Roseburn Air Pollution Modelling

An assessment of the Council's CCWEL Roseburn Study Air Quality Monitoring Report published 14th Oct 2019 by John Lamb, retired SEPA, expert with twenty years' experience in air pollution.

Background

Since December 1997 each local authority in the UK has been carrying out a review and assessment of air quality in their area. This involves measuring air pollution and trying to predict how it will change in the next few years. The aim of the review is to make sure that the national air quality objectives will be achieved throughout the UK by the relevant deadlines. These objectives have been put in place to protect people's health and the environment. If a local authority finds any places where the objectives are not likely to be achieved, it must declare an Air Quality Management Area." Defra [1]

Roseburn Terrace is part of a City Centre Air Quality Management Area (AQMA) that was designated by City of Edinburgh Council (CEC) in 2001, because the concentrations of nitrogen dioxide (NO_2) were exceeding the annual mean and 1-hourly air quality objectives.

Measuring nitrogen dioxide in Roseburn Terrace

CEC has used passive diffusion tubes (PDT) to measure NO_2 inside Roseburn Terrace since 2005. The measurements are published in a series of annual reports [2], and they show that the annual mean objective was exceeded every year from 2005 to 2009. These measurements have also shown that the concentrations on the south side of the Terrace are consistently higher than the north. This is expected, because Roseburn Terrace is a text book Street Canyon (see appendix 1).

The concentrations of NO_2 on the north side of the terrace dropped below 40 $\mu g.m^{-3}$ in 2009, and are still below the annual mean threshold value.

Unfortunately, CEC stopped measuring NO_2 on the south side of the street in 2009 (even though these measurements were consistently higher than the north side) therefore there are no data for the period 2010-2016. A mean leeward/windward ratio was calculated using data for 2005-2009 and this was used to calculate indicative figures for the missing years (see Table 1). These calculated figures (in red) suggest that the annual mean objective was likely to have been exceeded on the south side of the street, throughout this period. A PDT was returned to the south side of Roseburn Terrace in 2017 and the leeward/windward ratio was found to be 1.3 - confirming that the use of the 1.34 ratio was reasonable.

It was found that CEC had not followed the official guidance when it corrected PDT data [3] and published measurements for Roseburn Terrace are lower than they would have been if the guidance had been followed correctly. For example, in the case of 2017, the Council published a figure of 35 $\mu g.m^{-3}$ (below the safe threshold) when it should have been 40.3 $\mu g.m^{-3}$ (slightly above the safe threshold). See Appendix 2 for more detail.

[1] https://uk-air.defra.gov.uk/aqma/

[2] The LAQM reports can be viewed here:
http://www.edinburgh.gov.uk/info/20268/pollution/314/local_air_quality_management

[3] LAQM TG.16 was created to support local authorities in carrying out their duties under the Environment Act 1995, the Environment (Northern Ireland) Order 2002, and subsequent regulations.

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Windward	46	49	67	50	37	43.2	34.5	38	35	37	32	32	27
Leeward	69	77	69	64	49	58	46	51	47	50	43	42	35*

Leeward/ windward ratio	Actual					Calculated mean (2005-2009)							Act.
	1.5	1.57	1.04	1.28	1.33	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.30

Table 1: Passive diffusion tube measurements (µg.m^{-3}) taken from CEC annual reports. The calculated indicative figures (in red) have been calculated using a leeward/windward ratio of 1.34.
*This figure is wrong and it should be 40.3

It is important to note that the parking bays provide a space in which NO_2 can dilute before it arrives at the PDT, but the concentrations of NO_2 still exceed the annual mean objective on the south side of Roseburn Terrace. If the parking bays did not exist, the NO_2 could not dilute, therefore the figures in Table 1 would be higher.

The parking bays help to protect residents from the effects of pollution

Studies have shown that the concentrations of NO_2 fall rapidly as the distance from the traffic increases. This "Fall-off in NO_2 concentrations with distance from the road" is well documented and is described in paragraphs 7.77 to 7.79 of the UK and Scottish Government's Technical Guidance document, LAQM TG.16.

This was put to good use when Dundee City Council (DCC) measured high concentrations of NO_2 outside a residential property in the centre of the city. The Council officers understood that the concentrations of NO_2 reduce with distance, so DCC moved traffic one lane away from the residential building and it has reported a 19% reduction in the concentrations of NO_2.[4]

A similar situation exists in Roseburn Terrace. The parking bays push traffic one lane away from the residential buildings, creating a gap in which exhaust gases can dilute before they arrive at the façade of the buildings. The LAQM Helpdesk[5] explains this in a detailed response to the Moray Feu Residents Association, in which it states "the fall-off [in nitrogen dioxide] over the first two metres is particularly steep". Appendix 3 shows how this occurs in Roseburn Terrace, where the rapid drop in NO^2 concentrations takes place in the parking bays. The Parking bays therefore help to protect residents and local retailers from the effects of traffic pollution. If these bays were to be removed, traffic would move one lane closer to the buildings and the exhaust gases will no longer have room to dilute. The concentrations of NO_2 on the leeward side of a street canyon will be higher - adding to the already high levels of pollution at this side of Roseburn Terrace. The reverse of what was achieved in Dundee.

[4] Dundee City Council's Updating and Screening Assessment Report, 2015
[5] Local Air Quality Management Helpdesk, January 2011 (A Government funded group of experts who assist local authorities to improve air quality).

The cycling lobby has pointed out that bicycles do not emit gases, so how can the pollution get worse. It is nothing to do with the cyclists, it is about the design and layout of the street and the way traffic passes through it. Street design is as important as the number and type of vehicles that pass through it - a reduced number of vehicles can still cause an air quality problem in a poorly designed street.

Figure 1: View of Roseburn Terrace (looking east) is showing how parked vehicles push traffic into the outer lane, increasing the distance between the traffic and the passive diffusion tube (on the grey post) and the shops/residential properties. Through traffic defaults to the outer lane even when there are no parked vehicles.

Roseburn Terrace Modelling Study

CEC commissioned a computer dispersion model that has considered 1-hourly concentrations of NO_2 in Roseburn Terrace during the busy morning and evening periods (5 hours per day, Monday to Friday).

There are no reported exceedances of the 1-hourly objective for NO_2 in Scotland, so there was no requirement to model this standard. Modelling the 1-hourly concentrations will show that there is not a problem. It would have been preferable to model the annual mean concentrations of NO_2, because compliance with this standard has proved to be problematical at many locations across the whole of the United Kingdom - including Roseburn Terrace.

There is no clear relationship between the 1-hourly concentrations and the annual mean concentrations, so modelling the 1-hourly will not show how changes to the road layout will affect the annual mean concentrations. For example, the monitoring device on St. John's Road recorded exceedances of the 1-hourly and annual mean air quality objectives. As the engine technologies improved over the years, the emissions of NO_2 slowly reduced and the 1-hourly mean exceedances stopped in 2012 – but the annual mean objective continued to be exceeded for another 6 years.

Reasons for not accepting the findings of the Roseburn Terrace modelling study (updated 7 November 2019)

1. **The model has only considered 1-hourly concentrations.** LAQM TG.16 (Para 7.90) advises "Predicting exceedances of the NO_2 1-hour objective is not straightforward, as these will be highly variable from year to year, and from site to site." and "Dispersion models cannot predict short-term concentrations as reliably as annual mean concentrations. Moreover model verification is likely to be challenging."

   Modelling the 1-hourly concentrations is less accurate and no relevance in the case of Roseburn Terrace, because long-term monitoring has shown that it is the annual mean concentration of NO_2 that is at risk of being exceeded on the south side of the street, not the 1-hourly mean.

2. **The study has not assessed the implications for the health of the people who live and work in Roseburn Terrace**.

3. **The model has only considered 5 hours of traffic per day, Monday to Friday**. This is a busy arterial route and traffic passes through Roseburn Terrace 24 hours a day, seven days a week. This study should have considered all traffic over a period of one year.

4. **This is very important - model has not been verified**. "Verification involves a comparison between predicted and measured concentrations at one or more suitable local sites, and adjustment of the modelled concentrations if necessary".[6] The Roseburn Terrace model has not (and cannot) be verified, because there are no 1-hourly monitoring data for this location. CEC is unable to prove that this model is representative of the conditions that currently exist, or may exist within Roseburn Terrace, therefore it is not fit for purpose.

5. **The modelling study has generated data that appears to contradict the monitoring data**. The model suggests that the concentrations of NO_2 on the north side of the Terrace are higher than those on the south. This contradicts 13 years of monitoring data that have consistently shown that the highest concentrations exist on the south side of Roseburn Terrace. If the model had focused on the annual mean concentrations (as stated above), it could have used local monitoring data to test the model, to see if it was performing correctly. This would have provided greater confidence in the results.

6. **This is not an independent assessment:** this model was set up and run by the same company that has worked with City of Edinburgh Council to design the CCWEL, therefore the model is more likely to generate modelling results that will support claims that air quality will improve.

[6] Local Air Quality Management Technical Guidance TG.16, Para 6.11, bullet point 3

Appendix 1: Street Canyon

Roseburn Terrace is a text book example of a street canyon "*… where, the highest levels of air pollution often occur and the larger targets of impact are concentrated. The natural ventilation of urban streets is reduced mainly due to the presence of buildings. Within the urban canopy, wind vortices, low-pressure areas and channelling effects may be created under certain meteorological conditions, giving rise in some cases to air pollution hotspots. For example, high concentration levels have been often observed on the leeward side of regular canyons under perpendicular wind conditions."*[7] The orientation of the street - in relation to the prevailing wind - is an important consideration, because when a canyon is perpendicular to the prevailing wind direction, the dispersion of atmospheric pollution is extremely poor. The prevailing wind direction in Edinburgh is from the south west and almost perpendicular to the orientation of Roseburn Terrace.

Slow moving, congested traffic and vehicles accelerating from a standing start will emit more pollution. Additional traffic lights will add to the problem. The exhaust emissions become trapped between the buildings where they get recirculated, resulting in higher concentrations of pollutants on the leeward (south) side of the street, as shown below. Council monitoring on both sides of the street has confirmed that the concentrations of NO_2 are approximately 30% higher on the leeward side of Roseburn Terrace.

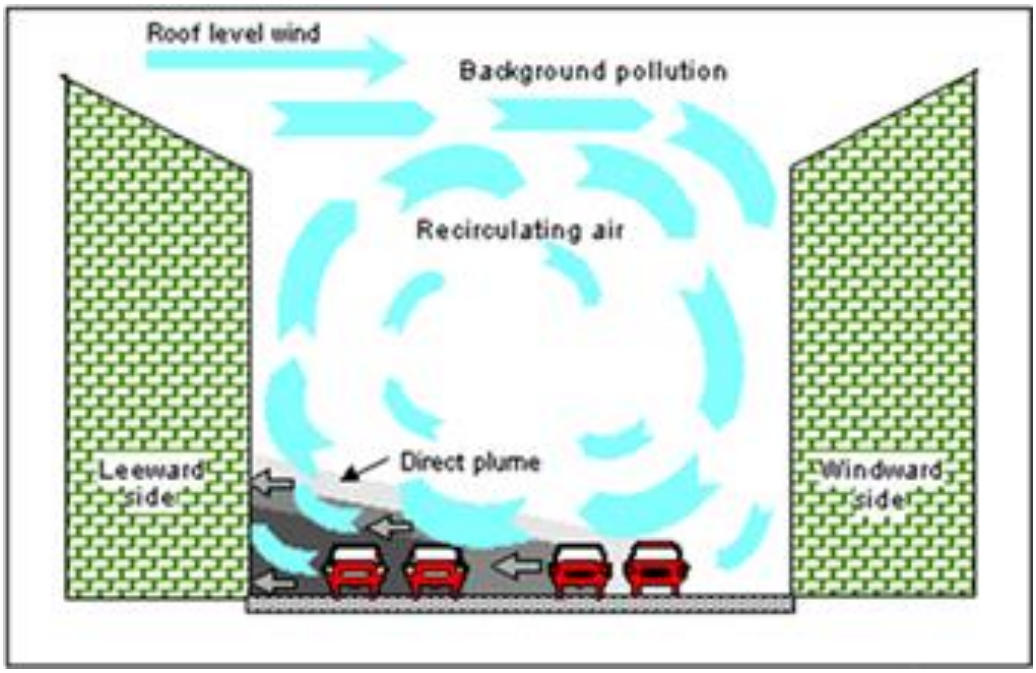


Figure 1: Schematic drawing showing environmental conditions that would exist in Roseburn Terrace (looking east to west)

Source: http://www.intechopen.com/books/air-quality-models-and-applications/urban-air-pollution-modeling

The proposed changes to the road layout will move traffic from the less polluted windward side of the street, to the more polluted leeward side. Traffic will also be moved one lane closer to the façade of the building, resulting in higher concentrations of NO_2 in an area where the levels are already sitting on the annual mean threshold.

Appendix 2: Passive Diffusion Tube Measurements in Roseburn Terrace

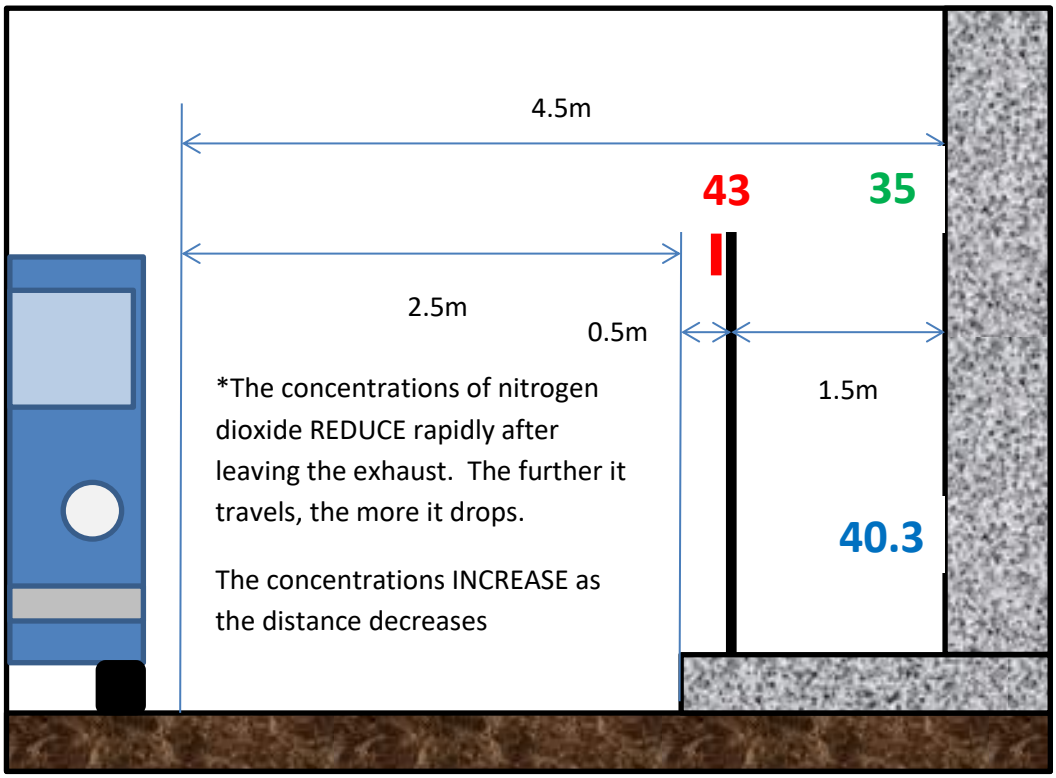
[7] Sotiris Vardoulakis, Bernard E.A. Fisher, Koulis Pericleous, Norbert Gonzalez-Flesca. Modelling air quality in street canyons : a review. Atmospheric environment, Elsevier, 2003, 37 (2), pp.155-182.

LAQM TG16 (Paragraph 7.79 states) clearly states "When using the NO_2 fall-off with distance calculator, it is important to justify the distances used in the calculation tool, as there may be circumstances when it is appropriate to treat the edge of the road (described within the tool as being the 'kerb') as being the edge of the carriageway with flowing traffic rather than the physical kerb, e.g. on some urban roads where the first lane is used for parking and therefore the flowing traffic is away from the physical kerb."

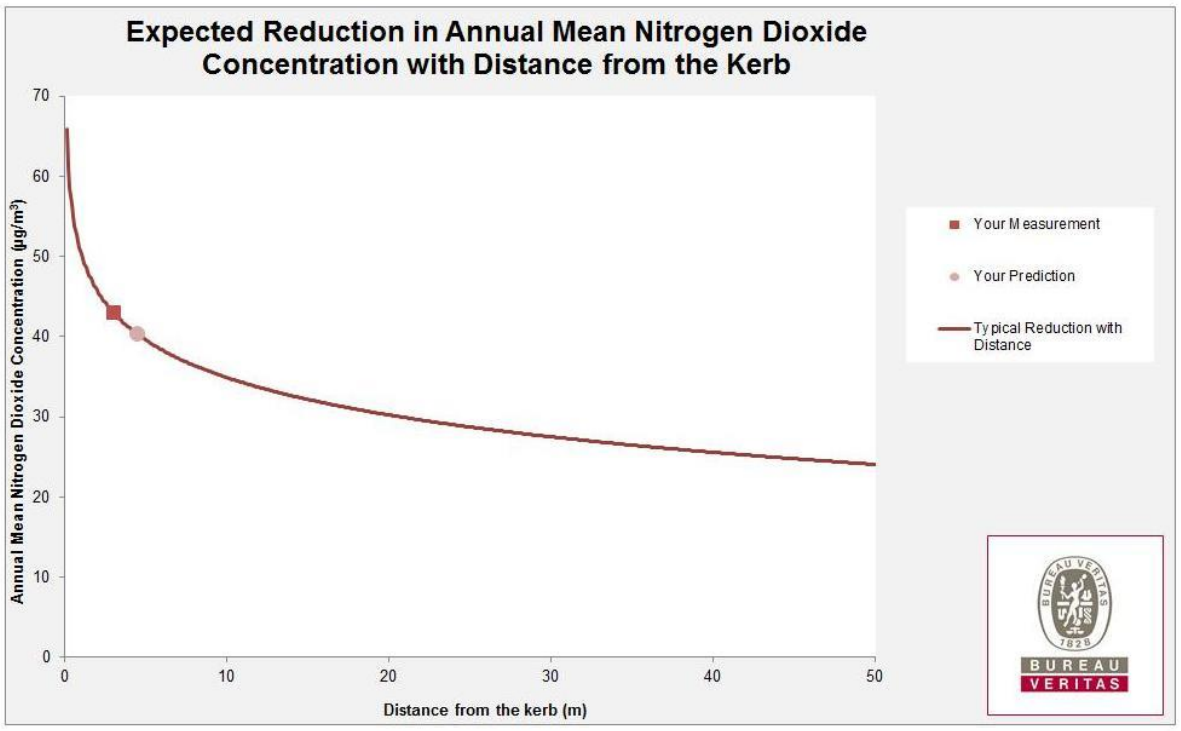
City of Edinburgh Council has ignored the parked vehicles and used the edge of the kerb to correct measurement data. This has produced a figure that is below the statutory 40 $\mu g.m^{-3}$ standard. If it had followed the guidance as described, the corrected figure is higher and slightly above the annual mean standard.

	CEC correction	LAQM TG16 correction
Distance of PDT from kerb	0.5m	3.0m
Distance Kerb to receptor	2.7m	4.5m
Background Concentration	17 $\mu g.m^{-3}$	17 $\mu g.m^{-3}$
Roadside (diluted) measurement*	43 $\mu g.m^{-3}$	43 $\mu g.m^{-3}$
Corrected measurement at facade	35 $\mu g.m^{-3}$	40.3 $\mu g.m^{-3}$

Passive diffusion tube measurement (south side of Terrace)
Data from CEC Annual Progress Report 2018



Appendix 3: Expected Reduction in Annual Mean Nitrogen Dioxide Concentration with Distance from the Kerb (current scenario)



This has been calculated using the "Nitrogen Dioxide fall off with distance" tool provided on the Defra website: https://laqm.defra.gov.uk/tools-monitoring-data/no2-falloff.html

Current scenario (with parking bay)

The greatest drop in NO_2 can be seen in the first 2-3m, and this would take place in the parking bay in Roseburn Terrace. The concentration of nitrogen dioxide at the outer boundary of the parking bay is 67 microgrammes per cubic metre. Within 3m, this falls to 43 (at the measuring device) and by the time the pollution reaches the façade, it has dropped to 40.

Future scenario (without parking bay)

Moving the curve 3m to the right can provide an indication of what may occur when the parking bays are removed and traffic is moved 3m closer to the façade. The concentration of nitrogen dioxide at the kerb will be 67 microgrammes per cubic metre and an estimated 48 microgrammes per cubic metre at the facade. An increase of 17%. Dundee City Council moved traffic one lane away from a residential property and achieved a 19% reduction in NO_2.