Health Impacts Assessment

Buckle St re-alignment project

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Prepared for

Transit New Zealand

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1 Executive Summary

The Ministry of Culture and Heritage have proposed the development of New Zealand Memorial Park in Wellington and this entails realignment of a section of Buckle Street, between Tory Street and Taranaki Street. The proposal by Transit New Zealand (Transit) is that the section of road be moved up to 40 m to the north and this will bring the road closer to the Mt Cook School. An appropriate health assessment was sought by Transit to identify any potential effects on the school community and recommend relevant mitigation, if any.

The health impacts report covers the following;

- Scope of a health assessment – what can and cannot be achieved
- Description of the problem
- Method and assumptions
- Analysis of air quality monitoring data
- Assessment of potential health risks
- Conclusions and recommendations

Health assessment is appropriately used where an activity has the potential to adversely affect health. It can comprise full Health Impact Assessment (HIA) if the scale and impact of the activity is sufficient, for example a national policy initiative or a health impact with potential for a regional effect. More commonly a targeted health assessment is used for specific appraisal of a project activity, for example a road change that alters traffic near a school. The present health assessment meets the criteria for a Prospective Assessment as recommended by the Public Health Advisory Committee (PHAC).

The actual method used in this HIA is a type of Health Risk Assessment (HRA) based on estimates of changes to the chemical and physical characteristics of the air at the Mt Cook School. If changes to air quality were found to be significant, a further aspect of the HRA would consider psychosocial and broader health impacts from

resultant changes to outdoor activity or use of the school facilities. However this was not found to be necessary.

NIWA carried out air quality monitoring and modelled expected changes in air quality resulting from the change in the road (NIWA, May 2008). They conclude that the realignment is not expected to lead to the exceedence of any health-based air quality standards or guidelines at Mt Cook School. The incremental worsening of air quality at the school is likely to be close to the level of detection of air quality instrumentation and not considered significant.

The anticipated change in air quality at the Mt Cook School is so minor that it will have no significant effect on exposure at the school to contaminants in air. Therefore the likelihood that the change in exposure will have adverse effects on health is extremely low. The uncertainties present in the assessment do not affect the reliability of this conclusion.

Given the very small size of the change in risk it is recommended not to attempt quantitative assessment of changes in health parameters. It is not necessary to continue ambient monitoring at the school nor is it necessary to monitor for health outcomes among the school community.

2 Introduction

2.1 Use of health assessment

Health assessment is appropriately used where an activity has the potential to adversely affect health. It can comprise full Health Impact Assessment[1] if the scale and impact of the activity is sufficient, for example a national policy initiative or a health impact with potential for a regional effect. More commonly a targeted health assessment is used for specific appraisal of a project activity, for example a road change that alters traffic near a school.

Health assessment is intended to inform decisions about whether to proceed with a policy or a project activity. It also informs choice of scale and locations, and how to control the activity, if necessary, in order to mitigate effects. Monitoring for the resultant exposures and or health outcomes can be a component of the recommendations that follow from such an assessment. The assessment is also important as a means of communication with an affected community about risk and risk management.

The Public Health Advisory Committee (PHAC) recommends prospective health impact assessment, described as:

> "Health impact assessment that takes place before a policy proposal is finalised, at a stage early enough to give input to the decision-making process, but late enough so that proposals are firm enough to assess."[i]

The present health assessment meets the criteria for a Prospective Assessment.

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[1] Health Impact Assessment is: A combination of procedures, methods and tools by which a policy may be assessed and judged for its potential effects on the health of the population, and the distribution of those effects within the population.. WHERE a Policy is a course of action through which the Government aims to achieve its objectives.
FROM A guide to Health Impact Assessment, Public Health Advisory Committee, Ministry of Health, June 2005.

2.2 Key stages in Health Impact Assessment

According to the PHAC the four key stages in the health impact assessment process are:

1) screening
2) scoping
3) appraisal and reporting
4) evaluation.

Screening is the initial process to assess a policy's suitability for health impact assessment. For the Buckle Street re-alignment project this screening took place early in the project planning phase. The PHAC suggest that during the screening stage some thought is given to which of the determinants of health are relevant to the policy. When Transit made the request for health assessment it was clear that the influence of traffic fumes on the health of children at the school was a main consideration. The relevant determinants of health include individual, cultural and social factors that may potentially interact with traffic fumes.

Scoping is undertaken after a decision to consider HIA. It highlights the key issues that need to be considered to define and shape the HIA. The scoping of the HIA for the Buckle St re-alignment project identified the following plan of action:

- Link the HIA to the air quality monitoring by NIWA as a co-ordinated consultancy project
- Explain what can and cannot be achieved through HIA
- Describe the problem of air quality as it might affect the school
- Document the methods used for the health assessment, and related assumptions
- Analyse the air quality monitoring data
- Provide assessment of the potential health risks
- Conclusions and recommendations

The appraisal and reporting stage identifies the relevant determinants of health and uses specific tools to identify and assess potential health impacts. For example,

where negative influences on health are identified, the report must discuss any specific mitigation measures that might be relevant.

Evaluation can be undertaken afterwards to assess the process used by the HIA and the extent to which the recommendations were taken up by the policy-makers (impact evaluation). Evaluation is not included as part of the current health assessment report.

3 Description of the problem

The Ministry of Culture and Heritage have proposed the development of New Zealand Memorial Park in Wellington and this entails realignment of a section of Buckle Street, between Tory Street and Taranaki Street. The proposal by Transit New Zealand (Transit) is that the section of road be moved up to 40 m to the north. A potential impact of this change could be a worsening of air quality at Mt Cook School, which is located on the northern side of the street and would therefore be located closer to this major road.

Transit requested HIA in relation to air quality effects at Mt Cook School. In order to adequately describe the problem it was necessary to obtain results from an air quality monitoring programme, run by NIWA, to ascertain current air quality. It was decided that 6 months of continuous monitoring would be sufficient for the impact assessment purposes and this was carried out between October 2007 and April 2008.

Mt Cook School is a full primary (years 1-8) with a school roll of 162 students and 13 teachers (2007). It has a decile rating of 2 and more boys (57%) than girls (43%). The ethnic composition is described as:[2]

New Zealand European/Pakeha	28%
Somali/Ethiopian	23%
Pacific	14%
Maori	12%

[2] Education Review Report: Mt Cook School Dec 2007. Education Review Office http://www.ero.govt.nz/ero/reppub/

Chinese	8%
South East Asian	7%
Other European	5%
Indian	3%

The school caters for students from a range of cultural and ethnic backgrounds and also has an early childhood centre at the site.

4 Methods used and assumptions

4.1 Approach to Buckle St re-alignment health assessment

The present health assessment has been prepared in accordance with the following documents, the approaches from which were adapted, in part, for the requirements of the present risk assessment process. A main adaptation has been to focus on specific localised issues of air quality because of the nature of the project that is being assessed. Thus the report does not include broader discussions of issues that affect health at the school; only those that relate to the anticipated changes in air quality.

- NZ Ministry of Health (1998) A guide to health impact assessment: Guidelines for public health services and resource management agencies and consent applications. Wellington: New Zealand
- European Centre for Health Policy (1999) Health impact assessment: Main concepts and suggested approach. The Gothenburg Consensus Paper, December 1999. WHO Regional Office for Europe
- EnHealth Council (2001) Health impact assessment guidelines. Department of Health and Ageing and EnHealth Council, Sept 2001, Canberra
- EnHealth Council (2004) Environmental health risk assessment: Guidelines for assessing human health risks from environmental

hazards. Department of Health and Ageing and EnHealth Council, June 2004, Canberra

- NZ Public Health Advisory Committee (2005) A guide to health impact assessment. Wellington: New Zealand
- NZ Ministry of Health/Manatu Hauora (2007) Whanau Ora Health Impact Assessment, April 2007, Wellington: New Zealand

4.2 Principles and methods of health risk assessment (HRA)

The Introduction includes an outline of Health Impact Assessment (HIA), especially as recommended by the PHAC, as an approach to assist decision-making. Internationally, focussed health risk assessment (HRA) is a tool used in the assessment of environmental effects. Sometimes it is viewed as a component of wider HIA, but it also serves as a direct method for health effects assessment when a specific environmental change is being evaluated. HRA provides information on health risks associated with pollutant exposure from a particular source by estimating the potential impact of chemical, physical, microbiological and/or psycho-social hazards on a specified human population or ecological system, under a certain set of conditions and timeframe.

The actual method used in this HIA is a type of HRA based on estimates of changes to the chemical and physical characteristics of the air at a school. If changes to air quality were found to be significant a further aspect of the HRA would consider psychosocial and broader health impacts from resultant changes to outdoor activity or use of the school facilities. However this was not found to be necessary.

4.3 Determinants of health

The World Health Organisation (WHO) defines *health* as a state, which encompasses *physical, mental and social well being*, and which mainly depends on the following factors, identified as "*determinants of health*":

- income and social status
- social support network
- employment and working conditions

- physical environment
- education
- healthy child development
- biology and genetic endowment
- health services
- personal health practices and coping skills

WHO notes that health is not merely the absence of disease or infirmity, and they highlight the need to take a broad view of the outcomes within the process of a health risk assessment. In practice, assessment of outcomes relies on an ability to measure change in any parameter. Assessment and risk management also rely on evidence-based information about parameters that affect health. Where knowledge is incomplete this becomes a matter of uncertainty surrounding the ability to present an assessment.

WHO (2006) explains that environmental equity refers to principles of social justice that promote the equitable distribution of the burdens and benefits of society. The relevance to air pollution lies with emerging evidence of inequities among the population in adverse health effects due to air pollution. Also WHO (2006) explains that there may be observed links between the spatial distribution of pollution sources and the presence of vulnerable members of the community. This is illustrated by the Buckle Street re-alignment, since the socioeconomic and ethnic status of students at the Mt Cook School demonstrates increased likelihood of vulnerable health status.

It is clear that susceptibility to the adverse effects of pollutants can be affected by underlying health. This is addressed by HRA through use of air quality guidelines that have been developed to protect people including those who are very young or old and those with already vulnerable health, for example children with asthma.

The WHO defines these air quality value guidelines as “levels of air pollution below which lifetime exposure, or exposure for a given averaging time, does not constitute a significant health risk. If these limits are exceeded in the short-term it does not mean that adverse effects automatically occur; however the risk of such effects increases.” *(Guidelines for Air Quality, WHO, Geneva, 2000).*

In a situation where air quality guidelines are clearly met, the specific health determinants of the community are unlikely to alter the HRA conclusion of very low health risk. Therefore, when air quality is good, particular health determinants among the exposed community are not discussed in detail as factors that might influence the predicted health outcome for the community.

4.4 The WHO model of HRA

The WHO model of Health Risk Assessment comprises four components that interact to produce information for risk management.

1 Issue identification

- This component identifies the main issues for the health risk assessment to investigate and address. It involves determination of health hazards through environmental sampling and analysis

2 Hazard assessment

- Hazard identification – epidemiological and toxicological
  - Determines potential risks and health problems that may be caused by the agent.
  - Determines intrinsic hazardous aspects, although risk from these may be controllable.
- Dose-response assessment
  - Evaluates quantitative and qualitative toxicological sources of information, used to estimate the incidence rate of adverse effects occurring in humans at varying levels of exposure, in the specific situation identified.
  - Reviews and evaluates epidemiological and experimental studies involving human and animal participants. These studies are used as empirical evidence to support predictions relating to human health.

3 Exposure assessment for the relevant population

- This involves determining the frequency, magnitude, duration, extent, and character of exposures to a hazard. Information used includes environmental sampling and analysis, modelling and monitoring reports.
- Comparison with general population exposure and guidelines.
- Relationship between susceptible subgroups and exposure.

4 Risk characterisation

- Interprets information in relation to those who are affected

4.5 Information sources

Critical evaluation of published sources of information is a key method within a health risk assessment. The process of HRA is intended to provide comprehensive and up-to-date information on any potential risks that may result in adverse effects to human health. Appendix A summarises the various international and local sources for medical, toxicological, legislative, or environmental data relied on by the present HRA.

4.6 MfE ambient air quality guidelines

The effects of air pollutants on health vary depending on the level of exposure and the susceptibility of the exposed population. Level of exposure is determined by proximity to sources, concentration and frequency, and duration of exposure. The susceptibility of the population is generally affected by factors such as the number of young children and older people, as well as the proportion of people suffering from asthma and other chronic respiratory conditions.

In New Zealand there is a regulated National Environmental Standard (NES) for some parameters of air quality – refer Table 1. Also, ambient air quality guidelines are developed by the Ministry for the Environment (MfE), and used by Regional Councils – refer Table 2. These tables present the contaminants that have been included in the present assessment.

Table 1. The Air Quality National Environmental Standards for CO, NO_2 and PM_{10}

Contaminant	Threshold concentration	Permissible excess
Carbon monoxide	10 mg m^{-3} as a running 8-hr mean	One 8-hr period in 12 months
Nitrogen dioxide	200 μg m^{-3} as a 1-hr mean	9 hours in 12 months
PM_{10}	50 μg m^{-3} as a 24-hr mean	One 24-hr period in 12 months

Table 2. GWRC Regional Ambient Air Quality Guidelines (AAQG). Those in bold are the same as the AQNES.

Contaminant	Maximum desirable level	Maximum acceptable level	Averaging time
Carbon monoxide	6 mg m^{-3}	30 mg m^{-3} **10 mg m^{-3}**	1 hour 8 hours
Nitrogen dioxide	95 μg m^{-3} 30 μg m^{-3}	**200 μg m^{-3}** 100 μg m^{-3}	1 hour 24 hours
PM_{10}		**50 μg m^{-3}** 20 μg m^{-3}	24 hours annual

4.7 WHO (2006) global update AQG

WHO have recently published a Air Quality Guideline (AQG) global update (2006) that includes new philosophies as a basis for establishing guidelines:

- Goals to reduce and minimise pollutants to achieve improved air quality as a benefit for its own sake.
- Comparison objectives for all countries to set strategies to achieve the lowered levels of air pollution now experienced in parts of the developed world.
- Precaution about possible health effects, where these are not yet demonstrated clearly in epidemiological or toxicological studies.
- Encouragement for governments to set policy agendas for improvement of air quality according to features of their own communities.
- Consideration of equity issues for people who may be at greater risk from air pollution through their location or access to health services.
- Recognition of equity for communities that may have less control over their environment through characteristics such as poverty or educational disadvantage.

4.8 Toxicology and epidemiology

Information from toxicology and epidemiology is critical in the process of setting evidence-based health protective guidelines.

Toxicological studies have been designed to evaluate the toxic effects associated with exposure to chemical hazards. Toxicological studies provide information relating to toxic effects and to potential health hazards likely to arise from single or repeated exposures, in terms of predicting potentially important toxicity endpoints and identifying potential target organs or systems.

Toxicology encompasses:

i. data on toxicokinetics – including the uptake process of potentially toxic substances by the body, the biotransformation the toxins undergo, the distribution of the substances and their metabolites in the issues, and the elimination of the substances and their metabolites;
ii. data on exposure-response relationship;
iii. data on exposure levels at which no effect is observed – NOAEL – or the lowest levels at which an effect could be observed – LOAEL.

Toxicology data is obtained from controlled animal or human experiments e.g., chronic or acute exposure duration studies in animals, and clinical or chamber studies in humans. It is generally limited by the framework of the experiment, varying responses among animal species, and by individual characteristics.

Despite the evident advantages of toxicology in studying risks from chemical exposure to a particular concentration of a substance, there will still be uncertainties as to what effects are expected in a wider population on exposure to a mixture of contaminants. In this context, epidemiological studies are important.

Epidemiological studies are crucial for assessing the association between environmental factors and health effects in humans and in estimating population risks that may be attributable to causative agents. Epidemiology is described by direct human observation and, when based on sound epidemiological methods, provides the most important evidence in risk characterisation. Epidemiological methods are used to investigate the potential cause of adverse

health effects, the natural history of health conditions, the description of the health status of populations, and to evaluate health-related interventions.

Data obtained from epidemiological studies may also be used to characterise population exposures, investigate perceived clusters of disease; develop health surveillance programmes to establish a baseline, and to monitor the consequences of risk management activities.

Human epidemiology data has a number of advantages over animal toxicology data. However its resolution may be limited through difficulties in estimating exposure precisely, and in accounting for either concurrent factors that may influence health outcomes or controlling bias. On its own, without concurrent toxicology, epidemiology cannot demonstrate cause.

4.9 Community health status and air quality

Reduced ambient air quality may contribute to the health status of the local population, with predominant effects on the respiratory and cardiovascular systems. It is also clear that people who have developed chronic cardio-respiratory disease through combined life factors are more vulnerable than others to presence of contaminants.

Thus it is important to consider the health status of a community both as a contributor to the overall risk from effects and also as a possible outcome of the exposures that arise. Another important aspect of response to contaminants is the frequency with which a community has “co-factors” other aggravators of health risk that combine with contaminants to produce an increased risk of effects. Examples of factors that elevate risk are pre-existing respiratory problems, young age, cardiovascular problems, allergic genetic predisposition, tobacco smoking, diabetes, occupational lung disease, and an at risk profile for weight/fitness.

Asthma has become more recognised as a major public health problem in the last 20 years. Many worldwide studies have documented a high prevalence of

asthma. The most comprehensive community-based international comparison for childhood asthma experience is the International Study of Asthma and Allergies in Childhood (ISAAC). The study examined asthma prevalence in more than 700,000 children from 56 countries, including 37,000 from six centres in New Zealand (Asher et al 1995). It used questionnaires and assessments for specified age groups, completed through schools. Thus it represents asthma symptoms among all children and is not limited to those who have hospital presentations with asthma. Oceania (includes New Zealand) had the highest world regional prevalence for "ever had asthma" (Asher et al 1998).

The major New Zealand results of the ISAAC survey were summarised in the report, "*The Burden of Asthma in New Zealand"* (Holt, Beasley 2001), published by the Asthma and Respiratory Foundation of New Zealand, in collaboration with the Medical Research Institute of New Zealand.
Some relevant results are in Table 3.

Table 3 Prevalence (%) of self reported asthma symptoms, among New Zealanders of different age groups

Age Group (years)		
	Wheeze (12 mth period)	**Ever Had Asthma**
6-7	24.5	26.5
13-14	30.2	24.4
20-44	25.7	*No data available*

"There are significantly higher lifetime and current prevalence rates of wheeze in children in low socio-economic status groups, but no relationship between socio-economic status of asthma diagnosis or bronchial hyper responsiveness." (Holt, Beasley 2001). For "asthma ever" and "wheeze in last 12 months" Maori 6 to 7 year olds had the highest prevalence at 31.7% and 27.6% followed by European at 25.9% and 24.2% with Pacific children the lowest at 21.2% and 22.0% (Pattemore et al 2004). By age 13 to 14 the difference between Maori and European had become small.

A major purpose of health-based AQG is to provide protection for such susceptible people and the prevention of aggravation of asthma is a key aspect.

5 Assessment of potential health risks

The NIWA assessment has included three parameters to represent the quality of the air – carbon monoxide, nitrogen dioxide and particulate matter PM_{10}. While each parameter has primary importance for health, the purpose of monitoring these contaminants is to depict the overall combined quality of air. A brief discussion follows to explain why the quality of air matters for human health. The reason for this discussion is to demonstrate the inherent potential for health risk from air quality and to place a context on risks associated with exposure to the Buckle St air quality, as monitored by NIWA (2008).

5.1 Air pollution exposure and health effects

In a particularly important early epidemiological study, known as the American six cities study, air pollution was positively associated with death from lung cancer and cardiopulmonary disease but not with death from other causes considered together (Dockery, Pope *et al*. 1993). Mortality was most strongly associated with air pollution that featured fine particulates, including sulphates. A re-analysis confirmed the 26% increase in all-cause mortality in the most polluted city (Steubenville, OH) as compared to the least polluted city (Portage, WI) (Krewski, Burnett *et al*. 2005). More recently, cardiovascular disease has been of significant interest with respect to demonstrated adverse effects from urban air pollution, especially effects associated with traffic exposure. In some studies, an increase in risk of heart attack or haemorrhagic stroke after traffic exposure has been shown to arise within a lag time of some hours to a few days (Yamazaki, Nitta 2007; WHO 2006). This is a reason for new attention to risks from daily changes in exposures to urban air pollutants.

Over the past two decades in New Zealand there has been a strong reduction in incidence of heart attack and stroke, among both men and women. Chronic lung diseases remain problematic and predominately determined in New Zealand by smoking prevalence. However cardiorespiratory diseases remain major sources of disability and premature death and accordingly effort has gone into examining what avoidable ill health might be achieved through changes in risk factor exposures among the population.

Studies of both hospitalisations and mortality studies for urban air pollution effects have been conducted internationally including several Australian cities. Similar New Zealand based work has recently been updated and released as an adjunct to formulation of air management policies (Fisher, Kjellstrom, Kingham et al 2007). This work has confirmed the general applicability to NZ of international observations of increased daily and cumulative mortality associated with increased levels of PM_{10}, especially among those aged over 65 years.

Numerous epidemiological studies show a close relationship between the number of respiratory illnesses and high concentrations of ambient air particulate matter (WHO 2006). Respiratory admissions, such as chronic obstructive pulmonary disease, acute and chronic bronchitis, asthma and pneumonia, have been reported in association with particulate air contaminants. Statistically significant increase in the morbidity and mortality from respiratory diseases has been reported for every 10 $\mu g/m^3$ increase in annual PM_{10} levels in ambient air in various countries. This is the basis for the WHO recommendations that there is no safe level of exposure to particulate (2000, 2006).

For children, although air pollution has long been thought to exacerbate minor acute illnesses, recent studies have suggested that air pollution, particularly traffic-related pollution, is associated with infant mortality and the development of asthma and atopy (Schwartz 2004). Lung development is adversely affected in children who live sufficiently close to motorways (Gauderman, Vora 2007; Gauderman, Avol 2004). Lifetime asthma and recent wheeze among children have been related to localised traffic exposure (McConnell, Berhane 2006). Concerns that childhood development of cancer may be affected by air pollution have been discussed (Savitz 1989). However in a large statistically robust study no increased cancer risk was found among

offspring of mothers living in high traffic density areas, either for all cancer sites or leukaemia (Reynolds, von Behren *et al* 2004).

5.2 Epidemiological information from NZ about particulate

The NZ MfE summarised the data on health effects associated with PM_{10} exposure in New Zealand (MfE, Air Quality technical report No. 39, August 2003). The data on health effects resulting from ambient air concentrations of particles in NZ has been recently updated with research projects based in Auckland and Christchurch, with more definitive results about spatial distributions of effects from air pollutants expected later in 2007.

The original study by Hales et al (2000) considered the association between daily mortality and PM_{10} ambient air levels and temperature. The study indicated an increase of 1% (0.5 – 2.2%) in all cause mortality and increase of 4% (1.5 –5.9%) in respiratory mortality in association with an increase in PM_{10} concentrations of 10 $\mu g/m^3$ (after a lag of one day) measured at the St Albans monitoring site in central Christchurch. A 1% increase in all-cause mortality (0.4 to 2.1%) and a 3% increase in respiratory mortality (0.1 to 6.0%) were associated with an increase of 1ºC above the third quartile (20.5ºC) of maximum temperature. No evidence of interaction between the effects of temperature and particulate air pollution was found. Thus it can be inferred that both temperature and particulate are independently associated with mortality.

The HAPINZ project has confirmed the general applicability to NZ of international observations of increased daily and cumulative mortality associated with increased levels of PM_{10}, especially among those aged over 65 years (Fisher, Kjellstrom, Kingham et al 2007).

5.3 Summary of health effects from particulate

Generally, health effects from particulate can vary with daily ambient concentration and size distribution. Effects associated with short-term exposures include increased

daily mortality, increased rates of hospital admissions for exacerbation of respiratory disease, fluctuations in the prevalence of bronchodilator use, cough increases, and peak flow reductions. According to the WHO, the current time-series epidemiological studies are unable to define a threshold below which no effects occur. (Guidelines for Air Quality, Geneva, 2000 and global update 2006). Moreover, recent studies suggest that even at low levels of PM_{10} (less than 100 $\mu g/m^3$) short-term exposure is associated with health effects. The current conclusion is that particulate is a non-threshold substance for health effects.

Long-term effects of particulate matter exposure are observed through mortality patterns and cardiovascular and respiratory morbidity; some effects are also associated with daily rises in exposures. Current research is clarifying the size, type and source of particulate associated with adverse effects, the role of combinations of contaminants and the vulnerability of different groups in the community.

5.4 Summary of health effects from oxides of nitrogen

Oxides of nitrogen have been a longstanding indicator of air quality with respect to combustion sources, including motor vehicles. They are important to include in any air quality monitoring for health impact assessment related to exposure to motor vehicle exhaust.

The WHO Air Quality Guidelines global update (2006) re-iterates that nitrogen dioxide (NO_2) is associated with the various adverse impacts on health. These include important effects among children: increased respiratory symptoms, onset of respiratory symptoms among infants, increased bronchitic symptoms for children with asthma. Other demonstrated effects for NO_2 among people with asthma include: direct effects on lung function and increased bronchial responsiveness at levels upwards of 200 $\mu g\ m^{-3}$.

Oxides of nitrogen are not only important for direct health effects, but can cause increased risk when present together with sulphur dioxide, particulate and ozone. Ambient air guideline levels are generally protective enough to account for these combined exposures from motor vehicles.

5.5 Summary of health effects from carbon monoxide

Carbon monoxide (CO) is generated through combustion, for example motor vehicle engines, and becomes problematic for human health where there is inadequate ventilation for its dispersal. Improvements in vehicle engines have led to marked reductions in CO from exhaust but it is still an air quality parameter regularly measured to assess motor vehicle impacts. Underground tunnels and car park buildings are classic situations for public health risk but outdoor spaces hold smaller risk. An important situation of demonstrated public health risk arises from tobacco smoking in an enclosed space, particularly in a motor vehicle, where there is also an additive risk from exhaust gases.

The health risks from CO have been included in the WHO ambient air quality guideline review (2000). The mechanism of adverse effects is from the binding of CO with haemoglobin to form carboxyhaemoglobin (COHb), which reduces the oxygen carrying capacity of the blood and impairs the release of oxygen to the tissues. The risks are particularly significant in pregnancy. Raised COHb levels are associated with risks for abnormality of heart function and risks for vehicle accidents, possibly through short-term reversible neurological effects.

At levels likely in outdoor air, carbon monoxide is an indicative parameter for motor vehicle exposure rather than a likely cause of health effects.

5.6 Assessment of health effects from Buckle St data

The data from the NIWA monitoring shows that background air quality meets ambient air guidelines intended to protect against health effects (see following section of this report). The peaks that arose were considered to be from a source other than the traffic on the road. Incremental changes from re-alignment of the road are modelled to be so small as to hardly be measurable in practice. Therefore, specific health effects from air contaminants from the road are not likely to be a significant contributor to health impacts in the locality.

6 Analysis of Air Quality Monitoring Data

The air quality monitoring methods and results are presented in a separate report by NIWA (May 2008). The monitoring comprised carbon monoxide, nitrogen dioxide and PM10 (particulate matter of size 10 µm or smaller). Peak concentrations from the six-month monitoring period were likely to be from sources other than the road. Despite this, the actual recorded peaks were used for maximal values. This is a source of likely overestimation of actual risk from the road re-alignment.

The peak extrapolated baseline data from monitoring was summed with the predictions of the peak impact of the realignment as detailed in the NIWA Screening Assessment. NIWA explain that such a simple summing is inherently conservative, as peak baseline and peak road impact may not coincide in time. This adds to a likely overestimation of risk to health.

A table from the NIWA results is reproduced below, to show the predicted maximum increases in exposure to contaminants with the road re-alignment.

NIWA (May 2008) Table 3. Comparison with AAQG

Contaminant	Averaging period	Predicted max increase	Max baseline	Predicted max impact	AAQG Maximum Acceptable Level	AAQG Maximum Desirable Level
CO / mg m^{-3}	8 hrs	0.16	3.8	3.96	10	6
	1 hr	0.42	7.0	7.42	30	none
PM_{10} / µg m^{-3}	24 hrs	0.43	31.9	32.3	50	none
	Annual	0.064	12.8	12.9	20	none
NO_2 / µg m^{-3}	1 hr	2.8	48.6	51.4	200	95
	24 hrs	2.3	24.8	28.1	100	30

NIWA conclude that the realignment, as modelled in the Screening Assessment, is not expected to lead to the exceedence of any health-based air quality standards or

guidelines at Mt Cook School. The incremental worsening of air quality at the school is likely to be close to the level of detection of air quality instrumentation and not considered significant.

7 Assessment of uncertainties

7.1 Uncertainties

Uncertainty can be defined as the lack of knowledge about the correct value for a specific exposure measure or estimate. Characterisation of uncertainty is an integral component of all steps in risk assessment process. It is a critical part of the process and must be addressed for each step of the risk assessment and for its cumulative effect from all the steps.

It is also important to emphasise that uncertainty analysis provides a valid basis for decision-making process and further risk management.

Specific uncertainties identified in this HRA are listed as follows.

7.1.1 Health hazard assessment

- Health effects of nitrogen dioxide (NO_2): short term exposure effects are described in published literature. Effects on chronic disease are not as clearly demonstrated.

- Health effects of particulate matter: clearly described in published literature, but dose response is not definitively determined currently, and there is insufficient clarity about implications of different types of particulate.

- Ecological studies: recent literature of the health effects from air pollution is based on ecological studies, which are observation of differences among people living in different places or at different times. Ecological studies have limitations in their methods because it is not possible to

control all variables since these studies take advantage of natural events rather than structured experiments.

7.1.2 Exposure assessment

The uncertainties related to the assessment of the local school exposure are:

- Six months duration monitoring data is available for oxides of nitrogen, particulate matter and carbon monoxide. Monitored data includes all point and general background sources. It is possible that the six months selected may vary from the pattern of a typical annual exposure but the reasons why this is not considered a significant issue are discussed by NIWA (May 2008).

- The estimation of individual exposure assumes 24-hour exposure among the community, whereas the school student exposure will be for a lesser time. This reduces the likely impacts so they will be less than those predicted in the HRA.

7.1.3 Health risk characterisation

The uncertainties related to the health risk characterisation are:

- Health status of exposed population: There is no specific local information, for example no health survey has been used at the school. This assessment presumes national health status applies, e.g. the rate of prevalence for asthma. This is acceptable where changes in air quality are so minor.

- Individual susceptibility: occasionally there is a rare individual with susceptibility that is greater than has been accounted for in population based guidelines. The methods used in this HRA have not sought to identify any such individual. This is considered acceptable because the exposures are expected to be far below amounts associated with health

effects in any people considered when guidelines have been determined. The likelihood that an unusually susceptible individual will experience adverse effects on health is extremely remote.

- Exposure is likely to have been overestimated: Health risk interpretation considers the highest possible exposure estimations (e.g. the worst-case exposure scenario, etc) as well as 'precautionary' approach in assessing the health risks (e.g. uncertainties factors applied to LOAEL, NOAEL, etc). Possible exposure is probably over-estimated rather than under-estimated, given the conservative methods used for exposure estimation.

8 Conclusions and recommendations

The Mt Cook School community has students from diverse ethnic backgrounds and the school has a decile 2 rating. There is also an early childhood centre at the site. Twelve percent of the students are Maori, 14% from Pacific families and 23% are from Somalia/Ethiopia. The children at the school are likely to have a greater vulnerability than the Wellington average for respiratory health problems potentially affected by air quality. It is important in this context to be satisfied that an assessment of health risk is undertaken in a sufficiently detailed manner to identify whether there might be any change in background risk to health.

The anticipated change in air quality at the Mt Cook School is so minor that it will have no significant effect on exposure to contaminants. Therefore the likelihood of adverse effects on health is extremely low. In a situation where there is minimal, if any, measurable change in air quality there is no useful purpose attempting to quantify changes in health prevalence, especially for a group of under 200 children. The health impact assessment can only provide a qualitative comment that the risk from contaminants is minimal, if any.

It is important that this conclusion is communicated clearly to the school community. The reason for the lack of quantified risk is not just because the number of students

is small nor that there is uncertainty about how much effect air pollution has on children's health. The lack of quantified health risk is primarily a result of the very small additional exposure expected after the road is moved nearer to the school.

Sometimes continued monitoring is recommended at a location where exposure to reduced air quality is an issue, especially if the exposed community are vulnerable to effects. In this case there is no merit in continued monitoring at this specific location, because the size of incremental effect is predicted to be so small. The use of appropriate locations for Regional monitoring of background air quality in Wellington is a different matter.

Likewise there is no particular need to monitor health outcomes among the school community after the road is moved.

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10 Glossary

Term	Definition
Aerosol	A suspension of solid or liquid particles in a gaseous medium
Alveolar	Relating to the air sacs in the lungs (alveoli)
Alveolitis	Inflammation of alveoli
AAQG	Ambient air quality guidelines
Angina	A medical condition in which lack of blood supply to the muscle of the heart causes severe chest pains
Anthropogenic	Resulting from the influence humans have on the natural world
Asthma	A disease of the respiratory system sometimes caused by allergies, with symptoms including coughing or wheezing, sudden difficulty in breathing, and a tight feeling in the chest
Atopic	Describes a condition that is caused by a hereditary tendency to produce specific antibodies (IgE) to certain allergens, such as occurs in hay fever, asthma or eczema
Background level	A typical or average level of a chemical in the environment. Background often refers to naturally occurring or uncontaminated levels
Bronchial	Relating to or affecting the tubes (bronchi) that carry air from the windpipe into the lungs
Bronchioles	A narrow tube inside the lungs that branches off the bronchi
Bronchitis	Inflammation of the mucous membrane in the bronchial tubes resulting from infection or irritation, and causing breathing problems and coughing
Bronchoconstriction	Relating to the bronchial tubes, which become narrow, eg. asthma
Cancer	A malignant tumour or growth caused when cells multiply uncontrollably
Carcinogenic	Capable of causing cancer
Cardiac	Relating to or affecting the heart
Cardiovascular	Relating to both the heart and the blood vessels
Chronic	Medical condition that lasts over a long period, sometimes causing long term change in the body
Ciliated	Describes cells with projecting threads (cilia), or organisms with cells

	of this type
Concomitant	Happening or existing along with or at the same time as something else
Confounding factors	Factors that can cause or prevent the outcome of interest, are not intermediate variables, and are not associated with the factors under investigation (e.g. In epidemiology)
Contaminant	Any substance or material that enters a system (the environment, human body, food, etc) where it is not normally found
Conjunctival	Pertaining to conjunctiva, a mucous membrane that covers the internal part of the eyelid, and the front of the eye
Contaminant	As opposed to pollutant, which might be naturally found+++++
Cornea	The transparent convex membrane that covers the pupil and iris of the eye
Dermal	Involving, located in, or made up of skin or its main layer (dermis)
Diabetes mellitus	A disorder in which there is no control of blood sugar, through inadequate insulin production (Type1) or decreased cellular sensitivity to insulin (Type2) causing kidney, eye and nerve damage if untreated
Dose-response relationship	The quantitative relationship between the amount of exposure to a toxicant and the incidence of the adverse effects
Dyspnoea	Difficulty in breathing
Eczema	A medical condition in which patches of skin become rough and inflamed with blisters which cause itching and bleeding
Emission	The discharge of contaminants into the air
Emphysema	A condition in which the air sacs of the lungs are damaged and enlarged, causing breathlessness
Endemic	Describes a disease occurring within a specific area, region or locale
Endocrine	Relating to glands that secrete hormones internally directly into the lymph or bloodstream
Epidemiology	The branch of medicine concerned with the incidence and distribution of diseases and other factors relating to health
Epithelium	The thin tissue forming the outer layer of the body's surface and lining the alimentary canal (gut) and other hollow structures
Exposure	The experience of coming into contact with some environmental condition that has either a beneficial or harmful effect
Gastrointestinal	Relating to the stomach and intestines

Genotoxic	Describes a poisonous substance which harms an organism by damaging the molecule that encodes genetic information in the nucleus of cells (DNA)
Glottis	The part of the larynx consisting of the vocal cords and the slit-like opening between them
Guideline value	A concentration value, and averaging period over which it applies, for assessing and managing ambient air quality
Immediately Dangerous to Life or Health (IDLH)	The maximum concentration of a contaminant from which one could escape within 30 minutes without any escape-impairing symptoms or irreversible health effects
Immune	Protected from getting a particular disease because of natural resistance; resistance acquired after catching the disease before; or resistance conferred by vaccination
Inert	Not readily changed by chemical or biological reaction
Influenza	A viral illness producing a high temperature, sore throat, runny nose, dry cough, muscle pain
Ingestion	Take something such as food or liquid into the body by swallowing or absorbing it
Inspiratory, Inhalable	Relating to the process of breathing in
Intracellular	Located or occurring within a cell or cells
Lowest-Observed-Adverse-Effect-Level (LOAEL)	Lowest concentration or amount of a substance, found by observation or experiment, which causes an adverse effect
Maximum Allowable Concentration (MAK) value	MAK value, set by MAK Commission, is the maximum concentration of a working material as gas, steam or aerosol in the air with an eight-hour exposure and an average number of hours worked per week of 40 hours, with which the health of the persons employed is not impaired.
Maximum acceptable values (MAV)	MAV of a substance is often used to assess acute exposure toxicity.]
Mean	The average of a set of quantities
Median	Denoting or relating to a value or quantity lying at the mid point of a frequency distribution of observed values or quantities, such that there is an equal probability of falling above or below it
Morbidity	The relative frequency of occurrence of a particular disease in a particular area

Mortality	The number of deaths that occur at a given time, in a given group, or from a given cause
Mucosa	A mucus-secreting epithelial tissue lining many body cavities and tubular organs including the gut and respiratory passages
Myocardial	Relating to or affecting the thick muscular wall of the heart
Nasopharyngeal	Relating to the nose and pharynx
Nasopharynx	The upper part of the pharynx, behind and above the soft palate, continuous with the nasal passages
Nausea	The unsettling feeling in the stomach that accompanies the urge to vomit
No-Observed Adverse Effect Level (NOAEL)	The dose of a chemical at which there were no statistically or biologically significant increases in frequency or severity of adverse effects seen between the exposed population and its appropriate control. Effects may be produced at this dose but they are not considered to be adverse
Particulate	Relating to or consisting of separate particles
Particle	Small discrete mass of solid or liquid matter
Pharynx	The membrane-lined cavity behind the nose and mouth, connecting them to the oesophagus
Physiological	Relating to the way in which a living organism or bodily part functions
Prevalence	The number of cases of an illness or condition that exists at a particular time in a defined population
Psychosocial	Relating to the interrelation of social factors, and individual thought and behaviour
Pulmonary	Relating to the lungs
Recommended Exposure Limit (REL)	A National Institute for Occupational Safety and Health (NIOSH) time-weighted average (TWA) concentrations for up to a 10-hour workday during a 40-hour workweek
Renal	Relating to the kidneys
Reproductive	Relating to the production of new offspring or individuals
Respirable	Fit or able to be breathed
Respiration	The act of breathing (i.e. Inhaling and exhaling) during which the lungs are provided with oxygen through inhaling and carbon dioxide is removed through exhaling
Respiratory	Relating to or affecting respiration or the organs of respiration
Rhinitis	**Inflammation of the mucous membranes of the nose usually**

	accompanied by a discharge of mucus, nasal congestion, sneezing, itching of the nose
Rhinoconjunctivitis	Rhinitis together with inflammation of the mucous membrane that lines the eyelids and is part of the eyeball
Route of exposure	The way in which a person may contact a chemical substance. For example, drinking (ingestion) or bathing (skin contact) are two different routes of exposure to contaminants that may be found in water
Short-Term Exposure Limit (STEL)	The American Conference of Governmental Industrial Hygienists (ACGIH) maximum concentration to which workers can be exposed for up to 15 minutes continually
Sinusitis	Inflammation of the membrane lining a paranasal sinus generally as a result of an upper respiratory infection or allergic response
Solubility	The extent to which one substance is able to dissolve in another
Somatic	Relating to or affecting the body, especially as distinct from the mind
Susceptibility	The likelihood of being affected by something
Symptom	Any perceptible change in the body or its functions that indicates disease or the kind or phases of disease
Threshold Limit Value (TLV)	The American Conference of Governmental Industrial Hygienists (ACGIH) concentration of a substance to which most workers can be exposed without adverse effect
Time-Weighted Average (TWA)	An allowable exposure concentration averaged over a normal 8-hour workday or 40 hour workweek
Toxicity	The degree to which something is poisonous
Toxicology	The branch of science concerned with the nature, effects and detection of poisons
Tracheobronchial	Relating to both the trachea and the bronchi
Transient	Lasting a short time
Uncertainty	Something that nobody can predict or guarantee
Upper respiratory tract	Relating to the air passages that connect the lungs with the exterior, including the nasal passages, trachea and bronchi
Viral	Relating to, typical of, or caused by a virus
Volatilise	To change into a vapour
Wheeze	Breathe with a whistling or rattling sound in the chest, as a result of obstruction in the air passages

11 APPENDIX A

11.1 International Sources of background information

International information source	Comment	Resource location
World Health Organisation (WHO)	WHO, a United Nations specialised agency for health, established April 7 1948, includes 192 Member States. It gives worldwide guidance in the field of health; sets global standards; co-operates with governments in strengthening national health programmes; and assists in developing and transferring appropriate health technology, information and standards.	WHO Avenue Appia 20 1211 Geneva 27 Switzerland
International Agency for Research on Cancer (IARC)	IARC, part of the WHO, co-ordinates and conducts research on the causes of human cancer, the mechanisms of carcinogenesis, and develops scientific strategies for cancer control.	IARC 150 Cours Albert Thomas, 69372 Lyon CEDEX 08, France www.iarc.fr
US National Institutes of Health National Library of Medicine (NLM)	NLM, world's largest medical library, collects materials in all areas of biomedicine and health care, biotechnology, the humanities, and the physical, life and social sciences. Its collection stands at 5.3 million items – books, journals, technical reports, manuscripts, microfilms, phonographs, and images.	National Institutes of Health Campus, Bethesda, MD, US www.nlm.nih.gov
MEDLINE	Database of more than 10m references to articles published in 4,300 refereed biomedical journals	MEDLINE CD ROM
Hazardous Substances Data Bank (HSDB)	HSDB is a comprehensive, scientifically reviewed, factual database with records for more than 4,500 toxic or potentially toxic chemicals. It has extensive information in various research areas: toxicity, environmental fate, human exposure, chemical safety, waste disposal,	US National Library of Medicine

	emergency handling, and regulatory requirements	
TOXLINE	Bibliographic database covering biochemical, pharmacological, physiological, and toxicological effects of various chemicals. It contains more than 2.5 million citations, many with abstracts and index terms, and CAS Registry Numbers	US National Library of Medicine
BIOSIS	Non-profit organisation established 1926. It accumulates biological and medical literature and processes approximately 550,000 items each year, from primary research and review journals, books, monographs, and conferences. Its information system contains more than 13 million citations	BIOSIS, Philadelphia, US www.biosis.org
Agency for Toxic Substances and Disease Registry (ATSDR)	An agency of the US Dept of Health and Human Services – takes responsive public health actions and provides health information to prevent harmful exposure and disease related to toxic substances.	Atlanta, GA, US www.atsdr.cdc.gov
US Environmental Protection Agency (EPA)	Government environment agency of the United States, EPA provides leadership in the nation's environmental science, research, education and assessment efforts and aims to protect human health and safeguard the natural environment.	EPA Ariel Rios Building 1200 Pennsylvania Ave, N.W. 3213A Washington DC, US www.epa.gov
American Industrial Hygiene Association (AIHA)	AIHA, founded 1939, is one of the largest international associations serving the needs of occupational and environmental health professionals practicing industrial hygiene in industry, government, labour, academic institutions, and independent organisations.	AIHA 2700 Prosperity Ave., Suite 250 Fairfax, VA, US www.aiha.org

11.2 Local Sources of background information

Local information source	Comment	Resource location
NZ Ministry for the Environment (NZ MfE)	Advises the Government on New Zealand's environmental laws, policies, standards and guidelines; monitors how they are working in practice, and takes any action needed to improve them; reports on the state of our environment, on local government performance, on environmental matters, and on the work of the Environmental Risk Management Authority and the Energy Efficiency and Conservation Authority.	www.mfe.govt.nz
NZ Statistics	Statistics New Zealand is a government department and NZ's national statistical office. It administers the Statistics Act 1975, and is the country's major source of official statistics.	www.stats.govt.nz
NZ Ministry of Health (NZ MoH)	MoH is the Government's principal agent and advisor on health and disability. It develops policy advice for the Government on health and disability issues; administers health regulations and legislation; funds health and disability support services; plans and maintains nationwide frameworks and specifications of service;, monitors sector performance and provides information to the wider health and disability sector and the public.	www.moh.govt.nz

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