Appendix D – Air Quality

A qualitative, high-level analysis of the potential air quality impacts associated with the different options have been carried out for the compliance and realistic scenarios for 2025, 2030 and 2045.

Annual emission rates (in kg per year) for NOx and particulate matter (PM_{10} and $PM_{2.5}$) for each road link have been obtained from the modelled scenario data by using Department for Environment, Food & Rural Affairs' (Defra) Emissions Factors Toolkit (EFT, version 12.0.1), published in December 2023.

For the prediction of future year emissions, the toolkit takes into account factors such as anticipated advances in vehicle technology and changes in fleet composition, such that emissions are assumed to reduce over time.

The EFT allows for the calculation of emissions arising from road traffic for all years between 2018 and 2050. For the 2025 and 2030 modelled scenarios, the respective data has been used but for 2045, 2030 emission factors have been used as this represents the limit of current available predictions. While the EFT provides emission rates for 2031-2050, these are provided for climate assessments and appraisals only.

The following parameters have been inputted into the EFT to determine the annual emission rates for each road link:

- Road type, e.g., urban, rural, motorway;
- Annual Average Daily Traffic flows (AADT, vehicles per day);
- Length (km) of each road link;
- Average vehicle speeds (km/h); and
- Percentage of Heavy-Duty Vehicles (% HDVs) per road link. HDVs encompass rigid and artic heavy goods vehicles (HGVs) and Public Service Vehicles (PSUs), i.e., buses and coaches.

The modelled scenario data provided for the analysis included the road type based on the TMfS framework which has twenty-three link classes to describe roads in Scotland. Defra's EFT has just three road link types, namely; urban, rural and motorway. The EFT road link types have been mapped to the TMfS link classes as shown in Table D-1 below.

Table D-1 – TMfS Link Classes Mapped to Defra Road Classes

LATIS Link Class	Description	Defra EFT Classification
1	Urban Central	Urban (Not London)
2	Urban Non Central – Single	Urban (Not London)

LATIS Link Class	Description	Defra EFT Classification
3	Urban Non Central – Dual	Motorway (Not London)
4	Small Town	Urban (Not London)
5	Suburban – Single	Urban (Not London)
6	Suburban – Dual	Motorway (Not London)
7	Urban Motorway	Motorway (Not London)
8	Urban Motorway < 70mph	Motorway (Not London)
9	Ramp at Grade Separation	Motorway (Not London)
10	Rural Single (high hilliness, high bendiness)	Rural (Not London)
11	Rural Single (medium hilliness, high bendiness)	Rural (Not London)
12	Rural Single (medium hilliness, medium bendiness)	Rural (Not London)
13	Rural Single (low hilliness, high bendiness)	Rural (Not London)
14	Rural Single (low hilliness, medium bendiness)	Rural (Not London)
15	Rural Single (low hilliness, low bendiness)	Rural (Not London)
16	Rural Dual (low hilliness, medium bendiness)	Motorway (Not London)
17	Rural Dual (low hilliness, low bendiness)	Motorway (Not London)
18	2-Lane Motorway (low hilliness, low bendiness)	Motorway (Not London)
19	3-Lane Motorway (low hilliness, low bendiness)	Motorway (Not London)
20	Roundabout Urban Central	Urban (Not London)

LATIS Link Class	Description	Defra EFT Classification
21	Roundabout Elsewhere	Rural (Not London)
22	Urban Dual 50mph	Motorway (Not London)
50	A9 with Average Speed Cameras	Motorway (Not London)

Total emissions for each year and option for the whole of Scotland have been derived by summing together the annual emission rates for each road link. Emissions have been calculated without the policy, i.e., 'Do Minimum' (DM), and with the policy, i.e., 'Do Something' (DS), in place.

The impacts, i.e., change in emissions, have been calculated on the basis of the difference between the DS and DM scenarios.

The percentage change in emissions in the DS scenario compared to the DM (future baseline) has been used to determine the magnitude of change from which the impact descriptor has been determined as either benefit or negative impact.

The impact descriptors used for the air quality assessment are outlined in Table D-2. The percentage change in emissions (1%, 5% and 10%) have been adapted from Table 2.91 in the Design Manual for Roads and Bridges LA 105 air quality guidance.

Table D-2 – Impact Descriptors

Impact Descriptor	Percentage (%) Change in Emissions
Major	>10
Moderate	>5
Minor	>1
No benefit or impact	≤ 1

Assumptions and Limitations

The TMfS model road link classifications have been transposed into the three, broader link classifications to allow emissions to be generated using Defra's EFT; these may not accurately represent each road.

The input data used in the assessment are derived from transport modelling, hence any assumptions used in that modelling are inherent to the assessment.

Changes in roadside air quality are quantified based on changes in emissions, derived from Defra's EFT. Air quality is 'additive', that is to say roadside levels are derived from a background component plus a roadside contribution. Therefore, any change in vehicle emissions will only reduce the roadside contribution directly (though they will also reduce background concentrations in the longer term).

While for primary pollutants, such as PM_{10} and $PM_{2.5}$, the reduction in emissions should be relatively proportional to any observed reduction in the roadside contribution of these pollutants. For secondary pollutants, such as nitrogen dioxide (NO_2), a reduction in emissions of NOx will lead to a reduction, but it may not be proportional to the decrease in NO_2 levels.

Real-world physical parameters, such as local topography, meteorological conditions, building effects, have not been considered. Photo-chemical effects on NO_2 levels, associated with sunlight and other pollutants, e.g., ozone, are also not considered.

Futures Assessment

Table D-3 to Table D-6 show that for option 1 with and without policy, for both the compliance and realistic modelling scenarios, no benefit or impact in road NOx, PM_{10} and $PM_{2.5}$ emissions is predicted.

100% compliance option 2 without policy results in a moderate benefit in road NOx emissions, a minor negative impact in PM_{10} emissions and no benefit or impact for $PM_{2.5}$ emissions in 2025 and 2030. For 2045, the assessment predicts a minor benefit for road NOx emissions, a minor negative impact for PM_{10} emissions and no benefit or impact for $PM_{2.5}$ emissions.

Option 2 without policy for the realistic scenario predicts a minor benefit in road NOx emissions, but no benefit or impact from PM_{10} and $PM_{2.5}$ emissions in 2025, 2030 and 2045.

Table D-9 shows that the option 2 with policy, 100% compliance scenario predicts a moderate benefit in road NOx emissions and no benefit or impact for PM_{10} and $PM_{2.5}$ emissions. For 2030 the assessment predicts a moderate benefit for NOx emissions, a minor negative impact for PM_{10} emissions and no benefit or impact for $PM_{2.5}$ emissions. For 2045, the assessment predicts a minor benefit in road NOx emissions, a minor negative impact for PM_{10} emissions and no benefit or impact for $PM_{2.5}$ emissions.

Option 2 with policy for the realistic scenario predicts a minor benefit in road NOx emissions, but no benefit or impact for the PM_{10} and $PM_{2.5}$ emissions in all years.

Table D-3 – Option 1 Without Policy and 100% Compliance

Year	NOx (Change in Emissions (kg/year))	PM_{10} (Change in Emissions (kg/year))	$PM_{2.5}$(Change in Emissions (kg/year))	NOx (% Change)	PM_{10} (% Change)	$PM_{2.5}$ (% Change)	NOx (Impact descriptor)	PM_{10} (Impact descriptor)	$PM_{2.5}$ (Impact descriptor)
2025	-30958	8989	3806	-0.40	0.84	0.63	No benefit or impact	No benefit or impact	No benefit or impact
2030	-13777	8419	3658	-0.34	0.76	0.60	No benefit or impact	No benefit or impact	No benefit or impact
2045	-16928	8794	3746	-0.35	0.65	0.50	No benefit or impact	No benefit or impact	No benefit or impact

Table D-4 – Option 1 Without Policy and Realistic Compliance

Year	NOx (Change in Emissions (kg/year))	PM_{10} (Change in Emissions (kg/year))	$PM_{2.5}$ (Change in Emissions (kg/year))	NOx (% Change)	PM_{10} (% Change)	$PM_{2.5}$ (% Change)	NOx (Impact descriptor)	PM_{10} (Impact descriptor)	$PM_{2.5}$ (Impact descriptor)
2025	-19220	4810	2029	-0.25	0.45	0.34	No benefit or impact	No benefit or impact	No benefit or impact
2030	-9142	4432	1915	-0.22	0.40	0.31	No benefit or impact	No benefit or impact	No benefit or impact
2045	-9960	4677	1990	-0.21	0.35	0.27	No benefit or impact	No benefit or impact	No benefit or impact

Table D-5 – Option 1 With Policy and 100% Compliance

Year	NOx (Change in Emissions (kg/year))	PM_{10} (Change in Emissions (kg/year))	$PM_{2.5}$ (Change in Emissions (kg/year))	NOx (% Change)	PM_{10} (% Change)	$PM_{2.5}$ (% Change)	NO (Impact descriptor)	PM_{10} (Impact descriptor)	$PM_{2.5}$ (Impact descriptor)
2025	-30145	8804	3731	-0.41	0.85	0.64	No benefit or impact	No benefit or impact	No benefit or impact
2030	-9580	7987	3536	-0.28	0.84	0.67	No benefit or impact	No benefit or impact	No benefit or impact
2045	-6693	8796	3942	-0.20	0.91	0.73	No benefit or impact	No benefit or impact	No benefit or impact

Table D-6 – Option 1 With Policy and Realistic Compliance

Year	NOx (Change in Emissions (kg/year))	PM_{10} (Change in Emissions (kg/year))	$PM_{2.5}$ (Change in Emissions (kg/year))	NOx (% Change)	PM_{10} (% Change)	$PM_{2.5}$ (% Change)	NOx (Impact descriptor)	PM_{10} (Impact descriptor)	$PM_{2.5}$ (Impact descriptor)
2025	-18631	4755	2013	-0.25	0.46	0.35	No benefit or impact	No benefit or impact	No benefit or impact
2030	-6683	4122	1817	-0.19	0.44	0.34	No benefit or impact	No benefit or impact	No benefit or impact
2045	-5305	4553	2033	-0.15	0.47	0.37	No benefit or impact	No benefit or impact	No benefit or impact

Table D-7 – Option 2 Without Policy and 100% Compliance

Year	NOx (Change in Emissions (kg/year))	PM_{10} (Change in Emissions (kg/year))	$PM_{2.5}$ (Change in Emissions (kg/year))	NOx (% Change)	PM_{10} (% Change)	$PM_{2.5}$ (% Change)	NOx (Impact descriptor)	PM_{10} (Impact descriptor)	$PM_{2.5}$ (Impact descriptor)
2025	-426990	11294	2575	-5.53	1.05	0.43	Moderate benefit	Minor negative impact	No benefit or impact
2030	-213165	12803	3944	-5.23	1.16	0.64	Moderate benefit	Minor negative impact	No benefit or impact
2045	-229053	16122	4832	-4.72	1.19	0.65	Minor benefit	Minor negative impact	No benefit or impact

Table D-8 – Option 2 Without Policy and Realistic Compliance

Year	NOx (Change in Emissions (kg/year))	PM_{10} (Change in Emissions (kg/year))	$PM_{2.5}$ (Change in Emissions (kg/year))	NOx (% Change)	PM_{10} (% Change)	$PM_{2.5}$ (% Change)	NOx (Impact descriptor)	PM_{10} (Impact descriptor)	$PM_{2.5}$ (Impact descriptor)
2025	-185422	4504	1057	-2.40	0.42	0.18	Minor benefit	No benefit or impact	No benefit or impact
2030	-93960	4838	1485	-2.30	0.44	0.24	Minor benefit	No benefit or impact	No benefit or impact

Year	NOx (Change in Emissions (kg/year))	PM_{10} (Change in Emissions (kg/year))	$PM_{2.5}$ (Change in Emissions (kg/year))	NOx (% Change)	PM_{10} (% Change)	$PM_{2.5}$ (% Change)	NOx (Impact descriptor)	PM_{10} (Impact descriptor)	$PM_{2.5}$ (Impact descriptor)
2045	-102153	5871	1687	-2.10	0.43	0.23	Minor benefit	No benefit or impact	No benefit or impact

Table D-9 – Option 2 With Policy and 100% Compliance

Year	NOx (Change in Emissions (kg/year))	PM_{10} (Change in Emissions (kg/year))	$PM_{2.5}$ (Change in Emissions (kg/year))	NOx (% Change)	PM_{10} (% Change)	$PM_{2.5}$ (% Change)	NOx (Impact descriptor)	PM_{10} (Impact descriptor)	$PM_{2.5}$ (Impact descriptor)
2025	-420285	10297	2214	-5.65	1.00	0.38	Moderate benefit	No benefit or impact	No benefit or impact
2030	-179451	10376	3429	-5.20	1.10	0.65	Moderate benefit	Minor negative impact	No benefit or impact
2045	-171063	12237	4310	-5.00	1.26	0.79	Minor benefit	Minor negative impact	No benefit or impact

Table D-10 – Option 2 With Policy and Realistic Compliance

Year	NOx (Change in Emissions (kg/year))	PM_{10} (Change in Emissions (kg/year))	$PM_{2.5}$ (Change in Emissions (kg/year))	NOx (% Change)	PM_{10} (% Change)	$PM_{2.5}$ (% Change)	NOx (Impact descriptor)	PM_{10} (Impact descriptor)	$PM_{2.5}$ (Impact descriptor)
2025	-181700	4027	883	-2.44	0.39	0.15	Minor benefit	No benefit or impact	No benefit or impact
2030	-78340	3866	1306	-2.27	0.41	0.25	Minor benefit	No benefit or impact	No benefit or impact
2045	-77137	4118	1384	-2.25	0.42	0.25	Minor benefit	No benefit or impact	No benefit or impact