15 Air Quality

An assessment has been carried out to determine the likely changes in local and regional air quality as a result of the operation of the proposed scheme due to projected changes in traffic movements on the road network. The results of the assessment have been evaluated with reference to the UK Government's Air Quality Strategy objectives and European Union limit values (set for the protection of human health) and nationally accepted significance criteria.

The traffic-related air pollutants considered were nitrogen oxides, nitrogen dioxide and fine particulate matter. Nitrogen deposition at designated ecological sites was also assessed. Local air quality impacts of construction are considered separately in Chapter 19 (Disruption Due to Construction).

Baseline air quality conditions were established using existing data provided on the Air Quality in Scotland website (monitoring data), in local authority Air Quality Review and Assessment Reports, and the results of an additional monitoring survey undertaken as part of this assessment.

Air quality monitoring in the vicinity of the proposed scheme shows that nitrogen dioxide concentrations and fine particulate concentrations meet the prescribed air quality standards. There are no Air Quality Management Areas in the vicinity of the proposed scheme.

Impacts of the proposed scheme were assessed for the year of opening (2017) and the design year (2032) using detailed dispersion modelling as agreed with SEPA and the relevant local authorities.

The predicted impacts on local air quality as a result of the proposed scheme are generally very small, therefore no mitigation measures are proposed with respect to operational traffic. It is considered that for the majority of modelled receptors (residential properties) within the study area the impacts of the proposed scheme would be Negligible for all pollutants. However, there are areas in the immediate vicinity of the proposed scheme where air quality impacts would be of Slight to Moderate Adverse significance and other areas (close to the Forth Road Bridge) where impacts would be of Slight Beneficial significance.

There would be some small increases and decreases in the amount and rate of nitrogen deposition at the modelled designated sites. The significance of these changes is assessed in Chapter 10 (Terrestrial and Freshwater Ecology).

The assessment of regional air quality shows an increase in total emissions of nitrogen oxides, fine particulate matter and carbon dioxide as a result of the proposed scheme (in both the opening and design years). This is consistent with the increase in vehicle kilometres travelled across the regional assessment study area which drives the increase in total emissions. The increase in carbon dioxide is not significant in global terms of pollutant release and the impact will be insignificant in terms of direct impact on global warming.

An emerging alternative approach to emissions calculations, which can take into account the emissions associated with stop-start traffic conditions, has been used as a supplementary assessment. This supplementary assessment indicates that some of the increase in emissions which would be expected with additional traffic and longer travel distances, is likely to be mitigated with improved scheme design and the implementation of ITS measures, which improve traffic flow and minimise stop-start traffic conditions.

15.1 Introduction

15.1.1 This chapter presents the assessment of the proposed scheme in terms of potential impacts on air quality. The chapter is supported by the following appendix, which is cross-referenced in the text where relevant:

- Appendix A15.1: Air Quality Model Evaluation.

15.1.2 Air quality studies consider levels of airborne pollutants. This chapter outlines relevant air quality management policies and legislation, describes the existing or 'baseline' air quality situation and assesses the predicted operational air quality impacts of the proposed scheme. The impacts are considered at both a local and regional level as described further below. Potential air quality impacts during construction are considered separately in Chapter 19 (Disruption Due to Construction).

15.1.3 The Main Crossing would carry the majority of vehicular traffic across the Firth of Forth whereas the Forth Road Bridge would be open for public transport, cyclists and pedestrians only, which constitutes a small proportion of overall traffic. The Main Crossing does not significantly increase the capacity of the road network over the Firth of Forth compared to the Forth Road Bridge and therefore the principal effect of the proposed scheme would generate a shift of traffic from the Forth Road Bridge to the Main Crossing, rather than a significant increase in traffic volumes.

15.1.4 In the area surrounding the proposed scheme, vehicle emissions are the dominant source of air pollution. The National Atmospheric Emissions Inventory (NAEI, 2006) shows that vehicle emissions constitute approximately 60-80% of overall emissions in this area. For this reason, and also because of the nature of the development, the assessment only considers those air pollutants emitted by vehicular traffic that have been identified as being of most concern by the UK Government's Air Quality Strategy and by UK and EU legislation. The main road traffic pollutants that can lead to poor air quality in relation to human health are oxides of nitrogen (NO_x), comprising mainly nitric oxide (NO) and nitrogen dioxide (NO_2), carbon monoxide (CO), volatile organic compounds (VOCs), particularly benzene and 1,3-butadiene, and fine particulate matter ($PM_{2.5}$, PM_{10}). However, local authorities have identified NO_2 and PM_{10} as the key road traffic pollutants of concern within this area of Scotland.

15.1.5 For local air quality the assessment focuses on NO_2, NO_x, PM_{10} and $PM_{2.5}$ (NO_x is included in addition to NO_2 as NO reacts with oxidants in the air to form NO_2, i.e. NO_2 concentrations are partially derived from NO_x concentrations). Other motor vehicle related pollutants are not of concern as current levels remain well within the relevant air quality standards and are therefore not considered further in this assessment.

15.1.6 Nitrogen deposition on designated ecological sites is also considered within the Stage 3 assessment as per DMRB guidance.

15.1.7 For regional air quality the DMRB also identifies carbon dioxide (CO_2)[1] as a pollutant of concern, being considered the most important greenhouse gas and is therefore used as the key indicator in relation to effects on climate change. Emissions of CO_2 are considered in the regional level assessment in addition to NO_x and PM_{10}.

Air Quality Policies, Legislation and Standards

Air Quality Limit Values and Objectives

15.1.8 Air quality limit values and objectives are quality standards for the protection of human health. They can be used (as they are used here) as assessment criteria for determining the significance of any potential changes in local air quality resulting from development (shown in Table 15.1).

15.1.9 European Union (EU) air quality policy sets the framework for national policy (i.e. at a Scottish level). The 'framework' EU Directive on Ambient Air Quality Assessment and Management came into force in September 1996 (Directive 96/62/EC) and is intended as a strategic framework for tackling air quality consistently, through setting EU-wide air quality limit values in four daughter directives, superseding and extending existing European legislation. The four daughter directives have been placed into national legislation. These EU limit values have been consolidated in the Air Quality Standards (Scotland) Regulations 2007. A new EU Directive (Directive 2008/50/EC) has more recently been announced that merges the four daughter directives into a single directive on air quality. The new Directive introduces a new limit value for fine particulate matter ($PM_{2.5}$) but does not change the existing air quality standards. This is yet to be transposed into UK policy (although is considered in this assessment).

[1] CO_2 is used generically throughout this chapter to refer to CO_2 and CO_2(e)

15.1.10 In a parallel process at the UK level, the Environment Act was published in 1995. The Act required the preparation of a national air quality strategy setting air quality standards and objectives for specified pollutants and outlining measures to be taken by local authorities (through the system of Local Air Quality Management (LAQM)) and by others 'to work in pursuit of the achievement' of these objectives. A National Air Quality Strategy (NAQS) was published in 1997 and subsequently reviewed and revised in 2000, and an addendum to the Strategy published in 2002. The current Strategy is The Air Quality Strategy for England, Scotland, Wales and Northern Ireland, 2007. The objectives which are relevant to local air quality management have been set into Regulations (Air Quality (Scotland) Regulations 2000 and Air Quality (Scotland) Amendment Regulations 2002).

15.1.11 Table 15.1 shows the EU air quality limit values and national air quality objectives for the pollutants of relevance to this study.

Table 15.1: EU Air Quality Limit Values and National Air Quality Objectives for Relevant Pollutants

Pollutant	Averaging Period	Objective/Limit Value	Compliance Date	Basis
Nitrogen dioxide (NO_2)	1 hour mean	200 µg/m^3, not to be exceeded more than 18 times a year (99.8th percentile)	31 Dec 2005	Scotland
			01 Jan 2010	EU
	Annual mean	40 µg/m^3	31 Dec 2005	Scotland
			01 Jan 2010	EU
NO_x*	Annual mean	30 µg/m^3	31 December 2000	Scotland
			19 July 2001	EU
Particulate matter (PM_{10})	Daily mean	50 µg/m^3, not to be exceeded more than 7 times a year (98.08th percentile)	01 Dec 2004	Scotland
			Not specified	EU
	Annual mean	40 µg/m^3	31 Dec 2004	Scotland
			Not specified	EU
		18 µg/m^3	31 Dec 2010	Scotland
Particulate matter ($PM_{2.5}$)	Annual mean	12 µg/m^3	2020	Scotland

*only applies to those parts of the UK >20km from an agglomeration (an urban area with a population of >250,000); and >5km from Part A processes, motorways and built up areas of > 5000 people

Planning Policy

15.1.12 The key sectors of relevance to planning and air quality are transport, industry and energy, since these are the main sources of air pollution. National planning policy is set out in Scottish Planning Policies (SPP), with SPP 17 'Planning for Transport' being relevant to air quality assessments of new transport infrastructure. The Scottish Government has also published Planning Advice Notes (PANs) of which PAN 51 'Planning, Environmental Protection and Regulation' and PAN 75 'Planning for Transport' make reference to air quality.

15.1.13 PAN51 provides government guidance on pollution control for local authorities when drawing up their development plans and making decisions on individual development applications.

15.1.14 While relevant to air quality, PAN 75 focuses on the promotion of sustainable transport solutions associated with new developments (e.g. applying maximum car parking standards, use of green travel plans etc) and therefore are more relevant to building-type developments rather than road schemes such as the proposed scheme.

15.2 Approach and Methods

Overall Approach

15.2.1 The assessment of air quality is made in terms of the difference between the air quality that would be likely with the proposed scheme (the 'Do-Something' scenario) and without the proposed scheme (the 'Do-Minimum' scenario) for both the anticipated year of opening (2017) and the design year 15 years after opening (2032), which represents the worst-case year with regards to traffic flows. The future Do-Minimum scenario assumes that the Forth Road Bridge is still in operation. In acknowledgement of the uncertainty over the future viability of the Forth Road Bridge, qualitative assessment of possible alternative Do-Minimum scenarios is provided separately in Appendix A15.1.

15.2.2 In order to allow comparison of future year pollutant concentrations with existing levels, pollutant concentrations have also been calculated for the 2005 base year. The Transport Model for Scotland (TMfS:05a) was used to establish the baseline and future year traffic composition. It is considered that using 2005 as base year is the best base year for which data are currently available and it is considered that it provides an acceptable proxy for the baseline and forecast traffic situations for the purposes of this assessment. In order to account for the M9 Spur extension in the assessed base case, 2005 traffic flows were distributed along the spur road and associated road links using the same percentage traffic split as in 2017. Further details on traffic data limitations are provided in the 'Limitations to Assessment' section.

15.2.3 The DMRB Stage 3 air quality assessment of the proposed scheme consists of the following components:

- a review of the existing air quality situation;
- collation of road traffic data and scoping out of road links outside the local study area with changes in traffic flows or speeds too small to influence air quality;
- an assessment of the changes in local air quality at representative receptors arising from the operation of the proposed scheme, as a result of the changing traffic;
- preparation of contour plots to determine the change in concentrations as a result of the proposed scheme across the local study area;
- an assessment of the changes in nitrogen deposition at designated ecological sites arising from the operation of the proposed scheme as a result of traffic flows on new carriageway and changes to traffic flows on the adjoining road network; and
- an assessment of the regional impacts of the proposed scheme on pollutant levels, as a result of traffic flows on new carriageway and changes to traffic flows on the adjoining road network.

15.2.4 The methodology used for the Stage 3 air quality assessment is based on DMRB Volume 11, Section 3, Part 1: HA207/07 (Highways Agency et al., 2007). This document provides a three-stage appraisal methodology, using scoping, screening and detailed modelling techniques where appropriate to allow comparison of pollutant concentrations with the relevant EU limit values and Scotland air quality objectives (shown in Table 15.1).

15.2.5 An assessment has been made of the concentrations of NO_2, PM_{10} and $PM_{2.5}$ at receptors near to the roads and junctions that form part of and are affected by the proposed scheme. Receptors were selected as those in closest proximity to the road at heavily trafficked road sections, at junctions where congestion or a reduction in speed may be expected and at sensitive areas such as designated ecological sites (as described in paragraphs 15.3.27 to 15.3.28). In addition, contour plots have been produced for the local study area, which illustrate pollutant levels at a 5m by 5m grid resolution.

Study Area

15.2.6 The study area for the local air quality assessment covered an area of approximately 9km (east-west) by 18km (north-south) and is shown on Figures 15.1. This includes the proposed scheme and the vast majority of affected road links defined by the application of DMRB criteria to the traffic data outputs from the traffic model (as described in paragraph 15.2.13). There are a limited number of road links that lie outside the study area but meet the DMRB screening criteria. In order to provide a robust assessment, an additional assessment was carried out for these affected road links where they are in close proximity to sensitive receptors. Figure 15.2 shows screened in links for both 2017 and 2032 as well as areas that were assessed in addition to the main study area.

15.2.7 The study area for nitrogen deposition on designated ecological sites was 200m either side of the proposed scheme and affected road links as per the study area for local air quality assessment.

15.2.8 The extent of the study area for the regional air quality assessment was governed by the extent of the transport model (Transport Model for Scotland; TMfS:05a, as explained in Chapter 4 (The Proposed Scheme)). Figure 15.3 shows the coverage of the modelled road network and thus the extent of the study area for the regional assessment. Whilst it is likely that the accuracy of the transport model decreases at road links far away from the core modelled area (e.g. links in London), the accuracy, in absolute terms is less critical than the forecast relative difference. The regional assessment is concerned with establishing the difference in total emissions comparing a scenario without the proposed scheme with a scenario incorporating the proposed scheme and hence links unaffected by the proposed scheme, whilst still included, would not contribute to the outcome of the assessment.

Baseline Conditions

15.2.9 Baseline conditions were assessed largely by desk study. Air Quality Review and Assessment documents from relevant local authorities were reviewed and existing local air quality established using information and published monitoring data from the reviewed reports and the UK Air Quality Archive.

15.2.10 Monitored background pollutant concentrations for the years 2005 and 2008 were obtained from the Edinburgh St. Leonards monitoring station and used in the dispersion model as described in paragraph 15.2.22.

15.2.11 Also, a NO_2 diffusion tube survey was carried out by Jacobs Arup over the period of March 2008 to February 2009 to obtain NO_2 concentration levels at strategically chosen locations (shown on Figures 15.4). The results of the survey complement monitoring data retrieved from Air Quality Review and Assessment documents and were used in the model evaluation process.

Air Quality Model Inputs

Road Traffic Data and Scoping

15.2.12 Road traffic data from the project transport model were used in the atmospheric pollutant dispersion modelling, and were collated in the form of annual average daily (24 hour) traffic flows (AADT), daily average speed and percentage of heavy goods vehicles (HGVs) for the existing road network for the base year (2005, with subsequent amendments to the road network for the future assessment years of 2017 and 2032 to include the M9 Spur extension (as described in paragraph 15.2.51: Limitations to Assessment). AADT flows have been used rather than diurnal traffic flows as this represents a worse case scenario. This is because traffic flows are averaged over a 24 hour period, resulting in higher than typical flows during stable and calm conditions (i.e. during the night and early morning hours) and thus resulting in worse case annual mean pollutant concentrations. The base year of 2005 was used for the air quality assessment as this is the base year for the project transport model. Future year traffic data (Do-Minimum and Do-Something scenarios) include traffic generated by committed developments within the transport study area.

15.2.13 The data were firstly interrogated to scope-in sections of road (links) where potential changes in traffic flows could influence local air quality significantly using the following DMRB thresholds (i.e. road links meeting any of these criteria are identified as 'affected links' and scoped into the assessment):

- road alignment would change by 5m or more; or
- daily traffic flows would change by 1,000 AADT or more, or
- Heavy Goods Vehicle (HGV) flows would change by 200 AADT or more; or
- daily average speed would change by 10 km/hr or more; or
- peak hour speed would change by 20 km/hr or more.

15.2.14 As described in paragraph 15.2.6, using the DMRB criteria aided the identification of the extent of the local study area. All road links within the local air quality study area for which traffic data were available (shown on Figures 15.1) were then included in the detailed dispersion model independent of whether or not they meet the DMRB criteria listed above.

15.2.15 To take account of junction delays, traffic speeds on road links around major junctions which have sensitive receptors in their vicinity, were reduced to 20kph. Speeds along all other road links were taken from the outputs of the transport model.

Industrial Sources

15.2.16 During consultation with SEPA and the relevant local authorities it was agreed to include emissions from Longannet Power Station in the dispersion modelling, this is located near Kincardine, approximately 10km to the west of the local study area. This is the biggest single industrial source in the vicinity of the proposed scheme. It was considered that emissions from other industrial installations in the vicinity of the proposed scheme (e.g. Grangemouth) would not contribute significant amounts of NO_x or particulates within the local air quality study area and in any case would be included in the background pollution data included in the modelling (as described in paragraph 15.2.22).

15.2.17 Information on annual emissions from the coal-fired power station was obtained from the Scottish Pollutant Release Inventory (SPRI) (SEPA, 2009). Stack height, diameter, efflux velocity and temperature were obtained in consultation with SEPA and the owners/operators (Scottish Power Limited). Table 15.2 lists model inputs for the power station. It should be noted that it is not the objective of the assessment to assess the impacts of the industrial source explicitly. The contribution from Longannet Power Station to overall pollutant levels is therefore included in the pollutant concentrations as presented in the results section of this chapter.

Table 15.2: Model Inputs for Longannet Power Station

Parameter	Model Input
Stack height	183m
Stack diameter	4 x 7.6m
Efflux velocity	13m/s
Temperature	134ºC
NO_x emissions	605.2 g/s
PM_{10} emissions	26.2 g/s
$PM_{2.5}$ emissions	11.8 g/s

Changes in Local Air Quality

Assessment Methodology

15.2.18 To assess the impact that traffic generated by the proposed scheme may have on local air quality, concentrations of traffic-related pollutants were forecast using dispersion modelling and compared to appropriate air quality standards (objectives and limit values). The following method applies to both the local air quality assessment and the additional assessment outside the local study area (the latter still forms part of the local air quality assessment).

15.2.19 Pollutant concentrations were forecast using the Atmospheric Dispersion Modelling System 'ADMS-Roads', which is a widely used model for assessing the air quality impacts of traffic-related emissions. Use of ADMS-Roads for this assessment was agreed with SEPA and the local authorities during consultation. The model calculates the dispersion of pollutants released from industrial and road traffic sources. For the purpose of this assessment, ADMS-Roads was used in conjunction with a Geographical Information System (GIS), ArcGIS.

15.2.20 ADMS-Roads has been used with the following inputs:

- road traffic flows, speed and %HGV (to derive transport related emission factors);
- stack height, diameter, efflux velocity, temperature and emission rates for NO_x, PM_{10} and $PM_{2.5}$ of Longannet Power Station;
- background pollutant concentrations;
- meteorological conditions; and
- topographical features, including surface roughness (the surface roughness value is selected based on the predominant land use in the model area).

15.2.21 The model calculates one-hour average concentrations for each hour during the year. The following model parameters and input files were used along with the industrial source and traffic data detailed above to run the model and predict pollutant concentrations for scenarios with and without the proposed scheme.

Background Pollutant File

15.2.22 It was agreed with SEPA and local authorities to use hourly pollutant background data from the Edinburgh St. Leonards urban background monitoring station which is the nearest monitoring station for which the required background data are available. This continuous monitoring station is located in Edinburgh at NGR 326265, 673136. Due to the nature of the monitoring site (urban background) it is possible that there is a certain degree of double counting of the road source contribution within the background component. However, the use of this monitoring site was considered to be most appropriate for the assessment. For the base year assessment, concentrations recorded and collated for 2005 were used to create the background pollutant file. For future year scenarios, concentrations recorded in 2008 at the Edinburgh St. Leonards monitoring site were factored based on the year of assessment and for the years 2017 and 2032 respectively using the method described in the Technical Guidance LAQM.TG(09) (Defra, 2009) in which background concentrations were calculated using a factor derived from mapped background concentrations (available on www.airquality.co.uk). As mapped background concentrations are only available to 2020, the 2020 background concentrations were used in calculations for the 2032 assessment year. Given that background concentrations are generally predicted to decrease with time (due to predicted improvements in technology), using the 2020 background concentrations is considered to allow a robust assessment of potential air quality impacts resulting from the proposed scheme.

15.2.23 Table 15.3 shows the annual average concentrations recorded at the Edinburgh St Leonards urban background monitoring station in 2005 and 2008. Projections for 2017 and 2032 (in accordance

with the above described method) are also provided. It is noted that NOx and NO_2 concentrations recorded at the Edinburgh St Leonards site in 2008 are noticeably higher than those recorded in 2005, which is further discussed in Appendix A15.1 (Air Quality Model Evaluation).

Table 15.3: Annual Average Background Concentrations (µg/m^3) at Edinburgh St Leonards Monitoring Site

Pollutant	2005	2008	2017	2032
NOx	36.4	53.5	37.7	35.3
NO_2	24.8	30.9	23.1	21.8
PM_{10}	18.4	15.3	13.9	13.7

15.2.24 In order to include $PM_{2.5}$ concentrations in the background file, a $PM_{2.5}$:PM_{10} ratio of 0.67 was assumed. This assumption is based on results of a study carried out by AEA for the Scottish Government (AEA, 2009).

Meteorology

15.2.25 Hourly sequential observation data were collated for wind speed, wind direction, temperature, rainfall, relative humidity and cloud cover from observations made at Turnhouse meteorological station (operated by the Met Office as part of a national network of sites), approximately 7km south of the study area.

15.2.26 As requested by SEPA and local authorities, meteorological data from a weather station maintained by ExxonMobil (located at the ExxonMobil chemical site at the Fife Ethylene Plant in Mossmorran, Cowdenbeath) were originally obtained as there was concern that the Turnhouse data would not be representative for coastal locations, which are prone to experience higher wind speeds. ExxonMobil provided wind speed and direction data, although noted that the data had not been ratified and that they use Turnhouse data for dispersion modelling. As a result, a sensitivity analysis using different sets of meteorological data was carried out, which showed that substituting Turnhouse data with ExxonMobil data did not give worse results. As a consequence, it was decided to use all data from the Turnhouse meteorological station to give a worst-case scenario.

15.2.27 A further sensitivity analysis was undertaken to identify which meteorological year would give highest pollutant concentrations at a number of randomly selected receptor locations (monitoring sites). The study showed that 2008 data gave worst case (i.e. highest) results at the majority of selected receptors. Therefore, meteorological data from 2008 were used in future year assessments. Table 15.4 shows the results of the sensitivity analysis for the selection of the meteorological year. The numbers in bold represent highest concentrations.

Table 15.4: Results of Meteorology Sensitivity Analysis – Annual Mean NO_2 Concentrations (µg/m^3)

Receptor	Grid Reference	2005	2006	2007	2008
1 Ferry Barns Cresent	312645, 680603	28.7	28.3	**28.8**	28.6
2 Selvage Street	312247, 683184	30.0	29.8	30.1	**30.2**
3 Carnegie Drive	309019, 687632	30.0	30.2	30.4	**30.5**
4 Rumblingwell	307866, 688231	28.5	28.5	28.7	**28.8**
5 Aytoun Grove	308328, 688426	27.4	27.5	**27.6**	27.5
6 Barrie Street	308381, 688251	27.6	27.7	**27.8**	27.7
7 Appin Crescent	309882, 687713	37.3	39.1	38.8	**39.5**
8 Appin Crescent	309882, 687720	32.7	**34.1**	33.8	**34.1**
9 Appin Crescent	309885, 687716	34.6	36.3	35.9	**36.4**
10 Admiralty Road	312103, 683439	30.6	30.5	30.7	**31.0**
11 Admiralty Road	312140, 683439	30.0	29.9	30.1	**30.4**
12 St Leonard School	309770, 686895	**27.7**	27.6	**27.7**	**27.7**

Other Model Parameters

15.2.28 The oxidation of NO to form NO_2 is a complex process that is dependant on several factors, including the relative availability of these two gases, ozone, volatile organic compounds, sunlight, temperature and residence time. The ADMS-Roads model includes a Chemical Reaction Scheme model which accounts for these factors with reference to local emissions and background contributions. The Chemical Reaction Scheme model was used for this assessment.

15.2.29 The extent of mechanical turbulence (and hence, mixing) in the atmosphere is affected by the roughness of the surface (i.e. ground) over which the air is passing. Typical surface roughness values range from 1m (for cities, forests and industrial) to 0.001m (for water or sandy deserts). In this assessment, the general land-use in the local study area can be described as open suburbia with a corresponding surface roughness of 0.5m.

15.2.30 A measure of stability of the atmosphere is the 'Monin-Obukhov length'. A Monin-Obukhov length of 30m was considered to be most appropriate for this assessment, as this represents mixed urban areas.

15.2.31 The ArcMap package was used to generate pollution contours and for subsequent spatial analysis, including calculation of the extent of each habitat type impacted within statutory designated nature reserves.

Local Air Quality Receptors

15.2.32 Receptors (specified points included in the air quality model) were generated as follows:

- a regular grid of receptors at 100m spacings;
- additional gridding to increase density of receptors along road sources (using 'intelligent gridding', a function within ADMS-Roads to enable the modelling of a wide area with a large number of roads);
- specific receptor points that were identified within the study area, including residential properties and other sensitive receptors, such as schools or hospitals which are closest to the road links, predicted to experience the greatest change in local air quality as a result of the proposed scheme (i.e. focussed around the proposed scheme and main access routes where greatest change in traffic flows is predicted to occur); and
- residential properties along road links where greatest change in traffic flows is predicted to occur and where the highest concentrations of road traffic pollutants would be expected (e.g. around junctions, due to congestion).

15.2.33 Fifty-one specific receptor points were selected for the assessment to calculate potential impacts of the proposed scheme at various sensitive locations. Criteria as described in paragraphs 15.2.5 and 15.2.32 were used to determine the most representative receptor locations. Table 15.5 and Figures 15.1 show receptor locations in the northern (N) and southern (S) study areas for the Stage 3 assessment. In addition, contour plots are provided showing pollutant concentrations at a 5m x 5m grid, thus covering all residential properties within the local study area.

Table 15.5: Local Air Quality Receptor Locations

Receptor	Grid Ref	Location Details
R1(N)	314001, 688940	18 Westfield Grove, Crossgates
R2 (N)	314510, 688709	Ardshallah, Inverkeithing Road, Crossgates
R3 (N)	312995, 688503	18 Sandybank, Halbeath
R4 (N)	314016, 688782	119 Dunfermline Rd, Crossgates
R5 (N)	314133, 688748	Crossgates Primary School, Crossgates
R6 (N)	311505, 687868	Touch Primary School, Dunfermline

Receptor	Grid Ref	Location Details
R7 (N)	311822, 687250	St Columba's High School, Dunfermline
R8 (N)	311922, 686179	71 Meldrum Court, Dunfermline
R9 (N)	313336, 685754	Mid Duloch Farm, Inverkeithing
R10 (N)	312541, 680687	Ferry Craig House, North Queensferry
R11 (N)	312630, 680717	15 Ferry Barns Court, North Queensferry
R12 (N)	312483, 681073	St Margaret's Hope Lodge, North Queensferry
R13 (N)	312667, 681880	24 Ferry Hills Road, North Queensferry
R14 (N)	312440, 682421	18 Whinny Hill Crescent, Inverkeithing
R15 (N)	312751, 684649	The Bungalow, Dunfermline
R16 (N)	312423, 683997	25 Park Lea, Rosyth
R17 (N)	313618, 683518	Inverkeithing High School, Hillend Road
R18 (N)	313299, 683470	39 Burleigh Crescent, Inverkeithing
R19 (N)	312302, 683570	25 Admiralty Rd, Rosyth
R20 (N)	311930, 683389	18 Castlandhill Road, Rosyth
R21 (N)	312193, 683042	114 Castlandhill Road, Rosyth
R22 (N)	312451, 682686	5 Mucklehill Park, Inverkeithing
R23 (N)	311230, 684444	231 Queensferry Road, Rosyth
R24 (N)	314404, 683811	7 Letham Hill Way, Hillend
R25 (N)	312378, 681008	St Margaret's Hope, North Queensferry
R26 (S)	312442, 678387	14 Farquhar Terrace, South Queensferry
R27 (S)	312900, 678391	Plewlands House, South Queensferry
R28 (S)	312381, 678005	45 Stoneyflats Crescent, South Queensferry
R29 (S)	312997, 677546	10 Scotstoun Green, South Queensferry
R30 (S)	311543, 677916	68 Echline Drive, South Queensferry
R31 (S)	311317, 678514	7 Linnmill, South Queensferry
R32 (S)	312620, 677132	12 Dundas Home Farm
R33 (S)	309177, 677649	11 Main Street, Newton
R34 (S)	311884, 674153	39 Cotlaws, Kirkliston
R35 (S)	309244, 675089	1 Beatly Road, Winchburgh
R36 (S)	311923, 673514	2 Millrig Cottages, Kirkliston
R37 (S)	312466, 674932	2 Newmains Road, Kirkliston
R38 (S)	312556, 674578	35 Main Street, Kirkliston
R39 (S)	311670, 678165	15 Springfield Terrace, South Queensferry
R40 (S)	308792, 677447	1 Winchburgh Road, Winchburgh
R41 (S)	312885, 677081	Newbigging Lodge, Dundas Home Farm
R42 (S)	312169, 677705	21 Long Crook, South Queensferry
R43 (S)	314275, 677370	16 Main Street, Dalmeny
R44 (S)	313018, 672669	61 Glasgow Road, Newbridge
R45 (S)	308851, 675000	16 Bennet Wood Terrace, Winchburgh
R46 (S)	314338, 676101	Standingstone Cottage
R47 (S)	311771, 677834	21 Echline, South Queensferry
R48 (S)	312955, 678047	Queensferry Primary School, South Queensferry
R49 (S)	312036, 678110	Echline Primary School, South Queensferry
R50 (S)	313228, 672605	104 Glasgow Road, Newbridge
R51 (S)	311446, 678603	Inchgarvie House

15.2.34 Additional receptors were chosen for the assessment of areas outside the local study area (within the additional assessment areas shown on Figure 15.2). Table 15.6 shows receptors used in the

additional assessment. These were again selected using the criteria described in paragraphs 15.2.5 and 15.2.32.

Table 15.6: Additional Local Air Quality Receptor Locations (Outside Local Study Area)

Receptor	Grid Ref	Location Details
Linlithgow		
R1 (Lin)	299267, 677585	1 Clark Avenue
R2 (Lin)	299317, 677695	Loch House
R3 (Lin)	298955, 677635	30 Clark Avenue
R4 (Lin)	299427, 677580	74 St Ninians Road
R5 (Lin)	299624, 677584	6 Parkhead Road
Polmont		
R1 (Pol)	294018, 678901	32 Eastcroft Drive
R2 (Pol)	293755, 679060	41 Orchard Grove
R3 (Pol)	294250, 678772	4 Eastcroft Drive
Kincardine		
R1 (Kin)	292949, 687322	45 Keith Street
R2 (Kin)	292957, 687283	31 Silver Street
R3 (Kin)	292909, 687328	26 Forth Street
R4 (Kin)	293031, 687248	13 Orchard Grove
Kelty		
R1 (Kel)	313462, 693962	23 Blair Drive
R2 (Kel)	313434, 694013	38 Clentry Crescent
R3 (Kel)	313295, 694381	1 Dullomuir Drive
R4 (Kel)	313371, 694116	16 Clentry Crescent
Cowdenbeath		
R1 (Cow)	316842, 691087	Birnie Ridge, 2 Bridge Street
R2 (Cow)	316847, 691161	3 Paterson Lane
Edinburgh		
R1 (Edb)	318005, 675293	624 Queensferry Road
R2 (Edb)	318545, 674990	564 Queensferry Road
R3 (Edb)	318621, 674917	7 Maybury Road
R4 (Edb)	318015, 675197	20 Strathalmond Green
R5 (Edb)	318540, 674940	10 Maybury Road
R6 (Edb)	319627, 674985	453 Queensferry Road
R7 (Edb)	320004, 675052	1c Clermiston Road North
R8 (Edb)	320531, 675108	393 Queensferry Road
R9 (Edb)	319074, 674217	224 Drum Brae Drive
R10 (Edb)	320204, 674516	66 Clermiston Road North

Model Evaluation

15.2.35 To verify the model, additional receptor points were chosen at locations of air quality monitoring stations, operated by the local authorities as well as by Jacobs Arup (as described in paragraphs 15.3.21 to 15.3.26 for further details of the air quality monitoring sites). The modelled pollutant concentrations were then compared to the observed pollutant concentrations. A total of 21 locations were used in the model evaluation. Figures 15.4 show the location of monitoring locations which were included in the verification process. Details on model evaluation are provided in Appendix A15.1.

Population Exposure

15.2.36 An assessment of population exposure was carried out by establishing the number of sensitive receptors that are predicted to experience a change in pollutant concentrations greater than 1% of the relevant air quality objective and limit value for NO_2, PM_{10} and $PM_{2.5}$.

15.2.37 The ArcGIS package was used to generate difference contours covering the local study area. The contours consist of 5m by 5m raster grids, with each grid containing the calculated pollutant concentration value. Address point data were overlain with the difference contour plot to enable a count of sensitive receptors that experience a change in concentration of 0.4㎎/m^3 for NO_2, 0.18㎎/m^3 for PM_{10} and 0.12㎎/m^3 for $PM_{2.5}$ respectively.

Changes in Nitrogen Deposition

Assessment Methodology

15.2.38 The DMRB states that any nature conservation sites ('designated sites') and their characteristics should be identified as part of the air quality assessment. The designated sites that should be considered for an assessment are those for which the designated features are sensitive to air pollutants, either directly or indirectly, and which could be adversely affected by the effect of air pollution on vegetation. Types of conservation sites to be included are Special Areas of Conservation (SAC) (Sites of Community Importance (SCI) or candidate Special Areas of Conservation (cSAC)), Special Protection Areas (SPA), potential Special Protection Areas (pSPA), Sites of Special Scientific Interest (SSSI) and Ramsar sites. Local designations such as Sites of Importance for Nature Conservation (SINC) are excluded from this assessment.

15.2.39 The DMRB includes a calculation procedure combining background air quality data with road traffic emissions to derive nitrogen deposition rates at each receptor. The years of assessment were for the baseline situation in 2005 (based on 2005 traffic data), 2017 and 2032, both with and without the proposed scheme. The results were compared directly to the critical load for calcareous grassland, saltmarsh fens, and neutral grassland which are the predominant sensitive habitats found in the SSSIs within the study area. The critical load for the deposition of nitrogen represents the exposure below which there should be no significant harmful effect for the assessed habitat, according to current knowledge.

15.2.40 Assessment of designated sites within the study area was carried out in accordance with the methodology outlined in Annex F of the DMRB guidance which assesses the traffic related dry deposition of nitrogen (in kilograms per hectare per year). This requires that annual mean NO_2 concentrations are calculated for a transect up to 200m away from each of the affected roads (roads that have been scoped in) within or near a designated site. The calculations were carried out for 2017 and 2032 with and without the proposed scheme at 50m intervals, starting from the closest point from the road that lies within or in close proximity to the site. When predicting future deposition rates, background nitrogen deposition rates (shown in Table 15.13) were reduced by 2% per year in accordance with DMRB guidance. This is because of the predicted improvements in vehicle technologies and abatement equipment.

15.2.41 In addition to nitrogen deposition, NO_x concentrations were calculated using ADMS-Roads at the assessed designated sites and compared to relevant objectives (shown in Table 15.1). High concentrations of NO_x can have an adverse effect on vegetation, including leaf or needle damage and reduced growth.

Nitrogen Deposition Receptors

15.2.42 There are several designated nature conservation sites within the local study area. Those included in the nitrogen deposition assessment were the Firth of Forth, Ferry Hills and St. Margaret's Marsh Sites of Special Scientific Interest (see Chapter 10: Terrestrial and Freshwater Ecology).

15.2.43 The results of the nitrogen deposition and NO_x concentration calculations contained within the air quality assessment provide input to the ecological assessment where the impacts of the proposed scheme on the integrity of relevant designated sites, and the significance of those impacts, is discussed in Chapter 10 (Terrestrial and Freshwater Ecology).

Changes in Regional Air Quality

Total Pollutant Emissions

15.2.44 Total emissions of NO_x, PM_{10} and CO_2 were calculated for the entire road network covered by the transport model (shown on Figure 15.3), independent of whether or not individual road links met the DMRB criteria. Total vehicle kilometres travelled along each road link were established using ArcGIS (to obtain the link length) and available traffic data. Emission factors were derived using the dataset incorporated in the DMRB worksheets version 1.03c (July 2007). For each road link total pollutant emissions per year were calculated. The emissions calculated for each link were then added to generate the total mass of emissions for each assessed scenario.

Impact Assessment

15.2.45 The National Society for Clean Air (NSCA) guidance (NSCA, 2006) provides an example of how to describe the significance of the impacts predicted from the air quality modelling for the pollutants NO_2 and PM_{10} for local air quality assessments. Tables 15.7 and 15.8 show examples of descriptors for magnitude of change and significance. These significance criteria have been used to assess local air quality impacts. The first step is to identify the descriptor of change in ambient concentrations for NO_2 and particulates (PM_{10} and $PM_{2.5}$) (shown in Table 15.7) according to the percentage change in annual mean concentrations (for both NO_2 and particulates). The descriptor can then be used to assess the impact significance for the two pollutants in relation to changes in the absolute concentration forecast from the modelling with the proposed scheme in place (shown in Table 15.8).

Sensitivity of Receptors

15.2.46 Discrete receptors were identified which would be sensitive to changes in air quality, i.e. schools, hospitals, residential and nature conservation sites as listed in paragraph 15.2.32. In addition, receptor points within 200m of links that meet the DMRB criteria are considered as being potentially 'susceptible' to resulting changes in local air quality and representative receptors were therefore included in the quantitative assessment.

Impact Magnitude

15.2.47 Table 15.7 below shows examples of descriptors for magnitude of change.

Table 15.7: Magnitude of Change related to Changes in Ambient Concentrations of NO_2 and PM_{10}

Change in Annual Mean $NO_2/PM_{10}/PM_{2.5}$ Concentration	Magnitude of Change
Increase/decrease >25%	Very Large
Increase/decrease 15-25%	Large
Increase/decrease 10-15%	Medium
Increase/decrease 5-10%	Small
Increase/decrease 1-5%	Very Small
Increase/decrease <1%	Extremely Small

Impact Significance

15.2.48 The impact significance descriptors shown in Table 15.8 take account of the magnitude of the change (both increase and decrease) and the absolute concentration in relation to the air quality

objective. Particular significance is given to a change that takes the pollutant concentration from below to above the objective or vice versa. This is because of the importance attributed to the objectives in assessing local air quality, as set out in PAN 51 (Scottish Executive, 2006).

Table 15.8: Impact Significance for NO_2 and PM_{10}

Absolute Concentration in Relation to Standard	Extremely Small	Very Small	Small	Medium	Large	Very Large
Decrease with scheme						
Above Standard with scheme.	Slight beneficial	Slight beneficial	Substantial beneficial	Substantial beneficial	Very substantial beneficial	Very substantial beneficial
Above Standard without scheme. Below with scheme.	Slight beneficial	Moderate beneficial	Substantial beneficial	Substantial beneficial	Very substantial beneficial	Very substantial beneficial
Below Standard without scheme, but not Well Below.	Negligible	Slight beneficial	Slight beneficial	Moderate beneficial	Moderate beneficial	Substantial beneficial
Well Below Standard without scheme.	Negligible	Negligible	Slight beneficial	Slight beneficial	Slight beneficial	Moderate beneficial
Increase with scheme						
Above Standard without scheme.	Slight adverse	Slight adverse	Substantial adverse	Substantial adverse	Very substantial adverse	Very substantial adverse
Below Standard without scheme. Above with scheme	Slight adverse	Moderate adverse	Substantial adverse	Substantial adverse	Very substantial adverse	Very substantial adverse
Below Standard with scheme, but not Well Below.	Negligible	Slight adverse	Slight adverse	Moderate adverse	Moderate adverse	Substantial adverse
Well Below Standard with scheme.	Negligible	Negligible	Slight adverse	Slight adverse	Slight adverse	Moderate adverse

Well Below standard = <75% of the standard level.

'Standard' in the context of this table relates to specific air quality objective or limit value in question – shown in Table 15.1

15.2.49 With regards to the regional assessment, no formal significance criteria exist for the assessment of total emissions (specifically CO_2 emissions) in environmental assessments. The significance of an increase in CO_2 emissions can be determined by testing whether the emissions can be balanced (or 'offset') by reducing emissions elsewhere. The common denominator for testing policy measures in this way is cost. The carbon costs of the proposed scheme are presented in the DMRB Stage 3 Scheme Assessment Report, Part C.

15.2.50 Her Majesty's Treasury maintains guidance on appraisal and evaluation in central government (referred to as 'the Green Book'). This states that '*all new policies, programmes and projects, whether revenue, capital or regulatory, should be subject to comprehensive but proportionate assessment, wherever it is practicable, so as best to promote the public interest. The Green Book presents the techniques and issues that should be considered when carrying out assessments'.* The Green Book makes direct reference to Defra guidance on how to value greenhouse gas emissions in government appraisals by determining the shadow price of carbon based on its social and economic cost (Defra, 2008). Carbon pricing for the proposed scheme is reported in the DMRB Stage 3 Scheme Assessment Report, Part C.

Limitations to Assessment

15.2.51 The base year in terms of traffic was taken to be 2005, using TMfS:05a data. 2005 is the base model calibration year. A series of forecast Do-Minimum and reference case scenarios are coded in the model for the future years of 2012, 2017, 2022 and 2027. The reference case models include

committed and agreed likely schemes which may affect travel patterns and traffic routing. These include features such as removal of tolls on the Forth Road Bridge and the M9 Spur extension which was completed after 2005 and is included in all forecast models from 2012 onwards. As noted previously, in order to provide a more up-to-date base case, traffic along the M9 Spur extension was included in the base case scenario based on a 2017 traffic distribution. TMfS:05a represents the best base year and forecast data currently available and it is considered that these provide an acceptable proxy for the baseline and forecast traffic situations for the purposes of this assessment.

15.2.52 The traffic information used to develop the air quality model is extracted from the Transport Model for Scotland. This model is a national strategic model and is expected to reflect traffic patterns on the national trunk road network, however the model may not fully reflect traffic levels as accurately on local roads. The DMRB Stage 3 Scheme Assessment Report, Part C includes a description of the more detailed local review of traffic patterns.

15.2.53 As described in paragraph 15.2.1, the years of assessment include future years of 2017 and 2032. There is an inherent limitation in the accuracy of background concentrations and vehicle emission factors projections so far into the future. However, the approach followed is consistent with current best practice and government guidance.

15.3 Baseline Conditions

Air Pollution Sources

Industrial Processes

15.3.1 Industrial air pollution sources are regulated through a system of operating permits or authorisations, requiring stringent emission limits to be met and ensuring that any releases are minimised or rendered harmless. Regulated (or prescribed) industrial processes are classified as Part A or Part B processes. Part A processes, regulated through the Integrated Pollution Prevention and Control (IPPC) system (EC Directive 96/91/EC on Integrated Pollution Prevention and Control) are regulated by SEPA. Part A processes have the potential for release of prescribed substances to air, land and water, and as such require an IPPC permit to operate. Part B processes are those regulated by the local authority through the Pollution Prevention and Control (PPC) system under the Pollution Prevention and Control (Scotland) Regulations 2000 as amended. Part B processes are smaller in scale than Part A processes and have the potential for release of prescribed substances to air only, requiring a PPC authorisation or permit to operate. Given the extent of the study area, there will be some Part B processes within the assessed area. However, due to the fact that they are controlled, it is considered unlikely that such processes would lead to a breach of air quality objectives.

15.3.2 There are a number of industrial processes regulated through the IPPC system within approximately 2km of the proposed scheme, including Dalmeny Tank Farm, South Queensferry (part of BP Exploration Co. Ltd), Shanks Chemical Services, several sewage treatment works, Rosyth Royal Dockyards Ltd and the Grampian County Food Group Ltd. However, as these processes are controlled by SEPA and potential releases to air are tightly regulated it is considered that such processes would not lead to a breach of air quality objectives. In addition, the above listed processes are not expected to release large amounts of NO_x and particulate matter. Industrial processes are also considered in local authority Air Quality Review and Assessment Reports.

15.3.3 In addition to the processes in the immediate vicinity of the proposed scheme, there are industrial sources which contribute to releases to air in Grangemouth, approximately 10km to the west of the study area and the Longannet Power Station in Kincardine, approximately 10km west of the local air quality study area. As noted in paragraph 15.2.16, SEPA and the relevant local authorities requested during consultation that emissions from the power station should be included in the assessment.

Local Authority Review and Assessment of Air Quality

15.3.4 Under the requirements of the Environment Act 1995 Part IV, local authorities are required to periodically review and assess air quality in their areas. If it is predicted that air quality concentrations will exceed national air quality objectives the local authority is required to declare an Air Quality Management Area (AQMA) around the area where the exceedance is predicted to occur.

15.3.5 There are no AQMAs within the local study area. Details on existing AQMAs declared by relevant local authorities are described in the paragraphs below.

City of Edinburgh Council

15.3.6 City of Edinburgh Council (CEC) undertook the first and second stages of the review and assessment process which concluded that NO_2 required further investigation at Stage 3 review and assessment (CEC, 2000). This concluded that the annual mean NO_2 objective was predicted to be exceeded in 2005 in eight locations in Edinburgh. On this basis CEC subsequently designated an AQMA for NO_2 covering the city centre, including the main roads into the city centre.

15.3.7 CEC produced an Air Quality Action Plan in July 2003 (CEC, 2003) which detailed measures to reduce NOx emissions in the AQMA in pursuit of the annual mean NO_2 objective.

15.3.8 An Updating and Screening Assessment (USA) was carried out in 2006 (CEC, 2006) which concluded that a second AQMA should be declared for the area around St. Johns Road in west Edinburgh city centre. As a result, an AQMA for NO_2 was declared on 31 December 2006.

15.3.9 A Detailed Assessment was undertaken in 2007 for Great Junction Street and West Port in central Edinburgh. The assessment identified that both these locations exceed relevant NO_2 objectives and are likely to continue to do so and therefore require to be designated AQMAs.

15.3.10 The Progress Report covering the period of 2005 to 2007 revealed that although traffic management initiatives had been undertaken, the progress at certain air quality hot spots was variable. It is stated that there are locations within the AQMA that are likely to fail the one hour objective for NO_2. This was supported by the 2008 Progress Report (CEC, 2008). As a result, a low emission study was commissioned by CEC to review various Low Emission Zone (LEZ) options and make recommendations to address air quality hotspots in Edinburgh. Taking account of the outcome of the study, CEC prepared a new draft Air Quality Action Plan (AQAP) covering the period of 2008 to 2010 in September 2008 (CEC, 2008). The 2008 Progress Report also identified the need for further Detailed Assessments at a city-wide level for PM_{10} and for Bernard Street, Commercial Street, Ferry Road, Easter Road, London Road, Hope Park Terrace and Glasgow Road for NO_2.

15.3.11 The local study area does not include the centre of Edinburgh or any of the designated AQMAs due to the fact that road links do not meet the DMRB criteria as listed in paragraph 15.2.13. Based on the fact that DMRB criteria are not predicted to be met, it is considered unlikely that the proposed scheme would have a significant impact on the AQMAs in Edinburgh. However, there are some road links outside the study area along Queensferry Road on the outskirts of Edinburgh that meet the DMRB criteria and as a result were included in an additional assessment carried out at areas outside the Forth Crossing corridor. The additional assessment is further discussed in Section 15.4 (paragraphs 15.4.48 to 15.4.56).

West Lothian Council

15.3.12 West Lothian Council (WLC) undertook the first and second stages of their review and assessment which concluded that all pollutants of concern would meet the relevant air quality objectives in the relevant years and hence no further assessment work was required.

15.3.13 The USA submitted in July 2006 (WLC, 2006) concluded that all pollutants would continue to meet the relevant air quality objectives and therefore no further assessment would be required. For PM_{10}, however, it was indicated that there is a risk of exceeding the annual objective of 18µg/m^3 in Linlithgow High Street. As a result it was recommended to continue the PM_{10} monitoring at Linlithgow High Street.

15.3.14 The Progress Report submitted in April 2007 (WLC, 2007) states that Linlithgow High Street would potentially have to be declared an AQMA due to a number of exceedances of the PM_{10} standard and the recorded annual mean being close to the objective. With regards to NO_2, the report concludes that there were no exceedances of relevant national objectives and therefore no further Detailed Assessment is required.

15.3.15 The study area does not include Linlithgow High Street. However, a screening exercise showed that the M9 westbound meets DMRB criteria as described in paragraph 15.2.13. An additional assessment was therefore carried out including sensitive receptors around the affected M9 stretch to assess potential impacts on local air quality. This is further discussed in Section 15.4, paragraphs 15.4.50 to 15.4.55.

Fife Council

15.3.16 Fife Council (FC) completed the second round of air quality review and assessment in 2003 with subsequent Progress Reports following in 2004 and 2005. The 2003 USA identified that high NO_2 concentrations were recorded at several kerbside locations within the Fife area. The 2004 Progress Report recommended that monitoring at the façade of buildings rather than kerbside locations should be undertaken to allow a better assessment of likely exposure. A revised monitoring programme was carried out in 2004 and automatic monitoring of NO_2 has been undertaken at two locations (Rosyth and Kincardine) in Fife.

15.3.17 In 2006 FC submitted an USA as part of the third round of air quality assessment (AEA, 2006). The USA concluded that it is unlikely that the air quality objective for NO_2 would be exceeded.

15.3.18 With regards to PM_{10}, the 2006 USA concluded that the 2004 air quality objective is unlikely to be exceeded but that the 2010 objective might be closely approached. It was recommended to continue automatic monitoring for a period covering at least one full year.

15.3.19 The 2007 Progress Report (AEA, 2007) concluded that there is a risk of exceeding the NO_2 and PM_{10} air quality objectives in Bonnygate, Cupar and a Detailed Assessment was carried out during 2007. In November 2008 FC designated an AQMA for the affected area in Bonnygate, Cupar.

15.3.20 As Bonnygate is located more than 40km to the northeast of the proposed Main Crossing, and DMRB criteria are not predicted to be met for roads in the area, it is very unlikely that the proposed scheme would have an adverse impact on the existing air quality hotspot.

Local Air Quality Monitoring

15.3.21 There are a number of continuous monitoring stations within the areas of Edinburgh, Fife and West Lothian; however, only three are located within the study area of the proposed scheme. Continuous monitors are 'real time' monitoring devices which actively sample and record pollutant concentrations continuously. Fife Council operates a continuous monitor in Dunfermline and a mobile monitoring station in Rosyth at NGR 311752, 683515. In their 2007 Progress Report, Fife Council reports a NO_2 concentration of 26µg/m^3 at this location for a six month period (October 2006-March 2007). Table 15.9 shows annual mean NO_2 concentrations at the two continuous monitoring sites in Fife for 2008.

Table 15.9: NO_2 Continuous Monitoring Results ($\mu g/m^3$)

Continuous Monitoring Station	Grid Reference	NO_2 Concentration 2008
Appin Crescent, Dunfermline	309912, 687738	30
Admiralty Road, Rosyth	311752, 683515	26

15.3.22 In addition, West Lothian Council operates a continuous monitoring station in Broxburn at NGR 308364, 672248. Monitoring data for this station are only available from August 2008 and are therefore not included in the assessment as monitoring needs to be undertaken for a full calendar year to enable comparison with the air quality objectives and limit values.

15.3.23 City of Edinburgh, Fife and West Lothian Councils also operate extensive networks of diffusion tubes for monitoring (diffusion tubes are a passive monitoring technique whereby absorption tubes are exposed for a period of four weeks, and then sent to a laboratory for analysis to obtain four week average monitored concentrations). However, none of the City of Edinburgh Council locations and only one of the West Lothian Council locations were considered to be representative of the study area. Table 15.10 lists diffusion tubes and associated monitored NO_2 concentrations, located in Dunfermline and Rosyth, Fife, up to 5km northwest of the Main Crossing as well as one diffusion tube location in Broxburn, West Lothian. All concentrations have been taken from local air quality management reports (as described above) produced by the relevant authorities and are bias-adjusted. The monitoring locations that have been used for model verification are shown on Figure 15.4.

Table 15.10: NO_2 Diffusion Tube Results for Fife and West Lothian ($\mu g/m^3$)

Diffusion Tube	Monitoring Type*	Grid Reference	NO_2 Concentration		
			2005	2006	2007
Admiralty Rd, Rosyth	KS	312103, 683439	31	32	36
Admiralty Rd 1, Rosyth	RS (F)	312103, 683439	26	32	33
Admiralty Rd 2, Rosyth	RS (F)	312103, 683439	26	33	33
Admiralty Rd 3, Rosyth	RS (F)	312103, 683439	23	32	33
St Leonards Primary School, Dunfermline	RS (F)	309770, 686895	n/a	20	19
Carnegie Drive (A), Dunfermline	RS (F)	309019, 687632	29	30	31
Carnegie Drive (B), Dunfermline	RS (F)	309019, 687632	27	31	31
Carnegie Drive (C), Dunfermline	RS (F)	309019, 687632	28	28	32
Rumblingwell, Dunfermline	R	307866, 688231	21	22	23
Aytoun Grove, Dunfermline	UB	308328, 688426	12	11	13
Barrie Street, Dunfermline	UB	308379, 688249	12	12	13
Appin Crescent (C), Dunfermline	RS	309882, 687713	29	30	35
Appin Crescent (1), Dunfermline	RS (F)	309882, 687720	23	24	27
East Main Street, Broxburn	RS	308306, 672217	33	38	n/a

KS – Kerbside; RS (F) – Roadside on building façade; UB – Urban Background

15.3.24 The results in Table 15.10 show that for 2005, 2006 and 2007 the annual mean NO_2 air quality objective as shown in Table 15.1 was met.

15.3.25 Additional monitoring was carried out by Jacobs Arup as part of this study in order to get a better understanding of local air quality and enable the assessment of model performance of the ADMS-Roads dispersion model. This monitoring was undertaken for a 12 month period from March 2008 to February 2009 allowing annual average concentrations to be robustly derived. Monitoring locations in the vicinity of the proposed scheme are shown on Figure 15.4 and listed in Table 15.11. Results of the NO_2 diffusion tube survey are shown in Table 15.12.

Table 15.11: NO_2 Diffusion Tube Survey – Location Details

Tube No	Grid Reference	Location details
1	311370, 678740	Linn Mill at Junction
2	312401, 678400	Farquahar Terrace; South Queensferry
3	312540, 678330	Morrison Gardens; South Queensferry
4	312410, 677890	Stoneyflatts Crescent; South Queensferry
5	312550, 677900	Ferry Muir Gait
6	311640, 674630	Buie Rigg; Kirkliston
7	299250, 677580	Essex Drive/Clark Ave; Linlithgow
8	292910, 687340	Keith Street; Kincardine
9	293010, 687280	Silver Street; Kincardine
10	300680, 686850	Chapel Street; High Valleyfield
11	304930, 685100	Main Road; Crombie
12	312260, 683190	Selvage Street; Rosyth
13	312650, 680600	Ferry Barns Crescent; North Queensferry
14	309273, 677728	Main Street; Newton

Table 15.12: NO_2 Diffusion Tube Results (mg/m^3) - Monitoring Survey

No.	Mar 08	April 08	May 08	June 08	July 08	Aug 08	Sept 08	Oct 08	Nov 08	Dec 08	Jan 09	Feb 09	Ave *
1	12.5	12.3	10.3	6.9	9.5	10.6	10.9	12.9	n/a	20.2	23.4	14.9	11.8
2	16.6	17.4	13.9	12.5	13.5	17.3	20.8	17.0	n/a	26.1	30.6	15.5	16.5
3	25.5	26.0	22.4	17.1	18.3	24.2	21.5	25.5	n/a	35.9	35.8	14.0	21.8
4	20.7	36.6	23.5	15.5	19.8	22.3	21.0	19.8	n/a	30.4	32.7	13.3	20.9
5	31.5	21.0	21.6	17.7	21.2	22.0	21.8	29.5	n/a	39.0	39.2	31.9	24.2
6	30.6	22.3	20.4	26.1	24.5	30.2	25.3	30.8	n/a	38.2	35.2	29.5	25.6
7	21.5	34.1	21.6	18.2	21.3	22.0	22.0	21.3	n/a	30.0	31.9	17.1	21.4
8	18.6	20.7	15.2	17.0	18.4	21.8	21.9	19.6	n/a	27.9	31.4	23.0	19.3
9	23.5	22.3	19.1	18.1	17.8	21.4	23.0	24.9	n/a	31.6	34.7	29.7	21.8
10	18.6	16.4	11.5	13.4	14.7	14.5	16.5	21.1	n/a	29.2	29.6	20.8	16.9
11	21.1	24.0	15.9	18.6	20.7	16.6	22.2	25.3	n/a	32.4	34.0	23.0	21.0
12	19.0	24.9	18.6	17.1	19.1	23.6	24.7	21.8	n/a	30.4	34.3	14.4	20.3
13	14.9	14.3	11.1	11.2	12.4	16.0	14.4	16.1	n/a	23.3	37.1	17.4	14.6
14	18.8	32.8	25.8	16.6	21.4	24.6	24.8	24.1	n/a	29.4	32.1	12.3	21.4

* Bias adjusted (factor of 0.9) derived using the spreadsheet-based tool available at www.airquality.co.uk/archive/laqm/tools.php

15.3.26 The monitored NO_2 concentrations shown in Table 15.12 show that there are currently no exceedances of the relevant air quality objective and limit value. The lowest NO_2 concentrations were measured at diffusion tube number 1 (Linn Mill). This location is fairly rural and close to the coast, where better dispersion is likely as a result of higher winds. Monitored NO_2 concentrations at diffusion tube number 6 (Buie Rigg, Kirkliston) are highest. Diffusion tube number 6 was located near M9 Junction 1A along the A8000, where higher NO_2 concentrations would be expected. However, the results show that the annual average NO_2 concentration at all diffusion tube locations was well below the air quality objective and limit value, even when accounting for the uncertainty in the monitoring method (see Appendix A15.1: Air Quality Model Evaluation).

Nitrogen Deposition Rates

15.3.27 As described in paragraph 15.2.42 the designated sites of nature conservation interest in the study area include the Firth of Forth SSSI, the Ferry Hills SSSI and the St. Margaret's Marsh SSSI.

15.3.28 Table 15.13 lists designated nature conservation sites included in this study, the reasons for their designation and critical loads for the features of special interest. The background nitrogen deposition rates (in kg/ha/yr) were taken from the APIS website (www.apis.ac.uk) for grid references 312029, 678687 (Firth of Forth SSSI), 312070, 681475 (St. Margaret's Marsh SSSI) and 312545, 681673 (Ferry Hills SSSI). Figure 15.1 shows the locations of assessed SSSIs.

Table 15.13: Nitrogen Critical Loads and Background Deposition Rates (2004*) (Kg N/ha/yr)

Designated site	Features of Special Interest	Critical Load	Background Deposition (Total Rate)
Firth of Forth SSSI	Neutral grassland	10-20	12.7
	Fen, marsh and swamp	10-35	12.7
St Margaret's Marsh SSSI	Saltmarsh fen; marsh and swamp	10-35	12.3
Ferry Hills SSSI	Calcareous grassland	15-25	12.3

* 2004 provides latest available data

Discrete Receptor Assessment – 2005 Base Year

15.3.29 Results of the base year calculations for the 51 discrete receptors as shown in Table 15.5 are included in the result tables in Section 15.4, Tables 15.16-15.17, Tables 15.20-15.21 and Table 15.24. The results show that generally pollutant concentrations in 2005 were below the relevant limit values. This is further discussed in Section 15.4.

15.3.30 With regards to nitrogen deposition, Table 15.14 lists the existing nitrogen deposition rates in 2005 for the three assessed designated sites, which are shown on Figure 15.1. Due to the fact that the Firth of Forth SSSI is crossed by the Forth Road Bridge and the Main Crossing, two different areas of the SSSI have been assessed. Similarly, three separate units of the Ferry Hills SSSI have been assessed as this SSSI comprises separate areas.

Table 15.14: Nitrogen Deposition Rates in 2005 (Kg N/ha/yr)

Receptor Name	Dry Deposition Rate in 2005	Total Deposition Rate* in 2005	Critical Load
Firth of Forth SSSI Unit 1	2.73	12.73	10-35
Firth of Forth SSSI Unit 2	2.76	12.76	10-35
St Margaret's Marsh SSSI	2.92	12.53	10-35
Ferry Hills SSSI Unit 1	3.47	13.08	15-25
Ferry Hills SSSI Unit 2	3.14	12.75	15-25
Ferry Hills SSSI Unit 3	3.65	13.25	15-25

* Total deposition rate comprises dry and wet deposition

15.3.31 Table 15.14 shows that in 2005 the lower levels of critical load bands are exceeded for the Firth of Forth SSSI and St. Margaret's Marsh SSSI but not for the Ferry Hills SSSI.

Total Pollutant Emissions

15.3.32 Regional emissions for 2005 have been calculated taking into account existing traffic flows, traffic composition and speeds along the full TMfS:05 transport network (shown on Figure 15.3). The aim of calculating total emissions is to enable a comparison between the Do-Minimum and Do-Something scenarios with regards to the pollutant emissions generated. The extent of the study area for the regional assessment should be as wide as possible to include changes in traffic resulting from the proposed scheme in areas that might be affected by the proposed scheme even if they are not in the immediate vicinity. Differences in emissions between the scenarios with and without the proposed scheme are reported in tonnes per annum rather than percentages as the actual tonnage of pollutant emitted per annum should be independent from the extent of the area provided it includes all affected road links. Emissions for NO_x, PM_{10} and CO_2 are presented in Table 15.15.

Table 15.15: Total Emissions within TMfS:05a Network 2005

Pollutant	Emissions (tonnes per annum)	Total vehicle kilometres travelled
NO_x	38,212	89,171,204
PM_{10}	1,222	
CO_2	8,424,191	

15.4 Potential Impacts

Introduction

15.4.1 The results of the assessment of local air quality impacts associated with the proposed scheme are presented below in terms of predicted air quality at local receptors and changes in nitrogen deposition at sensitive receptor sites. The results are presented by providing a baseline concentration (2005) and comparing the Do-Minimum and Do-Something scenarios for the years 2017 and 2032. In addition, this section includes the assessment of the regional air quality impacts.

Impacts on Local Air Quality

Model Evaluation

15.4.2 As described in Section 15.2, model verification was carried out by comparing the model results of annual mean NO_2 concentrations at receptor locations equivalent to existing monitoring locations within the study area. The results of the model evaluation are summarised and discussed in Appendix A15.1 (Air Quality Model Evaluation).

Model Results and Assessment of Significance

NO_2 Concentrations

15.4.3 Table 15.16 illustrates the annual mean NO_2 concentrations at modelled receptor points for the assessed years and scenarios and Table 15.17 shows the modelled NO_2 hourly mean concentrations (99.79th percentile). Figures 15.5 to 15.9 provide contour plots for the annual mean NO_2 concentrations for each of the modelled scenarios. Figures 15.10 and 15.11 show difference plots for annual mean NO_2 concentration differences between the Do-Minimum and Do-Something scenarios in 2017 and 2032 respectively.

Table 15.16: Modelled Annual Mean NO_2 Concentrations* ($\mu g/m^3$)

No	Location	2005	2017		2032	
		Base	Do-Minimum	Do-Something	Do-Minimum	Do-Something
R1	18 Westfield Grove, Crossgates	32.3	29.6	29.6	28.5	28.6
R2	Ardshallah, Inverkeithing Road, Crossgates	29.3	27.7	27.7	26.2	26.3
R3	18 Sandybank, Halbeath	32.1	29.6	29.6	28.3	28.3
R4	119 Dunfermline Rd, Crossgates	31.1	28.7	28.7	27.3	27.4
R5	Crossgates Primary School, Crossgates	29.4	27.9	27.9	26.5	26.5
R6	Touch Primary School, Dunfermline	28.0	27.2	27.2	25.7	25.7
R7	St Columba's High School, Dunfermline	27.8	27.0	27.0	25.5	25.5
R8	71 Meldrum Court, Dunfermline	28.2	27.1	27.1	25.6	25.6
R9	Mid Duloch Farm, Inverkeithing	29.1	27.7	27.8	26.4	26.4
R10	Ferry Craig House, North Queensferry	28.7	26.9	26.7	25.4	25.2
R11	15 Ferry Barns Court, North Queensferry	29.9	27.4	26.6	26.0	25.1

No	Location	2005	2017		2032	
		Base	Do-Minimum	Do-Something	Do-Minimum	Do-Something
R12	St Margaret's Hope Lodge, North Queensferry	28.4	26.8	28.8	25.3	27.3
R13	24 Ferry Hills Road, North Queensferry	29.9	27.0	27.6	26.0	26.1
R14	18 Whinny Hill Crescent, Inverkeithing	30.6	28.0	28.2	26.5	26.9
R15	The Bungalow, Dunfermline	30.1	28.4	28.5	27.1	27.2
R16	25 Park Lea, Rosyth	30.6	28.7	28.7	27.4	27.5
R17	Inverkeithing High School, Hillend Road	28.8	27.3	27.4	25.8	25.9
R18	39 Burleigh Crescent, Inverkeithing	29.0	27.4	27.5	26.0	26.1
R19	25 Admiralty Rd, Rosyth	30.3	28.4	28.5	26.9	27.1
R20	18 Castlandhill Road, Rosyth	28.9	27.3	27.2	25.8	25.8
R21	114 Castlandhill Road, Rosyth	29.4	27.6	27.7	26.1	26.3
R22	5 Mucklehill Park, Inverkeithing	30.5	28.0	28.2	26.5	26.9
R23	231 Queensferry Road, Rosyth	28.1	26.9	27.0	25.5	25.6
R24	7 Letham Hill Way, Hillend	29.0	27.3	27.4	25.8	25.9
R25	St Margaret's Hope, North Queensferry	27.9	26.5	30.3	25.0	28.9
R26	14 Farquhar Terrace, South Queensferry	28.8	27.4	27.0	26.1	25.5
R27	Plewlands House, South Queensferry	28.6	27.3	26.8	25.9	25.3
R28	45 Stoneyflats Cres., South Queensferry	29.7	28.2	26.8	26.9	25.4
R29	10 Scotstoun Green, South Queensferry	29.4	27.9	27.5	26.6	26.3
R30	68 Echline Drive, South Queensferry	28.4	27.4	28.1	26.3	26.9
R31	7 Linnmill, South Queensferry	27.3	26.7	27.5	25.2	26.0
R32	12 Dundas Home Farm	28.2	27.3	27.9	25.9	26.5
R33	11 Main Street, Newton	30.7	28.8	29.1	28.2	28.5
R34	39 Cotlaws, Kirkliston	32.9	30.0	30.1	29.3	29.0
R35	1 Beatly Road, Winchburgh	28.6	27.3	27.3	26.9	27.0
R36	2 Millrig Cottages, Kirkliston	31.3	28.8	28.6	28.2	28.1
R37	2 Newmains Road, Kirkliston	29.1	28.0	27.5	27.0	26.6
R38	35 Main Street, Kirkliston	30.6	28.9	28.4	28.7	28.4
R39	15 Springfield Terr., South Queensferry	27.7	26.9	27.4	25.5	26.1
R40	1 Winchburgh Road, Winchburgh	30.5	28.6	29.0	28.1	28.8
R41	Newbigging Lodge, Dundas Home Farm	29.2	28.0	28.2	26.7	26.9
R42	21 Long Crook, South Queensferry	29.7	28.2	27.3	27.2	26.1
R43	16 Main Street, Dalmeny	28.2	27.1	27.1	25.7	25.7
R44	61 Glasgow Road, Newbridge	35.0	31.0	31.0	29.9	30.0
R45	16 Bennet Wood Terrace, Winchburgh	28.5	27.5	27.8	27.1	27.1
R46	Standingstone Cottage	27.7	26.8	26.7	25.4	25.3
R47	21 Echline, South Queensferry	31.1	29.1	27.8	28.6	26.8
R48	Queensferry Primary School, South Queensferry	29.5	27.7	27.2	26.5	25.8
R49	Echline Primary School, South Queensferry	28.0	27.1	27.0	25.8	25.6
R50	104 Glasgow Road, Newbridge	35.3	31.1	31.1	30.0	30.1
R51	Inchgarvie House, South Queensferry	27.3	26.7	28.6	25.0	27.2

* Numbers are rounded to 1 decimal place

Table 15.17: Modelled 99.79th Percentile of Hourly Mean NO_2 Concentrations* (µg/m^3)

No	Location	2005	2017		2032	
		Base	Do-Minimum	Do-Something	Do-Minimum	Do-Something
R1	18 Westfield Grove, Crossgates	103.4	136.9	136.9	129.0	129.1
R2	Ardshallah, Inverkeithing Road, Crossgates	100.3	135.9	135.9	127.6	127.7
R3	18 Sandybank, Halbeath	99.5	135.7	135.7	127.5	127.4
R4	119 Dunfermline Rd, Crossgates	101.5	136.1	136.1	127.9	128.0
R5	Crossgates Primary School, Crossgates	99.8	135.5	135.6	127.3	127.3
R6	Touch Primary School, Dunfermline	98.5	135.2	135.2	127.0	127.0
R7	St Columba's High School, Dunfermline	98.4	135.2	135.2	126.9	126.9
R8	71 Meldrum Court, Dunfermline	98.8	135.1	135.1	126.9	126.9
R9	Mid Duloch Farm, Inverkeithing	99.6	135.5	135.5	127.4	127.4
R10	Ferry Craig House, North Queensferry	98.2	133.8	135.5	125.6	127.2
R11	15 Ferry Barns Court, North Queensferry	101.6	136.6	135.4	128.4	127.2
R12	St Margaret's Hope Lodge, North Queensferry	98.9	134.6	136.2	126.3	127.9
R13	24 Ferry Hills Road, North Queensferry	99.5	135.6	136.1	127.9	127.9
R14	18 Whinny Hill Crescent, Inverkeithing	99.9	136.2	136.4	128.0	128.2
R15	The Bungalow, Dunfermline	99.1	135.1	135.1	126.9	126.9
R16	25 Park Lea, Rosyth	99.1	135.4	135.4	127.1	127.1
R17	Inverkeithing High School, Hillend Road	99.2	135.6	135.6	127.3	127.4
R18	39 Burleigh Crescent, Inverkeithing	99.0	135.5	135.5	127.2	127.2
R19	25 Admiralty Rd, Rosyth	98.5	135.2	135.2	127.0	127.1
R20	18 Castlandhill Road, Rosyth	98.9	135.0	135.0	126.8	126.8
R21	114 Castlandhill Road, Rosyth	98.8	135.3	135.3	127.1	127.1
R22	5 Mucklehill Park, Inverkeithing	100.0	136.2	136.4	128.0	128.2
R23	231 Queensferry Road, Rosyth	98.9	135.1	135.1	126.9	126.9
R24	7 Letham Hill Way, Hillend	100.1	135.4	135.4	127.2	127.2
R25	St Margaret's Hope, North Queensferry	98.4	136.9	136.9	125.1	128.7
R26	14 Farquhar Terrace, South Queensferry	99.9	136.1	135.4	127.9	127.2
R27	Plewlands House, South Queensferry	99.9	135.4	135.2	127.3	127.0
R28	45 Stoneyflats Cres., South Queensferry	99.4	135.7	135.2	127.5	127.0
R29	10 Scotstoun Green, South Queensferry	100.4	135.7	135.6	127.6	127.4
R30	68 Echline Drive, South Queensferry	99.7	135.3	135.8	127.2	127.6
R31	7 Linnmill, South Queensferry	99.4	135.0	134.9	126.8	126.8
R32	12 Dundas Home Farm	99.3	135.8	135.6	127.6	127.4
R33	11 Main Street, Newton	101.8	136.8	137.1	129.2	130.4
R34	39 Cotlaws, Kirkliston	105.8	137.8	137.9	130.3	130.0
R35	1 Beatly Road, Winchburgh	98.2	135.3	135.4	127.3	127.6
R36	2 Millrig Cottages, Kirkliston	101.6	136.2	136.1	128.5	128.4
R37	2 Newmains Road, Kirkliston	99.5	135.9	135.6	127.7	127.7
R38	35 Main Street, Kirkliston	101.6	137.1	136.4	129.6	129.3
R39	15 Springfield Terr., South Queensferry	99.4	135.1	135.6	126.9	127.4
R40	1 Winchburgh Road, Winchburgh	101.0	136.3	136.9	128.6	130.4

No	Location	2005	2017		2032	
		Base	Do-Minimum	Do-Something	Do-Minimum	Do-Something
R41	Newbigging Lodge, Dundas Home Farm	99.3	135.8	135.7	127.5	127.4
R42	21 Long Crook, South Queensferry	100.9	135.9	135.4	128.0	127.3
R43	16 Main Street, Dalmeny	99.9	135.2	135.2	127.1	127.0
R44	61 Glasgow Road, Newbridge	106.9	138.4	138.4	130.4	130.5
R45	16 Bennet Wood Terrace, Winchburgh	98.4	135.6	135.6	127.4	127.4
R46	Standingstone Cottage	99.5	135.2	135.2	127.1	127.0
R47	21 Echline, South Queensferry	103.5	137.7	135.9	130.7	128.0
R48	Queensferry Primary School, South Queensferry	101.2	135.9	135.5	127.9	127.5
R49	Echline Primary School, South Queensferry	99.4	135.1	135.4	127.0	127.2
R50	104 Glasgow Road, Newbridge	105.5	138.2	138.1	130.2	130.2
R51	Inchgarvie House, South Queensferry	99.4	135.0	135.6	126.6	127.4

* Numbers are rounded to 1 decimal place

15.4.4 The results show that annual mean NO_2 concentrations are well below (i.e. less that 75% of the standard) the relevant objective and limit value of 40㎍/m^3 for the vast majority of receptors in all assessed future years and scenarios. Whilst concentrations at receptors R25 (St Margaret's Hope), R34 (39 Cotlaws), R44 (61 Glasgow Road) and R50 (104 Glasgow Road) are not predicted to be 'well below' (as defined in the footnote to Table 15.8) the objective and limit value, they are still comfortably within the objective and limit value. Similarly, modelled concentrations in 2005, whilst not 'well below' the objective and limit value at all receptors, are also all comfortably below the objective and limit value.

15.4.5 Forecast annual mean NO_2 concentrations for the assessed future year scenarios 2017 and 2032, with and without the proposed development are lower than those experienced at present for the vast majority of assessed receptors. This is expected due to predicted improvements in vehicle technology in the future.

15.4.6 The results of the 99.79th percentile of the hourly mean NO_2 concentrations show that at all receptor locations and for all assessed years and scenarios the hourly mean concentrations of NO_2 are well below the objective and limit value of 200㎍/m^3. The increase in the 99.79th percentile of the hourly mean NO_2 concentrations between the base year and future year scenarios is a result of different percentile distributions in the background monitoring data in 2005 and 2008, i.e. 2008 background monitoring data (from Edinburgh St Leonards monitoring site) have been used as the basis for calculating future year background concentrations and as 2008 pollutant concentrations are significantly higher than 2005 concentrations, the 99.79th percentiles of hourly NO_2 concentrations even when projected forward to 2017/2032 remain higher than in 2005.

15.4.7 Table 15.18 and Table 15.19 show the modelled percentage difference, resulting magnitude of change and significance in annual mean NO_2 concentrations for 2017 and 2032.

Table 15.18: Assessment of Significance for NO_2 in 2017

No	Location	2017		
		Modelled % Change*	Magnitude of Change	Significance
R1	18 Westfield Grove, Crossgates	+0.1	Extremely Small	Negligible
R2	Ardshallah, Inverkeithing Road, Crossgates	+0.1	Extremely Small	Negligible
R3	18 Sandybank, Halbeath	+0.1	Extremely Small	Negligible
R4	119 Dunfermline Rd, Crossgates	+0.1	Extremely Small	Negligible

No	Location	2017		
		Modelled % Change*	Magnitude of Change	Significance
R5	Crossgates Primary School, Crossgates	+0.1	Extremely Small	Negligible
R6	Touch Primary School, Dunfermline	0.0	Extremely Small	Negligible
R7	St Columba's High School, Dunfermline	+0.1	Extremely Small	Negligible
R8	71 Meldrum Court, Dunfermline	+0.1	Extremely Small	Negligible
R9	Mid Duloch Farm, Inverkeithing	+0.2	Extremely Small	Negligible
R10	Ferry Craig House, North Queensferry	-0.8	Extremely Small	Negligible
R11	15 Ferry Barns Court, North Queensferry	-3.0	Very Small	Negligible
R12	St Margaret's Hope Lodge, North Queensferry	+7.2	Small	Slight Adverse
R13	24 Ferry Hills Road, North Queensferry	+2.0	Very Small	Negligible
R14	18 Whinny Hill Crescent, Inverkeithing	+1.0	Very Small	Negligible
R15	The Bungalow, Dunfermline	+0.3	Extremely Small	Negligible
R16	25 Park Lea, Rosyth	+0.3	Extremely Small	Negligible
R17	Inverkeithing High School, Hillend Road	+0.4	Extremely Small	Negligible
R18	39 Burleigh Crescent, Inverkeithing	+0.4	Extremely Small	Negligible
R19	25 Admiralty Rd, Rosyth	+0.3	Extremely Small	Negligible
R20	18 Castlandhill Road, Rosyth	0.0	Extremely Small	Negligible
R21	114 Castlandhill Road, Rosyth	+0.3	Extremely Small	Negligible
R22	5 Mucklehill Park, Inverkeithing	+1.0	Very Small	Negligible
R23	231 Queensferry Road, Rosyth	+0.1	Extremely Small	Negligible
R24	7 Letham Hill Way, Hillend	+0.2	Extremely Small	Negligible
R25	St Margaret's Hope, North Queensferry	+14.0	Medium	Moderate Adverse
R26	14 Farquhar Terrace, South Queensferry	-1.7	Very Small	Negligible
R27	Plewlands House, South Queensferry	-2.0	Very Small	Negligible
R28	45 Stoneyflats Crescent, South Queensferry	-5.3	Small	Slight Beneficial
R29	10 Scotstoun Green, South Queensferry	-1.4	Very Small	Negligible
R30	68 Echline Drive, South Queensferry	+2.6	Very Small	Negligible
R31	7 Linnmill, South Queensferry	+3.0	Very Small	Negligible
R32	12 Dundas Home Farm	+2.0	Very Small	Negligible
R33	11 Main Street, Newton	+1.3	Very Small	Negligible
R34	39 Cotlaws, Kirkliston	+0.5	Extremely Small	Negligible
R35	1 Beatly Road, Winchburgh	0.0	Extremely Small	Negligible
R36	2 Millrig Cottages, Kirkliston	-0.5	Extremely Small	Negligible
R37	2 Newmains Road, Kirkliston	-2.0	Very Small	Negligible
R38	35 Main Street, Kirkliston	-2.0	Very Small	Negligible
R39	15 Springfield Terrace, South Queensferry	+2.0	Very Small	Negligible
R40	1 Winchburgh Road, Winchburgh	+1.3	Very Small	Negligible
R41	Newbigging Lodge, Dundas Home Farm	+0.6	Extremely Small	Negligible
R42	21 Long Crook, South Queensferry	-3.4	Very Small	Negligible
R43	16 Main Street, Dalmeny	+0.2	Extremely Small	Negligible
R44	61 Glasgow Road, Newbridge	0.0	Extremely Small	Negligible
R45	16 Bennet Wood Terrace, Winchburgh	+1.1	Very Small	Negligible
R46	Standingstone Cottage	-0.5	Extremely Small	Negligible

No	Location	2017		
		Modelled % Change*	Magnitude of Change	Significance
R47	21 Echline, South Queensferry	-4.6	Very Small	Negligible
R48	Queensferry Primary School, South Queensferry	-2.2	Very Small	Negligible
R49	Echline Primary School, South Queensferry	+0.4	Extremely Small	Negligible
R50	104 Glasgow Road, Newbridge	0.0	Extremely Small	Negligible
R51	Inchgarvie House, South Queensferry	+7.3	Small	Slight Adverse

* This is the percentage change between the 2017 Do-Minimum and Do-Something concentrations reported in Table 15.16.

Table 15.19: Assessment of Significance for NO_2 in 2032

No	Location	2032		
		Modelled % Change	Magnitude of Change	Significance
R1	18 Westfield Grove, Crossgates	+0.4	Extremely Small	Negligible
R2	Ardshallah, Inverkeithing Road, Crossgates	+0.4	Extremely Small	Negligible
R3	18 Sandybank, Halbeath	0.0	Extremely Small	Negligible
R4	119 Dunfermline Rd, Crossgates	+0.3	Extremely Small	Negligible
R5	Crossgates Primary School, Crossgates	+0.2	Extremely Small	Negligible
R6	Touch Primary School, Dunfermline	0.0	Extremely Small	Negligible
R7	St Columba's High School, Dunfermline	+0.1	Extremely Small	Negligible
R8	71 Meldrum Court, Dunfermline	+0.1	Extremely Small	Negligible
R9	Mid Duloch Farm, Inverkeithing	+0.2	Extremely Small	Negligible
R10	Ferry Craig House, North Queensferry	-1.1	Very Small	Negligible
R11	15 Ferry Barns Court, North Queensferry	-3.6	Very Small	Negligible
R12	St Margaret's Hope Lodge, North Queensferry	+7.9	Small	Slight Adverse
R13	24 Ferry Hills Road, North Queensferry	+0.4	Extremely Small	Negligible
R14	18 Whinny Hill Crescent, Inverkeithing	+1.4	Very Small	Negligible
R15	The Bungalow, Dunfermline	+0.5	Extremely Small	Negligible
R16	25 Park Lea, Rosyth	+0.4	Extremely Small	Negligible
R17	Inverkeithing High School, Hillend Road	+0.4	Extremely Small	Negligible
R18	39 Burleigh Crescent, Inverkeithing	+0.5	Extremely Small	Negligible
R19	25 Admiralty Rd, Rosyth	+0.7	Extremely Small	Negligible
R20	18 Castlandhill Road, Rosyth	+0.2	Extremely Small	Negligible
R21	114 Castlandhill Road, Rosyth	+0.7	Extremely Small	Negligible
R22	5 Mucklehill Park, Inverkeithing	+1.6	Very Small	Negligible
R23	231 Queensferry Road, Rosyth	+0.3	Extremely Small	Negligible
R24	7 Letham Hill Way, Hillend	+0.3	Extremely Small	Negligible
R25	St Margaret's Hope, North Queensferry	+15.4	Large	Slight Adverse
R26	14 Farquhar Terrace, South Queensferry	-2.0	Very Small	Negligible
R27	Plewlands House, South Queensferry	-2.3	Very Small	Negligible
R28	45 Stoneyflats Crescent, South Queensferry	-6.0	Small	Slight Beneficial
R29	10 Scotstoun Green, South Queensferry	-1.0	Very Small	Negligible
R30	68 Echline Drive, South Queensferry	+2.4	Very Small	Negligible
R31	7 Linnmill, South Queensferry	+3.1	Very Small	Negligible
R32	12 Dundas Home Farm	+2.3	Very Small	Negligible

No	Location	2032		
		Modelled % Change	Magnitude of Change	Significance
R33	11 Main Street, Newton	+0.9	Extremely Small	Negligible
R34	39 Cotlaws, Kirkliston	-0.8	Extremely Small	Negligible
R35	1 Beatly Road, Winchburgh	+0.3	Extremely Small	Negligible
R36	2 Millrig Cottages, Kirkliston	-0.4	Extremely Small	Negligible
R37	2 Newmains Road, Kirkliston	-1.5	Very Small	Negligible
R38	35 Main Street, Kirkliston	-1.3	Very Small	Negligible
R39	15 Springfield Terrace, South Queensferry	+2.0	Very Small	Negligible
R40	1 Winchburgh Road, Winchburgh	+2.4	Very Small	Negligible
R41	Newbigging Lodge, Dundas Home Farm	+0.9	Extremely Small	Negligible
R42	21 Long Crook, South Queensferry	-4.5	Very Small	Negligible
R43	16 Main Street, Dalmeny	+0.2	Extremely Small	Negligible
R44	61 Glasgow Road, Newbridge	+0.3	Extremely Small	Negligible
R45	16 Bennet Wood Terrace, Winchburgh	0.0	Extremely Small	Negligible
R46	Standingstone Cottage	-0.5	Extremely Small	Negligible
R47	21 Echline, South Queensferry	-6.5	Small	Slight Beneficial
R48	Queensferry Primary School, South Queensferry	-2.5	Very Small	Negligible
R49	Echline Primary School, South Queensferry	-0.7	Extremely Small	Negligible
R50	104 Glasgow Road, Newbridge	+0.3	Extremely Small	Negligible
R51	Inchgarvie House, South Queensferry	+8.9	Small	Slight Adverse

* This is the percentage change between the 2032 Do-Minimum and Do-Something concentrations reported in Table 15.16.

15.4.8 The magnitude of change for the majority of receptors in both 2017 and 2032 is very small or extremely small. In 2017 there are three receptors with small magnitude of change and one receptor R25 (St Margaret's Hope) with medium magnitude of change. The predicted concentrations at receptor R25 are below the objective and limit value, but not well below. The resulting significance of effect for receptor R25 is Moderate Adverse. The significance of effect for the majority of remaining receptors is rated as Negligible, Slight Adverse or Slight Beneficial significance.

15.4.9 In 2032 there are four receptors with small magnitude of change and one receptor R25 (St. Margaret's Hope) with a large magnitude of change, however, the predicted concentrations are well below the objective and limit value. The resulting significance of effect for the majority of receptors is Negligible. Some receptors are predicted to experience impacts of Slight Adverse or Slight Beneficial significance. Receptor R25 (St. Margaret's Hope) is predicted to experience impacts of Slight Adverse significance.

15.4.10 The annual mean NO_2 concentration contours for 2017 and 2032 for both the Do-Minimum and Do-Something scenarios show that NO_2 concentration objectives and limit values are met everywhere within the study area except at a small stretch on the M8, which has no relevant exposure (i.e. there are no sensitive properties where the air quality objectives would apply within the exceedance area).

15.4.11 The difference contour plots (Figures 15.10 and 15.11) show that with the proposed scheme there would be improvements with regards to local air quality around the Forth Road Bridge and deteriorations around areas of the Main Crossing. This is because traffic flows will shift from the Forth Road Bridge to the Main Crossing and hence areas around the Forth Road Bridge, which are exposed to elevated pollutant concentrations due to high traffic flows in the Do-Minimum scenario are predicted to experience an improvement of local air quality as traffic flows decrease. Equally, areas around the Main Crossing, with no traffic flows in the Do-Minimum scenario, will experience a

sharp increase in traffic volume and hence deterioration of local air quality. Due to the scale of the area affected by the proposed scheme, there are receptors in the vicinity of the Main Crossing which are predicted to experience deterioration of local air quality but are not covered by the assessment of discrete receptors as provided above. However, the contour plots provided show that whilst there are receptors that are likely to experience an increase in pollutant levels as a result of the proposed scheme, total concentrations at these locations (i.e. receptors along Society Road and Clufflat) are still well below the relevant limit values and objectives.

PM_{10} Concentrations

15.4.12 Table 15.20 presents calculated annual mean PM_{10} concentrations for 2017 and 2032 for the Do-Minimum and Do-Something scenarios. Table 15.21 shows the results of the calculated daily mean (98.08th percentile) PM_{10} concentrations. Annual mean PM_{10} concentration contour plots for the assessed years and scenarios are shown on Figures 15.12 to 15.16. Difference plots are provided in Figures 15.17 and 15.18. Contour plots for the daily mean (98.08th percentile) PM_{10} concentrations are provided in Figures 15.19 to 15.23.

Table 15.20: Modelled Annual Mean PM_{10} Concentrations* (µg/m^3)

No	Location	2005	2017		2032	
		Base	Do-Minimum	Do-Something	Do-Minimum	Do-Something
R1	18 Westfield Grove, Crossgates	18.9	14.2	14.2	14.0	14.1
R2	Ardshallah, Inverkeithing Road, Crossgates	18.6	14.0	14.0	13.8	13.9
R3	18 Sandybank, Halbeath	18.9	14.2	14.2	14.0	14.0
R4	119 Dunfermline Rd, Crossgates	18.8	14.1	14.1	13.9	13.9
R5	Crossgates Primary School, Crossgates	18.6	14.0	14.0	13.8	13.8
R6	Touch Primary School, Dunfermline	18.5	14.0	14.0	13.8	13.8
R7	St Columba's High School, Dunfermline	18.5	13.9	13.9	13.8	13.8
R8	71 Meldrum Court, Dunfermline	18.5	14.0	14.0	13.8	13.8
R9	Mid Duloch Farm, Inverkeithing	18.6	14.0	14.0	13.8	13.8
R10	Ferry Craig House, North Queensferry	18.6	14.0	14.0	13.8	13.8
R11	15 Ferry Barns Court, North Queensferry	18.7	14.1	14.0	13.9	13.8
R12	St Margaret's Hope Lodge, North Queensferry	18.4	14.0	14.2	13.8	14.0
R13	24 Ferry Hills Road, North Queensferry	18.7	14.0	14.0	13.9	13.9
R14	18 Whinny Hill Crescent, Inverkeithing	18.8	14.1	14.1	13.9	14.0
R15	The Bungalow, Dunfermline	18.7	14.1	14.1	13.9	13.9
R16	25 Park Lea, Rosyth	18.7	14.1	14.1	14.0	14.0
R17	Inverkeithing High School, Hillend Road	18.6	14.0	14.0	13.8	13.8
R18	39 Burleigh Crescent, Inverkeithing	18.6	14.0	14.0	13.8	13.8
R19	25 Admiralty Rd, Rosyth	18.7	14.1	14.1	13.9	13.9
R20	18 Castlandhill Road, Rosyth	18.6	14.0	14.0	13.8	13.8
R21	114 Castlandhill Road, Rosyth	18.6	14.0	14.0	13.8	13.9
R22	5 Mucklehill Park, Inverkeithing	18.7	14.1	14.1	13.9	14.0
R23	231 Queensferry Road, Rosyth	18.5	14.0	14.0	13.8	13.8
R24	7 Letham Hill Way, Hillend	18.6	14.0	14.0	13.8	13.8
R25	St Margaret's Hope, North Queensferry	18.5	13.9	14.5	13.8	14.4
R26	14 Farquhar Terrace, South Queensferry	18.6	14.0	14.0	13.8	13.8
R27	Plewlands House, South Queensferry	18.5	14.0	13.9	13.8	13.8

No	Location	2005	2017		2032	
		Base	Do-Minimum	Do-Something	Do-Minimum	Do-Something
R28	45 Stoneyflats Crescent, South Queensferry	18.6	14.0	13.9	13.9	13.8
R29	10 Scotstoun Green, South Queensferry	18.6	14.0	14.0	13.9	13.8
R30	68 Echline Drive, South Queensferry	18.5	14.0	14.1	13.8	13.9
R31	7 Linnmill, South Queensferry	18.4	13.9	14.0	13.7	13.8
R32	12 Dundas Home Farm	18.5	14.0	14.0	13.8	13.8
R33	11 Main Street, Newton	18.8	14.1	14.2	14.0	14.1
R34	39 Cotlaws, Kirkliston	19.2	14.4	14.5	14.3	14.4
R35	1 Beatly Road, Winchburgh	18.6	14.0	14.0	13.9	13.9
R36	2 Millrig Cottages, Kirkliston	18.7	14.1	14.1	13.9	14.0
R37	2 Newmains Road, Kirkliston	18.6	14.1	14.0	13.9	13.9
R38	35 Main Street, Kirkliston	18.8	14.2	14.1	14.1	14.1
R39	15 Springfield Terrace, South Queensferry	18.5	13.9	14.0	13.8	13.8
R40	1 Winchburgh Road, Winchburgh	18.8	14.1	14.2	14.0	14.1
R41	Newbigging Lodge, Dundas Home Farm	18.6	14.0	14.0	13.8	13.9
R42	21 Long Crook, South Queensferry	18.6	14.0	14.0	13.9	13.8
R43	16 Main Street, Dalmeny	18.5	13.9	14.0	13.8	13.8
R44	61 Glasgow Road, Newbridge	19.3	14.4	14.4	14.2	14.2
R45	16 Bennet Wood Terrace, Winchburgh	18.5	14.0	14.0	13.9	13.9
R46	Standingstone Cottage	18.5	13.9	13.9	13.8	13.8
R47	21 Echline, South Queensferry	18.9	14.2	14.1	14.1	13.9
R48	Queensferry Primary School, South Queensferry	18.7	14.0	14.0	13.9	13.8
R49	Echline Primary School, South Queensferry	18.5	13.9	13.9	13.8	13.8
R50	104 Glasgow Road, Newbridge	19.3	14.4	14.4	14.2	14.2
R51	Inchgarvie House, South Queensferry	18.4	13.9	14.1	13.7	13.9

*Numbers are rounded to 1 decimal place

Table 15.21: Modelled 98.08th Percentile of Daily Mean PM_{10} Concentrations* ($\mu g/m^3$)

No	Location	2005	2017		2032	
		Base	Do-Minimum	Do-Something	Do-Minimum	Do-Something
R1	18 Westfield Grove, Crossgates	36.4	34.4	34.4	34.0	34.1
R2	Ardshallah, Inverkeithing Road, Crossgates	36.4	34.1	34.1	33.7	33.7
R3	18 Sandybank, Halbeath	37.4	34.0	34.0	33.6	33.6
R4	119 Dunfermline Rd, Crossgates	36.5	34.2	34.2	33.8	33.8
R5	Crossgates Primary School, Crossgates	36.4	34.1	34.1	33.7	33.7
R6	Touch Primary School, Dunfermline	36.4	34.0	34.0	33.6	33.6
R7	St Columba's High School, Dunfermline	36.4	34.0	34.0	33.5	33.5
R8	71 Meldrum Court, Dunfermline	36.4	34.0	34.0	33.6	33.6
R9	Mid Duloch Farm, Inverkeithing	36.5	34.1	34.1	33.6	33.6
R10	Ferry Craig House, North Queensferry	36.7	34.0	34.1	33.5	33.6
R11	15 Ferry Barns Court, North Queensferry	36.3	34.2	34.0	33.8	33.6

No	Location	2005	2017		2032	
		Base	Do-Minimum	Do-Something	Do-Minimum	Do-Something
R12	St Margaret's Hope Lodge, North Queensferry	36.3	34.0	34.0	33.5	33.5
R13	24 Ferry Hills Road, North Queensferry	36.3	34.1	34.2	33.8	33.8
R14	18 Whinny Hill Crescent, Inverkeithing	36.4	34.3	34.3	33.8	33.9
R15	The Bungalow, Dunfermline	36.6	34.1	34.1	33.7	33.7
R16	25 Park Lea, Rosyth	37.1	34.0	34.0	33.5	33.5
R17	Inverkeithing High School, Hillend Road	36.5	34.1	34.1	33.6	33.6
R18	39 Burleigh Crescent, Inverkeithing	36.5	34.1	34.1	33.6	33.6
R19	25 Admiralty Rd, Rosyth	36.9	34.0	34.0	33.6	33.6
R20	18 Castlandhill Road, Rosyth	36.5	34.0	34.0	33.6	33.6
R21	114 Castlandhill Road, Rosyth	36.7	34.0	34.0	33.6	33.6
R22	5 Mucklehill Park, Inverkeithing	36.4	34.3	34.3	33.8	33.9
R23	231 Queensferry Road, Rosyth	36.4	34.0	34.0	33.6	33.6
R24	7 Letham Hill Way, Hillend	36.4	34.1	34.1	33.7	33.7
R25	St Margaret's Hope, North Queensferry	36.5	34.0	34.2	33.5	33.8
R26	14 Farquhar Terrace, South Queensferry	36.5	34.0	34.1	33.6	33.7
R27	Plewlands House, South Queensferry	36.4	34.1	34.0	33.6	33.6
R28	45 Stoneyflats Cres., South Queensferry	36.9	34.0	34.0	33.6	33.6
R29	10 Scotstoun Green, South Queensferry	36.3	34.2	34.2	33.8	33.8
R30	68 Echline Drive, South Queensferry	36.4	34.1	34.3	33.7	33.9
R31	7 Linnmill, South Queensferry	36.4	34.0	34.0	33.5	33.5
R32	12 Dundas Home Farm	36.5	34.0	34.0	33.5	33.5
R33	11 Main Street, Newton	36.6	34.3	34.3	34.0	34.0
R34	39 Cotlaws, Kirkliston	36.4	34.8	35.1	34.6	34.7
R35	1 Beatly Road, Winchburgh	36.6	34.0	34.0	33.6	33.6
R36	2 Millrig Cottages, Kirkliston	36.7	34.1	34.1	33.7	33.7
R37	2 Newmains Road, Kirkliston	36.6	34.0	34.0	33.6	33.6
R38	35 Main Street, Kirkliston	36.6	34.3	34.2	34.0	33.9
R39	15 Springfield Terrace, South Queensferry	36.4	34.0	34.1	33.6	33.7
R40	1 Winchburgh Road, Winchburgh	36.6	34.3	34.3	34.0	34.1
R41	Newbigging Lodge, Dundas Home Farm	36.6	34.0	34.0	33.5	33.5
R42	21 Long Crook, South Queensferry	36.5	34.2	34.1	33.8	33.7
R43	16 Main Street, Dalmeny	36.3	34.1	34.1	33.6	33.6
R44	61 Glasgow Road, Newbridge	36.4	34.8	34.8	34.4	34.4
R45	16 Bennet Wood Terrace, Winchburgh	36.6	34.0	34.0	33.5	33.5
R46	Standingstone Cottage	36.3	34.0	34.0	33.6	33.6
R47	21 Echline, South Queensferry	36.4	34.5	34.2	34.2	33.9
R48	Queensferry Primary School, South Queensferry	36.4	34.2	34.1	33.8	33.7
R49	Echline Primary School, South Queensferry	36.4	34.0	34.0	33.6	33.6
R50	104 Glasgow Road, Newbridge	37.4	34.2	34.2	33.8	33.8
R51	Inchgarvie House, South Queensferry	36.4	34.0	34.0	33.5	33.5

*Numbers are rounded to 1 decimal place

15.4.13 The results show that annual mean PM_{10} concentrations are below, but not well below the air quality objective (18µg/m^3) for future year scenarios. PM_{10} concentrations in 2005 largely exceed the 18µg/m^3 value, however, this objective only applies from 31 December 2010. Forecast concentrations of PM_{10} for the assessed future year scenarios 2017 and 2032, both with and without the proposed scheme are lower than those experienced at present. This is expected due to predicted improvements in vehicle technology in the future.

15.4.14 The results of the predicted 98.08th percentile of the daily mean PM_{10} concentrations show that concentrations are well below the relevant air quality objective (50µg/m^3) at all receptors for the assessed years and scenarios.

15.4.15 Table 15.22 and Table 15.23 show the modelled percentage difference, resulting magnitude of change and significance in annual mean PM_{10} concentrations for 2017 and 2032.

Table 15.22: Assessment of Significance for PM_{10} in 2017

No	Location	2017		
		Modelled % Change	Magnitude of Change	Significance
R1	18 Westfield Grove, Crossgates	0.0	Extremely Small	Negligible
R2	Ardshallah, Inverkeithing Road, Crossgates	0.0	Extremely Small	Negligible
R3	18 Sandybank, Halbeath	0.0	Extremely Small	Negligible
R4	119 Dunfermline Rd, Crossgates	0.0	Extremely Small	Negligible
R5	Crossgates Primary School, Crossgates	0.0	Extremely Small	Negligible
R6	Touch Primary School, Dunfermline	0.0	Extremely Small	Negligible
R7	St Columba's High School, Dunfermline	0.0	Extremely Small	Negligible
R8	71 Meldrum Court, Dunfermline	0.0	Extremely Small	Negligible
R9	Mid Duloch Farm, Inverkeithing	0.0	Extremely Small	Negligible
R10	Ferry Craig House, North Queensferry	-0.3	Extremely Small	Negligible
R11	15 Ferry Barns Court, North Queensferry	-1.1	Very Small	Slight Beneficial
R12	St Margaret's Hope Lodge, North Queensferry	+1.6	Very Small	Slight Adverse
R13	24 Ferry Hills Road, North Queensferry	+0.4	Extremely Small	Negligible
R14	18 Whinny Hill Crescent, Inverkeithing	+0.2	Extremely Small	Negligible
R15	The Bungalow, Dunfermline	+0.1	Extremely Small	Negligible
R16	25 Park Lea, Rosyth	0.0	Extremely Small	Negligible
R17	Inverkeithing High School, Hillend Road	0.0	Extremely Small	Negligible
R18	39 Burleigh Crescent, Inverkeithing	0.0	Extremely Small	Negligible
R19	25 Admiralty Rd, Rosyth	0.0	Extremely Small	Negligible
R20	18 Castlandhill Road, Rosyth	-0.1	Extremely Small	Negligible
R21	114 Castlandhill Road, Rosyth	0.0	Extremely Small	Negligible
R22	5 Mucklehill Park, Inverkeithing	+0.2	Extremely Small	Negligible
R23	231 Queensferry Road, Rosyth	0.0	Extremely Small	Negligible
R24	7 Letham Hill Way, Hillend	0.0	Extremely Small	Negligible
R25	St Margaret's Hope, North Queensferry	+4.3	Very Small	Slight Adverse
R26	14 Farquhar Terrace, South Queensferry	-0.3	Extremely Small	Negligible
R27	Plewlands House, South Queensferry	-0.3	Extremely Small	Negligible
R28	45 Stoneyflats Crescent, South Queensferry	-0.8	Extremely Small	Negligible
R29	10 Scotstoun Green, South Queensferry	-0.2	Extremely Small	Negligible
R30	68 Echline Drive, South Queensferry	+0.6	Extremely Small	Negligible

No	Location	2017		
		Modelled % Change	Magnitude of Change	Significance
R31	7 Linnmill, South Queensferry	+0.4	Extremely Small	Negligible
R32	12 Dundas Home Farm	+0.4	Extremely Small	Negligible
R33	11 Main Street, Newton	+0.2	Extremely Small	Negligible
R34	39 Cotlaws, Kirkliston	+0.9	Extremely Small	Negligible
R35	1 Beatly Road, Winchburgh	+0.1	Extremely Small	Negligible
R36	2 Millrig Cottages, Kirkliston	+0.1	Extremely Small	Negligible
R37	2 Newmains Road, Kirkliston	-0.3	Extremely Small	Negligible
R38	35 Main Street, Kirkliston	-0.6	Extremely Small	Negligible
R39	15 Springfield Terrace, South Queensferry	+0.4	Extremely Small	Negligible
R40	1 Winchburgh Road, Winchburgh	+0.5	Extremely Small	Negligible
R41	Newbigging Lodge, Dundas Home Farm	+0.2	Extremely Small	Negligible
R42	21 Long Crook, South Queensferry	-0.5	Extremely Small	Negligible
R43	16 Main Street, Dalmeny	0.0	Extremely Small	Negligible
R44	61 Glasgow Road, Newbridge	0.0	Extremely Small	Negligible
R45	16 Bennet Wood Terrace, Winchburgh	+0.1	Extremely Small	Negligible
R46	Standingstone Cottage	0.0	Extremely Small	Negligible
R47	21 Echline, South Queensferry	-1.1	Extremely Small	Negligible
R48	Queensferry Primary School, South Queensferry	-0.3	Extremely Small	Negligible
R49	Echline Primary School, South Queensferry	+0.1	Extremely Small	Negligible
R50	104 Glasgow Road, Newbridge	0.0	Extremely Small	Negligible
R51	Inchgarvie House, South Queensferry	+1.5	Very Small	Slight Adverse

* This is the percentage change between the 2017 Do-Minimum and Do-Something concentrations reported in Table 15.20.

Table 15.23: Assessment of Significance for PM_{10} in 2032

No	Location	2032		
		Modelled % Change	Magnitude of Change	Significance
R1	18 Westfield Grove, Crossgates	+0.1	Extremely Small	Negligible
R2	Ardshallah, Inverkeithing Road, Crossgates	+0.1	Extremely Small	Negligible
R3	18 Sandybank, Halbeath	-0.1	Extremely Small	Negligible
R4	119 Dunfermline Rd, Crossgates	+0.1	Extremely Small	Negligible
R5	Crossgates Primary School, Crossgates	0.0	Extremely Small	Negligible
R6	Touch Primary School, Dunfermline	0.0	Extremely Small	Negligible
R7	St Columba's High School, Dunfermline	0.0	Extremely Small	Negligible
R8	71 Meldrum Court, Dunfermline	0.0	Extremely Small	Negligible
R9	Mid Duloch Farm, Inverkeithing	0.0	Extremely Small	Negligible
R10	Ferry Craig House, North Queensferry	-0.4	Extremely Small	Negligible
R11	15 Ferry Barns Court, North Queensferry	-1.2	Very Small	Slight Beneficial
R12	St Margaret's Hope Lodge, North Queensferry	+1.7	Very Small	Slight Adverse
R13	24 Ferry Hills Road, North Queensferry	0.0	Extremely Small	Negligible
R14	18 Whinny Hill Crescent, Inverkeithing	+0.3	Extremely Small	Negligible
R15	The Bungalow, Dunfermline	+0.1	Extremely Small	Negligible
R16	25 Park Lea, Rosyth	0.0	Extremely Small	Negligible

No	Location	2032		
		Modelled % Change	Magnitude of Change	Significance
R17	Inverkeithing High School, Hillend Road	0.0	Extremely Small	Negligible
R18	39 Burleigh Crescent, Inverkeithing	+0.1	Extremely Small	Negligible
R19	25 Admiralty Rd, Rosyth	+0.1	Extremely Small	Negligible
R20	18 Castlandhill Road, Rosyth	-0.1	Extremely Small	Negligible
R21	114 Castlandhill Road, Rosyth	+0.1	Extremely Small	Negligible
R22	5 Mucklehill Park, Inverkeithing	+0.4	Extremely Small	Negligible
R23	231 Queensferry Road, Rosyth	0.0	Extremely Small	Negligible
R24	7 Letham Hill Way, Hillend	0.0	Extremely Small	Negligible
R25	St Margaret's Hope, North Queensferry	+4.5	Very Small	Slight Adverse
R26	14 Farquhar Terrace, South Queensferry	-0.4	Extremely Small	Negligible
R27	Plewlands House, South Queensferry	-0.3	Extremely Small	Negligible
R28	45 Stoneyflats Crescent, South Queensferry	-0.9	Extremely Small	Negligible
R29	10 Scotstoun Green, South Queensferry	-0.1	Extremely Small	Negligible
R30	68 Echline Drive, South Queensferry	+0.6	Extremely Small	Negligible
R31	7 Linnmill, South Queensferry	+0.4	Extremely Small	Negligible
R32	12 Dundas Home Farm	+0.5	Extremely Small	Negligible
R33	11 Main Street, Newton	+0.1	Extremely Small	Negligible
R34	39 Cotlaws, Kirkliston	+0.4	Extremely Small	Negligible
R35	1 Beatly Road, Winchburgh	+0.2	Extremely Small	Negligible
R36	2 Millrig Cottages, Kirkliston	+0.1	Extremely Small	Negligible
R37	2 Newmains Road, Kirkliston	-0.3	Extremely Small	Negligible
R38	35 Main Street, Kirkliston	-0.4	Extremely Small	Negligible
R39	15 Springfield Terrace, South Queensferry	0.4	Extremely Small	Negligible
R40	1 Winchburgh Road, Winchburgh	0.9	Extremely Small	Negligible
R41	Newbigging Lodge, Dundas Home Farm	0.3	Extremely Small	Negligible
R42	21 Long Crook, South Queensferry	-0.7	Extremely Small	Negligible
R43	16 Main Street, Dalmeny	0.0	Extremely Small	Negligible
R44	61 Glasgow Road, Newbridge	0.1	Extremely Small	Negligible
R45	16 Bennet Wood Terrace, Winchburgh	0.0	Extremely Small	Negligible
R46	Standingstone Cottage	0.0	Extremely Small	Negligible
R47	21 Echline, South Queensferry	-1.5	Very Small	Slight Beneficial
R48	Queensferry Primary School, South Queensferry	-0.3	Extremely Small	Negligible
R49	Echline Primary School, South Queensferry	0.0	Extremely Small	Negligible
R50	104 Glasgow Road, Newbridge	0.0	Extremely Small	Negligible
R51	Inchgarvie House, South Queensferry	+1.6	Very Small	Slight Adverse

* This is the percentage change between the 2032 Do-Minimum and Do-Something concentrations reported in Table 15.20.

15.4.16 In 2017 the magnitude of change at all receptors except R11 (15 Ferry Barns Court), R12 (St. Margaret's Hope Lodge), R25 (St. Margaret's Hope) and R51 (Inchgarvie House) is extremely small. Receptors R11, R12, R25 and R51 are predicted to experience a very small change. The resulting significance with regards to PM_{10} concentrations at all receptors experiencing extremely small changes is Negligible and at receptors with very small changes it is Slight Beneficial (R11) or Slight Adverse (R12, R25, R51).

15.4.17 In 2032 the magnitude of change at the vast majority of receptors (90%) is extremely small. Receptors R11 (Ferry Barns Court), R12 (St. Margaret's Hope Lodge), R25 (St. Margaret's Hope), R47 (21 Echline) and R51 (Inchgarvie House) are predicted to experience very small changes. The resulting significance with regards to PM_{10} concentrations at most receptors is Negligible. The significance at Receptors R11 and R47 is Slight Beneficial, whilst it is predicted that receptors R12, R25 and R51 will experience Slight Adverse impacts.

15.4.18 The annual mean PM_{10} concentration contours for 2017 and 2032 for both the Do-Minimum and Do-Something scenarios (Figures 15.13 to 15.16) show that PM_{10} concentration objectives and limit values are met everywhere.

15.4.19 The difference contour plots (Figures 15.17 and 15.18) show that there are improvements with regards to local air quality around the Forth Road Bridge and deteriorations around areas of the Main Crossing due to changes in traffic flows in these areas. For annual mean PM_{10} concentrations these areas of improvement and deterioration are restricted to the immediate vicinity of the Forth Road Bridge and the Main Crossing.

$PM_{2.5}$ Concentrations

15.4.20 Table 15.24 presents calculated annual mean $PM_{2.5}$ concentrations for 2017 and 2032 for the Do-Minimum and Do-Something scenarios.

Table 15.24: Modelled Annual Mean $PM_{2.5}$ Concentrations ($\mu g/m^3$)

No	Location	2005	2017		2032	
		Base	Do-Minimum	Do-Something	Do-Minimum	Do-Something
R1	18 Westfield Grove, Crossgates	12.7	9.2	9.2	9.0	9.0
R2	Ardshallah, Inverkeithing Road, Crossgates	12.5	9.0	9.0	8.8	8.8
R3	18 Sandybank, Halbeath	12.7	9.2	9.2	9.0	9.0
R4	119 Dunfermline Rd, Crossgates	12.6	9.1	9.1	8.9	8.9
R5	Crossgates Primary School, Crossgates	12.4	9.0	9.0	8.8	8.8
R6	Touch Primary School, Dunfermline	12.3	9.0	9.0	8.8	8.8
R7	St Columba's High School, Dunfermline	12.3	9.0	9.0	8.8	8.8
R8	71 Meldrum Court, Dunfermline	12.4	9.0	9.0	8.8	8.8
R9	Mid Duloch Farm, Inverkeithing	12.4	9.0	9.0	8.8	8.8
R10	Ferry Craig House, North Queensferry	12.4	9.0	9.0	8.8	8.8
R11	15 Ferry Barns Court, North Queensferry	12.6	9.1	9.0	8.9	8.8
R12	St Margaret's Hope Lodge, North Queensferry	12.3	9.0	9.2	8.8	9.0
R13	24 Ferry Hills Road, North Queensferry	12.6	9.0	9.1	8.9	8.9
R14	18 Whinny Hill Crescent, Inverkeithing	12.6	9.1	9.1	8.9	8.9
R15	The Bungalow, Dunfermline	12.5	9.1	9.1	8.9	8.9
R16	25 Park Lea, Rosyth	12.5	9.1	9.1	9.0	8.9
R17	Inverkeithing High School, Hillend Road	12.4	9.0	9.0	8.8	8.8
R18	39 Burleigh Crescent, Inverkeithing	12.4	9.0	9.0	8.8	8.8
R19	25 Admiralty Rd, Rosyth	12.5	9.1	9.1	8.9	8.9
R20	18 Castlandhill Road, Rosyth	12.5	9.0	9.0	8.8	8.8
R21	114 Castlandhill Road, Rosyth	12.5	9.0	9.0	8.8	8.8
R22	5 Mucklehill Park, Inverkeithing	12.6	9.1	9.1	8.9	8.9
R23	231 Queensferry Road, Rosyth	12.4	9.0	9.0	8.8	8.8

No	Location	2005	2017		2032	
		Base	Do-Minimum	Do-Something	Do-Minimum	Do-Something
R24	7 Letham Hill Way, Hillend	12.4	9.0	9.0	8.8	8.8
R25	St Margaret's Hope, North Queensferry	12.3	9.0	9.5	8.8	9.3
R26	14 Farquhar Terrace, South Queensferry	12.4	9.0	9.0	8.8	8.8
R27	Plewlands House, South Queensferry	12.4	9.0	9.0	8.8	8.8
R28	45 Stoneyflats Crescent, South Queensferry	12.5	9.0	8.9	8.9	8.8
R29	10 Scotstoun Green, South Queensferry	12.5	9.0	9.0	8.8	8.8
R30	68 Echline Drive, South Queensferry	12.4	9.0	9.1	8.8	8.9
R31	7 Linnmill, South Queensferry	12.3	8.9	9.0	8.7	8.8
R32	12 Dundas Home Farm	12.3	9.0	9.0	8.8	8.8
R33	11 Main Street, Newton	12.6	9.1	9.2	9.0	9.0
R34	39 Cotlaws, Kirkliston	12.9	9.4	9.5	9.3	9.3
R35	1 Beatly Road, Winchburgh	12.4	9.0	9.0	8.9	8.9
R36	2 Millrig Cottages, Kirkliston	12.6	9.1	9.1	8.9	8.9
R37	2 Newmains Road, Kirkliston	12.4	9.1	9.0	8.9	8.8
R38	35 Main Street, Kirkliston	12.6	9.2	9.1	9.1	9.0
R39	15 Springfield Terrace, South Queensferry	12.3	8.9	9.0	8.7	8.8
R40	1 Winchburgh Road, Winchburgh	12.6	9.1	9.2	9.0	9.1
R41	Newbigging Lodge, Dundas Home Farm	12.4	9.0	9.0	8.8	8.9
R42	21 Long Crook, South Queensferry	12.5	9.0	9.0	8.9	8.8
R43	16 Main Street, Dalmeny	12.3	9.0	9.0	8.8	8.8
R44	61 Glasgow Road, Newbridge	13.1	9.4	9.4	9.2	9.2
R45	16 Bennet Wood Terrace, Winchburgh	12.4	9.0	9.0	8.9	8.9
R46	Standingstone Cottage	12.3	8.9	8.9	8.7	8.7
R47	21 Echline, South Queensferry	12.8	9.2	9.1	9.1	8.9
R48	Queensferry Primary School, South Queensferry	12.5	9.0	9.0	8.9	8.8
R49	Echline Primary School, South Queensferry	12.3	9.0	9.0	8.8	8.8
R50	104 Glasgow Road, Newbridge	13.1	9.3	9.3	9.2	9.2
R51	Inchgarvie House, South Queensferry	12.3	8.9	9.1	8.7	8.9

15.4.21 The relevant objective for $PM_{2.5}$ in Scotland is 12㎎/m^3 and is applicable from 2020. The model results show that this limit value is predicted to be met in both 2017 and 2032 at all receptors for the Do-Minimum and Do-Something scenarios.

15.4.22 Tables 15.25 and 15.26 show the modelled percentage difference, resulting magnitude of change and significance in annual mean $PM_{2.5}$ concentrations for 2017 and 2032.

Table 15.25: Assessment of Significance for $PM_{2.5}$ in 2017

No	Location	2017		
		Modelled % Change*	Magnitude of Change	Significance
R1	18 Westfield Grove, Crossgates	0.0	Extremely Small	Negligible
R2	Ardshallah, Inverkeithing Road, Crossgates	0.0	Extremely Small	Negligible
R3	18 Sandybank, Halbeath	0.0	Extremely Small	Negligible

No	Location	2017		
		Modelled % Change*	Magnitude of Change	Significance
R4	119 Dunfermline Rd, Crossgates	0.0	Extremely Small	Negligible
R5	Crossgates Primary School, Crossgates	0.0	Extremely Small	Negligible
R6	Touch Primary School, Dunfermline	0.0	Extremely Small	Negligible
R7	St Columba's High School, Dunfermline	0.0	Extremely Small	Negligible
R8	71 Meldrum Court, Dunfermline	0.0	Extremely Small	Negligible
R9	Mid Duloch Farm, Inverkeithing	0.0	Extremely Small	Negligible
R10	Ferry Craig House, North Queensferry	-0.4	Extremely Small	Negligible
R11	15 Ferry Barns Court, North Queensferry	-1.5	Very Small	Slight Beneficial
R12	St Margaret's Hope Lodge, North Queensferry	+2.2	Very Small	Slight Adverse
R13	24 Ferry Hills Road, North Queensferry	+0.6	Extremely Small	Negligible
R14	18 Whinny Hill Crescent, Inverkeithing	+0.3	Extremely Small	Negligible
R15	The Bungalow, Dunfermline	+0.1	Extremely Small	Negligible
R16	25 Park Lea, Rosyth	0.0	Extremely Small	Negligible
R17	Inverkeithing High School, Hillend Road	0.0	Extremely Small	Negligible
R18	39 Burleigh Crescent, Inverkeithing	+0.1	Extremely Small	Negligible
R19	25 Admiralty Rd, Rosyth	0.0	Extremely Small	Negligible
R20	18 Castlandhill Road, Rosyth	-0.2	Extremely Small	Negligible
R21	114 Castlandhill Road, Rosyth	0.0	Extremely Small	Negligible
R22	5 Mucklehill Park, Inverkeithing	+0.3	Extremely Small	Negligible
R23	231 Queensferry Road, Rosyth	0.0	Extremely Small	Negligible
R24	7 Letham Hill Way, Hillend	0.0	Extremely Small	Negligible
R25	St Margaret's Hope, North Queensferry	+6.0	Small	Slight Adverse
R26	14 Farquhar Terrace, South Queensferry	-0.4	Very Small	Slight Beneficial
R27	Plewlands House, South Queensferry	-0.4	Extremely Small	Negligible
R28	45 Stoneyflats Crescent, South Queensferry	-1.1	Very Small	Slight Beneficial
R29	10 Scotstoun Green, South Queensferry	-0.2	Extremely Small	Negligible
R30	68 Echline Drive, South Queensferry	+0.9	Extremely Small	Negligible
R31	7 Linnmill, South Queensferry	+0.6	Extremely Small	Negligible
R32	12 Dundas Home Farm	+0.6	Extremely Small	Negligible
R33	11 Main Street, Newton	+0.3	Extremely Small	Negligible
R34	39 Cotlaws, Kirkliston	+1.3	Very Small	Slight Adverse
R35	1 Beatly Road, Winchburgh	+0.2	Extremely Small	Negligible
R36	2 Millrig Cottages, Kirkliston	+0.1	Extremely Small	Negligible
R37	2 Newmains Road, Kirkliston	-0.5	Extremely Small	Negligible
R38	35 Main Street, Kirkliston	-0.8	Extremely Small	Negligible
R39	15 Springfield Terrace, South Queensferry	+0.5	Extremely Small	Negligible
R40	1 Winchburgh Road, Winchburgh	+0.7	Extremely Small	Negligible
R41	Newbigging Lodge, Dundas Home Farm	+0.3	Extremely Small	Negligible
R42	21 Long Crook, South Queensferry	-0.7	Extremely Small	Negligible
R43	16 Main Street, Dalmeny	0.0	Extremely Small	Negligible
R44	61 Glasgow Road, Newbridge	0.0	Extremely Small	Negligible
R45	16 Bennet Wood Terrace, Winchburgh	+0.2	Extremely Small	Negligible
R46	Standingstone Cottage	0.0	Extremely Small	Negligible

No	Location	2017		
		Modelled % Change*	Magnitude of Change	Significance
R47	21 Echline, South Queensferry	-1.5	Very Small	Slight Beneficial
R48	Queensferry Primary School, South Queensferry	-0.4	Extremely Small	Negligible
R49	Echline Primary School, South Queensferry	+0.1	Extremely Small	Negligible
R50	104 Glasgow Road, Newbridge	0.0	Extremely Small	Negligible
R51	Inchgarvie House, South Queensferry	+2.1	Very Small	Slight Adverse

Table 15.26: Assessment of Significance for $PM_{2.5}$ in 2032

No	Location	2032		
		Modelled % Change*	Magnitude of Change	Significance
R1	18 Westfield Grove, Crossgates	+0.1	Extremely Small	Negligible
R2	Ardshallah, Inverkeithing Road, Crossgates	+0.1	Extremely Small	Negligible
R3	18 Sandybank, Halbeath	-0.1	Extremely Small	Negligible
R4	119 Dunfermline Rd, Crossgates	+0.1	Extremely Small	Negligible
R5	Crossgates Primary School, Crossgates	+0.1	Extremely Small	Negligible
R6	Touch Primary School, Dunfermline	0.0	Extremely Small	Negligible
R7	St Columba's High School, Dunfermline	0.0	Extremely Small	Negligible
R8	71 Meldrum Court, Dunfermline	0.0	Extremely Small	Negligible
R9	Mid Duloch Farm, Inverkeithing	0.0	Extremely Small	Negligible
R10	Ferry Craig House, North Queensferry	-0.5	Extremely Small	Negligible
R11	15 Ferry Barns Court, North Queensferry	-1.7	Very Small	Slight Beneficial
R12	St Margaret's Hope Lodge, North Queensferry	+2.4	Very Small	Slight Adverse
R13	24 Ferry Hills Road, North Queensferry	0.0	Extremely Small	Negligible
R14	18 Whinny Hill Crescent, Inverkeithing	+0.5	Extremely Small	Negligible
R15	The Bungalow, Dunfermline	+0.1	Extremely Small	Negligible
R16	25 Park Lea, Rosyth	-0.1	Extremely Small	Negligible
R17	Inverkeithing High School, Hillend Road	+0.1	Extremely Small	Negligible
R18	39 Burleigh Crescent, Inverkeithing	+0.1	Extremely Small	Negligible
R19	25 Admiralty Rd, Rosyth	+0.1	Extremely Small	Negligible
R20	18 Castlandhill Road, Rosyth	-0.1	Extremely Small	Negligible
R21	114 Castlandhill Road, Rosyth	+0.1	Extremely Small	Negligible
R22	5 Mucklehill Park, Inverkeithing	+0.6	Extremely Small	Negligible
R23	231 Queensferry Road, Rosyth	+0.1	Extremely Small	Negligible
R24	7 Letham Hill Way, Hillend	0.0	Extremely Small	Negligible
R25	St Margaret's Hope, North Queensferry	+6.3	Small	Slight Adverse
R26	14 Farquhar Terrace, South Queensferry	-0.6	Extremely Small	Negligible
R27	Plewlands House, South Queensferry	-0.4	Extremely Small	Negligible
R28	45 Stoneyflats Crescent, South Queensferry	-1.2	Very Small	Slight Beneficial
R29	10 Scotstoun Green, South Queensferry	-0.1	Extremely Small	Negligible
R30	68 Echline Drive, South Queensferry	+0.9	Extremely Small	Negligible
R31	7 Linnmill, South Queensferry	+0.6	Extremely Small	Negligible
R32	12 Dundas Home Farm	+0.7	Extremely Small	Negligible
R33	11 Main Street, Newton	+0.2	Extremely Small	Negligible

No	Location	2032		
		Modelled % Change*	Magnitude of Change	Significance
R34	39 Cotlaws, Kirkliston	+0.5	Extremely Small	Negligible
R35	1 Beatly Road, Winchburgh	+0.3	Extremely Small	Negligible
R36	2 Millrig Cottages, Kirkliston	+0.1	Extremely Small	Negligible
R37	2 Newmains Road, Kirkliston	-0.4	Extremely Small	Negligible
R38	35 Main Street, Kirkliston	-0.5	Extremely Small	Negligible
R39	15 Springfield Terrace, South Queensferry	+0.5	Extremely Small	Negligible
R40	1 Winchburgh Road, Winchburgh	+1.3	Very Small	Slight Adverse
R41	Newbigging Lodge, Dundas Home Farm	+0.5	Extremely Small	Negligible
R42	21 Long Crook, South Queensferry	-0.9	Extremely Small	Negligible
R43	16 Main Street, Dalmeny	+0.1	Extremely Small	Negligible
R44	61 Glasgow Road, Newbridge	+0.1	Extremely Small	Negligible
R45	16 Bennet Wood Terrace, Winchburgh	0.0	Extremely Small	Negligible
R46	Standingstone Cottage	0.0	Extremely Small	Negligible
R47	21 Echline, South Queensferry	-2.1	Very Small	Slight Beneficial
R48	Queensferry Primary School, South Queensferry	-0.5	Extremely Small	Negligible
R49	Echline Primary School, South Queensferry	0.0	Extremely Small	Negligible
R50	104 Glasgow Road, Newbridge	0.0	Extremely Small	Negligible
R51	Inchgarvie House, South Queensferry	+2.2	Very Small	Negligible

15.4.23 The results show that for the majority of modelled receptors for both 2017 and 2032 the magnitude of change is extremely small and the resulting significance is Negligible. In 2017 there are three receptors (R12 St. Margaret's Hope Lodge; R34 39 Cotlaws; R51 Inchgarvie House) which are forecast to experience very small increases of $PM_{2.5}$ concentrations and one receptor (R25 St. Margaret's Hope) which is predicted to experience a small magnitude of change. The resulting significance for these three receptors is Slight Adverse. The results further show that receptors R11 (15 Ferry Barns Court), R26 (14 Farquhar Terrace), R28 (45 Stoneyflatts Crescent) and R47 (21 Echline) are forecast to experience a very small improvement with regards to $PM_{2.5}$ concentrations. The resulting significance for these receptors is Slight Beneficial.

15.4.24 In 2032 there are three receptors which are forecast to be subject to Slight Adverse impacts and three receptors are predicted to experience Slight Beneficial impacts.

Population Exposure

15.4.25 As described in paragraphs 15.2.36-15.2.37, population exposure to changes in pollutant concentrations greater than 1% of the relevant air quality objective and limit value was established for NO_2, PM_{10} and $PM_{2.5}$ concentrations. For NO_2, all properties that are predicted to experience changes in NO_2 concentrations of ≥ 0.4μg/m^3 (deterioration) and ≤ -0.4μg/m^3 (improvement) were counted and are shown in Table 15.27 below. The PM_{10} difference contour plots for 2017 and 2032 were interrogated to establish property counts for receptors predicted to experience changes in PM_{10} concentrations of ≥ 0.18μg/m^3 (deterioration) and ≤ -0.18μg/m^3 (improvement). Equally, difference plots for $PM_{2.5}$ concentrations were created and used to establish the number and percentage of receptors predicted to experience an improvement or deterioration of more than 1% of the applicable limit value (i.e.± 0.12μg/m^3).

15.4.26 According to the address point data there is a total of 50,655 properties within the local air quality study area. It should be noted that the address point data do not include any future year developments and hence these were not considered in the assessment of population exposure. Table 15.27 below shows numbers of properties that are predicted to experience an improvement

and numbers of properties predicted to experience a deterioration of air quality in both 2017 and 2032. The table also shows associated percentages of the total of 50,655 properties within the study area.

Table 15.27: Population Exposure to Changes in Pollutant Concentrations

	2017		2032	
	Properties	**Percentage**	**Properties**	**Percentage**
NO_2				
Improvement	1225	2.4%	936	1.8%
Deterioration	633	1.2%	652	1.3%
PM_{10}				
Improvement	16	0.03%	20	0.04%
Deterioration	35	0.07%	28	0.06%
$PM_{2.5}$				
Improvement	55	0.11%	48	0.09%
Deterioration	63	0.12%	67	0.13%

15.4.27 With regards to NO_2, the results in Table 15.27 show that in both 2017 and 2032 more properties benefit from the proposed scheme than are negatively affected. The percentage of properties within the local study area affected by the proposed scheme is very small (4% in 2017 and 3% in 2032).

15.4.28 The results in Table 15.27 further show that for PM_{10} and $PM_{2.5}$ concentrations, more properties are predicted to experience a worsening than benefiting from the proposed scheme. However, the numbers of properties affected by changes in PM_{10} and $PM_{2.5}$ concentrations (positively or negatively) is extremely small (< 0.10% for PM_{10} and < 0.25% for $PM_{2.5}$ respectively).

15.4.29 The population exposure assessment shows that in general impacts on local air quality resulting from the proposed scheme are fairly localised and focused around the northern and southern bridge heads and access roads. The difference between numbers of properties predicted to experience an improvement and numbers of properties predicted to experience deterioration of local air quality is very small. The proposed scheme can therefore be described as neutral with regards to population exposure.

Nitrogen Deposition

15.4.30 Table 15.14 in Section 15.3 shows the existing nitrogen deposition rates in 2005 for the three assessed designated sites. The table shows that in 2005 the lower levels of critical load bands (exposure below which significant harmful effects do not occur according to present knowledge) are exceeded for all assessed SSSIs, with the exception of Ferry Hills SSSI.

15.4.31 The results of the nitrogen deposition calculations for 2017 and 2032 are contained below with the significance of the identified impacts discussed in Chapter 10 (Terrestrial and Freshwater Ecology).

Firth of Forth SSSI

15.4.32 The Firth of Forth designated site stretches along the coast and is intersected by both the proposed new scheme and the Forth Road Bridge. In order to establish nitrogen deposition rates associated with both roads, two representative locations were assessed. One (Unit 1) is located approximately 175m east of the Main Crossing and the second one (Unit 2) is cut by the Forth Road Bridge.

15.4.33 There is a trend of reduced dry deposition rates and total deposition rates between the assessed years 2017 and 2032 with or without the proposed scheme. In 2017 total deposition rates are just over the lower band of the critical load range (i.e. 10kg N/ha/yr) and below it in 2032. The results of

estimating nitrogen deposition at the Firth of Forth designated site in 2017 are presented in Table 15.28 and discussed in more detail in the paragraph below.

Table 15.28: Nitrogen Deposition at the Firth of Forth SSSI in 2017 (Kg N/ha/yr)

Transect Distance	Dry Deposition Rate on Transect in 2017		Total Deposition Rate in 2017		Critical Load
	Do-Minimum	Do-Something	Do-Minimum	Do-Something	
Unit 1					10-35
175m	2.66	2.72	10.17	10.23	
200m	2.67	2.72	10.17	10.23	
Unit 2					
0m	2.68	2.67	10.18	10.18	
50m	2.69	2.67	10.20	10.18	
100m	2.71	2.67	10.21	10.18	
150m	2.72	2.67	10.23	10.18	
200m	2.72	2.67	10.23	10.18	

15.4.34 The predicted contribution from local traffic to nitrogen deposition rates at the Firth of Forth SSSI unit 1 in 2017 varies between 2.66 kg N/ha/yr at 175m in the Do-Minimum scenario and 2.72 kg N/ha/yr at 175m in Do-Something scenario.

15.4.35 The highest dry nitrogen deposition increase in 2017 resulting from the proposed scheme at unit 1 is 0.06 kg N/ha/yr, which is an increase of less than 1% of the total deposition. The predicted increase in total nitrogen deposition rates would lead to an increase in exceedance of the lower band of the critical load for neutral grassland, fen, marsh and swamp, however, these locations are still within the upper band of the critical load range.

15.4.36 The dry deposition rates along the transect of unit 2 increase in the 2017 Do-Minimum scenario with increased distance. This is due to the fact that the designated site is close to the Forth Road Bridge, which is elevated at that point. Pollutant concentrations at ground level near the bridge are dispersed to lower concentrations.

15.4.37 Total deposition rates at unit 2 decrease when comparing the Do-Minimum with the Do-Something scenario. The calculated total deposition rates for unit 2 suggest that in 2017 deposition rates will exceed the lower band of the critical load in both the Do-Minimum scenario and the Do-Something scenario. However, total deposition rates are below the upper band of the critical load range.

15.4.38 Table 15.29 shows nitrogen deposition rates at the two assessed Firth of Forth designated site units in 2032.

Table 15.29: Nitrogen Deposition at the Firth of Forth SSSI in 2032 (Kg N/ha/yr)

Transect Distance	Dry Deposition Rate on Transect in 2032		Total Deposition Rate in 2032		Critical Load
	Do-Minimum	Do-Something	Do-Minimum	Do-Something	
Unit 1					10-35
175m	2.52	2.57	7.63	7.69	
200m	2.52	2.57	7.64	7.69	
Unit 2					
0m	2.53	2.52	7.65	7.64	
50m	2.55	2.52	7.66	7.64	
100m	2.57	2.52	7.68	7.64	
150m	2.58	2.52	7.69	7.64	
200m	2.59	2.52	7.70	7.64	

15.4.39 The results for unit 1 show that there is an increase in dry deposition of 0.05 Kg N/ha/yr between the Do-Minimum and Do-Something scenario, which is an increase of less than 1% of the total deposition. As described for the 2017 scenarios, dry deposition and total deposition rates decrease between the Do-Minimum and Do-Something scenario at unit 2. In 2032 total deposition rates are below the critical load range for both the Do-Minimum and Do-Something scenario.

Ferry Hills SSSI

15.4.40 The Ferry Hills SSSI is broken down into several units along the northern bridge approach corridor. As traffic volumes, speeds and percentages vary along the A90, the assessment has been carried out separately for different units.

15.4.41 Both dry deposition rates and total deposition rates decrease between 2017 and 2032. Total deposition rates are below the upper band of the critical load range in 2017 and 2032 for both the Do-Minimum scenario and Do-Something scenario but slightly exceed the lower band of the range in 2017. Table 15.30 shows nitrogen deposition at the Ferry Hills SSSI in 2017.

Table 15.30: Nitrogen Deposition at Ferry Hills SSSI in 2017 (Kg N/ha/yr)

Transect Distance	Dry Deposition Rate on Transect in 2017		Total Deposition Rate in 2017		Critical Load
	Do-Minimum	Do-Something	Do-Minimum	Do-Something	
Unit 1					
0m	3.01	2.71	10.52	10.22	15-25
50m	2.79	2.70	10.30	10.21	
100m	2.74	2.69	10.24	10.20	
150m	2.69	2.67	10.19	10.18	
200m	2.70	2.68	10.21	10.19	
Unit 2					
57m	2.88	2.89	10.39	10.40	15-25
100m	2.82	2.84	10.33	10.35	
150m	2.79	2.80	10.30	10.31	
200m	2.77	2.78	10.27	10.29	
Unit 3					
0m	3.09	3.11	10.60	10.62	15-25
50m	2.81	2.84	10.32	10.35	
100m	2.75	2.78	10.26	10.29	
150m	2.72	2.75	10.23	10.26	
200m	2.70	2.74	10.20	10.25	

15.4.42 Dry deposition rates along unit 1 decrease by up to 0.30 kg N/ha/yr next to the existing road (0m distance), due to the fact that the majority of traffic is shifted away from this unit. Dry deposition rates at unit 2 increase by between 0.01 Kg N/ha/yr and 0.02 kg N/ha/yr at all distances along the transect when comparing the Do-Minimum with the Do-Something scenario. Dry deposition rates at unit 3 increase by up to 0.04 kg N/ha/yr (at 200m distances) when comparing the Do-Minimum with the Do-Something scenario. Table 15.31 shows nitrogen deposition rates in 2032.

Table 15.31: Nitrogen Deposition at Ferry Hills SSSI in 2032 (Kg N/ha/yr)

Transect Distance	Dry Deposition Rate on Transect in 2032		Total Deposition Rate in 2032		Critical Load
	Do-Minimum	Do-Something	Do-Minimum	Do-Something	
Unit 1					
0m	2.88	2.56	7.87	7.55	15-25
50m	2.65	2.55	7.64	7.53	

Transect Distance	Dry Deposition Rate on Transect in 2032		Total Deposition Rate in 2032		Critical Load
	Do-Minimum	Do-Something	Do-Minimum	Do-Something	
100m	2.59	2.54	7.58	7.52	
150m	2.54	2.52	7.53	7.50	
200m	2.56	2.53	7.55	7.51	
Unit 2					
57m	2.73	2.76	7.72	7.74	15-25
100m	2.68	2.70	7.66	7.69	
150m	2.64	2.66	7.63	7.65	
200m	2.62	2.64	7.60	7.62	
Unit 3					
0m	2.96	2.97	7.94	7.96	15-25
50m	2.67	2.69	7.66	7.68	
100m	2.61	2.63	7.60	7.62	
150m	2.58	2.60	7.57	7.59	
200m	2.57	2.59	7.56	7.58	

15.4.43 In 2032 dry deposition rates for unit 1 decrease by up to 0.32 kg N/ha/yr in the immediate vicinity of the existing road (0m distance). Dry deposition rates at unit 2 increase by 0.03 kg N/ha/yr at 57m (closest point to road) and by 0.02 kg N/ha/yr at 100m, 150m and 200m distances along the transect when comparing the Do-Minimum with the Do-Something scenario. Dry deposition rates at unit 3 increase by up to 0.02 kg N/ha/yr.

St. Margaret's Marsh SSSI

15.4.44 Total deposition rates along a transect in St. Margaret's Marsh SSSI are below the critical load in 2017 and 2032 for both the Do-Minimum scenario and Do-Something scenario. Tables 15.32 and Table 15.33 show the nitrogen deposition results at St. Margaret's Marsh SSSI.

Table 15.32: Nitrogen Deposition at St. Margaret's Marsh SSSI in 2017 (Kg N/ha/yr)

Transect Distance	Dry Deposition Rate on Transect in 2017		Total Deposition Rate in 2017		Critical Load
	Do-Minimum	Do-Something	Do-Minimum	Do-Something	
0m	2.75	2.91	10.25	10.42	10-35
50m	2.71	2.78	10.22	10.29	
100m	2.69	2.74	10.20	10.25	
150m	2.67	2.72	10.18	10.22	
200m	2.66	2.70	10.17	10.21	

Table 15.33: Nitrogen Deposition at St. Margaret's Marsh SSSI in 2032 (Kg N/ha/yr)

Transect Distance	Dry Deposition Rate on Transect in 2032		Total Deposition Rate in 2032		Critical Load
	Do-Minimum	Do-Something	Do-Minimum	Do-Something	
0m	2.60	2.77	7.72	7.89	10-35
50m	2.56	2.63	7.68	7.75	
100m	2.54	2.59	7.66	7.70	
150m	2.52	2.57	7.64	7.68	
200m	2.51	2.55	7.63	7.67	

15.4.45 The results in Tables 15.32 and 15.33 show that whilst there is a small increase in dry deposition between the Do-Minimum and Do-Something scenario (0.16 kg N/ha/yr at 0m distance in 2017 and 0.17 kg N/ha/yr in 2032), total deposition rates in 2017 are within the upper band of the critical load

range for both the Do-Minimum and Do-Something scenarios (there is a small exceedance of the lower band of the critical load range in 2017). In 2032 total deposition rates are below the lower band of the critical load range for both the Do-Minimum and Do-Something scenarios.

NO_x Concentration

15.4.46 Table 15.34 below shows NO_x concentrations at assessed designated sites for 2005, 2017 and 2032.

Table 15.34: NO_x Concentrations at Designated Conservation Sites ($\mu g/m^3$)

Designated Site	Base	2017 NO_x Concentration		2032 NO_x Concentration	
	2005	Do-Minimum	Do-Something	Do-Minimum	Do-Something
Firth of Forth SSSI Unit 1	37.5	39.6	41.5	37.4	39.2
Firth of Forth SSSI Unit 2	40.3	41.3	39.9	39.2	37.6
Ferry Hills SSSI Unit 1	74.3	60.6	42.0	58.9	39.6
Ferry Hills SSSI Unit 2	49.5	47.2	47.6	45.1	45.9
Ferry Hills SSSI Unit 3	87.1	65.9	66.1	58.9	64.2
St Margaret's Marsh SSSI	42.3	42.5	50.7	40.3	48.9

15.4.47 The results in Table 15.34 show that the limit value for the protection of ecosystems and vegetation of 30$\mu g/m^3$ is exceeded at all locations and all scenarios. However, due to the vicinity of the M9 and Edinburgh in the south as well as the M90 and Rosyth/ Dunfermline in the north, the limit value does not apply to these SSSIs (as indicated in Table 15.1).

Assessment of Screened-in Links outside Local Study Area

15.4.48 In order to determine the potential impact of the proposed scheme at areas outside the local study area, traffic data obtained from the TMfS:05a were screened using the DMRB criteria as described in paragraph 15.2.13. Figure 15.2 shows links outside the study area which meet the DMRB criteria. Screened-in road links are mainly links along motorways or busy 'A' roads (M9, M876, A876, A985, A92, M90 and A90) and it can be expected that vehicle number changes slightly above the DMRB criteria would not have significant impacts on local air quality. However, an additional assessment was carried out at seven locations potentially affected by the proposed scheme, namely, Linlithgow, Polmont, Kincardine, High Valleyfield, Kelty, Cowdenbeath and Edinburgh. ADMS-Roads was used to assess air quality impacts at residential properties in the vicinity of screened-in links. Other than traffic data, the same model inputs as used for the main study were used in this additional assessment.

15.4.49 Table 15.35 shows NO_2 concentrations at discrete receptor locations in the seven areas listed above.

Table 15.35: Annual Mean NO_2 Concentrations at Receptor Locations in Additional Assessment Areas

Receptor Location	Grid Reference	2017		2032	
		Do-Minimum	Do-Something	Do-Minimum	Do-Something
Linlithgow					
1 Clark Avenue	299267, 677585	27.9	27.9	27.0	27.0
Loch House	299317, 677695	27.4	27.4	26.5	26.5
30 Clark Avenue	298955, 677635	27.7	27.7	26.8	26.8
74 St Ninians Road	299427, 677580	27.7	27.7	26.9	26.9
6 Parkhead Road	299624, 677584	27.5	27.5	26.6	26.6

Receptor Location	Grid Reference	2017		2032	
		Do-Minimum	Do-Something	Do-Minimum	Do-Something
Polmont					
32 Eastcroft Drive	294018, 678901	27.6	27.5	27.2	27.3
41 Orchard Grove	293755, 679060	27.6	27.6	27.4	27.5
4 Eastcroft Drive	294250, 678772	27.3	27.2	26.9	27.0
Kincardine					
45 Keith Street	292949, 687322	25.8	25.7	24.7	24.6
31 Silver Street	292957, 687283	25.8	25.7	24.7	24.6
26 Forth Street	292909, 687328	25.9	25.8	24.8	24.7
13 Orchard Grove	293031, 687248	25.4	25.4	24.2	24.1
Kelty					
23 Blair Drive	313462, 693962	27.9	28.1	26.4	26.6
38 Clentry Crescent	313434, 694013	28.0	28.2	26.5	26.7
1 Dullomuir Drive	313295, 694381	28.1	28.1	26.5	26.7
16 Clentry Crescent	313371, 694116	28.7	28.7	27.1	27.3
Cowdenbeath					
Birnie Ridge, 2 Bridge Street	316842, 691087	28.4	28.4	27.5	27.5
3 Paterson Lane	316847, 691161	27.3	27.3	26.0	26.0
Edinburgh					
624 Queensferry Road	318005, 675293	27.1	27.1	25.8	25.8
564 Queensferry Road	318545, 674990	29.2	29.2	28.0	27.9
7 Maybury Road	318621, 674917	28.4	28.3	26.9	26.9
20 Strathalmond Green	318015, 675197	27.2	27.2	25.9	25.9
10 Maybury Road	318540, 674940	28.2	28.2	26.9	26.9
453 Queensferry Road	319627, 674985	29.6	29.6	28.2	28.2
1c Clermiston Road North	320004, 675052	30.1	30.1	28.6	28.7
393 Queensferry Road	320531, 675108	29.3	29.4	27.8	27.9
224 Drum Brae Drive	319074, 674217	27.0	27.1	25.4	25.6
66 Clermiston Road North	320204, 674516	27.7	27.9	26.0	26.3

15.4.50 The results in Table 15.35 show that the difference in NO_2 concentrations in 2017 at all receptors is extremely small to very small (≤ 0.3㎎/m^3). There are extremely small improvements at some locations (Polmont, Kincardine, Edinburgh) and very small increases in pollutant concentrations at other locations (Linlithgow, Kelty, Edinburgh). The resulting significance at all receptors in 2017 is Negligible. In 2032, concentration differences between the Do-Minimum and the Do-Something scenarios range from extremely small to very small at all locations, resulting in an extremely small to very small magnitude of change. Due to the fact that total NO_2 concentrations modelled are well below the objective, the overall significance at all receptors in 2032 is Negligible.

15.4.51 Table 15.36 shows annual mean PM_{10} concentrations at the assessed receptor points.

Table 15.36: Annual Mean PM_{10} Concentrations at Receptor Locations in Additional Assessment Areas

Receptor Location	Grid Reference	2017		2032	
		Do-Minimum	Do-Something	Do-Minimum	Do-Something
Linlithgow					
1 Clark Avenue	299267, 677585	14.1	14.1	14.0	14.0
Loch House	299317, 677695	14.1	14.1	14.0	14.0
30 Clark Avenue	298955, 677635	14.1	14.1	14.0	14.0
74 St Ninians Road	299427, 677580	14.1	14.1	14.0	14.0
6 Parkhead Road	299624, 677584	14.1	14.1	13.9	13.9
Polmont					
32 Eastcroft Drive	294018, 678901	14.2	14.1	14.1	14.1
41 Orchard Grove	293755, 679060	14.2	14.2	14.2	14.1
4 Eastcroft Drive	294250, 678772	14.1	14.1	14.1	14.1
Kincardine					
45 Keith Street	292949, 687322	14.1	14.1	14.0	14.0
31 Silver Street	292957, 687283	14.1	14.1	14.0	14.0
26 Forth Street	292909, 687328	14.1	14.1	14.0	14.0
13 Orchard Grove	293031, 687248	14.1	14.1	14.0	14.0
Kelty					
23 Blair Drive	313462, 693962	14.1	14.2	14.0	14.0
38 Clentry Crescent	313434, 694013	14.2	14.2	14.0	14.1
1 Dullomuir Drive	313295, 694381	14.2	14.2	14.0	14.1
16 Clentry Crescent	313371, 694116	14.3	14.4	14.2	14.3
Cowdenbeath					
Birnie Ridge, 2 Bridge Street	316842, 691087	14.3	14.3	14.2	14.2
3 Paterson Lane	316847, 691161	14.0	14.0	13.8	13.8
Edinburgh					
624 Queensferry Road	318005, 675293	14.1	14.1	14.0	14.0
564 Queensferry Road	318545, 674990	14.3	14.3	14.2	14.2
7 Maybury Road	318621, 674917	14.2	14.2	14.0	14.0
20 Strathalmond Green	318015, 675197	14.1	14.1	14.0	14.0
10 Maybury Road	318540, 674940	14.1	14.1	14.0	14.0
453 Queensferry Road	319627, 674985	14.2	14.2	14.1	14.1
1c Clermiston Road North	320004, 675052	14.2	14.2	14.1	14.1
393 Queensferry Road	320531, 675108	14.1	14.1	14.0	14.0
224 Drum Brae Drive	319074, 674217	14.1	14.2	14.0	14.0
66 Clermiston Road North	320204, 674516	14.1	14.1	13.9	13.9

15.4.52 The assessment shows that there are almost no changes in PM_{10} concentrations between the Do-Minimum and the Do-Something scenarios in both assessed years. There are four receptors in 2017 that experience a 0.1$\mu g/m^3$ change and four receptors in 2032 that are predicted to experience a 0.1$\mu g/m^3$ change. The resulting significance for all receptors in both years is Negligible.

15.4.53 Table 15.37 shows annual mean $PM_{2.5}$ concentrations at the assessed receptor locations.

Table 15.37: Annual Mean $PM_{2.5}$ Concentrations at Receptor Locations in Additional Assessment Areas

Receptor Location	Grid Reference	2017		2032	
		Do-Minimum	Do-Something	Do-Minimum	Do-Something
Linlithgow					
1 Clark Avenue	299267, 677585	9.1	9.1	9.0	8.9
Loch House	299317, 677695	9.1	9.1	8.9	8.9
30 Clark Avenue	298955, 677635	9.1	9.1	8.9	8.9
74 St Ninians Road	299427, 677580	9.1	9.1	9.0	9.0
6 Parkhead Road	299624, 677584	9.1	9.1	8.9	8.9
Polmont					
32 Eastcroft Drive	294018, 678901	9.1	9.1	9.0	9.0
41 Orchard Grove	293755, 679060	9.2	9.2	9.1	9.1
4 Eastcroft Drive	294250, 678772	9.1	9.1	9.0	9.0
Kincardine					
45 Keith Street	292949, 687322	9.0	9.0	8.8	8.8
31 Silver Street	292957, 687283	9.0	9.0	8.8	8.8
26 Forth Street	292909, 687328	8.9	9.0	8.8	8.8
13 Orchard Grove	293031, 687248	8.9	8.9	8.8	8.8
Kelty					
23 Blair Drive	313462, 693962	9.1	9.1	9.0	9.0
38 Clentry Crescent	313434, 694013	9.1	9.2	9.0	9.0
1 Dullomuir Drive	313295, 694381	9.2	9.2	9.0	9.0
16 Clentry Crescent	313371, 694116	9.3	9.3	9.1	9.2
Cowdenbeath					
Birnie Ridge, 2 Bridge Street	316842, 691087	9.2	9.0	9.1	9.1
3 Paterson Lane	316847, 691161	9.0	8.9	8.8	8.8
Edinburgh					
624 Queensferry Road	318005, 675293	9.1	9.1	8.9	8.9
564 Queensferry Road	318545, 674990	9.3	9.3	9.1	9.1
7 Maybury Road	318621, 674917	9.2	9.2	8.9	9.0
20 Strathalmond Green	318015, 675197	9.1	9.1	8.9	8.9
10 Maybury Road	318540, 674940	9.1	9.1	8.9	8.9
453 Queensferry Road	319627, 674985	9.2	9.2	9.0	9.0
1c Clermiston Road North	320004, 675052	9.2	9.2	9.0	9.0
393 Queensferry Road	320531, 675108	9.1	9.1	8.9	8.9
224 Drum Brae Drive	319074, 674217	9.1	9.1	8.9	9.0
66 Clermiston Road North	320204, 674516	9.1	9.1	8.9	8.9

15.4.54 The results in Table 15.37 show that at the majority of assessed receptor points there are no changes in $PM_{2.5}$ concentrations as a result of the proposed scheme. In 2017 there are two receptors that are predicted to experience very small decreases in $PM_{2.5}$ concentrations ($\leq 0.2\mu g/m^3$) and two receptors that are forecast to experience a $0.1\mu g/m^3$ increase in $PM_{2.5}$ concentration.

15.4.55 In 2032 there are four receptors that are predicted to experience a 0.1㎎/m^3 change in $PM_{2.5}$ concentrations. The resulting significance for all receptors with unchanged or decreased $PM_{2.5}$ concentrations is Negligible, whilst the significance for two receptors, that are predicted to experience a very small increase in $PM_{2.5}$ concentrations, is Slight Adverse.

15.4.56 It can be concluded that the overall impact on local air quality in the vicinity of the assessed links is of Negligible significance at the vast majority of receptors.

Impacts on Regional Air Quality

15.4.57 Table 15.38 shows total emissions for the road network covered in the TMfS:05a for 2005 (base year), 2017 Do-Minimum and 2017 Do-Something scenarios as well as total distance travelled in each scenario and emissions per kilometre travelled

Table 15.38: Total Emissions within TMfS:05a Network 2017 (tonnes per annum) and Total Kilometres Travelled

Pollutant	Emissions 2005	Emissions 2017 Do-Minimum	Emissions 2017 Do-Something	Difference 2005/2017 Do-Minimum	Difference 2017DM/2017 Do-Something
NO_x	38,212	19,698	19,726	- 18,514	28
PM_{10}	1,222	549	551	- 673	2
CO_2	8,424,191	8,504,674	8,519,626	80,483	14,952
Total Km travelled	**2005**	**2017 Do-Minimum**	**2017 Do-Something**	**Difference 2005/2017 Do-Minimum**	**Difference 2017DM/2017 Do-Something**
	89,171,204	103,955,050	104,194,154	14,783,846	239,104

15.4.58 Predicted total emissions for NO_x and PM_{10} decrease in 2017 when comparing them to the 2005 base case, whereas CO_2 emissions rose between 2005 and 2017. This is likely to be a result of different emission factor trends between 2005 and 2017. Emission factors for all pollutants decrease with time, mirroring predicted improvements in vehicle technology and fuel efficiency, however, the decrease of emission factors for NOx and PM_{10} is much greater compared with the decrease of CO_2 emission factors. Increasing overall vehicle kilometres travelled overrides the improvements of emissions for CO_2, resulting in an overall increase in total emissions.

15.4.59 There is an increase in emissions for NO_x, PM_{10} and CO_2 when comparing the 2017 Do-Minimum and 2017 Do-Something scenarios. It should be noted that the increase in emissions between the Do-Minimum and Do-Something scenarios is consistent with the increase in vehicle kilometres travelled along the traffic links selected for the regional air quality assessment.

15.4.60 Table 15.39 shows total emissions for the road network covered in the TMfS:05a for 2005 (base year), 2032 Do-Minimum and 2032 Do-Something.

Table 15.39: Total Emissions within TMfS:05a Network 2032 (tonnes per annum) and Total Kilometres Travelled

Pollutant	Emissions 2005	Emissions 2032 Do-Minimum	Emissions 2032 Do-Something	Difference 2005/2032 Do-Minimum	Difference 2032DM/2032 Do-Something
NO_x	38,212	23,913	23,952	- 14,299	39
PM_{10}	1,222	670	672	- 552	2
CO_2	8,424,191	10,308,297	10,328,614	1,884,106	20,317
Total Km travelled	**2005**	**2032 Do-Minimum**	**2032 Do-Something**	**Difference 2005/2032 Do-Minimum**	**Difference 2032DM/2032 Do-Something**
	89,171,204	122,556,837	122,922,679	33,385,633	365,842

15.4.61 Predicted total emissions for NO_x and PM_{10} decrease in 2032 when comparing them to the 2005 base case, whereas CO_2 emissions raise between 2005 and 2032 (for the reasons explained in paragraphs above). There is an increase in emissions for NO_x, PM_{10} and CO_2 when comparing the 2032 Do-Minimum and 2032 Do-Something scenarios. As was the case in 2017, the increase in emissions between the Do-Minimum and Do-Something scenarios is consistent with the increase in vehicle kilometres travelled along the traffic links selected for the regional air quality assessment.

15.4.62 The national emission inventory for Scotland shows that the contribution from the transport sector to NO_x and PM_{10} emissions in 2006 was 71.8 kilotonnes and 4.4 kilotonnes respectively (NAEI, 2008). In 2032 the scheme is predicted to contribute 39 tonnes of NO_x and 2 tonnes of PM_{10}, which is less that 0.1% of the total transport emissions in Scotland in 2006. With regard to CO_2 emissions, the contribution from the proposed scheme in 2032 is 20,317 tonnes, which represents 0.16% of total transport sector emissions in Scotland in 2007 (12.4 million tonnes) (Scottish Government, 2009).

15.4.63 The National Emissions Ceiling Directive (NECD) includes upper limit targets of total UK pollutant emissions to be achieved by 2010. Pollutants included in this Directive are SO_2, NO_x, VOCs and ammonia (NH_3). The upper limit for total NOx emissions in the UK in 2010 is 1167 kilotonnes. The predicted contribution of the proposed scheme to NOx emissions in 2032 is 39 tonnes, approximately 0.003% of the 2010 limit value.

15.4.64 The effect of releasing CO_2 to the atmosphere is a contribution to climate change and consequent impacts such as sea level rise, flooding and a shift in rainfall patterns. There is international consensus that human activity is the one of the primary drivers of the observed changes in the global climate. This is based on long term measurements of climatic conditions and the results of a number of climate change models. The main human influence on the global climate is emissions of greenhouse gases such as CO_2. At present, just over 7 billion tonnes of CO_2 is emitted globally each year through fossil fuel use, and an additional 1.6 billion tonnes are emitted by land use change, largely by deforestation. In the context of these fluxes, the impact of any single development or infrastructure project will always be insignificant in terms of direct impact on climate change. It is however noted that, although relatively small, the increase in CO_2 emissions is contrary to the targets of the Climate Change (Scotland) Act 2009 which has a requirement to reduce emissions by 42% in 2020 (interim target) and 80% by 2050. Therefore the increase in CO_2 as a result of the proposed scheme will require offsetting by greater reductions elsewhere within Scotland.

15.4.65 The carbon cost of the proposed scheme is presented in the DMRB Scheme Assessment Report, Part C.

15.5 Mitigation

15.5.1 The predicted impacts on local air quality as a result of the proposed scheme are generally very small, therefore no mitigation measures are proposed with respect to operational traffic.

15.6 Residual Impacts

Local Air Quality

15.6.1 As described in Section 15.4 the majority of modelled receptors are predicted to experience Negligible significance impacts as a result of the proposed scheme. However, there is one receptor that is predicted to experience Moderate Adverse significance impacts with regards to NO_2 concentrations in 2017 and four modelled receptors are forecast to experience Slight Adverse significance impacts. There are four receptors in 2017 and three receptors in 2032 that are forecast to experience Slight Beneficial significance impacts.

15.6.2 The receptors chosen as discrete receptors are considered to be representative for all sensitive receptors in the local study area. The generated contour plots show that at all sensitive receptor

locations within the study area pollutant concentrations are below the relevant objective and limit values with or without the proposed scheme.

15.6.3 The population exposure assessment shows that impacts on local air quality resulting from the proposed scheme are fairly localised and focussed around the northern and southern bridge heads. Up to 4% of properties within the study area are predicted to experience changes in NO_2 concentrations. In 2032 approximately 1.8% are forecast to experience improvements and 1.3% are predicted to experience a deterioration of local air quality with regards to NO_2. The numbers of properties affected by changes in PM_{10} and $PM_{2.5}$ concentrations (positively or negatively) is extremely small (<0.10% and <0.25% respectively).

Changes in Nitrogen Deposition

15.6.4 Generally, total nitrogen deposition rates decrease between the base year 2005 and future years of 2017 and 2032. At all of the modelled SSSIs, total deposition rates slightly exceed the lower band of the critical load range (i.e. 10kg N/ha/yr) in 2017 but are below it in 2032 (rates are within the upper band of the critical load range in both years). The significance of the identified nitrogen deposition impacts is discussed in Chapter 10 (Terrestrial and Freshwater Ecology).

Regional Air Quality

15.6.5 The regional air quality assessment shows that total emissions of NO_x, PM_{10} and CO_2 are predicted to increase as a result of the proposed scheme. This is consistent with the increase in vehicle kilometres travelled across the regional assessment study area which drives the increase in total emissions.

15.7 Sensitivity Testing of CO_2 Emissions Using Paramics / PHEM Modelling

15.7.1 CO_2 emissions reported earlier in this chapter are based on traffic flows from the strategic traffic model, TMfS:05A as explained in Section 15.2. This approach uses Standard Department for Transport formulae (DMRB emission factors) to calculate CO_2 emissions based on model output speeds and volumes. This approach forecasts modest increases in CO_2 emissions, associated with the introduction of the proposed scheme.

15.7.2 Use of the strategic traffic model has the advantage of wide network coverage, so all of the network effects of the proposed scheme will be encompassed by the assessment. The methodology used to calculate emissions is consistent with many other road projects assessed in Scotland in recent years and it is recognised as the current best practice. However, the CO_2 calculations are based on average speeds and this approach is not capable of assessing the local impact of stop-start traffic conditions.

15.7.3 A new Passenger car and Heavy-duty Emission Model (PHEM[2]) based emissions calculation module has been developed. This can be used with microsimulation models such as S-Paramics (referred to generically as Paramics)[3]. The emissions evaluation using S-Paramics with PHEM relationships is a technique being developed on behalf of Transport Scotland, but not yet fully approved for use in scheme appraisal. The information obtained from this evaluation tool has been used to supplement the strategic calculations which are based on the Department for Transport formulae. The PHEM based results are intended to provide a more informed view of the likely locally generated impact of the proposed scheme.

[2] PHEM was developed by TUG (TU Graz – Institute for Internal Combustion Engines and Thermodynamics)

[3] Paramics and S-Paramics references relate to the use of S-Paramics version 2008.2 software

15.7.4 The PHEM model output is a series of emission factors, based on vehicle type, vehicle speed, vehicle loading and vehicle acceleration. This method calculates the rate of emission for each vehicle at each simulated timestep. The use of PHEM emissions relationships with the S-Paramics model offers the ability to take into account emissions from stop-start motoring, which is not fully reflected within the global evaluation within the air quality model which is based on traffic information from the Transport Model for Scotland (TMfS). The local PHEM based assessment therefore examines the localised effect of stop start motoring conditions on the congested approaches to the Forth Road Bridge and the localised benefits to be derived from relieving these conditions. It is recognised that this local assessment does not quantify wider impacts outwith the S-Paramics model area.

15.7.5 Traffic conditions in peak periods within the vicinity of the Forth Road Bridge are frequently congested. The established and standard methodology for calculating CO_2 emissions, (based on the Department for Transport formulae), relies on average traffic speed as the basis for calculation. In comparison to the Do-Minimum, the proposed scheme will result in smoother traffic flows and improved journey time reliability. The average speed calculated on the network, using the Department for Transport method, in the vicinity of the scheme in the Do-Minimum scenario, reflects a range of emissions conditions from traffic which is variously accelerating, braking, idling and cruising, rather than travelling steadily at that average speed. One of the features of the Managed Crossing Scheme is that traffic will be controlled to improve flow conditions and hence, reduce emission rates, compared with the current conditions.

15.7.6 Tests were undertaken using the S-Paramics / PHEM module to compare Do-Something traffic emissions with Do-Minimum emissions in the AM and PM modelled periods for 2017 forecasts. The scheme design in conjunction with ITS operation will result in improved fuel efficiency and lower emissions per kilometre. However, the Do-Something scheme involves additional travel distance for cross Forth traffic and additional traffic demand which result in increased CO_2 emissions.

15.7.7 The additional CO_2 emissions for the AM period are forecast to be 3.7 tonnes in the AM period and 14.7 tonnes in the PM period. These forecasts relate to AM and PM periods during average week day traffic. The proposed scheme involves some additional travel distance to cross the Forth and attracts more traffic to this part of the network. As a result of these two factors, the travel distance in terms of vehicle kilometres is expected to increase in the Do-Something scheme, compared with the Do-Minimum comparator.

15.7.8 Results of the test are presented in Tables 15.40 and 15.41.

Table 15.40: Total CO_2 Emissions within the Paramics Network in 2017 (tonnes)

Pollutant	Emissions 2017 Do-Minimum	Emissions 2017 Do-Something	Difference 2017DM/2017 Do-Something	% Change (local area) 2017 Do-Something versus 2017 Do-Minimum
CO_2 (Tonnes) AM	253.1	256.8	3.7	1.5%
CO_2 (Tonnes) PM	268.4	283.1	14.7	5.5%

Table 15.41: Total vehicle Kilometres within the Paramics Network in 2017

	Vehicle Kilometres 2017 Do-Minimum	Vehicle Kilometres 2017 Do-Something	Difference 2017DM/2017 Do-Something	% Change (local area) 2017 Do-Something versus 2017 Do-Minimum
AM	932,669	995,484	62,815	6.7%
PM	1,129,048	1,191,004	61,956	5.5%

15.7.9 If the fuel efficiency of the network operation were to remain constant, the rate of CO_2 per kilometre would also be expected to remain constant. Total vehicle kilometres is the measure of total distance travelled by all vehicles in the model network. If the Do-Something model were to operate

with the same level of fuel efficiency as the Do-Minimum, then we would expect the proportionate change in emissions to be similar to the increase in vehicle kilometres.

15.7.10 When we compare the increases in CO_2 in table 15.40 with the increases in vehicle kilometres in table 15.41, we can see that the percentage increase in CO_2 in the PM peak is similar to the percentage increase in travel in the PM peak. However, in the AM peak the percentage increase in CO_2 is significantly lower than the increase in travel distance and hence, less than might otherwise be expected. The test indicates that during the congested morning peak period, the forecast increase in CO_2 emissions from the additional traffic and distance travelled is reduced by the improved scheme design and operation of ITS, which reduces congestion.

15.7.11 There is less congestion relief forecast in the evening peak and therefore a smaller reduction in the predicted increase in CO_2 emissions during this period.

15.7.12 The proposed scheme is also likely to avoid the need for main cable replacement and other maintenance works that are envisaged as being necessary to retain the Forth Road Bridge in use in the absence of a replacement crossing. These works on the Forth Road Bridge, extending over an anticipated eight year period, would have a significant impact on traffic congestion and routing and hence emissions that the air quality assessment reported in this chapter does not take this impact into account. Please refer to Appendix A5.1 for more information on the impacts of these works.

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