Gauteng Transport Air Quality Management Plan

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The Gauteng Department of Roads and Transport (GDRT) identified the need for a Transport-specific Air Quality Management Plan (AQMP), focussing on transport related air pollution and noise problems. This paper reports on the motivation for this study, the approach, local constraints and findings. Transport related intervention strategies were derived from the transport emissions database and case study dispersion modelling.

Keywords: transport air quality management plan, Gauteng province, vehicle emissions, dispersion modelling, transport related intervention strategies.

1. Introduction

Emissions from vehicles have been identified as a growing problem in South-Africa with approximately 40% of these operational within Gauteng (DT, 2008). The increasing vehicle population in Gauteng combined with the fact that a significant proportion of the vehicles are old and often in poor condition, have highlighted the need for the development of interventions by formalising emission standards applicable to vehicles and vehicle fuels.

The Gauteng Department of Roads and Transport (GDRT) identified the need for a Transport-specific Air Quality Management Plan (AQMP), focussing on transport related air pollution and noise problems. This derived from the Gauteng AQMP (GDARD, 2009), identifying Vehicle Tailpipe Emissions and Noise Pollution as two of the problem areas within the province.

This paper focuses on the approach followed in developing a Transport specific AQMP and addresses the mitigation of transport related air pollution to ensure sustainable air pollution improvement reduction in the province. Noise related transport pollution formed part of the AQMP but not reported on in this paper.

2. Approach

The project aimed to provide the GDRT with an implementable Traffic specific AQMP, complementing the existing Provincial AQMP. This was done in a phased approach with the first phase including the understanding of the vehicle emissions situation in the province. The second phase included the development of an AQMP implementation plan through the setting of goals, objectives and targets and assisting the facilitation of public participation and stakeholder involvements.

3. Transport related Air Background

The Gauteng AQMP found that nitrogen dioxide (NO_2) exceeds ambient standards near busy roads and primarily derive from vehicle tailpipe emissions. Limited ambient monitored data in the province indicate that vehicles contribute 21% to overall SO_2 emissions; 48% to total NO_x emissions; 57% to total CO emissions; 17% of CO_2 and 86% of total benzene (GDARD, 2009; GDED, 2008; 2011). No clear link could be established for particulates to vehicle tailpipe emissions since these monitoring stations primarily measure PM_{10} and not $PM_{2.5}$.

The main causes for excessive vehicle tailpipe emissions were identified to be the use of old vehicles that are not maintained with new vehicles comprising a mix between Euro II to V standards and pre-Euro standard imports from China (OECD, 1999). It was found that around 10% of the South African vehicle population contributes more than 50% of the emissions. The growing number of aging vehicles has been highlighted as a major problem in South Africa (DT, 2008).

Poorly maintained vehicles and no controls on functioning catalysts in new vehicles are other reasons. This offers increased scope for Inspection and Maintenance (I&M) programmes. Experience from the US indicates that repairs become more expensive the older the vehicles are and around 27% of all vehicles that fail an I&M test, never pass and continue to operate. Also, a number of variables influence the effectiveness of I&M programmes and in some cases the only remedy is to retrofit an old worn engine. Fraud is also highlighted as one of the problems associated with I&M programmes (Stone, 2009).

Bad governance, specifically at local level, resulting in poor town planning and road infrastructure development is a cause for highly congested roads. The lack of public transport substantially adds to this problem with increasing heavy duty trucks on the roads due to the poor railway system. In addition, lagging fuel economy standards in South Africa have a significant impact on the emissions profile of the local vehicle parc.

4. Local Constraints

The development of the Gauteng Transport AQMP followed a technical assessment and a participatory approach. The latter identified constraints and challenges pertaining to AQM that can be summarised as follow:

- Financial and human resources remain one of the main constraints in Municipalities to fulfil their obligations in terms of Air Quality Management as set out in the Air Quality Act. The problems surrounding the maintenance and operation of ambient monitoring stations in all the municipalities are primarily a result of limited resources.

- Inter-governmental and inter-departmental communication and cooperation are major constraints in ensuring successful air quality management. A holistic approach is needed in the transport related air quality and noise management strategies.

- International studies have highlighted the importance of co-benefits between different environmental disciplines, specifically air quality management and climate change (Molina, 2011; UNEP, 2011). Traffic related air quality intervention strategies should be linked to provincial and municipal Climate Change Strategies, Transport Plans and Spatial Development Frameworks. Integration with the Environmental Impact Assessment approval process is also crucial.

- The political will to ensure the Air Quality Management strategies get priority. Development Frameworks (IDPs) will also ensure budget allocation at municipal level.

5. Transport related Air Quality Intervention Strategies

Four main emission reduction categories were identified from the literature:

- **Controlled emitters:** change in technology type scenario assumed all Euro0 vehicles to be scrapped and replaced by Euro II vehicles. The second scenario assumed all Euro I vehicles also to be replaced by a combination of Euro II, III and IV vehicles.

- **Controlled fuels:** petrol, diesel and Liquefied Petroleum Gas (LPG) splits based on the existing fuel specifications. These scenarios looked at the reduction in emissions through changing the fuel split. The fuel specifications on petrol and diesel were kept the same and standard LPG and hybrid options were used. Vehicles were moved between being all petrol to being all diesel, LPG or hybrid vehicles.

- **Inspection and Maintenance programmes:** the expected change in emissions between no I&M programmes in place and with I&M. The benefit of I&M programmes were incorporated into the technology scenarios where these were tested with and without I&M programmes in place.

- **Transport planning:** this set of scenarios looked at the effect of traffic flow on vehicle tailpipe emissions. The first three scenarios merely considered an increase in traffic on the freeway. Traffic was increased by 50% and 100% respectively, keeping the road capacity the same thereby increasing congestion. The second set of options within this scenario looked at increasing the number of people within a single vehicle, then moving more people to buses and onto taxis. In addition, a scenario was tested by reducing the number of heavy vehicles on the roads. The first option included removing all heavy trucks (>32 ton) from the roads with option two including the load of the heavy trucks into medium truck (<16 ton).

5.1 Vehicle tailpipe emissions quantification

In the absence of detailed local vehicle emissions factors, the emissions inventory was based on the very comprehensive set of emission rate factors developed by the European

Environment Agency (COPERT III and COPERT IV). The methodology covers regulated exhaust emissions of carbon monoxide, oxides of nitrogen, sulphur dioxide, particulate matter, volatile organic compounds (VOC) and lead, in addition to a number of other unregulated compounds. These emission factors also accommodate the dependence on vehicle types, engine types, fuel specification and vehicle speed. They also have reduction factors for the implementation of an I&M programme (Stone, 2009). Furthermore it accounts for fuel specifications, split between petrol and diesel vehicles, various vehicle categories and vehicle weight. Euro vehicles specs are included as well as LPG engines and hybrids. The number of vehicles per time period for all the various categories and various vehicles speeds are accounted for as well as congestion.

Data were obtained from various sources. Specialised Traffic Surveying Services (TES) reports from GDRT together with SANRAL Traffic Monitoring data were used for the emission calculations and testing of the emission reduction scenarios. Two case studies were selected, with Buccleuch interchange representative of a highly congested highway and Rembrandt Park in Edenvale as representative of a busy suburban roadway. Fuel sales from SAPIA were used to determine the fuel split percentage.

5.2 Dispersion modelling

The CALINE4 dispersion model, developed by the California Department of Transportation (Caltrans) was selected for this project. CALINE4 is the last in a series of line source air quality models and is based on the Gaussian diffusion equation and employs a mixing zone concept to characterise pollutant dispersion over the roadway.

The freeway scenarios were simulated as a case study. The same traffic numbers as used in the emissions modelling, were used in the dispersion modelling. Traffic volumes for each of the road sections were estimated (directly from monitoring data and calculated where necessary) for the hour. The entire interchange was simulated for CO, NOx and PM. These include the Freeway parc split scenarios with and without I&M as presented in Figure 1 and Figure 2 for NOx and PM. The freeway congestions scenarios, where the traffic volume increase and for the change in private versus public transport are shown in Figures 3 and 4 for NOx and PM.

The main conclusion reached from the dispersion modelling case study results was that the reduction in predicted ground level concentrations mirrors the reductions as per the emissions model scenarios. Thus, the percentage reductions as indicated by the emissions model can be regarded as indicative of potential ground level concentration improvements.

Dispersion models are useful in determining the potential impacts on residential or commercial areas near busy roads and can successfully be used to identify the most suitable placement for monitoring stations.

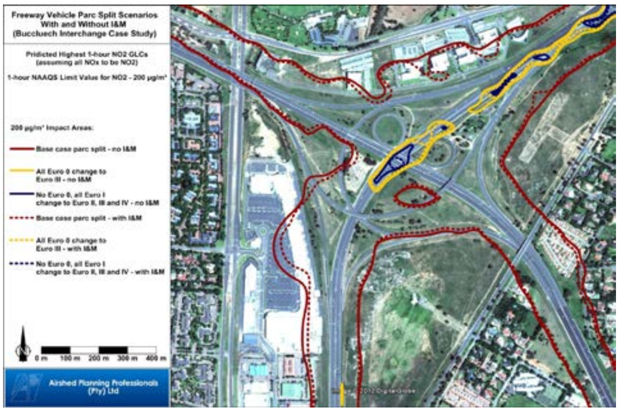

Figure 1: Freeway vehicle parc split scenarios with and without I&M (Buccleuch interchange as base case) for nitrogen dioxide emissions.

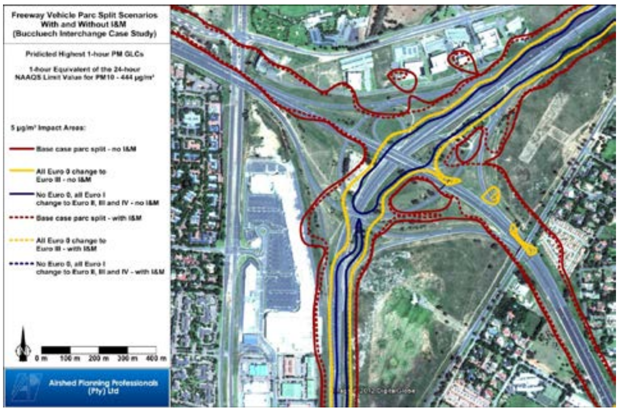

Figure 2: Freeway vehicle parc split scenarios with and without I&M (Buccleuch interchange as base case) for particulates.

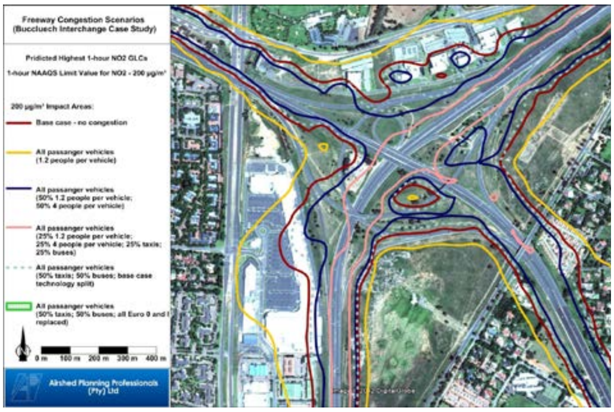

Figure 3: Freeway congestion scenarios by reducing the number of vehicles on the road for nitrogen dioxide emissions.

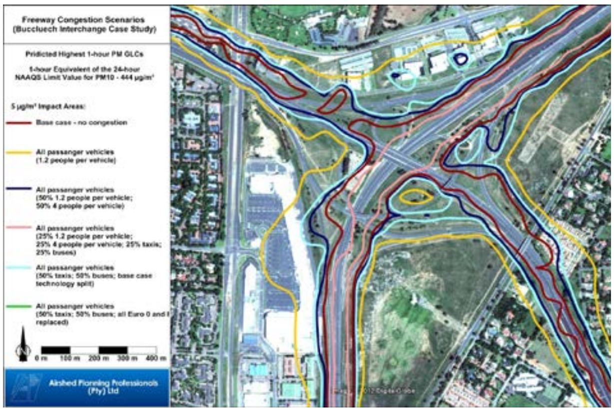

Figure 4: Freeway congestion scenarios by reducing the number of vehicles on the road for particulates.

6. Main Findings

The main findings from the emissions interventions are as follows:

- **Controlled emitters:** the most significant reduction of CO, NOx, VOC and PM emissions is through the removal of all Euro0 vehicles from the Gauteng roads and to replace these with Euro II technology. By replacing all Euro I vehicles as well, an even greater reduction in CO emissions will be achieved. The latter is most likely not a practical solution within the near future.

- **Controlled fuels:** the largest reduction in the overall air pollutants are by switching from petrol and diesel to LPG and hybrid vehicles. The latter reduces vehicle tailpipe emissions to insignificant levels. This is not a practical solution, and even if hybrid cars become more popular, a mix of vehicles on our roads will remain for many years. The aim is therefore to increase the number of LPG and hybrid vehicles as part of this mix. GDRT has already developed a policy to convert their vehicle fleet to LPG vehicles. This should be rolled out to other provincial and municipal departments. Also, by increasing petrol vehicles, PM emissions would decrease but CO and CO_2 would increase. By increasing diesel vehicles, PM will increase but CO and CO_2 will decrease benefitting long-term Climate Change strategies but potentially impacting negatively on human health and have a detrimental effect on short-term Climate Change policies.

- **I&M programmes:** the largest benefit is on the reduction of CO and CO_2 emissions with lower decreases in other pollutants. The benefit should be weighed against the cost of implementation. With the main benefit on Climate Change, these I&M programmes may be used to get CDM funding.

- **Transport planning:** the main benefit of car pooling will be that the air pollution will decrease due to fewer vehicles on the roads. By having an equal split between single users, multiple (four people) per car, taxis and busses, the biggest benefit is achieved. The benefit from more people using busses and taxis will be the greatest if these vehicles are all Euro II – IV technology, otherwise the pollutants actually increase. Due to the small percentage heavy vehicles on the freeway and suburban roads, no measurable improvements were noted by removing these vehicles from the roads. What were not considered as part of this scenario are the negative impacts from heavy duty vehicles on the road surfaces and causing traffic congestion. Generally, transport planning ensuring constant flow on the roads through more lanes on the highways, synchronised traffic lights in urban areas and well maintained roads should result in significant air pollution reduction alongside roads.

7. Acknowledgements

The GDRT team, including the Gauteng Metropolitan and District AQOs, are thanked for their contribution to this project.

8. References

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