Glasgow Emissions Analysis Report

Scottish Environment Protection Agency
Buidheann Dìon Àrainneachd na h-Alba

Main Points to Note

- Following the cyber-attack that significantly impacted SEPA's internal IT systems, an alternative approach for carrying out the modelling of proposed LEZs was agreed. This focuses on identifying changes to traffic emissions inside and outside the boundary of the proposed LEZ.

- The highest concentrations of annual-average NO_2 within the City Centre occur along roads dominated by bus emissions. Diesel car emissions dominate other key routes in and out of the City Centre.

- Implementation of the proposed LEZ will reduce NOx emissions within the City Centre where vehicles are required to meet strict exhaust emission standards. The highest level of reduction will occur on key bus routes inside the LEZ boundary.

- The LEZ will result in some displacement of non-compliant vehicles, with an increase in the numbers of cars on roads east of Saltmarket and High Street. Some of these roads are predicted to experience an increase in NOx emissions with an average increase of 14%.

- The next steps will focus on areas of the city that see an increase in vehicle emissions by developing the air-quality model to predict changes in roadside concentrations.

Scope of Report

Air Quality (AQ) modelling in Glasgow is ongoing as part of the National Modelling Framework (NMF) in support of the Scottish Government's Cleaner Air for Scotland Strategy (CAFS). This report summarises work carried out to calculate tail-pipe emissions of Nitrogen Oxides (NO_x) using outputs from the Glasgow traffic model which has been used to inform the planning of a Low Emission Zone (LEZ) for Glasgow City Council (GCC). This work has been carried out in line with the NMF, which has the aim to deliver a detailed and consistent approach to assessing AQ in Scotland's major cities. This report provides an early indication of where traffic-related emissions are likely to increase or decrease following the implementation of the LEZ.

An earlier report (Glasgow Low Emission Zone Modelling Summary Technical Report, 2018) shows that the NMF Glasgow model performs well when compared against observed AQ data, highlights how fleet composition changes can improve AQ on a city-wide basis and looks at source apportionment for different vehicle sectors. Some of the key findings from this work are included below.

It is important to note that this is an interim report due to technical issues described below. Further detailed AQ modelling will resume during the summer of 2021 to inform the final LEZ design and will focus on the changes in Nitrogen Dioxide (NO_2) concentrations associated with the changes in traffic patterns summarised below. Particulate Matter (PM) modelling will be included in further work.

SEPA Cyber Attack – and the Alternative Approach Taken

On Christmas Eve, the Scottish Environment Protection Agency (SEPA) was subject to a serious and complex criminal cyber-attack that significantly impacted our internal systems and our AQ modelling capabilities.

As part of SEPAs recovery plan a phased rollout to restore critical services to re-establish communication in order to continue providing priority regulatory, monitoring, flood forecasting and warning services. This included the delivery of our NMF obligations to assist in the final assessments of the LEZ options for each city.

Due to SEPAs inability to carry out AQ modelling, an alternative approach to allow for local authorities to report to committee in Spring 2021 was discussed at the LEZ Leadership Group meeting held on the 3rd of February 2021. The following steps were recommended by Scottish Government and SEPA on a way forward:

- Continuation of traffic modelling to define a small number of potential LEZ options or a preferred LEZ option for each city.

- SEPA to carry out emissions analysis on the traffic model outputs using the established NMF methodology. This will assess the impact of the LEZ by comparing traffic and emissions between the reference/base case and LEZ scenarios.

- SEPA to continue detailed AQ modelling during the consultation phase over the summer of 2021 to support the local authorities in finalising the preferred LEZ scheme for Ministerial approval.

Introduction and Background

Air quality management activities (including AQ monitoring) in Scotland have been primarily driven by the 2008 European Union Directive on ambient air quality and cleaner air for Europe (Directive 2008/50/EC), which was incorporated into Scottish law through the Air Quality Standards (Scotland) Regulations 2010 and 2016. At a domestic level, the Environment Act 1995 and Regulatory Reform (Scotland) Act 2014 set out the Local Air Quality Management (LAQM) regime to assist local authorities in achieving compliance with legal AQ standards and objectives set to protect human health.

The CAFS Strategy, published in 2015, sets out how Scottish Government and its partner organisations propose to further reduce air pollution and improve AQ to protect human health and fulfil Scotland's legal responsibilities as soon as possible. CAFS provides a clear commitment to the NMF to ensure that a consistent approach to modelling AQ in areas associated with the highest levels of poor AQ in all four major cities is taken. The NMF will provide tools and evidence to support the NLEF. The NLEF is an evidence-based appraisal process developed to help local authorities consider transport related actions to improve local AQ.

In September 2017, the Scottish Government's Programme for Government committed to the introduction of LEZs in Scotland's four biggest cities (Glasgow, Edinburgh, Aberdeen and Dundee) by 2020, with the first introduced in Glasgow in 2018. With the advent of COVID-19 and the subsequent lock-down restrictions and recovery measures the decision was made to temporarily pause the implementation of LEZs and the Scottish Government have since set a revised timetable for LEZs to be introduced across all four cities between February and May 2022.

CAFS has been subject to a formal review, with an updated strategy (CAFS2) expected to be published shortly in 2021 (to run to 2026). The initial findings of the review identified that Scotland was performing well on AQ, with the major pollutants continuing to fall as a result of actions taken to date. However, the review also recommended that there is more work to be carried out and Scotland must take a precautionary public health approach to further AQ reductions.

Emissions Analysis

A traffic model has been developed by SYSTRA to assess how traffic patterns could change in response to the implementation of a LEZ in Glasgow. The model predicts how non-compliant vehicles could be displaced by the LEZ and may re-route around the LEZ.

A comparison has been made between a 2022 'Reference' case and a 2022 LEZ case.

- Reference case traffic flows are based on those observed in 2019 with 2022 Committed Developments. The vehicle fleet composition is based on a fleet that is typical for Glasgow in 2020. The proportion of bus journeys being made by the lowest-emitting EURO VI buses in the LEZ was 40%.

- Traffic flows in the LEZ case are based on the Reference case with the added intervention of the LEZ. The vehicle fleet is also based on a fleet typical for

Glasgow in 2020, but the proportion of bus journeys being made by EURO VI buses was increased to 100%.

A comparison for a 2020 fleet year is a more precautionary approach than projecting how quickly the fleet could upgrade in the years leading up to the full introduction of the LEZ.

Traffic model outputs were firstly processed to make them compatible with the CERC emissions database tool (EMIT) using conversion factors derived from observed traffic data. Emission rates (g/km/s) could then be calculated for every road in the traffic model for the Reference and LEZ scenarios. Comparing emissions between these 2 scenarios enables any changes due to the LEZ to be identified.

The EMIT software used contains the latest emission factors from the Emission Factor Toolkit (EFT) version 10.

Traffic Pollutants described in this Report

The focus of the LEZ is on reducing local concentrations of Nitrogen Dioxide (NO_2) which is emitted directly from the tailpipe of road traffic. However, NO_2 is also chemically produced in the atmosphere from road traffic emissions of Nitrogen Oxide (NO). These two pollutants are referred to collectively as Nitrogen Oxides (NO_x).

The AQ modelling focused on predicting concentrations of NO_2, which is how compliance against AQ Standards is assessed. However, the AQ model has also been used to estimate the proportions of vehicle pollution that comes from different types of vehicle, e.g. diesel cars vs buses. This type of analysis is usually performed for NO_x, rather than NO_2. It is difficult to calculate the breakdown of NO_2 for different vehicles accurately because of the additional component of NO_2 that is created in the atmosphere. For this reason, the analysis of traffic model output currently focuses on emissions of NO_x only.

LEZ and Model Extents

The extent of the LEZ is shown in Figure 1, which is covered by the AQ and traffic model. It should be noted that areas further west including Dumbarton Road, Byres Road and Great Western Road are covered by the AQ model but not the traffic model. Areas to the east of the LEZ including Calton are covered by the traffic model but to a lesser extent by the AQ model.

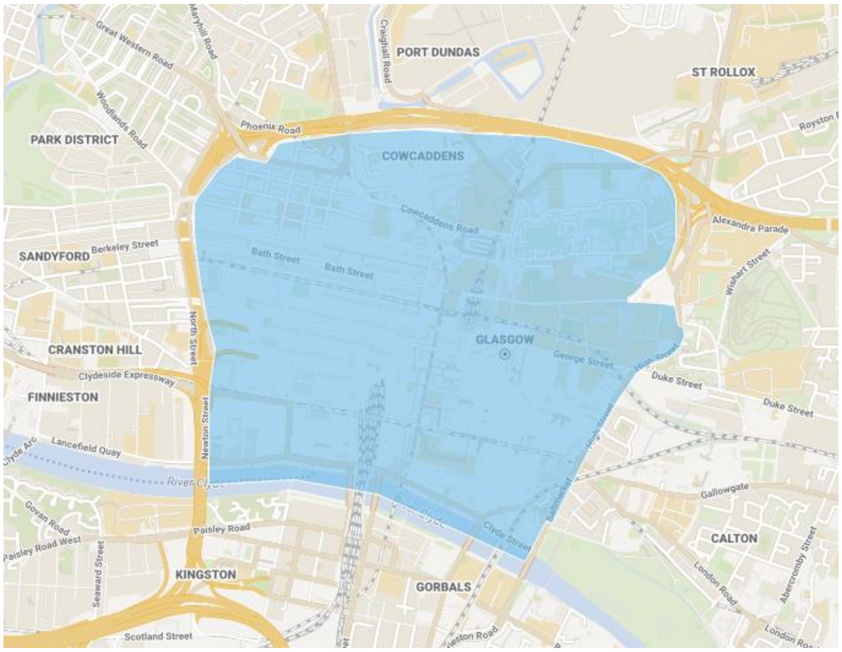

Figure 1 – LEZ extent covering the area of Glasgow City Centre bound between the M8 to the north and west, the River Clyde to the south and inclusive of Saltmarket and High Street to the east.

Air Quality Model: Pollutant Concentrations

Air quality modelling carried out previously was used to predict concentrations of NO_2 at a network of regular kerbside points across the city. The pink markers in Figure 2 show predicted exceedances of the annual average NO_2 limit value of $40\mu gm^{-3}$ for modelled vehicle speeds of 20km/h. Areas of exceedance are focused in the City Centre and in particular along major bus routes. Figure 3 shows that areas of predicted exceedance in the City Centre are still evident for higher vehicle speeds. The model results shown here were based on conditions in 2018.

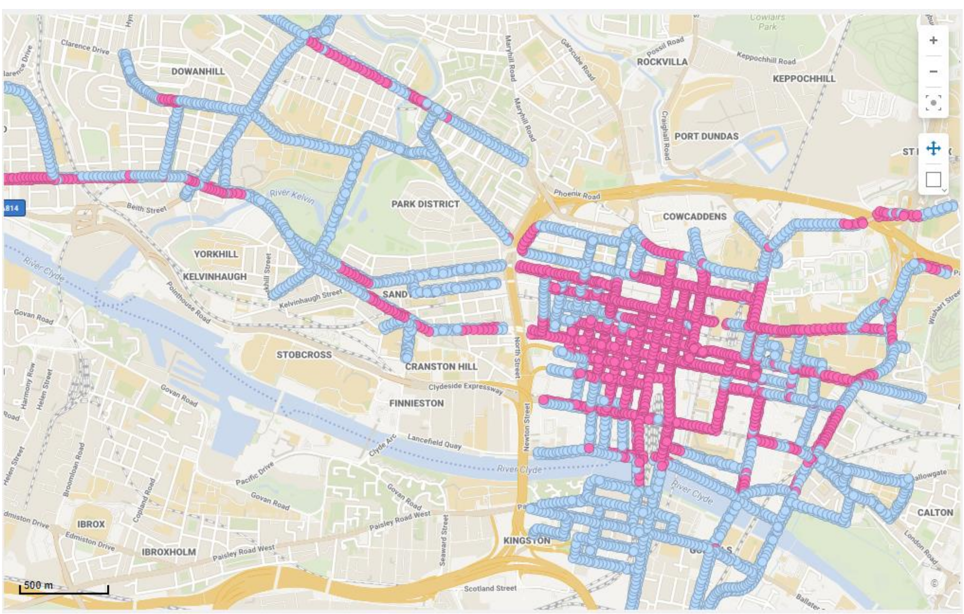

Figure 2 – Modelled concentrations of annual-average NO_2 above (pink) and below (blue) the limit value of $40µgm^{-3}$, for vehicle speeds of 20km/h.

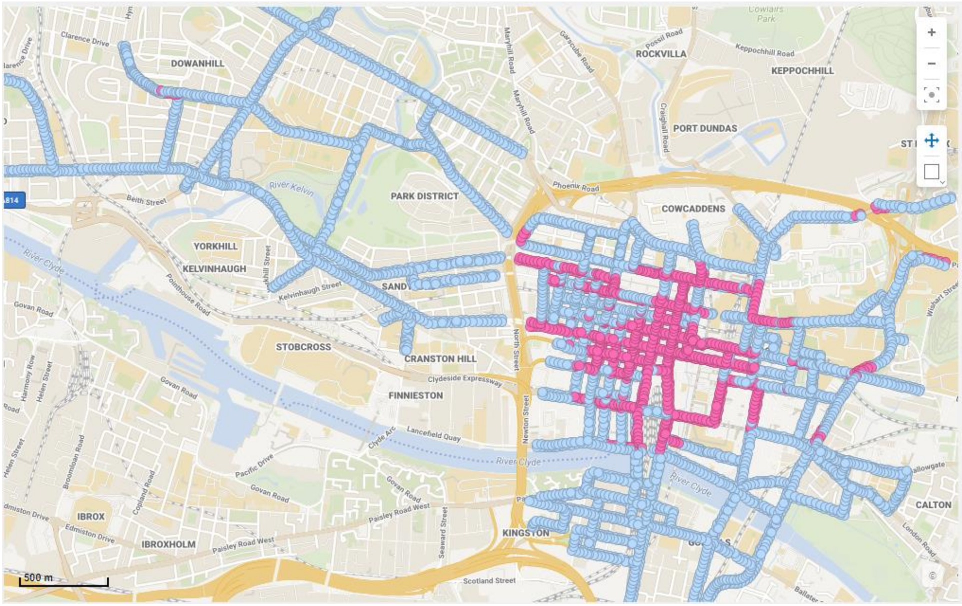

Figure 3 - Modelled concentrations of annual-average NO_2 above (pink) and below (blue) the limit value of $40µgm^{-3}$, for speed limits.

Air Quality Model: Emissions by Vehicle Type

The AQ model was also used to estimate the relative contribution to total levels of NO_x from different types of vehicles. This analysis showed that the greatest contributors to NO_x across the city are buses and diesel cars. Bus emissions are most dominant on roads inside the City Centre where the highest pollutant concentrations are measured and predicted (Figure 4). Diesel car emissions are dominant on other key routes in and out of the city (Figure 5).

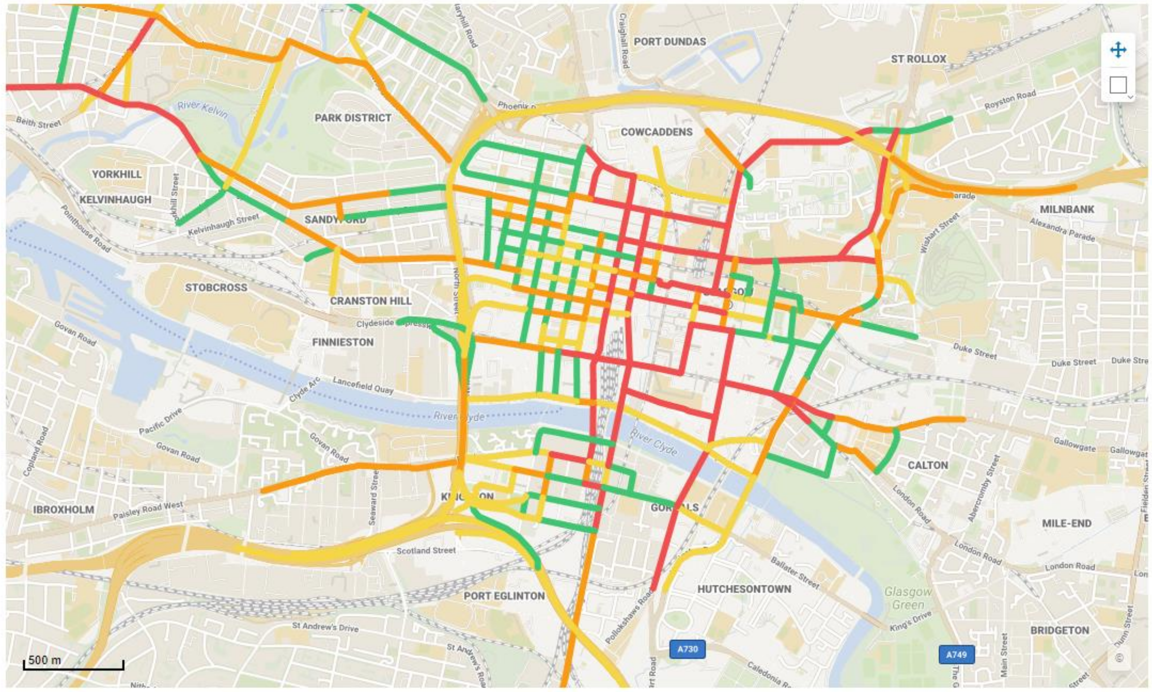

Figure 4 – The roads coloured in red are those dominated by bus emissions (highest 25%).

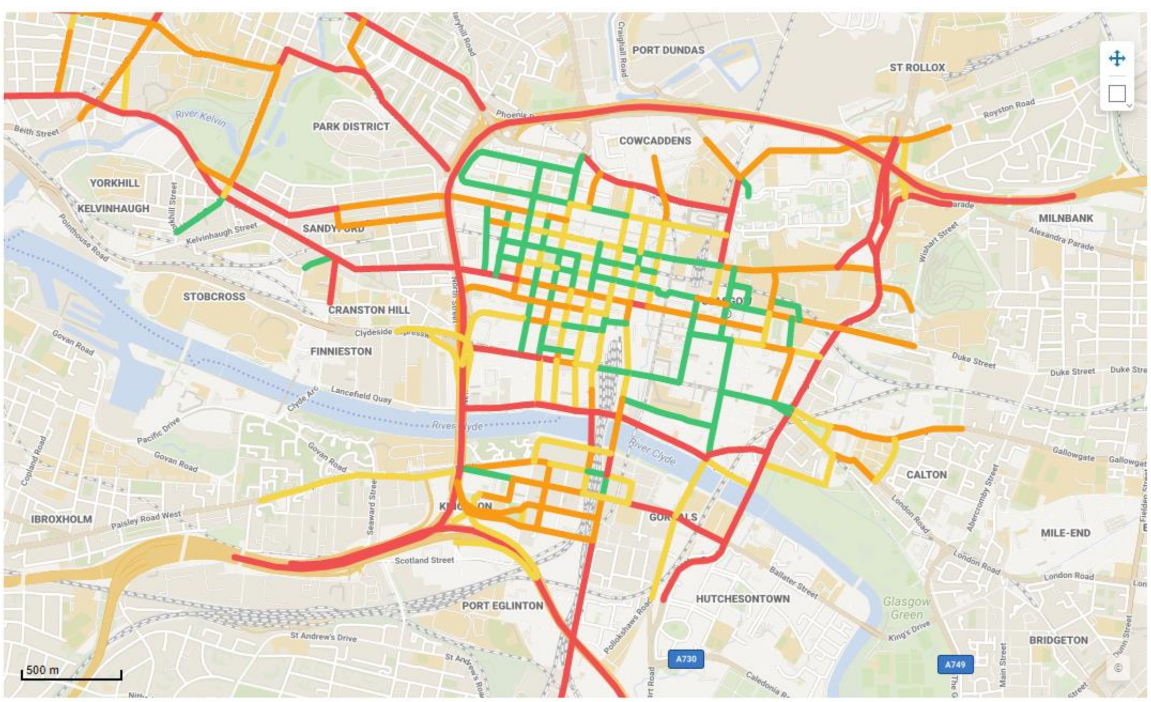

Figure 5 – The roads coloured in red are those dominated by diesel car emissions (highest 25%).

Traffic Model Analysis

The effects of the LEZ have been investigated both inside and outside of the LEZ boundary. The most significant emission reduction occurs inside the boundary where vehicles are required to meet strict emission standards. Some vehicles that do not meet the emission standards of the LEZ re-route around the edges of the LEZ boundary. This displacement of non-compliant vehicles has the potential to increase vehicle emissions.

On key bus routes inside the LEZ there is a significant reduction in NO_x emissions. For example, on Hope Street and Union/Renfield Street there is a predicted reduction of between 45 and 80% (average of approx. 70%). On the roads highlighted in black in Figure 6 there is a reduction in total NO_x emissions of over 60%.

These roads that see the greatest reduction in emissions due to the implementation of the LEZ coincide with those highlighted in Figures 2 and 3 where the highest pollutant concentrations are experienced.

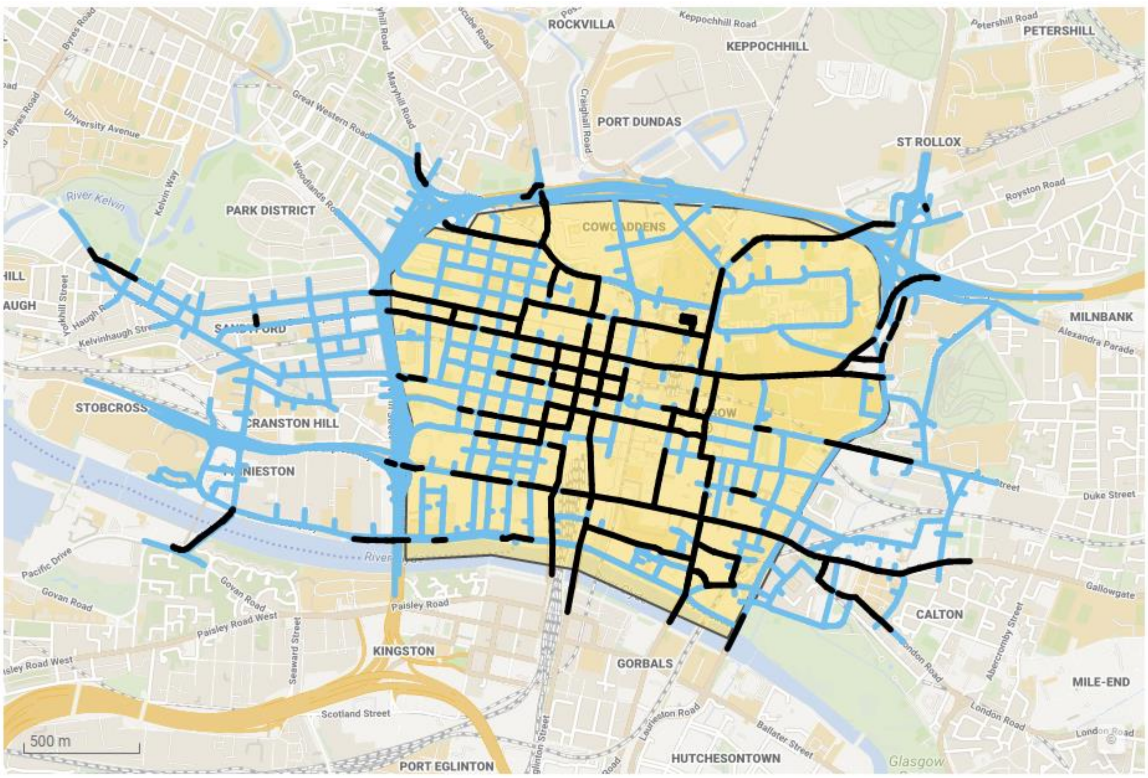

Figure 6 – Areas highlighted in black are predicted to see on average a 60% reduction in NO_x emissions. These are mostly key bus routes within the city City Centre which coincide with high pollutant concentrations and exceedances of the NO_2 annual limit value. The extent of the LEZ is shown in yellow.

There is an increase in car flow around the edge of the LEZ when compared against the Reference case. On the roads highlighted in black in Figure 7 there is an increase of over 100 cars per day, and on the roads highlighted in red there is an increase of between 500 and 1200 cars per day. The roads highlighted red also see an increase, on average, of 340 LGVs per day. There is a very small increase (average of 3) in the number of Rigid HGVs on these roads highlighted in red.

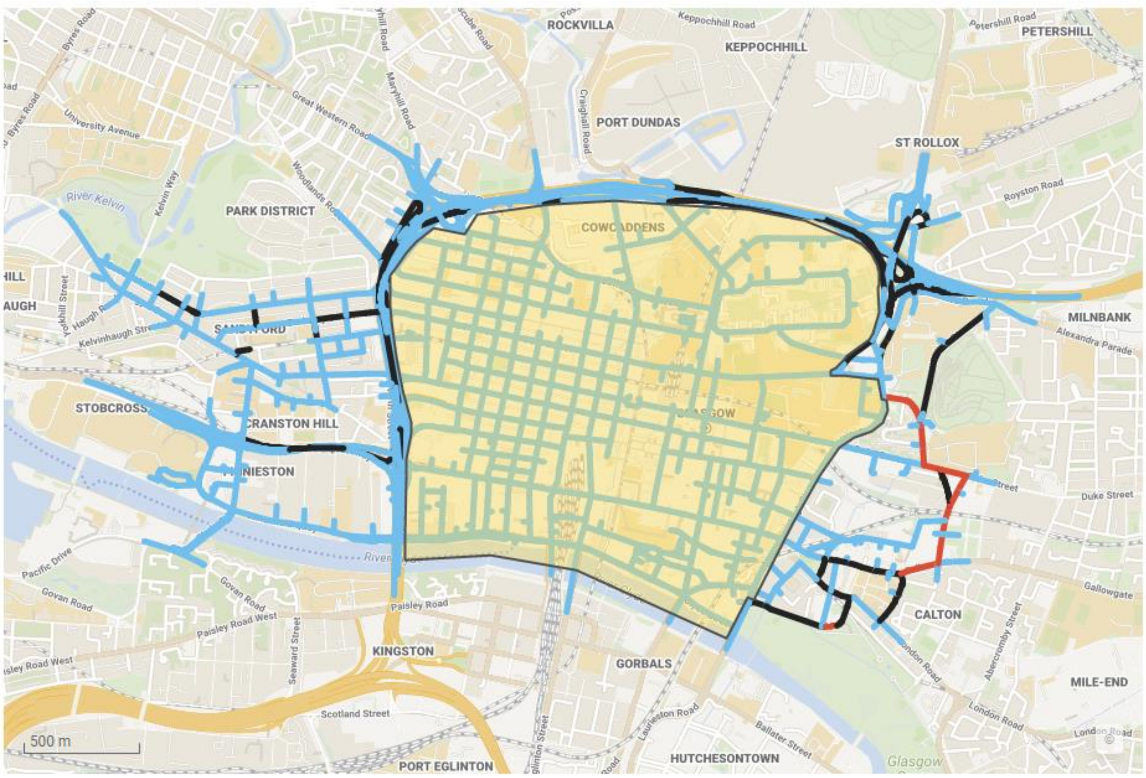

Figure 7 – Areas highlighted in black and red are predicted to see an increase in traffic flow due to displacement of journeys around the edge of the LEZ. The extent of the LEZ is shown in yellow.

The area of the model that sees an increase in traffic flow corresponds with a small number of roads that are predicted to see an overall increase in emissions of NO_x, due to the implementation of the LEZ. These are highlighted in black in Figure 8, and see an average increase in NO_x of 14%, with a maximum increase of 40%.

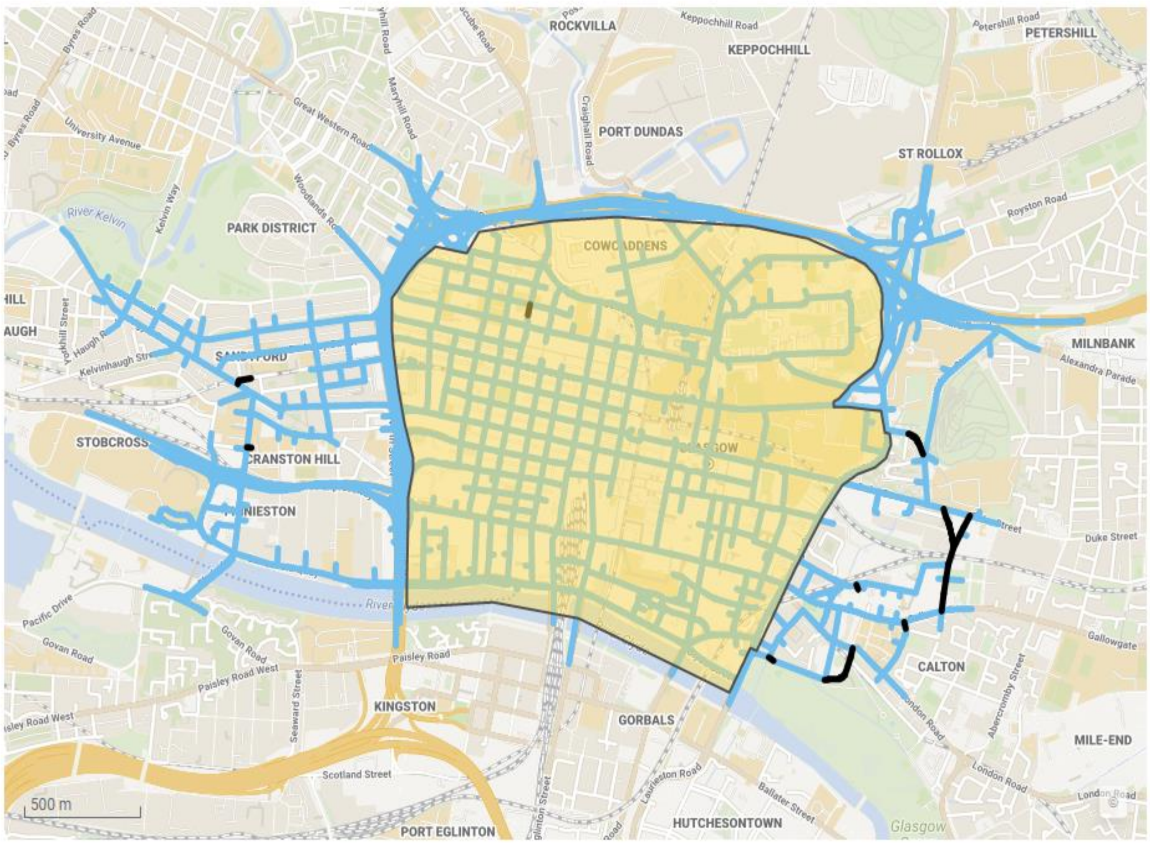

Figure 8 – Areas highlighted in black are predicted to see an overall increase in NO_x emissions due to displacement of journeys around the edge of the LEZ. The extent of the LEZ is shown in yellow.

The roads highlighted in Figure 8 that see an increase in NO_x emissions are also shown in Figure 9 within a rank of NO_x emissions on all roads in the model, for the Reference and LEZ cases. This emphasises that there is an overall significant reduction in emission rates on many roads.

The roads highlighted in black in Figure 9 are those that see an overall increase in NO_x emissions following the implementation of the LEZ. Most of these roads have low rates of emission and some of the links with relatively higher emissions represent very short sections of road.

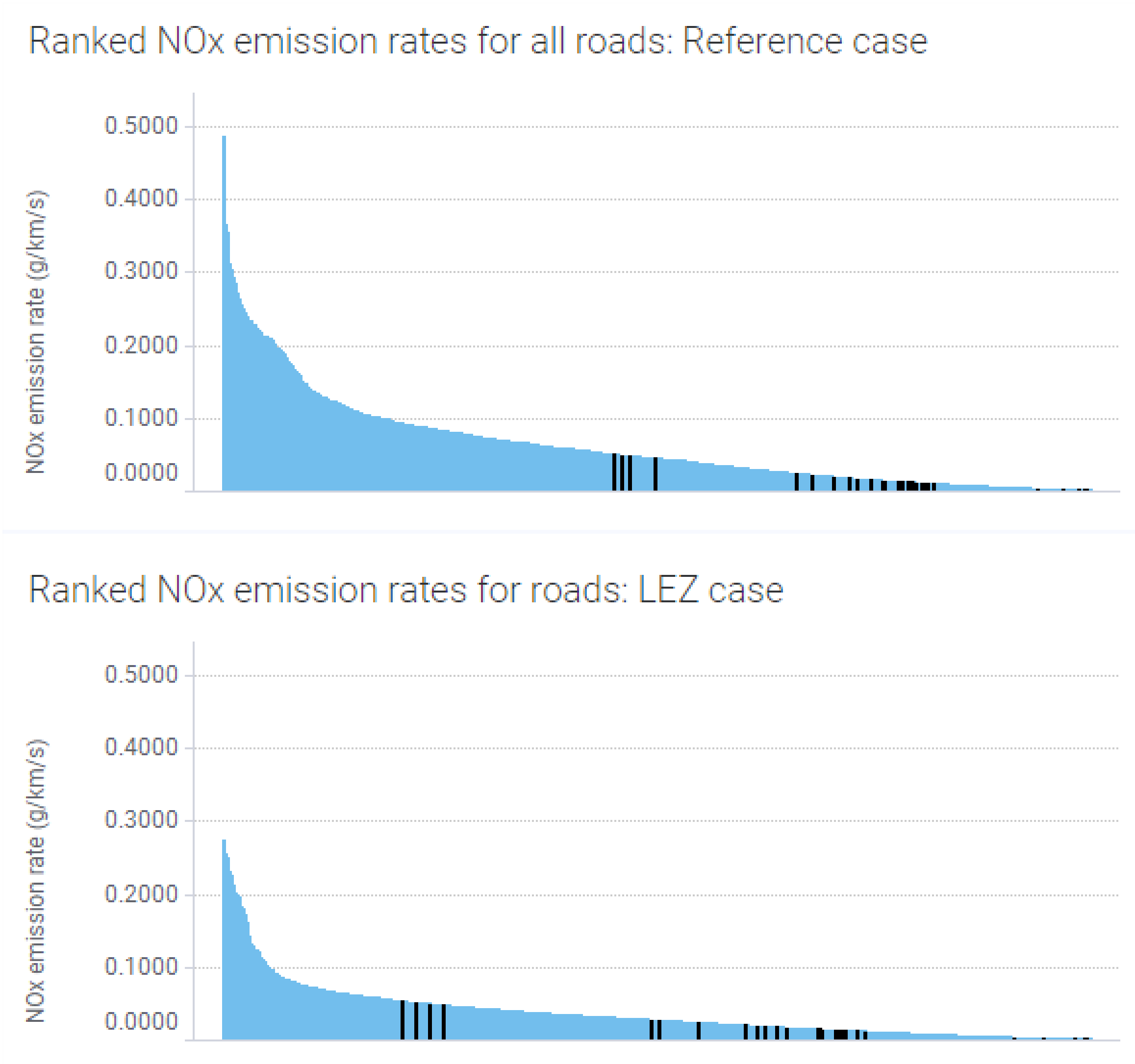

Figure 9 – NO_x emission rates on all roads in the traffic model for the Reference and LEZ scenarios.

Next Steps

The next stage of the analysis will be to use the predicted emissions rates from the traffic model as input to the AQ model. In Glasgow the emission analysis will also inform further development of the air-quality model. For example, the area of the city to the east of High Street that could see an increase in traffic flow was not identified for inclusion in the original model. The AQ model will therefore be extended into this area, to include a detailed study around John Knox St, which is where the most notable change in emissions is predicted to occur. Other surrounding streets that may see smaller increases in emission rates will also be analysed in the AQ model. It should be noted that current exceedances of the NO_2 limit value were identified mostly within the LEZ boundary, and to a lesser extent to the West of the city (Figures. 2 and 3).

For this next stage of AQ modelling the emission rates on each of the traffic model links will be mapped onto the larger air-quality model links. The results of this modelling will be visualised in a series of interactive maps and charts and made available to the local authority.

There is an additional 'demand reduction' scenario from the traffic modeling that simulates a 10% reduction in non-motorway traffic flow across all vehicle categories. This scenario which could affect the amount of traffic displacement will also be investigated.