissions meeting the Euro standards.

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

Currently, emissions of nitrogen oxides (NO_x), total hydrocarbon (THC), non-methane hydrocarbons (NMHC), carbon monoxide (CO) and Particulate Matter (PM) are regulated for most vehicle types.

Projection factors are only available up to 2030; however by this time the majority of vehicles on the roads are predicted to be Euro 6/VI and current emission forecasts are unable to account for any 'more stringent' vehicle emissions standards which may follow. Therefore, concentrations comprising road traffic emissions for 2030 are also used to estimate the 2040 and 2050 baselines, demonstrating a conservative approach..

Air Quality Objectives (AQO) are nationally set policy targets established by the Air Quality Strategy for England, Scotland, Wales and Northern Ireland often expressed as a maximum ambient concentration not to be exceeded, either without exception or with a permitted number of exceedances, within a specified timescale. They are based on standards which are the concentrations of pollutants in the atmosphere which can broadly be taken to achieve a certain level of environmental quality. The standards are based on assessment of the effects of each pollutant on human health including the effects on sensitive subgroups or on ecosystems.

(c) National Modelling vs. Local Monitoring

The two sources of air pollution concentration data described above are mutually exclusive; a summary comparison is provided in Table 2.3.

Table 2.3 - Summary comparison of National Modelling and Local Monitoring

National Modelling	Local Monitoring
Undertaken by Central Government (Defra) for reporting compliance with EU limit values to the European Commission	Undertaken by local authorities for comparison against AQOs
Undertaken up to 4m from the kerbside of national road network (A- Roads and Major Roads only). Note: some local roads are excluded from the model.	Undertaken at 'hot-spot' locations identified under the Local Air Quality management (LAQM) regime
Verified using high quality data capture national Automatic Urban and Rural Network (AURN) air quality monitoring sites	Excludes high quality AURN sites
Estimates air pollution concentrations at locations where no local monitoring is available	Provides measured air pollution concentrations representative of the immediate vicinity of the monitoring site only

The two sources of air pollution concentration data described above are therefore derived in different ways and are completely independent of each other.. As such there may be locations where projected locally monitored pollution concentrations and forecast nationally modelled pollution concentrations do not agree; this represents uncertainty in predicting future air quality.

Given the potential for uncertainty in air quality predictions, both air pollution concentration sources have been used to identify the potential risk of exceeding EU

Limit Values or AQOs. If either source of data indicates a potential for risk, the assessment assumes the potential for risk at that location exists.

2.1.4 Risk Evaluation

The risk of adverse local air quality impacts has been considered by establishing:

- likely future pollutant concentrations using forecast nationally modelled air quality concentrations and projected locally monitored air quality concentrations.
- Air quality concentrations are compared against relevant EU Limit Values and/or AQOs to determine the potential gap between the concentration value and the regulatory limit and therefore the sensitivity of that site (i.e. how close the concentration may be to a potential breach of the regulatory limit); and
- potential magnitude of change in pollutant emissions

The following concentration ranges have been used categorise the potential for breach of regulatory limits:

Concentration Range	Risk Category
>40 µg/m^3	Likely
35 – 40 µg/m^3	High
30 – 35 µg/m^3	Low
<30 µg/m^3	Unlikely

The risk assessment at this stage does not incorporate the promoters' mitigation measures and therefore the conclusions of risk for limit values presented do not reflect the schemes with mitigation in place. The influence of mitigation measures on risk would need to be determined during the second stage detailed quantitative assessment.

2.1.1 Monetisation

The overall approach to Air Quality Impact monetisation follows the procedure set out in the Valuing impacts on air quality: Supplementary Green Book guidance (May 2013)[3]. This identifies an initial damage cost exercise, followed if required by more detailed appraisal in consultation with Defra.

At the current stage of air quality analysis, monetisation of damage costs has been undertaken on a mass emissions basis, following the Air Quality Appraisal – Damage Cost methodology published by the Defra and the Interdepartmental Group on Costs and Benefits, Air Quality Subject Group[4], which includes tables (updated

[3] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/197893/pu1500-air-quality-greenbook-supp2013.pdf
[4] Defra 2011, Air Quality Appraisal – Damage Cost Methodology, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/182391/air-quality-damage-cost-methodology-110211.pdf

on www.gov.uk[5]) showing the damage costs for PM from different sources and within different geographical classifications, and also NO_x emissions. The damage costs, therefore, are undertaken on a national basis, but reflecting some aspects of local impact (Transport PM costs are prescribed by location (e.g. Outer London, Inner London), and elsewhere by the nature of the area affected (Urban medium, Urban Small). NO_x emissions damage costs are nationally defined.

The Damage Cost methodology document is clear that it is important to recognise that external costs vary according to a variety of wider environmental factors, including overall levels of pollution, geographic location of emission sources, and meteorology.

The mass emissions damage cost methodology applied here can take these issues into account only to a certain degree, but is likely not to reflect the detail or full extent of damage costs. Specifically, the damage costs methodology followed at this stage excludes several key effects as quantification and valuation of them is either not possible or is highly uncertain. Therefore, the mass emissions monetisation is likely to underestimate full damage costs related to areas including:

- Effects on cultural or historic buildings from air pollution;
- Potential additional morbidity from acute exposure to PM;
- Potential mortality effects in children from acute exposure to PM;
- Potential morbidity effects from chronic (long-term) exposure to PM or other pollutants; and
- Effects of exposure to ozone, including both health impacts and effects on materials.

With more detailed data allowing further appraisal of air quality impacts, it becomes possible to undertake further monetisation to identify damage costs in addition to initial mass emissions damage costs, via either an abatement cost (where breaches of legally binding EU Limit Values are considered to occur) or, following dispersion modelling, an impact pathway assessment, where health impacts (both mortality and morbidity) of PM_{10}, NO_x, SO_2, and NH_3 are estimated using dose-response functions provided by the Committee on the Medical Effects of Air Pollutants (COMEAP). PM_{10} and SO_2 estimates, in addition, include the impact of building soiling and the impact on materials respectively. The quantified health impacts are then valued using values derived from a contingent valuation study (currently, Defra 2004)[6].

Having established an emissions level above the baseline for the emissions areas of aircraft engines and aircraft brake and tyre wear; brake and tyre wear; APU use; GSE; stationary vehicles and car parking; and road traffic for each assessment year the calculation of the damage costs was accomplished through the use of the Air Quality Appraisal – Damage Cost methodology published by the Defra and the Interdepartmental Group on Costs and Benefits, Air Quality Subject Group[7]. This

[5] Defra 2013, Air quality: economic analysis, Table 1: IGCB Air quality damage costs per tonne, 2010 prices, https://www.gov.uk/air-quality-economic-analysis#damage-costs-approach

[4] 'Valuation of health benefits associated with reductions in air pollution', Defra (2004). Available at http://archive.defra.gov.uk/environment/quality/air/airquality/publications/healthbenefits/airpollution_reduction.pdf.

[7] Defra 2011, Air Quality Appraisal – Damage Cost Methodology, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/182391/air-quality-damage-cost-methodology-110211.pdf

includes tables, updated on www.gov.uk[8], showing the damage costs for PM from different sources and within different geographical classifications as well as NO_x emissions (see table 2.4 below).

The following aspects are included within these damage costs:

- Health – both chronic mortality effects (which consider the loss of life years due to air pollution);
- Morbidity effects (which consider changes in the number of hospital admissions for respiratory or cardiovascular illness); and
- Damage to buildings (through building soiling) and impacts on materials (PM only).

These forecast values are a recommended damage cost assessment method for incorporating air quality assessments into benefit-cost analysis and other policy analysis. These are applicable for use for damage up to £50 million. Proposals with large air quality impacts (over £50 million using damage costs) that are not expected to affect compliance with legal limits should be assessed using the impact pathway approach, which involves consultation with Defra.

The impact pathway approach is a more detailed way to value air quality changes. It estimates air pollution costs based on location-specific modelling of how changes in pollution affect air quality, but relies on standard estimates of impacts and their valuation. Proposals that change emissions in a way that affects compliance with legal obligations should use the abatement costs approach, which recognises that changes in emissions will affect the level, and cost, of action required to comply with such obligations. Both of these methodologies require information that is not available at this stage, so have not been attempted.

The different emissions areas were sorted into the appropriate categories from the guidance (see table 2.4 below).

Table 2.4 Emissions Categories for Damage Cost Methodology

Emission Area	Category assigned	Note
Aircraft engine and fugitive aircraft brake and tyre wear- Gatwick	Urban Medium	Gatwick was determined to be sufficiently proximate to Crawley, a Medium-sized Urban area, for emissions arising within the airport to be assigned to this category.
GSE - Gatwick		
APU - Gatwick		
Aircraft engine and fugitive aircraft brake and tyre wear- Heathrow	Outer London	Heathrow was determined to be within the Greater London boundaries so emissions arising within the airport are to be assigned to this category.
GSE - Heathrow		
APU - Heathrow		
Fugitive brake and tyre wear	PM Transport Average	Emissions from these areas are thought to be sufficiently spatially

[8] Defra 2013, Air quality: economic analysis, Table 1: IGCB Air quality damage costs per tonne, 2010 prices, https://www.gov.uk/air-quality-economic-analysis#damage-costs-approach

Emission Area	Category assigned	Note
Surface access transport		distributed for no one geographical categorisation to be appropriate. Therefore the average for Transport was used.
NO_x emissions from the above categories	NO_x	Was arising from any source was assigned to the NO_x category

The emissions exceeding the baseline level for a given year are multiplied by the damage cost for that year, and then discounted in accordance with Green Book guidance[9]. Due to the long term nature of this appraisal, with an assessment period of 60 years and looking 70 years into the future, the assumption of a declining long-term discount rate was utilised. For values in the years 2014 to 2044, the discount rate applied is 3.5%, for 2044 to the end of the assessment the discount rate applied is 3%. If the appraisal period were to extend beyond 2089 then a lower discount rate would be applied to that period.

In addition, to appropriately value future damage impacts, as many types of environmental damage will increase in value in conjunction with real increases in income, the costs are inflated over time using the Transport Appraisal Guidance (TAG) methodology[10], which utilises estimated GDP per household to determine the potential increase in value over time.

The presented values use the Central forecast, and also the Central-Low to Central-High range.

The monetisation has made use of the Damage Cost tables, TAG cost over time information, and Green Book discounting guidance in order to place a value upon the change in emissions brought about by each proposal. In addition, the use of the damage costs methodology is only strictly appropriate for where the impacts are less than £50 million and do not affect compliance will legal limits on air pollution, so its use in this assessment is indicative only.

2.2 Legislation

2.2.1 National Emissions Ceiling Directive (NECD)

The 2001 National Emissions Ceiling Directive[11] (NECD) set binding limits on Member States for the national emissions of four pollutants (NO_x, sulphur dioxide (SO_2), ammonia (NH_3) and non-volatile organic compounds), to be achieved by 2010 and not to be exceeded thereafter. The revision of the NECD is part of the implementation of the Thematic Strategy on Air Pollution[12] The proposal to amend the NECD is still under preparation and should set emission ceilings to be respected by 2020 for the four already regulated substances and for the primary emissions of Particulate Matter ($PM_{2.5}$) as well.

[9] HM Treasury, 2011, The Green Book
[10] DfT 2014, WebTAG: environmental impacts worksheets, https://www.gov.uk/government/publications/webtag-environmental-impacts-worksheets
[11] Directive 2001/81/EC of the European Parliament and of the Council of 23 October 2001 on national emission ceilings for certain atmospheric pollutants, Official Journal of the European Communities L309, pp 22-30
[12] Directive 2001/81/EC of the European Parliament and of the Council of 23 October 2001 on national emission ceilings for certain atmospheric pollutants, Official Journal of the European Communities L309, pp 22-30 http://ec.europa.eu/environment/archives/cafe/index.htm.

Note: The UK met the NECD 2010 target for NO_x; achieving emissions of 1,151 kilotonnes (Kt) per annum compared to a target of 1,167 Kt per annum. It has continued to meet the target through to the latest reported year (2012) with emissions of 1,062 Kt per annum.

The Gothenburg Protocol[13] is part of the Convention on Long-Range Transboundary Air Pollution which is itself an international agreement to protect human health and the environment from air pollution by control and reduction of, local and long-range, air pollution. The agreement covers Europe, North America and countries of Eastern Europe, Caucus and Central Asia as it is widely recognised that air pollutants can be carried long distances, and cross-boundaries, by winds.

The protocol is a multi-pollutant protocol designed to reduce acidification, eutrophication and ground-level ozone by setting emissions ceilings for sulphur dioxide (SO_2), nitrogen oxides (NO_x), volatile organic compounds (VOCs) and ammonia (NH_3) which were to be met by 2010. The UK met these targets and in 2012 Member States, including the UK, agreed a set of revisions to the Protocol to reduce targets for national emissions of the four pollutants, along with Particulate Matter ($PM_{2.5}$), for 2020 and beyond. The UK has agreed to reduce its NO_x emissions relative to 2005 (1580 Kt) by 55% in 2020 (711 Kt), similarly $PM_{2.5}$ (81 Kt) emissions will be reduced by 30% (57 Kt). It should be noted that, the Gothenburg Protocol National emission targets are currently under review and could be lowered further.

2.2.2 European Air Quality Management

In 1996 the European Commission published the Air Quality Framework Directive on ambient air quality assessment and management (96/62/EC)[14]. This Directive defined the policy framework for 12 air pollutants including NO_2 known to have harmful effects on human health and the environment. Limit Values (pollutant concentrations not to be exceeded by a certain date) for each specified pollutant were set through a series of Daughter Directives, including Directive 1999/30/EC (the 1st Daughter Directive)[15] which set Limit Values for nitrogen dioxide (NO_2) and particulate matter (PM) (amongst other pollutants) in ambient air.

In May 2008 the Directive 2008/50/EC[16] on ambient air quality and cleaner air for Europe (CAFE) came into force. This Directive consolidates previous Directives (apart from the 4th Daughter Directive) and makes provision for extended compliance deadlines for NO_2 and PM_{10}. The Directive has been transposed into national legislation in England by the Air Quality Standards Regulations 2010[17]. The Secretary of State (SoS) for the Environment has the duty of ensuring the air quality Limit Values are complied with.

[13] The Gothenburg Protocol to Abate Acidification, Eutrophication and Ground-level Ozone was first agreed in 1999 (through the UN Economic Commission for Europe), setting mandatory emission reductions for four major air pollutants (sulphur dioxide, nitrogen oxides, volatile organic compounds and ammonia), to be achieved by 2010. A revised protocol agreed in 2012 specifies further emission reduction commitments in terms of percentage reductions from base 2005 to 2020, and has been extended to cover one additional air pollutant, namely particulate matter (PM2.5).

[14] Directive 96/62/EC of 27 September 1996 on ambient air quality assessment and management

[15] Directive 1999/30/EC of 22 April 1999 relating to limit values for sulphur dioxide, nitrogen dioxide and oxides of nitrogen, particulate matter and lead in ambient air

[16] Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe

[17] The Air Quality Standards Regulations 2010, SI 2010/1001

2.2.3 Local Air Quality Management

Part IV of the Environment Act 1995[18] places a duty on the SoS for the Environment to develop, implement and maintain an air quality strategy with the aim of reducing atmospheric emissions and improving air quality. The national air quality strategy for England, Scotland, Wales and Northern Ireland[19] provides the framework for ensuring that air quality Limit Values are complied with based on a combination of international, national and local measures to reduce emissions and improve air quality. This includes the statutory duty, also under Part IV of the Environment Act 1995, for local authorities to undergo a process of local air quality management and declare Air Quality Management Areas (AQMAs) where necessary.

(a) European Union Limit Values and National Air Quality Objectives

The air quality Limit Values set by European and transposed into national law as Air Quality Objectives are based on recommended guideline values from the World Health Organization. Some pollutants have Standards expressed as annual mean concentrations due to the chronic way in which they affect health (i.e. effects occur after a prolonged period of exposure to elevated concentrations) and others have Standards expressed as 24-hour, 1-hour or 15-minute mean concentrations due to the acute way in which they affect health (i.e. after a relatively short period of exposure). Some pollutants have Standards expressed in terms of both long-term and short-term concentrations.

Table 2.5 sets out the air quality Standards for the pollutants relevant to this baseline assessment (NO_2, PM_{10} and $PM_{2.5}$).

Table 2.5 - Air quality standards for NO_2, PM_{10} and $PM_{2.5}$

Pollutant	Averaging Period	EU Limit Value	Air Quality Objective
Nitrogen dioxide (NO_2)	Annual Mean	40 µg/m^3	40 µg/m^3
	1-hour Mean	200 µg/m^3 [1]	200 µg/m^3 [1]
Particulate Matter (PM_{10})	Annual Mean	40 µg/m^3	40 µg/m^3
	24-hour Mean	50 µg/m^3 [2]	50 µg/m^3 [2]
Particulate Matter ($PM_{2.5}$)	Annual Mean	25 µg/m^3 [3]	25 µg/m^3 [3]
[1] not to be exceeded more than 18 times a year (99.8th percentile) [2] not to be exceeded more than 35 times a year (90.4th percentile) [3] to be complied with by 2015			

2.3 Assumptions and Limitations

The first stage assessment provides a basis for the quantification of unmitigated mass emissions and the risk of impacts at a national scale to be determined. Table 2.6 presents the key assumptions and their consequent limitations.

More sophisticated methods will be used in the second stage assessment to establish air quality concentrations in the baseline and the assessment of change associated with airport expansion once dynamic traffic modelling information is

[18] Environment Act 1995, Chapter 25, Part IV Air Quality
[19] The Air Quality Strategy for England, Scotland, Wales and Northern Ireland, Volume 1, July 2007

available. The dispersion modelling will consider two scenarios; unmitigated and mitigated to establish the effectiveness of the scheme promoters mitigation.

Table 2.6 – Key assumptions and limitations

Issue	Key Assumption	Key Limitation
S		
Airports Commission aircraft air transport movements (ATM) forecasts	Research by Leigh Fisher and the Civil Aviation Authority into the DfT forecast fleet mixes found that 'domestic freight' and 'international freight' are best represented by the B737 and B747, respectively. Aircraft listed as 'other' were assigned the forecast fleet mix's weighted average emission rate for each respective baseline year.	May over or under predict emissions
2030 Traffic flow, Heavy Duty Vehicles (HDV) and speed forecasts	The traffic flow forecasts are the outputs of a 'static model'; this only forecasts the change in total traffic flow in the annual average daily flow (AADF) and has not forecasted the change in the HDV% or speed change. The change in total traffic flows do not factor in the effect of congestion upon traveller's route choice, therefore the traffic flow forecasts should be treated with caution	The forecasts of vehicle numbers, types and speed on road links are likely to differ from dynamic traffic model (more accurate forecasts), therefore emissions are likely to under or over predict.
Aircraft engines and APU	To determine the proportion of $PM_{2.5}$ within PM_{10} it has been assumed that $PM_{2.5}$ makes up 100% of total PM_{10}.	May under or over predict.
Reliability of established tools for use within air quality assessments	Tools such as: • Emission Factor Toolkit V6.01 • National Compliance Model (PCM) • ICAO emission certificates • ICAO emission equations Are assumed to be robust and subject to quality assurance controls and are fit for purpose.	May under or over predict

Table 2.7 set out the assumptions and limitations behind the methods used to value the pollutant mass change.

Table 2.7 - Monetisation assumptions and limitations

Monetisation method	Assumption	Limitation
Pollutant mass emissions change between appraisal years	It was assumed that the change in pollutants between appraisal years is linear.	Likely to over or under predict the value of change in air quality
Pollutant mass emissions change after 2050	2050 change in mass emissions used within all sequential years to the end of the 60 year appraisal period.	Likely to over or under predict the change in air quality value.
Damage costs	All areas were allocated the damage cost unit per tonne.	Certain areas may be in exceedence and the Marginal Abatement Costs (MAC) approach applies. In these areas the method will underestimate the cost of pollutants.

2.4 Exclusions

Construction related emissions have not been assessed. It is assumed that all schemes will employ best practice construction methods, with appropriate control of dust. Insufficient information exists at this time to enable estimation of emissions from construction vehicles and mobile equipment.

Potential changes in infrastructure, such as alterations to the M23 slip road, have not been assessed. Such changes will be taken into account in detailed dynamic traffic modelling currently in development. Infrastructure changes such as proposals for tunnelling parts of the M25 have also not been considered in detail at this time.It is noted that such changes are likely to alter local pollutant dispersion conditions and may give rise to increased local concentrations.

Future development that may add or remove public exposure within the study areas, such as residential dwellings has not been assessed.

Non-airport related sources of pollutants of concern have not been currently identified.

Potential future mitigation measures to reduce emissions such as action undertaken in response to government policy or undertaken by scheme promoters, have not been taken into account in the baseline 2030 projections and the assessment of risk of exceeding limits with schemes in place.

Dispersion modelling has not been currently undertaken due to the lack of necessary data inputs, such as detailed dynamic traffic modelling.

The Do Minimum and Do Something scenarios will continue to be refined during the consultation period taking advantage of any additional relevant information that feeds into the assessment process.

Details regarding how these current exclusions will be included within Further Work can be found in Chapter 6.

3 Gatwick Airport Second Runway

This Section covers:
- Study Area
- National Assessment
  - Total mass emissions of key pollutants associated with airport activity
- Local Assessment
  - Proportions of mass emissions of key pollutants associated with airport activity and risk evaluation for EULVs/AQOs
- Monetisation
- Mitigation
- Commentary on Scheme Promoter's Submission
- Conclusion

3.1 Study Area

There are a number of populated areas within the 8km x 8km centered on Gatwick Airport Second Runway (Gatwick 2R) study area (see Appendix F**:** Figure 4).

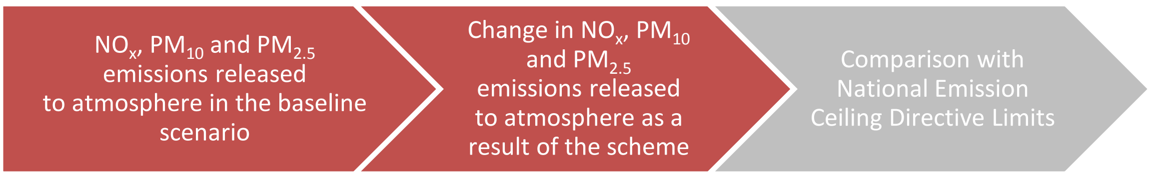
Statutory designated sites of nature conservation importance within the study area have been reviewed using the Air Pollution Information System (APIS). Glovers Wood SSSI was identified as a site that is potentially sensitive to air quality.

Natural England's Aviation Sensitivity Mapping (Biodiversity: Assessment Jacobs, 2014b) identifies Glover's Wood SSSI, and also House Copse SSSI and Buchan Hill Ponds SSSI, as potentially sensitive to air quality.

For the sensitive sites identified, it will be necessary to establish with scheme nitrogen deposition as part of the second stage assessment.

3.2 National

3.2.1 Change in Total Mass Emissions



National Atmospheric Emissions Inventory (NAEI) projections have been used to report the UK's status on compliance with the NECD and Gothenburg Protocol. NAEI projections up to 2030 (AEA, 2012). The new proportion of UK NO_x and $PM_{2.5}$ emissions of the Gothenburg Protocol targets with the addition of Gatwick R2's associated unmitigated pollutant increases are presented in Table 3.1. There are no NAEI projections for PM_{10} as this pollutant is not prescribed under the NECD or Gothenburg Protocols. The EC is currently revising its National Emissions Ceilings Directive for EU countries, with much tighter ceilings proposed for 2030. The UK could have tighter limits in 2030 meaning that targets may be more difficult to achieve.

Table 3.1 – NAEI NO_x and $PM_{2.5}$ emission projections for the UK

kilo tonnes / year (kt/y)	NO_x		$PM_{2.5}$	
	2025	2030	2025	2030
Gothenburg Protocols' 2020 emission targets	711		57	
NAEI emission pollutant projections	612	589	57	59
NAEI projection % of Gothenburg Protocol targets	86.07%	82.8%	100.00%	103.51%
NAEI projection + change associated with Gatwick 2R % of Gothenburg Protocol targets	86.12%	82.93%	100.01%	103.53%

Observation:

- Projected UK emissions include emissions from Gatwick Airport;
- UK emissions of NO_x are projected to meet current 2020 Gothenburg Protocol targets in both 2025 and 2030; and
- The change in $PM_{2.5}$ associated with Gatwick 2R could result in UK emissions exceeding the current 2020 emissions target in 2025 by 0.01% and cause the 2030 UK exceedence to increase by 0.03% relative to the 2020 emission target without mitigation measures in place.

Table 3.2 presents the total mass emissions (tonnes per annum) that have been calculated and attributed to associated airport activities in the Gatwick 2R baseline and the change associated with the Do Something scenario. Technological improvements with potential to reduce mass emissions have not been applied to all airport activities (see Appendix B for more information). In addition, scheme promoter mitigation measures with potential to reduce mass emissions have not been considered. The effect mitigation will have on mass emission estimates will be considered in the second stage assessment.

Table 3.2 - Gatwick 2R total annual air pollutant mass emissions

kt/y	NO_x			PM_{10}			$PM_{2.5}$		
	2030	2040	2050	2030	2040	2050	2030	2040	2050
Baseline 1R Total	4.4	4.3	3.9	0.091	0.093	0.093	0.072	0.074	0.073
Change due to Scheme 2R	0.6	1.3	2.7	0.017	0.035	0.056	0.013	0.027	0.044
New % of Total UK Projection	0.9	-	-	-	-	-	0.1	-	-

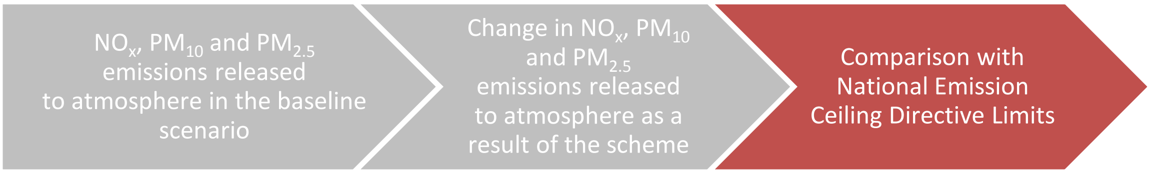
Observations:

- Do Something annual NO_x emissions by mass represent nine tenths of a percent of the entire NO_x emissions projected for the UK in 2030, an increase of two tenths of a percent onthe Baseline;

- $PM_{2.5}$ emissions are a sub-set of PM_{10} emissions and represent approximately one tenth of a percent of the entire $PM_{2.5}$ emissions projected for the UK in 2030 in the Do Something scenario; and

- Emissions of all pollutants increase between 2030 and 2040; this is due to increases in airport activity offsetting improvements in emissions from using a cleaner fleet.

3.2.2 Evaluation



The baseline NAEI 2025 projections are 86.07% of the current 2020 Gothenburg NO_x targets with the proportion of national NO_x emissions increasing to 86.12% with the second runway.

The baseline NAEI 2030 projections are 82.8% of the current 2020 Gothenburg NO_x targets with the proportion of national NO_x emissions increasing to 82.93% with the second runway.

While such contributions are likely to be accommodated in the context of the current Protocol targets, there remains a risk that the Protocol targets themselves may become tighter making any accommodation a greater challenge.

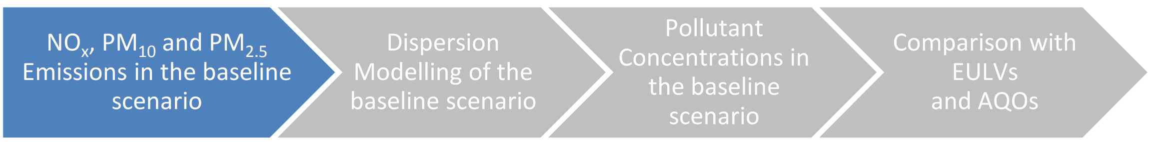
The baseline NAEI 2025 projections are 100% of the current 2020 Gothenburg $PM_{2.5}$ targets with the proportion of national $PM_{2.5}$ emissions increasing to 100.01% with the second runway.

The baseline NAEI 2030 projections are 103.5% of the current 2020 Gothenburg $PM_{2.5}$ targets with the proportion of national $PM_{2.5}$ emissions increasing to 103.53% with the second runway.

Emissions of $PM_{2.5}$ attributed to associated airport activities in the Do Something (1R+change with 2R) scenario in 2030 represent just over 4% of the projected exceedance of the 2020 Gothenburg Protocol target.

3.3 Local

3.3.1 Change in Mass Emissions broken down into proportions



Note: It is not just the total mass of emissions, but also the distance from the source to the receptor which causes poor air quality. This is why air quality surrounding roads are currently the focal point for air quality studies. Consequently, as sensitive receptors (human health and ecosystems) within close proximity to heavily polluting roads will experience poor air quality (NO_2, NO_x and PM concentrations).

Table 3.3 presents NO_x emissions (tonnes per annum) that have been calculated and attributed to associated airport activities in the Do Something scenario. These are compared with baseline mass emissions. Technological improvements with potential to reduce mass emissions have not been applied to all airport activities (see Appendix B for more information). In addition, scheme promoter mitigation measures with potential to reduce mass emissions have not been considered. The effect mitigation will have on mass emission estimates will be taken into account in the second stage assessment.

Table 3.3 - Gatwick 2R annual NO_x mass emissions by source

tonnes / year (t/y)	NO_x					
	Baseline			Change due to Scheme		
Emission Source	1R 2030	1R 2040	1R 2050	2R 2030	2R 2040	2R 2050
Aircraft engine	3,473.5	3,429.6	3,020.9	400.4 (+12 %)	978.7 (+29 %)	2,073.0 (+69 %)
Brake and tyre wear	-	-	-	-	-	-
APU	475.3	468.2	452.1	61.8 (+13 %)	144.4 (+31 %)	267.5 (+59 %)
GSE	176.8	169.9	165.1	36.0 (+20 %)	81.2 (+48 %)	88.4 (+54 %)
Road traffic – airport only*	261.8	281.9	296.9	85.0 (+32 %)	141.0 (+50 %)	231.0 (+78 %)
Total	4,387.4	4,349.6	3,935.0	583.3 (+13 %)	1,345.2 (+31 %)	2,659.8 (+68 %)

** Airport only includes fugitive emissions from surface access*

Table 3.4 presents PM_{10} emissions (tonnes per annum) that have been calculated and attributed to associated airport activities in the Do Something scenario. These are compared with baseline mass emissions.

Table 3.4 - Gatwick 2R annual PM_{10} mass emissions by source

tonnes / year (t/y)	PM_{10}					
	Baseline			Change due to Scheme		
Emission Source	1R 2030	1R 2040	1R 2050	2R 2030	2R 2040	2R 2050
Aircraft engine	14.9	15.4	14.8	2.1 (+14 %)	5.1 (+33 %)	11.2 (+76 %)
Brake and tyre wear	18.2	17.6	16.5	1.2 (+7 %)	2.6 (+15 %)	1.1 (+7 %)
APU	18.3	18.4	18.8	2.7 (+15 %)	6.5 (+35 %)	12.6 (67 %)
GSE	10.9	10.5	10.2	2.2 (+20 %)	5 (+48 %)	5.5 (+54 %)
Road traffic – airport only*	28.7	30.9	32.6	9.2 (+32 %)	15.3 (+50 %)	25.2 (+77 %)
Total	91.0	92.9	92.8	17.4 (+19 %)	34.6 (+37 %)	55.6 (+60 %)

** Airport only includes fugitive emissions from surface access*

Table 3.5 presents $PM_{2.5}$ emissions (tonnes per annum) that have been calculated and attributed to associated airport activities in the Do Something scenario. These are compared with baseline mass emissions.

Table 3.5 - Gatwick 2R annual $PM_{2.5}$ mass emissions by source

tonnes / year (t/y)	$PM_{2.5}$					
	Baseline			Change due to Scheme		
Emission Source	1R 2030	1R 2040	1R 2050	2R 2030	2R 2040	2R 2050
Aircraft engine	14.9	15.4	14.8	2.1 (+14 %)	5.1 (+33 %)	11.2 (+76 %)
Brake and tyre wear	12.7	12.4	11.6	0.8 (+6 %)	1.9 (+15 %)	0.8 (+7 %)
APU	18.3	18.4	18.8	2.7 (+15 %)	6.5 (+35 %)	12.6 (+67 %)
GSE	9.5	9.1	8.8	1.9 (+20 %)	4.3 (+47 %)	4.8 (+55 %)
Road traffic – airport only*	16.9	18.2	19.1	5.4 (+32 %)	9 (+49 %)	14.8 (+77 %)
Total	72.3	73.5	73.1	13 (+18 %)	26.9 (+37 %)	44.2 (+60 %)

** Airport only includes fugitive emissions from surface access*

(a) Road traffic emissions – Sensitivity Testing

Road traffic - airport only emission changes are based on passenger growth estimates provided by the scheme promoter. Sensitivity testing of road traffic emissions change estimates was undertaken using an Assessment of Need Carbon Capped (AoNCC) scenario from the Airports Commission

The sensitivity testing showed that road traffic - airport only emissions changes, provided in Table 3.3, were 113%, 76% and 58% higher respectively than AoNCC emission change estimates for mass emissions of NO_x in 2030, 2040 and 2050, due to a more optimistic forecast of passenger growth. In the Air Quality: Baseline report (Jacobs, 2014a), it was established that AoNCC emissions are lower than GAL's. This direction of change is the same in the net emission increase. Consequently, lower road emissions attributed to baseline and Gatwick 2R airport traffic would mean a lower risk of exceeding EULVs and/or AQOs at sensitive roadside receptors.

The sensitivity testing also showed that road traffic - airport only emission changes provided in Table 3.4 and 3.5, were 108%, 73/74% and 56/57% higher respectively than AoNCC emission change estimates for mass emissions of Particulate Matter (PM_{10} and $PM_{2.5}$) in 2030, 2040 and 2050, due to a more optimistic forecast of passenger growth from GAL. Lower road emissions attributed to increases in airport traffic would also mean a lower risk of exceeding EULVs and/or AQOs at sensitive roadside receptors. Due to limitations within the static traffic model, only traffic flow could be forecasted using modal share and passenger demand forecast data. As GAL's passenger demand forecast is greater than AoNCC and the modal share remains the same, GAL's greater passenger demand is the cause of greater emissions being calculated. The comparison of mass emissions calculated with the scheme promoters passenger demand forecast against the AoNCC is presented in Demand Forecast Scenarios and Emissions Appendix E: Table 1.

(b) Emissions contributions from the different airport sources

Figures 3.1 to 3.3 show the source apportionment across the different airport emissions sources, without mitigation from a scheme or from action responding to government policy, for each of the three pollutants.

Figure 3.1 – Change in NO_x annual mass emissions source apportionment

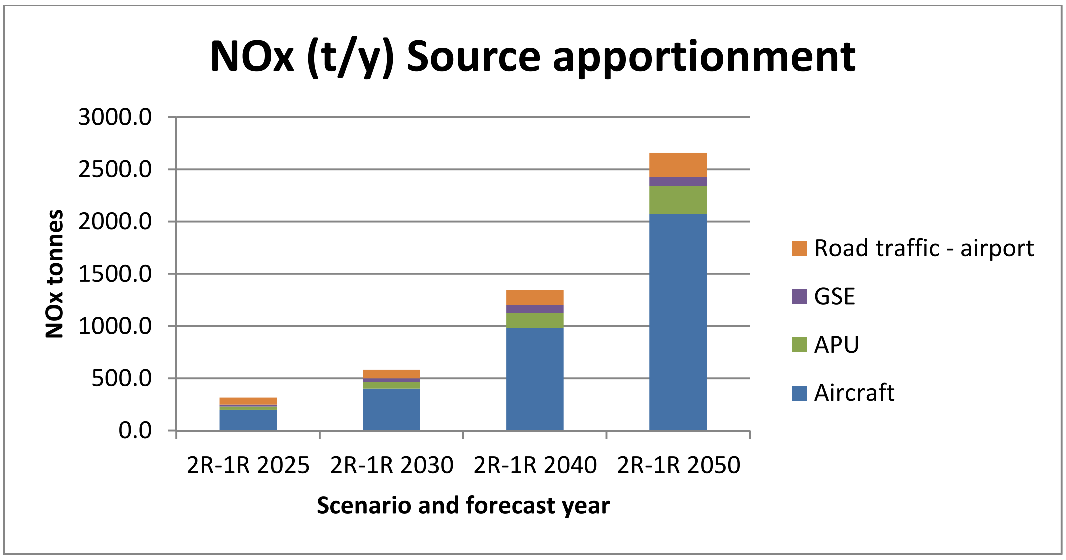


Figure 3.2 – Change in PM_{10} annual mass emissions source apportionment

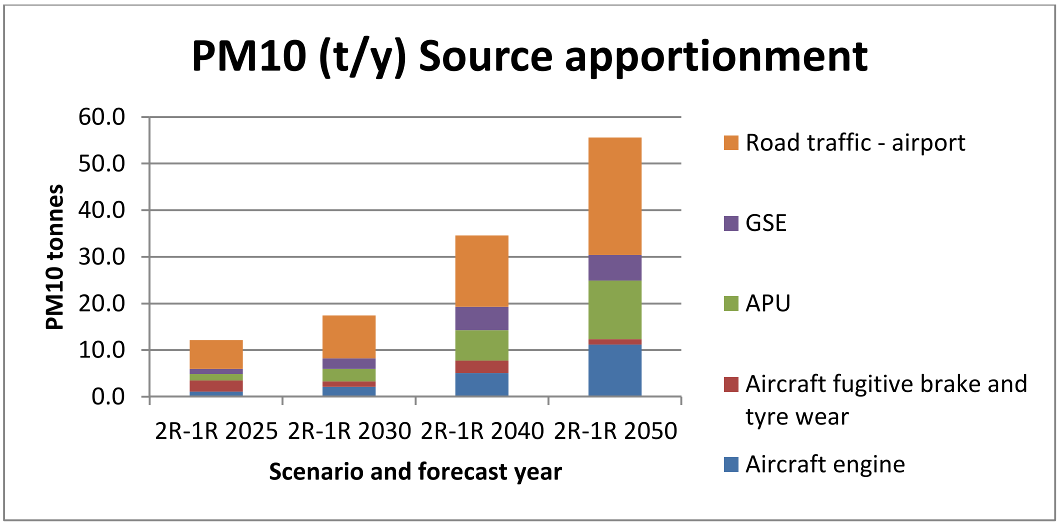
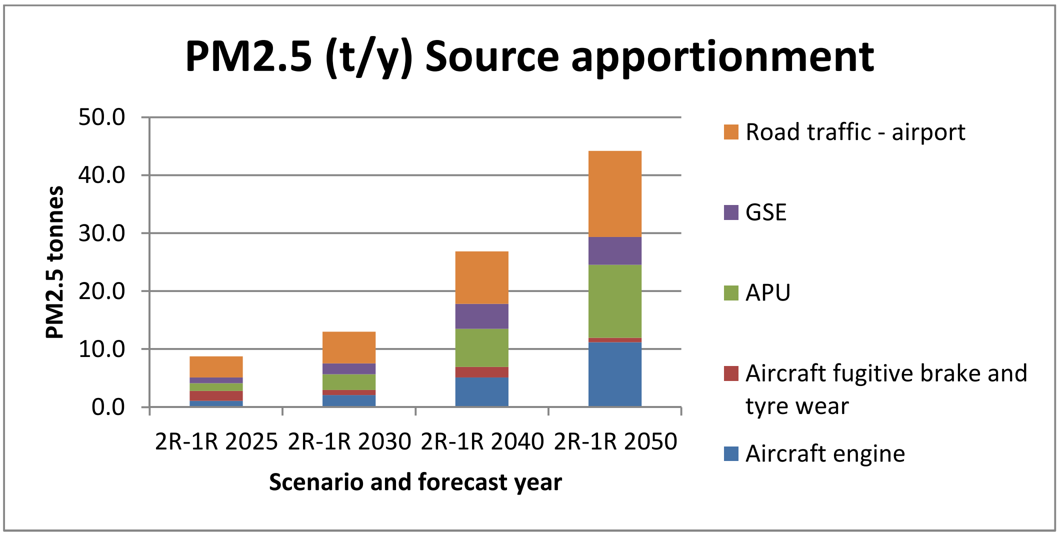


Figure 3.3 – Change in $PM_{2.5}$ annual mass emissions source apportionment



Observations:

- Increases in NO_x emissions are expected to rise from 13% in 2030 to up to 68% in 2050. The largest change in emissions are anticipated to come from aircraft engines rising from an additional 400 tonnes in 2030 to up to 2073 tonnes in 2050. Proportionally, the largest increase will be in road traffic emissions – airport only which are anticipated to increase by 32% in 2030 up to 78% in 2050. Aircraft engines emissions are directly proportional to the sustained increase in ATMs forecast over the appraisal years and road traffic emissions increase due to sustained growth in passenger demand.

- Increases in PM emissions (both PM_{10} and $PM_{2.5}$) are expected to rise from 18-19% in 2030 to up to 60% in 2050. The largest change in emissions is anticipated to come from road traffic emissions – airport only rising from an additional 9.2 tonnes in 2030 to up to 25.2 tonnes in 2050. Proportionally the largest increase will be in road traffic emissions – airport only which are anticipated to increase by 32% in 2030 up to 77% in 2050. Road traffic emissions increase due to sustained growth in passenger demand

3.3.2 Summary of sensitivity of receiving environment

(a) National Modelling and EULVs

Table 3.6 presents Defra's PCM modelled road links concentrations established within the Air Quality: Baseline report (Jacobs, 2014a). The Defra PCM concentrations presented below, are the baseline 2030 air quality concentrations associated with emission sources within the local area, adjusted for Euro 6/VI vehicle and aircraft engine technological improvements (see section 2.1.3). They do not reflect the potential for government policy or scheme promoter's mitigation measures to change local air quality concentrations.

A risk category has been applied (section 2.1.4) to rate the PCM locations' risk of exceeding EU Limit Values should Gatwick R2 cause increases in NO_2 concentrations. Both Defra PCM locations are predicted to be at low risk of exceeding the NO_2 EULVs of 40µg/m^3 in 2030. The location of these PCM links can be seen in Appendix F: Figure 4. With sufficiently detailed data to enable dispersion modelling in the second stage assessment, the evaluation of PCM locations exceeding EULVs will move from categorising risk to EULVs, to quantifying whether the impact is sufficient to exceed EULVs. This assessment will be used to inform the overall significance of Gatwick 2R for EULV compliance.

Table 3.6 - PCM 2030 baseline modelled road links within the study area for and risk of exceedance with Gatwick 2R

Road	2030 Modelled PCM Annual Mean NO_2 ($\mu g/m^3$) Baseline 2030	With scheme - Unmitigated Risk Category
AIRPORT WAY, A23	31.8	Low
LONDON ROAD, A23	31.0	Low

Note: Currently published Department for Environment and Rural Affairs (DEFRA) PCM projections have been undertaken with the Emission Factor Toolkit (EFT) V5.2c, which was superseded in June 2014 by EFT V6.01. The latest EFT revises overly optimistic uptake rates of Euro 6/VI vehicles in the future fleet mix, which is likely to increase projected emissions and predict higher pollution concentrations. This has been accounted for in Jacobs' classification of Risk by including NO_2 concentrations between 30-36$\mu g/m^3$ within the low risk category.

Defra's latest report to the EU on EULV compliance confirms that EULVs for PM_{10} are currently being met in all Zones within the UK. It also confirms that the target value for PM2.5 is also being met; but concedes that by 2020 one Zone (Greater London Urban Area) is unlikely to currently meet the Stage 2 EULV, even after the subtraction of the natural PM contribution. In the latest available year (2012), the PCM model has calculated there were no roadside locations within the baseline study area for Gatwick 2R that exceed the annual mean PM_{10} or $PM_{2.5}$ EULVs. While the PCM model does predict concentrations of PM in future years, these data are not currently published.

(b) Local Monitoring and AQOs

Note: Air pollution concentration data described by PCM modelling and local monitoring are incomparable. There may be locations where projected locally monitored pollution concentrations and forecast nationally modelled pollution concentrations do not agree; this represents uncertainty in predicting future air quality. Monitoring is also not always representative of relevant exposure where AQOs apply, and can be located closer to the emissions source than the receptors.

Table 3.7 presents projected NO_2 monitoring data established within the Air Quality: Baseline report (Jacobs, 2014a). The projected baseline 2030 NO_2 concentrations take account of a cleaner motor vehicle fleet mix (see section 2.1.3) but do not reflect future government policy or scheme promoter mitigation measures with the potential to change air quality. A risk category has been applied (section 2.1.4) which rates risk of exceeding AQOs at the monitoring locations should Gatwick R2 cause increases in NO_2 concentrations.

For 2030, no locations are predicted to exceed NO_2 AQOs, however projected annual mean NO_2 concentrations are predicted to pose a high risk of exceeding AQOs in locations along the A2011/Hazelwick Roundabout (Craw15). Craw15 can be seen in Appendix F: Figure 7. With sufficiently detailed data for dispersion modelling in the second stage assessment, the evaluation will move from rating the risk to AQOs, to quantifying whether the impact is sufficient to result in exceedence of AQOs at sensitive receptors and the significance of this impact. .

Local Authorities are required to Review and Assess air quality within their jurisdiction. If the findings of this review determine that air quality concentrations are exceeding AQOs, then Air Quality Management Areas (AQMAs) need to be established along with an Action Plan to actively manage factors causing poor air quality. AQMAs have not formed the basis to establish areas at risk of or exceeding AQOs, as these are based upon current monitoring data and concentrations are expected to change into the future. The monitoring locations that are within an AQMA have been identified with an asterix within Table 3.7, the rest of the monitoring locations are listed within Appendix C: Table C3.

Craw 15 is not within an existing AQMA. Projected NO_2 concentrations that are within both AQMAs and the study area do not show any risk of exceedence.

The monitoring data has had the IAN/170v3 projection factors applied, which take account of the emission reductions predicted as a result of Euro 6/VI vehicles penetration into the UK fleet mix and is considered a realistic identification of areas sensitive to changes in NO_2 concentrations. However, other future local or national air quality mitigation measures, such as London's proposed Ultra Low Emission Zone (ULEZ) are not included.

Table 3.7 – Projected baseline 2030 annual mean NO_2 air quality monitoring data concentration and risk of exceedance with Gatwick 2R

Local Authority Site ID	Monitoring Location	Annual Mean NO_2 ($\mu g/m^3$) Baseline 2030	With scheme unmitigated Risk Category
Craw15	Woodfield Lodge (Hazelwick roundabout)	35.9	High

* denotes monitoring locations that are currently within AQMAs

A Particulate Matter monitoring site has been identified within the Gatwick 2R study area at Horley approximately 0.4km north east from the existing airport boundary. The dominant source of emissions at these sites is from road traffic. This site uses monitoring equipment that provides results that can be directly compared with AQOs without further processing. Results at this site currently indicate no risk of exceedence.

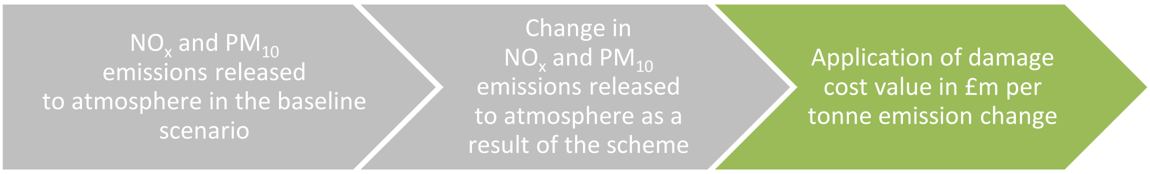
Additional Particulate Matter monitoring sites have also been identified within the study area for Gatwick 2R. While the results at these sites indicate there to be no risk of exceedance, the results currently cannot directly be compared with AQOs. This is due to monitoring equipment used at these locations not having successfully met equivalency requirements for reporting to the same Standards as Gravimetric-type devices (measure the mass of particulate matter). These sites are to be subject to further review in order to confirm this position.

While there is no well-established method for projecting local PM_{10} monitoring data to future years, concentrations are anticipated to decline as can be seen in national background mapping[20] and emission factor projections[21]. As such it is reasonable to

[20] http://uk-air.defra.gov.uk/data/laqm-background-maps?year=2011
[21] http://laqm.defra.gov.uk/review-and-assessment/tools/emissions-factors-toolkit.html

conclude with the information available, that there will also continue to be no risk of exceeding PM_{10} AQOs in the future.

3.4 Monetisation



At the current stage of air quality analysis, monetisation of damage costs has been undertaken on a mass emissions basis, following the Air Quality Appraisal – Damage Cost methodology published by the Defra and the Interdepartmental Group on Costs and Benefits, Air Quality Subject Group.

Defra's damage cost for a tonne of NO_x[22] with 2010 prices is £955. This unit value is fixed across all areas of the UK and remains the same for all emission sources. After the gross domestic product (GDP) uplift in today prices this equates to approximately £1,037 per tonne.

The cost placed on a tonne of PM_{10} is dependent on the area within the UK the pollutant is being emitted within and the source of the pollutant and has some local inputs to it. Further adjustment has been made to take into account macro-economic changes to future appraisal dates unit value per tonne.

The total cost of NO_x and PM_{10} over the 60 year appraisal period (based on the unmitigated change in mass emissions with the scheme in place) is £76.8m and £92.4m, respectively. The damage costs spanning over milestone appraisal periods can be found in Appendix D: Table 1.

At the second stage assessment, the change in local air quality concentrations modelled for sensitive receptors (human health and ecosysems) associated with airport expansion will be used to determine the cost of local air quality impacts.

3.5 Mitigation

3.5.1 National

Gatwick 2R operational emissions are not forecast to result in delays for compliance with the NO_x emission ceiling. The UK exceeds the $PM_{2.5}$ emission ceiling target value in 2030. No matter what mitigation measures GAL implements, the airport expansion will result in some increases in $PM_{2.5}$. However, the change in emissions are a small proportion of total UK emissions and represents a 0.02% increase relative to 2030 NAEI UK projections.

The principal source of $PM_{2.5}$ is airport only road traffic and APUs; therefore this is where airport related emission reduction management for $PM_{2.5}$ should be focused. A reduction in $PM_{2.5}$ emissions can be achieved by a greater uptake in fixed ground and electrical power; this effectively cuts back the APU run times per LTO cycle. $PM_{2.5}$ emissions could be further reduced by a larger proportion of passengers travelling to Gatwick by train.

[22] NOx emissions value is on a national basis.

3.5.2 Local

Both the with and without mitigation scenarios proposed for Gatwick R2 will be assessed in the second stage assessment. The necessity of further mitigation at a local air quality level will be determined by the supplementary results from dispersion modelling. This will establish whether mitigation is required to improve local air quality concentrations within EULVs and/or AQOs.

3.6 Commentary on Scheme Promoter's Submission

Commentary on the scheme promoter's submission has been made with reference to Jacobs' independent assessment and considers comparisons in two areas:

1. mass emission estimates made within the scheme promoter's emissions inventory; and
2. the scheme promoters local air quality assessment.

The comparison has been made for the without 'end around taxiways' scenario.

3.6.1 National

Tables 3.8, 3.9 and 3.10 show the comparison of the scheme promoter's emissions inventory with Jacobs' mass emission estimates for NO_x, PM_{10} and $PM_{2.5}$, respectively.

These have only been compared against 2040 as this is the only year for which GAL has provided a change in emissions. Jacobs have combined APU emissions and aircraft fugitive emissions from brake and tyre wear into total aircraft emissions and compared this against the sum of the scheme promoter's ground and elevated emissions.

Table 3.8- Comparison of GAL Scheme Promoters' NO_x emissions (tonnes) inventory with Jacobs' Mass Emissions Estimate

Emission Source	NO_x (t/y)		% Difference
	Scheme Promoter	Jacobs	
Aircraft – elevated	587.8	-	-
Aircraft – ground	361.6	-	-
APU	-	144.4	-
Fugitive aircraft brake and tyre wear	-	-	-
Aircraft engine only		978.7	
Aircraft total	949.4	1,123.1	18.3
GSE	14.8	81.2	448.7
Road Network	36.1	141.0	290.2
Stationary sources	21.7	-	-
Car park	2.5	-	-
Road Network - non airport	-3.7	-	-
Total	**1,020.9**	**1,345.2**	**31.8**

- Not included within assessor reported emissions inventory

Table 3.9 - Comparison of GAL Scheme Promoters PM_{10} emissions (tonnes) inventory with Jacobs' Mass Emissions Estimate

Emission Source	PM_{10} (t/y)		% Difference
	Scheme Promoter	Jacobs	
Aircraft – elevated	2.4	-	-
Aircraft – ground	8.7	-	-
APU	-	6.5	-
Fugitive aircraft brake and tyre wear	-	2.6	-
Aircraft engine only	-	5.1	-
Aircraft total	11.2	14.3	28.2
GSE	2.5	5.0	98.0
Road Network	10.7	15.3	42.9
Stationary sources	0.3	-	-
Car park	-	-	-
Road Network - non airport	-0.7	-	-
Total	**24.1**	**34.6**	**43.8**

- Not included within assessor reported emissions inventory

Table 1.10 - Comparison of GAL Scheme Promoters $PM_{2.5}$ emissions (tonnes) inventory with Jacobs' Mass Emissions Estimate

Emission Source	$PM_{2.5}$ (t/y)		% Difference
	Scheme Promoter	Jacobs	
Aircraft – elevated	2.4	-	-
Aircraft – ground	6.6	-	-
APU	-	6.5	-
Fugitive aircraft brake and tyre wear	-	1.9	-
Aircraft engine only	-	5.1	-
Aircraft total	9.1	13.5	49.2
GSE	1.4	4.3	220.2
Road Network	5.7	9.0	59.7
Stationary sources	0.3	-	-
Car park	-	-	-
Road Network - non airport	0.5	-	-
Total	**16.9**	**26.9**	**59.0**

- Not included within assessor reported emissions inventory

The key emissions sources to focus on are aircraft total and road network as these are the dominant emissions sources of NO_x, PM_{10} and $PM_{2.5}$. Jacobs' aircraft total emissions are 18.3%, 28.2% and 49.2% greater than the scheme promoter's; while Jacobs' road network emissions are 290.2%, 42.9% and 59.7% greater than the scheme promoter's respectively.

The principal reasons behind these emissions estimate differences are listed below:

- Aircraft emissions
  - Jacobs have used the ICAO time in modes (TIM), whilst the scheme promoter has used airport specific time TIMs.
  - The scheme promoter's National Air Traffic Services (NATs) category average for climb out and taxi/idle is broadly comparable to ICAOs TIMs, although ICAOs take-off is longer and the scheme promoter's approach is longer.
  - GAL's scheme promoter states 'future engine variants were also applied, taking into account reduced NO_x emissions due to improved combustion systems and unchanged fuel efficiency', whereas Jacobs have not applied any technological advancements yielding reduced emissions.
  - The weighted average approach used by Jacobs may, in specific circumstances, assign emission rates greater than aircraft engine specific emission rates.
  - Two sets of APU run times were provided to Jacobs by the scheme promoter; these included average APU run times in a direct response to Jacobs' questions and also APU run times for certain NATs categories with a technical appendix. Jacobs have used the average APU run times provided in the direct response, which may overestimate the emissions calculated by the scheme promoter.
  - The above factors within Jacobs' assessment have more than compensated for the difference in ATMs the scheme promoter has used (496,214 in 2040) and the Airports Commission demand forecast ATMs Jacobs have used (379,752 in 2040).

- Road traffic
  - Jacobs have used road traffic emission from a static traffic model; whereas the scheme promoter used more detailed dynamic traffic modelling to account for changes in speed, capacity, fleet composition, and re-routing.
  - Jacobs have included road traffic emissions associated with the entire traffic network available; whereas the scheme promoter has included road traffic emissions from a more defined study area.
  - Appendix F: Figure 1 shows the scheme promoter's study area and the total traffic network Jacobs' have included to show the difference in the extent of roads.

- Ground Support Equipment (GSE)
  - The scheme promoter has used an existing emissions inventory of GSE plant from 2010 and scaled this up using increases in passenger demand, with reduction applied for technological improvements.
  - Jacobs have used the ICAO 'Simple Approach' with no improvement in vehicle efficiency or abatement technology taken into account.

Jacobs' assessment has found that the resulting increase in NO_x emissions associated with the airport can be accommodated if the emissions ceiling target remains the same; this agrees with the scheme promoter's position.

Contrary to the scheme promoter's position however is Jacobs' review of $PM_{2.5}$ emissions which finds that the UK would not be on track to meet its emissions ceiling targets for this pollutant and that Gatwick 2R may affect this further.

3.6.2 Local

(a) Local Monitoring and AQOs/National Modelling and EULVs

After Jacobs' have established what the impact of Gatwick R2 is through dispersion modelling in the second stage assessment, a comparison will be made against the scheme promoters results.

(b) Scheme Promoter's Mitigation

The scheme promoter for Gatwick 2R has not indicated any need for mitigation as a result of the inclusion of a number of conservative assumptions within their assessment leading to their conclusion of no significant adverse impacts. As such, Jacobs are unable to comment on the scheme promoter's committed mitigation measures.

3.7 Conclusions

3.7.1 National

Technological improvements with potential to reduce mass emissions have not been applied to all airport activities (see Appendix B for more information). In addition, scheme promoter mitigation measures with potential to reduce mass emissions have not been considered. The effect mitigation will have on mass emission estimates will be considered in the second stage assessment.

The National Atmospheric Emissions Inventory (NAEI) projects UK total emissions of NO_x and $PM_{2.5}$ up to and including the year 2030. These projections include emissions from Gatwick airport.

UK emissions of NO_x are expected to meet current 2020 Gothenburg Protocol targets in both 2025 and 2030. The baseline NAEI 2025 projections are 86.07% of the current 2020 Gothenburg NO_x targets with the proportion of national NO_x emissions increasing to 86.12% with the second runway The baseline NAEI 2030 projections are 86.07% of the 2020 Gothenburg NO_x targets with the proportion of national emissions increasing to 86.12% with the second runway. While such contributions are likely to be accommodated in the context of the current Protocol targets; there remains a risk that the Protocol targets themselves may become tighter making any accommodation a greater challenge.

The baseline NAEI 2025 projections are 100% of the current 2020 Gothenburg $PM_{2.5}$ targets with the proportion of national $PM_{2.5}$ emissions increasing to 100.01% with the second runway The baseline NAEI 2030 projections are 103.5% of the current 2020 Gothenburg $PM_{2.5}$ targets with the proportion of national $PM_{2.5}$ emissions increasing to 103.53% with the second runway. Emissions of $PM_{2.5}$ attributed to associated airport activities with Gatwick 2R in 2030, represent just over 4% of the projected exceedance of the 2020 Gothenburg Protocol target.

The principal sources of $PM_{2.5}$ are airport only road traffic and APUs; therefore this is where airport related emission reduction management for $PM_{2.5}$ should be focused. A reduction in $PM_{2.5}$ emissions can be achieved by a greater uptake in fixed ground and electrical power; this effectively cuts back the APU run times per LTO cycle. $PM_{2.5}$ emissions could be further reduced by a larger proportion of passengers travelling to Gatwick by train.

3.7.2 Local

Currently, air quality surrounding roads is typically the focal point for air quality studies as motor vehicles are the dominant source of oxides of nitrogen (NO_x) and nitrogen dioxide (NO_2). Therefore sensitive receptors (human health and ecosystems) within close proximity to heavily polluting roads will experience poor air quality (NO_2, NO_x and PM concentrations).

Defra's National compliance PCM model and Jacobs' projected NO_2 concentrations were established for the 2030 without scheme baseline. These concentrations take account of vehicle technological improvements, although they do not reflect potential governmental policy or the scheme promoter's mitigation measures with the potential to change air quality. A risk category has been applied (section 2.1.4) which rates the risk of exceeding AQOs and EU Limit Values, for the monitoring and PCM locations, should Gatwick R2 cause increases in NO_2 concentrations.

For 2030, no locations are predicted to exceed NO_2 AQOs or EU Limit Values, however 2030 projected annual mean NO_2 concentrations are predicted to pose a high risk of exceeding AQOs in locations along the A2011/Hazelwick Roundabout (Craw15). With sufficiently detailed data for dispersion modelling in the second stage assessment, the evaluation will move from rating the risk of exceedance of AQOs/EULVs, to quantifying whether the impact is sufficient to result in exceedence of AQOs/EULVs at sensitive receptors and the significance of this impact.

For the PM monitoring site identified within the Gatwick 2R study area at Horley, approximately 0.4km north east from the existing airport boundary, the dominant source of emissions is from road traffic. This site uses monitoring equipment that provides results that can be directly compared with AQOs without further processing. Results at this site currently indicate no risk of AQO exceedance.

Additional PM monitoring sites have also been identified within the GAL study area where the results indicate no risk of exceedance. However, the results from these sites currently cannot directly be compared with AQOs. This is due to monitoring equipment used at these locations not having successfully met equivalency requirements for reporting to the same Standards as Gravimetric-type devices (measure measuring the mass of particulate matter). These sites are to be subject to further review in order to confirm this position.

While there is no well-established method for projecting local PM_{10} monitoring data to future years, concentrations are anticipated to decline as can be seen in national background mapping[23] and emission factor projections[24]. As such it is reasonable to conclude from the information available, there will also continue to be no risk of exceeding PM_{10} AQOs in the future.

Both the with and without mitigation scenarios for Gatwick R2, will be assessed in the second stage assessment. The necessity of further mitigation at a local air quality level will be determined by the supplementary results from dispersion modelling. This will establish whether mitigation is required to improve local air quality concentrations within EULVs and/or AQOs.

[23] http://uk-air.defra.gov.uk/data/laqm-background-maps?year=2011
[24] http://laqm.defra.gov.uk/review-and-assessment/tools/emissions-factors-toolkit.html

3.7.3 Monetisation

At the current stage of air quality analysis, monetisation of damage costs has been undertaken on a mass emissions basis, following the Air Quality Appraisal – Damage Cost methodology published by the Defra and the Interdepartmental Group on Costs and Benefits, Air Quality Subject Group.

The total cost of NO_x and PM_{10} over the 60 year appraisal period based on the unmitigated change in mass emissions with the scheme in place) is £76.8m and £92.4m, respectively. The damage costs spanning over milestone appraisal periods can be found in Appendix D: Table 1.

At the second stage assessment, the change in local air quality concentrations modelled for sensitive receptors (human health and ecosysems) associated with airport expansion will be used to determine the cost of local air quality impacts.

4 Heathrow Airport Northwest Runway

This Section covers:

- Study Area
- National Assessment
    - Total mass emissions of key pollutants associated with airport activity
- Local Assessment
    - Proportions of mass emissions of key pollutants associated with airport activity and risk evaluation for EULVs/AQOs
- Monetisation
- Mitigation
- Commentary on Scheme Promoter's Submission
- Conclusion

4.1 Impact Assessment Study Area

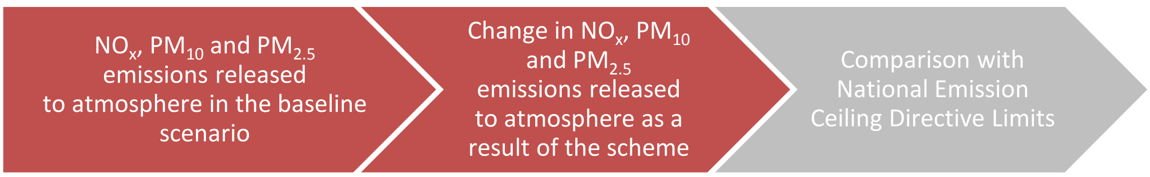
There are a number of populated areas within the study area for the Heathrow Airport Northwest Runway (Heathrow NWR) scheme (see Appendix F**:** Figure 5). In addition, there are also a number of statutory designated sites of nature conservation importance.

A review of statutory designated sites within the baseline study area that might be sensitive to changes in air quality was undertaken, using APIS. This identified the following sites: Staines Moor (SSSI), Wraysbury Reservoir (SSSI) and South West London Waterbodies (SPA).

Natural England's Aviation Sensitivity Mapping identified the: Wraysbury No.1 Gravel Pit, Wraysbury & Hythe End Gravel Pits, Staines Moor and Kempton Park Reservoirs as sites sensitive to air quality changes.

These sites are likely to be mostly influenced by road traffic emissions. It will be necessary to assess the impact of the proposed scheme on road traffic emissions in the vicinity of these sites and the impacts of Nitrogen deposition as part of the second stage assessment.

4.2 National



4.2.1 Change in Total Mass Emissions

National Atmospheric Emissions Inventory (NAEI) projections have been used to report the UK's status on compliance with the NECD and Gothenburg Protocol. NAEI projections up to 2030 (AEA, 2012) are presented in Table 4.1. There are no NAEI projections for PM_{10} as this pollutant is not prescribed under the NECD or Gothenburg Protocols. However, the EC is currently revising its National Emissions Ceilings Directive for EU countries, with much tighter ceilings proposed for 2030. The UK could have tighter limits in 2030 meaning that targets may be more difficult to achieve. NAEI projections present national emission projections in five year intervals covering the relevant years for the scheme in 2030 only. Projections for 2025 have been used as the background for 2026.

Table 4.1 – NAEI NO_x and $PM_{2.5}$ emission projections for the UK

kilo tonnes / year (kt/y)	NO_x		$PM_{2.5}$	
	2025	2030	2025	2030
Gothenburg Protocols' 2020 emission targets	711		57	
NAEI emission pollutant projections	612	589	57	59
NAEI projection % of Gothenburg Protocol targets	86.07%	82.8%	100.00%	103.51%
NAEI projection + change associated with Heathrow NWR % of Gothenburg Protocol targets	86.29%	83.21%	100.10%	103.63%

Observations:

- Projected UK emissions include emissions from Heathrow Airport;
- UK emissions of NO_x are projected to meet current 2020 Gothenburg Protocol targets in both 2025 and 2030; and
- The change in $PM_{2.5}$ associated with Heathrow NWR in 2026 causes UK emissions to exceed the 2020 emission target by 0.1% and the 2030 UK exceedence to increase by 0.12% relative to the 2020 emission target.

Table 4.2 presents the total mass emissions (tonnes per annum) that have been calculated and attributed to associated airport activities in the Heathrow NWR baseline and the change associated with the Do Something scenario without any mitigation in place. Technological improvements with potential to reduce mass emissions have not been applied to all airport activities (see Appendix B for more information). In addition, scheme promoter mitigation measures with potential to reduce mass emissions have not been considered. The effect mitigation will have on mass emission estimates will be considered in the second stage assessment.

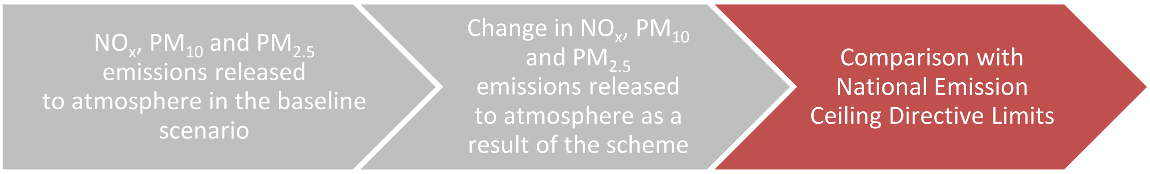
Table 4.2 – Heathrow NWR total annual air pollutant mass emissions

kt/y	NO_x			PM_{10}			$PM_{2.5}$		
	2030	2040	2050	2030	2040	2050	2030	2040	2050
Baseline 2R Total	11.0	10.3	8.7	0.134	0.124	0.110	0.104	0.097	0.086
Change due to NWR Scheme	2.6	3.5	3.3	0.09	0.10	0.05	0.07	0.08	0.04
New % of Total UK Projection	2.3	-	-	-	-	-	0.3	-	-

Observations:

- Do Something annual NO_x emissions by mass represent 2.3 percent of the entire NO_x emissions projected for the UK in 2030, an increase of six tenths of a percent from the Baseline;
- $PM_{2.5}$ emissions are a sub-set of PM_{10} emissions and represent approximately three tenths of a percent of the entire $PM_{2.5}$ emissions projected for the UK in 2030 in the Do Something scenario; and
- Emissions of all pollutants increase between 2030 and 2040; this is due to increases in airport activity offsetting improvements in emissions from using a cleaner fleet.

4.2.2 Evaluation



The baseline NAEI 2025 projections are 86.07% of the 2020 Gothenburg NO_x targets with the proportion of national emissions increasing to 86.29% with the third runway in 2026.

The baseline NAEI 2030 projections are 82.8% of the 2020 Gothenburg NO_x targets with the proportion of national emissions increasing to 83.21% with the third runway in 2030.

While such contributions are likely to be accommodated in the context of the current Protocol targets; there remains a risk that the Protocol targets themselves may become tighter making any accommodation a greater challenge.

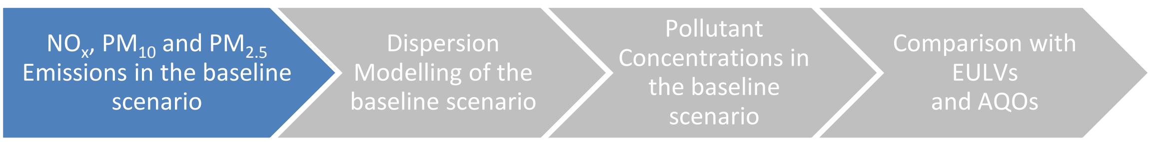
The baseline NAEI 2025 projections are 100.00% of the 2020 Gothenburg $PM_{2.5}$ targets with the proportion of national emissions increasing to 100.10% with the third runway in 2026.

The baseline NAEI 2030 projections are 103.51% of the 2020 Gothenburg $PM_{2.5}$ targets with the proportion of national emissions increasing to 103.63% with the third runway in 2030.

Emission of $PM_{2.5}$ attributed to associated airport activities in the Do Something scenario in 2030 represent almost 9% (0.07 kt/yr) of the projected exceedance of the current 2020 Gothenburg Protocol target.

4.3 Local

4.3.1 Change in Mass Emissions broken down into proportions



Note: It is not just the total mass of emissions, but also the distance from the source to the receptor which causes poor air quality. This is why air quality surrounding roads are currently the focal point for air quality studies. Consequently, sensitive receptors (human health and ecosystems) within close proximity to heavily polluting roads will experience poor air quality (NO_2, NO_x and PM concentrations).

Table 4.3 presents NO_x emissions (tonnes per annum) that have been calculated and attributed to associated airport activities in the Do Something scenario. These are compared with baseline mass emissions. Technological improvements with potential to reduce mass emissions have not been applied to all airport activities (see Appendix B for more information). In addition, scheme promoter mitigation measures with potential to reduce mass emissions have not been considered. The effect mitigation will have on mass emission estimates will be considered in the second stage assessment.

Table 4.3 - Heathrow NWR annual NO_x mass emissions by source

tonnes / year (t/y)	NO_x					
	Baseline			Change due to Scheme		
Emission Source	2R 2030	2R 2040	2R 2050	3R 2030	3R 2040	3R 2050
Aircraft engine	10,168.8	9,544.2	7,924.7	2,192.8 (+22%)	3,005.9 (+31%)	2,979.9 (+38%)
Brake and tyre wear	-	-	-	-	-	-
APU	293.7	233.0	217.2	75.4 (+26%)	133.7 (+57%)	90.3 (+42%)
GSE	278.6	258.0	281.2	223.3 (+80%)	298.5 (+116%)	161.5 (+57%)
Road traffic – airport only*	248.7	259.5	273.9	63.2 (+25%)	105.5 (+41%)	106.1 (+39%)
Total	10,989.8	10,294.6	8,696.9	2,554.6 (+23%)	3,543.7 (+34%)	3,337.8 (+38%)

** Airport only includes fugitive emissions from surface access*

Table 4.4 presents PM_{10} emissions (tonnes per annum) that have been calculated and attributed to associated airport activities in the Do Something scenario. These are compared with baseline mass emissions.

Table 4.4 - Heathrow NWR annual PM_{10} mass emissions by source

tonnes / year (t/y)	PM_{10}					
	Baseline			Change due to Scheme		
Emission Source	2R 2030	2R 2040	2R 2050	3R 2030	3R 2040	3R 2050
Aircraft engine	27.9	27.8	26.2	8.7 (+31%)	13.7 (+49%)	11.5 (+44%)
Brake and tyre wear	51.8	41.8	26.7	59 (+114%)	63.4 (+152%)	17.2 (+64%)
APU	7.7	7.6	7.3	2.4 (+31%)	3.6 (+47%)	3.6 (+49%)

GSE	17.2	16.0	17.4	13.6 (+79%)	18.2 (+114%)	10 (+57%)
Road traffic – airport only*	29.6	30.9	32.6	7.5 (+25%)	12.6 (+41%)	12.6 (+39%)
Total	134.2	124.1	110.2	91.2 (+68%)	111.5 (+90%)	54.9 (+50%)

** Airport only includes fugitive emissions from surface access*

Table 4.5 presents $PM_{2.5}$ emissions (tonnes per annum) that have been calculated and attributed to associated airport activities in the Do Something scenario. These are compared with baseline mass emissions.

Table 4.5 - Heathrow NWR annual $PM_{2.5}$ mass emissions by source

tonnes / year (t/y)	$PM_{2.5}$					
	Baseline			Change due to Scheme		
Emission Source	2R 2030	2R 2040	2R 2050	3R 2030	3R 2040	3R 2050
Aircraft engine	27.9	27.8	26.2	8.7 (+31%)	13.7 (+49%)	11.5 (+44%)
Brake and tyre wear	36.2	29.2	18.7	41.3 (+114%)	44.4 (+152%)	12.1 (+65%)
APU	7.7	7.6	7.3	2.4 (+31%)	3.6 (+47%)	3.6 (+49%)
GSE	15.0	13.9	15.1	11.8 (+79%)	15.8 (+114%)	8.7 (+58%)
Road traffic – airport only*	17.2	17.9	18.9	4.4 (+26%)	7.3 (+41%)	7.3 (+39%)
Total	104.0	96.5	86.2	68.6 (+66%)	84.8 (+88%)	43.2 (+50%)

** Airport only includes fugitive emissions from surface access*

(a) Road traffic emissions – Sensitivity Testing

Road traffic - airport only emission changes are based on passenger growth estimates provided by the scheme promoter. Sensitivity testing of road traffic emissions change estimates was undertaken using an Assessment of Need Carbon Capped (AoNCC) scenario from the Airports Commission.
The sensitivity testing showed that road traffic - airport only emissions changes, provided in Table 4.3, were 26%, 12% and 13% higher respectively than AoNCC emission change estimates for mass emissions of NO_x in 2030, 2040 and 2050.

The sensitivity testing also showed that road traffic - airport only emission changes, provided in Table 4.4 and Table 4.5, were 28%, 13% and 14% higher respectively than AoNCC emission change estimates for mass emissions of Particulate Matter (PM_{10} and $PM_{2.5}$) in 2030, 2040 and 2050.

The emissions are higher because a greater net change in traffic flows have been forecast with the scheme demand forecast and modal share adjustment factor.
These traffic inputs will be entered in a dynamic traffic model and the resulting traffic data will be modelled within the second stage assessment..

A lower road traffic emissions change with Heathrow NWR AoNCC scenario would mean a smaller change in air quality concentrations. The comparison of mass emissions calculated with the scheme promoters passenger demand forecast against the AoNCC is presented in Demand Forecast Scenarios and Emissions AppendixE: Table 2.

(b) Emissions contributions from the different airport Sources

Figures 4.1 to 4.3 show the source apportionment across the different airport emissions sources for each of the three pollutants excluding any mitigation measures as suggested by the scheme promoter of government policy that may develop.

Figures 4.1 to 4.3 show the source apportionment of the three pollutants.

Figure 4.1 - NO_x annual mass emissions source apportionment

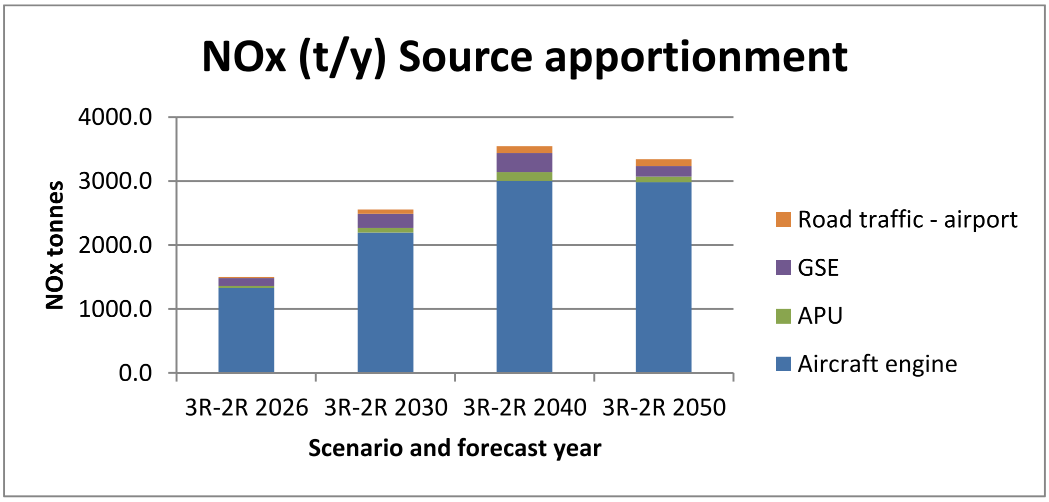


Figure 4.2 - PM_{10} annual mass emissions source apportionment

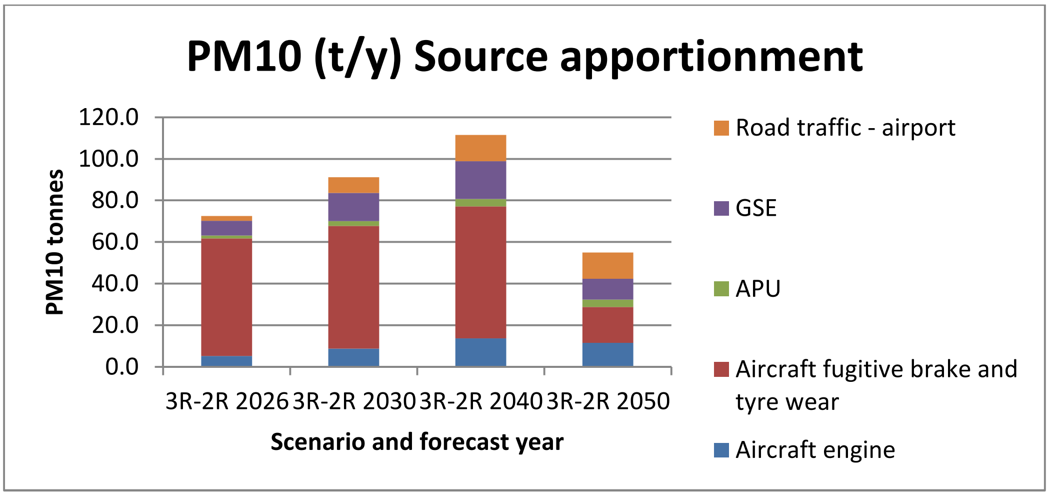
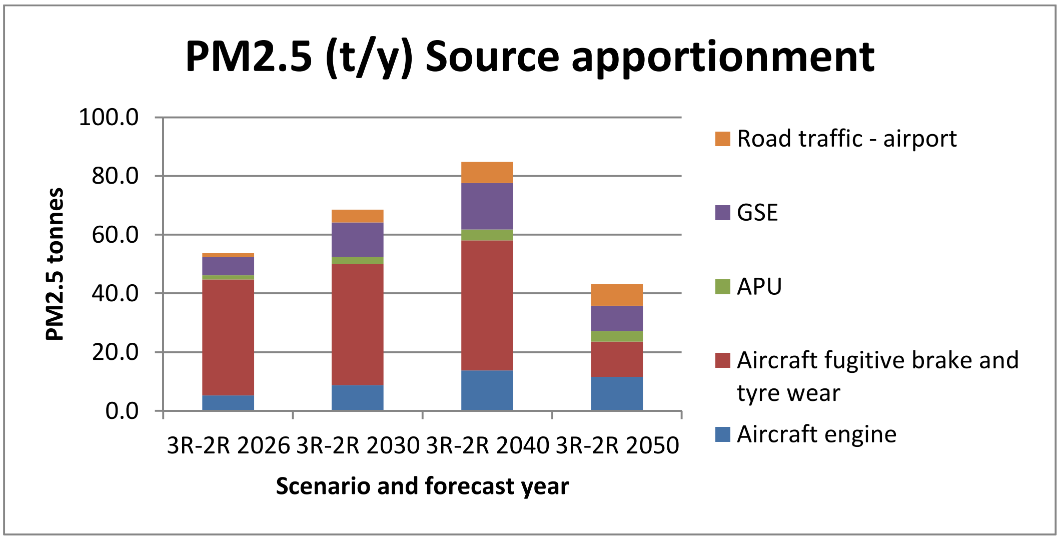


Figure 4.3 - $PM_{2.5}$ annual mass emissions source apportionment



Observations:

- Increases in NO_x emissions are expected to rise from 23% in 2030 to up to 38% in 2050 without mitigation. The largest change in emissions are anticipated to come from aircraft engines rising from an additional 2,193 tonnes per annum in 2030 up to a peak in 2040 of just over 3,000 tonnes per annum before decreasing towards 2050 with 2,980 tonnes per annum. Proportionally the largest increase will be in GSE emissions which are anticipated to increase by 80% in 2030 up to 116% in 2040 before reducing to 57% in 2050. The methodology used to calculate GSE emissions are driven by two factors; proportion of short-haul (smaller emission rate per LTO) and long-haul (larger emissions rate per LTO) aircraft and the ATMs. There is an increase in both the number of long-haul flights and ATMs.

- Increases in PM_{10} emissions are expected to rise from 70% in 2030 to up to 82% in 2040 before decreasing in 2050 to 43%. The largest change in emissions is anticipated to come from aircraft brake and tyre wear rising from an additional 59.6 tonnes in 2030 to up to 59.8 tonnes in 2040 with a decrease to 15 tonnes in 2050. Proportionally the largest increase will be in aircraft brake and tyre wear which are anticipated to increase by 114% in 2030 up to 152% in 2040 and decreases to 64% in 2050. The main contributing factor to emissions from aircraft brake and tyre wear are the large increase in ATMs between 2030 to 2040, with a less substantial increase between 2040 and 2050.

- Increases in $PM_{2.5}$ emissions are expected to rise from 69% in 2030 to up to 85% in 2040 before decreasing in 2050 to 43%. The largest change in emissions is anticipated to come from aircraft brake and tyre wear rising from an additional 41.7 tonnes in 2030 to up to 41.9 tonnes in 2040 with a decrease to 10.5 tonnes in 2050. Proportionally the largest increase will be in aircraft brake and tyre wear which are anticipated to increase by 115% in 2030 up to 143% in 2040 and decreases to 56% in 2050. The main contributing factor to emissions from aircraft brake and tyre wear are the large increase in ATMs between 2030 to 2040, with a less substantial increase between 2040 and 2050.

4.3.2 Summary of sensitivity of receiving environment

(a) National Modelling and EULVs

Table 4.6 presents Defra's PCM modelled road links concentrations as established within the Air Quality: Baseline report (Jacobs, 2014a). The Defra PCM concentrations, presented below, are the baseline 2030 air quality concentrations associated with emission sources within the local area, adjusted for Euro 6/VI vehicle and aircraft engine technological improvements (see section 2.1.3). They do not reflect the potential for government policy or scheme promoter's mitigation measures to change local air quality concentrations. A risk category has been applied (section 2.1.4) to rate the PCM locations' risk of exceeding EU Limit Values should Heathrow NWR cause increases in NO_2 concentrations.

For one location (Bath Road, A4), annual mean NO_2 concentrations are predicted to be a likely risk of exceeding the NO_2 EU limit value of 40µg/m^3. While at other locations within the study area the risk is low. These PCM links can be seen within Appendix F: Figure 5.

With sufficiently detailed data to enable dispersion modelling in the second stage assessment, the evaluation of PCM locations exceeding EULVs will move from categoring risk to EULVs, to quantifying whether the impact is sufficient to exceed EULVs. This assessment will be used to inform the overall significance of Heathrow NWR for EULV compliance.

Table 4.6 - PCM 2030 baseline modelled road links within the study area and risk of limit exceedance with Heathrow NWR

Road	Baseline 2030 Modelled PCM Annual Mean NO_2 (µg/m^3)	With scheme - Unmitigated Risk Category
BATH ROAD, A4	43.2	Likely
COLNBROOK BY-PASS, A4	42.9	Likely
THE PARKWAY, A312	31.2	Low
GREAT SOUTH-WEST ROAD, A30	30.0	Low

Note: Currently published PCM projections have been undertaken with the Emission Factor Toolkit (EFT) V5.2c, which was superseded in June 2014 by EFT V6.01. The latest EFT revises overly optimistic uptake rates of Euro VI vehicles in the future fleet mix, which is likely to increase projected emissions and predict higher pollution concentrations. This has been accounted for in Jacobs' Risk Evaluation for the local assessment. This has been accounted for in Jacobs' classification of Risk by including NO_2 concentrations between 30-36µg/m^3 within the low risk category.

Defra's latest report to the EU on EULV compliance confirms that EULVs for PM_{10} are currently being met in all Zones within the UK. It also confirms that the target value for $PM_{2.5}$ is also being met; but concedes that by 2020 one Zone (Greater London Urban Area) is unlikely to currently meet the Stage 2 EULV, even after the subtraction of the natural contribution. In the latest available year (2012) the PCM model has calculated there were no roadside locations within the Heathrow NWR study area that exceed the annual mean PM_{10} or $PM_{2.5}$ EULVs. While the PCM model does predict concentrations of PM in future years, these data are not currently published.

(b) Local Monitoring and AQOs

Note: Air pollution concentration data described by PCM modelling and local monitoring are mutually exclusive. There may be locations where projected locally monitored pollution concentrations and forecast nationally modelled pollution concentrations do not agree; this represents uncertainty in predicting future air quality.

Table 4.7 presents projected NO_2 monitoring data established within the Air Quality: Baseline report (Jacobs, 2014a). The projected baseline 2030 NO_2 concentrations take account of a cleaner motor vehicle fleet mix (see section 2.1.3) but do not reflect government policy or scheme promoter mitigation measures with the potential to change air quality. A risk category has been applied (section 2.1.4) which rates the risk of exceeding AQOs at the monitoring locations should Heathrow NWR cause increases in NO_2 concentrations.

For 2030, projected local monitoring data shows that at locations along the M4 (Cont_HD2) at London Hillingdon, approximately 1.8km from the existing site boundary, annual mean NO_2 concentrations are predicted to have a likely risk of exceeding the NO_2 AQO of 40µg/m^3; the dominant source of emissions at this site is from road traffic. While at other locations within the study area, the risk is low to unlikely. These monitoring locations can be seen in Appendix F: Figure 5.

With sufficiently detailed data for dispersion modelling in the second stage assessment, the evaluation will move from rating the risk of projected monitoring locations exceeding AQOs, to quantifying whether the impact is sufficient to result in exceedence of AQOs at sensitive receptors and the significance of this impact.

Local Authorities are required to Review and Assess air quality within their jurisdiction. If the findings of this review determine that air quality concentrations are exceeding AQOs then Air Quality Management Areas (AQMAs) need to be established along with an Action Plan to actively manage factors causing poor air quality. AQMAs have not formed the basis to establish areas at risk of or exceeding AQOs, as these are based upon current monitoring data and concentrations are expected to change into the future. The monitoring locations that are within an AQMA have been identified with an asterix within Table 4.7, the rest of the monitoring locations are within Appendix C: Table C3. The projected monitoring data shows that there is a location within AQMAs that is still at a high risk of exceeding NO_2 AQOs in 2030.

The monitoring data has had the IAN/170v3 projection factors applied, which take account of the emission reductions predicted as a result of Euro VI vehicles penetration into the UK fleet mix and is considered a realistic identification of areas sensitive to changes in NO_2 concentrations. However, other future local or national air quality mitigation measures, such as London's proposed Ultra Low Emission Zone (ULEZ) are not included.

Table 4.7 Study Area for Heathrow Airport - Projected annual mean NO_2 air quality monitoring data concentration: 2030

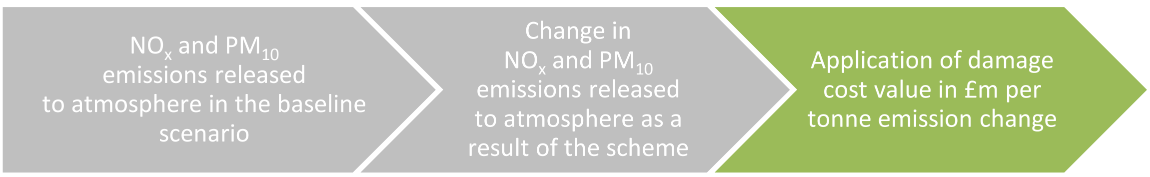
Local Authority Site ID	Monitoring Location	Annual Mean NO_2 ($\mu g/m^3$)	Risk Category
HD71*	Oxford Avenue, Cranford	24.3	Unlikely
Cont_HD1*	London Heathrow LHR2	31.7	Low
Cont_HD2*	London Hillingdon	37.8	High
SP14*	Flintlock Close, Stanwell	19.0	Unlikely
SP48*	Riverside Road, Stanwell	21.8	Unlikely

* denotes monitoring locations that are currently within AQMAs

Eighteen PM_{10} or $PM_{2.5}$ monitoring sites have been identified within the Heathrow NWR study area. These can be seen in Appendix C. Six of these sites can be directly compared with AQOs and currently do not indicate a risk of exceedence of PM AQOs. Twelve of these sites use monitoring equipment that provides results that cannot be directly compared with AQOs without further processing. This is due to monitoring equipment used at these locations not having successfully met equivalency requirements for reporting to the same Standards as Gravimetric-type devices (measure measuring the mass of particulate matter). While the results at these sites indicate there to be no risk of exceedance without any suggested mitigation measures being in place, these sites are to be subject to further assessment in order to confirm this position.

While there is no well-established method for projecting local PM_{10} monitoring data to future years, concentrations are anticipated to decline as can be seen in national background mapping[25] and emission factor projections[26]. As such it is reasonable to conclude with the information available, that there will also continue to be no risk of exceeding PM_{10} AQOs in the future.

4.4 Monetisation



At the current stage of air quality analysis, monetisation of damage costs has been undertaken on a mass emissions basis, following the Air Quality Appraisal – Damage Cost methodology published by the Defra and the Interdepartmental Group on Costs and Benefits, Air Quality Subject Group.

[25] http://uk-air.defra.gov.uk/data/laqm-background-maps?year=2011
[26] http://laqm.defra.gov.uk/review-and-assessment/tools/emissions-factors-toolkit.html

Defra's damage cost for a tonne of NO_x[27] with 2010 prices is £955. This unit value is fixed across all areas of the UK and remains the same for all emission sources. After the gross domestic product (GDP) uplift in today prices this equates to approximately £1,037 per tonne.

The cost placed on a tonne of PM_{10} is dependent on the area within the UK the pollutant is being emitted within and the source of the pollutant and has some local inputs to it. Further adjustment has been made to take into account macro-economic changes to future appraisal dates unit value per tonne.

The total cost of NO_x and PM_{10} over the 60 year appraisal period (based on the unmitigated change in mass emissions with the scheme in place) is £121.2m and £373.1m, respectively. The damage costs spanning over milestone appraisal periods can be found in Appendix D Table 2.

At the second stage assessment the change in local air quality concentrations modelled at sensitive receptors (human health and ecosysems) associated with airport expansion will be used to determine the cost of local air quality.

4.5 Mitigation

4.5.1 National

Heathrow NWR operational emissions are not forecast to result in delays for compliance with the current 2020 Gothenburg Protocol NO_x targets. . The UK exceeds the $PM_{2.5}$ emission ceiling target value in 2030. No matter what mitigation measures Heathrow implements the airport expansion will result in some increases in $PM_{2.5}$. However, the change in emissions are a small proportion of total UK emissions and represents a 0.1% increase relative relative to 2020 Gothenburg Protocol emission targets.

The principal source of $PM_{2.5}$ is aircraft fugitive brake and tyre wear and APUs; therefore this is where airport related emission reduction management for $PM_{2.5}$ should be focused. A reduction in $PM_{2.5}$ emissions will be achieved by a greater uptake in fixed ground and electrical power; this effectively cuts back the APU run times per LTO cycle. Reverse thrust will reduce the proportion of aircraft speed reduction from brake and tyre friction, although will have a side effect of greater NO_x emissions per LTO.

4.5.2 Local

Mitigation of road traffic emissions may be required along Bath Road, A4 and the M4, Hillingdon. Such mitigation will be dependent on the magnitude of any potential impacts at this location and the viability of its implementation, but may include traffic management and/or rerouting. The necessity of mitigation at a local air quality level will be determined by the supplementary results from dispersion modelling. This will establish whether mitigation is required to improve local air quality concentrations within EULVs and/or AQOs.

[27] NOx emissions value is on a national basis.

4.6 Commentary on Scheme Promoter's Submission

Commentary on the scheme promoter's submission has been made with reference to Jacobs' independent assessment and considers comparisons in two areas:

1. Mass emission estimates made within the scheme promoter's emissions inventory; and
2. The scheme promoters local air quality assessment.

4.6.1 National

Tables 4.8, 4.9 and 4.10 show the comparison of the scheme promoter's emissions inventory with Jacobs' mass emission estimates for NO_x, PM_{10} and $PM_{2.5}$, respectively.

These have only been compared against 2030 as this is the only year for which HAL has provided a change in mass emissions. Jacobs has combined APU emissions and aircraft fugitive emissions from brake and tyre wear into total aircraft emissions and compared this against the sum of the scheme promoter's ground and elevated emissions.

Table 4.8 - Comparison of HAL Scheme Promoters' NO_x emissions (tonnes) inventory with Jacobs' Mass Emissions Estimate

Emission Source	NO_x (t/y)		% Difference
	Scheme Promoter	Jacobs	
Aircraft	790.0	2,192.8	
Fugitive aircraft brake and tyre wear	-	-	-
APU	-	75.4	-
Aircraft total	790.0	2,268.1	187.1
Airside Vehicles	48.6	223.3	359.5
Road traffic – airport	10.7	63.2	492.6
Road traffic - non-airport	-0.1	-	-
Total	**849.2**	**2,554.6**	**200.8**

- Not included within assessor reported emissions inventory

Table 4.9 - Comparison of HAL Scheme Promoters PM_{10} emissions (tonnes) inventory with Jacobs' Mass Emissions Estimate

Emission Source	PM_{10} (t/y)		% Difference
	Scheme Promoter	Jacobs	
Aircraft	10.2	8.7	-14.3
Fugitive aircraft brake and tyre wear	-	59.0	-
APU	-	2.4	-
Aircraft total	10.2	70.1	589.2
Airside Vehicles	2.5	13.6	449.2
Road traffic – airport	2.4	7.5	216.6
Road traffic - non-airport	1.0	-	-
Total	**16.0**	**91.2**	**469.3**

- Not included within assessor reported emissions inventory

Table 4.10 - Comparison of HAL Scheme Promoters $PM_{2.5}$ emissions (tonnes) inventory with Jacobs' Mass Emissions Estimate

Emission Source	PM_{10} (t/y)		% Difference
	Scheme Promoter	Jacobs	
Aircraft	7.9	8.7	10.0
Fugitive aircraft brake and tyre wear	-	41.3	-
APU	-	2.4	-
Aircraft total	7.9	52.4	560.7
Airside Vehicles	1.9	11.8	521.2
Road traffic – airport	1.3	4.4	234.0
Road traffic - non-airport	0.5	-	-
Total	**11.6**	**68.6**	**490.1**

- Not included within assessor reported emissions inventory

The key emissions sources to focus on here are aircraft total and road network as these are the largest emissions sources of NO_x, PM_{10} and $PM_{2.5}$. Jacobs' aircraft total emissions estimates are 187.1%, 589.2% and 560.7% greater than the scheme promoter's respectively; and Jacobs' airport road traffic emissions estimates are 492.6% 216.6% and 234% greater than the scheme promoter's respectively.

The principal reasons behind the emissions difference are listed below:

- Aircraft emissions
  - Jacobs has used the ICAO time in modes (TIM), whilst the scheme promoter has used airport specific time TIMs.
  - The scheme promoter's National Air Traffic Services (NATs) category average for approach and taxi/idle is broadly comparable to ICAO's TIMs, although the scheme promoter's climb-out mode is longer than ICAO's. Comparison between the scheme promoter's take-off and ICAO's take-off has not been possible.
  - HAL forecasts ATMs of 570,000 in 2030 while the Airports Commission's demand forecast is for 652,216 ATMs. The Airports Commission's demand forecast for 2030 therefore has approximately 14.4% more ATMs within the emissions calculations.

- Road traffic
  - Jacobs has used unmitigated road traffic emissions from a static traffic model; whereas the scheme promoter used more detailed dynamic traffic modelling to account for changes in speed, capacity, fleet composition, and re-routing and took account of mitigation measures.
  - Jacobs has included road traffic emissions associated with the entire traffic network available; whereas the scheme promoter has included road traffic emissions from a more defined study area.
  - Appendix F: Figure 2 shows the scheme promoter's study area and the total traffic network Jacobs has included to show the difference in the extent of roads.

- Ground Support Equipment (GSE)
    - The scheme promoter has used an existing emissions inventory of GSE plant from AEA's 2008/2009 study and scaled this up using passenger demand, with reductions applied for technological improvements.
    - Jacobs has used the ICAO 'Simple Approach' with no improvement in vehicle efficiency or abatement technology taken into account.

Jacobs' assessment has found that the resulting increase in NO_x emissions associated with the airport is likely to be accommodated between projections and the emissions ceiling target; this agrees with the scheme promoter's position.

Jacobs' review of $PM_{2.5}$ emissions however finds that the UK would not be on track to meet its emissions ceiling targets for this pollutant and that Heathrow NWR may delay this further.

4.6.2 Local

(a) National Modelling and EULVs

Sensitive receptors along Bath Road, A4 have not been presented within the scheme promoters report to inform the EULV compliance risk assessment.

While Jacob's review has indicated that receptors along this link may be at risk of exceeding the annual mean NO_2 EULV without any mitigation measures suggested for the scheme or government policy changes, the scheme promoter has predicted that the Hatton residential area will experience the highest annual mean NO_2 concentrations of 31.6µg/m^3 in 2030 within the Heathrow NWR study area. According to Jacobs' risk categorisation, this location is of low risk of exceeding the annual mean NO_2 EULV.

(b) Local Monitoring and AQOs

After Jacobs' have established what the impact of Heathrow NWR is, through dispersion modelling in the second stage assessment, a comparison will be made against the scheme promoters results.

(c) Scheme Promoter's Mitigation

The following mitigation measures are committed by the scheme promoter; Jacobs' comments are included below each measure.

- The new northwest runway has been positioned as close to the existing northern runway as possible to reduce cumulative effect upon sensitive receptors in the area of expansion.
    - Jacobs Comment – Agree. The greater the distance between the emission source and receptor the lower concentrations will be for all pollutants.
- The alignment of new roads have been positioned as far away as possible from sensitive receptors.
    - Jacobs Comment – Agree. The greater the distance between the emission source and receptor the lower concentrations will be for all pollutants.
- Steeper glide slopes

  - Jacobs Comment – Agree. The greater the distance between the emission source and receptor the lower concentrations will be for all pollutants.
- HAL will provide all aircraft with fixed electrical ground power and pre conditioned air
  - Jacobs Comment – Partially Agree. Will reduce APU emissions during time at stand and taxiing; however should electricity be supplied by on site combustion processes, such as biomass burning, this could worsen the local air quality.
- HAL will provide fuel for hydrogen fuel cell powered vehicles and charging points for electric vehicles to incentivise their use.
  - Jacobs Comment – Partially agree; but again should electricity be supplied by on site combustion processes, such as biomass burning, this could worsen the local air quality.
- HAL will develop airside vehicle and GSE pooling
  - Jacobs Comment – Disagree. Making greater use of old-stock will likely increase local emissions. Updating the fleet to more efficient fuel use and abatement technology or zero emission vehicles will however reduce emissions.
- Collaborative airport decision making improve co-ordination between pilots and air traffic control to reduce hold, taxi times and stacking
  - Jacobs Comment – Agree. Reduces fuel usage for aircraft engines and APUs reducing emissions released.

It is acknowledged that the scheme promoter also identifies a number of additional measures that are currently under consideration, such as the introduction of a congestion charge for passengers travelling to the airport and/or increasing NO_x emission charges to air travel companies for landing high emission aircraft at Heathrow. Jacobs encourage the adoption of any additional measures that prove viable.

4.7 Conclusions

4.7.1 National

Technological improvements with potential to reduce mass emissions have not been applied to all airport activities (see Appendix B for more information). In addition, scheme promoter mitigation measures with potential to reduce mass emissions have not been considered. The effect miigation will have on mass emission estimates will be considered in the second stage assessment.

The NAEI projects UK total emissions of NO_x and $PM_{2.5}$ up to and including the year 2030. These projections include emissions from Heathrow Airport.

UK emissions of NO_x are expected to meet current 2020 Gothenburg Protocol targets in both 2025 and 2030. The baseline NAEI 2025 projections are 86.07% of the current 2020 Gothenburg NO_x targets with the proportion of national emissions increasing to 86.29% with the third runway in 2026. The baseline NAEI 2030 projections are 82.8% of the 2020 Gothenburg NO_x targets with the proportion of national emissions increasing to 83.20% with the third runway. While such contributions are likely to be accommodated in the context of the current Protocol targets; there remains a risk that the Protocol targets themselves may become tighter making any accommodation a greater challenge.

The baseline NAEI 2025 projections are 100.00% of the 2020 Gothenburg $PM_{2.5}$ targets with the proportion of national emissions increasing to 100.10% with the third runway in 2026. The baseline NAEI 2030 projections are 103.51% of the 2020 Gothenburg $PM_{2.5}$ targets with the proportion of national emissions increasing to 103.63% with the third runway in 2030. Emissions of $PM_{2.5}$ attributed to associated airport activities in the Heathrow NWR in 2030 represent almost 9% of the projected exceedance of the current 2020 Gothenburg Protocol target.

The principal source of $PM_{2.5}$ is aircraft fugitive brake and tyre wear and APUs; therefore this is where airport related emission reduction management for $PM_{2.5}$ should be focused. A reduction in $PM_{2.5}$ emissions will be achieved by a greater uptake in fixed ground and electrical power; this effectively cuts back the APU run times per LTO cycle. Reverse thrust will reduce the proportion of aircraft speed reduction from brake and tyre friction, although will have a side effect of greater NO_x emissions per LTO.

4.7.2 Local

Emissions of NO_x, PM_{10} and $PM_{2.5}$ are projected to increase with increased passenger demand without any form of mitigation measures implemented whether they be scheme specific or mitigation as a result of changes to government policy. Aircraft engines are the dominant emission source of NO_x across all assessment years. Aircraft brake and tyre wear is the dominant source of PM_{10} until 2050 when road traffic – airport only becomes the dominant source. Aircraft brake and tyre wear is the dominant source of $PM_{2.5}$ from 2030 to 2040, when road traffic – airport only becomes the dominant source in 2050.

Defra National compliance model and Jacobs' projected NO_2 concentrations were established for the 2030 without scheme baseline. These concentrations take account of vehicle technological improvements, although they do not reflect potential governmental policy or the scheme promoter's mitigation measures with the potential to change air quality. A risk category has been applied (section 2.1.4) which rates the risk of exceeding AQOs and EU Limit Values, for the monitoring and PCM locations should Heathrow NWR cause increases in NO_2 concentrations.

Defra's national modelling indicates there to be a low to likely risk of exceeding annual mean NO_2 EULVs within the Heathrow NWR study area. The likely risk is identified along the A4 at sections of Bath Road Colnbrook-by-pass.. Projected local monitoring also indicates there to be a low to high risk of exceeding annual mean NO_2 AQOs within the same study area. The high risk locations have been identified along the M4, Hillingdon. With sufficiently detailed data for dispersion modelling in the second stage assessment, the evaluation will move from rating the risk of exceedance of AQOs/EULVs, to quantifying whether the impact is sufficient to result in exceedence of AQOs/EULVs at sensitive receptors and the significance of this impact.

Eighteen PM_{10} or $PM_{2.5}$ monitoring sites have been identified within the Heathrow NWR study area. Six of these sites can be directly compared with AQOs and currently do not indicate a risk of exceedence of PM AQOs. Twelve of these sites use monitoring equipment that provides results that cannot be directly compared with AQOs without further processing. While the results at these sites indicate there to be no risk of exceedance without any suggested mitigation measures being in place, these sites are to be subject to further assessment in order to confirm this position.

While there is no well-established method for projecting local PM_{10} monitoring data to future years, concentrations are anticipated to decline as can be seen in national background mapping[28] and emission factor projections[29]. As such it is reasonable to conclude with the information available, that there will continue to be no risk of exceeding PM_{10} AQOs in the future.

Mitigation of road traffic emissions may be required along Bath Road, A4 and the M4, Hillingdon. Such mitigation will be dependent the magnitude of any potential impacts at these locations and the viability of its implementation, but may include traffic management and/or rerouting. Both the with and without mitigation scenarios for Heathrow NWR will be assessed in the second stage assessment. The necessity of mitigation at a local air quality level will be determined by the supplementary results from dispersion modelling. This will establish whether mitigation is required to improve local air quality concentrations within EULVs and/or AQOs.

4.7.3 Monetisation

At the current stage of air quality analysis, monetisation of damage costs has been undertaken on a mass emissions basis, following the Air Quality Appraisal – Damage Cost methodology published by the Defra and the Interdepartmental Group on Costs and Benefits, Air Quality Subject Group.

The total cost of NO_x and PM_{10} over the 60 year appraisal period is £121.2m and £373.1m, respectively. The damage costs spanning over milestone appraisal periods can be found in Appendix D Table 2.

At the second stage assessment, the change in local air quality concentrations modelled for sensitive receptors (human health and ecosysems) associated with airport expansion will be used to determine the cost of local air quality impacts.

[28] http://uk-air.defra.gov.uk/data/laqm-background-maps?year=2011
[29] http://laqm.defra.gov.uk/review-and-assessment/tools/emissions-factors-toolkit.html

5 Heathrow Airport Extended Northern Runway

This Section covers:

- Study Area
- National Assessment
  - Total mass emissions of key pollutants associated with airport activity
- Local Assessment
  - Proportions of mass emissions of key pollutants associated with airport activity and risk evaluation for EULVs/AQOs
- Monetisation
- Mitigation
- Commentary on Scheme Promoter's Submission
- Conclusion

5.1 Study Area

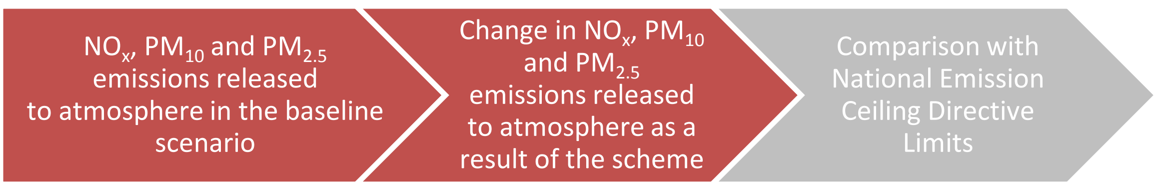
There are populated areas within the study area for the Heathrow Airport Extended Northern Runway (Heathrow ENR) scheme (see Appendix F: Figure 6). In addition, there are also a number of statutory sites of nature conservation importance.

A review of designated sites sensitive to changes in air quality within the baseline study area was undertaken using APIS. This identified the following sites: Staines Moor (SSSI), Wraysbury Reservoir (SSSI) and South West London Waterbodies (SPA).

Natural England's Aviation Sensitivity Mapping identified as potentially sensitive to air quality impacts: Wraysbury No.1 Gravel Pit, Wraysbury & Hythe End Gravel Pits, Staines Moor and Kempton Park Reservoirs.

These sites are likely to be mostly influenced by road traffic emissions. It will be necessary to assess the impact of the proposed scheme on road traffic emissions in the vicinity of these sites and the impacts of Nitrogen deposition as part of the second stage assessment.

5.2 National



5.2.1 Change in Total Mass Emissions

National Atmospheric Emissions Inventory (NAEI) projections have been used to report the UK's status on compliance with the NECD and Gothenburg Protocol. NAEI projections up to 2030 (AEA, 2012) are presented in Table 5.1. There are no NAEI projections for PM_{10} as this pollutant is not prescribed under the NECD or Gothenburg Protocols. However, the EC is currently revising its National Emissions Ceilings Directive for EU countries, with much tighter ceilings proposed for 2030. The UK could have tighter limits in 2030 meaning that any targets may be more difficult to achieve. NAEI projections present national emission projections in five year intervals covering the relevant years for the scheme in 2030 only. Projections for 2025 have been used as the background for 2026.

Table 5.1 – NAEI NO_x and $PM_{2.5}$ emission projections for the UK

kilotonnes / year (kt/y)	NO_x		$PM_{2.5}$	
	2025	2030	2025	2030
Gothenburg Protocols' 2020 emission targets	711		57	
NAEI emission pollutant projections	612	589	57	59
NAEI projection % of Gothenburg Protocol targets	86.07%	82.8%	100.00%	103.51%
NAEI projection + change associated with Heathrow ENR % of Gothenburg Protocol targets	86.29%	83.21%	100.10%	103.63%

Observations:

- Projected UK emissions include emissions from Heathrow Airport;
- UK emissions of NO_x are projected to meet current 2020 Gothenburg Protocol targets in both 2025 and 2030; and
- The change in $PM_{2.5}$ associated with Heathrow NWR in 2026 causes UK emissions to exceed the 2020 emission target by 0.1% and the 2030 UK exceedence to increase by 0.12% relative to the 2020 emission target.

Table 5.2 presents the total mass emissions (tonnes per annum) that have been calculated and attributed to associated airport activities in the Heathrow ENR baseline and the change associated with the Do Something scenario without any mitigation in place. Technological improvements with potential to reduce mass emissions have not been applied to all airport activities (see Appendix B for more information). In addition, scheme promoter mitigation measures with potential to reduce mass emissions have not been considered. The effect mitigation will have on mass emission estimates will be considered in the second stage assessment.

Table 5.2 - Heathrow ENR total annual air pollutant mass emissions

kt/y	NO_x			PM_{10}			$PM_{2.5}$		
	2030	2040	2050	2030	2040	2050	2030	2040	2050
Baseline 2R Total	11.0	10.3	8.7	0.135	0.124	0.111	0.104	0.097	0.086
Change due to ENR Scheme	2.6	3.4	2.8	0.09	0.10	0.05	0.07	0.08	0.04
New % of Total UK Projection	2.3	-	-	-	-	-	0.3	-	-

Observations:

- Do Something annual NO_x emissions by mass represent 2.3 percent of the entire NO_x emissions projected for the UK in 2030, an increase of six tenths of a percent from the Baseline;

- $PM_{2.5}$ emissions are a sub-set of PM_{10} emissions and represent approximately three tenths of a percent of the entire $PM_{2.5}$ emissions projected for the UK in 2030 in the Do Something scenario; and

- Emissions of all pollutants increase between 2030 and 2040; this is due to increases in airport activity offsetting improvements in emissions from using a cleaner fleet.

5.2.2 Evaluation

The baseline NAEI 2025 projections are 86.07% of the 2020 Gothenburg NO_x targets with the proportion of national emissions increasing to 86.29% with the third runway in 2026.

The baseline NAEI 2030 projections are 82.8% of the 2020 Gothenburg NO_x targets with the proportion of national emissions increasing to 83.21% with the third runway in 2030.

While such contributions are likely to be accommodated in the context of the current Protocol targets; there remains a risk that the Protocol targets themselves may become tighter making any accommodation a greater challenge.

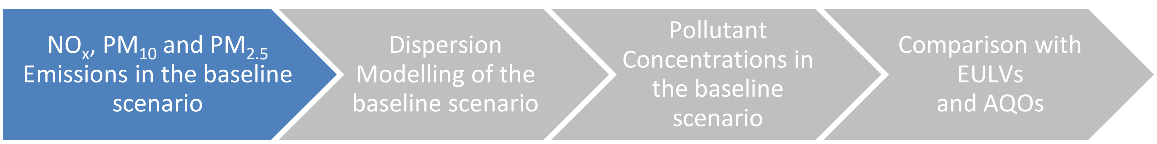
The baseline NAEI 2025 projections are 100.00% of the 2020 Gothenburg $PM_{2.5}$ targets with the proportion of national emissions increasing to 100.10% with the third runway in 2026.

The baseline NAEI 2030 projections are 103.51% of the 2020 Gothenburg $PM_{2.5}$ targets with the proportion of national emissions increasing to 103.63% with the third runway in 2030.

Emission of $PM_{2.5}$ attributed to associated airport activities in the Do Something scenario in 2030 represent almost 9% (0.07 kt/yr) of the projected exceedance of the current 2020 Gothenburg Protocol target.

5.3 Local

5.3.1 Change in Mass Emissions broken down into proportions



Note: It is not just the total mass of emissions, but also the distance from the source to the receptor which causes poor air quality. This is why air quality surrounding roads are currently the focal point for air quality studies. Consequently, sensitive receptors (human health and ecosystems) within close proximity to heavily polluting roads will experience poor air quality (NO_2, NO_x and PM concentrations).

Table 5.3 presents NO_x mass emissions (tonnes per annum) that have been calculated and attributed to associated airport activities in the Do Something scenario. These are compared with baseline mass emissions. Technological improvements with potential to reduce mass emissions have not been applied to all airport activities (see Appendix B for more information). In addition, scheme promoter mitigation measures with potential to reduce mass emissions have not been considered. The effect this will have on mass emission estimates will be considered in the second stage assessment.

Table 5.3 – Heathrow ENR annual air pollutant mass emissions by source

tonnes / year (t/y)	NO_x					
	Baseline			Change due to Scheme		
Emission Source	2R 2030	2R 2040	2R 2050	3R 2030	3R 2040	3R 2050
Aircraft engine	10,168.8	9,544.2	7,924.7	2,249.4 (+22 %)	2,909.2 (+30 %)	2,503.2 (+32 %)
Brake and tyre wear	-	-	-	-	-	-
APU	293.7	233.0	217.2	77.0 (+26 %)	121.6 (+52 %)	76.8 (+35 %)
GSE	278.6	258.0	281.2	227.2 (+82 %)	273.6 (+106 %)	140.1 (+50 %)
Road traffic – airport only*	253.7	264.7	279.4	64.5 (+25 %)	93.3 (+35 %)	98.5 (+35 %)
Total	10,994.8	10,299.9	8,702.5	2,618.2 (+24%)	3,397.8 (+33 %)	2,818.5 (+32 %)

**** Airport only includes fugitive emissions from surface access***

Table 5.4 presents PM_{10} emissions (tonnes per annum) that have been calculated and attributed to associated airport activities in the Do Something scenario. These are compared with baseline mass emissions.

Table 5.4 – Heathrow ENR annual PM_{10} mass emissions by source

tonnes / year (t/y)	PM_{10}					
	Baseline			Change due to Scheme		
Emission Source	2R 2030	2R 2040	2R 2050	3R 2030	3R 2040	3R 2050
Aircraft engine	27.9	27.8	26.2	10.0 (+36%)	11.6 (+42%)	9.4 (+36%)
Brake and tyre wear	51.8	41.8	26.7	59.6 (+115%)	59.8 (+143x%)	15.0 (+56%)
APU	7.7	7.6	7.3	2.4 (+31%)	3.1 (+41%)	3.0 (+41%)
GSE	17.2	16.0	17.4	13.8 (+80%)	16.6 (+104%)	8.6 (+49%)

Road traffic – airport only*	30.0	31.3	33.0	7.6 (+25%)	11.0 (+35%)	11.6 (+35x%)
Total	134.5	124.4	110.5	93.5 (+70%)	102.2 (+82%)	47.7 (+43%)

Airport only includes fugitive emissions from surface access

Table 5.5 presents $PM_{2.5}$ emissions (tonnes per annum) that have been calculated and attributed to associated airport activities in the Do Something scenario. These are compared with baseline mass emissions.

Table 5.5 - Heathrow ENR annual $PM_{2.5}$ mass emissions by source

tonnes / year (t/y)	$PM_{2.5}$					
	Baseline			Change due to Scheme		
Emission Source	2R 2030	2R 2040	2R 2050	3R 2030	3R 2040	3R 2050
Aircraft engine	27.9	27.8	26.2	10 (+36%)	11.6 (+42%)	9.4 (+36x%)
Brake and tyre wear	36.2	29.2	18.7	41.7 (+115%)	41.9 (+143%)	10.5 (+56%)
APU	7.7	7.6	7.3	2.4 (+x31%)	3.1 (+41%)	3 (+41%)
GSE	15.0	13.9	15.1	11.8 (+79x%)	15.8 (+114%)	8.7 (+58%)
Road traffic – airport only*	17.4	18.2	19.2	4.4 (+25%)	6.4 (+35%)	6.8 (+35%)
Total	104.2	96.7	86.5	70.4 (+68%)	78.8 (+81%)	38.4 (+44%)

(a) Road traffic emissions – Sensitivity Testing

Road traffic - airport only emission changes are based on passenger growth estimates provided by the scheme promoter. Sensitivity testing of road traffic emissions change estimates was undertaken using an Assessment of Need Carbon Capped scenario from the Airports Commission (AoN CC).

The sensitivity testing showed that road traffic - airport only emissions changes, provided in Table 5.3, were 16%, 9% and 9% higher respectively than AoNCC emission change estimates for mass emissions of NO_x in 2030, 2040 and 2050.

The testing also showed that road traffic - airport only emission changes, provided in Table 5.4 and Table 5.5, were 13/14%, 7% and 7% higher respectively than AoNCC emission change estimates for mass emissions of Particulate Matter (PM_{10} and $PM_{2.5}$) in 2030, 2040 and 2050..

The emissions are higher because a greater net change in traffic flows have been forecast with the scheme demand forecast and modal share adjustment factor. These traffic modelling inputs will be entered in a dynamic traffic model and the resulting traffic data will be modelled within the second stage assessment to confirm current findings.

A lower road emissions change with Heathrow ENR AoNCC scenario would mean a smaller change in air quality concentrations. AoN CC is presented in Demand Forecast Scenarios and Emissions Appendix E: Table 3.

(b) Emissions contributions from the different airport sources

Figures 5.1 to 5.3 show the source apportionment across the different airport emissions sources for each of the three pollutants.

Figure 5.1 - NO_x annual mass emissions source apportionment

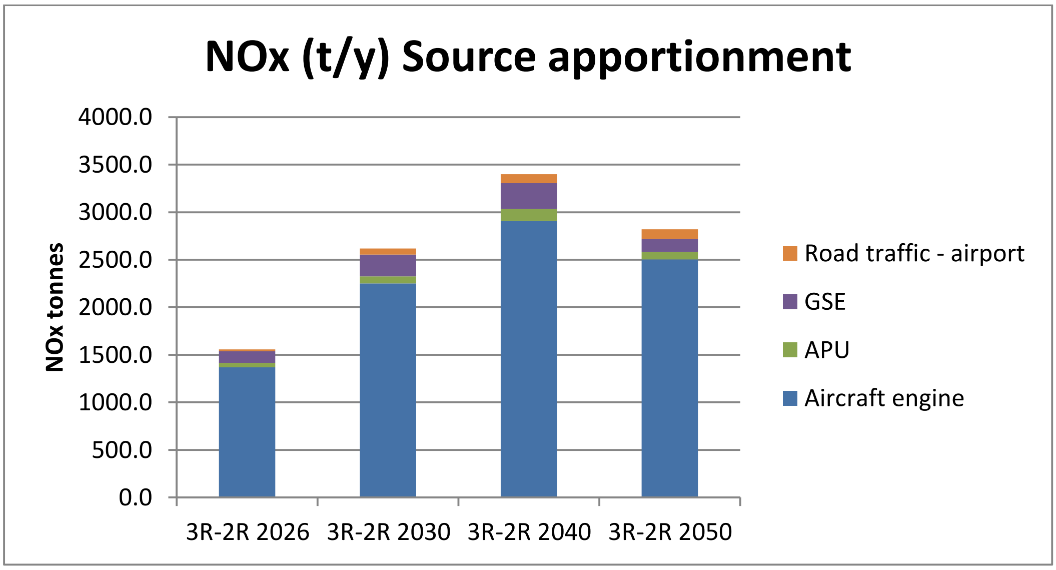


Figure 5.2 - PM_{10} annual mass emissions source apportionment

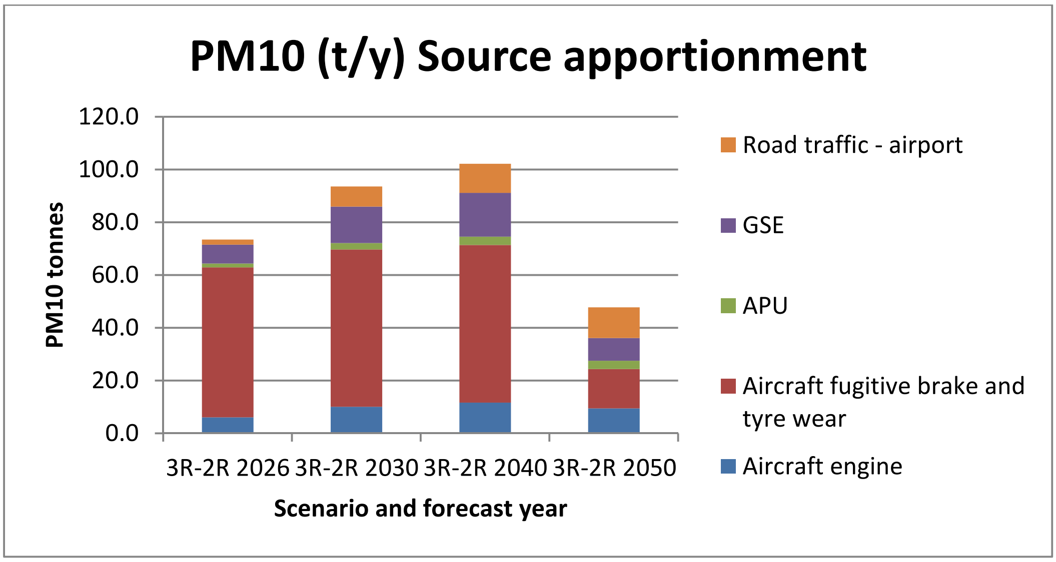
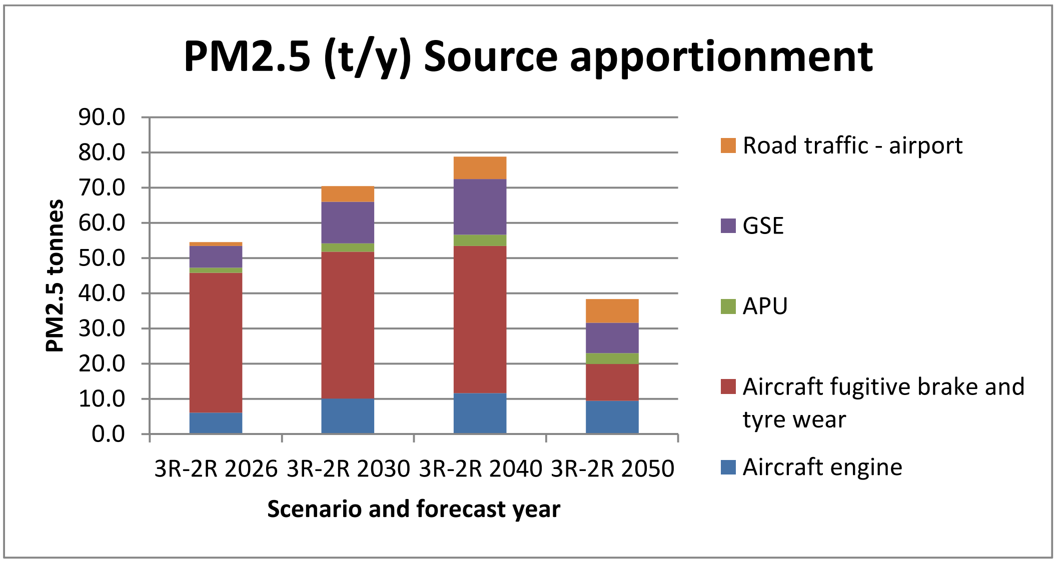


Figure 5.3 - $PM_{2.5}$ annual mass emissions source apportionment



Observations:

- Increases in NO_x emissions are expected to rise from 24% in 2030 to up to 33-32% in 2040 and 2050 without mitigation. The largest change in emissions are anticipated to come from aircraft engines rising from an additional 2,250 tonnes per annum in 2030 up to a peak in 2040 of 2,909 tonnes per annum before decreasing towards 2050 with 2,503 tonnes per annum. This occurs as fleet rollover in later forecast years aircraft fleet mix is cleaner. Proportionally the largest increase will be in GSE emissions which are anticipated to increase by 82% in 2030 up to 102% in 2040 before reducing to 50% in 2050.

- Increases in PM_{10} emissions are expected to rise from 70% in 2030 to up to 82% in 2040 before decreasing in 2050 to 43%. The largest change in emissions is anticipated to come from aircraft brake and tyre wear rising from an additional 59.6 tonnes in 2030 to up to 59.8 tonnes in 2040 with a decrease to 15 tonnes in 2050. As aircraft with higher emissions rates per LTO cycle are removed from the fleet mix.This occurs as fleet rollover in later forecast years aircraft fleet mix is cleaner. Proportionally the largest increase will be in aircraft brake and tyre wear which are anticipated to increase by 115% in 2030 up to 143% in 2040 and decreases to 56% in 2050.

- Increases in $PM_{2.5}$ emissions are expected to rise from 68% in 2030 to up to 81% in 2040 before decreasing in 2050 to 44%. The largest change in emissions is anticipated to come from aircraft brake and tyre wear rising from an additional 41.7 tonnes in 2030 to up to 41.9 tonnes in 2040 with a decrease to 10.5 tonnes in 2050. This occurs as fleet rollover in later forecast years aircraft fleet mix is cleaner. Proportionally the largest increase will be in aircraft brake and tyre wear which are anticipated to increase by 115% in 2030 up to 143% in 2040 and decreases to 56% in 2050.

5.3.2 Summary of sensitivity of receiving environment

(a) National Modelling and EULVs

Table 5.6 presents Defra's PCM modelled road links concentrations established within the Gatwick baseline report (Jacobs, 2014a). The Defra PCM concentrations, presented below, are the baseline 2030 air quality concentrations associated with emission sources within the local area, adjusted for Euro 6/VI vehicle and aircraft engine technological improvements (see section 2.1.3). They do not reflect the potential for government policy or scheme promoter's mitigation measures to change local air quality concentrations. A risk category has been applied (section 2.1.4) to rate the PCM locations' risk of exceeding EU Limit Values should should Heathrow ENR cause increases in NO_2 concentrations.

For one PCM location (Bath Road, A4), annual mean NO_2 concentrations are predicted to be a likely risk of exceeding the NO_2 EU limit value of 40µg/m^3. While at other locations within the study area the risk is low. These PCM links can be seen within Appendix F: Figure 6.

With sufficiently detailed data to enable dispersion modelling in the second stage assessment, the evaluation of PCM locations exceeding EULVs will move from categoring risk to EULVs, to quantifying whether the impact is sufficient to exceed EULVs. This assessment will be used to inform the overall significance of Heathrow ENR.

Table 5.6 - PCM baseline 2030 modelled road links within the study area and risk of limit exceedancescheme risk category with Heathrow ENR

Road	Baseline 2030 Modelled PCM Annual Mean NO_2 (µg/m^3)	With scheme - Unmitigated Risk Category
BATH ROAD, A4	43.2	Likely
COLNBROOK BY-PASS, A4	42.9	Likely
THE PARKWAY, A312	31.2	Low
GREAT SOUTH-WEST ROAD, A30	30.0	Low

Note: Current PCM projections have been undertaken with the Emission Factor Toolkit (EFT) V5.2c, which was superseded in June 2014 by EFT V6.01. The latest EFT revises overly optimistic uptake rates of Euro VI vehicles in the future fleet mix, which is likely to increase projected emissions and predict higher pollution concentrations. This has been accounted for in Jacobs' classification of Risk by including NO_2 concentrations between 30-36µg/m^3 within the low risk category

Defra's latest report to the EU on EULV compliance confirms that EULVs for PM_{10} are currently being met in all Zones within the UK. It also confirms that the target value for $PM_{2.5}$ is also being met; but concedes that by 2020 one Zone (Greater

London Urban Area) is unlikely to currently meet the Stage 2 EULV, even after the subtraction of the natural contribution. In the latest available year (2012) the PCM model has calculated there were no roadside locations within the Heathrow ENR study area that exceed the annual mean PM_{10} or $PM_{2.5}$ EULVs. While the PCM model does predict concentrations of PM in future years, these data are not currently published.

(b) Local Monitoring and AQOs

Note: Air pollution concentration data described by PCM modelling and local monitoring are mutually exclusive. There may be locations where projected locally monitored pollution concentrations and forecast nationally modelled pollution concentrations do not agree; this represents uncertainty in predicting future air quality.

Table 5.7 presents projected NO_2 monitoring data established within the Air Quality: Baseline report (Jacobs, 2014a). The projected baseline 2030 NO_2 concentrations take account of a cleaner motor vehicle fleet mix (see section 2.1.3) but do not reflect government policy or scheme promoter mitigation measures with the potential to change air quality. A risk category has been applied (section 2.1.4) which rates the risk of exceeding AQOs at the monitoring locations should Heathrow ENR cause increases in NO_2 concentrations.

For 2030, projected local monitoring data shows that at locations along the M4 (Cont_HD2) at London Hillingdon, approximately 1.8km from the existing site boundary, annual mean NO_2 concentrations are predicted to be a likely risk of exceeding the NO_2 AQO of $40 \mu g/m^3$; the dominant source of emissions at this site is from road traffic. While at other locations within the study area, the risk is low to unlikely. These monitoring locations can be seen in Appendix F: Figure 9.

With sufficiently detailed data for dispersion modelling in the second stage assessment, the evaluation of exceeding AQOs will move from rating the risk of projected monitoring locations exceeding based upon required increase to reach AQOs, to quantifying whether the impact is sufficient to result in exceedence of AQOs at sensitive receptors and the significane of this impact.

Local Authorities are required to Review and Assess air quality within their jurisdiction. If the findings of this review determine that air quality concentrations are exceeding AQOs then Air Quality Management Areas (AQMAs) need to be established to an Action Plan to actively manage factors causing poor air quality. AQMAs have not formed the basis to establish areas at risk of or exceeding AQOs, as these are based upon current monitoring data. The monitoring locations that are within an AQMA have been identified with an asterix within Table 4.8, the rest of the monitoring locations are within Appendix C: Table C3. The projected monitoring data shows that there is a location within AQMAs that is still at a high risk of exceeding NO_2 AQOs in 2030.

The monitoring data that has had the IAN/170v3 projection factors applied takes account of the reductions predicted as a result of Euro 6/VI vehicles penetration into the UK fleet mix and is considered a more realistic identification of areas sensitive to changes in air quality in NO_2 concentrations. However, other future local or national air quality mitigation measures, such as London’s proposed Ultra Low Emission Zone (ULEZ) are not included.

Table 5.7 Study Area for Heathrow Airport - Projected annual mean NO_2 air quality monitoring data concentration: 2030

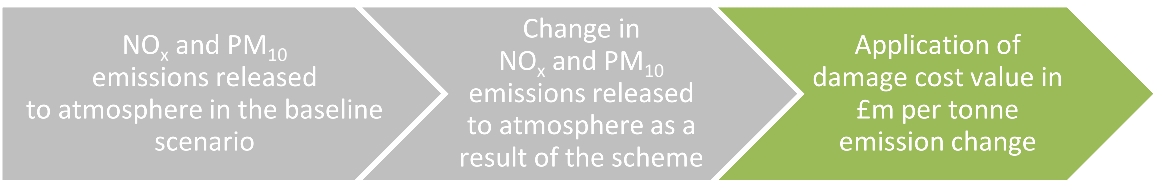
Local Authority Site ID	Monitoring Location	Annual Mean NO_2 (µg/m^3)	Unmitigated Risk Category
HD71*	Oxford Avenue, Cranford	24.3	Unlikely
Cont_HD1*	London Heathrow LHR2	31.7	Low
Cont_HD2*	London Hillingdon	37.8	High
SP14*	Flintlock Close, Stanwell	19.0	Unlikely
SP48*	Riverside Road, Stanwell	21.8	Unlikely

* denotes monitoring locations that are currently within AQMAs

Eighteen PM_{10} or $PM_{2.5}$ monitoring sites have been identified within the Heathrow ENR study area. Six of these sites can be directly compared with AQOs and currently do not indicate a risk of exceedence of PM AQOs. Twelve of these sites use monitoring equipment that provides results that cannot be directly compared with AQOs without further processing. This is due to monitoring equipment used at these locations not having successfully met equivalency requirements for reporting to the same Standards as Gravimetric-type devices (measure the mass of particulate matter). While the results at these sites do not indicate there to be a risk of exceedance without mitigation measures from the scheme or changes to government policy, these sites are to be subject to further review by Jacobs in order to confirm this position.

While there is no well-established method for projecting local PM_{10} monitoring data to future years, concentrations are anticipated to decline as can be seen in national background mapping[30] and emission factor projections[31]. As such it is reasonable to conclude that there will also continue to be no risk of exceeding PM_{10} AQOs in the future.

5.4 Monetisation



At the current stage of air quality analysis, monetisation of damage costs has been undertaken on a mass emissions basis, following the Air Quality Appraisal – Damage Cost methodology published by the Defra and the Interdepartmental Group on Costs and Benefits, Air Quality Subject Group.

Defra's damage cost for a tonne of NO_x[32] with 2010 prices is £955. This unit value is fixed across all areas of the UK and remains the same for all emission sources.

[30] http://uk-air.defra.gov.uk/data/laqm-background-maps?year=2011
[31] http://laqm.defra.gov.uk/review-and-assessment/tools/emissions-factors-toolkit.html
[32] NOx emissions value is on a national basis.

After the gross domestic product (GDP) uplift in today prices this equates to approximately £1,037 per tonne. The emissions value assigned to NO_x is on a national basis.

The cost placed on a tonne of PM_{10} is dependent on the area within the UK the pollutant is being emitted within and the source of the pollutant and has some local inputs to it.Further adjustment has been made to take into account macro-economic changes to future appraisal dates unit value per tonne.

The total cost of NO_x and PM_{10} over the 60 year appraisal period is £107.9m and £341.5m, respectively. The damage costs spanning over milestone appraisal periods can be found in Appendix D Table 3.

At the second stage assessment the change in local air quality concentrations modelled at sensitive receptors (human health and ecosysems) associated with airport expansion will be used to determine the cost of local air quality.

5.5 Mitigation

5.5.1 National

Heathrow ENR operational emissions are not forecast to result in delays for compliance with the current 2020 Gothenburg Protocol NO_x targets. The UK exceeds the $PM_{2.5}$ emission ceiling target value in 2025 and 2030. No matter what mitigation measures Heathrow Hub implements the airport expansion will result in some increases in $PM_{2.5}$. However, these are a small proportion of total UK emissions and represent 0.1% and 0.12% increase in the UK's 2025 and 2030 emissions relative to 2020 Gothenburg Protocol emission targets.

The principal source of $PM_{2.5}$ is aircraft fugitive brake and tyre wear and APUs, therefore this is where airport related emission reduction management for $PM_{2.5}$ should be focused. A reduction in $PM_{2.5}$ emissions will be achieved by a greater uptake in fixed ground and electrical power; this effectively cuts back the APU run times per LTO cycle. Reverse thrust will reduce the proportion of aircraft speed reduction from brake and tyre friction, although will have a side effect of greater NO_x emissions per LTO.

5.5.2 Local

Mitigation of road traffic emissions may be required along Bath Road, A4 and the M4, Hillingdon. Such mitigation will be dependent the magnitude of any potential impacts at this location and the viability of its implementation, but may include traffic management and/or rerouting. The necessity of mitigation at a local air quality level will be determined by the supplementary results from dispersion modelling. This will establish whether mitigation is required to improve local air quality concentrations within AQOs and EU limit values.

5.6 Commentary on Scheme Promoter's Submission

Commentary on the scheme promoter's submission has been made limited to committed mitigation measures. The Heathrow ENR scheme promoter did not submit a mass emissions inventory and the impact assessment comprised a review of existing Air Quality Management Areas (AQMAs) and existing monitoring data;

consequently no comparisons can be made with Jacobs' independent review at this time.

5.6.1 Scheme Promoter's Mitigation

The following Mitigation Measures are committed by the Scheme Promoter; Jacobs' comments are included below each measure.

- 'Embedded mitigation' the modal shift of passengers travelling by public transport is proposed to increase from 38% to 50%.
  - Partially agree - if the modal shift is entirely accounted for by the scheme promoter's proposed transport developments.
- Adjusting the proposed infrastructure layout to increase distance between source and receptors.
  - Agree - the greater the distance between the emission source and receptor, the lower concentrations will be for all pollutants.
- Incorporate the use of ventilation systems within the M25 tunnel away from sensitive receptors.
  - Agree - this will reduce the concentrations of pollutants at sensitive receptors close to the tunnel portals. Detailed dispersion modelling will be required to establish whether mitigation is necessary and if mitigation can yield required reductions to bring pollutants under AQOs.
- The extended runway will move take-offs further away from the airport boundary.
  - Agree – the greater the distance between the emission source and receptor, the lower concentrations will be for all pollutants.
- Development of take-off, landing and taxiing schedule to reduce emissions.
  - Agree – if this could be implemented accounting for capacity constraints. It could reduce the fuel used for APUs and aircraft engines and in turn emissions.
- Incentivising airlines to use cleaner aircraft through the use of landing charges.
  - Partially agree – as long as the financial incentive to use cleaner aircraft at Heathrow is sufficient to encourage the purchase of less polluting aircraft to land at Heathrow.
- Providing fixed ground electrical points and preconditioned air
  - Partially Agree – this will reduce APU emissions during time at stand and taxiing; however it will depend on the energy source - if the energy is supplied by on site combustion electricity generation, e.g. biomass, this could worsen local air quality.
- Provide low emission or electric airside support vehicles.
  - Agree – this will reduce pollutant emissions as site of use.

5.7 Conclusions

5.7.1 National

Technological improvements with potential to reduce mass emissions have not been applied to all airport activities (see AppendixB for more information). In addition scheme promoter mitigation measures with potential to reduce mass emissions have not been considered. The effect mitigation will have on mass emission estimates will be considered in the second stage assessment.

The NAEI projects UK total emissions of NO_x and $PM_{2.5}$ up to and including the year 2030. These projections include emissions from Heathrow Airport.

UK emissions of NO_x are expected to meet current 2020 Gothenburg Protocol targets in both 2025 and 2030. The baseline NAEI 2025 projections are 86.07% of the 2020 Gothenburg NO_x targets with the proportion of national emissions increasing to 86.29% with the third runway. The baseline NAEI 2030 projections are 82.8% of the 2020 Gothenburg NO_x targets with the proportion of national emissions increasing to 83.20% with the third runway. While such contributions are likely to be accommodated in the context of the current Protocol targets; there remains a risk that the Protocol targets themselves may become tighter making any accommodation a greater challenge.

The baseline NAEI 2025 projections are 100.00% of the 2020 Gothenburg $PM_{2.5}$ targets with the proportion of national emissions increasing to 100.10% with the third runway in 2026. The baseline NAEI 2030 projections are 103.51% of the 2020 Gothenburg $PM_{2.5}$ targets with the proportion of national emissions increasing to 103.63% with the third runway in 2030. Emissions of $PM_{2.5}$ attributed to associated airport activities in the Heathrow NWR in 2030 represent almost 9% of the projected exceedance of the current 2020 Gothenburg Protocol target.

The principal source of $PM_{2.5}$ is aircraft fugitive brake and tyre wear and APUs; therefore this is where airport related emission reduction management for $PM_{2.5}$ should be focused. A reduction in $PM_{2.5}$ emissions will be achieved by a greater uptake in fixed ground and electrical power; this effectively cuts back the APU run times per LTO cycle. Reverse thrust will reduce the proportion of aircraft speed reduction from brake and tyre friction, although will have a side effect of greater NO_x emissions per LTO.

5.7.2 Local

Emissions of NO_x, PM_{10} and $PM_{2.5}$ are projected to increase with increased passenger demand without any form of mitigation measures implemented whether they be scheme specific or mitigation as a result of changes to government policy.. Aircraft engines are the dominant emission source of NO_x across all assessment years. Aircraft brake and tyre wear is the dominant source of PM_{10} until 2050 when road traffic – airport only becomes the dominant source. Aircraft brake and tyre wear is the dominant source of $PM_{2.5}$ from 2030 to 2040, when road traffic – airport only becomes the dominant source in 2050.

Defra's National compliance model and Jacobs' projected NO_2 concentrations were established for the 2030 baseline.. These concentrations take account of vehicle technological improvements, although they do not reflect potential governmental policy or the scheme promoter's mitigation measures with the potential to change air quality.. . A risk category has been applied (section 2.1.4) which rates the risk of exceeding AQOs and EU Limit Values, for the monitoring and PCM locations should Heathrow ENR cause increases in NO_2 concentrations.

Defra's national modelling indicates there to be a low to likely risk of exceeding annual mean NO_2 EULVs within the Heathrow ENR study area. The likely risk is identified along the A4 (Bath Road Colnbrook-by-pass). Projected local monitoring also indicates there to be a low to high risk of exceeding annual mean NO_2 AQOs within the same study area. The high risk locations have been identified along the M4, Hillingdon. With sufficiently detailed data for dispersion modelling in the second stage assessment, the evaluation of exceeding AQOs/EULVs will move from rating the risk of locations exceeding AQOs/EULVs, to quantifying whether the impact is sufficient to result in exceedence of AQOs/EULVs at sensitive receptors and the significane of this impact.

Eighteen PM_{10} or $PM_{2.5}$ monitoring sites have been identified within the Heathrow ENR study area. Six of these sites can be directly compared with AQOs and currently do not indicate a risk of exceedence of PM AQOs. Twelve of these sites use monitoring equipment that provides results that cannot be directly compared with AQOs without further processing. While the results at these sites indicate there to be no risk of exceedance without any suggested mitigation measures being in place, these sites are to be subject to further assessment in order to confirm this position.

While there is no well-established method for projecting local PM_{10} monitoring data to future years, concentrations are anticipated to decline as can be seen in national background mapping[33] and emission factor projections[34]. As such it is reasonable to conclude with the information available, that there will continue to be no risk of exceeding PM_{10} AQOs in the future.

Mitigation of road traffic emissions may be required along Bath Road, A4 and the M4, Hillingdon. Such mitigation will be dependent the magnitude of any potential impacts at this location and the viability of its implementation, but may include traffic management and/or rerouting. The necessity of mitigation at a local air quality level will be determined by the supplementary results from dispersion modelling. This will establish whether mitigation is required to improve local air quality concentrations within EULVs and/or AQOs.

5.7.3 Monetisation

At the current stage of air quality analysis, monetisation of damage costs has been undertaken on a mass emissions basis, following the Air Quality Appraisal – Damage Cost methodology published by the Defra and the Interdepartmental Group on Costs and Benefits, Air Quality Subject Group.

The total cost of NO_x and PM_{10} over the 60 year appraisal period is £107.9m and £341.5m, respectively. The damage costs spanning over milestone appraisal periods can be found in Appendix D Table 3.

At the second stage assessment, the change in local air quality concentrations modelled for sensitive receptors (human health and ecosysems) associated with airport expansion will be used to determine the cost of local air quality impacts.

[33] http://uk-air.defra.gov.uk/data/laqm-background-maps?year=2011
[34] http://laqm.defra.gov.uk/review-and-assessment/tools/emissions-factors-toolkit.html

6 Further Work

This Section covers:

- the additional work which will be undertaken when dynamic traffic modelling data is available which will allow further analysis to be completed including advanced dispersion modelling

The Do Minimuim and Do Something scenarios will continue to be refined during the consultation period taking advantage of any additional relevant information that feeds into the assessment process.

This work will include:

- Study areas
  - The geographical scope of the baseline and impact assessments will be refined during the consultation period taking advantage of any additional relevant information that feeds into the assessment process. This will include an extended desk-based review of existing ambient air quality conditions across the entire extent of the current traffic data network using local monitoring data.
  - A review of traffic changes on routes of new proposed surface access (such as alterations to the M23 slip road, and the introduction of an M25 tunnel) and all existing surface access routes will also be undertaken.

- Advanced dispersion modelling
  - The mass emissions methodology will be enhanced to incorporate detailed dispersion modelling of all emission sources required to calculate exposure to pollutant concentrations at relevant receptors (human health and ecosystems).
  - This will be conducted in accordance with the processes, practices and datasets specified in Local Air Quality Management, Technical Guidance LAQM.TG(09) (DEFRA, 2009).

- Non-airport related sources in the local area surrounding the airport
  - Non-airport related sources of pollutants of concern will be identified using national maps of background concentrations. These concentrations will be included as part of the advanced dispersion modelling.

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Glossary

The following table lists and explains key technical terms used in this report.

GLOSSARY	
AADT	Annual Average Daily Traffic (vehicles per day)
AADF	Annual Average Daily Flow (vehicles per day)
AQMA	Air Quality Management Area
AURN	Automatic Urban and Rural Network (air quality monitoring)
BAM	Beta Attenuation Monitor
CO	Carbon Monoxide
Defra	Department for Environment, Food and Rural Affairs
DfT	Department for Transport
DMRB	Design Manual for Roads and Bridges, produced by the Highways Agency
EF	Emission Factor
EFD	Emissions Factor Database
EFT	Emissions Factor Toolkit
EPER	European Pollutant Emissions Register
GIS	Geographical Information Systems
GPS	Global Positioning System
HDV Vehicles	Heavy Duty Vehicles, ie, all vehicles more than 3.5 tonnes including Heavy Goods and buses
HGV	Heavy Goods Vehicles
IPC	Intregrated Pollution Control
IPPC	Integrated Pollution Prevention and Control
kph	Kilometres per hour
LAEI	London Atmospheric Emission Inventory
LAPPC	Local Air Pollution Prevention and Control
LAQM	Local Air Quality Management
LDF	Local Development Framework
LDV	Light Duty Vehicles
LGV	Light Goods Vehicles
mppa	million passengers per annum
NATS	National Air Traffic Services

NAEI	National Atmospheric Emissions Inventory
NFR	Nomenclature For Reporting
NO	Nitrogen monoxide, also termed Nitric oxide
NO_2	Nitrogen dioxide
NOX	Nitrogen oxides (NO + NO_2)
NTM	National Traffic Model
O_3	Ozone
OS	Ordnance Survey
PAHs	polycyclic aromatic hydrocarbons
PM_{10}	Airborne particulate matter passing a sampling inlet with a 50% efficiency cut-off 10 µm aerodynamic diameter and which transmits particles of below this size
$PM_{2.5}$	Airborne particulate matter passing a sampling inlet with a 50% efficiency cut-off 2.5 µm aerodynamic diameter and which transmits particles of below this size
ppb	Parts per billion (1,000,000,000)
ppm	Parts per million (1,000,000)
QA/QC	Quality Assurance and Quality Control
RDS	Regional Development Strategy
RMSE	Root Mean Square Error
RSD	Relative Standard Deviation
SO2	Sulphur dioxide
SSF	Smokeless Solid Fuel
STP	Standard Temperature and Pressure
TEOM	Tapered Element Oscillating Microbalance
TRAMAQ	TRAffic Management and Air Quality Research Programme
TRC	Traffic Regulation Condition
TSP	Total Suspended Particulate
UVF	Ultra-Violet Fluorescence
VCM	Volatile Correction Model
VOC	Volatile organic compound

Appendix A: Key Air Pollutants and Health Effects

Nitrogen oxide (NO_x),

NO_2 is a colourless, odourless gas which has been shown to have adverse health effects including causing respiratory irritation in asthmatics. There is believed to be a threshold at which it has an impact. It is formed principally from the oxidation of nitric oxide (NO) through the action of ozone in the atmosphere. Combustion in air forms mainly NO and with some NO_2 (collectively termed 'NO_x') from the combination of atmospheric nitrogen and oxygen. NOx emitted from internal combustion engines as well as other forms of combustion and formed from natural sources such as lightning. NO_x is a precursor to PM_{10}.

Particulate Matter (PM_{10} and $PM_{2.5}$)

PM_{10} and $PM_{2.5}$ is the fraction of particulate matter (dust) in the air with an average aerodynamic diameter of less than 10 μm and 2.5 μm, respectively. This size range of particulate matter can penetrate deep into the lungs and has been shown to have a range of adverse health effects. These include a causal association with cardiovascular and respiratory illnesses. According to the AQS, 'it is not currently possible to discern a threshold concentration below which there are no effects on the whole population's health' as scientific research cannot say whether any concentration of PM_{10} or $PM_{2.5}$ at all does no harm. There is no proven safe threshold. In terms of harm, economically PM_{10} and $PM_{2.5}$ is costed as being many times as harmful as NO_2. PM_{10} and $PM_{2.5}$ is formed from both man-made and natural sources. Primary PM_{10} and $PM_{2.5}$ is formed from the incomplete combustion of fuel (e.g. soot from diesel exhausts), sea-salt and wind-blown dust. Secondary PM_{10} and $PM_{2.5}$ is formed in the atmosphere from other pollutants such as NO_x and sulphur oxides, and in certain circumstances in photochemical smogs. PM_{10} and $PM_{2.5}$ has a residence time of several days in the atmosphere, so pollution events occur in southern England when polluted air is blown from the continent.

Appendix B: Methodology - Background Information

This appendix includes additional background information on the approach taken for the air quality assessment including more detailed explanations on the different mass emission sources and the assumptions and limitations relevant to the methodology applied.

B1 Airport Mass Emissions Sources

Aircraft Engine Emissions from landing and take-off (LTO) cycle

Aircraft-related emissions, including engine exhaust emissions in the landing and take-off cycle below 915m (3,000 feet) (e.g. take off, landing, approach and idle) have been calculated with the ICAO 'Simple Approach A' (ICAO, 2011), which is strongly influenced by the change in ATMs.

The PM emissions rate was derived using the PM emission source method within the ICAO airport air quality manual (ICAO, 2011). This follows the first order of approximation method Version 3 developed by the Federal Aviation Authority (FAA) which allows for the calculation of PM from aircraft engines using smoke numbers measured during engine emissions certification. The ICAO 'Simple Approach – A' uses ICAO reference testing times time in mode for the calculation of NO_x and PM emission rates per landing and take-off cycle (LTO). These are provided in Table B2.1.

Table B1.1 - ICAO emission certification testing procedure time in mode

Modal movement	Duration (minutes)	Thrust %
Taxi/Idle	26	7
Take-off	0.7	100
Climb-out	2.2	85
Approach	4	30

Aircraft models within the fleet mix forecasts that did not have NO_x or PM emission rates within the 'Simple Approach - A' emission rate table were assigned an average weighted emission rate for the year in which that aircraft was forecasted to appear. The average weighted emission rate was established by multiplying the aircraft's annual ATM by the emission rate for an engine, where there was an ICAO emission rate[35] (ICAO, 2011), then taking that forecast year's total annual mass emissions and dividing by the total number of ATMs.

A more detailed 'Simple Approach' is currently in development to eliminate the use of weighted averages and use scheme specific times in mode. Further to this, Sustainable Aviation's fuel burn efficiency trajectories indicated within the carbon dioxide (CO_2) Road Map (SA, 2012) have been used to account for improvements in airframes and engines.

Fugitive PM emissions from aircraft brake and tyre wear

Emissions from aircraft brake and tyre wear follows the Programme for Sustainable Development at Heathrow (PSDH) (DfTb, 2006) methodology used to quantify PM_{10}

[35] Attachment B – Table 1

emissions from aircraft landings. The National Environment Technology Centre (NETCEN)[36] undertook research into PM_{10} emission rates from aircraft brake and tyres in 2006. This was based on the relationship between the aircraft weight and commonly fitted tyres developed with NETCEN research (Curran, 2006).

The NETCEN research has only a partial assignment of aircraft brake and tyre wear emission rates for PM_{10} to all the aircraft within the fleet mix. A weighted average has been established for each baseline year following the same weighted average approach applied to aircraft engines and assigned to the remaining non-assigned aircraft.

In order to estimate the $PM_{2.5}$ fraction of PM_{10} emissions, the particle size distribution of total Particulate Matter emitted from brake and tyre wear has been derived following particle size distribution of motor vehicles (EEA, 2013). The PSDH methodology also used research into particle size distribution of motor vehicles brake and tyre wear to aircraft.

Fugitive PM emissions from surface access brake and tyre wear

The fugitive emissions from surface access brake and tyre wear are included within the total Particulate Matter emissions for ‘road traffic – airport only’ for all schemes. These emissions are the total of fugitive brake and tyre and volatile and non-volatile emissions released from vehicles exhausts.

Surface access emissions from airport associated traffic only

The ICAO ‘Advanced Approach - A’ has been followed to compile an emissions inventory of traffic associated with the airport on the strategic road network within the traffic forecast study area (Appendix F: Figures 1 to 3).

The Annual Average Daily Traffic (AADT) and Heavy Duty Vehicle (HDV) flows have been sourced from the DfT’s traffic counts on strategic routes (DfTa, 2014). In the absence of speed data from the traffic forecast, speed data was taken from 2012 speed limits and all vehicles were assigned the maximum speed for each road section within all baseline years. The AADT, speed (kph) and HDV proportions sourced following the above methodology were used to populate the Emissions Factors Toolkit version 6 (EFTV6) released June 2014 (DEFRA, 2014).

The EFT is published by Defra and the Devolved Administrations to assist local authorities in carrying out Review and Assessment of local air quality as part of their duties under the Environmental Act 1995. The EFT allows users to calculate road vehicle pollutant emission rates for NO_x, PM_{10}, $PM_{2.5}$ and hydrocarbons for a specified year, road type, vehicle speed and vehicle fleet composition.

Car park emissions constitute a small proportion of surface access’s total emissions. Therefore it is not anticipated that including supplementary car park emissions will substantially increase surface access emission impacts.

Emissions from railways have not been calculated as the routes serving the airports are electrified, with all train services to Heathrow and the vast majority of train services to Gatwick provided by electric trains. By 2030 it is assumed this will be 100% in both locations.

[36] A previous trading name for a Ricardo-AEA company

Auxiliary Power Unit (APU) Emissions

It has been assumed that on-board facilities power requirement will be supplied solely by APU across all three schemes. This is a conservative assumption as it is expected that power used for on-board environmental control systems and electrics whilst at the terminal stand will more frequently be sourced from fixed electrical ground power (FEGP).

A detailed ICAO 'Simple Approach' has been used for the calculation of NO_x from APUs. A less detailed 'Simple Approach' has been used for the calculation of PM_{10}. The APU emissions database from a NETCEN assessment of airports surrounding London (NETCEN, 2004) has been used within this assessment and assigned to the aircraft that these APUs are commonly fitted to.

As the manufacture's APU emission database does not contain PM emission rates the 'Simple Approach' has been adopted. The 'Simple Approach' assigns an emission rate to narrow and wide aircraft. The split of aircraft into short and long haul was carried out following guidance provided by ICAO and assumes the following for the DfT aircraft ATM fleet mix: Narrow2 (single aisle aircraft with 2 engines), regional jet, domestic, other and Turboprop are short haul aircraft and wide (2) (double aisle aircraft with two engines), wide (3)4 (double aisle aircraft with 3 or 4 engines) and international are long haul aircraft. This was carried out following the Civil Aviation Authority's long-haul and short-haul use for specific aircraft.

APU run times used within the emissions calculations are as stated by the scheme promoters within their response to a data request. The APU run times were derived from the existing operations in 2012 for Gatwick and anticipated operation restrictions in 2015 for Heathrow, respectively. For Gatwick and Heathrow it is anticipated that both improved infrastructure for Fixed Electrical Ground Power (FEGP) and stricter controls will be put in place for APU run times by 2030; therefore the APU run times are conservative predictions for 2030. In Gatwick's scheme promoter's APU run time data submission, the same APU run times were assigned to both short-haul and long-haul aircraft. In Heathrow Airport Limited scheme promoter's APU run time data submission, different APU run times were assigned to short-haul and long-haul aircraft. Table B1.2 displays APU run times received from the scheme promoters.

Table B1.2 - APU run times for all airports with and without expansion

Scheme	Long-Haul APU run times (s)	Short-Haul APU run times (s)
Gatwick Airport Limited Second Runway	7142	7142
Heathrow Airport Northwest Runway	2400	1200
Heathrow Airport Extended Northern Runway	2400	1200

Heathrow Airport Northwest Runway scheme's APU run times are considered to be similar to Heathrow Airport Extended Northern Runway APU run times from Jacobs' high level analysis of forecasted aircraft flows. Consequently the same run times were used for both.

Ground Support Equipment (GSE)

It is anticipated that ground support will be from electrically powered vehicles by 2030. As a sensitivity test an ICAO 'Simple Approach' has been undertaken to capture the changes in mass emissions associated with GSE should they be powered by combustion engines.

B2 Detailed Assumptions and Limitations

Additional explanation on the assumptions and limitations for the assessment approach is set out below.

Aircraft engine emissions

The ICAO 'Simple Approach - A' uses the assumptions made in Table B2.1 for aircraft engine emissions.

Table B1.3 - Aircraft engines emissions activity assumptions and limitations

Aircraft engine emissions activity	Assumption	Limitation
PM emissions	The 'ICAO' most commonly installed engine for a specific aircraft was referenced for emissions data.	Does not calculate emissions based upon actual engine installed.
Times in mode	The ICAO reference testing times in mode were used.	The emissions do not capture the airports aircraft movement operating times and emissions reflect changes in ATMs only.
Department for Transports aircraft ATM forecasts	Research by Leigh Fisher and the Civil Aviation Authority into the DfT forecast fleet mixes found that 'domestic freight' and 'international freight' are best represented by the B737 and B747, respectively. Aircraft listed as 'other' were assigned the forecast fleet mix's weighted average emission rate for each respective baseline year.	May over or under predict emissions

Fugitive particulate matter emissions from aircraft brake and tyre wear

For fugitive PM emissions associated with aircraft brake and tyre wear, the ICAO 'Simple Approach' uses the assumptions made in Table B2.2.

Table B2.2 - Fugitive Particulate Matter emissions from aircraft brake and tyre wear activity assumptions and limitations

Fugitive particulate matter emissions	Assumption	Limitation
PM particle size distribution	Little is known about aircraft brake and tyre wear particle size distribution. Subsequently, car brake and tyre wear particulate size distributions have been adopted. $PM_{2.5}$ has been assumed to be 70% of PM_{10} emissions (EEA, 2013)	This may over or under predict $PM_{2.5}$ emissions.

Fugitive Particulate Matter emissions from surface access brake and tyre wear and airport associated traffic only

The ICAO 'Simple Approach' uses the assumptions made for fugitive PM emissions associated with surface access brake and tyre wear and airport associated traffic only (Table B2.3).

Table B2.3 - Fugitive Particulate Matter emissions from surface access brake and tyre wear activity assumptions and limitations

Fugitive particulate matter emissions	Assumption	Limitation
2030 Traffic flow, HDV and speed forecasts	The traffic flow forecasts are the outputs of a 'static model'; this only forecasts the change in total traffic flow in the Annual Average Daily Traffic (AADF)and has not forecasted the change in the HDV% or speed change. The change in total traffic flows do not factor in the effect of congestion upon traveller's route choice, therefore the traffic flow forecasts should be treated with caution	The forecasts of vehicle numbers, types and speed on road links are likely to differ from dynamic traffic model (more accurate forecasts), therefore emissions are likely to under or over predict.

Fugitive particulate matter emissions	Assumption	Limitation
2025/2026, 2040 and 2050 Traffic flow, HDV and speed forecasts	Traffic flow Annual Average Daily Traffic (AADT) forecasts were only carried out for 2030. Therefore, traffic flows were derived for the aforementioned appraisal years with the following assumptions: A constant modal share of 34% of passengers travelling by car was applied to all appraisal years The Airports Commission passenger demand for the aforementioned years was used to derive the traffic flows Speed limits for 2012 have been applied to all appraisal years HDV% of traffic flows remain the same as 2012 DfT measured traffic counts	Traffic flow reductions from 2030 to 2025/2026 are reduced equally on all road links. Conversely for 2040 and 2050, traffic flow growth is equal on all road links. In reality the reduction/growth may not occur equally across all road links. Cars % of modal share is expected to fall. Speed limits are likely to vary between appraisal years, due to varying levels of capacity on roads HDV% are likely to decrease due to modal shift of goods delivery. Due to the conservative approach for many traffic data parameters, it is likely that emissions will be over predicted.
Emissions rates applied to cars for 2040 and 2050	In the absence of any forecast fleet mixes beyond 2030. Emission rates from the 2030 fleet mix have been applied to 2040 and 2050.	No new Euro standard vehicles are currently forecast to be brought in to the fleet mix after 2025. Between 2025 and 2030 there are anticipated to be an increased number of Euro 6/VI vehicles operating under failed catalyst conditions. This is expected to deteriorate emissions to 2030. It is however likely that there will be further improvements in emission rates beyond 2030, therefore this approach will likely over predict emissions.

Auxillary Power Units (APU)

The assumptions and limitations of APU activity used in the ICAO ‘Simple Approach’ are outlined in Table B2.4.

Table B2.4 - APU activity assumptions and limitations

APU activity	Assumption	Limitation
Traffic flow, HDV and speed forecasts	To determine the proportion of $PM_{2.5}$ within PM_{10} it has been assumed that $PM_{2.5}$ makes up 100% of total PM_{10}.	May under or over predict.

Appendix C: Monitoring Site Locations

C1 Gatwick 2R Study Area

Table C1 NO_2 Monitoring data within Gatwick's study area projected to 2030

Site ID	Location description	X	Y	Projected 2030 NO_2 ($\mu g/m^3$)
Craw1	BarMed High Street	526770	136780	24.2
Craw2	Furnace Farm Rd	528410	135628	13.7
Craw3	Birch Lea	528501	138377	14.4
Craw4	Headley Close	529864	138204	14.4
Craw5	Lynhurst Cottage	527110	139530	15.7
Craw6	Charlwood Nursery	526320	139860	11.1
Craw7	Rowley Cottage	527760	140070	13.1
Craw8	Balcombe Rd	529490	141460	16.3
Craw9	Steers Lane	529307	139611	17.5
Craw10	Gatwick Airport Tri-location	529411	141493	18.3
Craw11	11 Tinsley Close	528446	138084	28.1
Craw12	10 Tinsley Close	528445	138094	26.1
Craw13	6 Tinsley Close	528385	138064	22.9
Craw14	Pegler Way	526761	136949	20.9
Craw15	Woodfield Lodge(Hazelwick RÆbout	528153	137912	35.9
Craw16	Woodfield Lodge (Northgate Ave)	528153	137871	26.8
Craw17	Brighton Road Level crossing	526743	136349	24.8
Craw18	West Green Drive	526599	136638	18.3
Craw19	5 High Street	526752	136420	20.2
ContCraw1	Gatwick East CRI	529411	141493	31.3
ContCraw2	Gatwick Airport (LGW3)	528583	140825	20.9
ContCraw3*	Michael Crescent, Horley (RG1)	528204	142330	13.7
ContCraw4*	Horley Gardens Estate, Horley South (RG2)	528552	141855	18.9
ContCraw5	Poles Lane, Crawley (RG3)	526419	139640	11.8
MSAQ7	Crabbet Park, Worth	530440	137280	19.0
RB11*	RB11: Riverside	528103	142228	17.5
RB12*	Horley Police Station,	528424	142934	21.2

Site ID	Location description	X	Y	Projected 2030 NO_2 ($\mu g/m^3$)
	Massetts Road, Horley			
RB13	Public Car Park, off Massetts Road, Horley	528362	142983	18.4
RB24_25_26*	Urban Background Michael Crescent	528208	142337	17.1
RB51*	Wolverton Gardens	527873	142606	18.8
RB52*	Wolverton Gardens	527892	142463	19.6
RB53*	Cheyne Walk	528030	142373	22.5
RB54*	Crescent Way	528112	142321	19.2
RB55*	Crescent Way	528254	142196	20.4
RB56*	The Crescent	528386	142080	19.9
RB57*	The Crescent	528499	141953	19.3
RB58*	The Crescent	528538	141897	20.6
RB59*	The Crescent	528602	141789	21.0
RB60*	The Crescent	528607	141910	21.0
RB61*	The Crescent	528578	142006	17.3
RB64*	The Drive	528589	142552	19.6
RB65*	The Drive	528581	142635	21.0
RB66*	Fairfield Avenue	528499	142512	18.8
RB67*	Fairfield Avenue	528462	142366	19.3
RB68*	Fairfield Avenue	528505	142246	19.2
RB69*	Upfield	528335	142224	19.0
RB70*	Upfield	528360	142384	18.0
RB73*	Upfield	528172	142679	18.6
RB74*	Meadowcroft Close	529149	141953	18.5
RB75*	Roundabout, The Coronet	529203	142192	17.5
RB76*	Limes Avenue	528958	142468	16.4
RB77*	Staffords Place	528789	142570	17.3
RB78_79_80*	The Crescent	528553	141857	20.4
RB98*	16/17 Woodroyd Gardens	527931	142231	21.3
RB99_100_101	Rural: Poles Lane Pumping Station, Crawley	526421	139639	14.6
RB102	Field near Bridleway, Hathersham Farm, Horley	530937	144272	21.7
RB128*	Between 83 and 85 Victoria Road, Horley	528502	142952	27.1
RB129*	1, Russell's Crescent,	528250	142806	23.1

Site ID	Location description	X	Y	Projected 2030 NO_2 (µg/m^3)
	Horley.			
RB131*	15, Russell's Crescent, Horley.	528402	142737	17.5
RB132*	32, Russell's Crescent, Horley.	528533	142779	19.2
ContRG 1*	Michael Crescent, Horley	528208	142337	18.8
ContRG 2*	74 The Crescent, Horley	528554	141855	20.3
ContRG 3	Poles Lane Pumping Station, Crawley	526420	139638	13.3

* denotes monitoring locations that are currently within AQMAs

Table C2 Existing PM_{10} Monitoring data within Gatwick R2 study area

Site ID	Location description	2012 annual average PM_{10} (µg/m^3)	Gravimetrically equivalent
CRI	Gatwick East	21	N
LGW3	Gatwick Airport	22	N
RH1*	Horley	19	Y

* denotes monitoring locations that are currently within AQMAs

C 2 Baseline Heathrow Airport study Area

Table C3 Heathrow NO_2 monitoring data projected to 2030

Site ID	Location description	X	Y	Projected 2030 NO_2 (µg/m^3)
HD31*	AURN Monitoring Station	506951	178605	29.3
HD31*	AURN Monitoring Station	506951	178605	28.9
HD31*	AURN Monitoring Station	506951	178605	27.3
HD42*	Uxbridge Technical College	510417	180752	22.5
HD51*	4 Colham Avenue	506334	180266	22.5
HD55*	Harold Avenue	509917	179015	25.5
HD56*	15 Phelps Way	509796	178633	23.3
HD57*	25 Cranford Lane	508756	177717	24.9
HD58*	Brendan Close	508412	177124	25.2
HD59*	7 Bomber Close	507294	177322	23.3
HD60*	Harmonsworth Green	505753	177760	20.4
HD61*	Heathrow Close	504848	176770	24.6
HD62*	1 North Hyde Gardens, Hayes	510283	178878	25.3
HD63*	370 Sipson Road, Sipson,	507150	178028	15.7

Site ID	Location description	X	Y	Projected 2030 NO_2 (µg/m^3)
HD64*	34 Hatch Lane, Sipson	505875	177610	21.2
HD65*	28 Pinglestone Close, Sipson	506081	177071	20.7
HD66*	486 Sipson Road, Sipson	507305	177518	21.9
HD67*	31 Tavistock Road	505729	180290	19.6
HD71*	Oxford Avenue, Cranford	509557	176974	24.3
HD72*	2 Vineries Close	507236	177927	20.7
HD79a*	Rear Garden of 86 Stormount Drive (Attached to building)	508310	179577	22.2
HD79b*	Corner of Swallowfield Way and Kestrel Way (Railside)	508310	179600	20.7
HD80a*	Rear Garden of 86Stormount Drive (Attached to railside fence)	508537	179606	22.1
HD80b*	Corner of Swallowfield Way and Kestrel Way (Roadside)	508542	179650	22.9
HD81*	61 Windsor Park R	509721	177082	22.7
HD82*	Hall Lane	508811	177118	30.8
HD83*	81 Pennine Way	508577	177272	25.8
HD84*	26 Rayner Close	508151	177360	22.8
HD85*	296-298 High Street	508769	177463	35.0
HD86*	331 High Street	508750	177534	35.3
HD87*	1 Pondside Close	508674	177485	24.2
HD88*	9 Sipson Lane	508648	177713	27.8
HD89*	293 High Street	508705	177681	33.4
HD90*	22 Richards Close	508839	177782	22.5
HD91*	118 High Street	508771	178071	25.6
HD92*	57 Bedweel Gardens	509224	178525	28.6
HD93*	29 Bedwell Gardens	509251	178619	27.0
HD94*	19 Dudley Place	508842	178796	21.9
HD95*	100 Sipson Road	506720	178964	28.8
HD96*	Station Rd / Porters Way Junction	506503	179469	33.2
HD97*	33 Harmondsworth Rd	506435	178886	24.5
HD98*	1 Laurel Lane	506152	178908	22.8
HD99*	120 The Brambles	506225	178510	25.4
HD100*	1-2 Littlefield Ct	505920	177189	25.3
HA81*	M4 Roadside û Cranford Drive	509815	178355	33.1
HA82*	M4 Residential û Cranford Drive	509808	178326	30.8
HD200*	49 Zealand Avenue Lamp Post (1)	505920	177188	27.3
HD202*	49 Silverdale Gardens, Hayes Lamp Post (8)	510361	179820	23.5
HD203*	Blyth Road, Hayes Lamp Post	509683	179486	28.5

Site ID	Location description	X	Y	Projected 2030 NO_2 ($\mu g/m^3$)
	(4)			
HD204*	Side of 104 Yiewsley High Street (front of 1A Fairfield Road) Lamp Post (2)	506108	180493	25.1
HD205*	1 Porters Way (corner with Kingston Lane) Lamp Post (1)	506503	179510	26.2
HD206*	5-7 Mulberry Crescent, West Drayton Lamp Post (18)	507141	179628	19.2
HD207*	35 Emden Close, West Drayton Lamp Post (14)	507580	179812	23.1
HD208*	Side of 50 St. Christopher's Drive Lamp Post (13)	510761	180766	19.4
HD213*	10 West End Lane, Harlington Lamp Post (2)	508773	177352	26.5
HD214*	R/O 130 Cleave Avenue, Hayes Lamp Post (33)	509499	178370	29.2
Cont_HD1*	London Heathrow LHR2	508399	176746	31.7
Cont_HD2*	London Hillingdon	506900	178600	37.8
Cont_HD5*	Hillingdon 3 û Oxford Avenue	509557	176994	25.8
Cont_HD6*	London Harlington	508300	177800	22.8
Cont_HD7*	Hillingdon Sipson	507325	177282	24.2
Cont_HD8*	London Harmondsworth	505561	177661	20.1
Cont_HD9*	Heathrow Green Gates	505630	176930	22.0
Cont_HD10*	Heathrow Oaks Road	505714	174503	19.9
HS51*	Marjory Kinnon School	509127	174568	18.2
HS52*	Bedfont Library	508873	173722	19.1
HS53*	Church of the good shepherd	510986	176032	21.5
HS54*	Cranford Community School	510810	177667	29.9
HS55*	Cranford Library	510747	176687	28.8
HS65*	Eastbourne Road	511840	172745	21.9
HS66*	Brainton Avenue	510975	173646	26.8
HSCRANA*	Cranford Avenue Park	510370	178198	19.3
HSCRANB*	Cranford Avenue Park	510370	178198	18.2
HSCRANC*	Cranford Avenue Park	510370	178198	18.2
HS73*	Browells Lane, Feltham	510578	172857	22.9
HS75*	Cardinal Road	510678	173247	27.4
HS76*	Clements Court	511570	175015	20.9
HS77*	Beaversfield Park	511990	175973	17.4
HS86*	Jolly Waggoners	510955	176567	31.6
HS87a*	Henleys Roundabout	511545	176430	31.0
MYR1*	Myrtle Road	509334	174997	22.9
MYR2*	Myrtle Road	509334	174997	23.8
MYR3*	Myrtle Road	509334	174997	23.2
FELT 1*	Hanworth Road	510676	173245	29.1
FELT 2*	Hanworth Road	510676	173245	27.8
FELT 3*	Hanworth Road	510676	173245	27.2
Cont_HS1*	Cranford	510370	177195	19.9
Cont_HS5*	Hatton Cross	509355	174989	24.6
Cont_HS6*	Feltham	510683	173259	29.0
StBuck1	Iver, Old Slade Lane	503679	178566	21.6

Site ID	Location description	X	Y	Projected 2030 NO_2 ($\mu g/m^3$)
StBuck2	Iver, Victoria Cres	504056	180901	24.7
Eal81*	Featherstone Primary School, Western Road, Southall, UB2 5JT	511475	178899	29.5
Eal82*	Featherstone Primary School, Western Road, Southall, UB2 5JT	511475	178899	29.8
Eal83*	Featherstone Primary School, Western Road, Southall, UB2 5JT	511475	178899	29.4
Eal84*	150 Brent Road, Southall, UB2	511170	179251	28.0
Eal102*	Blair Peach School, Beaconsfield Road	511680	180071	20.1
Eal103*	Blair Peach School, Beaconsfield Road	511680	180071	18.7
Eal104*	Blair Peach School, Beaconsfield Road	511680	180071	19.2
Cont_Eal3*	Southall	511677	180071	21.8
RY10*	M25B Staines	502730	173480	39.8
RY11*	M25B Staines	502730	173480	38.9
RY12*	M25B Staines	502730	173480	44.7
Slough5	ColnbrookáBy-pass	503196	177349	30.6
Slough7	ElbowáMeadows	503856	176538	29.6
Slough13	HortonáRoadá(CaravanáPark)	503136	175654	24.3
Slough15	LakesideáRoad	503877	177459	33.6
Slough21	Pippins	503542	176827	23.2
Cont_Slough2	SLH 3 & SLH6 - Slough Colnbrook (Pippins)	503542	176827	19.6
Cont_Slough4	SLH 5 - Slough Colnbrook (Lakeside, Tan Hse Farm)	503551	177258	21.5
Cont_Slough5	SLH8 and 9	503569	177385	20.5
SP12*	Stanwell New Road, Stanwell North	504538	172318	21.2
SP13*	Shortwood County Infant School, Stanwell North	504494	172098	19.6
SP14*	Flintlock Close, Stanwell	504228	175098	19.0
SP15*	Horton Road, Stanwell Moor	504161	175123	18.7
SP16*	Oaks Road/Russell Drive, Stanwell South (3 tubes)	505729	174496	19.1
SP17*	Oaks Road/Russell Drive, Stanwell South (3 tubes)	505729	174496	19.8
SP18*	Oaks Road/Russell Drive, Stanwell South (3 tubes)	505729	174496	19.7
SP19*	Bedfont Road/Long lane, Stanwell South	506850	174253	25.4
SP24*	Yeoveney Close, Staines	502577	172777	18.5
SP25*	Moor Lane, Staines	503188	172063	16.0
SP26*	St MaryÆs Crescent, Staines	505635	173949	21.4
SP30*	Horton Road, Stanwell Moor	504030	175272	19.9
SP31*	Ashford Hospital, Stanwell	506265	172681	25.8

Site ID	Location description	X	Y	Projected 2030 NO_2 ($\mu g/m^3$)
SP47*	Hadrian Way, Stanwell	506194	173445	18.7
SP48*	Riverside Road, Stanwell	506010	174516	21.8
SP49*	Runnymede Cottages, Moor Lane, Staines	502605	173274	23.5
WM13	Wraysbury Road	502009	172544	25.2
WM13a	Wraysbury Road	502108	172461	26.3
WM15	Wraysbury Road	502261	172318	32.7
WM15a	Wraysbury Road	502257	172339	29.7
WM15b	Wraysbury Road	502577	172098	28.8

* denotes monitoring locations that are currently within AQMAs

Table C4 Existing PM_{10} Monitoring data within Heathrow NWR and Heathrow ENR study area

Site ID	Location description	2013 annual average PM_{10} ($\mu g/m^3$)	Gravimetrically equivalent
LHR2*	Northern perimeter of Heathrow Airport	26.1	N
EA7*	Ealing - Southall	20.5	Y
LH0*	Hillingdon - Harlington	19.8	N
RHE*	Richmond Upon Thames - Hanworth Road	24.9	Y
EI7*	Ealing - Southall FDMS	21.4	N
EI2*	Ealing - Southall Railway	22.8	Y
HS2*	Hounslow Cranford	19.3	N
HS9*	Hounslow Feltham	23.0	N
HS7*	Hounslow Hatton Cross	20.8	N
HS6*	Hounslow Heston	28.4	N
HIL4*	Hillingdon Harmondsworth OS	17.4	N
HIL1*	Hillingdon Harmondsworth	21.8	Y
HIL5*	Hillingdon Hayes	29.3	Y
HI3*	Hillingdon Oxford Avenue	21.3	N
SLH6	Slough Colnbrook	18.9	N
SLH5*	Slough Lakeside 1 Osiris	18.7	N
SL59	Slough Lakeside 2	20.4	Y
SL59	Slough Lakeside 2 Osiris	24.6	N

* denotes monitoring locations that are currently within AQMAs

Table C5 Existing $PM_{2.5}$ Monitoring data within Heathrow NWR and Heathrow ENR study area

Site ID	Location description	2013 annual average PM_{10} ($\mu g/m^3$)	Gravimetrically equivalent
LHR2*	Northern perimeter of Heathrow	10.9	Y
TDO*	Richmond-Upon-Thames	16.7	Y
HIL4*	Hillingdon Harmondsworth OS	8.1	Y
SLH5*	Slough Lakeside 1 Osiris	7.5	Y
SL59	Slough Lakeside 2 Osiris	9.7	Y

* denotes monitoring locations that are currently within AQMAs

Appendix D: Monetisation Tables

Table D1.1 Gatwick R2 60 year appraisal damage costs and key appraisal snapshots

Appraisal period	Cost
Total Present Value Damage - PM10 (£ million)	**£92.4**
Total Present Value Damage - NOX (£ million)	**£76.8**
Total Air Quality Damage Costs (£ million)	**£169.2**
Snapshot 2030 (£)	**£1,131,932**
Snapshot 2040 (£)	**£2,065,958**
Snapshot 2050 (£)	**£3,828,326**
Snapshot 2060 (£)	**£3,511,196**

Table D1.2 Heathrow NWR 60 year appraisal damage costs and key appraisal snapshots

Appraisal period	Cost
Total Present Value Damage - PM10 (£ million)	**£373.1**
Total Present Value Damage - NOX (£ million)	**£121.2**
Total Air Quality Damage Costs (£ million)	**£494.3**
Snapshot 2030 (£)	**£11,850,861**
Snapshot 2040 (£)	**£12,502,690**
Snapshot 2050 (£)	**£7,102,774**
Snapshot 2060 (£)	**£6,514,397**

Table D1.3 Heathrow ENR 60 year appraisal damage costs and key appraisal snapshots

Appraisal period	Cost
Total Present Value Damage - PM10 (£ million)	**£341.5**
Total Present Value Damage - NOX (£ million)	**£107.9**
Total Air Quality Damage Costs (£ million)	**£449.4**
Snapshot 2030 (£)	**£12,156,365**
Snapshot 2040 (£)	**£11,588,762**
Snapshot 2050 (£)	**£6,065,965**
Snapshot 2060 (£)	**£5,563,476**

Appendix E: Demand Forecast Scenarios and Emissions

Table 1 Total Gatwick 2R emissions for GAL's MPPA and the Assessment of Need Carbon Capped Scenario

Scenario	Appraisal Years (NO_x) t/y		
	2030	2040	2050
Scheme Promoters MPPA	85.0	141.0	231.0
Assessment of Need Carbon Capped Scenario	40.0	80.0	145.8
% change	-53.0	-43.3	-36.9
Scenario	**Appraisal Years (PM_{10}) t/y**		
Scheme Promoters MPPA	9.2	15.3	25.2
Assessment of Need Carbon Capped Scenario	4.4	8.9	16.1
% change	-51.8	-42.3	-36.0
Scenario	**Appraisal Years ($PM_{2.5}$) t/y**		
Scheme Promoters MPPA	5.4	9.0	14.8
Assessment of Need Carbon Capped Scenario	2.6	5.2	9.5
% change	-52.0	-42.5	-36.2

Table 2 Total Heathrow NWR emissions for HAL's MPPA and the Assessment of Need Carbon Capped

Scenario	Appraisal Years (NO_x) t/y		
	2030	2040	2050
Scheme Promoters MPPA	63.2	105.5	106.1
Assessment of Need Carbon Capped Scenario	50.0	94.5	94.1
% change	-20.9	-10.5	-11.4
Scenario	**Appraisal Years (PM_{10}) t/y**		
Scheme Promoters MPPA	7.5	12.6	12.6
Assessment of Need Carbon Capped Scenario	5.9	11.1	11.1
% change	-22.1	-11.5	-12.4
Scenario	**Appraisal Years ($PM_{2.5}$) t/y**		
Scheme Promoters MPPA	4.4	7.3	7.3
Assessment of Need Carbon Capped Scenario	3.4	6.5	6.4
% change	-21.9	-11.3	-12.2

Table 3 Total Heathrow ENR emissions HH MPPA and the Assessment of Need Carbon Capped

Scenario	Appraisal Years (NO_x) t/y		
	2030	2040	2050
Scheme Promoters MPPA	64.5	93.3	98.5
Assessment of Need Carbon Capped Scenario	55.6	85.8	90.6
% change	-13.8	-8.0	-8.0
Scenario	**Appraisal Years (PM_{10}) t/y**		
Scheme Promoters MPPA	7.6	11.0	11.6
Assessment of Need Carbon Capped Scenario	6.7	10.3	10.9
% change	-11.9	-6.6	-6.6
Scenario	**Appraisal Years ($PM_{2.5}$) t/y**		
Scheme Promoters MPPA	4.4	6.4	6.8
Assessment of Need Carbon Capped Scenario	3.9	6.0	6.3
% change	-12.2	-6.8	-6.8

Appendix F: Figures

1. Gatwick Airport Second Runway (Gatwick R2) Two Runway Road Traffic - Airport Only NO_x, PM_{10} and $PM_{2.5}$ Emissions (t/y)
2. Heathrow Airport Northwest Runway (Heathrow NWR) Three Runway Road Traffic - Airport Only NO_x, PM_{10} and $PM_{2.5}$ Emissions (t/y
3. Heathrow Airport Extended Northern Runway (Heathrow ENR) Three Runway Road Traffic - Airport Only NO_x, PM_{10} and $PM_{2.5}$ Emissions (t/y)
4. 2030 Pollution Climate Mapping (PCM) NO_2 Modelled Results Within Gatwick Airport Second Runway (Gatwick R2)
5. 2030 Pollution Climate Mapping (PCM) NO_2 Modelled Results Within Heathrow Airport Northwest Runway (Heathrow NWR) Study Area
6. 2030 Pollution Climate Mapping (PCM) NO_2 Modelled Results Within Heathrow Airport Extended Northern Runway (Heathrow ENR) Study Area
7. NO_2 Projected to 2030 Within Gatwick Airport Second Runway (Gatwick 2R) Study Area
8. NO_2 Projected to 2030 Within Heathrow Airport Northwest Runway (Heathrow NWR) Study Area
9. NO_2 Projected to 2030 Within Heathrow Airport Extended Northern Runway (Heathrow ENR) Study Are