TRANSPORT ENGINEERING RESEARCH NEW ZEALAND LIMITED

SUMMARY REPORT

ANALYSIS OF THE IMPACT OF HEAVY VEHICLES ON COMMUNITIES:

ENVIRONMENTAL ANALYSES AND REMEDIAL TREATMENT DEVELOPMENT

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Contents

Introduction

Heavy vehicles form an integral part of modern living. They are one of the primary methods of moving and distributing goods throughout New Zealand. The number of kilometres driven per year by heavy vehicles is steadily increasing. Between 1998 and 2001 the total distance travelled by heavy vehicles increased by 17% from 2873 million kilometres to 3355 million kilometres (Baas & Bolitho, 2003)[1]. It is clear that heavy vehicles are becoming an increasingly prevalent feature in the road environment.

While some studies have focused on how other road users react to heavy vehicles, (e.g. Charlton, et al 2002)[2], in New Zealand there has been little systematic research into how residents on main truck routes are affected by heavy vehicles. In order to increase understanding about how heavy vehicles affect residents, Luther, Alley, Baas, Ludvigson, Wigmore, and Charlton (2002)[3] surveyed a total of 255 residents on main arterial roads and state highways in Auckland, Whangarei, Gisborne, and Mt Maunganui. The survey focused on answering three questions: 1) how much of a concern are traffic and heavy vehicles in comparison to other community concerns (such as access to facilities, and services); 2) how much of a concern are heavy vehicles in comparison to other traffic issues (e.g. traffic volume and speed), and; 3) what are the specific effects of heavy vehicles on residents' lives and activities.

To address the first research question residents were asked what things they liked and disliked about their community. Results showed that the traffic in general

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[1] Baas, P.H., & Bolitho, H. (2003). Profile of the heavy vehicle fleet – update 1997-2001. (TERNZ Technical Report). Report contracted by the Land Transport Safety Authority. Hamilton, NZ: Transport Engineering Research NZ Ltd.

[2] Charlton, S.G., Newman, J.E., Luther, R.E., Alley, B.D., & Baas, P.H. (2002). Road user interactions – patterns of road use and perceptions of driving risk. (TERNZ Technical Report). Report contracted by the Foundation for Research Science and Technology. Hamilton, NZ: Transport Engineering Research NZ Ltd.

[3] Luther, R.E., Alley, B.D., & Baas, P.H. Ludvigson, T., Wigmore, B.J., Charlton, S.G. (2002). Road user interactions – analysis of the impact of heavy vehicles on arterial roads and state highways. (TERNZ Technical Report). Report contracted by the Foundation for Research Science and Technology. Hamilton, NZ: Transport Engineering Research NZ Ltd

was the most frequently mentioned community concern, followed by heavy vehicles. Residents in Gisborne and Whangarei were substantially more likely to state that they disliked heavy vehicles than Auckland and Mt Maunganui residents. Within the communities of Gisborne and Whangarei, respondents that were home during the day, were female, or had children were most likely to mention that they disliked heavy vehicles.

To answer the second research question (how much of a concern are heavy vehicles in comparison to other traffic issues) residents were asked about the impact of various traffic characteristics (e.g., traffic speed, volume, composition) on their perceptions of the danger and nuisance of the traffic in their area. Results showed that perceptions of danger caused by traffic and roads differed markedly between Aucklanders and non-Aucklanders. The aspects of traffic that Aucklanders rated as most dangerous were traffic speed, access, and traffic congestion. The aspects of traffic that non-Aucklanders rated as most dangerous were traffic speed, busy intersections, and heavy vehicles. In terms of the nuisance aspect of the traffic, analyses showed that the main nuisance factors for both groups were traffic noise (often this was heavy vehicle noise), heavy vehicle and general traffic vibrations, and congestion. This indicated that many residents found heavy vehicles to be a nuisance and some considered them to be dangerous.

Finally, to answer the third research question, residents were questioned about the effects of heavy vehicles on their lifestyle and behaviour. The analysis showed that respondents' perceptions of heavy vehicles were not related to the volume of heavy vehicles traffic they experienced. Perceived heavy vehicle volume was more strongly related to lifestyle factors, such as where respondents lived, whether they had children, and how they used the road (for example, did they cycle). Furthermore, perceived, rather than actual heavy vehicle volumes, were significantly related to respondents' ratings of overall traffic danger and nuisance, the perceived safety of heavy vehicles, and whether they spontaneously mentioned disliking heavy vehicles. The activities that residents most often noted as being affected by heavy vehicles were household/family activities, use of property, cycling, sleeping and resting.

From the results outline above it was possible to form a tentative 'profile' of the types of communities and residents that are perhaps more likely to be affected by

heavy vehicles. The following list provides a broad profile of situation were residents are more likely to be affected by heavy vehicles:

- Residents in smaller cities and towns with lower traffic volumes;
- Areas where many residents are at home during the day;
- Areas where many residents have school age children;
- Areas where many residents walk and/or cycle;
- Areas where an increase in the volume of heavy vehicle may impact on property values.

This profile provides a description of groups who appeared to be affected by heavy vehicles more than other groups. However, it should be noted that most of the roads surveyed reported some effects of heavy vehicles and roads with higher traffic volumes reported concerns about traffic issues in general.

The results of this study showed that heavy vehicles are a significant community issue for residents on main arterial roads and state highways and that a specific demographic are more likely to be affected by them. It is interesting to note that residents showed a much stronger dislike of heavy vehicles in the roads where the actual volume was the lowest (these roads were in Whangarei and Gisborne). Therefore, it is important to try and establish the causes of negative perceptions of heavy vehicles (given that it is not related to the sheer volume). One issue that was not addressed by the research outlined above was the specific environmental characteristics of the roads surveyed. Environmental characteristics can include the road classification, geometric configuration, the nature of the road lighting, the type and condition of the road surface, and the nature of the houses in the area. It is possible that factors such as the type of road seal may affect the volume of noise caused by heavy vehicles. Therefore the following research sought to systematically catalogue the environmental characteristics of each road surveyed in Luther et al (2002) in order to identify any environmental factors that may have contributed to residents' perceptions of the heavy vehicles.

In addition, while Luther et al (2002) sought to characterise community concerns with heavy vehicles, the report did not suggest any remedial treatments that may alleviate these concerns. As a result, a second goal of the current research was to provide some potential remedial treatments that may alleviate some of the concerns about heavy vehicles raised by residents. This study used the available data on

resident perceptions and experiences of heavy vehicles together with environmental data to construct treatments that may help alleviate residents concerns about the heavy vehicles that travel through their area.

Methodology

Environmental Survey Site Selection

The sites where environmental surveys were completed were those chosen for the 'Impact of Heavy Vehicles on Communities Study' completed by TERNZ in 2002. The four cities surveyed were Auckland, Whangarei, Gisborne, and Mt Maunganui.

In all communities, the roads selected for surveying were classified as either regional arterial roads or state highways (except for Crawford Rd in Gisborne). The roads were selected to reflect a range of percentages of heavy vehicles to total traffic volume, ranging from 2.08% to 32%. The details of the roads selected are provided in Appendix A.

Environmental Survey Development

The environmental survey form developed for this research project was based on one used for the Auckland Car Crash Injury Study (ACCIS)[4], a research project undertaken by the Injury Prevention Research Centre at the University of Auckland. The survey enabled researchers to make a record of the geometric, topographic, and other physical features of each site. Traffic volumes and traffic speed were measured.

For this study, the Environmental Survey was modified to fit the needs of the second phase of the communities project. Additional features were added including noise measurements, the type of house construction, and separation between the road and dwellings fronting that road.

Data Collection

Data for the environmental survey was collected in off-peak traffic hours. At each road site, at least two data collectors were used to collect environmental survey

[4] Norton, R., & Connor, J. (ongoing). Auckland Car Crash Study. Injury Prevention Research Centre at the University of Auckland

data, including measurements of noise levels and traffic speeds, and obtaining photos of the site and environs.

Recording Physical Features of the Road and Surrounding Areas

The Environmental Survey included a checklist of questions that the researcher could go through and record measurements and observations. Physical features of the road including details of the geometry, gradient, lane markings, widths, footpath and verge, lighting, and road surface were recorded. Details of the surrounding area including type of house construction, distance and elevation of dwellings from the road boundary, and general residential ambience and amenity were also collected.

Noise Readings

Noise readings were taken using a Quest 2400 Sound Level Meter. Sound readings were taken at kerbside and at property boundaries on both sides of the road. Noise readings were recorded at each site every 10 seconds for 8-10 minutes. In addition, each time a truck passed the sound meter the reading was also recorded and marked separately. Readings were taken from a hand held position approximately 1 metre above the ground, with the meter directed at right angles to the kerbline and parallel to the ground. In windy conditions, a foam filter was used with the meter. The noise reading methodology employed was intended to provide researchers with a general understanding of the general level of noise in the communities surveyed and also a measure of the level of noise the heavy vehicles generated on average.

Traffic Speed Readings

Traffic speed-readings were taken using a Marksman LTI 20.20 laser speed gun. They were taken for vehicles travelling in both directions on the road surveyed. Each direction was surveyed for approximately 10 minutes, or so that a minimum of 20 readings were obtained. A speed-reading was taken for every vehicle that passed the speed gun during this time (that could practically be measured). These measurements were intended to identify the range of speeds that cars were travelling at in the area.

Photographs

A number of photos were taken at each site, to assist in recalling the road geometry, layout, type of house construction, and general neighbourhood amenity. Photos from the same relative position were taken for each site.

Results

The data collected in the environmental survey was divided into roads where the majority of residents mentioned disliking heavy vehicles and those where they did not. In effect, this meant that roads were divided by community because residents in Auckland and Mt Maunganui generally did not mention disliking heavy vehicles, whereas those in Whangarei and Gisborne typically did. The following table provides an outline of which roads were in each group and the overall traffic volume and heavy vehicle volume for these roads.

Table 1. Details of Roads Surveyed

Spontaneously Mentioned Disliking Heavy Vehicles			**Did Not Spontaneously Mention Disliking Heavy Vehicles**		
Road Name	*Volume (VPD)*	*Heavy Vehicles (VPD)*	*Road Name*	*Volume (VPD)*	*Heavy Vehicles (VPD)*
Awapuni Rd (Gisborne)	5400	500	Balmoral Rd (Auckland)	10656	3908
Crawford Rd (Gisborne)	900	160	Hillsborough Rd (Auckland)	13200	1710
Hatea Dr (Whangarei)	6673	906	Mangere Rd (Auckland)	42000	13440
Lytton Rd (Gisborne)	6900	350	Manukau Rd (Auckland)	12992	276
Manu Rd (Whangarei)	18184	927	Maunganui Rd (Mt Maunganui)	35247	2081
Wainui Rd (Gisborne)	10800	330	Remuera Rd (Auckland)	12200	1590
			Mill Rd (Whangarei)	14429	488
			Kepa Rd (Auckland)	23400	1400
			West End Rd (Auckland)	17000	510
			Donovan St (Auckland)	18500	1480

Environmental Survey Results

The results of the environmental survey were collated and divided into the two groups described above. A comparison of road geometry and driver behaviour between groups showed very few differences between roads where residents mentioned disliking heavy vehicles and those where they did not. In general, the average speeds driven on all the roads surveyed were similar (and generally within 5kph of the speed limit). The seal used on the roads was also similar, with the

majority of roads being sealed in either asphaltic concrete or friction mix. In addition, there were also few geometric differences between roads. In particular, the distances between resident's houses and the traffic were similar on all roads.

However, a few notable differences were recorded between roads where residents mentioned disliking heavy vehicles and those where they did not. These were related to noise levels and house construction types. Results related to these issues are outlined in detail below.

Noise Levels (Kerbside and Boundary)

Tables 2 and 3 illustrate the recorded noise levels for the roads surveyed. Table 2 shows the results for roads where heavy vehicles were spontaneously mentioned as a dislike and Table 3 shows the results for roads where they were not. An analysis of Table 2 shows that the average noise at the kerbside was 67 db with the 85th percentile noise being 76 db. The average truck and motorcycle noise at the kerbside was 88 db. By comparison, for roads in Table 3 the average noise at the kerbside was 79 db with the 85th percentile noise being 85 db. The average truck and motorcycle noise at the kerbside was 95 db. These results indicate that roads where residents did not mention disliking heavy vehicles were notably noisier than roads where the residents did.

Table 2. Noise Levels for Roads where Heavy Vehicles were mentioned as a Dislike

Road Name	**Average Noise at Kerbside (db)**	**85th Percentile Noise at Kerbside (db)**	**Truck and Motorcycle noise at Kerbside (db)**	**Average Noise at Boundary (db)**	**85th Percentile Noise at Boundary (db)**	**Truck and Motorcycle Noise at Boundary (db)**
Awapuni Rd (Gisborne)	66	75	88	66	74	85
Crawford Rd (Gisborne)	56	65	87	54	61	72
Hatea Dr (Whangarei)	76	82	90	75	82	94
Lytton Rd (Gisborne)	60	71	84	58	67	83
Manu Rd (Whangarei)	74	81	92	75	82	96
Wainui Rd (Gisborne)	68	80	92	64	72	80

Further analysis of Table 2 shows that the average noise level at property boundaries was 65 db with the 85th percentile noise level being 73 db. The average

truck and motorcycle noise at the boundary was 85 db. By comparison, in Table 3, the average noise at the property boundary was 77 db with the 85th percentile noise being 83 db. The average truck and motorcycle noise at the boundary was 94 db. Again, roads that did not mention disliking heavy vehicles were generally louder than roads that did.

Table 3: Noise Levels for Roads where Heavy Vehicles were not mentioned as a Dislike

Road Name	**Average Noise at Kerbside (db)**	**85th Percentile Noise at Kerbside (db)**	**Truck and Motorcycle noise at Kerbside (db)**	**Average Noise at Boundary (db)**	**85th Percentile Noise at Boundary (db)**	**Truck and Motorcycle Noise at Boundary (db)**
Balmoral Rd (Auckland)	79.7	89.2	99	78.8	81.8	100
Hillsborough Rd (Auckland)	78.6	85	98	78.6	84.4	92
Mangere Rd (Auckland)	81.9	88.7	102	81	87.7	104
Manukau Rd (Auckland)	75.1	79.8	89	75	78.8	91
Maunganui Rd (Mt Maunganui)	76.9	83.8	89.2	74.8	79.7	83.8
Remuera Rd (Auckland)	79.9	85.7	96	76.3	82.3	96
Mill St (Whangarei)	76.1	81.4	85.9	76.8	83.6	93.7
Kepa Rd (Auckland)	81.2	88.1	99	77.8	84.6	93
West End Rd (Auckland)	80.9	86.9	94	80.2	85.6	100
Donovan St (Auckland)	80.1	85.7	96	77.1	82.3	96

The research team was also interested in whether changes in traffic noise were related to mentioning disliking heavy vehicles instead of just the level of noise itself. At the kerbside the difference between the average noise level and the noise level when a truck or motorcycle was passing for roads that mentioned disliking heavy vehicles was 21 db. For roads that did not mention disliking heavy vehicles the difference was 16 db. At the boundary the average noise difference for roads that mentioned disliking heavy vehicles was 20 db and for those that didn't it was 17 db. Therefore, on roads where residents mentioned that they disliked heavy vehicles there was generally a greater change in the noise level when a heavy vehicle passed. It is also notable that, the residents on roads where heavy vehicles were spontaneously mentioned as a dislike, also consistently rated noise as a nuisance (average 70% of

residents) ahead of the those on roads where residents did not mention that dislike (average 60% of residents).

House construction

House construction can impact on the level of noise and vibrations from vehicles that might be felt within the building. Table 4 provides details on the type of noise protection (fencing, trees etc) that existed around the houses in the roads surveyed and also the type of house construction. As the table shows, most areas had minimal to moderate noise protection. Almost all the roads where residents spontaneously mentioned disliking heavy vehicles had minimal noise protection. There were also some differences in building construction, in the roads where residents mentioned that they disliked heavy vehicles the homes were almost all characterised as light weight/low cost construction. By comparison, on the roads where residents did not mention disliking heavy vehicles, the houses were often described as timber and brick/ moderate cost or solid construction/high cost.

Table 4: Noise Protection and House Construction on Roads Surveyed

Road Name	**Noise Protection (e.g. Fence)**	**House Construction**
SPONTANEOUSLY MENTIONED DISLIKING HEAVY VEHICLES		
Awapuni Rd (Gisborne)	Minimal	Lightweight/low cost
Crawford Rd (Gisborne)	Minimal	Lightweight/low cost
Hatea Dr (Whangarei)	Moderate	Timber or Brick/medium cost
Lytton Rd (Gisborne)	Minimal	Lightweight/low cost
Manu Rd (Whangarei)	Minimal	Lightweight/low cost
Wainui Rd (Gisborne)	Minimal	Lightweight/low cost
DID NOT SPONTANEOUSLY MENTION DISLIKING HEAVY VEHICLES		
Balmoral Rd (Auckland)	Moderate	Solid construction/high cost
Hillsborough Rd (Auckland)	Minimal	Timber or Brick/medium cost
Mangere Rd (Auckland)	Minimal	Lightweight/low cost
Manukau Rd (Auckland)	Minimal	Timber or Brick/medium cost
Maunganui Rd (Mt Maunganui)	Minimal	Lightweight/low cost
Remuera Rd (Auckland)	Moderate	Solid construction/high cost
Mill Rd (Whangarei)	Minimal	Timber or Brick/medium cost
Kepa Rd (Auckand)	Good	Solid construction/high cost
West End Rd (Auckland)	Moderate	Solid construction/high cost
Donovan St (Auckland)	Moderate	Timber or Brick/medium cost

Conclusions – Environmental Survey

Luther et al (2002) showed that dislike of heavy vehicles by residents that live on heavy vehicle routes was not related to the number of vehicles that use a particular road. Instead this study showed that dislike of heavy vehicles was strongly related to which city the respondents lived in and other demographic characteristics. Residents in Whangarei and Gisborne were much more likely to state that they disliked, and were negatively affected by, heavy vehicles than residents in Auckland and Mt Maunganui. It was therefore of interest to establish whether the concerns of the residents of Whangarei and Gisborne relating to heavy vehicles were caused by any aspect of the road environment.

The results of this environmental analysis showed that there were very few differences in environment between those roads where residents mentioned disliking heavy vehicles and those where they did not. The only notable differences were that in the roads where residents mentioned disliking heavy vehicles the change in noise level from general background noise to when a truck passed was greater than for roads where residents didn't mention disliking heavy vehicles. In addition, on roads where residents mentioned disliking heavy vehicles the building construction was often of a low cost type. This type of building may have poorer insulation qualities resulting in greater levels of noise and vibration.

The main conclusion for this phase of this study must be that there are no obvious environmental differences in the areas where people mentioned disliking heavy vehicles. Therefore, there are no 'quick fix' solutions (such as changing seal type) that suggest themselves. Therefore, the second phase of this study focused on using road design techniques to alleviate some of the issues experienced by residents.

Remediation Treatments

Many of these problems that residents mention with heavy vehicles are inter-related and may therefore be addressed by an integrated approach to road design. For example, design that encourages heavy vehicles to slow down may not only alleviate residents concerns about vehicle speed but may also help to reduce their concern about noise and vibrations. In addition, designs that encourage heavy vehicles to slow down may contain lane narrowing to reduce speed, this may also serve to create a 'soft barrier' between residents and heavy vehicles that may alleviate some of their concerns about children's activities (for example, cycling). As mentioned previously in this report, many residents have negative perception about heavy vehicles, and concerns about general traffic issues, such as speeding and access to properties, may take on a greater significance when heavy vehicles are present. Therefore, the suggested remediation treatments, illustrated in the following table, will use an integrated approach to attempt to alleviate as many of the residents concerns as possible.

Perceived problem	**Objective of treatment**	**Possible REMEDIAL OR mitigation treatment**	**Benefits**	**Disbenefits**	**Recommendations**
1. Speed	Slow speed of trucks down	1.1 Narrow road	Perceived to be safer	May impact on cycle lanes	Recommended
		1.2 Speed humps	Speeds slower	Increase noise level	Not recommended
		1.3 Reflectorised raised pavement markers	Provides a visual perception of narrowing the road, thereby reducing speeds	May increase noise if trucks and vehicles drive over them	May be appropriate in situations where the travel path of vehicles is kept within the lane.
2. Noise	Reduce noise for residents	2.1 Double glazing	Reduce noise in the inside of the dwelling	Residents may object. Costly	Recommended
		2.2 Reclad exterior	Reduce the noise attenuation properties of the dwelling	Residents may object. Costly	May be appropriate for dwellings with a light weight construction
		2.3 Provide landscaping on road verge or within properties	Provides a visual interruption of the traffic	May impact on visibility from driveways or to pedestrians.	Recommended

		2.4 Noise attenuation fence	If constructed appropriately may reduce noise level in front yard and dwelling	Severs communities, and isolates residents	Not recommended
		2.5 Resurface with "quiet" road surface material.	Reduce road tyre / road surface noise*	Costly	Recommended for roads with high volumes of traffic, or where heavy vehicles traffic is expected to increase significantly
		2.6 Increase the level of monitoring and maintenance of road surface	Reduces noise by reducing the possibility of an uneven road surface. Reduces vibrations		Recommended
3. Vibrations	Reduce perceived level of vibration	3.1 Slow speed by road narrowings as in 1.1 above			Recommended
		3.2 Reseal road with quieter surfacing material	Reduces noise. Smooths surface	Costly	Recommended
		3.3 As in 2.			Recommended
4. Sleeping / resting	Provide basic quiet period each night	4.1 Adopt a by-law prohibiting nighttime HV traffic (possibly between hours 10pm – 6am) daily.	Ensures there is a quiet period each night	Requires Local Govt Act. Transport and commercial operators may object to any restrictions to working hours.	Recommended on roads that are predominantly residential, with lower volumes of general traffic; and as a mitigation measure where heavy vehicle volumes are expected to increase significantly
5. Family activities	Provide "safer" environment	5.1 As in 1.1, 2.1 and 2.3 above			Recommended
6. Walking / Cycling	Provide "safer" environment with good cross connections over roads	6.1 Introduce pedestrian / cyclist central refuge islands at regular intervals	Increases residents' ability to walk or cycle. Improves sense of community. Slows traffic speeds	Introduces no stopping parking restrictions outside residential houses.	Recommended

		6.2 Install signalised pedestrian crossings to cater for vulnerable road users such as young and elderly pedestrians.	Increases residents' ability to walk or cycle. Improves sense of community.		Recommended where appropriate
7. Exhaust	Reduce the level of exhaust fumes	7.1 As in 2.3 and 4.1			Recommended

Appendix A – Roads Chosen for Surveying

City	Road Name	Location	Road Classification	AVERAGE VEHICLES PER DAY (7 DAYS)	AVERAGE HEAVY VEHICLES PER DAY (7 DAYS)	% HEAVY VEHICLES PER DAY (7 DAYS)
Auckland	Mangere Rd	North of Hospital Rd	Regional Arterial	42000	13440	32.0
Auckland	Balmoral Rd	West of St Andrews Rd	Regional Arterial	10656	3908	26.83
Auckland	Hillsborough Rd	West of Cape Horn Rd	Regional Arterial	13200	1710	13.0
Auckland	Remuera Rd	West of Waiatarua Rd	Regional Arterial	12200	1590	13.0
Auckland	Donovan St	West of McFadzean Dr	Regional Arterial	18500	1480	8.0
Auckland	Kepa Rd	East of Patterson Ave	Regional Arterial	23400	1400	6.0
Auckland	West End Rd	East of Fife St	Regional Arterial	17000	510	3.0
Auckland	Manukau Rd	North of Turama Rd	Regional Arterial	12992	276	2.1
Tauranga	Maunganui Rd	East of Hewletts Rd	State Highway	35247	2081	5.9
Gisborne	Awapuni Rd	East of Stanley Rd	State Highway	5400	500	9.0
Gisborne	Lytton Rd	South of Gladstone Rd	Regional Arterial	6900	350	5.0
Gisborne	Wainui Rd	South of Rutene Rd	State Highway	10800	330	3.0
Gisborne	Crawford Rd	Full length	Minor Road	900	160	18.0
Whangarei	Manu Rd	West of Western Hills Dr	State Highway	18184	927	5.37
Whangarei	Hatea Dr	South of Nixon St	Regional Arterial	6673	906	5.75
Whangarei	Mill Rd	North of Nixon St	Regional Arterial	14429	488	3.5