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Technical Note: Southampton CAZ Air Quality Modelling

Project: 1863 Southampton CAZ
Client: Local Residents
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Introduction

1. Brook Cottage Consultants was instructed by a group of residents to undertake a review of the air quality modelling report (AQ3) produced for the development of proposals for a Clean Air Zone (CAZ) in Southampton[1].

2. This review is on the compliance with the European Union Air Quality Directive (EU AQD) limit value (LV) for nitrogen dioxide (NO_2). It does not consider the predicted concentrations at locations other than alongside Defra's PCM road links. This note does not consider the results at the local monitoring sites as this data is not relevant for assessing compliance with the EU AQD.

3. The road traffic data for the air quality modelling was supplied by Systra using the road transport component of the Solent Transport Model. This sub-regional transport model (SRTM) is a suite of five linked models, one of which is the road transport model. This model is described in the Transport Modelling Methodology report (T3) dated 22 May 2018 and the SRTM Model Forecasting Summary dated 14 November 2018. These reports have not been reviewed due to a lack of expertise in transport modelling.

4. The AQ3 report concludes (p256) (my emphasis) "*These results indicate that compliance is likely to be achieved in the 'do minimum scenario', but there are residual risks around uncertainty in the modelling and if Euro 6 does not perform as expected. Given this outcome* measures to manage this risk should be pursued*, although implementing a* full city-wide CAZ B would seem disproportionate *in this respect even though it would reduce concentrations and consequently the risk of exceedance. A package of non-charging measures would seem more appropriate for managing this risk, although the package of the non-charging measures modelled had limited impact. This suggests further complementary measures should be pursued, including measures could reduce emissions from light duty vehicles, to help management* (sic) *this risk*." Surely the analysis included the non-charging measures most likely to be deliverable and produce material air quality benefits. So, it is difficult to understand what these further measures could be.

5. It should be noted that the cost-benefit analysis shows that a Class B CAZ would have a positive net present value of £15.67m over the period 2020 to 2030 at 2018 prices. That is the benefits outweigh the costs by over £15m. It delivers:

    - The largest air pollutant emission reductions but has the largest costs.
    - Avoids deliverability risks of non-charging options.

[1] Ricardo Energy & Environment, 2018, Southampton Clean Air Zone Feasibility Study – Air Quality Results Report (AQ3), dated 18 December 2018.

- Delivers large air quality emissions reductions, which will deliver greatest health and environmental benefits, from which poorer households will benefit most.
- The largest impact is on business, with potential adverse effects on HGV and coach operators, and taxi drivers who may struggle most with affordability of upfront costs of compliance with a Class B CAZ.
- Also, there will be some indirect impact on household affordability (although less so than for businesses).
- There is a potential risk around difficulty of identifying taxis under a charging CAZ in the absence of national database.

Key Conclusions of the Air Quality Modelling

6. The key conclusion of the December 2018 air quality modelling undertaken by Ricardo (as reported in AQ3) are summarised below. The limit value is 40 µg/m^3; the Ricardo report uses a value of 35µg/m^3 as an indicator of road links which are "*potentially at risk of exceedance*".
7. 2020 'Do minimum'
    - In 2020 with no further measures the 40 µg/m^3 NO_2 limit value (LV) is predicted to be exceeded on one part of the M27 within the City boundary. The annual mean NO_2 concentration is predicted to be 50 µg/m^3 in 2020 on M27 (link ID 75258). This road is the responsibility of Highways England (HE) not Southampton City Council (SCC).
    - Elsewhere within the City the LV is predicted to be achieved. The maximum predicted concentration on a SCC road is 38 µg/m^3. There are five road links with predicted concentrations between 35 µg/m^3 (i.e. where there is considered to be a risk of exceedance) and the limit value of 40 µg/m^3.
    - The LV will continue to be exceeded on six links of the M27 and M3 outside the city boundary. Southampton City Council have no jurisdiction over the air quality on these roads; they are the responsibility of HE who have not published any detailed plans on how the LV will be achieved on motorways.
8. Impact of the Non-Charging CAZ
    - The non-charging measures modelled have a maximum impact of 0.1 µg/m^3 (section 4.1). On average the reduction in annual mean NO_2 concentrations is 0.1%. This is so small that it is inconsequential.
9. Impact of the CAZ B
    - The CAZ B is predicted to reduce NO_2 concentrations by 2 to 13%, with an average reduction of 6.4% according to the report (ID 75259 M27 in Test Valley Borough reduces from 66 to 53 µg/m^3, which is a 20% reduction. This is outside Southampton City).
    - The CAZ B does not change the number of road links that exceed the LV, but it results in very significant reductions in predicted concentrations on the motorways, making it easier for Highways England to achieve the LV.

- The CAZ B does reduce the number of links greater than 35 µg/m^3 within the Southampton City boundary from 6 to 2 with one of these being the M27 (ID 75258).
- Outside of the city boundary on the surrounding motorway network the CAZ B reduces the number of links above 35 µg/m^3 from 8 to 6.

Southampton City Council Proposal

10. Southampton City Council (SCC) have proposed a non-charging CAZ, however the non-charging measures modelled are predicted to make an insignificant impact on the predicted concentrations. There is no evidence provided that other non-charging measures will have a material impact.
11. SCC state that their proposed package of non-charging measures will mitigate the risk of exceedance, increase the likelihood that compliance is achieved before 2020 and promotes on going improvements in air quality. The maximum reduction in NO_2 concentrations predicted is 0.1 µg/m^3 (i.e. 0.25% of the LV) and such a small impact cannot mitigate the risk.
12. The Garnham Judgement in Client Earth No 2 is clear that the achievement of the LV must not just be possible but must be likely. The AQ3 report suggests that there is only a 50% chance of compliance when 40 µg/m^3 is predicted. This suggests that a lower value should be used to assess compliance (see Appendix 1), although It is not easy to determine exactly where the cut-off between 'possible' and 'likely' should be.
13. No model is 100% certain. The accuracy of a model can be assessed using the root mean square error (RMSE). The AQ3 modelling had a RMSE of 4.7 µg/m^3, rounded to 5 µg/m^3. Therefore, all results above 35 µg/m^3 are considered by Ricardo to be potentially at risk of exceedance. At 35 µg/m^3 there is a 20% chance that the LV will be exceeded. This seems to be a reasonable cut-off for identifying 'likely compliance', i.e. compliance is much more likely than non-compliance.
14. The highest predicted concentration at a road that SSC is responsible for is 38 µg/m^3. This is the A3024 near Northam Bridge (ID 46963). Figure 12 in AQ3 (reproduced in the Appendix) suggests that there is approximately a 33% chance of the LV being exceeded when 38 µg/m^3 is predicted (note it is difficult to accurately read the data from the graph).
15. It should be noted that the RMSE is based on the 2015 baseline. There will be additional uncertainties associated with forecasting future (2020) concentrations. Several sensitivity tests were undertaken to quantify the sensitivity of the model to the assumptions used.
16. These suggest that the model is not very sensitive to the assumption made regarding the effectiveness of the non-charging measures and the growth of the port. The latter is somewhat surprising because the growth between 2015 and 2020 was reduced in the final modelling from 29% to just 2% in the options modelling.
17. The model is sensitive to assumptions regarding the emissions performance of Euro 6 diesel light duty vehicles and the proportion of NO_2 emitted in the NOx from diesel vehicles (known as f-NO_2). The former increases roadside NO_2 concentration and the latter reduces them.
18. The impacts of the sensitivity tests are summarised below:

- Higher levels of port growth – this increases concentration by a maximum of 0.5 µg/m^3 and does not have an impact on the results.
- Lower performance of Euro 6 diesel cars and vans increased concentrations by up to 2 µg/m^3 which increased the concentration at one road link up to 40 µg/m^{3}and another to just over 35 µg/m^3 in the '*do minimum'* scenario. This increases the risk of an exceedance arising in 2020.
- Reducing the f-NO_2 by 40% significantly reduces concentrations and removes all the locations potentially at risk of exceedance in the '*do minimum'* scenario.
- The non-charging measures essentially have no impact on concentrations, so lowering the assumed impact in the model also has no effect on predicted concentrations.

Highways Agency

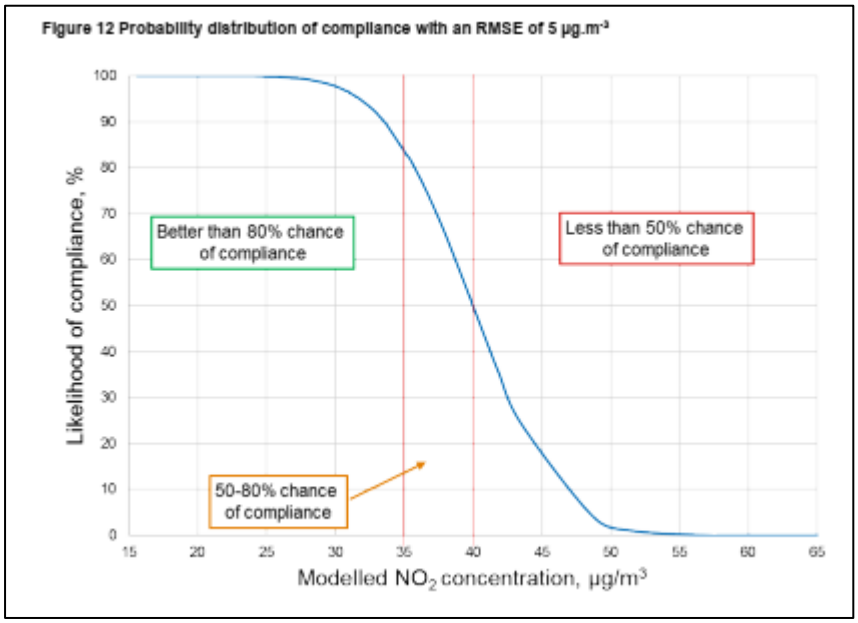
19. A quick search of HE's website suggests that there is no readily available information regarding their plan to meet the NO_2 LV on the roads it is responsible for. The Southampton modelling shows that high concentrations of NO_2, exceeding the LV, exists on several motorway links in and around Southampton and yet there appear to be no measures to resolve this issue.
20. A CAZ B in Southampton has been shown to have significant benefits on those motorway links with high concentrations. It is unknown whether SCC worked closely with HE during the development of the CAZ proposals, but it seems apparent that a joined up approach is needed, the implementation of any charging CAZ in Southampton should be (largely) funded by central government and therefore there should be no good reason not to work together.

Appendix 1

Uncertainty

21. The root mean square error (RMSE) of the Ricardo RapidAir model is estimated to be 4.7 µg/m^3, generally rounded to 5 µg/m^3 in the reports. A perfect (but unachievable) match between model and measured data would give a value of 0 µg/m^3. 5 µg/m^3 is 12.5 per cent of the LV.
22. The Local Air Quality Management Technical Guidance (LAQM.TG16) states "If the RMSE values are higher than ±25% of the objective being assessed, it is recommended that the model inputs and verification should be revisited in order to make improvements. For example, if the model predictions are for the annual mean NO2 objective of 40µg/m3, if an RMSE of 10µg/m^3 or above is determined for a model, the local authority would be advised to revisit the model parameters and model verification. Ideally an RMSE within 10% of the air quality objective would be derived, which equates to 4µg/m3 for the annual average NO2 objective."
23. The RMSE is a measure of the accuracy of the model. It is a measure of the average error or uncertainty of the model. It compares the modelled and measured data, and implicitly assumes that the measured data is accurate. Most of the measured data is collected using diffusion tubes, considered an indicative method, because it is not very accurate. According to the EU AQD an indicative measurement technique for NO_2 must meet an uncertainty data quality objective of ±25% (the reference method - chemiluminescent analysers – has a data quality objective of ±15%).

24. Figure 12 from AQ3 shows what a RMSE of 5 µg/m^3 means in terms of the likelihood of compliance with the limit value. At a modelled concentration of 35 µg/m^3 there is an 80% chance of compliance, and at 40 µg/m^3 there is a 50% chance of compliance.



25. There is a temptation to interpret this graph as meaning that at 38 µg/m^3 (the highest modelled concentration in 2020 along a road that Southampton City Council is responsible for) the chance of compliance is somewhere between 60 and 70 per cent. But this is wrong because there are additional uncertainties in the projection of future concentrations.

26. To address the uncertainties associated with forecasting future concentrations several sensitivity tests were undertaken to understand how sensitive the air quality concentrations are to specific assumptions in the modelling.

27. In summary:

- Higher levels of port growth increases concentrations by a maximum of 0.5 µg/m^3. This was concluded to have no impact on the results.
- Lower emissions performance of Euro 6 diesel light duty vehicles increased concentrations by up to 2 µg/m^3 which pushed one location up to 40 µg/m^3 and another to just over 35 µg/m^3 in the '*do minimum*' scenario which increases the risk of an exceedance in 2020.
- Reducing the proportion of nitrogen dioxide within the NOx (f-NO2) emitted from vehicle exhausts by 40%. This significantly reduces modelled concentrations and indicates the model is sensitive to assumption made about engine types and performance.
- Lower impact of the non-charging CAZ option to assess whether air quality would be affected if non charging options were not delivered as anticipated – the impact of this option was limited so there is no scope to reduce the benefit.

28. The emission sensitivity test increases projected NO_2 concentration by 1- 2 µg/m^3, but this does not cause an exceedance of the limit value anywhere.

29. The potential impacts of the following are discussed in the report but not quantified.
    - Emissions at low speeds.
    - Zonal vs full model domain calibration
    - Background NO2 calibration
    - f-NO2 and calibration
    - Surface roughness length
    - Meteorology
30. However, not all future uncertainties can be quantified or screened out due to unlikely material impacts (because we have no future measured data to compare with the model outputs). The sensitivity tests and discussion on sensitivity cannot account for unknown issues which have yet to arise.
31. At a modelled concentration of 38 µg/m^3 (ID 46963, A3024) the chance of non-compliance in 2020 is possibly more than 40% (and not the 33% mentioned in paragraph 14).