National Environmental Standards for Air Quality: Implementation

Gap Analysis: Enhancing PM_{10} Emissions Inventories in New Zealand

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Executive Summary

Emissions inventories provide fundamental information for assessing discharges to air for given sources and/or areas. In tandem with air quality monitoring, data analysis and modelling, sources of air pollution may be identified and apportioned. This information can assist with the development of air quality management strategies and be used to evaluate the effectiveness of meeting air quality standards. Despite advancements in the design and reliability of emissions inventories in recent years, there are still gaps and limitations with these tools. This document provides an overview of existing PM_{10} emissions methodologies in New Zealand, discusses gaps in our present knowledge and makes recommendations on how to advance to more effective and reliable emissions inventories.

Critical to the development of improved emissions inventories in New Zealand is the need for better estimates of PM_{10} from domestic home heating. There are a number of measures underway to improve these methodologies, including advances in data collection, data quality assurance and the development of locally specific emissions factors. Reliable data are also required for the other key emissions sources, particularly the industrial sector where the largest uncertainties currently exist. By ensuring that quality data is collected, applied and updated, more robust air emissions information are expected to be produced, helping local authorities meet the new National Environmental Standards and bring about better air quality

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Introduction

Emissions inventories provide information that is essential to understanding the sources of air pollution. This information can be used to assess the effectiveness of measures to meet air quality standards as well as assist with the development air management strategy. With the implementation of the National Environmental Standards (NES) for air quality, one of the key issues for local authorities will be the need for good-quality data. Reliable emissions information will be a prerequisite for assessing sources of air pollution and in evaluating management measures to achieve reductions in concentrations of contaminants. A better understanding of the gaps and limitations within existing emissions inventories will help direct further research and enhance current methodologies to provide more effective and robust air quality management tools.

The 'Emissions Inventories' objective, as part of the Foundation for Research Science and Technology's - Protecting New Zealand's Clean Air Programme (Contract number: C01X0405), aims to develop and improve methods and tools for constructing and validating emissions inventories of air pollutants in New Zealand, for all contaminants, and from all sources. In the first year of this programme (2004-05), existing inventory information pertaining to PM_{10} were assessed[1], and new estimates for key emissions sectors (home heating, motor vehicles and industry) were calculated, as part of the determination of local air quality management areas (LAMAs) across New Zealand (See:http://www.niwa.co.nz/ncces/news_background.html). These outputs will help local authorities identify areas where NES may be breached, assist in the prioritisation of monitoring programmes and determine where air quality management measures may need to be applied[2]. In addition, the outputs will contribute to the new National Pollution Inventory in 2008.

A number of advances have been made in this objective already, as a result of issues identified in this gap analysis. However, there remain a number of significant uncertainties regarding emission inventory methodologies (and the associated emissions estimates). The purpose of this report is to detail gaps and limitations in current methods and to provide recommendations for improving the quality of inventory data collected. The report also outlines the methodology used to provide basic emission estimates for PM_{10} in New Zealand at the spatial resolution of census area units. The latter assessment is of limited value in deriving air quality management measures but is a useful tool for assessing probable high emission density areas and in prioritising air quality monitoring and management programmes. More in-depth analyses will be carried out in due course.

This report comprises:

Part 1: Gaps and limitations with existing inventory methodologies in New Zealand.
Part 2: Overview of the methodology and limitations associated with the census area unit PM_{10} estimates for the National Pollution Inventory.
Part 3: Recommendations for enhancing future emissions inventories.

[1] PM_{10} was the focus of this initial assessment because the NES lists this pollutant as the main compliance criterion. In later revisions, account will be taken of other pollutants. These may include carbon monoxide (CO), sulphur oxides (SO_x), nitrogen oxides (NO_x) and volatile organic compounds (VOC's). In addition to these contaminants, greenhouse gases such as carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O), among others, can be valuable additions to a national emissions inventory.
[2] Note that several other objectives in this programme also require enhanced inventory information: mitigation options need inventory data to test effectiveness; emissions data are an essential input to predictive modelling, and effects assessments can use inventory data to examine the potential determinants of health effects.

Part 1: Gaps and limitations in existing inventory methodologies in New Zealand

Assessments of PM_{10} using the emissions inventory methodology have been carried out in New Zealand for more than a decade[3]. While a number of improvements have been made to inventory methodologies during this period – including the release of the 'Good Practice Guide on Preparing Air Emissions Inventories' in 2001[4] - there remain uncertainties with all emission inventory studies. This section presents an overview of the main gaps in existing inventories in New Zealand.

Gaps and limitations with existing inventories include:

- Uncertainties in emission estimates.
- Inventory design – classification of source categories.
- Inventory design - spatial resolutions.
- Inventory design - temporal resolutions.
- Frequency of repetition.
- Methods for estimating contributions from natural sources, and other sources such as resuspended road dusts.

Uncertainties in emission estimates

The basic methodology of an emissions inventory relies upon the use of emission factors (EFs) to provide a measure of discharge for a specific type of activity and fuel consumption (e.g. PM_{10} emitted per kilometre travelled in a motor vehicle). However. EFs in New Zealand are often derived from international test data, and these may not always be suited to local conditions. This can lead to varying levels of confidence in the resulting estimates, make comparisons between inventories awkward, and even cause debate among inventory developers on what constitutes the most appropriate EF choice. Performing field trials and emissions tests in New Zealand (with perhaps even the release of National EF Standards) may help to alleviate some of these issues[5].

Existing emission factors for domestic home heating currently rely on a combination of information derived from the latest international research and development and laboratory simulations of real-life operating emissions from testing carried out in New Zealand. The convenience of this approach must be questioned, however, given the small number of appliances actually tested within New Zealand and the applicability of laboratory experiments to realistically simulate operating conditions of burners operated in the home. The uncertainty associated with EFs used for solid fuel burning would be reduced if testing efforts included a greater number of different age categories of appliances, carried out under conditions representative of operation in New Zealand. Acknowledgement is made of testing carried out as part of a Sustainable Management Fund/Environment Canterbury and Nelson City Council funded project. However, more burner tests are required before this information can be used for emission inventory or air quality management purposes. An additional project co-funded by Environment Waikato and the Foundation for Research, Science and Technology (FRST) proposes to provide further information that can be used to improve our understanding of real

[3] A summary of existing emission inventories are presented in the document 'Emission Inventories for PM_{10} in New Zealand' (MfE, 2003).
[4] The GPG (Wilton, 2001) outlines survey methodologies for gathering information from different sources and targets methods for improving the quality of New Zealand inventory data.
[5] For some activities, such as stack emissions from industrial sources, EFs are not required as emissions data are typically provided as part of resource consent conditions.

life emissions from solid fuel burners in New Zealand. Region-specific fuel factors as well as new and improved EFs for home heating will help to reduce the uncertainty in emissions estimates.

Improvements to the daily fuel use data could be made through diary type surveys used in conjunction with domestic home heating surveys. These could involve a smaller number of households, who record data on daily fuel use for input into the inventory. A survey of this type was carried out in Christchurch during 2002. Location-specific conversions for log weight could also be determined either in conjunction with the above survey or as a separate exercise. This survey would involve weighing a selection of averaged sized logs from household woodpiles to give an average weight of a log. For practical reasons, a smaller number of households would be used for the above surveys, relative to the heating methods and fuels survey. The more households surveyed, however, the greater the likelihood that outputs would be representative of average fuel use and fuel weights.

Another source of uncertainty often produced in emission inventories relates to the availability and quality of activity data which are sometimes not optimal. Variable data collection methods can impact upon the quality and reliability of activity data, which can in turn cause significant challenges when attempting to use the inventories to assess appropriate management strategies and when comparing different inventories. While these difficulties are often addressed using reasoned assumptions and surrogate information, the uncertainties produced from using these data remain until the gaps have been filled. Other related issues include the application of activity data from one region to another - which may or may not be representative of conditions in another place. Quality methods of collecting and recording accurate activity data are imperative for good quality inventories.

The main activity data collected for inventories in New Zealand are domestic home heating methods and fuels, estimates of vehicle kilometres travelled (VKT) for different levels of congestion and industrial data such as fuel consumption, control equipment or quantities of material manufactured. Limitations associated with domestic heating and outdoor burning surveys include poor survey design and sample size issues. These issues have been addressed in the 2001 Good Practice Guide for Preparing Emission Inventories (MfE, 2001).

Collection of quality activity data for motor vehicles is more problematic, particularly in areas where road network models are not available or maintained. Part 2 of this report outlines a new methodology for estimating emissions from motor vehicles and makes further recommendations to improve understanding of reliability of different methodologies for estimating emissions from motor vehicles. Collection of activity data from industrial sources can also be challenging, particularly in areas that are less restrictive in terms of requiring resource consents. In these areas methods of identifying industrial and commercial activities for inclusion in inventories is limited and additional consideration of methods would be of value.

Inventory design – categorisation of source categories

The different frameworks used to construct emissions inventories can also place limits on their utility. For instance, the choice of unusual source categorisations can make comparisons to inventories with alternative categorisations awkward. Examples of this include outdoor burning, lawn mowing and off-road vehicle sources. This situation can also make the grouping of data from different inventories difficult. While the ultimate selection of sources for an inventory should be based upon the issue facing a specific place, greater consistency would be of value – particularly given the introduction of the NES.

Inventory design – spatial resolution

Limitations with existing spatial resolutions include inconsistency across different inventories and perhaps more importantly inadequate resolution to allow the successful application of additional tools such as air quality modelling. Different spatial[6] scales for inventories can pose some problems for those attempting to collate data from different areas to provide a national perspective. While national consistency is a relatively low priority for those designing inventories, there may be some advantages in providing data in a consistent format for use in research projects that have potential benefits to local and regional authorities.

Air quality modelling requires the use of spatially distributed emissions data, which is combined with meteorological information to provide estimates of concentrations. An inventory with a poor spatial resolution can limit the use of air quality modelling to assess spatial variations in concentrations. A basic method for allocating PM_{10} emissions to a finer spatial resolution (for example, census area units (CAU) or mesh blocks) is using the proportion of the population of the study area residing in each CAU or mesh block. This may be appropriate in areas where PM_{10} emissions are dominated by domestic home heating but is unlikely to apply where industry is a predominant source. Moreover, variations in the age of dwellings in different study areas are likely to significantly impact of PM_{10} emission estimates. A number of inventories collect domestic heating data for different areas in locations where significant inter-city variations in heating patterns are likely. For example, the 2005 Hamilton air emissions inventory divided the urban area into seven sub-areas.. The refinement of techniques for spatially allocating emissions to account for industrial sources, motor vehicle emissions and likely variations in domestic heating emissions would be of value.

Inventory design – temporal resolution

One limitation in existing inventories is the design focus around 24-hour average PM_{10}, as the primary air quality issue in most urban areas of New Zealand. While suitable for the NES for PM_{10}, this design provides limited information for managing annual average PM_{10} concentrations relative to the 2002 ambient air quality guideline of 20 $\mu g\ m^{-3}$ (annual average). Comparing different timeframes by scaling up or down emissions data from designs focusing on 24-hour average PM_{10} does have its limitations, particularly when the emissions sources vary across time (most notably domestic home heating). A more formalised approach to emissions reporting design would improve inter-regional and national emissions inventory information.

As a result of the identification of this limitation, modifications have been made to the design of domestic home heating, outdoor burning surveys and industrial methodologies to include annual activity data for these sources. Additional methods for assessing temporal variations in motor vehicle emissions would be of value.

Updating inventories

To be of use in developing management measures to reduce PM_{10} concentrations, emission inventories need to be up-to-date. The 2001 Good Practice Guide for Preparing Emission

[6] Regional emissions inventories typically use territorial boundaries or collations of census area units. For some applications such as modelling a finer spatial resolution using grid allocations may be required. Air quality management may also be tempted to use residential zoning as per a district plan. This can pose difficulties as different spatial units are not by necessity linked to one another, hence scaling up and down can be a significant challenge.

Inventories recommends that inventories be repeated every 3-5 years (MfE, 2001). This is particularly important in locations where air quality management is required. In New Zealand air emission inventories have been carried out for many regions or urban areas within regions that experience poor air quality. However, many of these were prepared between 1997 and 2001 and have not been updated in more recent years. As a result, many councils who need to implement air management strategies to meet the NES do not have up-to-date air emissions data. Relying on outdated emission inventories to develop management measures to reduce PM_{10} concentrations is not recommended because of changes in home heating methods and fuels with time.

Methods for estimating emissions from natural sources

A further limitation (and most often ignored) in existing emissions inventories is the lack of techniques available to estimate natural sources of PM_{10} such as sea spray and wind blown dust. An additional source for which robust techniques are lacking is resuspended road dusts, which may contribute significant PM_{10} to warrant inclusion in inventory studies. Some air quality experts underline the need to estimate these emissions given they can represent a significant component of PM_{10} concentrations. Under these circumstances, we suggest that until satisfactory inventory methods have been developed, alternative methods of source determination such as apportionment modelling with chemistry may better handle this challenge.

In summary, it is crucial the gaps and limitations outlined in this section are minimised. By ensuring that better quality data is collected, applied and updated, more robust air emissions information are expected to be produced and therein contribute to improved air quality management.

Part 2: National Pollution Inventory – PM_{10} estimates

This section outlines the development of a methodology for estimating emissions across the whole of New Zealand including areas where no inventory data are available from the key PM_{10} sources: home heating, motor vehicles and industry. The limitations of these new methods are identified and discussed. Recommendations are made on how to bridge these gaps in our knowledge.

Home heating emissions

In the recently released local air management areas (LAMA) document (Fisher *et al.*, 2005) a screening methodology was outlined to estimate PM_{10} from domestic emissions from home heating by census area unit (CAU) across New Zealand. The full details of this methodology can be obtained from: http://www.niwa.co.nz/ncces/news_background.html. In brief, the methodology relies upon census data collected on the number of dwellings in each CAU that use wood, coal, gas, electricity or other heating methods. Note that census data are only available every five years, so interpolation of data between censuses is required for annual patterns to be determined. This information is then used in conjunction with estimates of average daily fuel use for both wood and coal, and estimates of average emission rates for each fuel to estimate PM_{10} emissions for each CAU.

> The equation below shows the method used to estimate emissions:
>
> Emissions PM_{10} per CAU = no. of dwellings using wood x emission rate (wood) x daily fuel use (wood) + no of dwellings using coal x emission rate (coal) x daily fuel use (coal)

The main concern with this methodology is that it does not allow for variations in emissions from similar types of burners. This could be significant, as areas with a large number of modern low emission burners are assumed to have the same emissions as areas dominated by older burners and open fires. The emission rates can even vary by more than a factor of three for a modern versus an older burner. Similarly, the estimates of fuel use are not location or appliance specific. For example, it is assumed that open fires and enclosed appliances will have similar fuel use and that fuel use in an area such as Auckland, where open fires are often used for aesthetic purposes, will be similar to other places where they may be the sole method of heating a room.

A more accurate method of estimating emissions would be to conduct a home heating survey to determine the numbers of households using different appliance types and fuel quantities. This method would allow for the application of more specific emission rates and has been used in a number of emission inventory studies across New Zealand. The results from these types of studies are not typically available by individual CAU, so the resulting total estimates will more than likely be required to be distributed across the relevant CAUs based on the proportion of the population residing in each CAU. This assumption would likely produce uncertainties as spatial variations in burner types are common, particularly across larger cities. In the absence of survey information, the census based approach is regarded as an acceptable first-order screening method.

Estimates of domestic heating emissions from past inventory surveys can be integrated into the resulting database using the census distribution methods outlined above and by adjusting the estimates to a baseline year (such as 2001). The adjustment for a base year of 2001 assumes that the proportions of the population using different heating methods and fuel quantities will be the same from one year to the next. In reality this will vary from year to year.

A comparison of the estimates of PM_{10} emissions made using the CAU methodology to emission estimates from home heating surveys showed significant variations across different locations, under- or over-estimating PM_{10} emissions relative to the inventory surveys by up to a factor of two. Despite this, the CAU methodology is presently the best option available for assessing home heating emissions in the absence of home heating survey data. While the data generated via this screening methodology were adequate for the purpose of identifying high-density emission areas for the development of LAMAs, the data generated are not sufficiently detailed or robust to be used to develop regulations or in the evaluation of the effectiveness of air quality management measures.

Recommendations + Future Improvements

- Emissions estimates (for instance, from surveys) need to be integrated with data from other emissions sources (for instance, from fuel sales) to validate and cross-check the certainty/uncertainty of inventory information.
- Resolution or refinement of the following issues would likely improve the quality of home heating PM_{10} emission data:

  - Update estimates with the MfE ‘warm homes’ project data
  - Determine the numbers of households using different appliance types and fuel quantities at the CAU level.
  - Integrate results with the results from household energy use surveys.

Industry

In the recently-released local air management areas (LAMAs) document an updated methodology was presented to estimate PM_{10} from major industrial dischargers in New Zealand. Details of the methodology can be found at:
http://www.niwa.co.nz/ncces/news_background.html. The initial focus was on combustion related emissions, but this was extended to include relevant process emissions, including some quarries and mining activities. While more national consistency is desired, this approach is viewed as preliminary and subject to review.

In brief, the methodology relies upon the collection of activity data (process and combustion) and the application of emission factors to these data. Emissions factors were largely derived from USEPA AP-42. Activity data were obtained from Regional Councils’ resource consent files[7], and/or previous emissions inventories that have been completed by Councils. Where gaps existed or no information was available, a number of different web-based sources were consulted - including: Direct commercial websites (e.g. Fonterra, AFFCO); Industry trade groups (e.g. New Zealand Forest Industries); Regional Councils; New Zealand Government (e.g. Ministry for the Environment, New Zealand Food and Safety Authority, Ministry of Forestry, Ministry of Economic Development).

[7] Many regions have large industrial air discharge consent holders. In general these are well managed through established RMA practices and consent conditions.

The equation shows the method used to estimate emissions:

Contaminant emissions (kg/day) = Fuel used (t/day) x Emission factor (kg/t)

To account for the varying quality of emissions calculations, a reliability index was introduced and presented with the data. This index signals areas where improvements in the data are needed. It is anticipated that many of the figures that currently show low reliability will be updated as more information becomes available from the Councils. This approach is very similar to the scheme used within AP-42 and other national emissions inventory methodologies. When the location of specific industrial operations was not clear, an effort was made to find locations through the various web-based sources listed above. Once a street address or locality was identified, the coordinates were found using mapping software. When the exact location was unknown but the general area was identified a subjective estimate was made.

Recommendations + Future Improvements

- The high number of low reliability scores listed in the reliability index indicates a lack of useful activity data, and/or lack of detail about the exact location. Much of this data needs to be improved by Councils.
- Future studies on industrial emissions would benefit by taking into account the following:
  - Councils should make resource consent conditions more available by posting them on the internet.
  - Councils should create a list of their respective major industrial dischargers and update it periodically.
  - Information requested from consent holders includes fuel use factors to enable more effective application of emissions factors.
  - Council staff should review the discharge information and supply updates.

Motor Vehicle emissions

In the recently released local air management areas (LAMAs) document a new methodology was presented to estimate PM_{10} from motor vehicles[8] by census area unit (CAU) across New Zealand. The details can be obtained from: http://www.niwa.co.nz/ncces/news_background.html. In brief, the methodology relies upon the collection and use of three principle strands of data: total number of vehicle kilometres travelled (VKT), number and type of vehicles that comprise the fleet (limited to petrol and diesel engines) and emission rate of PM_{10} by each particular vehicle type.

The vehicle kilometres travelled (VKT) data is based on the 1994 National Traffic Database (NTD), which is updated each year using traffic counts made at sites across every Territorial Local Authority (TLA) in New Zealand. These data are disaggregated by MoT into 14 regions and further split into 4 different road types: motorway, urban, suburban and rural. VKT is also disaggregated into light duty (<3500 kg) and heavy duty (>3500 kg) vehicles. Nationally, the

[8] This methodology only considers the on-road use of motor vehicles. It excludes emissions from the off-road use of vehicles and other forms of transportation, such as trains, ships and aircraft. These other transportation sources of PM_{10} may be included in future revisions of the inventory.

95% confidence interval for annual VKT was +/-1.3%. On the basis of an average of 31 sites per Territorial Local Authority (TLA), the estimate of annual VKT for each TLA is expected to have a precision of approximately +/-10.4% [95% confidence interval] (MoT, 2005, personal communication). It is likely that VKT for some regions may be over-estimated using this approach, while in others VKT may be too low. Hence, emission estimates will be higher in those areas where typical driving patterns deviate most from the assumed TLA averages.

An alternative method of obtaining VKT on a regional scale is to search the Land Transport New Zealand's (LTNZ) vehicle registration data warehouse. This database contains odometer readings as recorded at the time of each warrant of fitness check. Obtaining VKT from the LTNZ data warehouse provides the advantage that the vehicle type can be more precisely defined than simply light and heavy duty. This method of estimating VKT has been attempted on a small sample of TLAs and shows considerable promise be used as a cross check for the regional VKT obtained from the NTD. Note this method tends to give higher VKT than the modelling, probably due to the modelling underestimate of rural road use[9].

The most significant limitations of using VKT data from either the NTD or from the LTNZ data warehouse are that seasonal and diurnal variations in VKT cannot be defined, and that the spatial disaggregation of VKT is limited to the regional and TLA levels, respectively for the NTD and the LTNZ. All three of these limitations can be overcome when a detailed roading network model is available for an area. However, while VKT obtained from a roading network model is very detailed in terms of diurnal variation and can give a very fine spatial resolution (often down to street level) the outputs are modelled data that are only as good as the data that is actually put into the model before the data can be relied upon. While the LTNZ or roading network model methods have their advantages, they are both more resource intensive to set up and run. These methods should therefore be investigated further. In the interim, the NTD data are easily available and this provides for a nationally consistent approach[10].

The vehicle fleet data were obtained from the LTNZ vehicle registration data warehouse. The LTNZ vehicle registration data warehouse was interrogated to provide the numbers of vehicles registered in 2004 for each of the TLA's in the 14 Regions (2001 data were not easily available). These data are continuously updated as vehicles pass through the warrant of fitness programme. The TLA fleet data were disaggregated into eight vehicle classes. These data were then used to determine the VKT travelled in each TLA and the PM_{10} emission rates (dependent on fleet composition) for each TLA. VKT travelled in a particular TLA was estimated by aggregating all the relevant TLA vehicle fleet data up into a regional fleet, determining the proportion of the regional fleet registered in each TLA and then redistributing the total regional VKT to each TLA based on the proportion of the regional fleet registered in that particular TLA. There are a number or assumptions taking inherent in this methodology, and while they are reasonable they can add up to considerable uncertainty.

The NZTER database (MoT, 2000) was used as the source of PM_{10} tailpipe emission factors for the 8 vehicle classes. For these classes, emission factors were derived for each of the four types of road (motorway, urban, suburban and rural). This database is widely used in NZ for planning and assessment purposes. The most significant issue with NZTER relates to the uncertainty in the origins and the accuracy and precision of the vehicle PM_{10} EFs it provides. This issue is widely acknowledged and NZTER must be used with these limitations in mind. Estimates of EFs are also often based on measurements of volunteer fleets, which may or may not be maintained

[9] At the same time, the method may also underestimate true VKTs as vehicle odometer readings are not entered until their first warrant check, after two years.

[10] In the future it may be possible and effective to use a combination of all three methods.

in a more thorough manner. The Auckland Regional Council and MoT are currently planning an upgrade of the NZTER. The effects of brake and tyre wear and re-suspension of roadway PM_{10} were also accounted for. In view of the uncertainties surrounding non-tailpipe PM_{10} EFs a "middle of the road" re-suspension EF equivalent to 30 % of the tailpipe emissions was adopted (Venkatram et al 1999). This EF should be revisited in the future as more robust estimates become available[11]. This issue creates a large uncertainty in total vehicle emissions and should be comprehensively reviewed.

As VKT data and vehicle registration data are only available at TLA level, a proxy measure of vehicle activity was used to disaggregate TLA PM_{10} to CAU. The proxy measure chosen was population. The total PM_{10} for each TLA was disaggregated to the relevant CAUs using the CAU/TLA population ratio (e.g. If a CAU contains 3% of a given TLA population it was subsequently assigned 3% of the TLAs total PM_{10} emissions). The use of population data as a proxy measurement to disaggregate TLA PM_{10} to CAU is a relatively weak link in the vehicle emission methodology. A more accurate estimate of PM_{10} by CAU could be obtained if VKT or vehicle fleet data were available at the CAU level.

Recommendations + Future Improvements

- Investigate and compare VKT data obtained from:
  - National Traffic Database
  - Land Transport New Zealand's (LTNZ) vehicle registration data warehouse
  - Regional roading network models
- Refine and validate tailpipe and non-tailpipe PM_{10} emission factors
- Develop alternative methods to disseminate the TLA PM_{10} to CAU. Possibly move from CAUs toward a GIS platform, road network map
- Vary driving condition assumptions (i.e. amount of free and congested flow) on a finer spatial scale. Perhaps to a regional or even TLA level
- Investigate seasonal, weekday and diurnal variation in VKT

[11] Depending on the vehicle and road type under consideration, DEFRA provide re-suspension emission factors that are in the order of two to ten times higher than tailpipe emissions. Jaecker-Voirol & Pelt (2000) also suggest these emissions are several times greater than vehicle exhaust emissions In contrast, the results from recent PM_{10} source apportionment studies carried out in New Zealand do not clearly show that re-suspended PM_{10} is a large proportion of the total PM_{10} from vehicles.

Part 3: Report Summary and Recommendations

The main objective of an emissions inventory is to assess the quantity of emissions (in the place of direct measurements) discharged to air for a given source and area. Emissions inventories therefore provide important information to assist with developing air management strategies and to assess the effectiveness of meeting the air quality standards. But, as highlighted throughout this document emission inventories do have limitations which can produce significant uncertainties and errors.

Given the large contribution of domestic home heating to PM_{10} emissions in most urban areas of New Zealand, improving the quality of these emission estimates is critical to the overall advancement of robust and reliable emissions inventories – in particular areas requiring management intervention to meet the NES. There are a number of measures underway to improve these methodologies, including advancements in data collection, data quality assurance and the development of New Zealand specific emissions factors. Additional efforts are also being made to improve the quality of the data collected for the other key emissions sources - in particular the industrial sector where arguably the largest uncertainties currently exist.

To summarise, the following list prioritises the existing uncertainties and indicates some requirements for improvements in New Zealand PM_{10} emissions inventories.

- Real-life emission factors for domestic solid fuel burning
- Daily fuel use for domestic solid fuel burning
- Estimates of vehicle kilometres travelled in urban areas of New Zealand (particularly locations where there is no existing road network model)
- Emission factors for sources such as motor vehicles industry and outdoor burning
- Improved temporal and spatial estimation methodologies
- A methodology for assessing background or natural emissions (including implementation of non-inventory methods for evaluating these sources)
- Standards to collect and present emissions information
- Application of a consistent methodology for basic data gathering to be used in all regions (a more formalised approach would likely improve inter-regional and national reporting)
- Maintenance of a regularly updated national database of emissions
- Regular updates on emissions inventories to enable trends to be monitored and determined
- Further research on the relationship between emissions and monitoring results
- Improved estimates of natural emissions and resuspended road-dust.

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