ESR
Science for Communities

Air quality-related public health impacts from land use and transport:

Literature Review

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1. INTRODUCTION

As part of the *Health Risks from Transport Emissions in New Zealand* research project, Emission Impossible Limited (EIL) were contracted to undertake a brief literature review on quantifying the health impacts of land use and transport emissions, including the ability to consider the benefits of alternatives. While guidance and tools exist in New Zealand to assess public health impacts associated with transport emissions from roading projects, land use impacts are less well supported.

For this review, we undertook a rapid-fire review of resources available in several select overseas jurisdictions and this report summarises the current state of information. Despite organisations acknowledging that land use influences how transport is undertaken and, in turn, the associated harmful and greenhouse gas emissions, little guidance is available on best practice methods for assessing impacts.

From the resources reviewed, the *Emissions Factors Toolkit* developed by the UK Department of Environment Food and Rural Affairs (DEFRA) and a preliminary emissions assessment undertaken for the Auranga subdivision by the MADE Group offer good starting points for stimulating discussion on developing guidance for New Zealand.

Our review is presented in the following sections and covers:

- Background on the impact and assessment of transport activities on public health
- Resources reviewed with summarised findings
- Conclusions.

A glossary and all references are included at the end.

2. BACKGROUND

2.1 IMPACT OF TRANSPORT ACTIVITIES ON PUBLIC HEALTH

Transport activities have direct and indirect public health effects, some of which are negative (e.g. air pollution) but others which are positive (e.g. increased physical activity).

A well-designed transport system reduces reliance on non-renewable resources and fits into the natural and physical environment in ways which avoid, remedy or mitigate adverse effects on the environment. Intrinsic to this is good urban design, as land use dictates the need for, and extent of, travel in any given area.

Facilitating transport by active modes reduces adverse effects caused by emissions of harmful air pollutants and greenhouse gases as well as generating better outcomes such as public health benefits from increased activity levels, improved safety, reduced noise and better-connected communities.

Shifting from car-dominated urban development towards mixed-use development oriented around public and active transport is important to improving air quality and meeting climate change objectives. This shift requires land use decisions for residential, commercial and industrial areas (both brownfield and greenfield), new and significantly modified transport options (roads, railway lines and stations, public transport hubs etc), and other infrastructure that impact on vehicle use, to be developed in a way that reduces the desire for and need for car trips.

2.2 ASSESSING IMPACTS OF TRANSPORT ACTIVITIES

To date in New Zealand, assessing how transport activities influence air pollution levels has typically been limited to assessing the impacts of vehicles associated with road infrastructure only. For example:

- A new road or motorway assesses the direct air quality impacts from the number of vehicles on just that stretch of road.
- A large retail complex (e.g. a new supermarket) looks at the amount of traffic generated by the activity to inform the need for any traffic controlling requirements, with the minimum required number of carparks specified in the District Plan.
- A new brownfields residential subdivision assesses how many cars will go into the neighbouring existing road network and whether additional traffic controlling devices are required.

Little consideration has usually been given to determine whether better, more environmentally, air quality friendly, ways exist to get people to where they need to go instead of the passenger car. For example, whether:

- Adding a bus lane as part of the road or motorway would reduce the number of road lanes that would be required
- The supermarket would need fewer carparks if it was on a train line
- Placing a small shopping centre within walking distance of the brownfields subdivision would mean fewer trips by car for residents to get 'a bottle of milk and loaf of bread'.

This lack of a ‘holistic’ assessment has led to missed opportunities to reduce transport-related air pollutants (and greenhouse gases). Going forward, the methodology needs to be broadened to incorporate assessing the impacts of land use options on how transport is undertaken and then calculating the associated changes in air quality emissions from the various options.

A wealth of policy documents exists in New Zealand supporting efforts to reduce emissions through improved integration of transport, land use and employment to reduce the reliance on private cars. Policy documents from numerous central government and regional agencies all recognise that the shift away from car-centric urban development towards mixed-use development oriented around public and active transport is critically important to meeting climate change objectives.

The current legislative framework in New Zealand, the Resource Management Act 1991, requires assessments of traffic-related air quality emissions for large roading projects (usually through the designation process). Land use activities generally require land use consents for small projects (e.g. supermarkets) or plan changes of district plans for large projects (public or private).

The authors are only aware of one project in New Zealand where the air quality impacts from land use and transport have been assessed– MADE Group (Kuschel & Metcalfe 2021)[1]. This project was part of a Private Plan Change to determine whether the location of a new train station would impact the amount of traffic (and hence air quality emissions) generated. This preliminary assessment found:

> “*many of the current integrated transport assessment methodologies are not fit for purpose for assessment of transport emissions impacts. We have made some broad assumptions to inform this assessment. However, we consider that there is a need for development of methodologies and guidance” (p23).*

This literature review seeks to identify best practice approaches that could be adopted consistently for these types of assessment in New Zealand to address the current knowledge gaps[2].

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[1] Note this assessment was undertaken by Emission Impossible Ltd.

[2] This literature review is not an exhaustive list of all land use, transport and air quality related information. Rather it is a preliminary investigation into organisations that are generally considered to have similar approaches to air quality management as New Zealand.

3. RESOURCES REVIEWED AND SUMMARY OF FINDINGS

This chapter describes the documents and websites that were reviewed for organisations generally considered to have similar approaches to air quality management as New Zealand.

Each resource has its reference highlighted (with web links provided for easy access) together with a brief set of key points about each.

Note: As this is a rapid-fire review, the documents highlighted do not comprise an exhaustive list of all land use, transport and air quality-related information. However, they cover the critical resources.

3.1 UNITED STATES ENVIRONMENTAL PROTECTION AGENCY (US EPA)

3.1.1 Smart growth

Mixed Use Trip Generation Model 2022

Website (last updated 1 September 2022)

A set of linked models that estimate internal capture of trips within mixed-use developments as well as walking and transit use for trips starting or ending in mixed-use developments.

The models have been validated against actual traffic counts at mixed-use developments across the country. The method is currently used in several regions in California, Washington, and New Mexico, and the Virginia Department of Transportation adopted it as a state-wide standard for determining the traffic impacts of urban developments.

The overall model is an excel spreadsheet and provides answers in vehicle miles travelled (VMT). It has no reference to air quality emissions but may be able to be used to generate more detailed vehicle kilometres travelled (VKT) in NZ for mixed use activities.

The website also refers to other resources that describe the standard trip generation methods and other recent efforts to better understand the impacts of mixed-use developments and related smart growth strategies:

- *Trip and Parking Generation Technical Resources*, Institute of Transportation Engineers (ITE). Links to trip generation publications and other resources.
- *Enhancing Internal Trip Capture Estimation for Mixed-Use Developments*, National Cooperative Highway Research Program Report 684, 2011. This method, similar in scope to the US EPA method described above, estimates peak-period internal capture rates for mixed-use developments for use in standard ITE trip generation applications.
- *Effects of TOD on Housing, Parking, and Travel*, Transit Cooperative Research Program Report 128, 2008. This report gives insight into the characteristics of residents of transit-oriented development (TOD), including their trip generation rates.

3.1.2 Brownfield and infill development resources

Comparison of assessment methodologies 2001

US EPA (2001a). Comparing Methodologies to Assess Transportation and Air Quality Impacts of Brownfield and Infill Development. Report EPA-231-R-01-001, Office of Policy, Economics and Innovation, US Environmental Protection Agency, June 2001. Report link

Discusses different methodologies linked to state implementation plan (SIP) impact assessments. However, report is from 2001.

Measuring air quality and transportation impacts 2007

US EPA (2007). *Measuring the Air Quality and Transportation Impacts of Infill Development*. Report EPA 231-R-07-001, US Environmental Protection Agency, November 2007. Report link

Report looks at three case studies to assess how traffic models can be used to consider infill (mixed use) housing and air quality impacts. Concludes that methodologies must be customised to fit each region. But does identify limitations of traditional traffic models and describes specific concepts and techniques that can serve as a starting point for modifying most regional travel demand models.

> *"Although less vehicle travel and fewer emissions are reasonable outcomes to expect from infill development, quantifying such benefits has proved challenging. In most cases, the forecasting models used for regional transportation planning are not set up to capture the effect of innovative land use strategies. Therefore, they typically do not capture the changes in vehicle travel generated by increasing development in walkable communities with convenient access to transit. Quantifying benefits is also complicated by the need to establish baseline development trends. In other words, measuring the net benefit of a set of infill projects requires establishing where development would have otherwise gone.*
>
> *This report summarizes three case studies, each testing slightly different approaches to these analytical problems within traditional four-step travel-demand models. The analysis shows how standard forecasting tools can be modified to capture at least some of the transportation and air quality benefits of brownfield and infill development" (pg i)."*

Includes:

- Indices to reflect how mixed-use development changes travel patterns
- Adjustments to account for shifts to non-motorised travel
- Smaller analysis zones in the models to capture the impact of neighbourhood land use patterns
- Emissions estimates based on the number of car trips as well as by distance travelled

The three case studies are:

- Denver – shifting jobs and households to 10 town centres
- Charlotte – increased development in a single transit corridor
- Boston – redirecting new development to brownfields sites in the I-495 corridor.

References the following additional documents:

- *Granting Air Quality Credit for Land Use Measures: Policy Options*, EPA SR99-09-01, US EPA.

- *The Transportation and Environmental Impacts of Infill Versus Greenfield Development: A Comparative Case Study Analysis*, EPA publication number 231-R-99-005. US EPA.

The main issue is that the report is from 2007 and refers to the US EPA Traffic Emissions Model *MOBILE 6*. This has since been replaced by *MOVES3* (US EPA 2020) which is the US EPA version of New Zealand's *Vehicle Emissions Prediction Model* (VEPM 6.3) (NZTA 2022).

MOVES3 does not account for land use and therefore requires that any modelling predictions are through the transport model. As this study highlights, these generally do not deal with the granular level required.

3.1.3 Land use guidance

Improving air quality through land use activities 2001

US EPA (2001b). *EPA Guidance: Improving Air Quality Through Land Use Activities*. Transportation and Regional Programs Division, Office of Transportation and Air Quality, US Environmental Protection Agency, January 2001. Report link

Document provides guidance to:

- Describe the options for accounting for the air quality benefits of land use activities in the air quality planning and transportation planning processes (i.e. state implementation plans (SIPs), and conformity determinations)
- Help determine which option is appropriate for a chosen land use activity and
- Help model the air quality impacts of land use activity.

Is aimed at air quality (AQ) non-attainment or maintenance areas of the US and provides links to the transportation planning processes. Refers to five ways urban form impacts travel activity:

- Density
- Land use mix
- Transit accessibility
- Pedestrian environment/urban design factors
- Regional patterns of development.

References several studies that have been done to account for emissions from transport due to land use - Portland, Oregon (1996), Los Angeles, California (1994)[3], Baltimore, Maryland and Washington, DC (1992).

Section 2 details the policy and technical considerations to account for the air quality benefits of land use in SIPs. Discusses in generic terms how land use inputs can be included in transport models for travel demand forecasting - speed and VMTs.

[3] Johnston RA, Rodier CJ, Choy M & Abraham JE (2000). *Air Quality Impacts of Regional Land Use Policies.* Prepared for U.S. Environmental Protection Agency, Urban and Economic Development Division, Washington, DC.

States that:

"travel demand forecasting is a process where transportation planners predict expected travel activity throughout a region. Travel demand models are commonly used to make these predictions through the "4- step modelling" process. This process is described briefly below.

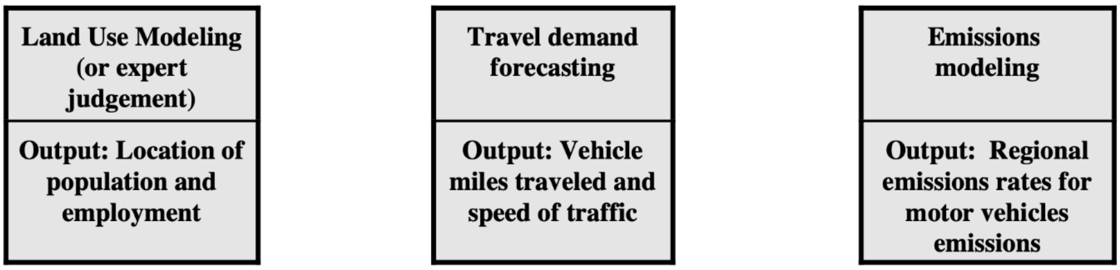
First, an area is divided up into travel analysis zones, from which trips originate and to which trips are destined. The amount of population, households and employment forecasted for a zone will affect how much travel will occur in and between zones. Employment is used to represent not only work activities, but also shopping, lunch and other types of trips. Then, the model performs the following 4 steps:

1. ***Trip Generation**: The trip generation step uses the land use assumptions to estimate the number of trip ends (productions and attractions) for each zone. The trips are generated by trip type, such as "home-based work," "home-based other" or "non-home based."*
2. ***Trip Distribution**: The trip distribution step links the productions with the attractions. Demand for travel between two zones is related to the number of trips in and out of the zone, and the amount of impedance (i.e., the effect of time, distance, and/or cost on travel activity).*
3. ***Modal Choice**: In some areas, the travel demand model also produces estimates of trips by mode (e.g., highway, transit, or other modes). Mode choice models may take into consideration factors such as demographic group, cost, trip purpose, and relative travel times.*
4. ***Trip Assignment**: Trip assignment involves assigning vehicle trips to specific links of the travel network. Travel demand models also estimate the speeds that vehicles travel, based on how congested the road network is.*

This process generates VMT and speed data that is directly used to estimate motor vehicle emissions."

Figure 3 on p30 (reproduced below) shows the relationship between the land use inputs, travel demand forecasting, and the emissions modelling.

FIGURE 3. RELATIONSHIP BETWEEN LAND USE MODELING, TRANSPORTATION PLANNING, AND EMISSIONS MODELING.



The report does not include any specific methods for undertaking assessments.

3.2 CALIFORNIA AIR RESOURCES BOARD (CARB)

Policy Brief on the Impacts of Transit Access 2013

Tal G, Hardy S & Boarnet MG (2013). *Policy Brief on the Impacts of Transit Access (Distance to Transit) based on a Review of the Empirical Literature.* Prepared by the University of California for the California Air Resources Board, 3 December 2013. Report link

Investigates literature detailing impacts on VMT due to distance people must walk to rail and bus stations.

Identifies that

> *"no available studies provide direct evidence of the effect of distance to transit on greenhouse gas (GHG) emissions. However, to the extent that it leads to reduced vehicle use, improving transit access may help reduce GHGs."*

Discusses some of the co-benefits associated with improved transit access but does not cover air quality.

Technical report refers to modelling changes in modes in *Ch 6 – Method to assess health impacts from cycling and walking by undertaking a cost-based approach*.

Air Quality and Land Use Handbook 2017

CARB (2017). *Strategies to Reduce Air Pollution Exposure Near High-Volume Roadways: Technical Advisory.* Research Division, California Environmental Protection Agency | Air Resource Board, 2017. Report link

Identifies an optimal average speed of between 33 and 55 mph to minimise fuel consumption and traffic emissions.

Includes near roadway air quality levels.

Talks about the benefits of compact, infill development and the requirement to consider air quality impacts from very large roadways (>50,000 vehicles/day for a rural area or 100,000 vehicles/day in an urban area).

Discusses air quality impacts and improvements related to road corridors to improve air flow, effects of sound walls, vegetation, indoor filtration and some traffic calming devices.

3.3 VICTORIA TRANSPORT POLICY INSTITUTE (VTPI), CANADA

The Victoria Transport Policy Institute, based in British Columbia, is an independent research organization dedicated to developing innovative and practical solutions to transportation problems. They provide a variety of resources available free to help improve transportation planning and policy analysis.

Evaluating Transportation Land Use Impacts 2022

Litman T (2022). *Evaluating Transportation Land Use Impacts – Considering the Impacts, Benefits and* Costs *of Different Development Patterns.* 25 Oct 2022. Report link

The report examines ways that transportation decisions affect land use patterns, and the resulting economic, social and environmental impacts.

Identifies that certain transportation planning decisions tend to increase sprawl (dispersed, urban-fringe, automobile-dependent development), while others support smart growth (more compact, infill, multi-modal development).

Discusses how these development patterns have various economic, social and environmental impacts and describes specific methods for evaluating these impacts in transport planning.

Does not discuss air quality.

3.4 EUROPEAN COMMISSION

3.4.1 Sustainable Urban Development Planner for Climate Change Adaptation (SUDPLAN)

Website

Engardt M, Johansson C & Gidhagen L. (2011). Web Services for Incorporation of Air Quality and Climate Change in Long-Term Urban Planning for Europe. In: Hřebíček J, Schimak G, Denzer R (eds) Environmental Software Systems. Frameworks of eEnvironment. ISESS 2011. *IFIP Advances in Information and Communication Technology*, vol 359. Springer, Berlin, Heidelberg. Report link

Describes a web-service that will allow end-users in an arbitrary European city to consider population growth, transportation design and energy productions effects on air quality and climate change.

Looks promising for predicting air pollution levels at a city-wide meta scale but unable to locate web-service as research project apparently closed in 2012 and was not adopted by the European Union.

3.4.2 Transport Research and Innovation Monitoring and Information Systems (TRIMIS)

Website

Discusses land use and transport but provides no specific information on assessing air quality impacts except references to TRANSPLUS (details below).

TRANSport Planning, Land Use and Sustainability (TRANSPLUS) 2003

European Commission – Community Research (2003). *TRANSPLUS – Achieving Sustainable Transport and Land Use with Integrated Policies – Contract EVK4-CT-1999-00009 – Final Report.* European Commission – Community Research, December 2003. Report link

Discusses the need for integrated Land Use and Transport (LUT) policies to reduce impacts from motor vehicles.

Talks about strategies and policy implementation including a menu of LUT measures and supporting tools.

Advises that current modelling tools are not particularly effective and refers to several city case studies to show how assessment approaches are being undertaken.

Refers to several other TRANSPLUS projects, including:

- TRANSPLUS – System Analysis of Trends and Strategies – Deliverable 1 (2000)
- TRANSPLUS – Impacts of Megatrends on Transport and Land Use in Europe – Deliverable 1.1 (2000)
- OECD-ECMT – Implementing Sustainable Urban Travel Policies – Final Report (2002)
- European Commission – Thematic Strategy on the Urban Environment (TSUE) – Twelve Candidate Countries Overview Report (2003)
- TRANSPLUS – Assessment of Integrated Land Use and Transport Planning Strategies – Deliverable 2 (2002)

- TRANSPLUS – Assessment of development strategies – Deliverable 2.1 (2002)
- TRANSPLUS – Assessment of Implementation Strategies – Deliverable 3 (2002)
- TRANSPLUS – Public transport-oriented development – Deliverable 3.1 (2002)
- TRANSPLUS – Pedestrian and cycling friendly structure development – Deliverable 3.2 (2002)
- TRANSPLUS – Car restriction development – Deliverable 3.3 (2002)
- TRANSPLUS – Land Use and Transport Indicators – Deliverable 3.4 (2002)
- TRANSPLUS – Supporting models and indicators – Deliverable 2.2 (2002)
- TRANSPLUS ACCESS – Case studies reports – Assessment of planning and implementation strategies in five AAC cities (2003)
- TRANSPLUS ACCESS – Synthesis Report – Assessment of planning and implementation strategies – 2003.

Notes that

> *"A full account of what models have been used in the TRANSPLUS case studies, their outputs, strengths and weaknesses, and in particular the evaluation of their capability to handle and assess integrated LUT measures is provided in TRANSPLUS Deliverable 2.2. (available at www.transplus.net)."*

However, website no longer exists. TRIMIS no longer have the reports and our search has not located them elsewhere.

3.5 UNITED KINGDOM

3.5.1 Department for Environment, Food & Rural Affairs (DEFRA)

Assessing wider impacts of air quality policy (AQ0961) 2015

DEFRA (2015a). *Assessing wider impacts of air quality policy (AQ0961) – Final Report.* Prepared by Amec Foster Wheeler Environment & Infrastructure UK Limited with Systra and Energy Saving Trust for UK Department for Environment, Food and Rural Affairs, June 2015. Report link

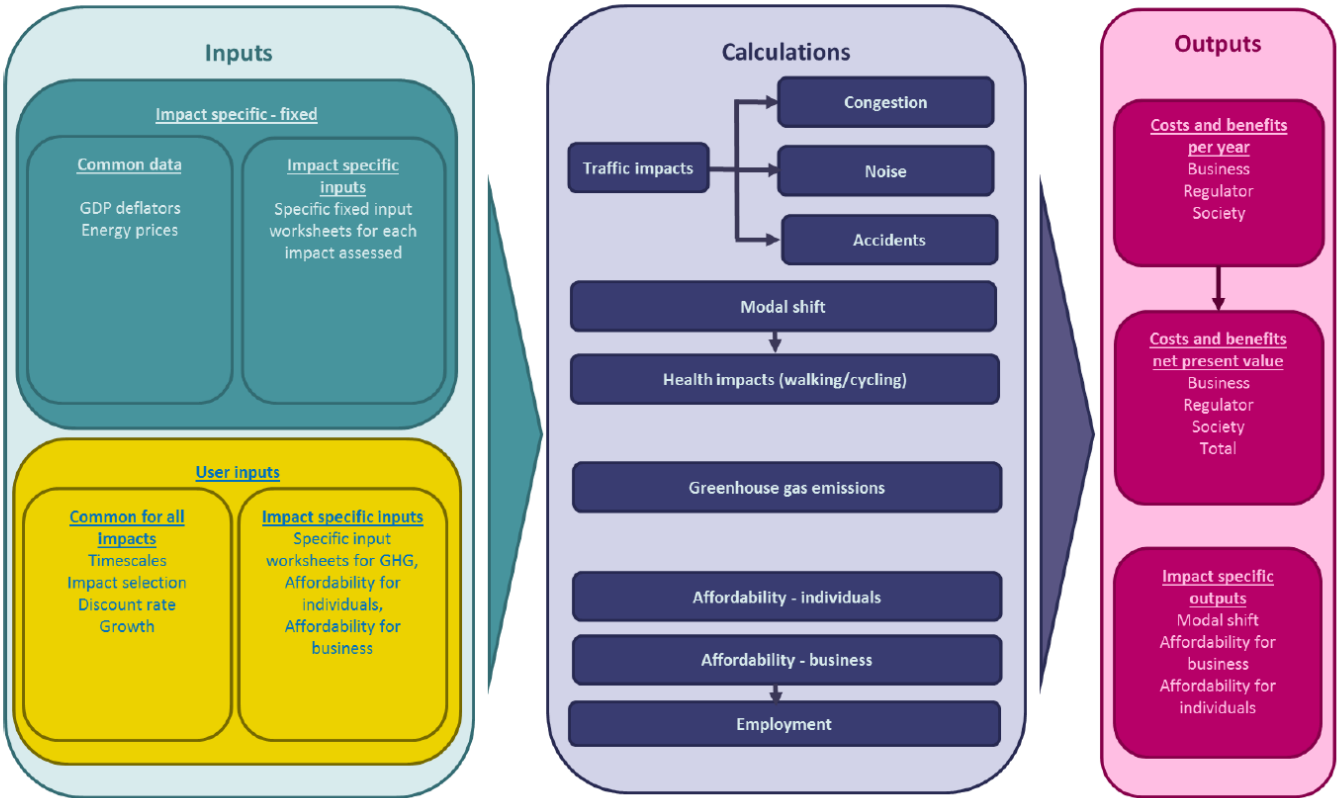
Study designed to assess the potential wider impacts of air quality policy options and to deliver more comprehensive estimation of potential benefits and costs of options, as outlined in Figure 5.1 of DEFRA 2015a (reproduced below).

The final report provides a summary of the literature review undertaken with a good summary of UK requirements in 2015 and is supported by an excel model, Technical Specifications (DEFRA 2015b) and User Guide (DEFRA 2015c).

The model is particularly designed to improve the assessment of transport-related interventions as it allows for quantification of the costs and benefits linked to changes in traffic intensity (specifically congestion, noise and safety). It also allows the quantification of health impacts resulting from switching from car travel to active modes of transport (cycling or walking).

The model can also assess impacts on greenhouse gases.

Figure 5.1 Structure of the Wider Impacts Model



Emissions Factors Toolkit v11.0 2021

Website (last updated November 2021)

The *Emissions Factors Toolkit* (EFT) is published by DEFRA and the Devolved Administrations to assist local authorities in carrying out review and assessment of local air quality as part of their duties under the Environmental Act 1995 as amended by the Environment Act 2021.

The EFT allows users to calculate road vehicle pollutant emission rates for oxides of nitrogen (NOx), particulate matter (PM_{10} and $PM_{2.5}$) and carbon dioxide (CO_2) for a specified year, road type, vehicle speed and vehicle fleet composition.

The toolkit consists of an excel model and a Users Guide and includes non-exhaust carbon dioxide equivalents (CO_2e) for battery charging of electric vehicles.

3.5.2 UK Department for Transport (UK DfT)

Transport Analysis Guidance (TAG) Website 2022

Website (last updated 19 October 2022)

Details how to conduct transport studies. Contains best practice guidance for assessing transport projects including worksheets:

- Cost benefit analysis (A1)
- Economic impacts (A2)
- Environmental impacts (A3)
- Social and distributional impacts (A4)
- Uni-modal appraisal (A5).

The *Environmental impacts module* (A3) includes sections on air quality and greenhouse gases. The Air section uses a Local Air Quality Workbook (LAQ) (part of the TAG Data book) and identifies that the project steps are:

- Scoping
- Quantification
- Assessment of Impacts
- Monetary valuation
- Consideration of distributional impacts of changes in air quality (TAG Unit A4.2).

The *Distributional Impacts Model* (A4.2) assessments include:

- **Screening** – in particular "consideration should also be given to the number and locations of schools in the area as well as other places where children are likely to spend time outdoors such as nurseries, playgrounds, parks and other open spaces. The screening for air quality impacts should also identify if there are any Air Quality Management Areas (AQMAs) within close proximity" (pg 25)
- **Assessment** – including which areas will be impacted, identifying social groups and amenity areas in the impact area
- **Appraisal of Impact** – map impact areas, investigate impact according to deprivation index and 'winners and losers'.

TAG Module A5.1 *Active Mode Appraisal* (May 2020) – refers to costs of active mode for comparison.

TAG Module A5-4 *Marginal External Costs* (May 2020) – discusses how to allocate marginal external costs for vehicles under different circumstances including for a shift to low emission and zero emission vehicles.

The TAG approach is very detailed and includes an assessment of impact of traffic related emissions, social equity and external costs. However, land use changes are not explicitly included.

3.5.3 Transport Scotland

Scottish Transport Appraisal Guidance (STAG) Technical Database 2015

Transport Scotland (2022). *Scottish Transport Appraisal Guidance (STAG) Technical Database*. Database, accessed 22 November 2022. Report link

Section 7 – Environment – section 7.4.3 Local Air Quality discusses how to assess air quality impacts from transport projects. Transport model outputs include change in speed by mode by model area and changes in passenger car unit/VKT by mode by model area.

Breaks air emissions estimations into 2 categories – Strategic and Project. Introduces the concept of an 'emissions exposure estimate'. Includes an Air Quality Valuation Spreadsheet for calculating monetary values for air pollutants.

Table 7.6 (reproduced below) provides damage cost values by pollutant.

Valuing changes in air pollution

All of the damage costs and marginal abatement costs required to value air quality impacts are included in Table 7.6.

Table 7.6: Damage cost and marginal abatement cost values by pollutant (2010 prices, 2010 values)

	Central Value	Low value	High value
PM_{10} damage costs (£/household/1µg/m^3)	92.7	48.6	105.4
NO_x damage costs (£/tonne)	955	744	1085
NO_x marginal abatement costs (£/tonne)	29,000	27,000	73,000

Values for NO_x emissions are in £ per tonne, while PM_{10} values are £ per household per 1µg/m^3 and should be applied to the overall score for the scheme as reported in the TAG LAQ Workbook.

Very *similar* approach to UK DfT.

Note: Damage cost values by pollutant are provided in the New Zealand *Monetised Benefits and Costs Manual* (MBCM) produced by Waka Kotahi (NZTA 2021). At time of writing, these are being reviewed to reflect updated estimates of the Value of Statistical Life (VoSL) and New Zealand-specific damage costs developed in the latest Health and Air Pollution in New Zealand study (HAPINZ 3.0) (Kuschel *et al* 2022).

3.6 VICTORIA STATE GOVERNMENT, AUSTRALIA

Department of Transport Website 2022

Website

Changes made in December 2021 to the Transport Integration Act 2010 to ensure land use planning decisions put the transport user, and how they move, rather than individual transport modes at the centre of the transport system.

Aims to ensure that transport projects include all modes not just vehicles.

Does not discuss air quality other than to note that the vision for the inner west of Melbourne is to improve air quality and liveability by reducing vehicle movements (mainly freight) through local streets.

3.7 INTERNATIONAL RESEARCH PAPERS

Affum J, Brown A & Chan Y (2003). Integrating air pollution modelling with scenario testing in road transport planning: The TRAEMS approach. *The Science of the Total Environment* **312**(1-3):1–14, 1 August 2003. Paper link

Refers to a *Transport Add-on Environmental Modelling System* (TRAEMS), which is a GIS-based environmental model to evaluate the consequence of road traffic impacts in urban areas.

Paper investigates the air pollution and fuel consumption modules and undertakes case studies at city-wide and local-area scales.

[Model was developed in 1998 by Griffith University, Queensland. Unable to locate copy of model.]

Boogaard H, Janssen N, Fischer P, Kos G, Weijers E, Cassee F, van der Zee S, de Hartog J, Meliefste K, Wang M, Brunekreef B & Hoek G (2012). Impact of low emission zones and local traffic policies on ambient air pollution concentrations. *The Science of the Total Environment* **435-436**:132–140, 1 October 2012. Paper link

Study investigated air pollution at street level before and after implementation of local traffic policies including low emission zones (LEZ) directed at heavy duty vehicles (trucks) in five Dutch cities.

The study found that with the exception of one urban street where traffic flows were drastically reduced, the local traffic policies including LEZ were too modest to produce significant decreases in traffic-related air pollution concentrations.

Frank LD, Sallis JF, Conway TL, Chapman JE, Saelens BE & Bachman W (2006). Many Pathways from Land Use to Health: Associations between Neighborhood Walkability and Active Transportation, Body Mass Index, and Air Quality. *Journal of the American Planning Association* **72** (1):75-87 Paper link

Evaluates the association between a single index of walkability incorporating land use, street connectivity, net residential density, and retail floor area ratios, with health-related outcomes in King County, Washington.

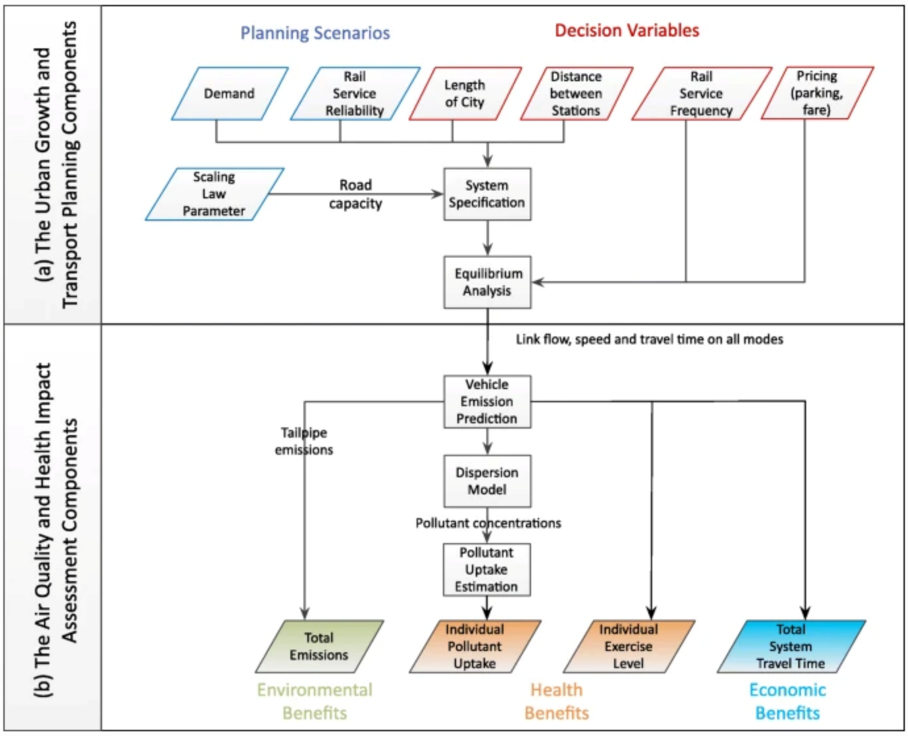
Found a 5% increase in walkability to be associated with a per capita 32.1% increase in time spent in physically active travel, a 0.23-point reduction in body mass index, 6.5% fewer vehicle miles travelled, 5.6% fewer grams of oxides of nitrogen (NOx) emitted, and 5.5% fewer grams of volatile organic compounds (VOC) emitted.

Wang J & Connors D (2018). Urban Growth, Transport Planning, Air Quality and Health: A Multi-Objective Spatial Analysis Framework for a Linear Monocentric City. *Journal of Networks and Spatial Economics* **18**: 839-874 Paper link

Paper looks at inclusion of potential health benefits of transport investment decisions using a methodology that assesses multi-modal transport - i.e. it assesses the potential health impact of active modes both as a means to replace car trips and as an access for multi-modal trips with public transport.

An overview of the modelling suite is depicted in Fig. 2 (reproduced below), consisting of two sets of sub-components: (a) the urban growth and transport planning components; and (b) the air quality and health impact assessment components. The urban growth and transport planning components include two processes: (i) system specification; and (ii) equilibrium analysis.

Fig. 2



An overview of the modelling suite of urban growth, transport planning, air quality and health impact assessment components

Identifies that:

> *"despite a rich literature linking transport modelling to air quality as well as health impact assessment of modal shifts from car to cycling, there are a few knowledge gaps in the existing methodology:*
>
> - *the health **impact should include both** physical activity benefits and pollutant uptake*
> - *the localised **effect on spatial pattern of air quality** as a result of transport choices (e.g. mode choice, route choice, etc.) of residents should be considered and*
> - *the **exposure encountered by travellers on different modes at different locations** throughout their trip should be estimated based on their physical activity on different modes as well as the spatial pattern of air quality concentrations."*

Yigitcanlar T & Kamruzzaman M (2014). Investigating the interplay between transport, land use and the environment: a review of the literature. *International Journal Environmental Science and Technology* **11**:2121–2132 Paper link

Review of literature within a Special Issue on Transport, Land Use and the Environment in the International Journal Environmental Science and Technology. Very generic.

Zhang L, Hong JH, Nasri A & Shen Q (2012). How built environment affects travel behavior: A comparative analysis of the connections between land use and vehicle miles traveled in US cities. *Journal of Transport and Land Use* **5**(3):40-52 Paper link

Found that promoting compact, mixed-use, small-block and infill developments can be effective in reducing VMT per person. However, the effectiveness of land use plans and policies encouraging these types of land developments varies.

Identified several factors that potentially influence the connection between built environment shifts and VMT changes including urban area size, existing built environment characteristics, transit service coverage and quality, and land use decision-making processes.

3.8 NEW ZEALAND

3.8.1 Ministry for the Environment (MfE)

Good Practice Guide for Assessing Discharges to Air from Land Transport 2008

MfE (2008). *Good Practice Guide for Assessing Discharges to Air from Land Transport*. Ministry for the Environment, Wellington, New Zealand, June 2008. Report link

Provides good practice protocols for assessing discharges to air from land transport in New Zealand, to enable transport and policy planners to determine whether a project is likely to have significant air quality impacts.

Only considers the effects of emissions to air from land transport, and principally those from petrol and diesel on-road vehicles.

Uses a three-tiered approach to ensure that the level of assessment undertaken reflects the likely level of effect from a proposal. The three tiers of assessment being:

- **Tier 1: preliminary assessment** identifies whether significant air quality effects are likely
- **Tier 2: screening assessment** uses straightforward dispersion modelling techniques
- **Tier 3: full assessment**, requires more complex modelling and site-specific data.

Tier 1 and Tier 2 assessment procedures apply only to the assessment of emissions from motor vehicles. Assessment of other land transport projects (e.g., railways and tunnels) requires specialist input.

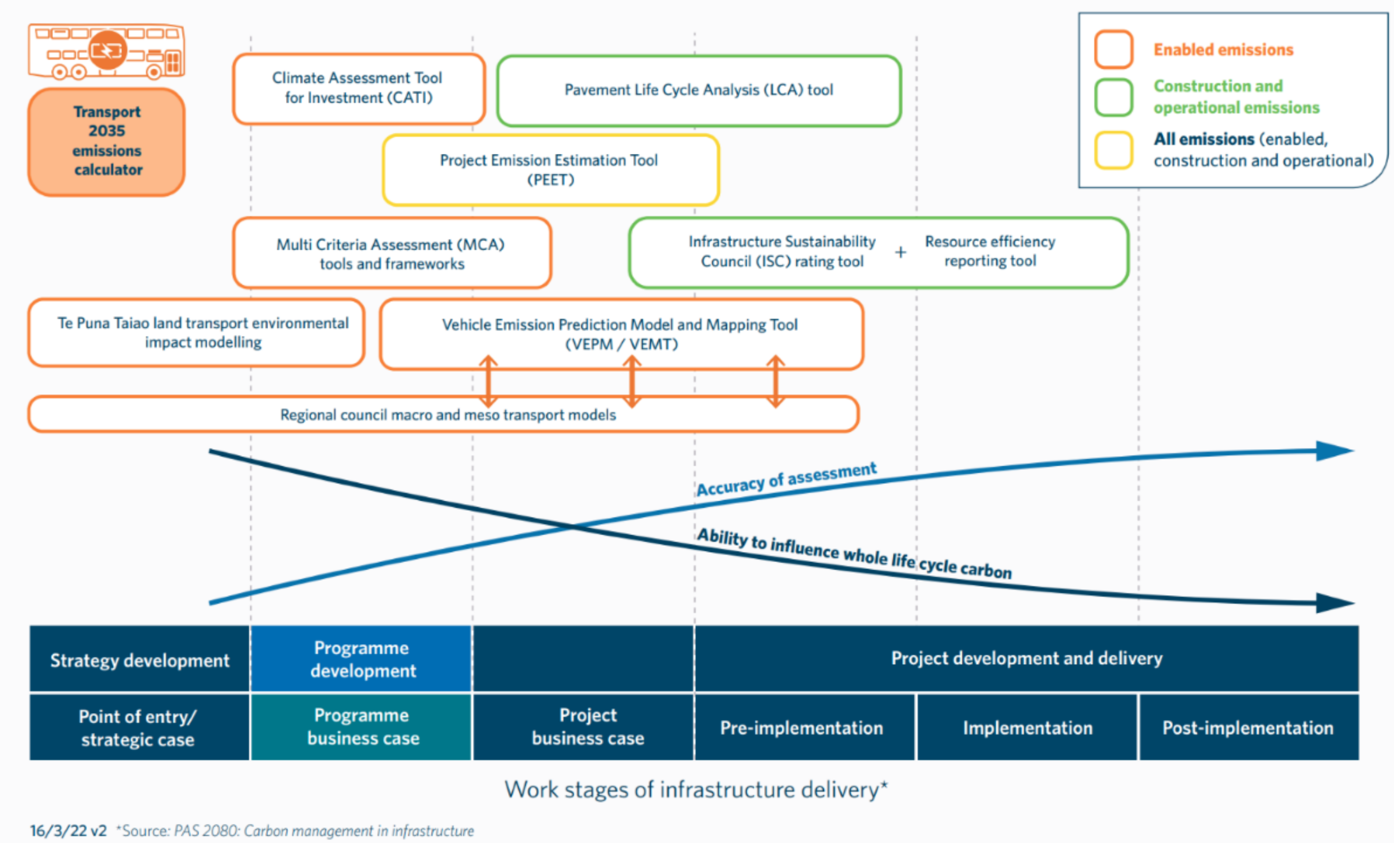
The focus of the Tier 3 assessment is also on emissions from motor vehicles, but **the same general principles are applicable to any transport project or traffic-generating development**. This type of assessment is detailed and will likely include traffic modelling, vehicle emissions estimation and dispersion modelling.

3.8.2 Waka Kotahi NZ Transport Agency

Waka Kotahi is developing a suite of tools to help decision makers plan for lower emissions in transport planning (as shown in the following graphic) - many of which could be applied in some form to land use projects.

The tools illustrated are a mix of qualitative (e.g. CATI) and quantitative (e.g. PEET, VEPM, VEMT) and some combine both (e.g. MCA, ISC) and look at enabled (e.g. tailpipe emissions) or embedded emissions of construction and maintenance.

Some of these are currently available, some have been released as beta versions for user testing and others are still in development.



Monetised Benefits and Costs Manual (MBCM) 2021

NZTA (2021). *Monetised benefits and costs manual*. Version 1.5, Waka Kotahi NZ Transport Agency, updated 1 August 2021. Report link

The MBCM is the standard for the economic evaluation of land transport activities in New Zealand.

It sets out economic evaluation procedures and values used in calculating benefit–cost ratios, necessary for applications seeking investment where a cost–benefit appraisal is a mandatory requirement.

In addition to proving values for the social costs of crashes, it **includes damage cost values for air quality and greenhouse gas emissions as well as health benefits associated with increased walking and cycling**.

Note: At time of writing, the MBCM cost values are being reviewed to reflect updated estimates of VoSL and New Zealand-specific damage costs developed in the HAPINZ 3.0 study (Kuschel *et al* 2022).

Vehicle Emissions Prediction Manual (VEPM) 2022

NZTA (2022). *Vehicle emissions prediction model (VEPM) 6.3*. Waka Kotahi NZ Transport Agency, April 2022. Report link

VEPM is an average speed model which predicts real world emission factors for the New Zealand fleet under typical road, traffic, and operating conditions, based on the different vehicle technologies present and the relative VKT by each vehicle class. Factors are available for 2001 to 2050.

VEPM provides estimates that are suitable for air quality assessments and regional emissions inventories.

Project Emissions Estimation Tool (PEET)

A beta version of PEET (V3.0) has been made available for testing and to identify areas for further development. Beta version link

PEET is a GHG emissions estimation tool that has been developed for use in the early stages of a land transport infrastructure project. PEET uses standard design examples and industry research to enable calculation of a high-level estimation of the GHG emissions through the life cycle of a project, including:

- construction
- operations and maintenance
- vehicle use (by calculating enabled and/or avoided emissions through applying VEPM).

PEET includes elements for state highways, local roads and rail and has been developed in collaboration with Waka Kotahi, Auckland Transport and KiwiRail.

Transport 2035

A beta version of Transport 2035 has been made available for testing and to identify areas for further development. Beta version link

Transport 2035 is a web-based tool designed for Local Government transport planners, designers, and operators to help them consider the impact different transport choices could make in reducing greenhouse gas (GHG) emissions caused by vehicles and transport in their region.

The tool provides a graphic display of emissions from different types of transport, showing inclining emission projections in the current context of growing transport GHGs. It then presents modified projections of “future scenarios” based on different interventions with different modes of transport for transport system users.

Using this tool, a user can explore how specific changes to their region's transport network will affect its carbon emissions in 2035. They can visualise what options are available to them and which ones to explore for emissions reduction, so they contribute to the Emissions Reduction Plan target of a 41% reduction by 2035.

The tool uses the Avoid-Shift-Improve framework, an internationally recognised framework for sustainable transport ensuring the reduction of environmental impacts and improving access and liveability.

Te Puna Taiao

For more information refer to this link

Te Puna Taiao is a macro-level, integrated environmental outcomes modelling tool. This model is being developed to help assess the likely impact that different combinations of operational policies, programmes and projects will have on the environment. Some of the interventions modelled are:

- Mode shift and urban form (e.g. public transport and active mode infrastructure investment, integrated ticketing)
- Travel planning (e.g. promoting use of the electric vehicle charging network)
- Policy and regulatory settings (e.g. clean car programme, spatial planning).

Climate Assessment Tool for Investment (CATI)

For more information refer to this link

CATI is being developed to better understand the profile of an investment programme. It provides a qualitative emissions profile of the investment programme but does not forecast actual emissions (e.g. CO_2e).

3.8.3 Other

Auranga Transport Emissions Assessment 2021

Kuschel G & Metcalfe J (2021). *Auranga Transport Emissions Assessment Stage 1: Drury West Train Station Locations*. Report by Emission Impossible Ltd for the MADE Group Ltd, 7 December 2021.

Undertakes a quantitative assessment of emissions and subsequent cost/benefits generated by trips to and from the proposed Auranga town centre, comparing two different locations for a train station (Drury West). Scenarios assess active mode uptakes ranging from all car - to car-orientated - to all active modes.

The assessment confirms *that:*

> *"the design of an area is critical to its emissions and public health outcomes'* (pg i)"

and finds that the location of the train station could significantly influence the air quality-related health benefits received from transitioning to a less car-orientated urban design.

> *"In the worst case, designing Drury West to be totally car-reliant would result in \$1.5 M in public health costs (June 2019 prices) and release 42,025 tonnes of carbon (CO_2e), 39.6 tonnes of nitrogen oxides (NO_X) and 7.5 tonnes of particulate matter (PM_{10}) over the period 2021 to 2048.*
>
> *In contrast, even with only 50% uptake of active modes, Auranga's transit-oriented design applied over the whole Drury West area would deliver \$79.3 M (June 2019 prices) in public health benefits, with emissions halved to 21,012 tonnes CO_2e, 19.8 tonnes of NO_X and 3.8 tonnes of PM_{10}."*(pg i)"

4. CONCLUSIONS

4.1 STATE OF CURRENT ASSESSMENT GUIDANCE

This literature review found little definitive information is available on how to **assess** the impacts of a variety of land use options on transport. There is even less information for how to then calculate the associated changes in air quality emissions from the various options.

Most resources acknowledge that reducing vehicle use is good for the environment and for reducing greenhouse gases. However, the analysis of improvements in environmental outcomes tends to **qualitative rather than quantitative**, i.e. reduced vehicle use = cleaner environment.

When investigating transport projects, an assessment of environmental performance (air quality) is usually undertaken based primarily on emissions per VKT[4] and estimates of total VKT per option (European Commission, US EPA, UK DfT, Transport Scotland, CARB, Victoria Australia). The VKTs are calculated by traditional transport models and only a few have the capacity to directly consider travel modes other than motor vehicles (DEFRA, UK DfT, Transport Scotland, US EPA, Frank *et al*) for areas.

A few assessments include air quality emissions from land use and transport (DEFRA, MADE Group, TRANSPLUS).

The review found that all methods based on transport models (predicting use of various modes by VKT) tend to have transport models that are:

- **Not granular enough** – the transport models need to be at regional, local and neighbourhood level to be able to incorporate and ascertain different modes of transport. Even including rail was generally using a linear model. MADE Group used one of the most local methods which included the ability to consider multi-modal travel. Lack of granularity means that comparison between different modes at a neighbourhood level cannot be undertaken.
- **Essentially 'road' based**. US EPA and DEFRA have some options that include other land use and mixed use.
- **No ability to consider 'why the trip is being made'**- i.e. a trip is just from the node to another node rather than to school and then the shops and home.

One of the outcomes from the transport model emissions prediction process was that there was very little analysis undertaken to determine improvements in air quality due to changes of modes within areas. Two US EPA investigations did compare between a road and a rail system.

Once air emissions were calculated, any benefits were estimated using a cost benefit analysis approach. This is a suitable technique for enabling comparisons between different, unrelated outcomes (e.g. speed of road trip vs air quality benefits vs cost of building rail line).

The DEFRA model and the MADE Group's Auranga assessment both used techniques to enable alterations in mode to be considered. The UK DEFRA model includes walking and

[4] Or VMT (vehicle miles travelled) in the United States.

cycling modes for comparison and the MADE approach allowed consideration of types of trip (why the trip was being made).

4.2 DEVELOPMENT OF NEW ZEALAND-SPECIFIC GUIDANCE

From the findings of the literature review, several steps would need to be undertaken if New Zealand-specific guidance was to be developed.

4.2.1 Scoping questions

The initial step would be defining the scope and implementation of any proposed approach for assessing land use and transport-related air quality emissions, by asking:

1. Should land use and transport projects require assessment?
    a. Should all land use and transport projects be assessed?
2. What would assessing land use and transport projects achieve?
3. Is assessing land use and transport related air quality emissions an issue for all regional councils within NZ or just larger ones with elevated transport-related air emissions?
4. How do we undertake an assessment?
    a. What needs to be assessed?
    b. At what scale do we need to undertake assessments?

4.2.2 Standardised assessment approach/es

Following on from the scoping, the next step would be to develop a standardised approach (or suite of approaches if a tiered assessment framework is considered warranted).

The literature suggests that different types of land use projects require different assessment approaches. Small, local projects will likely require very granular information whereas large transport infrastructure projects (such as new motorways) will necessitate broader brush assumptions. This has implications for New Zealand regarding how relevant assessments may be for smaller locations compared to the cost of undertaking the assessment.

Currently, there is no standardised approach being used for any land use projects in New Zealand. This prevents different land use and/or transport projects from being compared and inevitably leads to ad hoc, inadequate assessment, mitigation and control of air emissions. Guidance would help solve this.

New Zealand already provides guidance on other air quality matters through several good practice guides (GPGs). These are well-used and have served to improve air quality assessments by air quality practitioners. A GPG for assessing the air quality impacts from transport-related emissions resulting from land use activities could also be adopted[5] (in conjunction with an assessment model as discussed in section 4.2.3 below).

[5] There is already a Good Practice Guide for Assessing Discharges to Air from Land Transport (MfE 2008). This GPG could be adapted to include land use projects.

Development of any GPG would require the support of the Ministry for the Environment (MfE), the National Air Quality Working Group (NAQWG), Te Manatū Waka Ministry of Transport (MoT), Waka Kotahi and air quality practitioners.

4.2.3 An integrated land use/transport/ air quality model

An effective method for supporting standardised assessments (as part of a GPG) would be an integrated land use/transport/air quality model. The DEFRA model and the MADE approach (in particular) could be used as a foundation from which a New Zealand-specific model could be developed.

The development of a 'local' model would need to be undertaken in consultation with the NAQWG, MoT, Waka Kotahi, and large council transport groups (e.g. Auckland Transport).

A model would likely need to include the following:

1. A method to transfer the current New Zealand transport models node and VKT approach to a more 'neighbourhood' focus (in addition to the current local and regional focus).
2. A method to incorporate standard assumptions regarding expected VKTs for motor vehicles (particularly cars) and alternative modes of transport for certain types of land use (e.g. buses, walking, cycling in mixed use, residential and business districts)
3. A method to incorporate non-standard assumptions of item 2 above
4. Use of VEPM 6.3 or later (NZTA 2022) to estimate vehicle emissions
5. A standardised cost/benefit approach and damage cost values such as those in the MBCM (NZTA 2021).

GLOSSARY

AQ	air quality
AQMA	air quality management area
CARB	California Air Resources Board, United States
DEFRA	Department for Environment, Food and Rural Affairs, United Kingdom
CO_2	carbon dioxide, a greenhouse gas
CO_2e	carbon dioxide equivalent, a way to express the impact of each different greenhouse gas in terms of the amount of CO_2 that would create the same amount of warming
EFT	*Emissions Factors Toolkit*, published by DEFRA
GHG	greenhouse gas
GPG	good practice guide
HAPINZ 3.0	*Health and Air Pollution in New Zealand* study, based on 2016
harmful pollutant	an air pollutant which causes adverse health effects
ITE	Institute of Transportation Engineers
LAQ	local air quality
LEZ	low emission zone
LUT	land use and transport
MBCM	*Monetised Benefits and Costs Manual*, produced by Waka Kotahi
MfE	*Manatū Mō Te Taio*, Ministry for the Environment
MoT	*Te Manatū Waka*, Ministry of Transport
NAQWG	National Air Quality Working Group, representing councils and agencies responsible for air quality management in New Zealand
NO_X	oxides of nitrogen
NZTA	*Waka Kotahi* NZ Transport Agency
PM	particulate matter
$PM_{2.5}$	particulate matter less than 2.5 µm in diameter, sometimes referred to as fine particulate
PM_{10}	particulate matter less than 10 µm in diameter, includes fine particulate (less than 2.5 µm) and coarse particulate (2.5 µm to 10 µm)
SIP	state implementation plan

SUDPLAN	*Sustainable Urban Development Planner for Climate Change Adaptation*, produced by European Commission
TAG	transport analysis guidance
Te Whatu Ora	*Te Whatu Ora* Health New Zealand
TOD	transit-oriented development
TRAEMS	*Transport Add-on Environmental Modelling System,* developed by Griffith University, Queensland
TRANSPLUS	TRANSport Planning, Land Use and Sustainability, programme by European Commission
TRIMIS	Transport Research and Innovation Monitoring and Information Systems, website developed by European Commission
UK	United Kingdom
UK DfT	United Kingdom Department for Transport
µm	micrometre, one millionth of a metre
US EPA	United States Environmental Protection Agency
VEPM	*Vehicle Emission Prediction Model*, developed by Waka Kotahi to predict air emission and fuel consumption of the New Zealand vehicle fleet
VKT	vehicle kilometres travelled
VMT	vehicle miles travelled
VoSL	value of statistical life
VOC	volatile organic compound
VTPI	Victoria Transport Policy Institute, Canada
Waka Kotahi	*Waka Kotahi* NZ Transport Agency

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