ADMS-Airport and its application to PSDH and the R3/Mixed Mode consultation for Heathrow

Study conducted for DfT

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- Key Factors affecting AQ at Airports
- Features of ADMS-Airport
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- AQ Monitoring at Heathrow
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1) Key factors affecting air quality at airports

Key factors affecting air quality at airports

- Emissions
- Background concentrations
- Meteorology
- Near field dispersion processes
- Chemical reactions

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2) Features of ADMS-Airport

Features of ADMS-Airport

- An extension of ADMS-Urban – Gaussian type model nested in regional trajectory model
- Includes chemical reaction scheme, meteorological preprocessor, Monin-Obukhov and mixed layer scaling for boundary layer structure
- Allowance for up to 6500 sources: road (1500, each with up to 50 vertices), point, line area and volume (1500), grid sources (3000) and up to 500 runway sources (exhaust modelled as moving jets)
- Other airport features
  - Hour by hour time varying data
  - Multi-segment line sources e.g. taxi ways
  - GIS link displays line, volume and runway sources

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Features: MODELLING EXHAUSTS AS MOVING JETS - TAKE-OFF

- Models engine exhausts as moving jet sources
- As the aircraft accelerates
  - buoyancy and emissions increasingly spread along the runway
  - the exhaust jet sees a faster ambient wind speed, this affects the plume rise
- The plume from the faster aircraft rises less than that from a slower aircraft

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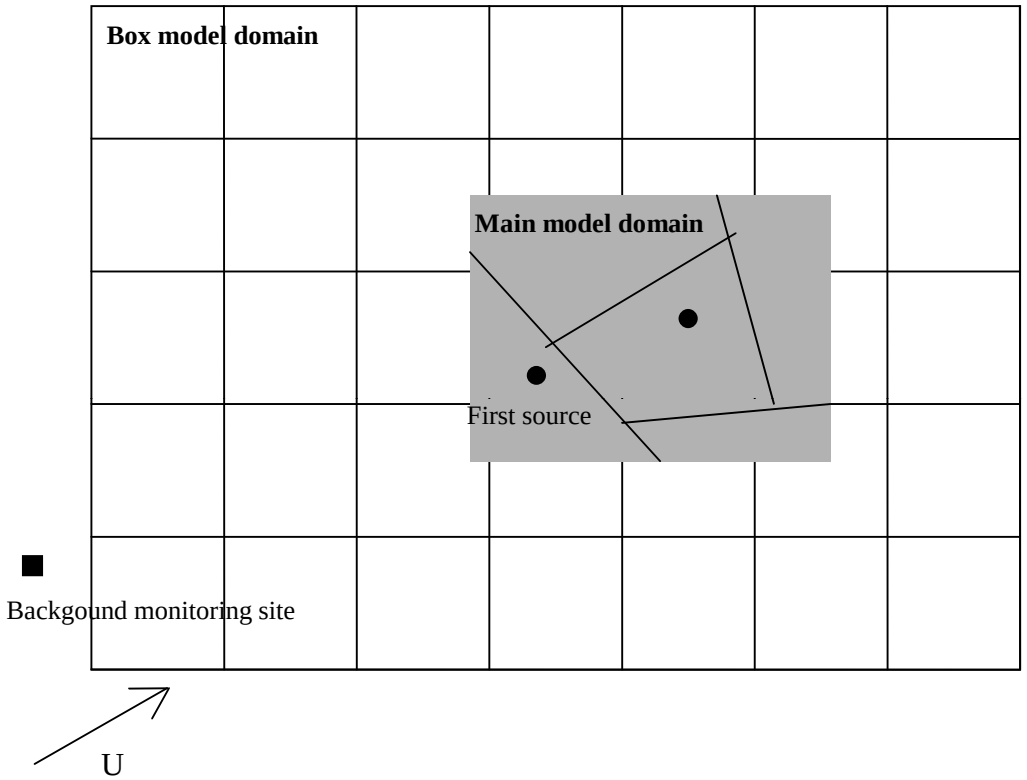
Local and Regional Scales



- Main model nested within large, area-wide trajectory model

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3) Model Set-Up and Emissions

Heathrow: SCENARIOS

- 2010 Segregated Mode (2010SM)
- 2015 Segregated Mode (2015SM)
- 2015 Segregated Mode with Easterly Preference (2015EP)
- 2015 Segregated Mode with No Cranford Agreement (2015NoC)
- 2015 Mixed Mode (2015MM)
- 2015 Mixed Mode with traffic mitigation (2015MMRd)
- 2030 Mixed Mode (2030MM)
- 2020 Third Runway (2020R3)
- 2030 Third Runway (2030R3)

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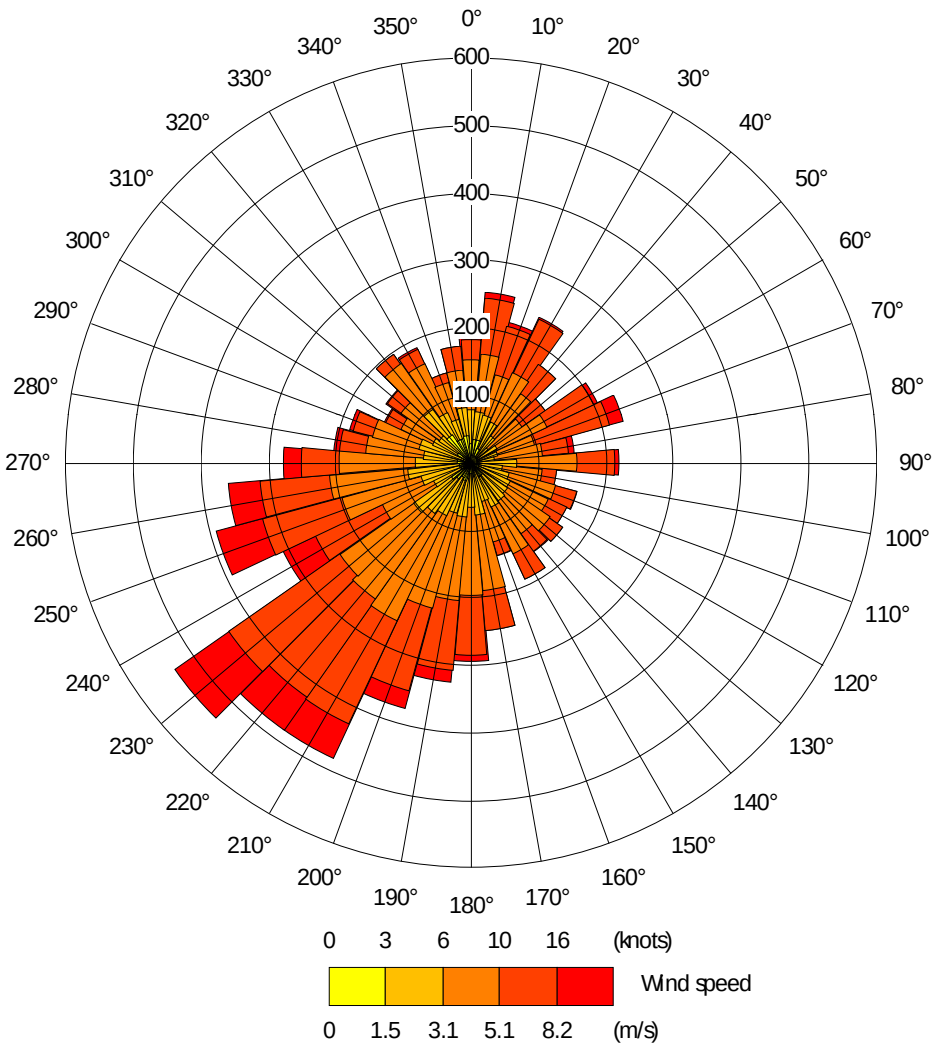
Heathrow: METEOROLOGICAL DATA 2002



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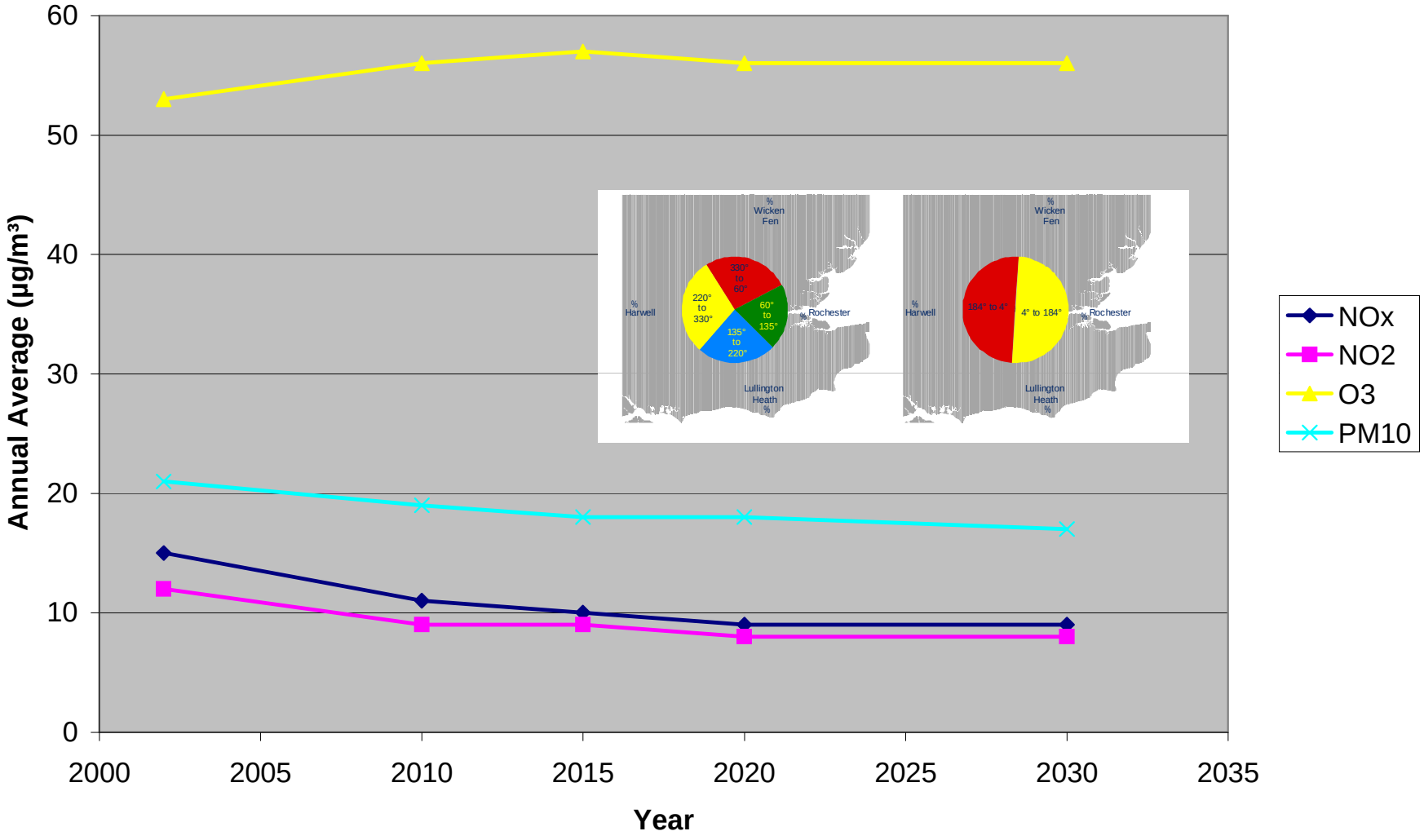
Heathrow: BACKGROUND CONCENTRATIONS, AVERAGE



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Heathrow: EMISSION SOURCES

- Gridded sources for all of London (LAEI,NAEI)
- Roads – local to Heathrow from LAEI (London Atmospheric Emissions Inventory) and the Heathrow Inventory (Heathrow area road traffic data from Hyder)
- LTO: taxi-in, taxi-out, landing, approach, initial climb, climb out (AEA)
- Other: APU, airside vehicles, car parks, taxi ranks modelled as area or volume sources (AEA)

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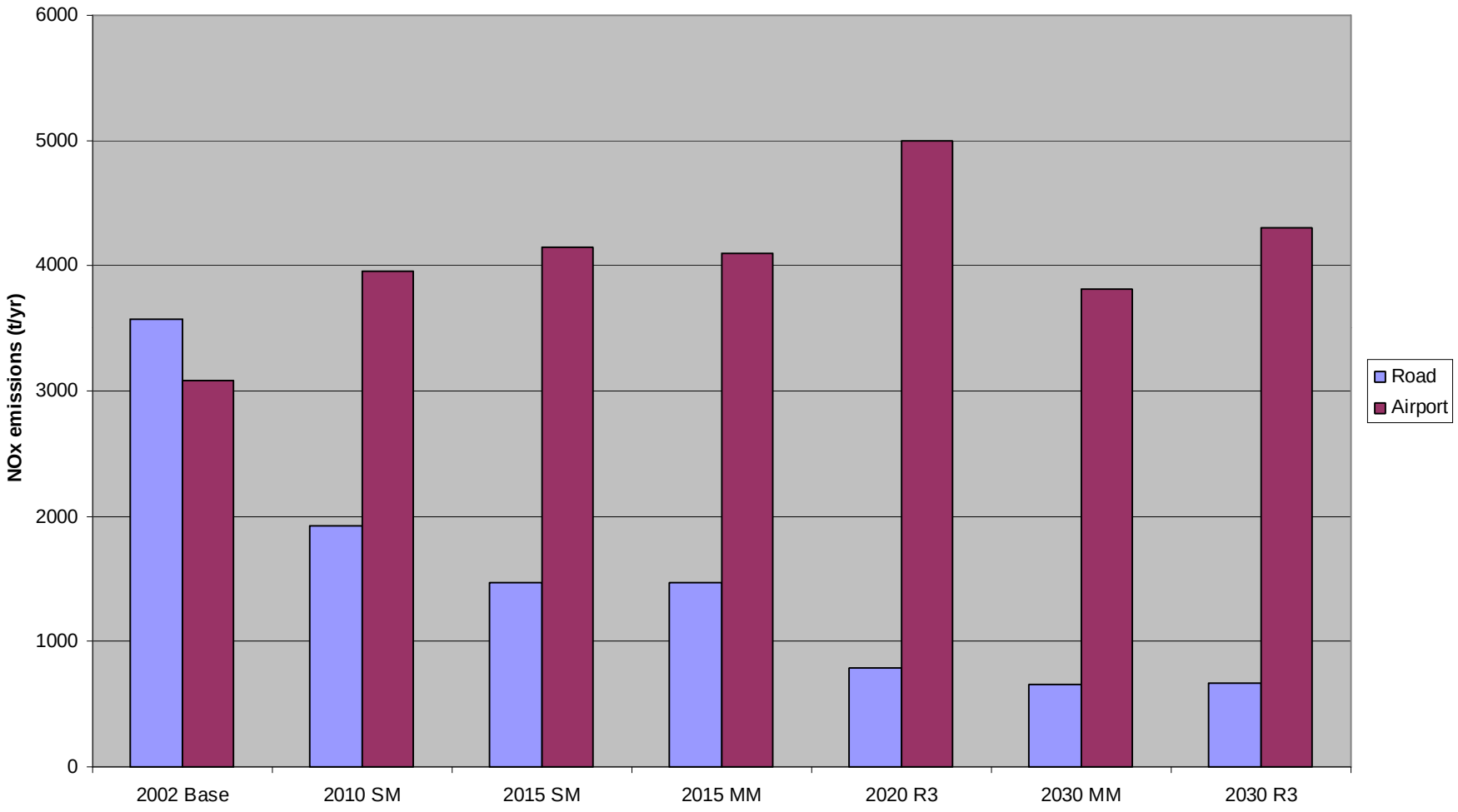
Heathrow: ANNUAL NOx EMISSIONS, ROAD & AIRPORT



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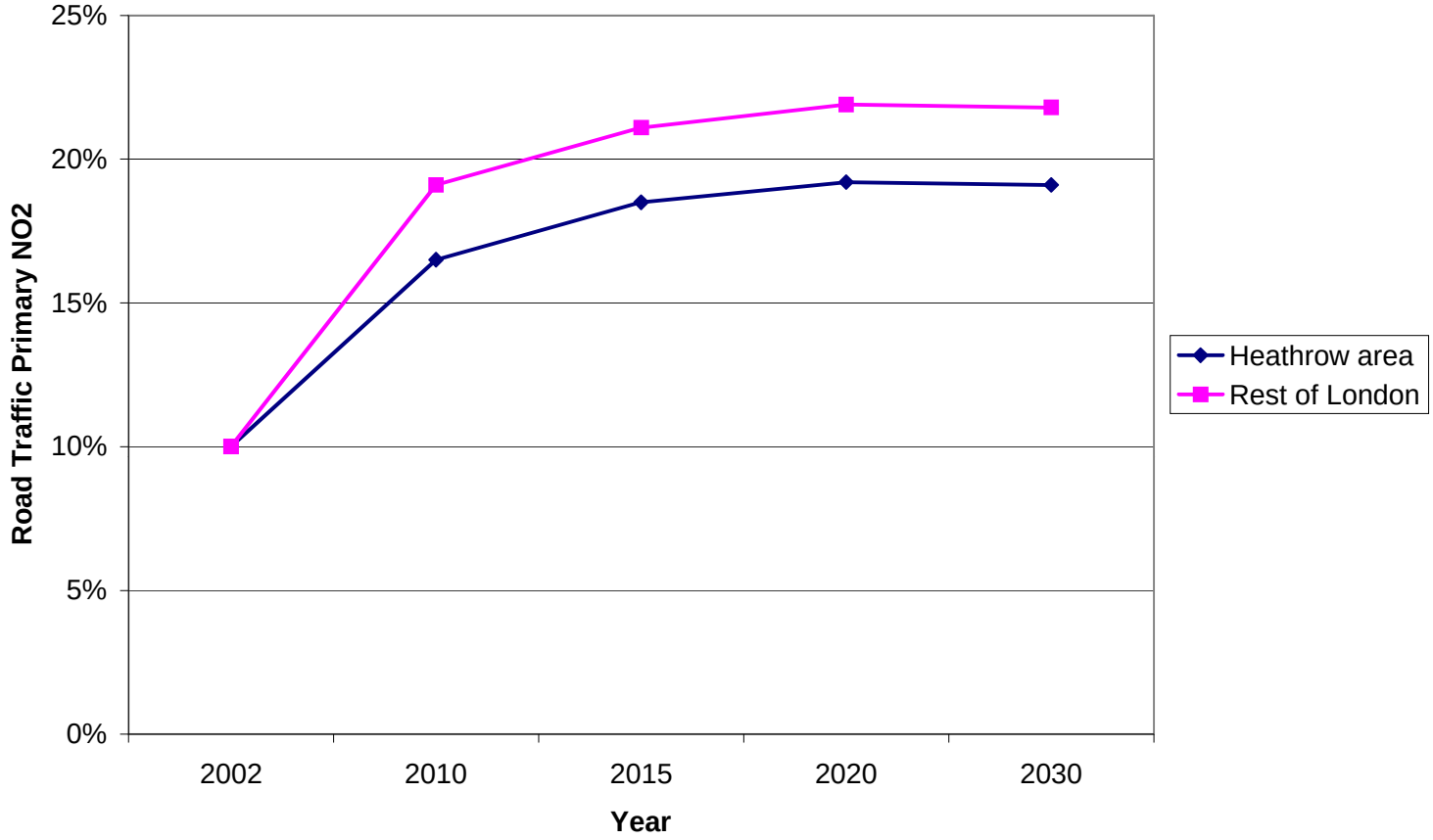
Heathrow: PRIMARY NO2 EMISSIONS



Industrial sources: 10% primary NO2 assumed
Primary NO2 for aircraft depends on thrust
100% - 4.5%; 85% - 5.3%; 30% - 15.0%; 7% - 37.5%

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Heathrow: TRAFFIC EMISSION FACTORS

- Light duty vehicles, arabic numerals: 4, 5, 6
- Heavy duty vehicles, roman numerals: IV, V, VI
- Motorcycles, arabic numerals: 4, 5, 6 but may have different entry dates from the light duty vehicles

	Euro 5 and V	**Euro 6 and VI**
Petrol cars	Jan 2010	-
Petrol LGVs	Jan 2011	-
Diesel cars	Jan 2010	Jan 2015
Diesel LGVs	Jan 2011	Jan 2016
HDVs	Oct 2008	Jan 2013

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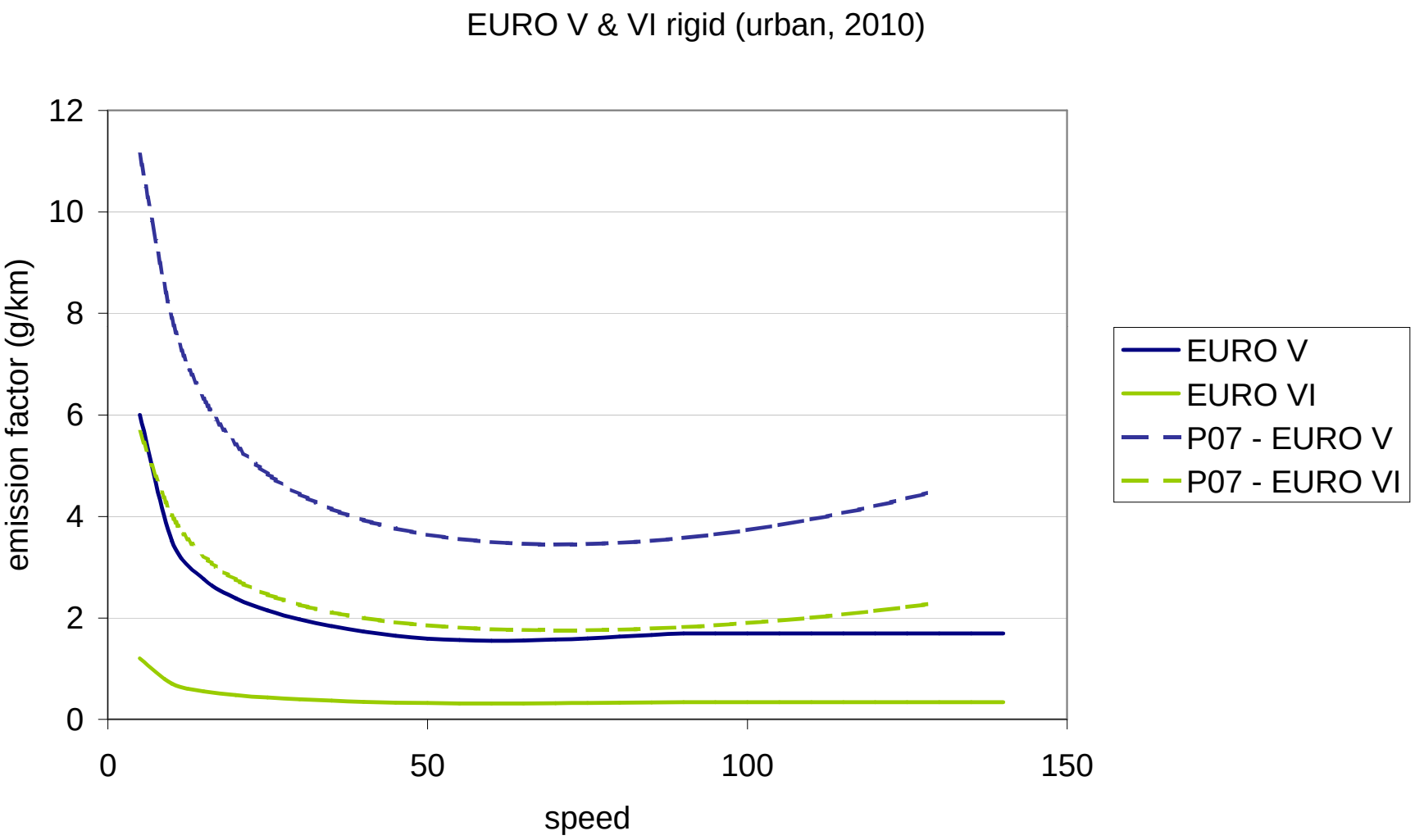
Heathrow: TRAFFIC EMISSION FACTORS – RIGID HDV



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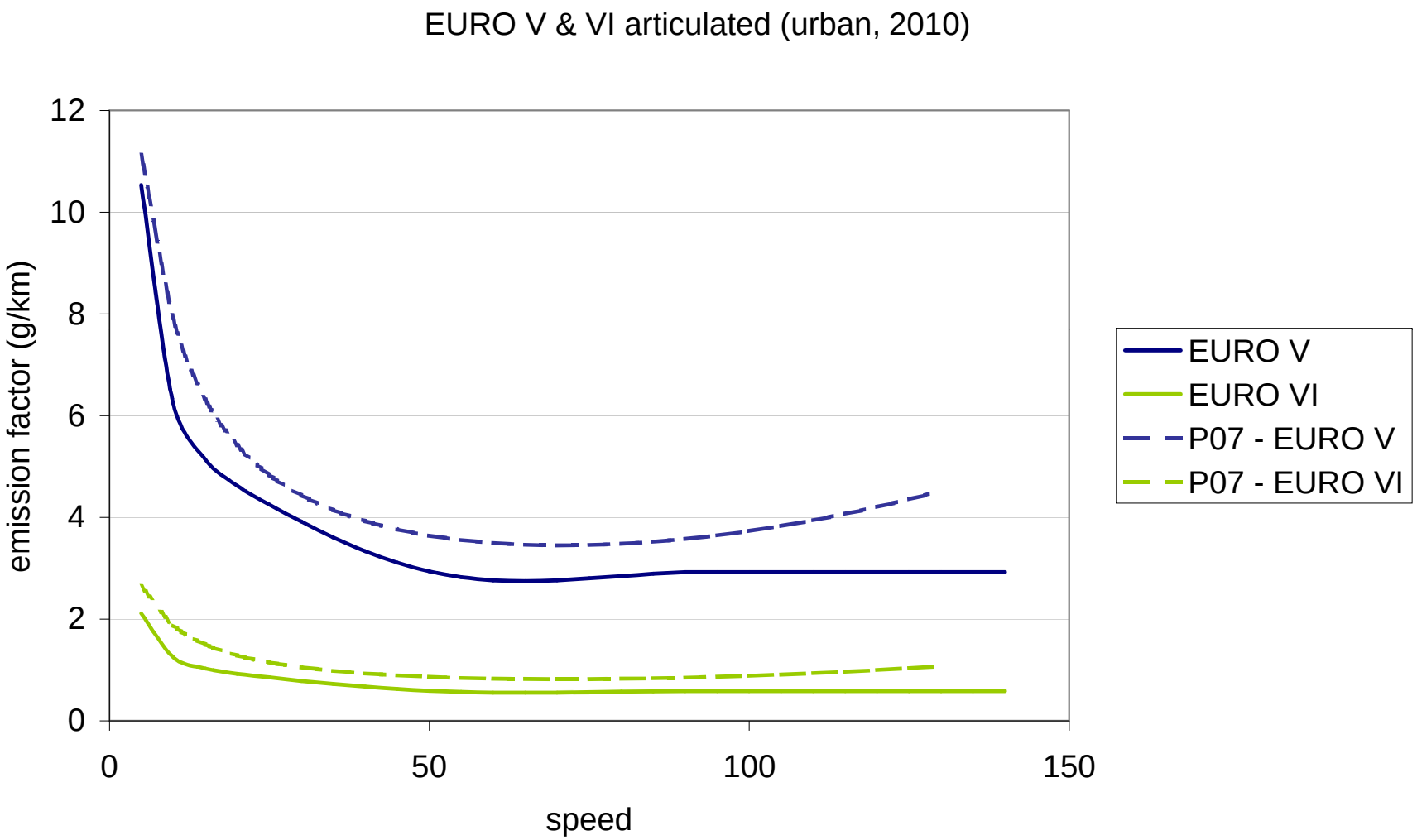
Heathrow: TRAFFIC EMISSION FACTORS – ARTIC HDV



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Heathrow: CURRENT AIRCRAFT EMISSIONS

TAKE-OFF 1

- BA have developed a method to relate information on take-off thrust to be derived from information on actual take-off weight
- The methodology is based on analysis of an extensive set of FDR and weight data for the fleet at Heathrow
- The method has been extended for use with airlines other than BA and aircraft outside the data set by adding 5% to the estimate of thrust to account for uncertainties

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Heathrow: CURRENT APU EMISSIONS

- NOX
  - BA defined 6 APU class, each aircraft at Heathrow was assigned to one the classes
  - Model emission indices were derived by BA from the detailed manufacturers' data
- PM10
  - BA found a large variability in modal PM10 emission rates
  - The variability was found to be reduced if the PM10 emission rates were expressed as a function of the corresponding NOX index
  - Three classes of APU were defined with different NOX-PM10 relationships

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Heathrow: FUTURE AIRCRAFT EMISSIONS

TAKE-OFF

- Based on judgement by Qinetiq on evolution of aircraft engines for current fleet and future fleet.
- Takes into account manufacturers targets, technology expectations
- Emissions primarily characterised in terms relative to CAEP/4 limits
- Higher average take-off thrust settings on R3

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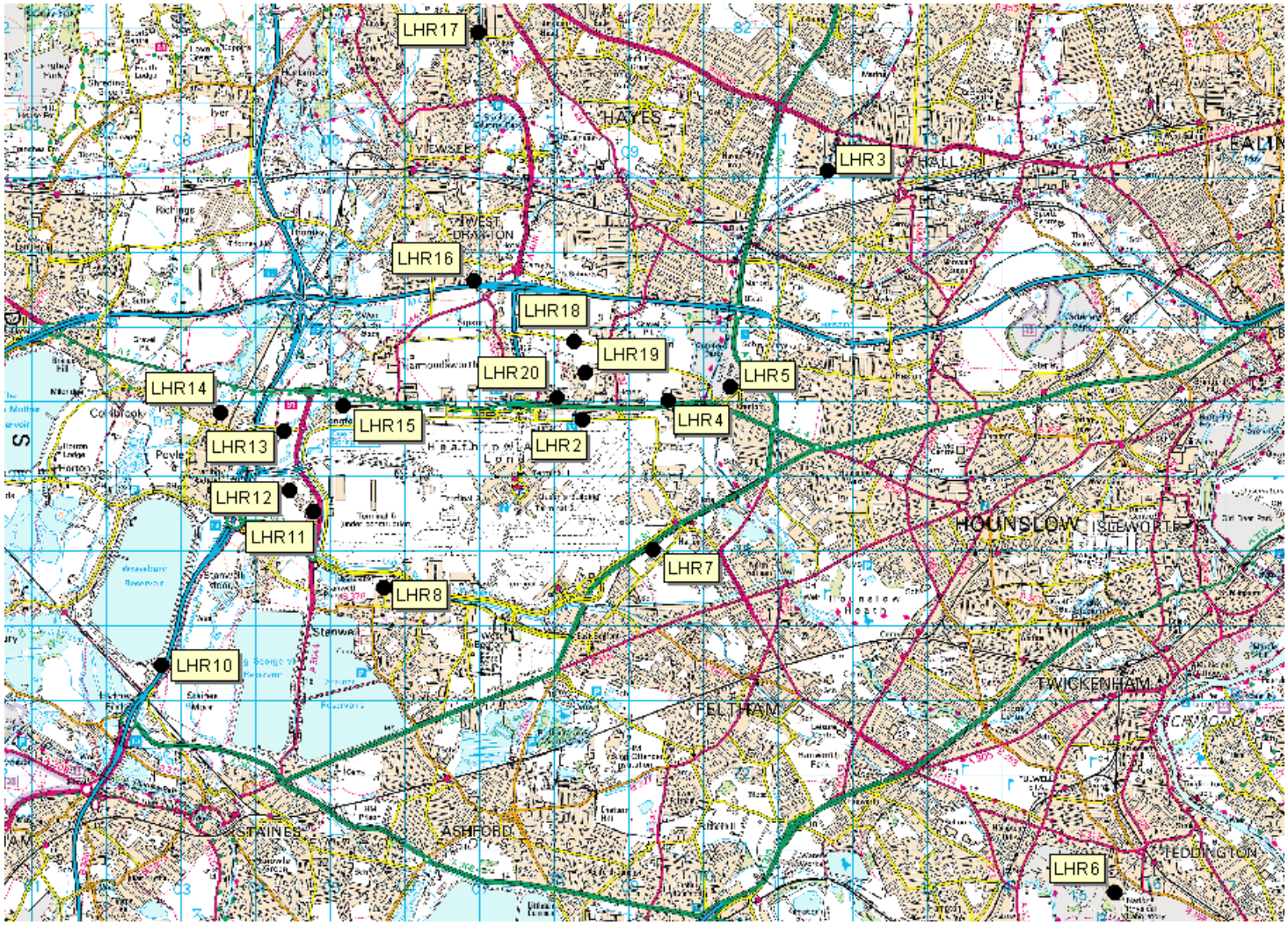
4) AQ Monitoring at Heathrow

Heathrow: AMBIENT MONITORING SITES 1



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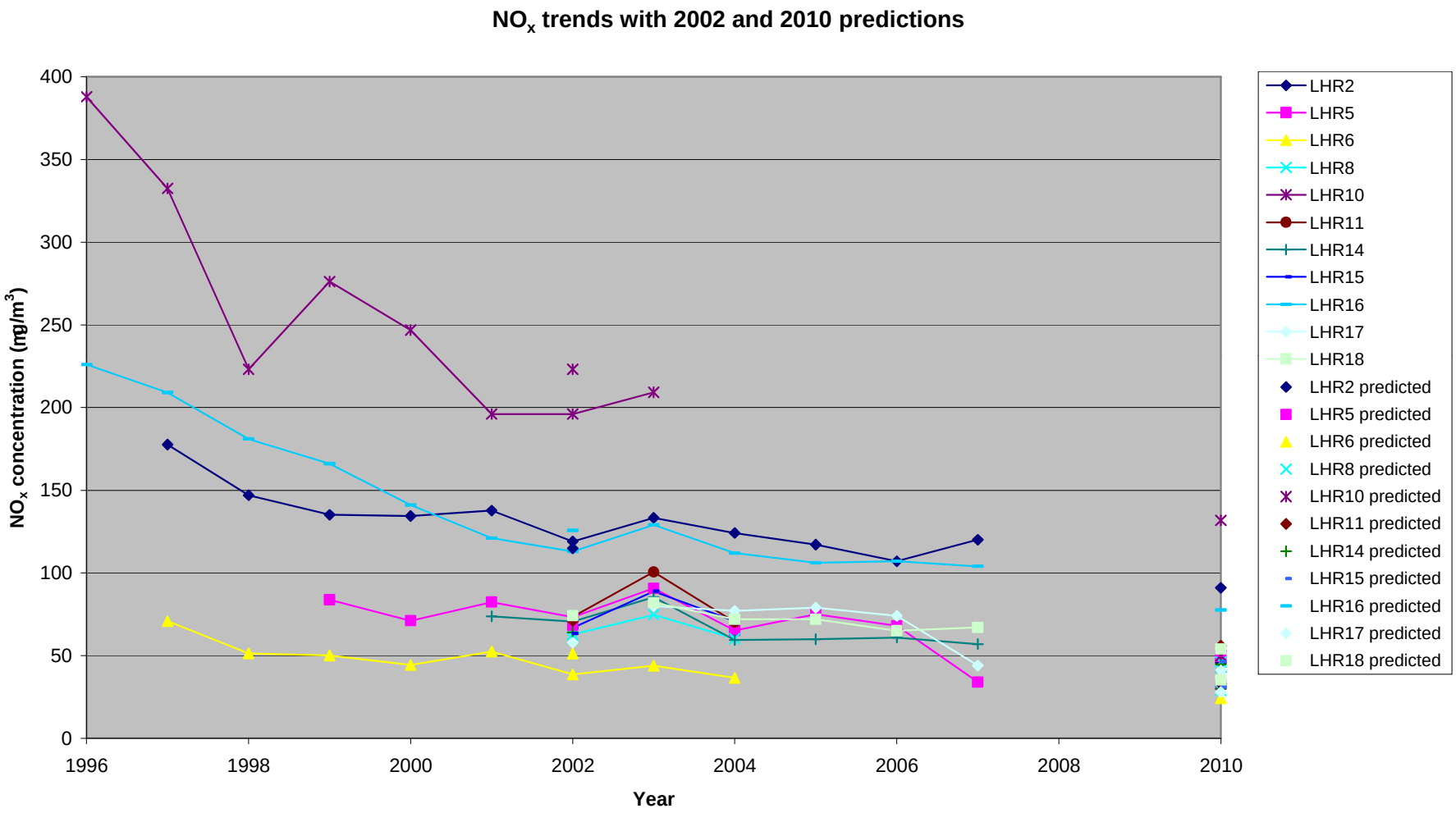
Heathrow: MONITORED NOX CONCENTRATIONS



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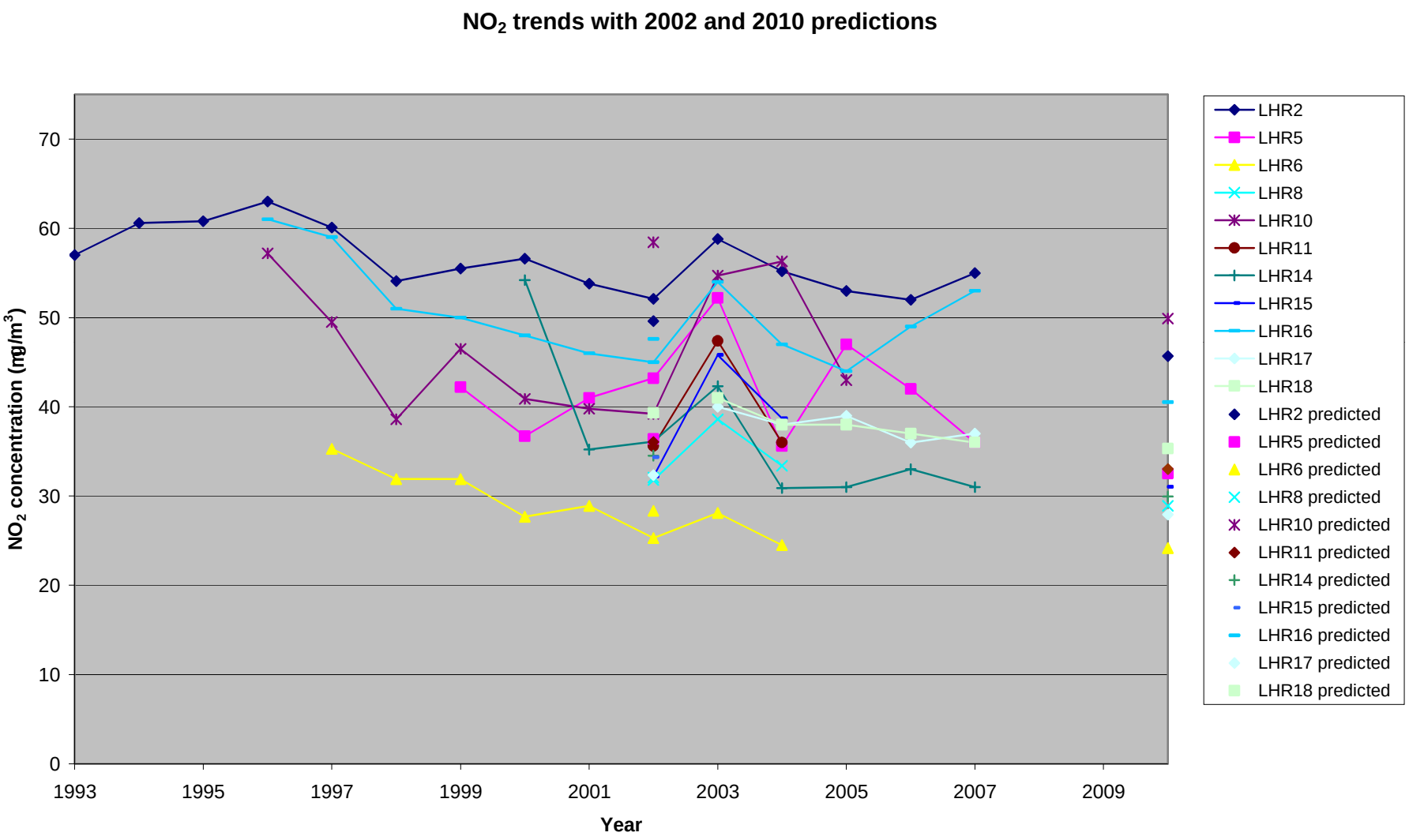
Heathrow: MONITORED NO2 CONCENTRATIONS



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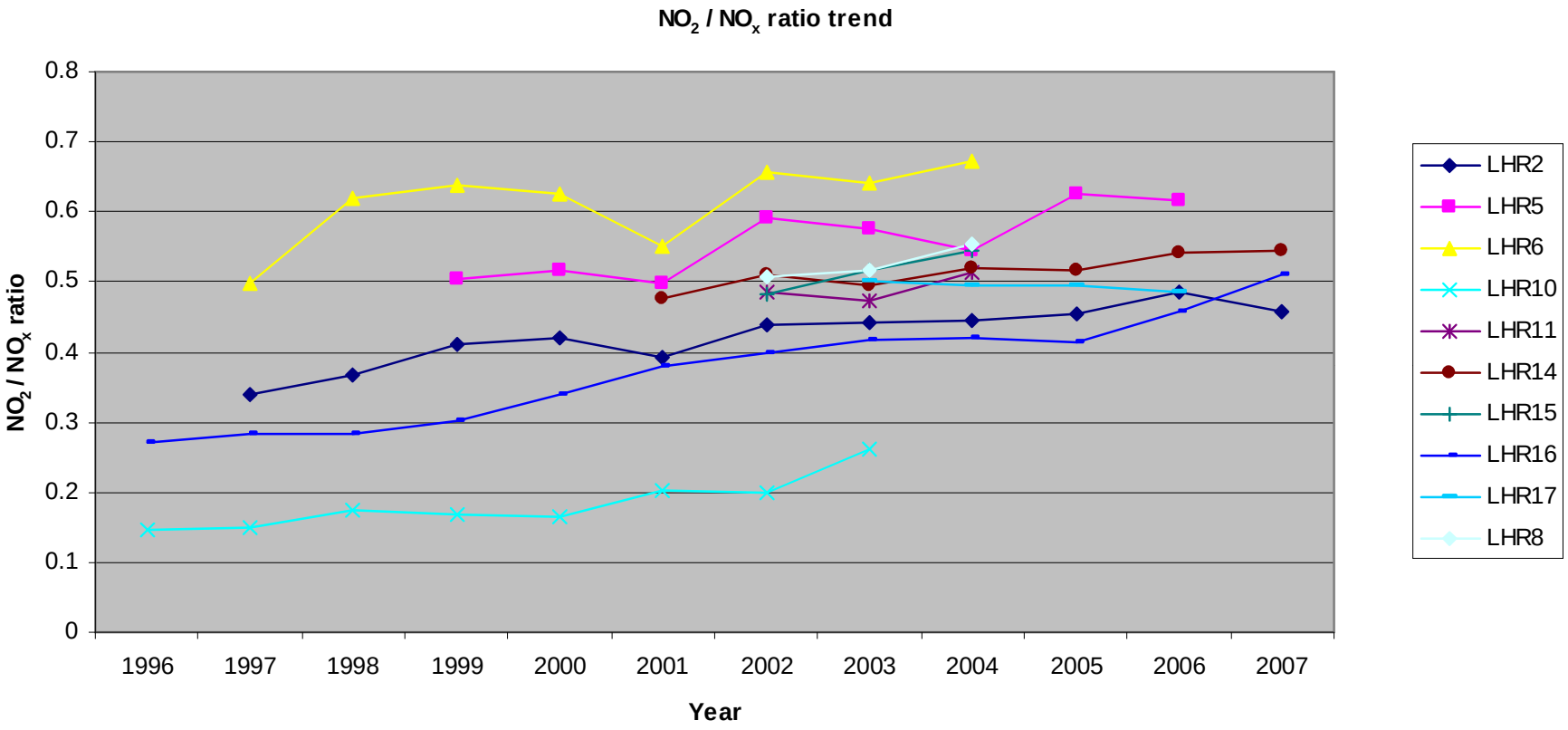
Heathrow: MONITORED NO2/NOX RATIO



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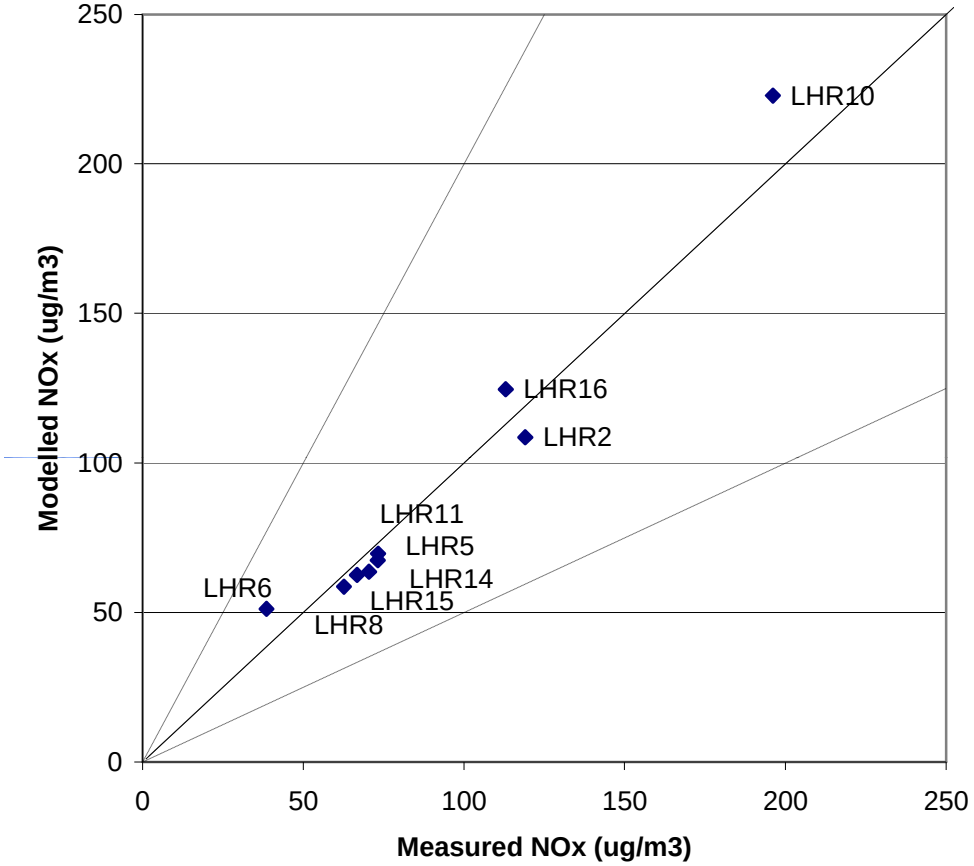
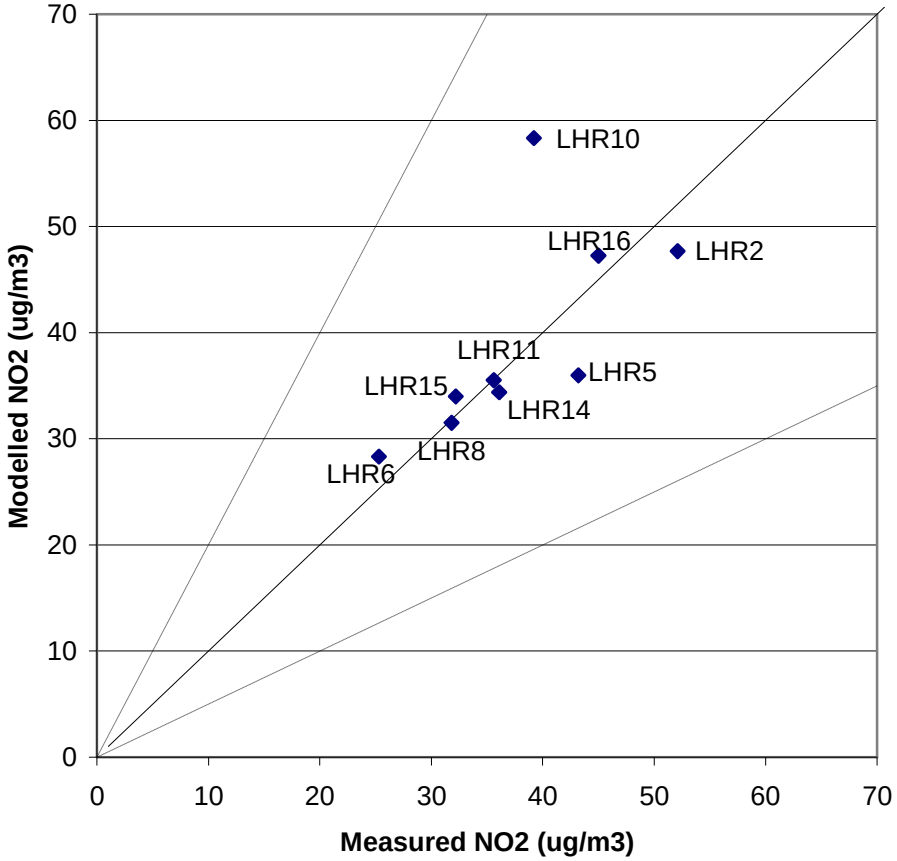
5) Model performance and Results





Scatter plot comparison of monitored and modelled annual average NOX and NO2

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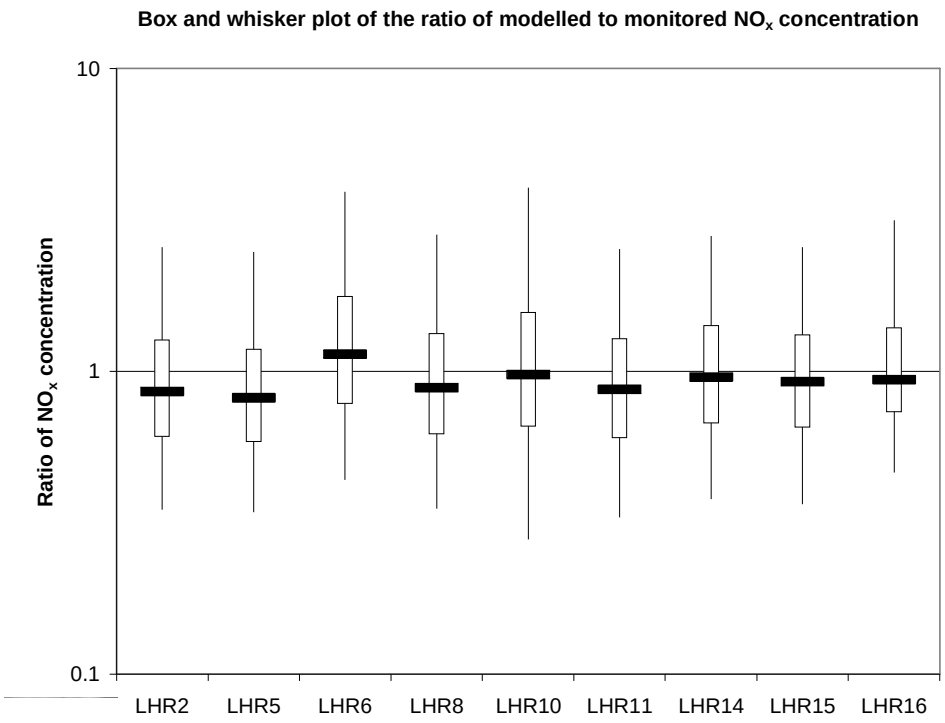
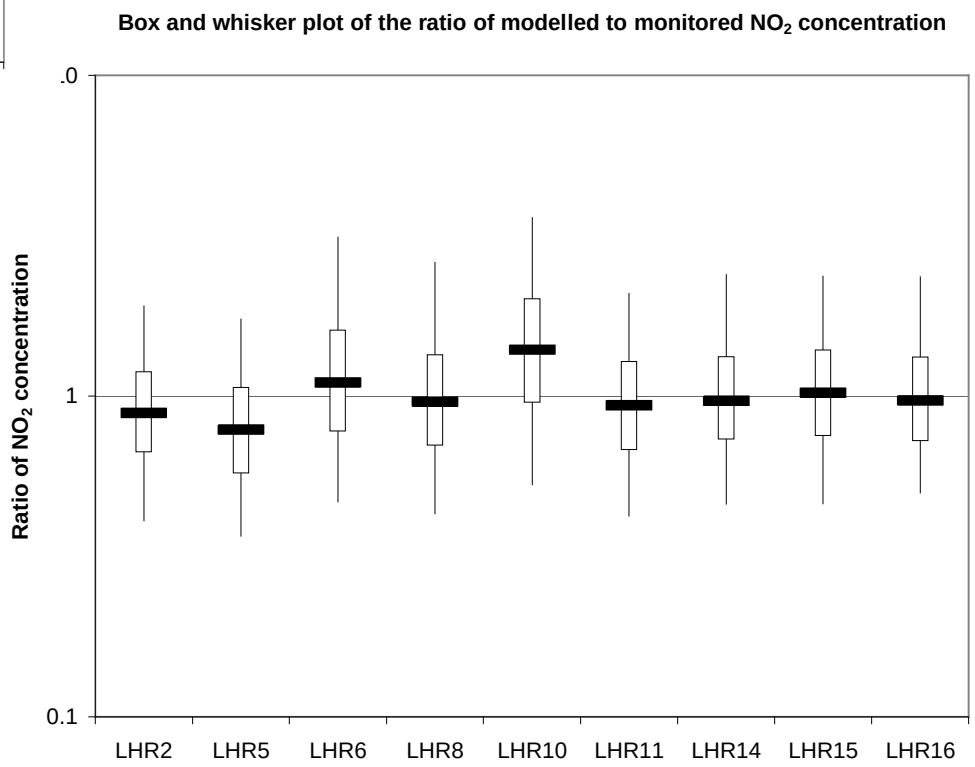
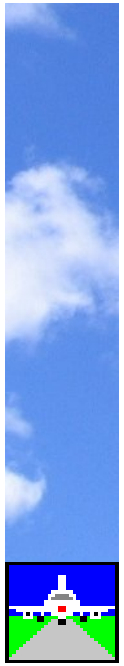


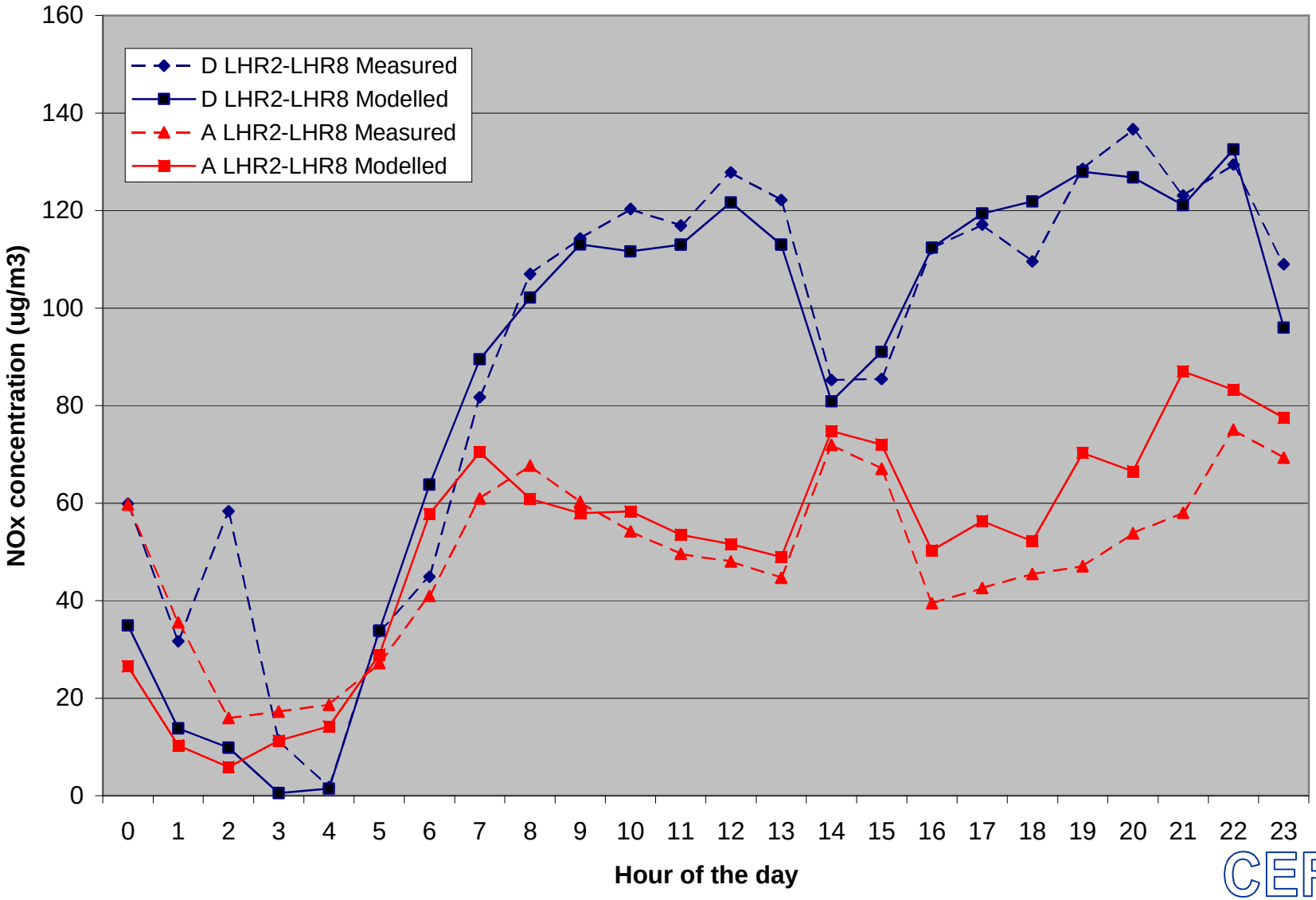
LHR2 "<u>Box and whisker</u>" plots for the ratio of (calculated/monitored) concentrations, NO_X (top) and NO_2 (bottom).





The lines indicate the 75th, 50th and 25th percentiles and the lines extend from the 95th to 5th percentile.

LHR2 diurnal variation ADMS-Airport (solid line) compared with measured data (dotted line), different runway use



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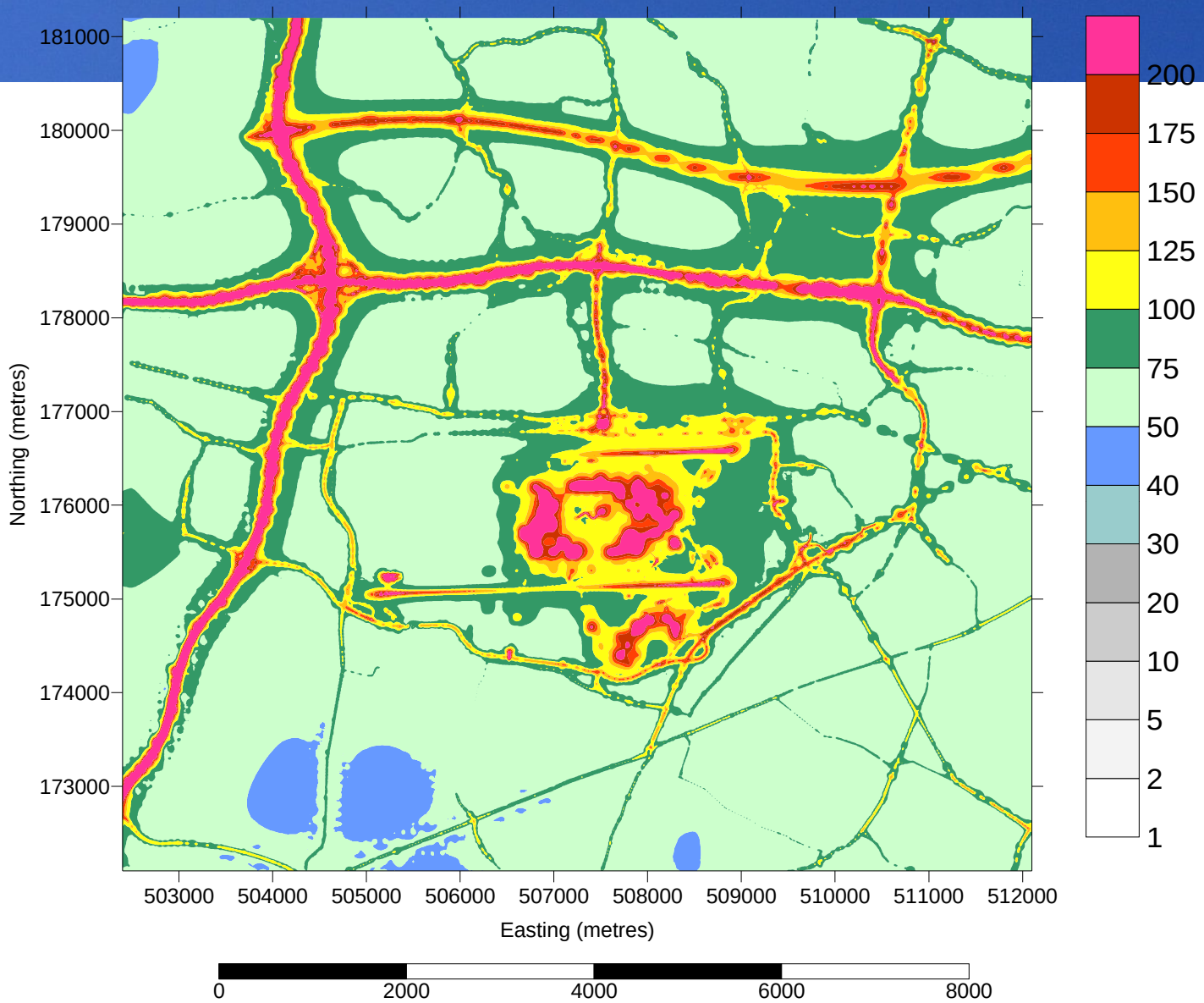
Base
Case
NOX



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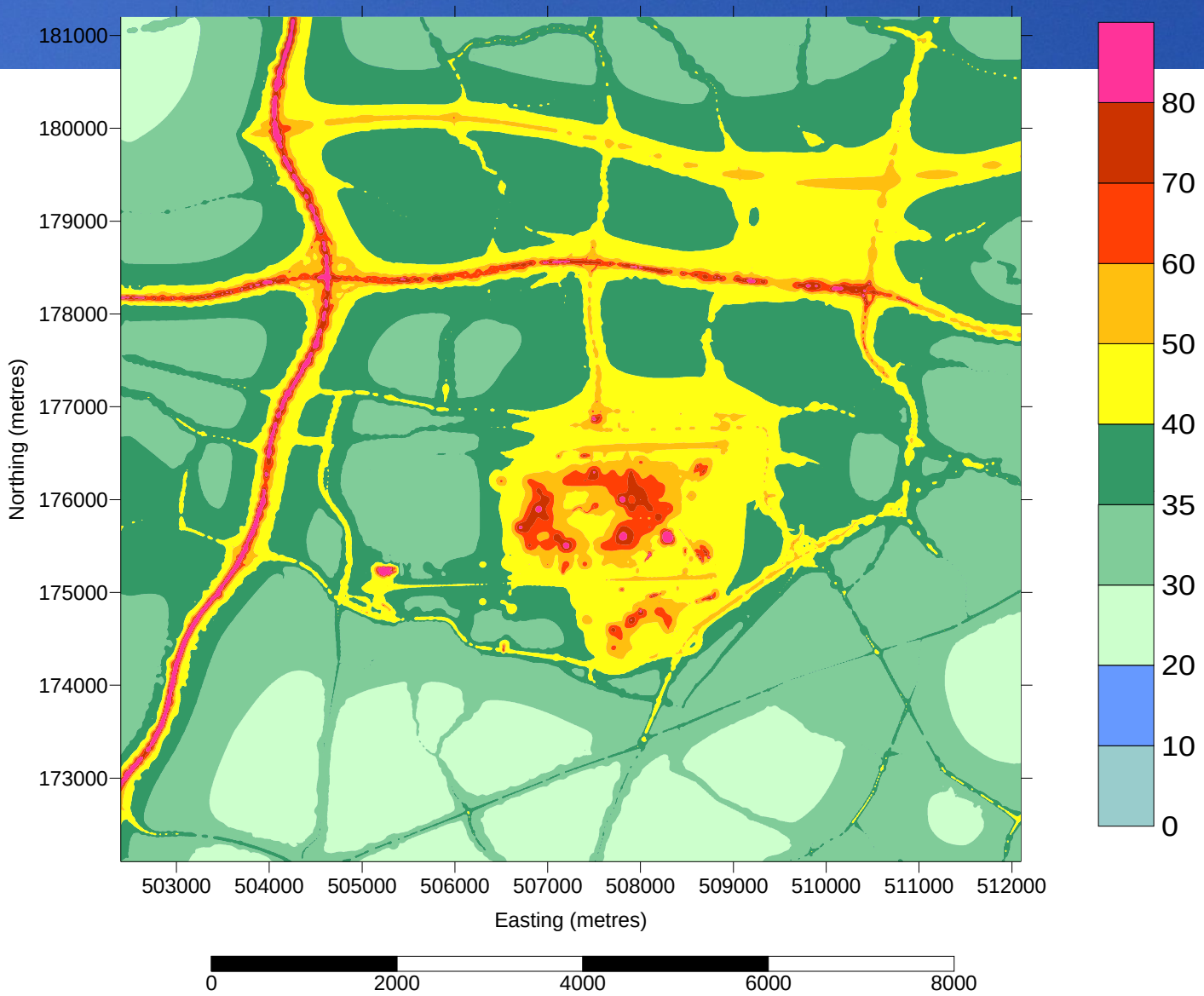
Base
Case
NO2



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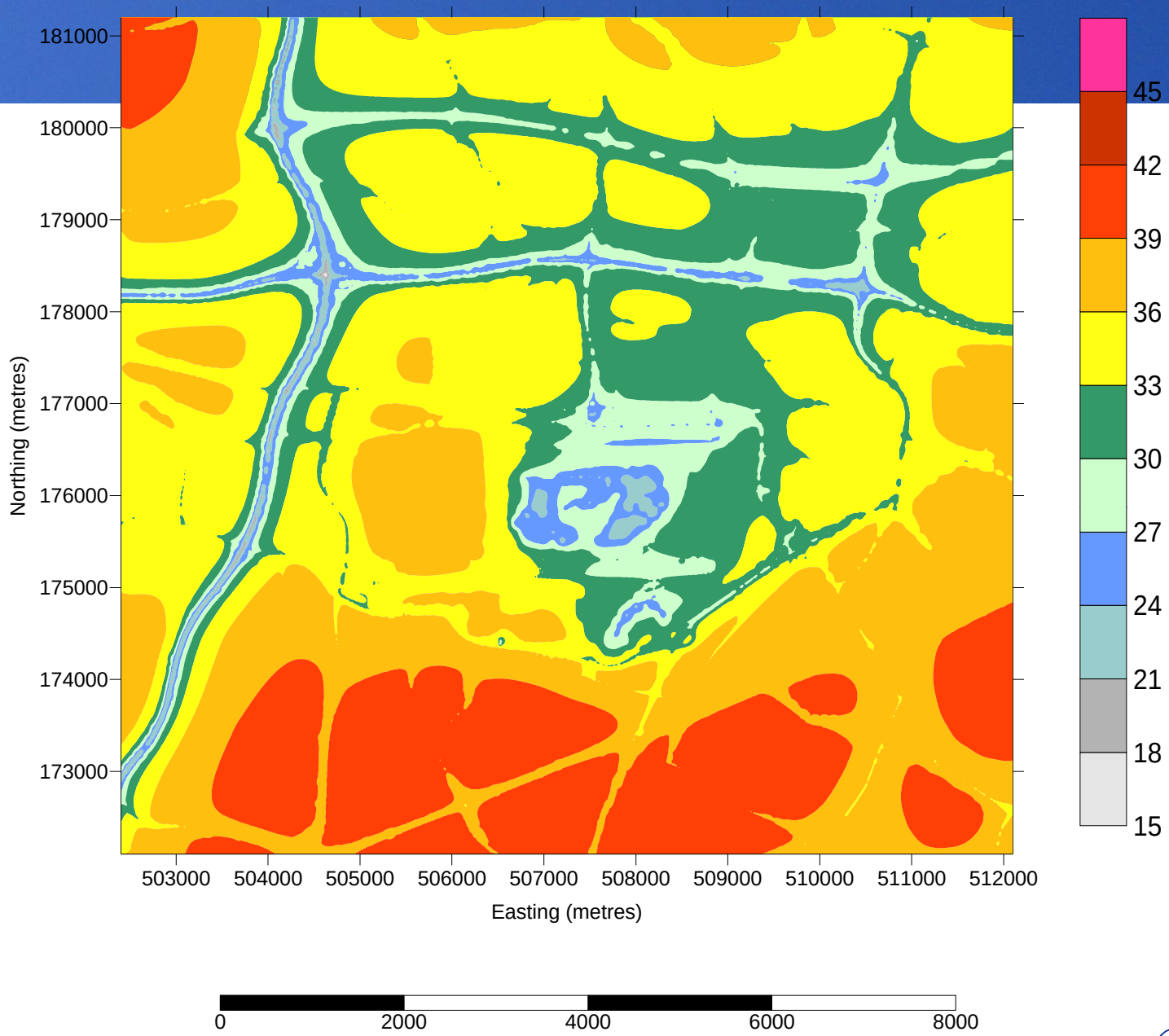
Base Case ozone



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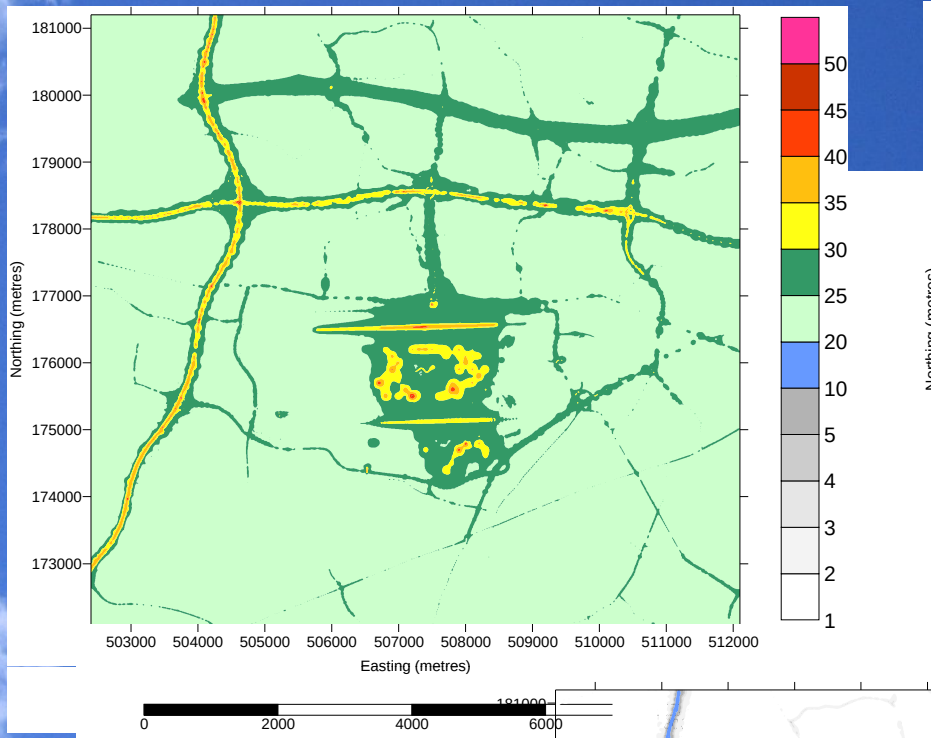
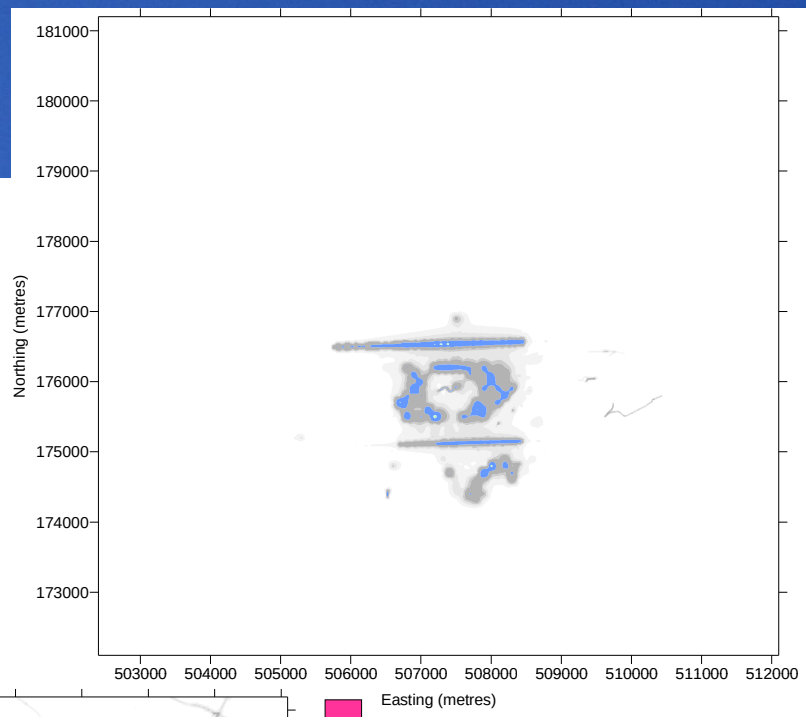
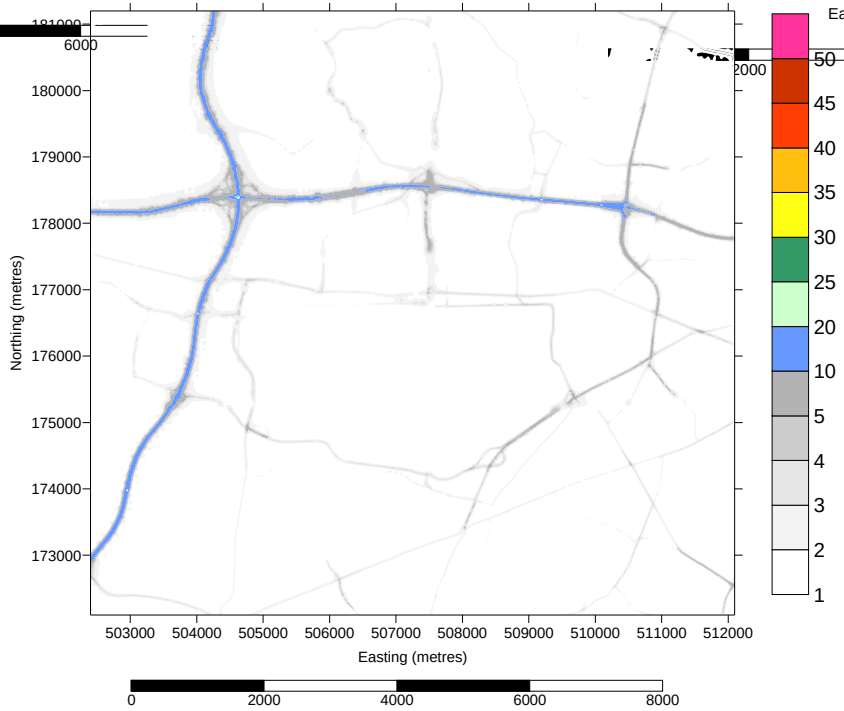




PM10 due to
-All sources (top left)
-Airport and other airport sources (top right)
-Road sources (bottom)



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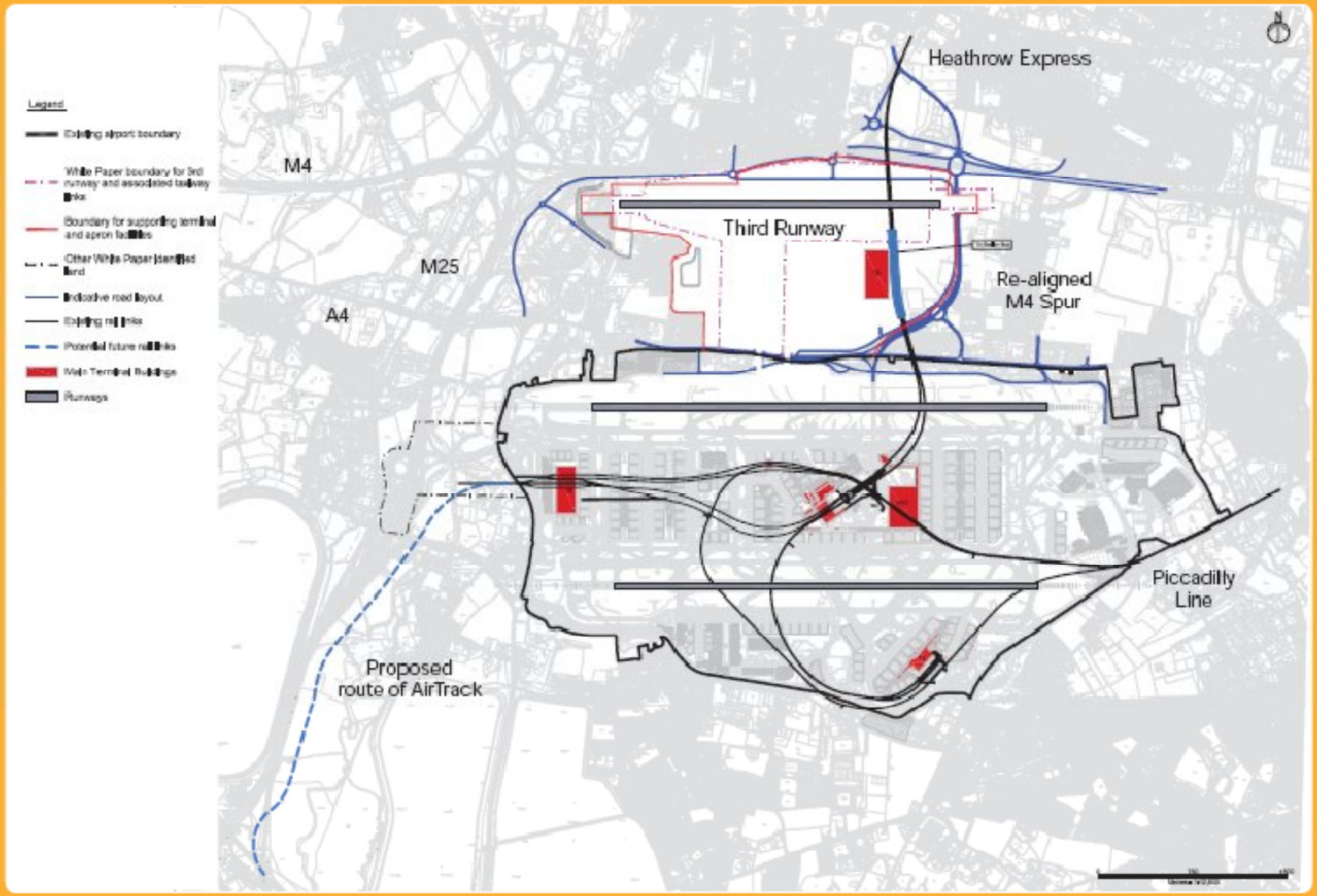

Page 41, "Adding Capacity at Heathrow Airport: Consultation Document",
Department for Transport, November 2007

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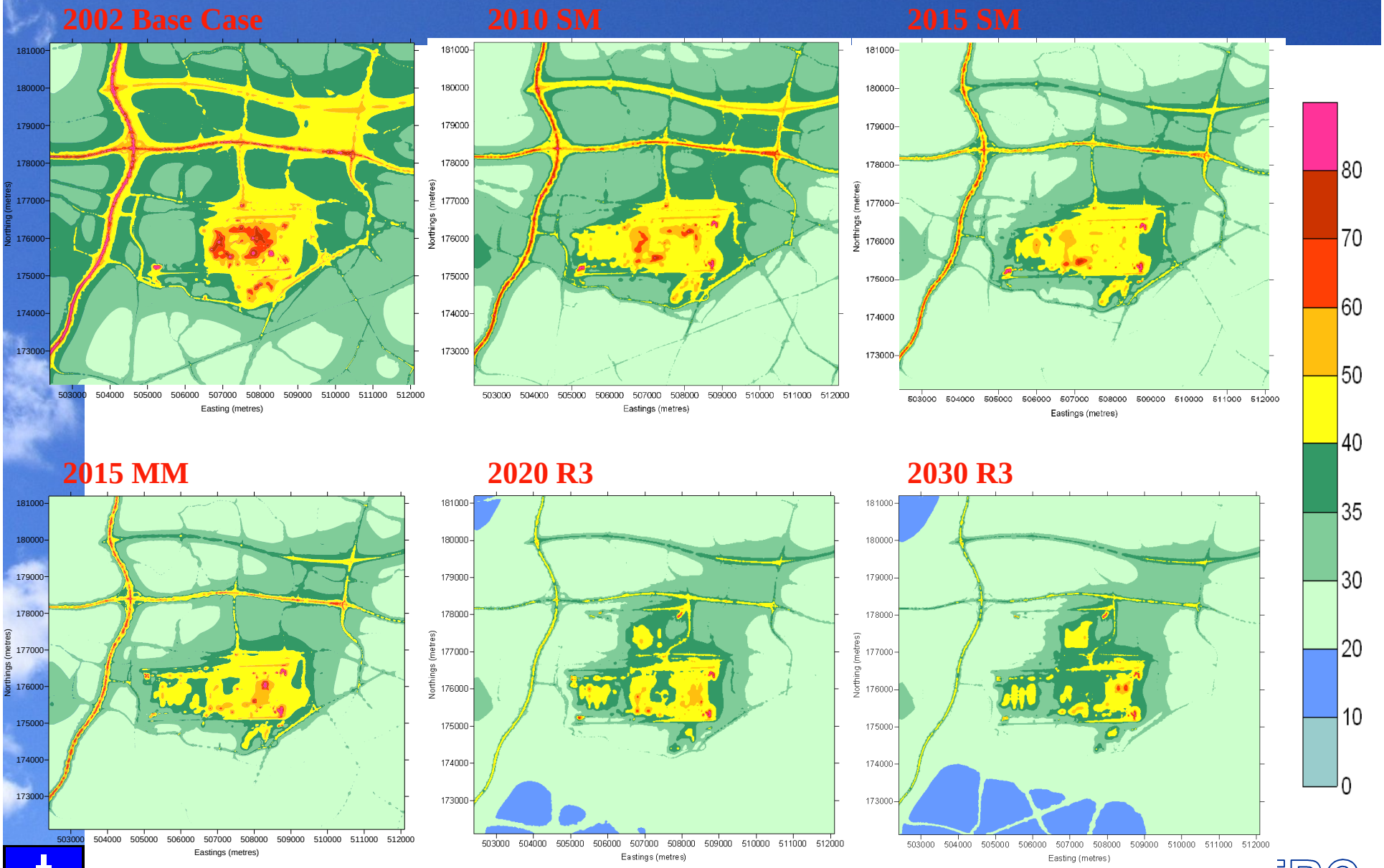
Predicted NO_2 concentrations



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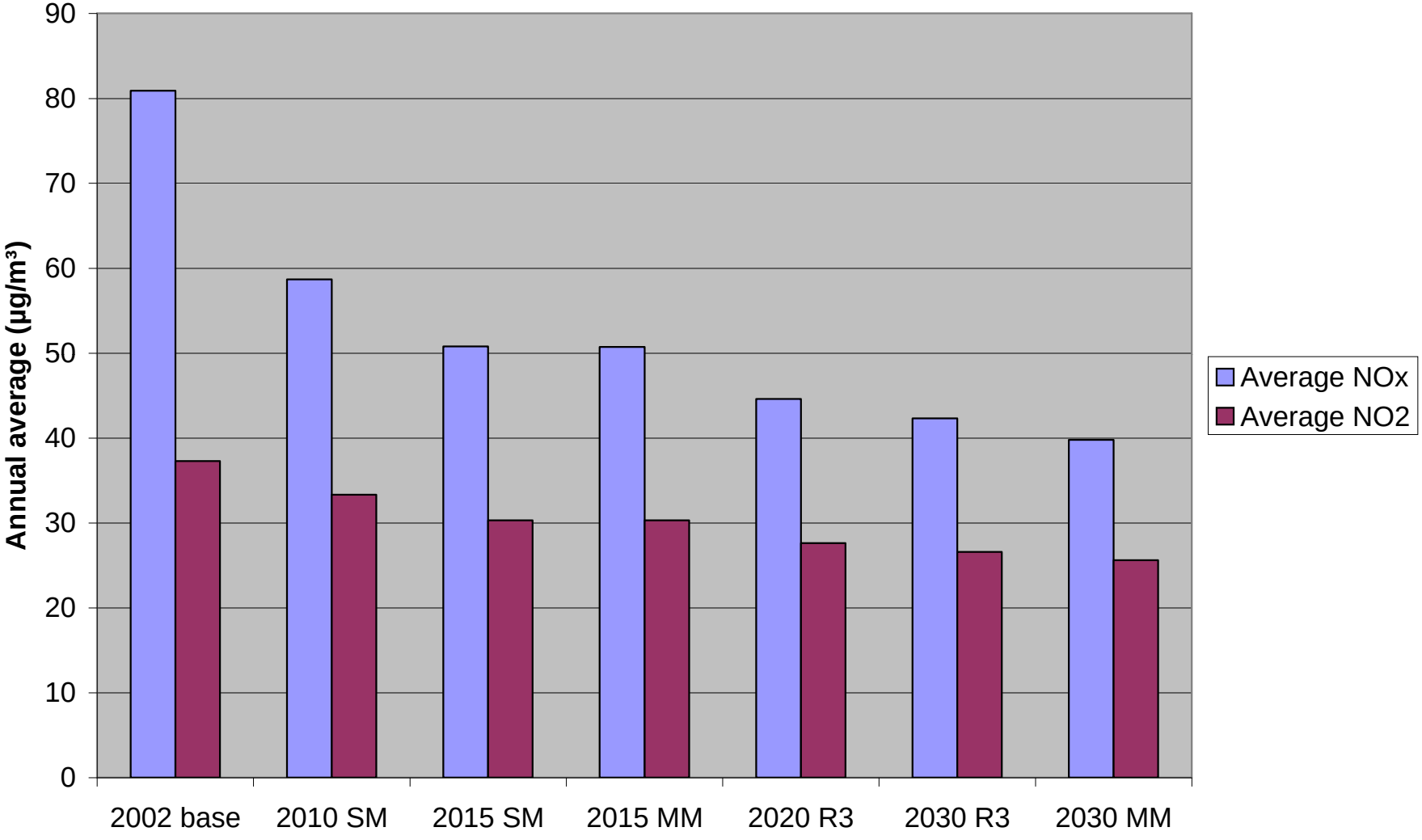
Scenarios: ANNUAL AVERAGE CONCENTRATION OF NOx and NO2 ACROSS THE DOMAIN



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Scenarios: NUMBER OF PROPERTIES & POPULATION PREDICTED TO EXCEED NO2 LIMIT

Case	Properties	Population
2002 Base	7336	17581
2010SM	1386	3126
2015SM	56	139
2015MM	91	199
2015MMrd	35	75
2030MM	0	0
2020R3	0	0
2030R3	0	0

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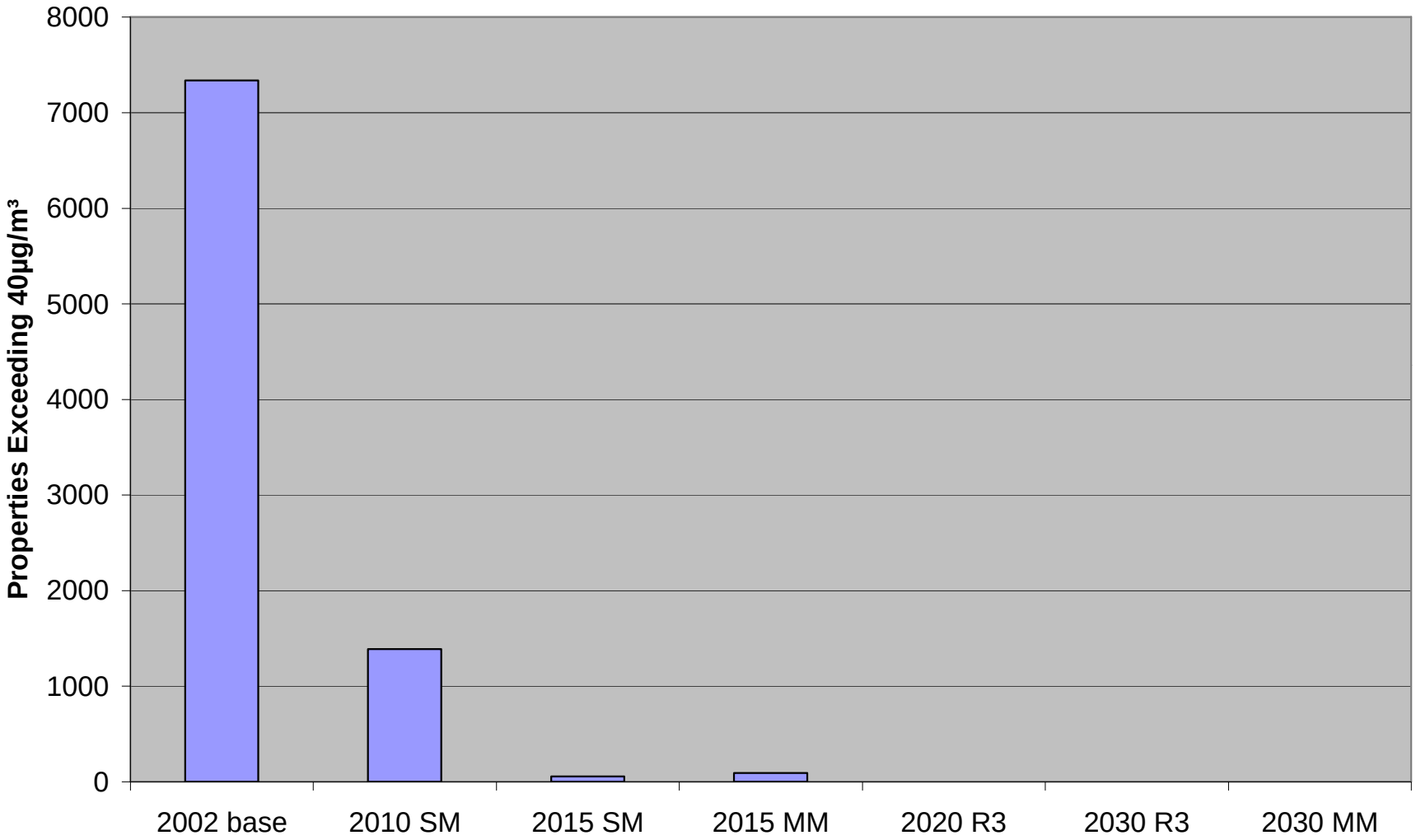
Scenarios: NUMBER OF PROPERTIES PREDICTED TO EXCEED NO2 LIMIT



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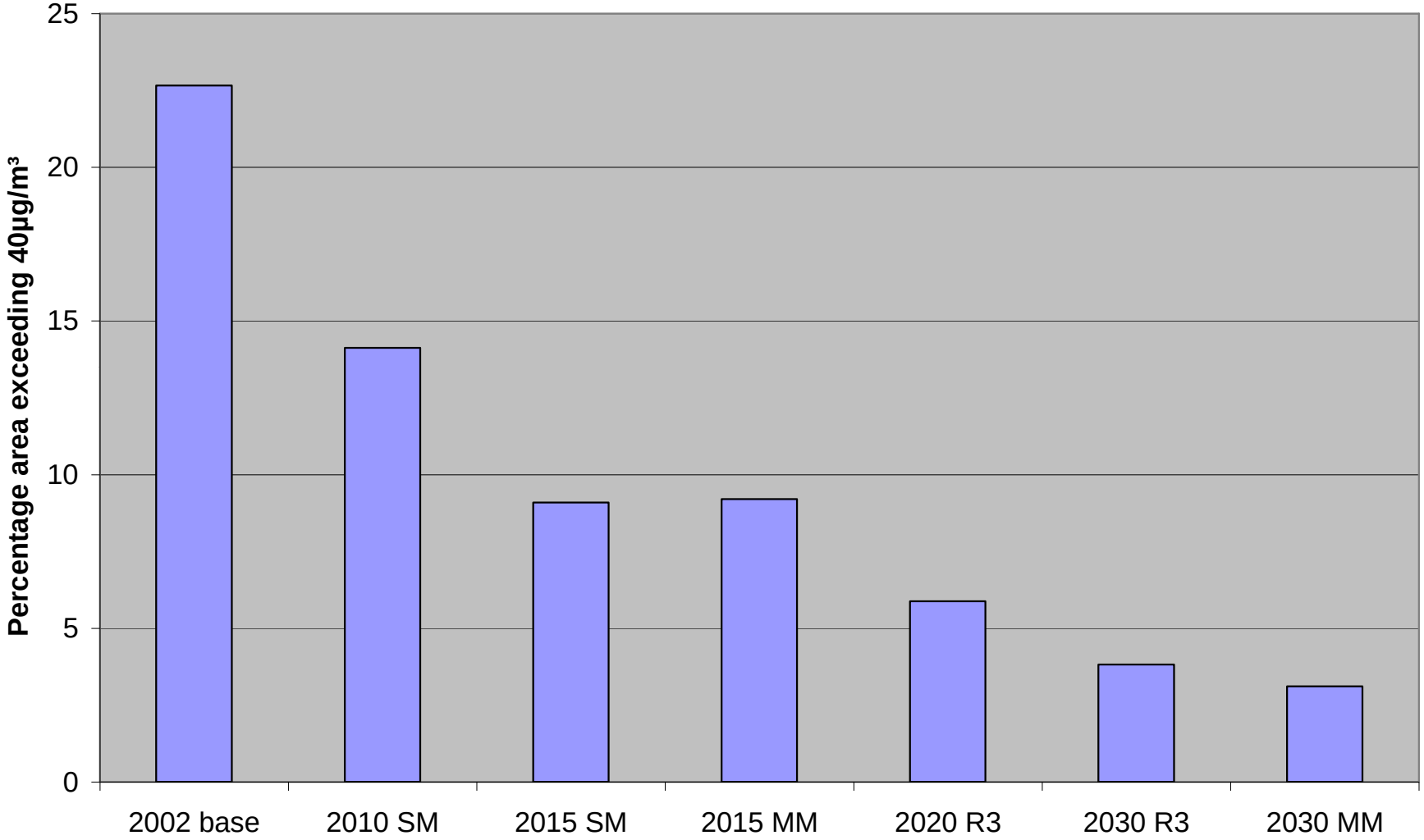
Scenarios: PERCENTAGE AREA OF DOMAIN EXCEEDING NO2 LIMIT



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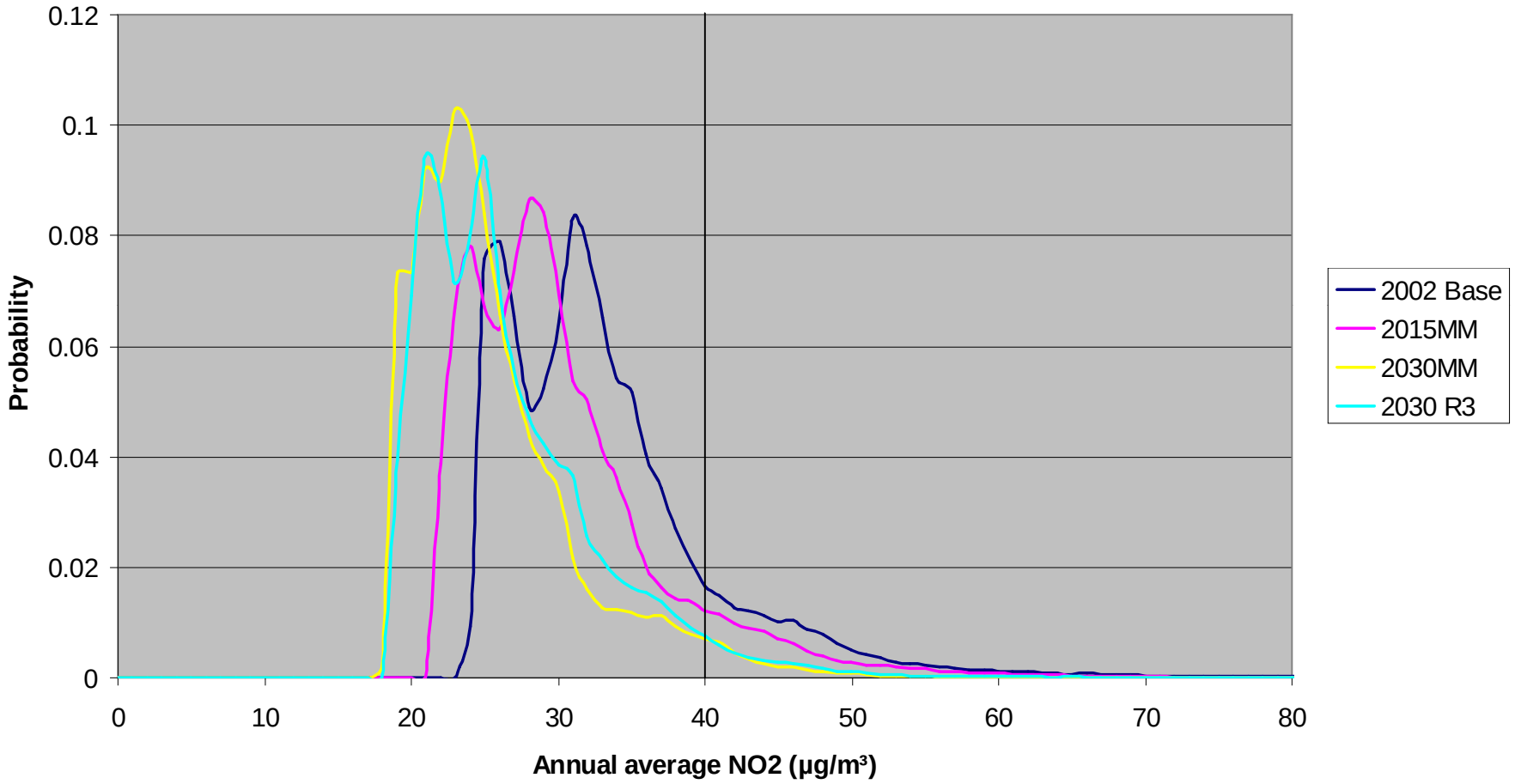
Scenarios: PDFs OF ANNUAL AVERGAE NO2 CONCENTRATIONS



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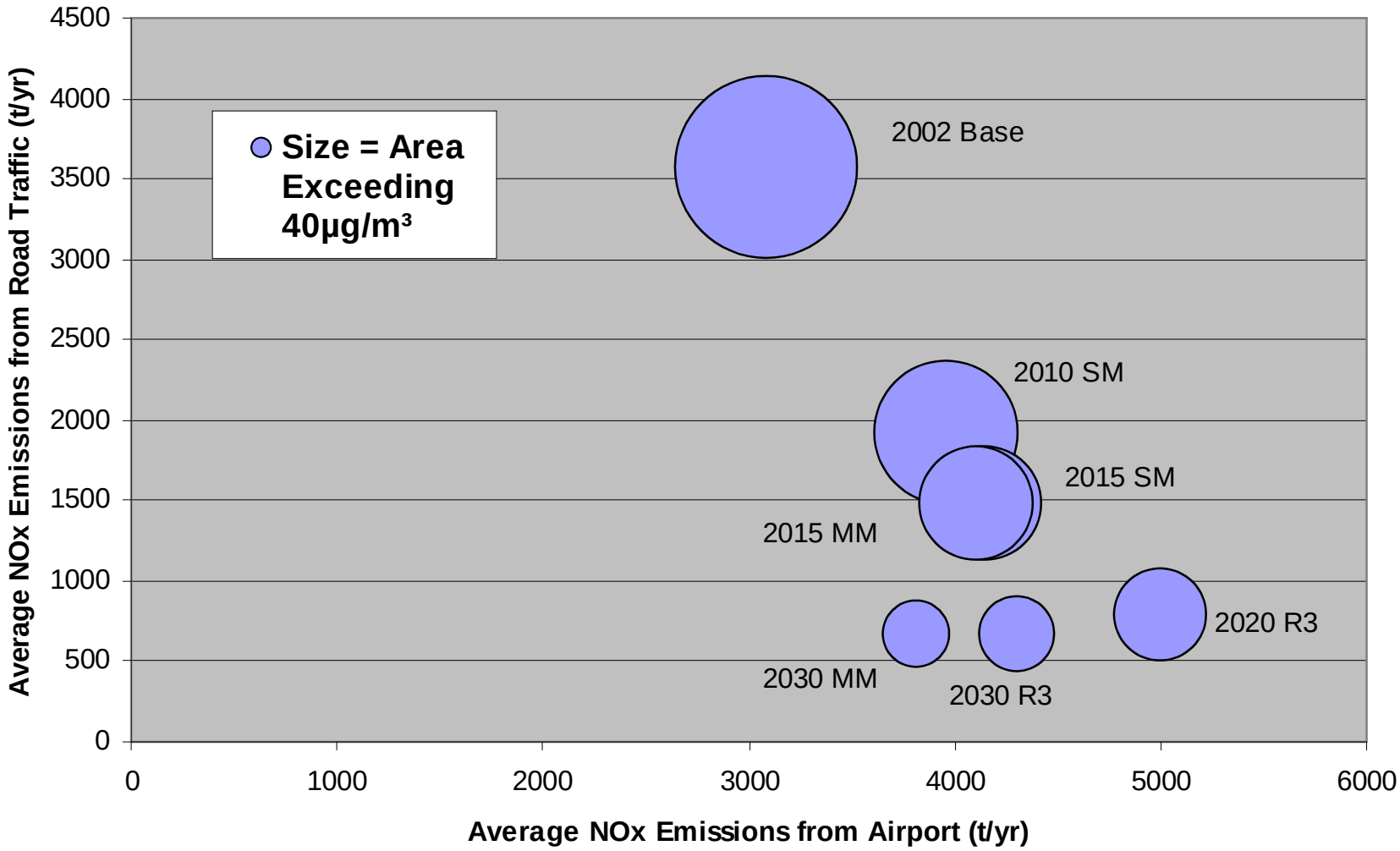
Scenarios: AREA EXCEEDING NO2 LIMIT AS A FUNCTION OF AIRPORT AND ROAD NOX EMISSIONS



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Conclusions

Key factors affecting pollutant concentrations in the neighbourhood of airports include the following:

- Emissions including primary NO_2
- Background concentrations e.g. O_3
- Meteorology
- Near field dispersion processes
- Chemical reactions

Heathrow Mixed Mode and R3 – Consultation period over; DfT preparing response

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