Detailed Assessment of Revocation of Crieff AQMA

Perth & Kinross Council

SWECO

Change list

Ver	Date	Description of the change	Reviewed	Approved by
V01	16.02.2024	FINAL	JS	JS

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Executive Summary

Sweco UK Ltd was commissioned by Perth and Kinross Council to prepare a Detailed Assessment in support of the proposed revocation of Crieff AQMA. The assessment has been undertaken to investigate the potential scale and extent of exceedances of the Scottish Air Quality Objectives (SAQOs) in the study area to determine whether the requirement for the AQMA remains valid or if the AQMA meets the requirements for revocation.

The AQMA was declared in 2014 for exceedances of both the annual mean NO_2 and PM_{10} objectives. It encompasses an area between the Y-Junction at Perth Road and Dollerie Terrace, follows the A85 east to East High Street, the Cross, High Street, James Square then on to West High Street stopping at the junction of Galvemore Street and Lodge Street and north up to Comrie Street to the Y-Junction at Coldwells Road and mid-point of Comrie Street.

A Further Assessment was undertaken in 2015 which concluded that the AQMA boundary was appropriate and the requirement for the AQMA was still valid.

This Detailed Assessment report describes a dispersion modelling study of road traffic emissions in Crieff. The assessment has determined annual mean concentrations of NO_2 and PM_{10} at this location.

A combination of latest council monitoring data and atmospheric dispersion modelling using ADMS-Roads have been used to conduct the study. The study utilises Sweco’s existing air quality model that was updated in 2019/2020 to include the Perth and Kinross regional transport model. The model had a base year of 2018 and meteorological data for 2018. The study also utilises traffic data that was commissioned in 2023 which included three automatic traffic counters on the A85 in Crieff.

The assessment has considered:

- The last five years of monitoring data
- 2018 and 2023 traffic data
- Source apportionment analysis
- Assessment of potential future concentrations
    - Met sensitivity of 5 years of meteorological conditions.
    - The potential increase in traffic volume required to result in exceedance of the NO_2 and PM_{10} annual mean objectives.

The report has indicated the following:

- Local monitoring has shown there is a downward trend in measured concentrations within the AQMA and that the annual mean concentrations for NO_2 and PM_{10} have stayed well below the objective since the last exceedance in 2018.
- The modelling for 2023 did not predict any exceedances of the SAQOs for annual mean NO_2 or PM_{10} at any of the sensitive receptors across the study area.
- A future year scenario was considered to predict what increases in traffic flow within the AQMA would lead to an exceedance of the respective pollutant objectives. These results cannot be determined with 100% certainty; however, it was predicted that significant traffic

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increases of 68-367% would be required for NO_2 and 410-1361% for PM_{10}.

A review of monitoring data and dispersion modelling carried out to support this Detailed Assessment indicates that the NO_2 and PM_{10} annual mean objective is no longer exceeded within the Crieff AQMA, or at any locations considered within the study area.

The future year scenario also concluded that it is considered unlikely that the SAQ annual mean NO_2 and PM_{10} objective will be exceeded in future years, thus the AQMA is considered to meet the requirements for revocation. It is recommended that the Council gives consideration to doing so under Section 83 (2) of the Environment Act 1995. It is further recommended that the Perth and Kinross Council to undertake continued monitoring within the AQMA to identify any changes in air quality concentrations as a precaution.

1 Introduction

The Environmental Act 1995 and subsequent regulations require local authorities to assess compliance in their area with the standards and objectives set out in the Air Quality Strategy for England, Scotland, Wales and Northern Ireland 2007 (AQS). The air quality standard and objectives are defined in the Air Quality (Scotland) Regulations 2000, Air Quality (Scotland) Amendment Regulations 2002 and Air Quality Standards (Scotland) Regulations 2016.

The process by which local authorities access compliance with AQS objectives is known as Local Air Quality Management (LAQM). The LAQM process commenced in 1998, and since then Perth and Kinross Council have regularly reviewed and assessed air quality within its boundaries, targeting areas of anticipated poor air quality, and then report on the results annually.

In 2011, Perth and Kinross's air quality Annual Progress Report[1] indicated that nitrogen dioxide (NO_2) and particulate matter (PM_{10}) concentrations at various locations in Crieff had exceeded, or were very close to, the Annual Mean Objective. A Detailed Assessment[2] was commissioned in 2013 and the results confirmed the need to declare an Air Quality Management Area (AQMA) in Crieff due to exceedances of both the PM_{10} and NO_2 annual mean standards. The Crieff AQMA came into effect on 14 April 2014. The extent of the AQMA is shown in Figure 1.1.

A Further Assessment[3] was undertaken in 2015. The monitoring and dispersion modelling indicated that exceedances of the NO_2 and PM_{10} annual mean objectives were still occurring within the Crieff AQMA. The boundary of the AQMA was therefore still appropriate.

[1] Available at: https://www.pkc.gov.uk/media/35451/Progress-Report-2011/pdf/PR_Report_2011_Final_Version.pdf?m=636104961774370000
[2] Available at: https://www.pkc.gov.uk/media/36004/2013-Detailed-Assessment-of-Air-Quality-in-Crieff/pdf/AEA_Crieff_Assessment.pdf?m=636104961742030000
[3] Available at: https://www.pkc.gov.uk/media/35954/2015-Further-Assesment-of-Air-Quality-in-Crieff/pdf/ED45590_Crieff_FA_Final_report_final_March2015.pdf?m=636104961683370000

FIGURE 1.1: CRIEFF AQMA

The Crieff AQMA incorporates an area from the Y-Junction at Perth Road and Dollerie Terrace, following the A85 east to East High Street, the Cross, James Square then onto West High Street stopping at the junction of Galvemore Street and Lodge Street and north up to Comrie Street to the Y-Junction at Coldwells Road and mid-point of Comrie Street. The AQMA takes in the whole buildings along East High Street, High Street, West High Street and Comrie Street.

In 2019, the Crieff Air Quality Action Plan (AQAP)[4] was finalised by a steering group including representatives from Perth & Kinross Council (PKC), Transport Scotland and the Tayside and Central Scotland Transport Partnership (TACTRAN). The aim of the AQAP was to develop a package of measures to reduce emissions of nitrogen oxides and fine particulate matter within the AQMA to acceptable levels. These measures are outlined in Table 1.1.

TABLE 1.1: CRIEFF AQAP MEASURES

Priority	Measure No.	Measure	Timescale
Strategic Measures			
A.	1	Liaise with the Scottish Government regarding the consideration of national measures to reduce background concentrations of PM.	Medium/ Long
	2	Improving Links with Local Transport Policies	Medium
	3	Improve Links with Regional Transport Strategy	Medium
	4	Ensure Integration of Air Quality with Other Council Strategies and Policies	Medium

[4] Available at: https://consult.pkc.gov.uk/ecs/crieff-draft-air-quality-action-plan-consultation/user_uploads/2019-perth---kinross-council-crieff-air-quality-action-plan.pdf

	5	Local Development Plan – Assess merit of further development in Crieff	Long
Move Traffic Away from AQMA			
B.	1	Redirect local road traffic movements away from the A85	Medium
	2	Incentivise parking out with the AQMA (e.g. reduce/remove on street parking, increased signage)	Short/ Medium
Traffic Management			
C.	1	Possible provision of smart parking in Crieff	Medium
	2	Urban Traffic Control Systems congestion management	Medium
	3	Anti-idling Enforcement	Medium
	4	Undertake a review of the current locations of pedestrian crossings	Short
	5	Limit or prioritise traffic turning right on to High Street	Short
Reduce Emissions from Source			
D.	1	Encourage private and public operators to pursue cleaner vehicles	Long
	2	Maintenance of the Local/Voluntary Bus Quality Partnership	Long
	3	School Travel Plans	Long
	4	Public transport improvements	Long
	5	Restrict access for polluting vehicles with the AQMA	Long
	6	Implement Eco Stars scheme for HGV and bus operators	Short
Reduce Emissions by Reducing Demand for Traffic			
E.	1	Promotion of lift sharing and development of car clubs	Short/ Medium
	2	Travel Plans for large institutions and businesses	Short
	3	Create and implement PKC Corporate Travel Plan	Medium
	4	Promotion of active travel	Short
	5	Awareness raising and education, presentations at local school's/community meetings	Short
	6	Cycling and walking routes to be routed to link in with the campus for sport.	Short
	7	Provision of PKC "Champions" for transportation methods	Short
Reduce Emissions from Non-Transport Sources			

F.	1	Biomass Installations and other developments likely to cause pollution – review developments which may cause pollution	Short
Other Measures			
G.	1	Increase AQ Monitoring Network	Medium/ Long
	2	Regional AQ Modelling Study	Short
	3	Cycling and walking routes to be incorporated into transport model	Short
	4	Transport assessments for developments to be required as part of the planning process	Medium

NO_2 and PM_{10} annual mean concentrations have remained below the objective levels since 2019, decreasing steadily following the introduction of the AQAP.

2 Policy Context

Scottish policy in relation to the LAQM process is set out in Local Air Quality Management LAQM TG (22)[5] and Policy Guidance (PG(S)(23))[6].

The policy guidance describes the air quality objectives to be applied in assessing air quality and the review and assessment process. The relevant aspects are described in Sections 2.1 and 2.2 below.

This guidance is intended to help local authorities with their local air quality management duties under Part IV of the Environment Act 1995. It sets out:

- The statutory background and the legislative framework within which local authorities have to work
- The principles behind reviews and assessments of air quality and the recommended steps that local authorities should take
- How local authorities should handle the designation of Air Quality Management Areas (AQMAs) and the drawing up and implementation of action plans
- Suggestions for taking forward the development of local air quality strategies
- Suggestions on how local authorities should consult and liaise with others
- The role of transport-related measures in improving air quality
- The general principles behind air quality and land use planning
- The effects of biomass on air quality
- The relationships between air quality and noise policy.

This guidance was issued by the Scottish Ministers under section 88(1) of the 1995 Act. Local authorities should have regard to it when undertaking their local air quality management duties, as required under section 88(2) of the Act. The guidance should be taken into account by all local authority departments involved in local air quality management (LAQM), including environmental health, corporate services, planning, economic development and transport planning. The guidance complements the information and advice contained in Cleaner Air for Scotland 2 (CAFS2)[7], which was published in July 2021 replacing the original strategy published in 2015.

2.1 National Legislation and Policy

Part IV of the Environment Act 1995[8], requires the UK Government to publish an Air Quality Strategy and local authorities to review, assess and manage air quality within their areas. This is known as Local Air Quality Management (LAQM)[9].

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[5] Available at: https://www.scottishairquality.scot/laqm/technical-guidance
[6] Available at: https://www.scottishairquality.scot/laqm/technical-guidance
[7] Available at: https://www.gov.scot/publications/cleaner-air-scotland-2-towards-better-place-everyone/
[8] Environment Act 1995.
[9] Local Air Quality Management Technical Guidance LAQM.TG (16). April 2016. Department for Environment, Food and Rural Affairs

The 2007 Air Quality Strategy[10] establishes the policy for ambient air quality in the UK. It includes the National Air Quality Objectives (AQOs) for the protection of human health and vegetation for 11 pollutants. Those AQOs included as part of LAQM are prescribed in the Air Quality (Scotland) Regulations 2000, the Air Quality (Amendment) (Scotland) Regulations 2002 and the Air Quality (Scotland) Amendment Regulations 2016. It is worth noting that the Scottish Government has adopted a fine particulate matter (PM_{10}) annual mean objective that is more stringent than the UK or EU standard. The Scottish PM_{10} standard is written into regulation and therefore carries equivalent weight to the Limit Value based standards.

Table 2.1 presents the AQOs for Nitrogen dioxide (NO_2) and Particulate Matter (PM_{10}).

TABLE 2.1: RELEVANT OBJECTIVES FOR THE PROTECTION OF HUMAN HEALTH

Pollutant	Concentrations	Measured As
Nitrogen Dioxide (NO_2)	200 µg/m^3 not to be exceeded more than 18 times per year	One-hour mean
	40 µg/m^3	Annual mean
Particulate Matter (PM_{10})	50 µg/m^3 not to be exceeded more than 7 times per year	24-hour mean
	18 µg/m^3	Annual mean

The NAQOs apply to external air where there is relevant exposure to the public over the associated averaging periods within each objective. Guidance is provided within the Local Air Quality Management Technical Guidance 2022 (LAQM.TG (22)) issued for Local Authorities, on where the AQOs apply as detailed in Table 2.2. The objectives do not apply in workplace locations, to internal air or where people are unlikely to be regularly exposed (i.e. centre of roadways).

TABLE 2.2: LOCATIONS WHERE AIR QUALITY OBJECTIVES APPLY

Averaging Period	Objectives Should Apply at:	Objectives Should Generally Not Apply at:
Annual mean	All locations where members of the public might be regularly exposed. Building façades of residential properties, schools, hospitals, care homes etc.	Building façades of offices or other places of work where members of the public do not have regular access. Hotels, unless used as a permanent residence. Gardens of residential properties. Kerbside sites (as opposed to locations at the building façade), or any location where public exposure is expected to be short term.

[10] The Air Quality Strategy for England, Scotland, Wales and Northern Ireland. 2007. Department for Environment, Food and Rural Affairs

24-hour mean and eight-hour mean	All locations where the annual mean objective would apply, together with hotels. Gardens of residential properties’	Kerbside sites (as opposed to locations at the building façade), or any location where public exposure is expected to be shorter than either the 24- or 8-hour relevant mean.
One-hour mean	All locations where the annual mean and 24- and 8-hour mean objectives apply. Kerbside sites (for example, pavements of busy shopping streets). Those parts of car parks, bus stations and railway stations etc. which are not fully enclosed, where members of the public might reasonably be expected to spend one hour or more. Any outdoor locations where members of the public might reasonably expect to spend one hour or longer.	Kerbside sites where the public would not be expected to have regular access.
15-min mean	All locations where members of the public might reasonably be exposed for a period of 15 minutes or longer.	
*** – Such locations should represent parts of the garden where relevant public exposure to pollutants is likely, for example where there is seating or play areas. It is unlikely that relevant public exposure to pollutants would occur at the extremities of the garden boundary, or in front gardens, although local judgement should always be applied.**		

2.2 Review and Assessment Process

The LAQM process requires that local authorities carry out regular reviews of air quality in the form of annual assessment reports. Where an assessment identifies that there is a risk that an air quality objective will be exceeded at a location with relevant public exposure then a Detailed Assessment is undertaken. Detailed assessments consider any risk of exceedance of an objective in greater depth in order to determine whether or not an exceedance is likely.

Where a likely exceedance of an objective is identified, the Council are required to declare an Air Quality Management Area (AQMA), a designated area in which the Council have an obligation to develop and implement an Air Quality Action Plan (AQAP) plan to improve air quality.

In designating an AQMA, policy guidance[11] states:

‘Local authorities have a duty under Section 83(1) of the 1995 Act to designate AMQAs where the air quality objectives are unlikely to be met or met beyond the required date. AQMAs must be designated officially by means of an order.’

[11] Available at: https://www.scottishairquality.scot/sites/default/files/publications/2023-04/Air-Quality-Cleaner-Air-for-Scotland-2-LAQM-PG%28S%29-23-revison-final-22-March-23_0.pdf

Where, however, it is defined that the air quality within an AQMA meets air quality objectives, then local authorities can amend or revoke an AQMA. Policy guidance[10] states:

'Local authorities are able to amend or revoke an existing AQMA order at any time as set out under section 83(2) of the 1995 Act. Where an authority considers it necessary to do this, Scottish Government expects the authority to consult with SEPA and all other statutory consultees, businesses, members of the public and other interested parties in the vicinity of the AQMA. All available supporting information to justify the amendment or revocation should be provided to the Scottish Government before any changes take effect (and this should take the form of a revocation proposal report) A local authority may submit a proposal to amend or revoke an existing AQMA order at any time.'

'There are no set criteria on which an amendment or revocation decision will be based, and the Scottish Government considers each request on a case-by-case basis. A minimum requirement however will normally be at least three consecutive years where the objectives of concern are being achieved and where monitoring data demonstrates that further exceedances of the objective are unlikely to occur. This monitoring data and information will be routinely collected through the review and assessment process and where required, additional monitoring and modelling studies. A specific detailed assessment for the AQMA is not specifically required to be conducted to proceed with AQMA amendment or revocation.'

To revoke an AQMA it is, therefore, necessary to demonstrate compliance with the NAQS objectives but also demonstrate or justify the cause for improvement in air quality.

Once compliance is demonstrated PG(S)(23) states that the AQMA order should be amended or revoked within the shortest possible time, and PG(S)(23) provides the suggested minimum content for a revocation proposal that includes detailed technical assessment as represented by this study.

2.3 Overview of the Assessment

Based on the continued measured compliance with NO_2 and PM_{10} objectives since 2019 it is proposed to revoke the Crieff AQMA. This report forms a Detailed Assessment of both pollutants to identify whether the AQMA should be revoked.

The general approach taken in the assessment was:

- Collect and analyse recent traffic data (2023), local monitoring, and background concentration data for use in a dispersion modelling study.
- Review historic measurement data and trends.
- Use of the existing dispersion model for Crieff based off data provided by Systra's regional Transport Model for Perth & Kinross in 2018.
- Modification of the existing dispersion modelling to produce numerical predictions of annual mean NO_2 and PM_{10} concentrations in 2023.
- Use dispersion modelling to produce contour plots showing the expected spatial variation of the annual mean concentrations of pollutants.
- Recommend if Perth & Kinross Council should retain or revoke the Crieff AQMA within the study area.

- Assess the likelihood of exceedance of the NAQS objects in the future by considering differing meteorological conditions.

The modelling methodologies provided for Detailed Assessments are outlined in the Scottish Government and Defra Technical Guidance LAQM.TG(22) and were used throughout this study.

3 Data used to support the assessment.

3.1 Maps

Ordnance Survey based GIS data of the model domain and a road alignment GIS dataset were used in the assessment.

3.2 2018 Traffic model and air quality model

Systra UK currently host and manage the Perth and Kinross regional transport model. The model was used to inform the original Crieff Detailed Assessment and Further Assessment. The model was updated in 2019/2020 to a base year of 2018.

To support ongoing Action planning support for the Crieff AQAP Sweco updated the air quality model for Crieff in line with the new 2018 model.

The 2018 traffic data were provided as average hourly flows over a 12-hour period (07:00-19:00) for each respective road link within the study area (see Figure 5.1). A time varying profile was also provided by Systra which ensured that traffic data across the 24-hour period was considered in the model. The time varying profiles for weekdays, Saturday and Sunday were applied to all modelled road links.

The traffic data were provided as a GIS shapefile which included:

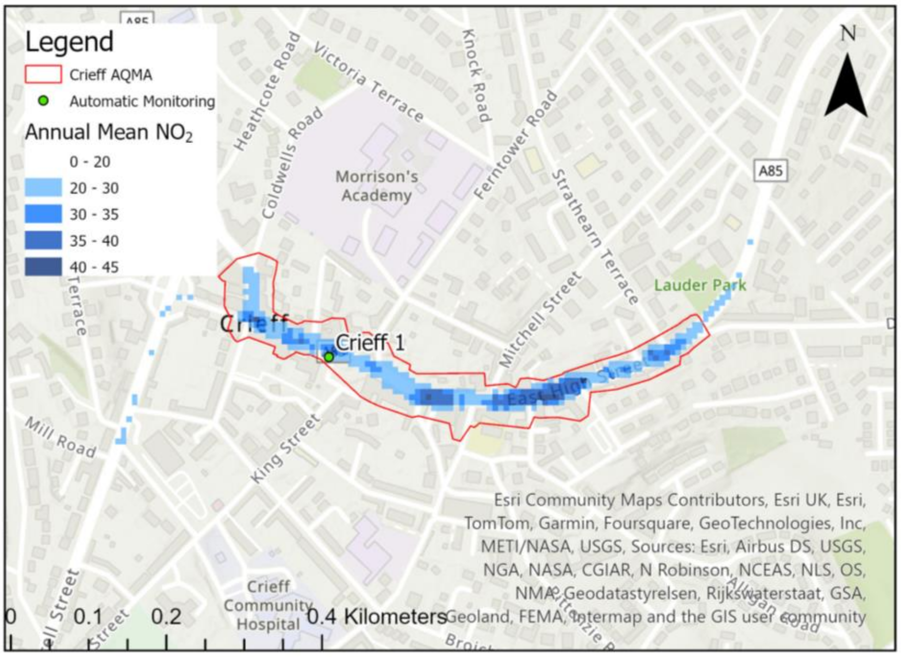
- the full road geometry
- full details of the different vehicle classes
- average speeds data in kilometres per hour (kph).

The road alignment was corrected in line with OS MasterMap Highways network data provided by the Council.

This model used the latest version of the EFT, background concentrations and LAQM tools available at the time of the update. Full details of the 2018 model and the model verification are provided in Appendix A.

The 2018 modelling results indicated that there were still predicted exceedances within the AQMA (see Figure 3.1). The results also showed that the location of the automatic station was not in the location of the highest concentrations.

FIGURE 3.1: 2018 MODELLING RESULTS



For this assessment a 2023 road traffic emissions scenario has been considered. The method of this assessment was consulted and agreed with SEPA prior to commencement.

3.3 2023 Road traffic scenario

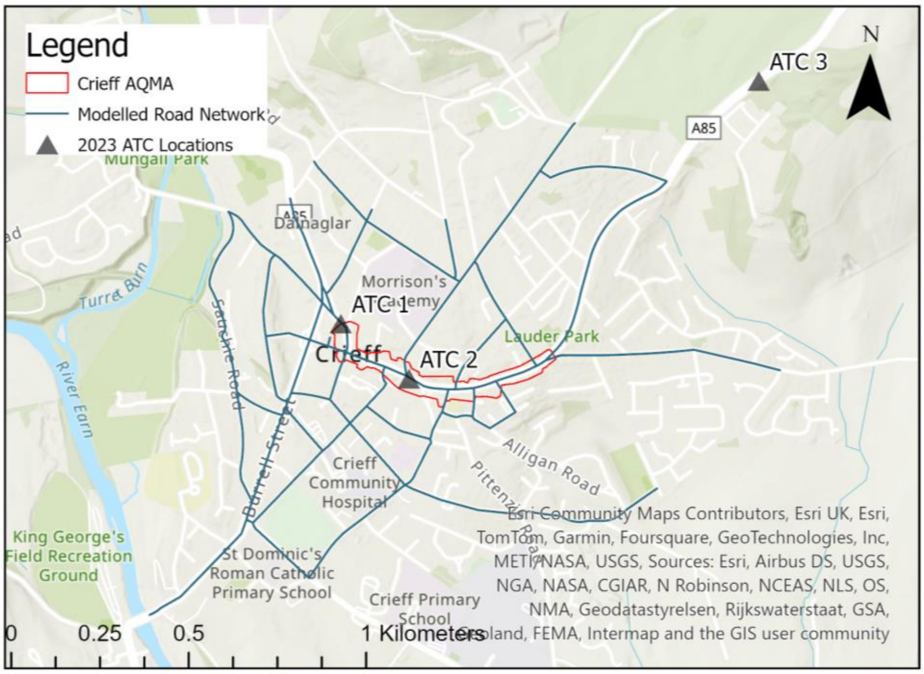
The regional traffic model has not been updated since 2018 and therefore it was proposed to undertake new counts in 2023 so that the latest traffic data were used to update the model based on these new data and run as a 2023 scenario, due to the timing of completion of the study in 2023.

On behalf of the Council Sweco commissioned Automatic Traffic Counters (ATCs) to survey 24-hour traffic flows for a 7-day period at two locations within the AQMA and one location close to the nearest DfT count point. The survey was conducted between 21st November 2023 and 27th November 2023. These locations are shown in Figure 3.2 and are summarised below:

- ATC 1 – Comrie Street, Crieff (within AQMA)
- ATC 2 – High Street, Crieff (within AQMA)
- ATC 3 – Perth Road, Crieff (near to DfT count point)

The 2023 traffic data were comprised of hourly total vehicle flows across 13 vehicle classes and average speeds were provided in the form of kilometres per hour (kph).

FIGURE 3.2: 2023 ATC LOCATIONS



The 2018 dispersion model was then updated to the 2023 scenario by replacing the traffic data on the modelled A85 road links within the AQMA.

- ATC 1 data replaced 2018 traffic data on all modelled road links on Comrie Street (A85), within the AQMA.
- ATC 2 data replaced 2018 traffic data on all modelled road links on West High Street, High Street and East Street, within the AQMA.

For modelled road links outside of the AQMA, the traffic data remained unchanged. This was because the 2023 traffic data only captured the A85, and therefore, would not be representative of smaller roads in the study area.

Full details of the traffic data used in the study is found in Appendix 2.

3.4 Vehicle emission factors

This assessment has used the inbuilt emission factors within ADMS ROADS EXTA. By inputting the traffic data into the model this allows the model to take into account recirculation of the vehicle movements. The latest version of the Emissions Factor Toolkit in ADMS is EFT v10.1 that was released in August 2020. While at the time of the assessment there was a v11 this update did not change the emission factors for Scotland and for NOx or PM10 emissions.

3.5 Meteorological data

For the 2023 scenario meteorological data for 2018 measured at the Strathallen site was used for the modelling assessment due to the use of a previously undertaken model verification carried out in 2019. The meteorological measurement site is located approximately 7.5km south-east of the study area.

Meteorological measurements are subject to their own uncertainty which will unavoidably carry forward into this assessment.

3.6 Background Concentrations

The Scottish air quality background maps[12] were used to assess current background concentrations of NOx and NO_2 in the vicinity of the site. This resource provides estimated annual mean background concentrations of key pollutants at a resolution of 1x1km for Scotland.

This assessment uses the most recent 2018 based background maps and associated tools in the post-processing of the modelled results.

The latest 2023 projected mapped background concentrations from the grid squares within the study area are provided in Table 3.1.

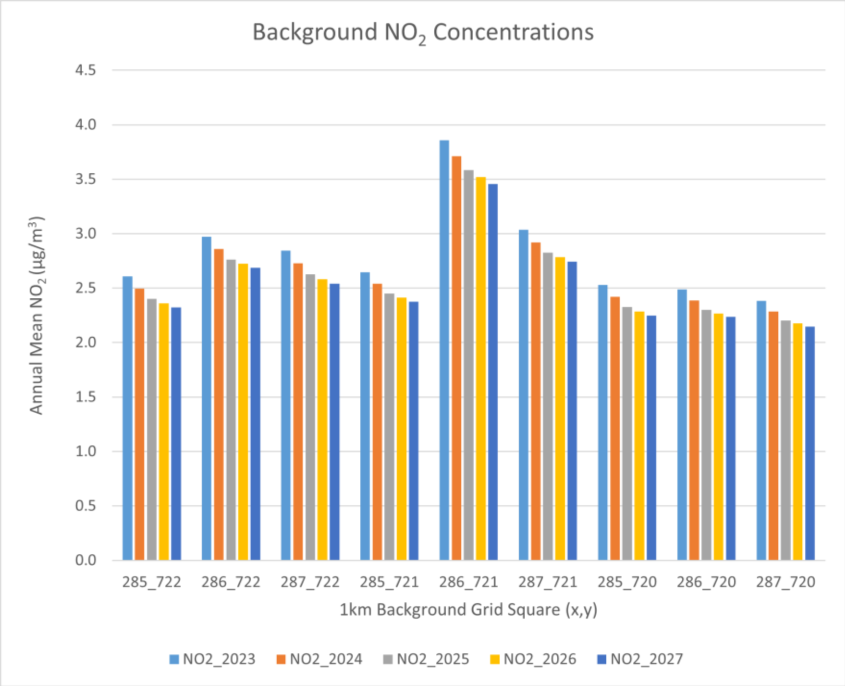
TABLE 3.1: 2023 ANNUAL MEAN BACKGROUND CONCENTRATIONS (μG/M³)

Grid Square	Background Concentrations			
	Year	NOx	NO_2	PM_{10}
285500 722500	2023	3.6	2.6	9.0
286500 722500	2023	4.1	3.0	7.5
287500 722500	2023	3.9	2.8	8.0
285500 721500	2023	3.7	2.6	9.2
286500 721500	2023	5.4	3.9	8.7
287500 721500	2023	4.2	3.0	10.0
285500 720500	2023	3.5	2.5	9.4
286500 720500	2023	3.4	2.5	8.4
287500 720500	2023	3.3	2.4	9.5

Background concentrations for NO_x and NO_2 are predicted to decline in future years, the trend in background concentrations is presented in Chart 1. This clearly shows a forecasted downward trend in annual mean NO_2 from 2023. PM background concentrations also improve, however their forecasted decrease in not as considerable over the period.

[12] Scottish Air Quality, 2018, Background Maps, accessed at: https://www.scottishairquality.scot/data/mapping/data

CHART 1: TREND IN ANNUAL MEAN NO_2 2023 TO 2027



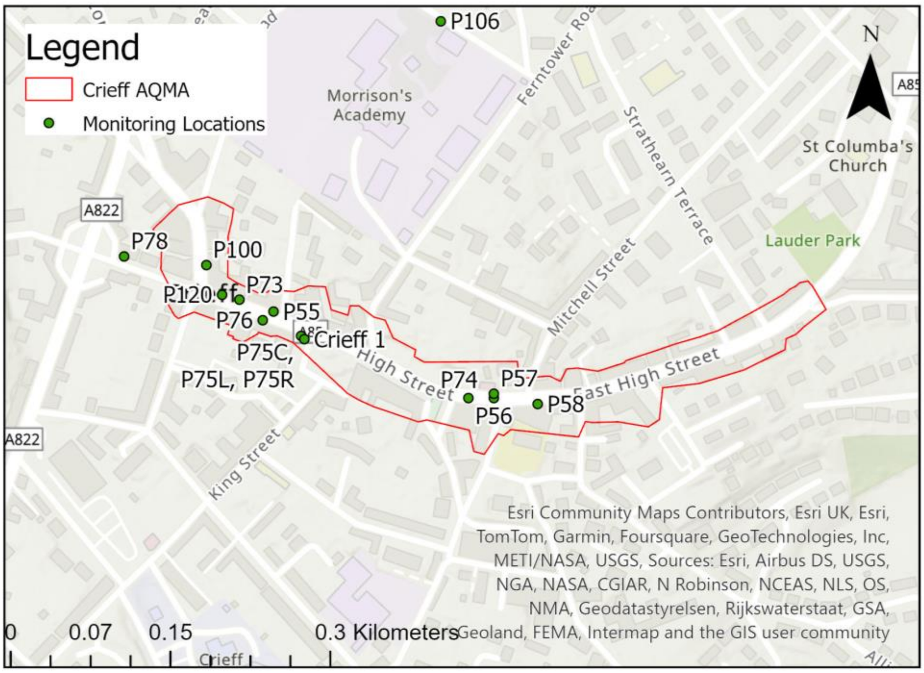
4 Monitoring Data

The 2023 Air Quality Annual Progress Report (APR)[13] was published by Perth & Kinross Council in July 2023. Full details of the QA/QC for all measurement data are provided in the latest APR. While annual mean concentrations measured during 2020 and 2021 have been included, these should be considered not representative of current air quality in the AQMA. These measurements have a degree of uncertainty due to being recorded during the Covid-19 Pandemic when there were a number of Scottish Government imposed restrictions on public movement. All LAQM reports published by Perth & Kinross Council can be found at https://www.pkc.gov.uk/article/15307/Air-quality-reports.

During 2022, Perth & Kinross Council undertook automatic (continuous) monitoring at four locations and non-automatic (passive) monitoring at 76 locations throughout its jurisdiction. The automatic monitoring sites measured nitrogen dioxide (NO_2) and particulate matter (PM_{10}, $PM_{2.5}$ and PM_1). The non-automatic monitoring sites measured NO_2.

Of these monitoring locations, 13 are within the vicinity of the study area and are all roadside or urban centre sites. All monitoring within the study area is presented in Figure 4.1.

FIGURE 4.1: MONITORING LOCATIONS



[13] Available upon request from Perth and Kinross Council

4.1 Local Monitoring

The automatic monitoring site at James Square, Crieff (Crieff 1) has not shown any exceedance of the annual mean NO_2 or annual mean PM_{10} concentrations between the period from 2018 to 2022. Most recently in 2022, the monitor recorded annual average NO_2 measuring 12.3 µg/m^3 and annual average PM_{10} measuring 9.7 µg/m^3. Overall, both pollutant concentrations have decreased over the period. The site uses a gas-phase chemiluminescence detection monitoring technique for NO_2 and FIDAS monitoring for PM.

In 2022, all diffusion tube monitoring locations measured annual mean NO_2 concentrations less than 40 µg/m^3. The highest annual mean NO_2 concentrations in 2022 were recorded at an urban centre location on West High Street (P73) with a concentration of 24.0 µg/m^3, which is well below the AQO of 40 µg/m^3. The monitoring site is located within the Crieff AQMA and has shown an overall decrease in NO_2 concentrations since 2018, this is shown in Chart 2 below.

Full details of the monitoring results located within the study area, ranging from 2018-2022 are provided in Table 4.1 and Table 4.2. The monitoring considered for model verification is discussed further in Section 5.9 and Appendix 1.

It is important to note that there is a degree of uncertainty in diffusion tube monitoring data, largely due to the accuracy of results obtained which tend to be ±20% accurate.

TABLE 4.1: AUTOMATIC MONITORING RESULTS 2018-2022 (µG/M^3)

Site ID	Site Name	X	Y	Pollutant	2018	2019	2020	2021	2022
Crieff 1	James Square, Crieff	286363	721614	NO_2	17.4	16.3	13.1	13.0	12.3
				PM_{10}	10.0	9.0	7.0	9.0	9.7

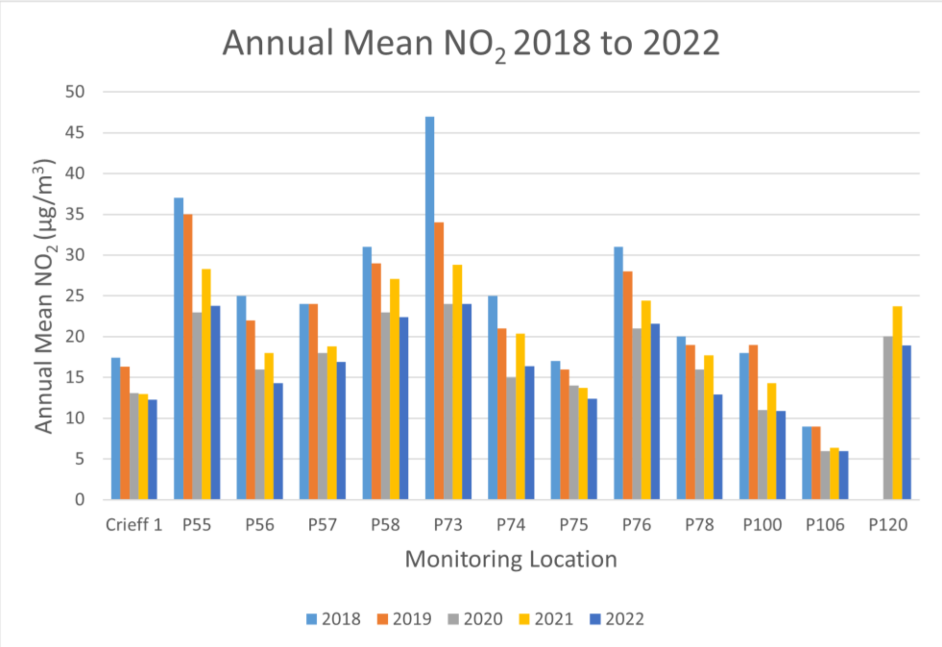
TABLE 4.2: NON-AUTOMATIC NO_2 MONITORING RESULTS (µG/M^3)

Site ID	Site Name	X	Y	In AQMA	2018	2019	2020	2021	2022
P55	7 West High Street, Crieff	286334	721640	Yes	37.0	35.0	23.0	28.3	23.8
P56	39 High Street, Crieff	286541	721559	Yes	25.0	22.0	16.0	18.0	14.3
P57	62 High Street, Crieff	286541	721563	Yes	24.0	24.0	18.0	18.8	16.9
P58	9 East High Street, Crieff	286582	721553	Yes	31.0	29.0	23.0	27.1	22.4
P73	19 West High Street, Crieff	286302	721651	Yes	47.0	34.0	24.0	28.8	24.0
P74	43 High Street, Crieff	286517	721559	Yes	25.0	21.0	15.0	20.4	16.4
P75C, P75L, P75R	RTM, Crieff	286360	721617	Yes	17.0	16.0	14.0	13.7	12.4

P76	10/12 West High Street, Crieff	286324	721632	Yes	31.0	28.0	21.0	24.4	21.6
P78	1 Lodge Street, Crieff	286194	721692	Yes	20.0	19.0	16.0	17.7	12.9
P100	9 Comrie Street, Crieff	286271	721684	Yes	18.0	19.0	11.0	14.3	10.9
P106	Victoria Terrace, Crieff	286491	721913	No	9.0	9.0	6.0	6.4	6.0
P120	25 West High St, Crieff	286286	721656	Yes	-	-	20.0	23.7	18.9

The trend in annual mean concentrations from 2018 is presented in Chart 2 and clearly shows a downward trend from 2018. The only exceeding NO_2 annual mean concentration was recorded at monitoring location P73 in 2018.

CHART 2: TREND GRAPH 2018 TO 2022



4.2 Zephyr Monitoring

Additional monitoring at Bridgend Perth and Crieff was required to gain a further understanding of pollutant concentrations at locations within street canyon environments. Due to the size and power required for automatic monitoring sites, sensor technology was identified as being the most suitable monitoring method for measuring in hotspot areas.

The automatic monitoring sites at Bridgend and Crieff are both examples of this, whether neither automatic monitoring site could be positioned within the street canyon environments where elevated levels of air pollution are expected.

Earthsense Zephyr Air Quality Monitoring was undertaken at two locations (Bridgend Perth and Crieff). The Zephyr sensors monitored both gaseous (NO_x, NO_2, O_3) and particulate pollutants (PM_{10}, $PM_{2.5}$, PM_1).

The Zephyr monitor in Crieff was located at the junction of James Square and A85 for a period of 8 months between 6th April 2022 and 9th December 2022 with a data capture rate of 87%.

The results of the monitoring found that the NO_2 period mean at the Crieff Zephyr sensor measured 10.5 µg/m^3 compared to 9.9 µg/m^3 measured at the automatic monitoring site (Crieff 1). These concentrations are both well below the annual mean objective of 40 µg/m^3. The short-term NO_2 objective was also not exceeded across the period.

The PM_{10} period mean at the Crieff Zephyr sensor measured 8.9 µg/m^3 compared to 8.5 µg/m^3 measured at the automatic monitoring site (Crieff 1). These concentrations are both well below the annual mean objective of 18 µg/m^3. The short-term PM_{10} objective was also not exceeded across the period.

5 Modelling Methodology

5.1 Modelling of Air Quality in 2023

The 2023 modelling scenario used the existing dispersion model which was undertaken for a baseline year of 2018. To update the modelling to 2023, the model included the following amendments:

1. Use of the Department for Transport's latest available manual count point data[14] (2022 at time of reporting) to calculate a Car/LGV vehicle split on the A85. This was then applied to the 2023 traffic data for ATC 1 and 2.
2. Substitution of the 2018 modelled road links on Comrie Street (within the AQMA) with ATC 1 traffic flows.
3. Substitution of the 2018 modelled road links on West High Street, High Street and East High Street (within the AQMA) with ATC 2 traffic flows.
4. Update Emission Factor Toolkit to version 10.1 within ADMS-Roads v5 and the emission year to 2023.

5.2 Future Air Quality Scenario

As the revocation of the Crieff AQMA would be implemented in 2024, an exercise has been carried out to understand what level of traffic increase over the next five years would lead to an exceedance of the NO_2 and PM_{10} objectives. This exercise was undertaken using interpolation of the predicted concentrations and the traffic flow data and does not involve dispersion modelling.

5.3 Modelling Software

Annual mean concentrations of NO_2 and PM_{10} during 2018 and 2023 have been modelled within the study area using the atmospheric dispersion model ADMS-Roads (version 5.0.0.1).

The model has been verified by comparison of the modelled predictions of local emission contributions for NOx (road-NO_x) and PM_{10} (road-PM_{10}) with local monitoring results. The available automatic monitoring and roadside diffusion tube measurements within the study area (described in Section 4 above) were used to verify the model predictions.

Following initial comparison of the modelled concentrations with the available monitoring data, refinements were made to the model input to achieve the best possible agreement with the diffusion tube measurements. Further information on model verification is provided in Section 5.8 and Appendix 1

A surface roughness of 1 m was used in the modelling to represent the urban conditions in the model domain. A limit for the Monin-Obukhov length of 30 m was applied to represent a town.

The source-oriented grid option was used in ADMS-Roads. This option provides a fine resolution for predicted pollutant concentrations close to the modelled roads within a wider grid for predicted concentrations further away from the

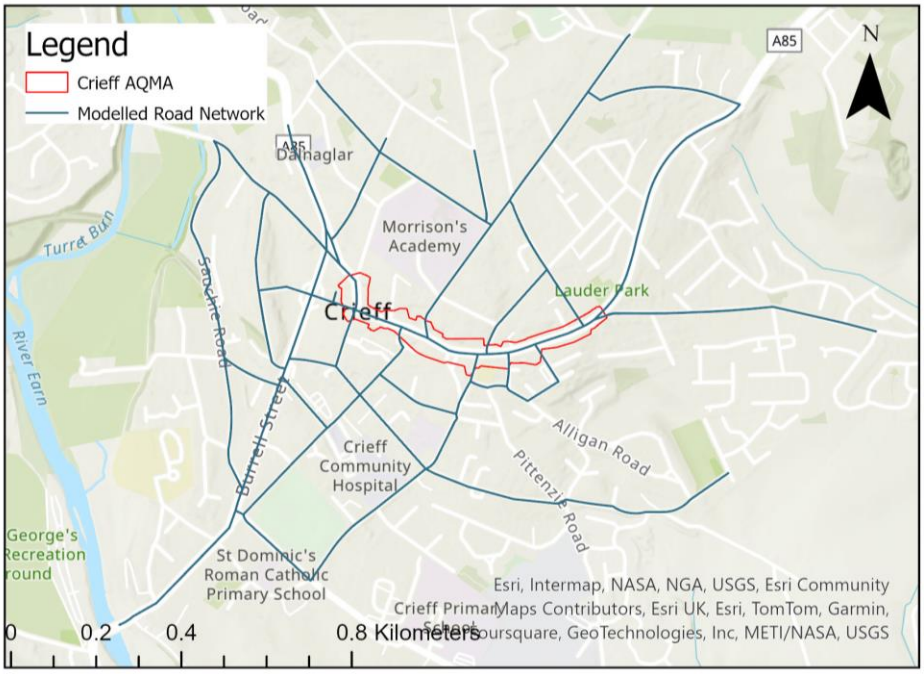
[14] Available at: https://roadtraffic.dft.gov.uk/manualcountpoints/90113

road. The predicted concentrations were interpolated to derive values between the grid points. This allows contours showing the predicted spatial variation of pollutant concentrations to be produced and added to the digital base mapping.

5.4 Study Area

The study area comprises of sensitive receptors where the annual mean objective for NO_2 and PM_{10} applies at many locations situated in Crieff. The study area including the roads modelled are presented in Figure 5.1.

FIGURE 5.1: STUDY AREA



5.5 Receptor Locations

The model has been used to predict NO_2 and PM_{10} annual mean concentrations at sensitive receptors within the study area. The receptors are located at the façade of buildings in the model domain where relevant exposure exists. The receptors have been modelled at a height of 1.5m to represent human exposure at the ground floor level and where appropriate, at 4m to represent human exposure at the first-floor level. The locations of the selected receptors are presented in Table 5.1 and Figure 5.2.

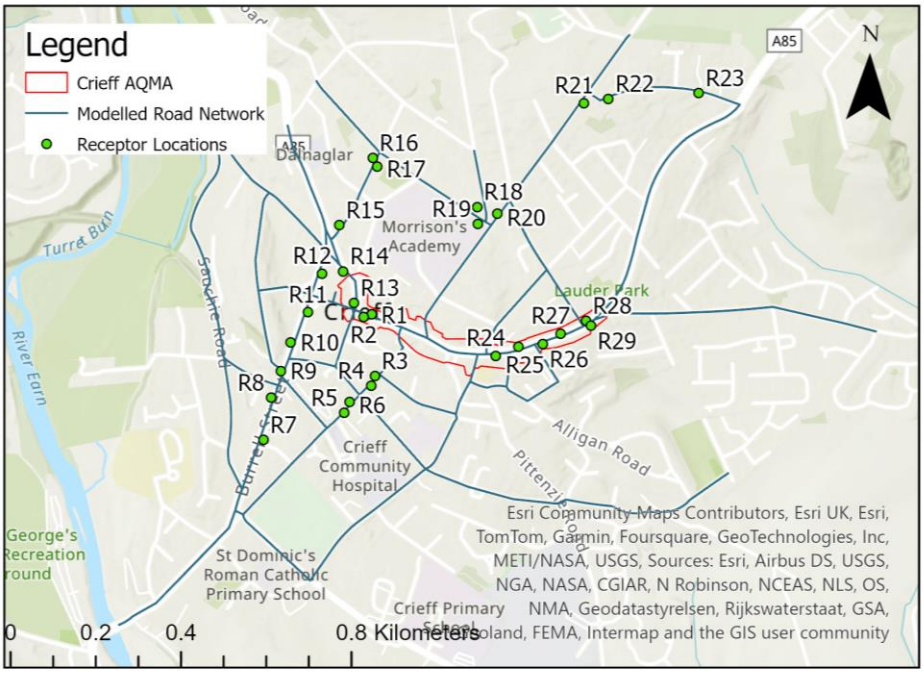
TABLE 5.1: RECEPTOR LOCATIONS

Receptor ID	Type	Address	In AQMA?	X	Y	Z
R1	Residential	21 West High St - 1st floor	Yes	286300.8	721651.2	4.0
R2	Residential	30 West High St - 1st floor	Yes	286282.1	721646.9	4.0

Receptor ID	Type	Address	In AQMA?	X	Y	Z
R3	Residential	33 King St	No	286308.6	721505.7	1.5
R4	Residential	54 King St	No	286299.4	721482.6	1.5
R5	Residential	86 King St	No	286236.9	721419.0	1.5
R6	Residential	61 King St	No	286248.5	721444.6	1.5
R7	Residential	60 Burrell St	No	286046.5	721355.8	1.5
R8	Residential	55 Burrell St	No	286064.7	721454.9	1.5
R9	Residential	43 Burrell St	No	286087.3	721517.4	1.5
R10	Residential	25A Burrell St	No	286110.9	721584.2	1.5
R11	Residential	14 Burrell St	No	286151.8	721655.1	1.5
R12	Residential	8 Burrell St	No	286184.0	721746.3	1.5
R13	Residential	2 Comrie St - 1st floor	Yes	286259.1	721677.4	4.0
R14	Residential	40 Comrie St	No	286234.1	721751.5	1.5
R15	Residential	St Ninian’s Court, Heathcote Rd	No	286224.8	721859.6	1.5
R16	Residential	Heathcote Rd 2	No	286303.2	722017.7	1.5
R17	Residential	Heathcote Rd 3	No	286313.7	721996.7	1.5
R18	Residential	3 Victoria Terrace	No	286548.2	721902.6	1.5
R19	School	Beatrice Mason Primary Building	No	286550.0	721862.7	1.5
R20	Residential	Upper Fernton, Ferntower Rd	No	286595.6	721887	1.5
R21	Residential	1 Connaught Terrace	No	286798.9	722145.9	1.5
R22	Hotel	Murraypark Hotel	No	286856.7	722156.4	1.5
R23	Residential	Connaught Terrace 2	No	287068.7	722169.9	1.5
R24	Residential	13 East High Street - 1st floor	Yes	286591.3	721553.2	4.0
R25	Residential	40A East High St	Yes	286645.3	721572.9	1.5

Receptor ID	Type	Address	In AQMA?	X	Y	Z
R26	Residential	59 East High St	Yes	286702.6	721581.7	1.5
R27	Residential	76 East High St	Yes	286743.8	721604.4	1.5
R28	Residential	81 East High St	Yes	286804.1	721635.4	1.5
R29	Residential	93 East High St	Yes	286815.0	721623.6	1.5

FIGURE 5.2: RECEPTOR LOCATIONS



5.6 Street Canyons

The assessment included the street canyons identified on segments of Comrie Street, West High Street, High Street and East High Street. To account for the ‘street canyon’ effect a simple canyon module was used within ADMS Roads; this required the respective sensitive receptors identified to be modelled within approximately 0.5m of the roadside to assess the potential for elevated pollutant concentrations. Full details of the canyon are in Appendix 2.

5.7 Limitations

The following limitations apply to this assessment:

- Traffic data was sourced from a regional transport model which does not have the local detail around junctions regarding speed etc that smaller bespoke models would have.

- The traffic data provided was for the 12-hour period between 0700hrs and 1900hrs. This was factored in order to simulate a 24hr flow, but may over-predict flows for off-peak hours between 1900hrs and 0700hrs.
- To maintain consistency with the 2018 model the same Defra LAQM tools were used as per the 2018 assessment. These may over-predict with reference to the latest LAQM tools available due to increased reductions in vehicle emissions and unforeseen changes in the national fleet composition resulting from UK Government policy and the increased availability of electric vehicles (EV) and EV charging points.

5.8 Model Verification

Model verification is the comparison of modelled results with available local monitoring data. This identifies how well the model is performing. The most recent guidance available at the time of model verification for the 2018 modelling assessment was LAQM.TG (16), which recommends making the adjustment to the road contribution of the pollutant only. This process is unchanged in LAQM.TG (22). The model is refined as part of the verification process to reduce uncertainties within the modelling. Further information on the verification process including the linear regression analysis is available in Appendix 1.

5.9 Model Outputs

For each modelled scenario, the ADMS-Roads model predicted the local road emissions contributions for NO_x (road-NO_x) and PM_{10} (road-PM_{10}) to the respective annual mean concentration at all discrete receptors.

To calculate the total annual mean concentration for PM_{10} at each receptor, the corresponding annual mean background for each year of assessment, sourced from Air Quality in Scotland's background pollutant maps[12], was added to the respective road contribution.

Annual mean road-NO_x was converted to total annual mean NO_2 concentrations using Defra's NO_x to NO_2 Calculator v8.1[15]. This calculator converts the road-NO_x concentration at each discrete receptor to road-NO_2 and enables the background NO_2 contribution to be accounted for to derive the total annual mean NO_2 concentration.

The calculator applies a default value for the primary NO_2 fraction (f-NO_2) – the proportion of road-NO_x that is emitted directly as NO_2 – which is representative of the selected traffic mix and assessment year within the calculator. For this study, the default f-NO_2 for 'All other urban UK traffic' mix was selected in the absence of detailed local vehicle fleet mix data.

[15] Available at: https://laqm.defra.gov.uk/air-quality/air-quality-assessment/nox-to-no2-calculator/

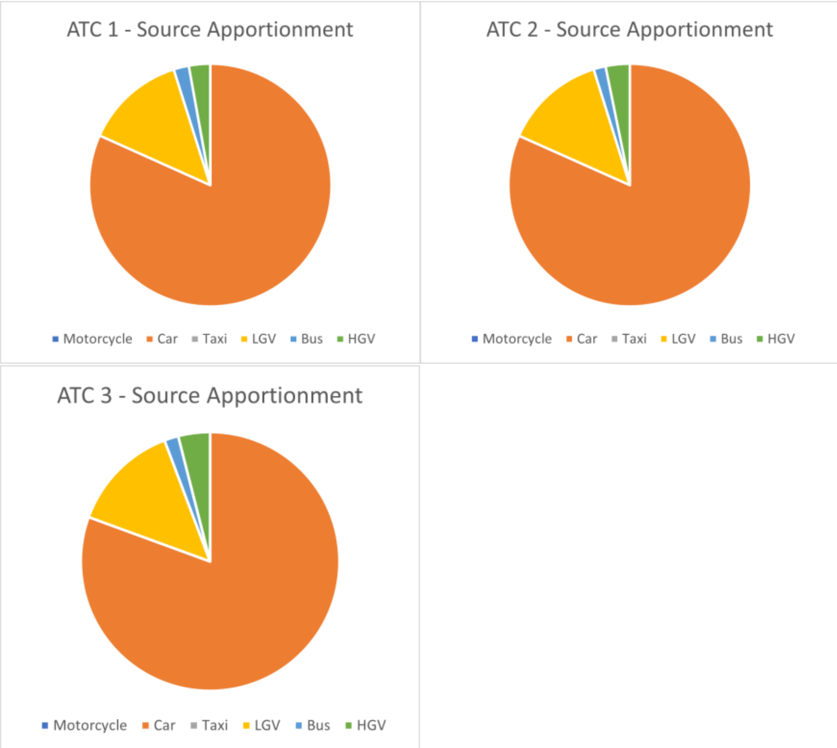
6 Source apportionment

A source apportionment analysis of the two traffic sources was carried out to understand the change in vehicle fleet between 2018 and 2023.

6.1.1 2018 Traffic Sources

A source apportionment analysis on the 2018 Perth and Kinross Regional Transport Model is shown below in Chart 3. The pie charts show the vehicle fleet composition at the respective locations of the three ATC sites conducted in 2023. These splits were approximately 81.3% cars, 13.5% LGVs, 1.8% Buses and 3.3% HGVs.

CHART 3: 2018 PERTH AND KINROSS REGIONAL TRANSPORT MODEL SOURCE APPORTIONMENT

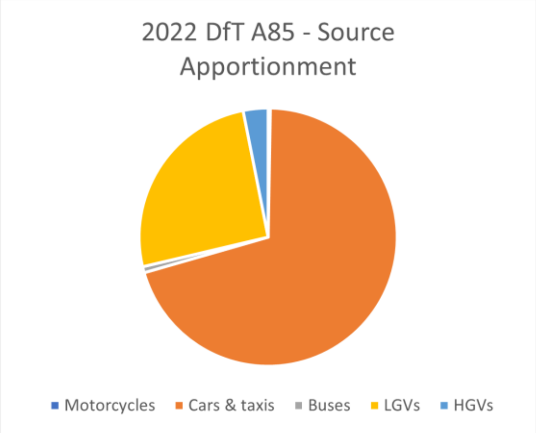


6.1.2 2022 DfT Traffic Sources

The Department for Transport's (DfT) latest and most local available manual count point data (site number: 90113[16]) is approximately 0.8km north-east of the study area on the A85 towards Gilmerton in 2022. The traffic source apportionment at the site is shown below in Chart 4 below. The chart shows the vehicle fleet splits were approximately 70.3% cars, 25.6% LGVs, 0.8% Buses, 3.1% HGVs and 0.3% motorcycles.

[16] Available at: https://roadtraffic.dft.gov.uk/manualcountpoints/90113

CHART 4: 2022 DFT SOURCE APPORTIONMENT



The source apportionment above was then used to calculate a Car/LGV vehicle split which was applied to the traffic data in 2023. This was necessary as the two vehicle fleets (cars and LGVs) were grouped together in the data provided by the transport consultant. The split was 73.3% cars and 26.7% LGVs.

6.1.3 2023 Traffic Sources

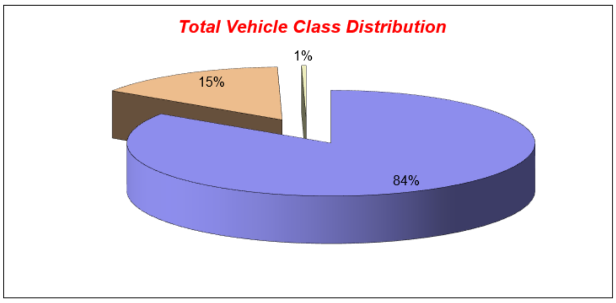
Source apportionment analysis on the 2023 ATC sites is shown in Charts 5-7 below. These charts were provided by the transport consultant and were broken down into three vehicle classes:

1. Purple – Car and LGVs
2. Orange – Rigid HGVs and Buses
3. Yellow – Arctic HGVs

The average vehicle splits across the three locations were approximately 83% Car and LGVs, 16% Rigid HGVs and Buses, and 1% Artic HGVs.

When compared to both 2018 and 2022 traffic sources, the 2023 traffic data shows a signicant increase in %HGVs. This was raised with the Transport Consultant who checked the data and confirmed there were no issues. The Transport Consultant also confirmed that they ussually see a percentage of 10-20% for HGVs outside of urban areas.

CHART 5: 2023 ATC 1 SOURCE APPORTIONMENT (NORTHBOUND – TOP, SOUTHBOUND – BOTTOM)



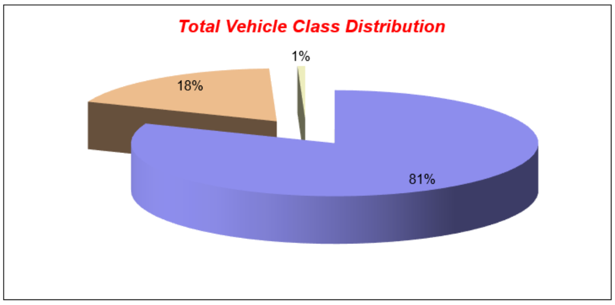
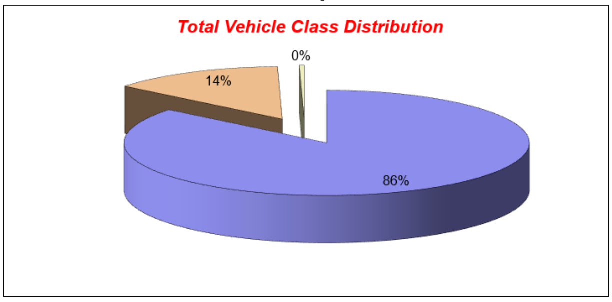


CHART 6: 2023 ATC 2 SOURCE APPORTIONMENT (NORTHBOUND – TOP, SOUTHBOUND – BOTTOM)



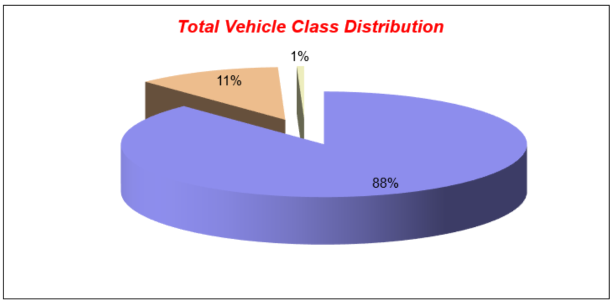
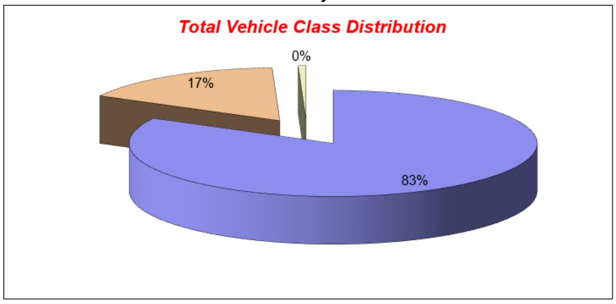
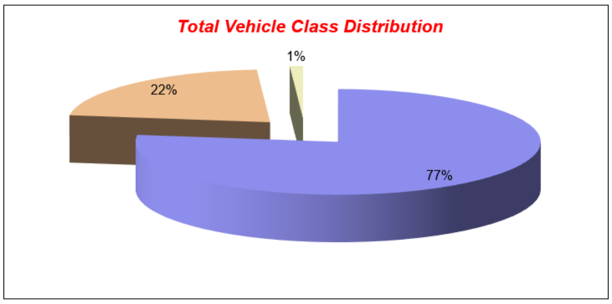


CHART 7: 2023 ATC 3 SOURCE APPORTIONMENT (NORTHBOUND – TOP, SOUTHBOUND – BOTTOM)





7 Modelled Results

7.1 NO_2 Modelled Concentrations

Adjusted NO_2 annual mean concentrations at the specified receptors for both 2018 and 2023 are presented within this section.

The highest receptor concentration in both 2018 and 2023 were modelled at R25 (40A East High Street). In 2018, the model predicted an annual mean NO_2 concentration of 41.0 µg/m^3 which then decreased to 27.6 µg/m^3 in 2023. In this period, background concentrations of NO_x have also improved.

With an RMSE of 8.06, the worst-case modelled prediction at R25 would take the NO_2 annual mean concentration to 35.7 µg/m^3, well below the objective level of 40 µg/m^3.

The annual mean concentrations were predicted to be lower than 36 µg/m^3, more than 10% below the objective, at all locations indicating that the revocation of the AQMA can be justified.

Full receptor results can be found in Table 7.1 below.

TABLE 7.1: COMPARISON OF 2018 AND 2023 MODELLED ANNUAL MEAN CONCENTRATIONS (µG/M^3) FOR NO_2 AT SENSITIVE RECEPTORS

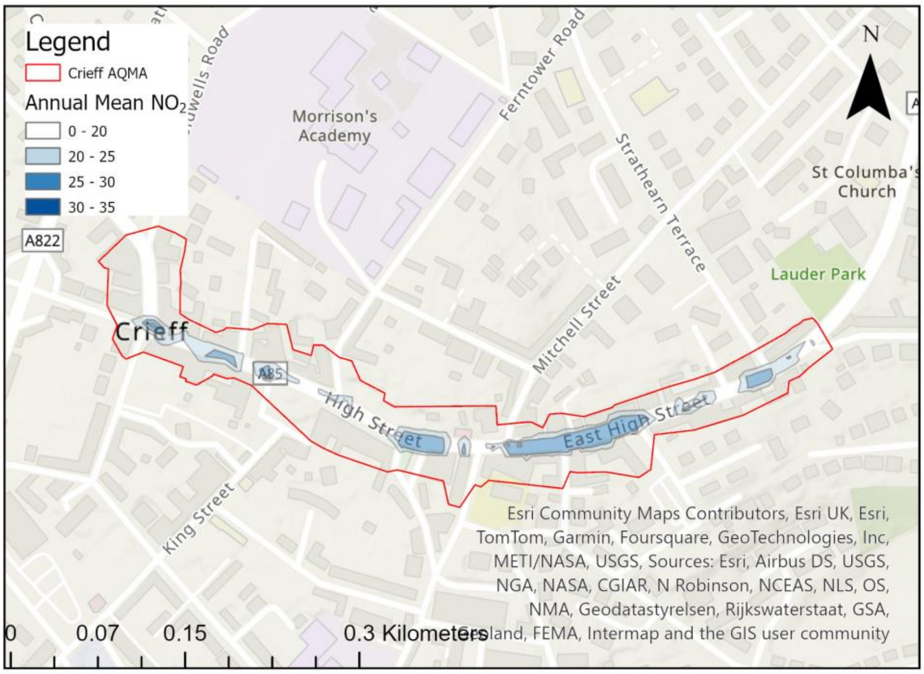
Receptor	Address	2018 Concentrations (µg/m^3)			2023 Concentrations (µg/m^3)		
		Adjusted Road NO_x	Background NO_x	NO_2 Annual Mean	Adjusted Road NO_x	Background NO_x	NO_2 Annual Mean
R1	21 West High St - 1st floor	58.8	5.9	33.9	37.8	4.9	23.4
R2	30 West High St - 1st floor	62.1	5.9	35.4	40.0	4.9	24.5
R3	33 King St	11.5	5.9	10.6	7.0	4.9	7.4
R4	54 King St	12.8	5.9	11.2	7.7	4.9	7.8
R5	86 King St	26.1	5.9	18.3	15.6	4.9	12.1
R6	61 King St	11.5	5.9	10.5	6.9	4.9	7.3
R7	60 Burrell St	14.4	5.9	12.1	8.5	4.9	8.3
R8	55 Burrell St	12.8	5.9	11.3	7.6	4.9	7.7
R9	43 Burrell St	15.3	5.9	12.6	9.0	4.9	8.5
R10	25A Burrell St	13.1	5.9	11.4	7.8	4.9	7.8
R11	14 Burrell St	21.1	5.9	15.7	12.5	4.9	10.4
R12	8 Burrell St	10.3	5.9	9.9	6.2	4.9	7.0

Receptor	Address	2018 Concentrations (µg/m^3)			2023 Concentrations (µg/m^3)		
		Adjusted Road NO_x	Background NO_x	NO_2 Annual Mean	Adjusted Road NO_x	Background NO_x	NO_2 Annual Mean
R13	2 Comrie St - 1st floor	39.1	5.9	24.7	22.9	4.9	15.9
R14	40 Comrie St	12.4	5.9	11.1	7.7	4.9	7.8
R15	St Ninian's Court, Heathcote Rd	6.8	5.9	8.0	4.0	4.9	5.7
R16	Heathcote Rd 2	2.2	4.8	4.8	1.3	4.0	3.7
R17	Heathcote Rd 3	2.4	5.9	5.5	1.4	4.9	4.3
R18	3 Victoria Terrace	2.8	5.9	5.7	1.7	4.9	4.4
R19	Beatrice Mason Primary Building	3.1	5.9	5.9	1.8	4.9	4.5
R20	Upper Fernton, Ferntower Rd	5.8	5.9	7.4	3.5	4.9	5.5
R21	1 Connaught Terrace	2.5	4.8	5.0	1.5	4.0	3.8
R22	Murraypark Hotel	2.8	4.8	5.2	1.7	4.0	3.9
R23	Connaught Terrace 2	3.0	4.4	5.0	1.8	3.6	3.8
R24	13 East High Street - 1st floor	74.1	5.9	40.5	45.1	4.9	26.9
R25	40A East High St	75.4	5.9	41.0	46.7	4.9	27.6
R26	59 East High St	74.9	5.9	40.9	45.1	4.9	26.9
R27	76 East High St	64.1	5.9	36.2	38.5	4.9	23.8
R28	81 East High St	27.8	5.9	19.1	17.3	4.9	13.0
R29	93 East High St	26.9	5.9	18.7	16.8	4.9	12.7

The contour plot for annual mean NO_2 concentrations in 2023 for the modelled study area supports this justification, presented in Figure 7.1.

The contour plot shows that while there are elevated concentrations on the A85, within the AQMA, the annual mean concentrations are well below 40 µg/m^3, with the highest concentrations within the centre of the road and not at the façade of the sensitive receptors.

FIGURE 7.1: MODELLED ANNUAL MEAN NO_2 CONCENTRATIONS (µG/M^3)



7.2 PM_{10} Modelled Concentrations

PM_{10} annual mean concentrations at the specified receptors for both 2018 and 2023 are presented within this section.

The highest receptor concentration was modelled at R27 (76 East High Street) in 2018 with a predicted annual mean PM_{10} concentration of 11.3 µg/m³. In 2023, the highest receptor concentration was modelled at R26 (59 East High Street) with a predicted annual mean PM_{10} concentration of 10.6 µg/m³. In this period, background concentrations of PM_{10} also decreased by 0.5 µg/m³.

The annual mean concentrations were predicted to be below the PM_{10} annual mean objective of 18 µg/m³ at all locations indicating that the revocation of the AQMA can be justified.

Full receptor results can be found in Table 7.2 below.

TABLE 7.2: COMPARISON OF 2018 AND 2023 MODELLED ANNUAL MEAN CONCENTRATIONS (µG/M³) FOR PM_{10} AT SENSITIVE RECEPTORS

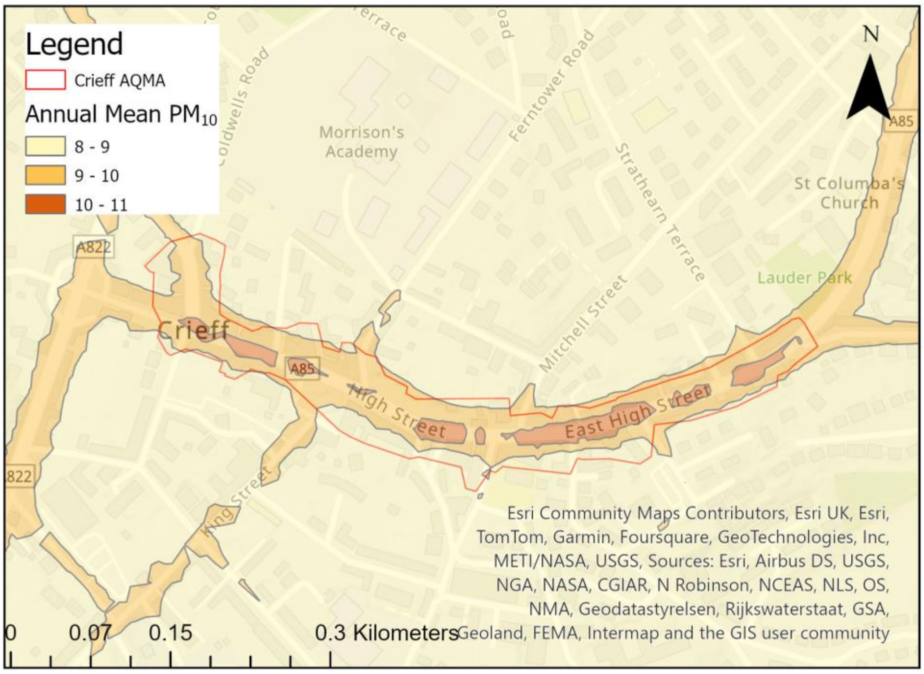
Receptor	Address	2018 Concentrations (µg/m³)			2023 Concentrations (µg/m³)		
		Adjusted Road-PM_{10}	Background PM_{10}	PM_{10} Annual Mean	Adjusted Road-PM_{10}	Background PM_{10}	PM_{10} Annual Mean
R1	21 West High St - 1st floor	1.5	9.2	10.7	1.5	8.7	10.2
R2	30 West High St - 1st floor	1.6	9.2	10.8	1.6	8.7	10.3
R3	33 King St	0.3	9.2	9.6	0.3	8.7	9.0
R4	54 King St	0.4	9.2	9.6	0.4	8.7	9.1
R5	86 King St	0.8	9.2	10.0	0.7	8.7	9.4
R6	61 King St	0.3	9.2	9.6	0.3	8.7	9.0
R7	60 Burrell St	0.5	9.2	9.7	0.5	8.7	9.2
R8	55 Burrell St	0.4	9.2	9.7	0.4	8.7	9.1
R9	43 Burrell St	0.4	9.2	9.7	0.4	8.7	9.1
R10	25A Burrell St	0.4	9.2	9.6	0.4	8.7	9.1
R11	14 Burrell St	0.7	9.2	9.9	0.6	8.7	9.3
R12	8 Burrell St	0.3	9.2	9.6	0.3	8.7	9.0
R13	2 Comrie St - 1st floor	0.9	9.2	10.1	0.8	8.7	9.5
R14	40 Comrie St	0.3	9.2	9.6	0.3	8.7	9.0

Receptor	Address	2018 Concentrations (µg/m^3)			2023 Concentrations (µg/m^3)		
		Adjusted Road-PM_{10}	Background PM_{10}	PM_{10} Annual Mean	Adjusted Road-PM_{10}	Background PM_{10}	PM_{10} Annual Mean
R15	St Ninian's Court, Heathcote Rd	0.2	9.2	9.4	0.2	8.7	8.9
R16	Heathcote Rd 2	0.1	8.0	8.0	0.1	7.5	7.6
R17	Heathcote Rd 3	0.1	9.2	9.3	0.1	8.7	8.8
R18	3 Victoria Terrace	0.1	9.2	9.3	0.1	8.7	8.8
R19	Beatrice Mason Primary Building	0.1	9.2	9.3	0.1	8.7	8.8
R20	Upper Fernton, Ferntower Rd	0.2	9.2	9.4	0.2	8.7	8.9
R21	1 Connaught Terrace	0.1	8.0	8.1	0.1	7.5	7.6
R22	Murraypark Hotel	0.1	8.0	8.1	0.1	7.5	7.6
R23	Connaught Terrace 2	0.1	8.4	8.5	0.1	8.0	8.1
R24	13 East High Street - 1st floor	2.0	9.2	11.2	1.8	8.7	10.5
R25	40A East High St	2.0	9.2	11.2	1.9	8.7	10.6
R26	59 East High St	2.1	9.2	11.3	1.9	8.7	10.6
R27	76 East High St	1.8	9.2	11.0	1.6	8.7	10.3
R28	81 East High St	0.7	9.2	10.0	0.7	8.7	9.4
R29	93 East High St	0.7	9.2	9.9	0.6	8.7	9.4

The contour plot for annual mean PM_{10} concentrations in 2023 for the modelled study area supports this justification, presented in Figure 7.2.

The contour plot shows that while there are elevated concentrations on the A85, within the AQMA, the annual mean concentrations are well below 18 µg/m^3. The figure also demonstrates that the largest contributor to the annual mean PM_{10} is the background concentrations.

FIGURE 7.2: MODELLED ANNUAL MEAN PM_{10} CONCENTRATIONS (µG/M^3)



8 Future Air Quality

8.1 Met Sensitivity

Pollutant concentrations may vary significantly from one year to the next due to the influence of meteorological conditions. It is important that authorities avoid cycling between declaring, revoking and declaring again, due simply to these variations. Therefore, this assessment has considered the potential effects on pollutant concentrations across five years of meteorological conditions. A five-year period is generally considered to provide an adequate reflection of meteorological variability in air quality modelling. This provides certainty that any future exceedances that might occur in more adverse meteorological conditions are unlikely. This sensitivity analysis shows how sensitive the area is to the effects of the meteorological conditions.

The MET sensitivity results from five years for NO_2 can be found in Appendix 3 – MET Sensitivity.

The results identified that year 5 had the highest annual mean concentration for the largest proportion of receptors. The receptors' standard deviation ranged between 0.02 and 0.99 across the 5-year period.

The NO_2 results for each receptor were also tested using a single factor ANOVA test. This statistical test is used to check whether datasets are different from one another when a single variable is changed each time a test is repeated. In this case only meteorology for five different years was changed to determine the effect on predicted concentrations. All other variables, such as traffic flow, emissions and road alignments, remain the same for each test. The ANOVA test specifically looks at the variance in the mean average for each of the five tests. The summary for each of the five years tested is shown in Table 8.1.

TABLE 8.1 ANOVA TEST SUMMARY STATISTICS

Year	Receptors	Sum of Annual Mean NOx Predictions	Average of Annual Mean NOx Predictions	Variance in Annual Mean NOx Predictions
2014	29	157.7	5.439	32.129
2015	29	147.6	5.090	28.989
2017	29	152.8	5.270	30.622
2018	29	155.8	5.372	31.597
2019	29	168.8	5.821	36.794

The ANOVA test was undertaken using a confidence interval of 95%. This assumes that 95% of each sample fits within a normal statistical distribution. The resulting *p* value (a measure of the variance) was greater than 0.05 (0.992) indicating that none the predictions from the five years are in the 5% of values potentially outside of the normal distribution and therefore not statistically significantly different from one another.

The test was repeated with the results from only the nine modelled receptors located within the AQMA and the test statistics are shown in Table 8.2.

TABLE 8.2 ANOVA TEST SUMMARY STATISTICS FOR AQMA RECEPTORS

Year	Receptors	Sum of Annual Mean NOx Predictions	Average of Annual Mean NOx Predictions	Variance in Annual Mean NOx Predictions
2014	9	114.4	12.716	20.564
2015	9	108.5	12.059	17.707
2017	9	111.9	12.429	18.611
2018	9	113.6	12.623	19.685
2019	9	123.1	13.672	22.094

The resulting *p* value from this test was 0.955 showing that within the AQMA all of the results were within a normal statistical distribution. This shows that the datasets for each of the five years were not statistically significantly different from one another.

This assessment provides the confidence that the effects of meteorological conditions on this area are negligible and therefore exceedances of the annual mean objective in the future due to meteorological variations are highly unlikely.

8.2 2029 Scenario

8.2.1 Methodology

As the revocation of the Crieff AQMA would be implemented in 2024, this future year scenario considers the next five years post revocation.

In the absence of future year traffic data, an exercise has been carried to understand what level of traffic increase in 2029 would lead to an exceedance of the NO_2 or PM_{10} objective within the AQMA.

The steps to complete this exercise were:

- Find the existing 24-hour AADT of the nearest modelled road link to each sensitive receptor within the AQMA as well as the adjusted modelled road-NO_x/PM_{10} in 2023.
- Calculate the concentration of road-NO_x/PM_{10} in 2029 that would lead to an exceedance of the annual mean objectives. This considered Scottish Air Quality's background concentrations in 2029.
- Produce an exceedance factor to work out the level of increase required for the existing road-NO_x/PM_{10} to exceed objectives.
- Multiple the existing 24-hour AADT in 2023 by the exceedance factor to calculate the 24-hour AADT required for exceedance of objectives in 2029.

8.2.2 Results

<u>NO_2</u>

The projected traffic flows in 2029 are shown in Table 8.3 below.

The exercise showed that projected traffic flows in 2029 would need to increase significantly at all receptors for there to be exceedances of the NO_2 objective. The smallest and largest increases were both predicted on East High Street.

The smallest would be a 68% increase at R25, and the largest would be a 367% increase was at R29.

TABLE 8.3: PROJECTED TRAFFIC FLOW IN 2029 TO RESULT IN EXCEEDANCE OF NO_2 OBJECTIVE

Location	Traffic flow in 2023 (24-hour AADT) (a)	2023 Adjusted Road NOx (µg/m³) (b)	Road NOx required to result in exceedance of 40µg/m³ (c)	2023 NO_2 Concentrations (µg/m³)	2029 NO_2 Concentrations * (µg/m³)	Projected traffic flow in 2029 to result in exceedance (24-hour AADT) =(c/b)*a	% increase in traffic flow for exceedance to occur
R1	7,171	37.8	78.5	23.4	22.5	14,896	108
R2	7,171	40.0	78.5	24.5	23.6	14,069	96
R13	2,627	22.9	78.5	15.9	15.3	8996	242
R24	7,171	45.1	78.5	26.9	25.9	12,468	74
R25	7,171	46.7	78.5	27.6	26.6	12,055	68
R26	7,171	45.1	78.5	26.9	25.9	12,482	74
R27	7,171	38.5	78.5	23.8	22.9	14,615	104
R28	7,171	17.3	78.5	13.0	12.4	32,554	354
R29	7,171	16.8	78.5	12.7	12.2	33,467	367
***These concentrations were not modelled. The concentrations are the 2023 modelled concentrations with updated 2029 backgrounds.**							

PM_{10}

The projected traffic flows in 2029 are shown in Table 8.4 below.

The exercise showed that projected traffic flows in 2029 would need to increase significantly at all receptors for there to be exceedances of the PM_{10} objective. The smallest and largest increases were both predicted on East High Street. The smallest would be a 410% increase at R26, and the largest would be a 1361% increase at R29.

TABLE 8.4: PROJECTED TRAFFIC FLOW IN 2029 TO RESULT IN EXCEEDANCE OF PM_{10} OBJECTIVE

Location	Traffic flow in 2023 (24-hour AADT) (a)	2023 Adjusted Road PM_{10} (µg/m³) (b)	Road PM_{10} required to result in exceedance of 18µg/m³ (c)	2023 PM_{10} Concentrations (µg/m³)	2029 PM_{10} Concentrations * (µg/m³)	Projected traffic flow in 2029 to result in exceedance (24-hour AADT) =(c/b)*a	% increase in traffic flow for exceedance to occur
R1	7,171	1.5	9.5	10.2	10.0	46,280	545
R2	7,171	1.6	9.5	10.3	10.1	43,480	506
R13	2,627	0.8	9.5	9.5	9.3	32,206	1126
R24	7,171	1.8	9.5	10.5	10.3	37,408	422
R25	7,171	1.9	9.5	10.6	10.4	36,796	413
R26	7,171	1.9	9.5	10.6	10.4	36,580	410
R27	7,171	1.6	9.5	10.3	10.1	42,861	498
R28	7,171	0.7	9.5	9.4	9.2	100,804	1306
R29	7,171	0.6	9.5	9.4	9.2	104,781	1361
***These concentrations were not modelled. The concentrations are the 2023 modelled concentrations with updated 2029 backgrounds.**							

Summary

Although the information in both Table 8.3 and Table 8.4 is indicative, it highlights that a substantial increases in traffic flow would be required before any potential exceedance of either air quality objective in 2029.

9 Conclusion and Recommendations

Sweco UK Ltd was commissioned by Perth and Kinross Council to prepare a Detailed Assessment to determine the requirement for an AQMA in Crieff as part of the Council's proposal for revocation of the AQMA under Section 83 (2) of the Environment Act 1995.

The Crieff AQMA was declared in 2014 for exceedances of both the annual mean NO_2 and PM_{10} objectives. Previous studies have shown that the predominant source of NO_2 was road traffic emissions.

A review of the monitoring data has shown that there is a downward trend in measured concentrations within the AQMA and that the annual mean concentrations for NO_2 and PM_{10} have stayed well below the objectives since the last exceedance in 2018.

A dispersion modelling study of road traffic emissions in Crieff was conducted to determine the spatial extent of annual mean NO_2 and PM_{10} concentrations in 2023. This concluded that there are currently no locations within the study area where there is predicted to be an exceedance of either pollutant objective. The highest predicted concentrations are located within the current AQMA boundary but are significantly below the respective objective values.

In order to revoke the AQMA it is essential to have confidence that measured NO_2 and PM_{10} concentrations will not rise above the objective levels again in the coming years. Whilst this can never be determined with 100% certainty, a future year scenario predicted that traffic flows within the AQMA would have to increase significantly for either pollutant to exceed their respective objectives. For NO_2, an increase in future traffic flow of between 68% and 367% would be required. For PM_{10}, an increase of between 410% and 1361% would be required.

It is, therefore, concluded that it is unlikely that the SAQ annual mean NO_2 and PM_{10} objectives will be exceeded in future years, supporting the Council's proposal for revocation of the AQMA under Section 83 (2) of the Environment Act 1995.

As stated in PG(S)(23), there is an expectation that action plans and air quality strategies will continue to be implemented post revocation for previously declared AQMA and the Scottish Government provides funding routes to achieve this.

While the current automatic monitor is not placed in the worst-case location due to limitations of the High Street environment to accommodate an analyser, it is recommended that the Council continue to monitor annual mean NO_2 and PM_{10} in these locations for a further 3-year period. This is to provide the certainty that pollutant concentrations will remain below the objectives.

Figures

SWECO

Appendix 1 – Model Verification

Verification is the process of comparing modelled results with the available local monitoring data. This identifies how accurate the modelled results are in comparison to monitored results and provides a clearer indication on how well the model is performing. The process includes checking and refining model input data to better align modelled results with monitored results. Modelled results were adjusted in accordance with LAQM.TG(16) guidance, which remained unchanged in LAQM.TG(22).

The 2018 model was initially verified using monitored data from 11 monitoring sites (Crieff 1, P55, P56, P57, P58, P73, P74, P75C/P75L/P75R, P76, P78, P100) on or within close proximity to the A85 where the AQMA exists, as identified in Table 4.1 and Table 4.2. However, three of these sites were removed from the verification exercise for the following reasons:

- Site ID P55, P58 – both monitoring sites are within 1 m of the kerb. LAQM.TG(22) classes these locations as kerbside locations and therefore are not appropriate for modelling. For this reason, P55 and P58 were not used.
- Site ID 75C/P75L/P75R – sited at James Square, this is co-located with the automatic site (Crieff 1) and, therefore, given the greater reliability of automatic monitored data, Crieff 1 was used in preference for model verification.

Therefore, the eight monitoring locations that were used in the verification were Crieff 1, P56, P57, P73, P74, P76, P78 and P100.

The unadjusted modelled road-NOx values at each site were converted to total annual mean NO_2 concentrations, inclusive of background, using Defra's NOx to NO_2 calculator and compared with the monitored equivalent, as presented in Table A.1. At the time of the verification, the most recent projected background concentrations were from a base year of 2017.

TABLE A.1: COMPARISON OF UNADJUSTED MODELLED AND MEASURED ANNUAL MEAN NO_2 2018 CONCENTRATIONS (µg/m^3)

Site ID	Modelled road-NO_x	Background NO_x`	Total Modelled NO_2	Total Monitored NO_2	% Difference (Mod vs Mon)
Crieff 1	10.6	7.4	8.9	17.0	-47.6
P56	22.5	7.4	15.2	47.0	-67.8
P57	25.1	7.4	16.5	31.0	-46.8
P73	6.4	7.4	6.7	18.0	-62.9
P74	26.7	7.4	17.3	25.0	-30.9
P76	10.2	7.4	8.7	25.0	-65.0
P78	12.7	7.4	10.1	24.0	-58.0
P100	7.0	7.4	7.0	20.0	-65.0

The initial comparison of modelled vs monitored total NO_2 concentrations identified that the model was underpredicting at all monitoring sites, by as great as 67.8% of the equivalent monitored value. The RMSE, representing the average error in the air quality model, was 16.23 µg/m³ (40.6% of the NO_2 annual mean objective) for the unadjusted model. The fractional bias (FB) was +0.8.

The statistical analysis of the unadjusted model suggests an underperforming model with all modelled values significantly underpredicting and an RMSE value greater than 25% of the objective level.

As such, it was deemed essential to progress verification to compare the modelled and monitored road-NO_x values, with derivation of an appropriate modelled road-NO_x adjustment factor.

A summary of the data comparison and derived model adjustment factors is presented in Table A.2, in addition to the final comparison of the adjusted modelled total annual mean NO_2 concentrations with the equivalent monitored data.

TABLE A.2: COMPARISON OF ADJUSTED MODELLED AND MEASURED ANNUAL MEAN NO_2 2018 CONCENTRATIONS (µg/m³)

Site ID	Unadjusted Modelled road-NO_x	Monitored road-NO_x	Road-NO_x Adjustment factor	Adjusted Road-NO_x	Total NO_2		% Difference (Mod vs Mon)
					Adjusted (model)	Monitored	
Crieff 1	10.6	26.1	2.73 (see Figure A.1)	28.8	18.3	17.0	7.9
P56	22.5	95.4		61.3	33.3	47.0	-29.1
P57	25.1	55.9		68.5	36.4	31.0	17.3
P73	6.4	28.1		17.6	12.6	18.0	-29.9
P74	26.7	42.7		72.9	38.2	25.0	52.7
P76	10.2	42.7		27.9	17.9	25.0	-28.4
P78	12.7	40.5		34.7	21.2	24.0	-11.5
P100	7.0	32.2		19.2	13.5	20.0	-32.7

The comparison of total adjusted NO_2 modelled and monitored data demonstrates that all adjusted modelled values have reduced to within 52.7% of the equivalent monitored value. The magnitude of the under or overpredictions of the modelled value has decreased to below 30% for most sites, with the exception of P74 and P100, thus showing an improvement in the model.

The statistical analysis of the adjusted model demonstrates this improvement with the RMSE value decreasing by half to 8.06 µg/m³ (20.2% of the NO_2 annual mean objective), within the accepted value of 25%. Similarly, the fractional bias for the adjusted model had decreased to +0.1, demonstrating a improvement relative to the un-adjusted model. However, this still shows the model has a tendency to underpredict.

As such, the ADMS-Roads model with road-NO_x emissions from the road-NO_x adjustment applied is a robust and representative model for predicting atmospheric dispersion of NO_x emissions from the modelled road emission sources within the identified study area.

The model adjustment factor derived for road-NO_x through the verification process was subsequently applied to all model outputs for each assessment year scenario.

Verification of PM_{10} is made difficult as there is only one monitoring location within the study area. A comparison of the modelled vs monitored road-PM_{10} showed the model overpredicted the road-PM_{10} value by 78%. Therefore, as a conservative approach, no adjustment factor was applied to road-PM_{10} in both assessment year scenarios.

It should be noted that any dispersion modelling study has a degree of uncertainty associated with it as the best representation of actual conditions given the limitations of the data inputs available. All reasonable steps have been taken to reduce this uncertainty where possible.

Appendix 2 – Traffic Data

TABLE A.3: TRAFFIC DATA

Link ID	Road Width (m)	Canyon Height (m)	Average Speed 07:00 – 19:00 (kph)	2018 Baseline Model		2023 Model	
				Total flow 07:00 -19:00	%HGV	Total flow 07:00 -19:00	%HGV
1_4	7	n/a	42.9	2873	3%	-	-
1_5	7	n/a	105.7	2983	4%	3104	13%
2_5	7	n/a	17.9	3822	3%	3104	13%
2_629	6	n/a	28.2	478	1%	-	-
2_6	10	12	25.9	4041	3%	3104	13%
3_61	6	n/a	26.0	801	0%	-	-
3_7	13	14	23.3	3896	4%	3104	13%
3_6	10	12	24.7	3931	3%	3104	13%
4_1	7	n/a	49.9	2983	4%	-	-
4_201	7	n/a	49.2	2872	3%	-	-
5_2	7	n/a	17.7	4009	3%	3120	11%
5_1	7	n/a	28.8	2873	3%	3120	11%
5_127	7	n/a	24.6	1245	0%	-	-
6_3	10	12	26.5	4041	3%	3120	11%
6_2	10	12	26.8	3930	3%	3120	11%
7_3	13	14	24.5	3710	3%	3120	11%
7_8	11.5	14	24.2	3893	4%	3104	13%
7_55	5	14	16.9	98	0%	-	-
8_9	3	-	23.7	4181	3%	3104	13%
8_7	11.5	14	24.8	3801	3%	3120	11%
9_53	3	-	32.8	325	1%	-	-
9_8	7	-	23.4	3705	3%	3120	11%
9_28	11	14	18.3	4227	3%	3120	11%
10_598	17	14	20.9	4228	3%	3104	13%
10_28	12	14	21.2	3249	3%	3104	13%
12_32	7	-	18.5	3854	3%	3104	13%
12_27	3.5	-	25.6	2017	1%	-	-
12_13	12	14	23.4	2565	4%	3104	13%
13_12	12	14	21.6	4433	3%	3120	11%
13_23	6	-	27.3	378	0%	-	-

Link ID	Road Width (m)	Canyon Height (m)	Average Speed 07:00 – 19:00 (kph)	2018 Baseline Model		2023 Model	
				Total flow 07:00 -19:00	%HGV	Total flow 07:00 -19:00	%HGV
13_562	7	-	34.9	1651	5%	-	-
13_420	12.5	10	16.2	1483	3%	1299	14%
14_423	7	-	42.8	1382	1%	-	-
14_18	7	-	41.3	2632	4%	-	-
14_15	6	-	25.7	15	0%	-	-
14_562	7	-	21.0	2858	3%	-	-
15_14	6	-	17.7	78	0%	-	-
15_16	6	-	31.7	77	0%	-	-
16_455	6	-	46.1	105	0%	-	-
16_17	6	-	38.0	164	0%	-	-
16_15	6	-	24.8	18	0%	-	-
17_16	6	-	48.2	95	0%	-	-
17_19	6	-	17.4	163	0%	-	-
18_19	7	-	38.5	2822	4%	-	-
18_14	7	-	37.2	3738	3%	-	-
18_34	6	-	19.0	51	0%	-	-
19_17	6	-	21.8	95	0%	-	-
19_18	7	-	36.8	3607	3%	-	-
19_667	7	-	25.0	2919	4%	-	-
20_34	3	-	41.1	332	0%	-	-
20_22	6	-	24.6	234	0%	-	-
20_23	6	-	27.2	229	0%	-	-
22_20	6	-	25.4	444	0%	-	-
22_26	8	12	23.2	493	0%	-	-
22_38	7.4	-	25.8	1037	0%	-	-
22_36	8.4	12	31.3	1710	1%	-	-
23_13	6	-	15.8	687	0%	-	-
23_20	6	-	26.1	360	0%	-	-
25_26	8	10	36.5	1650	1%	-	-
26_40	8.7	8	30.4	618	0%	-	-
26_22	8	12	32.3	1735	1%	-	-
26_25	8	10	27.0	148	0%	-	-

Link ID	Road Width (m)	Canyon Height (m)	Average Speed 07:00 – 19:00 (kph)	2018 Baseline Model		2023 Model	
				Total flow 07:00 -19:00	%HGV	Total flow 07:00 -19:00	%HGV
27_25	8	10	25.1	1965	1%	-	-
28_10	12	14	24.5	4227	3%	3120	11%
28_9	11	14	24.6	3249	3%	3104	13%
29_31	6.5	12	23.9	869	4%	-	-
30_358	6	-	32.5	607	4%	-	-
31_30	8	10	27.2	869	4%	-	-
32_598	7	-	28.7	3856	3%	3104	13%
32_12	7	-	25.8	3984	3%	3120	11%
34_18	6	-	19.3	372	0%	-	-
36_233	7	-	26.2	1563	1%	-	-
36_22	8.4	12	29.4	922	0%	-	-
37_309	7.4	-	23.9	467	0%	-	-
37_38	7.4	-	30.3	614	0%	-	-
37_43	3	-	18.9	340	0%	-	-
37_124	7	-	27.6	740	0%	-	-
38_37	7.4	-	31.5	832	0%	-	-
38_22	7.4	-	25.1	800	0%	-	-
40_26	8.7	8	28.1	358	1%	-	-
40_48	5.8	-	38.2	497	0%	-	-
42_52	2.9	-	15.4	669	0%	-	-
43_51	3	-	33.8	340	0%	-	-
45_53	5.8	-	43.6	860	0%	-	-
45_52	5.8	-	33.2	294	1%	-	-
48_52	5.8	-	32.9	497	0%	-	-
48_40	5.8	-	47.5	278	1%	-	-
51_42	3	-	15.8	340	0%	-	-
52_48	5.8	-	31.8	278	1%	-	-
52_42	5.8	-	18.4	314	0%	-	-
52_45	5.8	-	21.7	869	0%	-	-
53_99	3	-	14.6	33	0%	-	-
53_45	3	-	49.2	315	1%	-	-
53_9	3	-	23.0	842	0%	-	-

Link ID	Road Width (m)	Canyon Height (m)	Average Speed 07:00 – 19:00 (kph)	2018 Baseline Model		2023 Model	
				Total flow 07:00 -19:00	%HGV	Total flow 07:00 -19:00	%HGV
54_55	3	-	14.6	36	0%	-	-
55_59	3	-	13.8	127	0%	-	-
58_60	6	-	24.2	824	0%	-	-
59_58	3	-	14.8	127	0%	-	-
60_61	6	-	23.5	826	0%	-	-
60_58	6	-	29.1	755	0%	-	-
61_3	6	-	17.0	877	0%	-	-
61_60	6	-	29.1	755	0%	-	-
63_210	6	-	34.9	15	0%	-	-
63_64	5.7	12	33.4	403	1%	-	-
64_8	6.6	12	17.2	403	1%	-	-
69_80	6	-	39.2	391	0%	-	-
69_74	6	-	10.1	762	0%	-	-
74_312	7	-	15.8	736	0%	-	-
74_69	6	-	14.1	831	0%	-	-
75_311	7	-	50.3	736	0%	-	-
75_312	7	-	49.0	739	0%	-	-
80_69	6	-	40.1	310	0%	-	-
80_82	6	-	41.4	314	0%	-	-
82_80	6	-	42.9	288	0%	-	-
82_98	6	-	33.2	299	0%	-	-
85_98	6	-	48.0	304	0%	-	-
85_183	6	-	38.6	252	0%	-	-
98_82	6	-	33.3	321	0%	-	-
98_85	6	-	47.1	288	0%	-	-
99_54	3	-	17.8	33	0%	-	-
124_311	7	-	49.3	739	0%	-	-
124_37	7	-	35.9	735	0%	-	-
127_5	7	-	31.4	1319	1%	-	-
127_128	7	-	40.9	1245	0%	-	-
128_127	7	-	39.3	1319	1%	-	-
128_129	7	-	47.7	1245	0%	-	-

Link ID	Road Width (m)	Canyon Height (m)	Average Speed 07:00 – 19:00 (kph)	2018 Baseline Model		2023 Model	
				Total flow 07:00 -19:00	%HGV	Total flow 07:00 -19:00	%HGV
129_130	7	-	49.5	1132	0%	-	-
129_128	7	-	45.0	1319	1%	-	-
130_129	7	-	49.8	1188	1%	-	-
130_135	7	-	44.6	1106	0%	-	-
135_130	7	-	47.4	1166	1%	-	-
135_136	7	-	47.7	875	1%	-	-
136_137	7	-	44.0	747	1%	-	-
136_135	7	-	46.5	1030	2%	-	-
137_136	7	-	43.7	873	2%	-	-
164_202	7	-	48.1	2826	4%	-	-
164_207	7	-	48.7	2694	3%	-	-
183_85	6	-	35.4	259	0%	-	-
201_4	7	-	48.6	2983	4%	-	-
201_202	7	-	48.7	2798	3%	-	-
202_164	7	-	47.6	2792	3%	-	-
202_201	7	-	50.0	2835	4%	-	-
204_207	7	-	45.9	2734	4%	-	-
204_208	6	-	21.0	432	7%	-	-
207_164	7	-	50.7	2734	4%	-	-
207_204	7	-	51.1	2694	3%	-	-
208_204	6	-	22.0	483	3%	-	-
208_209	6	-	49.2	202	4%	-	-
209_208	6	-	42.0	371	3%	-	-
209_215	6	-	41.7	226	4%	-	-
210_382	6	-	41.7	334	1%	-	-
210_629	6	-	46.0	292	2%	-	-
210_63	6	-	40.1	243	1%	-	-
211_383	6	-	22.6	585	4%	-	-
211_358	6	-	33.9	300	1%	-	-
211_617	6	-	17.9	396	1%	-	-
212_379	6	-	38.5	318	5%	-	-
212_383	6	-	53.1	257	2%	-	-

Link ID	Road Width (m)	Canyon Height (m)	Average Speed 07:00 – 19:00 (kph)	2018 Baseline Model		2023 Model	
				Total flow 07:00 -19:00	%HGV	Total flow 07:00 -19:00	%HGV
214_215	6	-	18.5	277	3%	-	-
214_363	6	-	45.3	245	8%	-	-
214_379	6	-	42.0	307	2%	-	-
215_214	6	-	17.0	226	4%	-	-
215_209	6	-	41.8	277	3%	-	-
224_226	7	-	40.8	1227	1%	-	-
224_233	7	-	17.6	1142	0%	-	-
226_227	7	-	47.5	1246	1%	-	-
226_224	7	-	40.4	901	0%	-	-
227_226	7	-	53.4	862	0%	-	-
227_245	7	-	50.8	1247	1%	-	-
229_231	7	-	33.1	3223	3%	-	-
229_230	3	-	28.2	211	0%	-	-
229_253	7	-	50.4	2507	5%	-	-
230_249	7	-	20.2	266	0%	-	-
230_248	7	-	43.7	285	0%	-	-
231_229	7	-	31.8	2714	4%	-	-
231_667	7	-	16.9	3633	3%	-	-
231_232	6	-	32.3	953	0%	-	-
232_233	6	-	19.2	1000	0%	-	-
232_231	6	-	30.5	1185	0%	-	-
233_36	7	-	21.7	1355	0%	-	-
233_232	6	-	16.3	1248	1%	-	-
233_224	7	-	21.6	1115	1%	-	-
234_250	7	-	41.2	450	0%	-	-
234_253	7	-	47.9	2953	3%	-	-
234_235	7	-	38.3	2683	4%	-	-
235_240	7.4	-	12.8	1755	2%	-	-
235_234	7	-	40.9	2916	3%	-	-
235_246	7	-	30.4	3349	4%	-	-
236_328	7	-	47.8	3281	4%	-	-
236_246	7	-	38.0	3471	3%	-	-

Link ID	Road Width (m)	Canyon Height (m)	Average Speed 07:00 – 19:00 (kph)	2018 Baseline Model		2023 Model	
				Total flow 07:00 -19:00	%HGV	Total flow 07:00 -19:00	%HGV
237_333	7	-	45.1	3253	4%	-	-
237_328	7	-	49.1	3395	3%	-	-
238_333	7	-	44.0	3392	3%	-	-
240_241	7.4	-	13.7	1391	3%	-	-
240_235	7.4	-	13.8	1891	2%	-	-
240_245	7	-	16.7	862	0%	-	-
241_256	7.4	-	34.6	1391	3%	-	-
241_240	7.4	-	13.6	1162	1%	-	-
242_262	7	-	31.4	420	0%	-	-
242_666	7.4	-	31.1	1159	1%	-	-
245_227	7	-	45.8	862	0%	-	-
245_240	7	-	34.5	1247	1%	-	-
246_235	7	-	29.8	3470	3%	-	-
246_236	7	-	35.6	3349	4%	-	-
247_250	7	-	26.5	695	0%	-	-
247_248	7	-	50.0	133	0%	-	-
248_247	7	-	51.5	285	0%	-	-
248_230	7	-	50.9	133	0%	-	-
249_571	5.4	-	34.6	183	0%	-	-
249_230	7	-	26.2	373	0%	-	-
250_247	7	-	36.6	450	0%	-	-
250_234	7	-	31.4	695	0%	-	-
253_229	7	-	46.6	3226	3%	-	-
253_234	7	-	51.0	2455	5%	-	-
256_241	7.4	-	30.5	1162	1%	-	-
256_666	7.4	-	30.3	1391	3%	-	-
262_310	7	-	45.1	419	0%	-	-
263_309	7	-	38.7	584	0%	-	-
263_310	7	-	39.9	398	0%	-	-
309_37	7.4	-	23.9	583	0%	-	-
309_263	7	-	45.3	467	0%	-	-
310_262	7	-	40.4	374	0%	-	-

Link ID	Road Width (m)	Canyon Height (m)	Average Speed 07:00 – 19:00 (kph)	2018 Baseline Model		2023 Model	
				Total flow 07:00 -19:00	%HGV	Total flow 07:00 -19:00	%HGV
310_263	7	-	35.4	512	0%	-	-
311_75	7	-	50.9	739	0%	-	-
311_124	7	-	47.3	735	0%	-	-
312_74	7	-	21.6	739	0%	-	-
312_75	7	-	43.2	736	0%	-	-
328_237	7	-	48.2	3263	4%	-	-
328_236	7	-	47.9	3408	3%	-	-
333_238	7	-	45.2	3256	4%	-	-
333_237	7	-	48.2	3387	3%	-	-
358_407	6	-	13.0	451	1%	-	-
358_30	6	-	32.1	43	1%	-	-
358_211	6	-	28.4	749	3%	-	-
363_214	6	-	37.3	270	2%	-	-
363_364	6	-	34.6	184	10%	-	-
364_363	6	-	16.9	154	2%	-	-
379_212	6	-	41.2	247	2%	-	-
379_214	6	-	43.9	327	6%	-	-
382_210	6	-	35.7	508	2%	-	-
382_617	6	-	46.0	182	0%	-	-
383_212	6	-	44.7	326	5%	-	-
383_211	6	-	17.7	346	2%	-	-
407_414	6	-	29.5	292	2%	-	-
407_358	6	-	12.5	332	2%	-	-
407_413	6	-	16.8	218	0%	-	-
408_413	6	-	30.9	157	1%	-	-
411_418	6	-	28.2	162	2%	-	-
411_655	6	-	19.9	76	1%	-	-
411_481	6	-	34.3	181	2%	-	-
411_412	6	-	31.5	253	2%	-	-
412_414	6	-	34.3	232	2%	-	-
412_411	6	-	33.3	291	2%	-	-
413_407	6	-	20.7	157	1%	-	-

Link ID	Road Width (m)	Canyon Height (m)	Average Speed 07:00 – 19:00 (kph)	2018 Baseline Model		2023 Model	
				Total flow 07:00 -19:00	%HGV	Total flow 07:00 -19:00	%HGV
413_408	6	-	33.6	218	0%	-	-
414_407	6	-	37.7	232	2%	-	-
414_412	6	-	35.0	292	2%	-	-
416_420	10	10	19.2	1813	3%	1299	14%
416_419	7	-	22.4	1475	2%	1299	14%
417_419	7	-	30.6	1394	3%	-	-
417_421	7	-	38.0	1277	3%	-	-
417_458	6	-	17.1	146	1%	-	-
418_458	6	-	35.8	193	1%	-	-
418_411	6	-	24.7	126	2%	-	-
419_416	7	-	21.9	1474	3%	986	17%
419_423	6	-	22.2	309	1%	-	-
419_417	7	-	25.6	1218	3%	-	-
420_13	12.5	10	11.7	1813	3%	986	17%
420_416	10	10	25.0	1479	3%	986	17%
421_423	7	-	24.7	1009	3%	-	-
421_417	7	-	28.3	1387	3%	-	-
421_422	7	-	17.7	2073	2%	-	-
422_421	7	-	20.9	2181	3%	-	-
422_459	7	-	39.3	2075	2%	-	-
423_419	6	-	18.2	153	1%	-	-
423_421	7	-	22.4	1016	2%	-	-
423_14	7	-	43.4	1490	2%	-	-
423_424	7	-	44.9	611	0%	-	-
424_425	7	-	53.9	611	0%	-	-
424_423	7	-	39.8	572	0%	-	-
425_424	7	-	42.4	573	0%	-	-
425_426	7	-	41.4	705	0%	-	-
425_456	6	-	17.7	51	0%	-	-
426_425	7	-	47.6	606	0%	-	-
426_457	7	-	49.1	705	0%	-	-
455_456	6	-	50.9	105	0%	-	-

Link ID	Road Width (m)	Canyon Height (m)	Average Speed 07:00 – 19:00 (kph)	2018 Baseline Model		2023 Model	
				Total flow 07:00 -19:00	%HGV	Total flow 07:00 -19:00	%HGV
455_16	6	-	48.9	51	0%	-	-
456_425	6	-	22.7	105	0%	-	-
456_455	6	-	50.9	51	0%	-	-
457_587	7	-	46.6	667	0%	-	-
457_426	7	-	39.8	606	0%	-	-
458_418	6	-	32.8	147	1%	-	-
458_417	6	-	20.4	193	1%	-	-
459_422	7	-	43.0	2181	3%	-	-
459_460	7	-	51.7	2080	2%	-	-
460_461	7	-	45.6	2043	3%	-	-
460_459	7	-	43.5	2180	3%	-	-
461_460	7	-	42.4	2140	3%	-	-
476_481	6	-	15.7	173	2%	-	-
481_411	6	-	33.1	173	2%	-	-
481_476	6	-	21.2	181	2%	-	-
562_13	7	-	28.1	2868	3%	-	-
562_14	7	-	31.1	1656	5%	-	-
563_562	3	-	16.8	47	0%	-	-
571_572	5.4	-	25.7	166	0%	-	-
571_249	5.4	-	43.5	270	0%	-	-
572_571	5.4	-	32.3	261	0%	-	-
572_573	5.4	-	19.7	166	0%	-	-
573_572	5.4	-	15.5	261	0%	-	-
573_574	5.4	-	25.9	166	0%	-	-
574_573	5.4	-	27.7	261	0%	-	-
574_575	5.4	-	45.7	166	0%	-	-
575_574	5.4	-	45.9	261	0%	-	-
575_576	5.4	-	38.7	166	0%	-	-
576_575	5.4	-	39.8	261	0%	-	-
576_579	5.4	-	48.1	166	0%	-	-
577_578	5.4	-	30.2	166	0%	-	-
577_579	5.4	-	51.1	261	0%	-	-

Link ID	Road Width (m)	Canyon Height (m)	Average Speed 07:00 – 19:00 (kph)	2018 Baseline Model		2023 Model	
				Total flow 07:00 -19:00	%HGV	Total flow 07:00 -19:00	%HGV
578_587	7	-	46.7	564	0%	-	-
578_577	5.4	-	37.8	261	0%	-	-
579_577	5.4	-	51.5	166	0%	-	-
579_576	5.4	-	50.2	261	0%	-	-
587_578	7	-	85.9	667	0%	-	-
587_457	7	-	97.3	564	0%	-	-
598_32	7	-	18.5	3984	3%	3120	11%
598_10	17	14	22.5	3249	3%	3120	11%
598_29	8.8	12	14.9	870	4%	-	-
617_211	6	-	19.1	182	0%	-	-
617_382	6	-	43.9	396	1%	-	-
629_2	6	-	26.8	387	2%	-	-
629_210	6	-	45.4	347	1%	-	-
655_411	6	-	22.5	82	1%	-	-
666_256	7.4	-	34.4	1159	1%	-	-
666_242	7.4	-	34.7	1391	3%	-	-
667_19	7	-	38.4	3633	3%	-	-
667_231	7	-	24.7	2919	4%	-	-
‘ - ‘ indicates that the 2018 baseline year data was carried through into the 2023 model.							

Appendix 3 – MET Sensitivity Results

TABLE A.4: MET SENSITIVITY - NO_X

Receptor	Annual Mean NO_x Concentration (µg/m³)					Range + Standard deviation	Worst case year
	2014	2015	2017	2018	2019		
R1	14.15	13.06	13.43	13.84	15.53	15.5 - 13.1 stdv. 0.95	Year 5
R2	14.68	14.22	14.43	14.65	15.37	15.4 - 14.2 stdv. 0.43	Year 5
R3	2.65	2.30	2.43	2.55	2.75	2.7 - 2.3 stdv. 0.18	Year 5
R4	2.76	2.72	2.94	2.83	3.26	3.3 - 2.7 stdv. 0.22	Year 5
R5	5.80	5.35	5.59	5.71	6.11	6.1 - 5.3 stdv. 0.28	Year 5
R6	2.63	2.26	2.38	2.52	2.71	2.7 - 2.3 stdv. 0.18	Year 5
R7	2.93	3.11	3.31	3.13	3.52	3.5 - 2.9 stdv. 0.22	Year 5
R8	3.16	2.36	2.45	2.79	2.96	3.2 - 2.4 stdv. 0.34	Year 1
R9	3.73	2.81	2.85	3.29	3.43	3.7 - 2.8 stdv. 0.39	Year 1
R10	3.22	2.42	2.48	2.84	2.98	3.2 - 2.4 stdv. 0.34	Year 1
R11	4.36	4.50	4.76	4.57	5.13	5.1 - 4.4 stdv. 0.3	Year 5
R12	2.18	2.21	2.32	2.27	2.47	2.5 - 2.2 stdv. 0.11	Year 5
R13	8.30	8.24	8.39	8.39	8.98	9 - 8.2 stdv. 0.3	Year 5
R14	3.17	2.54	2.55	2.81	3.08	3.2 - 2.5 stdv. 0.29	Year 1
R15	1.34	1.44	1.51	1.47	1.54	1.5 - 1.3 stdv. 0.08	Year 5
R16	0.49	0.45	0.47	0.49	0.50	0.5 - 0.4 stdv. 0.02	Year 5
R17	0.50	0.51	0.55	0.53	0.57	0.6 - 0.5 stdv. 0.03	Year 5
R18	0.59	0.58	0.62	0.62	0.65	0.6 - 0.6 stdv. 0.03	Year 5
R19	0.69	0.61	0.66	0.67	0.73	0.7 - 0.6 stdv. 0.05	Year 5
R20	1.28	1.17	1.23	1.28	1.35	1.3 - 1.2 stdv. 0.07	Year 5
R21	0.53	0.53	0.58	0.55	0.61	0.6 - 0.5 stdv. 0.03	Year 5
R22	0.60	0.59	0.63	0.61	0.69	0.7 - 0.6 stdv. 0.04	Year 5
R23	0.67	0.62	0.65	0.66	0.71	0.7 - 0.6 stdv. 0.03	Year 5
R24	16.76	15.76	16.20	16.53	17.65	17.6 - 15.8 stdv. 0.71	Year 5
R25	17.25	16.20	16.84	17.10	18.86	18.9 - 16.2 stdv. 0.99	Year 5
R26	16.40	15.82	16.35	16.51	17.23	17.2 - 15.8 stdv. 0.5	Year 5
R27	14.53	13.34	13.75	14.10	15.47	15.5 - 13.3 stdv. 0.82	Year 5
R28	6.28	5.88	6.09	6.33	6.66	6.7 - 5.9 stdv. 0.29	Year 5
R29	6.09	6.01	6.38	6.16	7.30	7.3 - 6 stdv. 0.53	Year 5