*Ashburton Second Urban Bridge and Associated New Road*

# Assessment of Effects on Air Quality

**Ashburton District Council**

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## Ashburton District Council


Prepared by I. A Kvatch
Environmental Scientist

Reviewed by V.K. Dravitzki
Research Manager
Materials & Environmental Science

Opus International Consultants Ltd
Christchurch Office
20 Moorhouse Avenue
PO Box 1482, Christchurch Mail Centre,
Christchurch 8140
New Zealand

Telephone: +64 3 363 5400
Facsimile: +64 3 365 7858



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# Contents

# Glossary

| | |
|---|---|
| **ADC** | Ashburton District Council |
| **AADT** | annual average daily traffic |
| **AAQG** | Ambient Air Quality Guidelines |
| **ASUB** | Ashburton Second Urban Bridge project |
| **CNRRP** | Canterbury Natural Resources Regional plan |
| **CO** | carbon monoxide – vehicle emitted contaminant |
| **MfE** | Ministry for the Environment |
| **NO and NO2** | oxide of nitrogen and nitrogen dioxide – vehicle emitted contaminants |
| **NESAQ** | National Environmental Standards for Air Quality |
| **NZTA** | New Zealand Transport Authority |
| **PM10** | particulate matter - vehicle emitted contaminant |
| **RAAQT** | Regional Ambient Air Quality Targets |
| **VERM 5.0** | Vehicle emission prediction model – model to calculate vehicle emission rates |

# 1 Introduction

This report describes the assessment of impacts on the local air quality from the construction of a new bridge across Ashburton River and associated link roads in Ashburton. This assessment was required to prepare the Notice of Requirements for Ashburton District Council (ADC). It is a desktop investigation of potential discharges to air from this Project, including fugitive dust emissions from earthworks during construction and vehicle emissions from traffic flows on the bridge and on link roads.

The assessment predicts impacts of discharges to air on the properties located along Chalmers Avenue and the new road connecting the bridge and Grahams Road. The assessment gives priority to those properties with residential dwellings located along Chalmers Avenue and in the immediate vicinity of the new link road. The assessment applies an approach as recommended in the *Good Practice Guide for Assessing Discharges to Air from Land Transport* (MfE June 2008).

# 2 Description of the Project

ADC proposes to construct a new 2 lane bridge across the Ashburton River to connect Chalmers Avenue on the true left side of the river, and East Tinwald through farmland to the intersection with Grahams Road. The proposed new bridge and associated new road is collectively referred to herein as the Ashburton Second Urban Bridge project (ASUB). The location of the new bridge and the link road is shown in Figure 1.

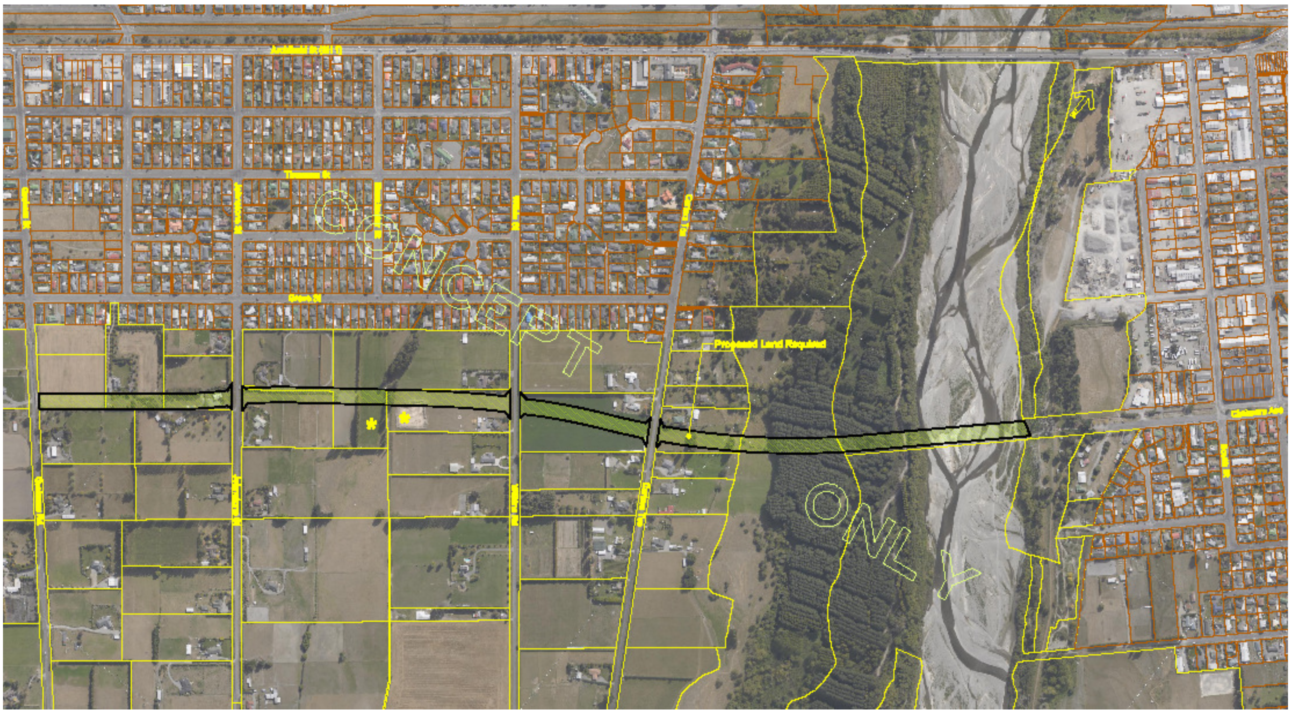



**Figure 1: Ashburton 2nd Urban Bridge Project**

ADC is seeking a new designation to include the entire infrastructure associated with the ASUB project including a 2-lane bridge, traffic lanes (including cycle lanes and parking), footpaths / pedestrian connections, intersections, stormwater infrastructure, landscaping, ancillary road infrastructure (e.g.; services within the road corridor), and road construction.

The proposed designation area runs in parallel to SH1 through the farm land south of Tinwald, starting from the western end of Chalmers Road and Ashburton River until the t-shape intersection with Grahams Road. The designation area is approximately 2.3 km long including a new route and the bridge. There will be a number of residential dwellings adjacent to the designation boundary, and these residences can potentially be exposed to vehicle emissions from the new road. For the residences located in the immediate vicinity of the designation area, impacts of the Project on the local air quality need to be assessed for both construction (fugitive dust emissions) and operation (vehicle emissions) conditions.

## 2.1 Existing Road Network and Traffic Flows

Vehicle number plate surveys undertaken in 2006, and repeated again in 2012, indicate that the bulk of the traffic on the existing bridge during peak times is local traffic between Tinwald and Ashburton. Less than 30% of the traffic is “through traffic” on SH1. The existing state highway bridge is nearing capacity at present, but is still functioning adequately most of the time. The traffic issue on the current bridge is a local traffic issue and the ASUB project will primarily be to serve the local traffic needs of the Tinwald and Ashburton communities. Once constructed, the ASUB will become an extension of the existing urban road network within east Tinwald and Ashburton township and will be maintained and controlled by ADC. It will not become the state highway.

Physical construction of the ASUB is not required until approximately 2026, at which time traffic congestion on the existing bridge is expected to reach a point which justifies the need for a second bridge. Traffic modelling indicates that up to 14,000 vehicles per day (vpd) are likely to use a second bridge by 2026, with between 5-10% expected to be heavy goods vehicles (HGVs). This traffic is likely to distribute amongst side roads to the north and south of the bridge and is expected to result in an overall reduction in total average travel time for all vehicles in the Ashburton urban area.

### 2.1.1 Forecast Traffic Volumes

Traffic modelling indicates that in the future traffic volumes on key routes throughout Ashburton are likely to increase significantly by 2026 regardless of a second bridge and the current road network in this area will not be able to distribute traffic flows effectively. This is expected to result in significant congestion and delays at a number of locations, including the existing bridge and the intersection of SH1 with Moore Street (SH77). Cconstruction of a new bridge and modification of the local roads will redistribute traffic flows from the Ashburton central area and SH1 to the southern suburb of Ashburton and Tinwald. Traffic on local roads south of Tinwald, and through Chalmers Avenue will increase after construction of the new bridge.

## 2.2 Local Weather and Environment

Long term meteorological observations show that climate in Ashburton is similar to other Canterbury areas. The inland location makes it dry compare to the coastal areas with more pronounced extremes with cold winter or periods of drought during the summer time. The area is influenced by the Southern Alps and cold southerly winds.  New Zealand Metservice maintains a meteorological station, at Ashburton airport. The station is about 4.5 km west from the city centre, and it was assumed that the meteorological data from this station will be representative for the assessment area.

Meteorological records and the air quality monitoring data shows that high air pollution levels may occur in Ashburton in winter, when temperature inversions are developing in the area during relatively calm, cool and clear weather conditions. The highest concentrations occur during winter months, when calm weather conditions prevail and concentrations of air contaminants build up overnight or during early morning hours. The long term meteorological observations show that prevailing winds in this area are from the north and north-northwest directions. A wind rose from the Ashburton airport weather station is provided in Figure 2.

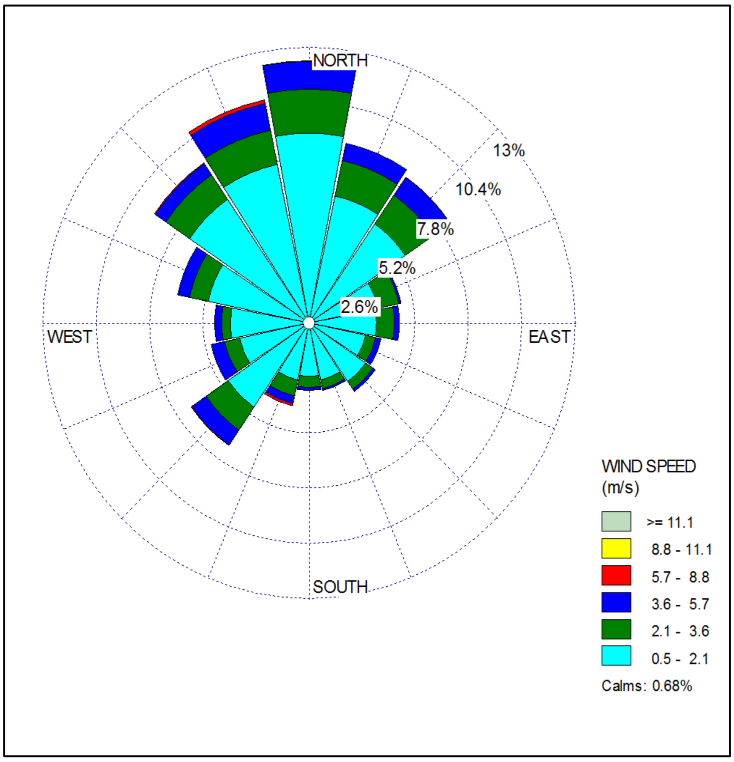



**Figure 2: Ashburton Windrose**

The wind speed is an important parameter effecting dispersion of air contaminants. Figure 3 shows a frequency distribution of different wind speeds in the area. It could be seen that 73.7 % of all winds occurring in Ashburton are from 0.5 to 2.1 m/s, and they correspond to very light or light wind conditions. These weather conditions prevent dispersion of air contaminants and are responsible for increasing air pollution levels and high air pollution events monitored every year in Ashburton.

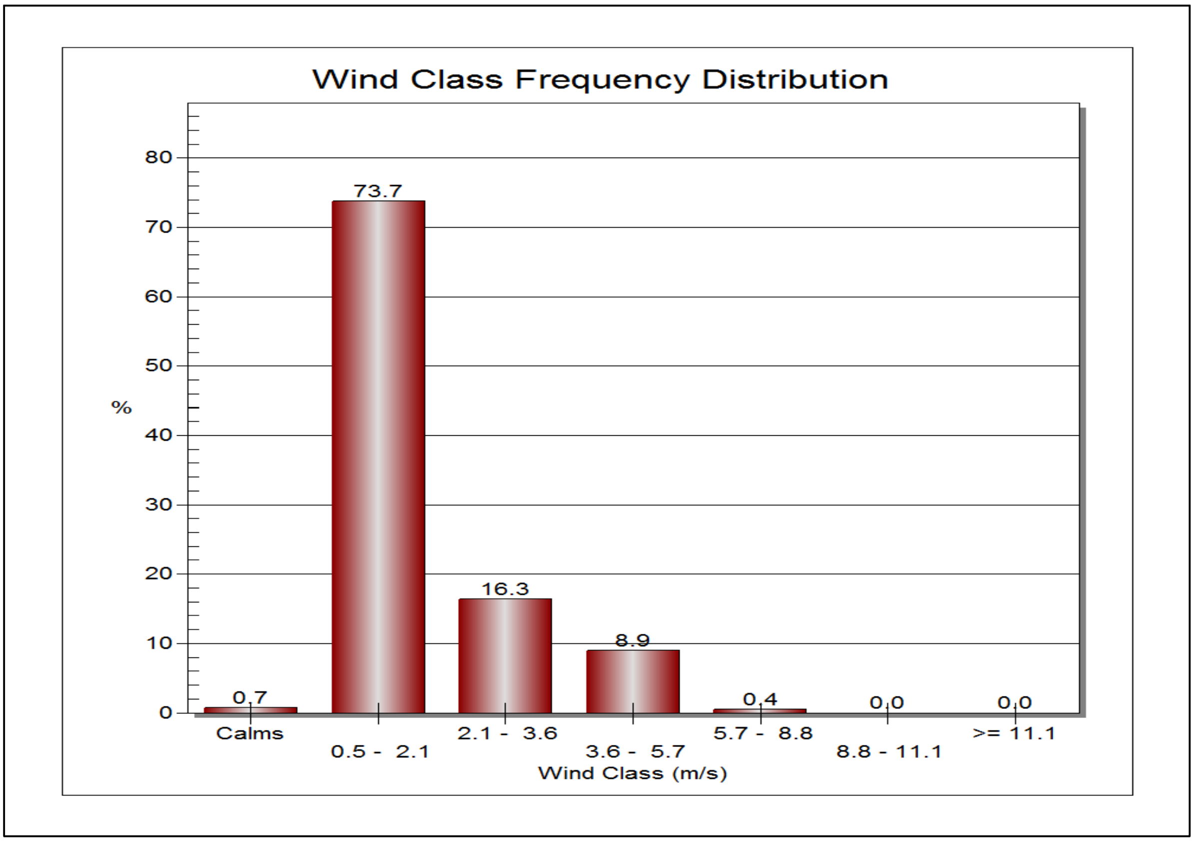



**Figure 3: Wind speed frequency distribution for Ashburton**

## 2.3 Potential Emissions from ASUB

### 2.3.1 Fugitive Dust Emissions

Potential fugitive dust emissions from road construction activities consist primarily of dust and particulate materials ($PM_{10}$). Most references suggest that the dispersion and deposition of large airborne particles appears within 100 - 150 metres from the road construction area. Other references also suggest that impacts of $PM_{10}$ emissions are insignificant, because dust generated from the road construction activities is generally coarse and dispersion is very limited except under dry and windy weather conditions.

### 2.3.2 Vehicle Emissions

Motor vehicle emissions consist of the engine exhaust emissions, evaporation of fuel, brake dust, tyre wear and road surface dust. The amount of emitted contaminants depends on the type of vehicle and the type of driving mode. For some contaminants such as carbon monoxide, the highest emissions occur under congested traffic conditions or at intersections, where emissions are typically much higher than when compared to free flowing traffic. For oxides of nitrogen, emission rates are highest at free flowing high speeds. The air quality impact of vehicle emissions arises from the collective effect of the individual vehicles, both through the total number of vehicles and through the vehicle interaction in congested or free flow conditions.

The environmental indicators and air contaminants recognised as relevant to road transport include carbon monoxide (CO), oxides of nitrogen ($NO_2$), fine particulates ($PM_{10}$ and $PM_{2.5}$) and sulphur dioxide ($SO_2$) (MfE June 2008). Other contaminants that may have potential environmental impacts include volatile organic compounds (VOC), ozone, benzene and polycyclic aromatic hydrocarbons.

In many air quality assessments, concentrations of carbon monoxide, oxides of nitrogen and $PM_{10}$ have been often used as indicators of the air quality. It is taken that if each of these indicator species are within acceptable levels then all other contaminants should also be at acceptable levels. This approach is recognised in the Ministry for the Environment's *Good Practice Guide for Assessing Discharges to Air from Land Transport* (MfE, June 2008).

Oxides of nitrogen are calculated as the sum of nitric oxide (NO) and nitrogen dioxide ($NO_2$). Nitric oxide is formed in combustion processes at high temperatures, so emission rates increase with vehicle speed and engine temperature. Nitric oxide is oxidised to nitrogen dioxide in ambient air in a process accelerated by the presence of ozone and influenced by volatile hydrocarbons. Most of the link roads in this project will have speed limit of 50 km/h, and the effect of nitrogen dioxide emissions will be less pronounced and depends on increased number of vehicles, not on the speed of traffic flows.

Emissions of carbon monoxide and fine particulates increase in situations of traffic congestion. Under free flowing traffic conditions, the impact of these contaminants on the local air quality should not be an issue. However the air quality monitoring data shows that $PM_{10}$ concentrations exceed Air Quality standards in Ashburton. The emission inventory undertaken by Canterbury Regional Council in 2007 shows than motor vehicles contribute only 3% to total $PM_{10}$ emissions in Ashburton (see Table 2.1), and this contribution can be considered as insignificant.

**Table 2.1: Contribution of air contaminants by different sources in Ashburton**

| Contaminant | Domestic home heating | | Motor vehicles | | Industrial and commercial activities | | Total kg |
|---|---|---|---|---|---|---|---|
| | kg | % | kg | % | kg | % | |
| $PM_{10}$ | 765 | 84 | 29 | 3 | 112 | 12 | 906 |
| $PM_{2.5}$ | 732 | 86 | 21 | 2 | 95 | 11 | 848 |
| CO | 6377 | 69 | 2505 | 27 | 308 | 3 | 9190 |
| $NO_x$ | 86 | 14 | 405 | 67 | 114 | 19 | 605 |

Source: Environment Canterbury (November 2008), Inventory of emissions to air in regional Canterbury towns, 2007, Report No. R08/96 ISBN 978-1-86937-944-5

Emissions of other vehicle contaminants, including sulphur dioxide, organic compounds and aromatic hydrocarbons strongly depend on composition of fuel, so changes in fuel specification can reduce or increase their impact. Changes in driving conditions and redirection of traffic flows within the Ashburton and Tinwald area will have only a minor effect on the emissions of these contaminants.

# 3 Assessment Methodology

There are three levels of the air quality assessment (Tier 1, Tier 2 and Tier 3) specified in the Ministry for the Environment (MfE) *Good Practice Guide for Assessing Discharges to Air from Land Transport* (June 2008).

The Tier 1 assessment is a qualitative preliminary assessment to collect background information at the beginning of the project. The objectives are to identify key issues and determine the appropriate levels of the assessment. For larger projects the Tier 1 preliminary assessment provides an opportunity to identify key air quality issues early in the process.

A Tier 2 screening dispersion-modelling study provides conservative estimates of likely air quality impacts. This means the assessment can provide confidence that a project will not result in significant air quality impacts. However, the air quality monitoring data in Ashburton shows that air contaminants specifically PM10 regularly exceed the standard threshold for air quality. It appears that the Tier 3 approach will be more appropriate in this case.

Based on a preliminary investigation and regarding the intensity of traffic flow, vehicle speed and the location of potentially affected receptor sites, this assessment should go somewhere in between a Tier 2 and Tier 3 approach. Ashburton has the existing air pollution problem specifically in winter time, so the contribution and effect of the redirected traffic flows need to be assessed.

This assessment will be based on the following input data: predicted traffic flows, vehicle fleet compositions and estimated vehicle emission rates. The local meteorological conditions will be included in the modelling using the real time weather data from the Ashburton airport weather station. The modelling will predict ambient air concentrations of vehicle emitted contaminants for residential properties and primacies adjacent to the new bridge, new link road and Chalmers Avenue, to illustrate and quantify the anticipated level of impact.

The future environment of the assessment area is taken into account using predicted traffic flows in 2026 and estimated vehicle emission rates. The assessment of the future air quality at receptor sites (the existing residential dwellings) along a new link road will also be applicable for the future environment. All residential dwellings constructed in the future will be exposed to the same air quality as the existing dwellings used in the assessment.

## 3.1 Air Quality Assessment Objectives

The following objectives have been considered in the assessment of vehicle emissions from the ASUB project.

- Estimate of the existing local ambient air quality, taking into account ambient air quality monitoring data, meteorological conditions and topography of the area.
- Determination of vehicle emissions those are likely to be discharged by traffic flows on the existing roads and in the future after construction of the bridge.
- Assessment of the dispersion of vehicle contaminants towards residential properties and other sensitive sites adjacent to the new bridge and link roads; and

- Compare predicted concentrations with those required in the Regional Air Quality Management Plan for Ashburton, and the national standards and air quality guidelines.

## 3.2 Scope of Assessment

The scope is as defined in the MfE *Good Practice Guide for Assessing Discharges to Air from Land Transport* (MfE, June 2008). This report follows the MfE recommendations and provides the following information:

- Description of the Project including location of the proposed second bridge, a new link road and the existing environment
- Description of potential vehicle and fugitive dust emissions associated with the Project
- Assessment methodology
- Statutory requirements and assessment criteria for air quality
- Collection of the data on local weather conditions, air quality, existing and future traffic condition and traffic predicted after construction of a new bridge, vehicle emission data and anticipated construction activities
- Using air pollution dispersion modelling to predict anticipated vehicle emissions and roadside concentrations of vehicle emitted contaminants
- Interpretation of modelling results and assessment of potential operational air quality effects and effects of fugitive dust emissions during the construction period
- Recommendations for the Construction Air Quality Management including dust mitigation measures and ambient air quality monitoring if it would be required.

# 4 Statutory Requirements and Assessment Criteria for Air Quality

Several documents are applicable to establish the statutory environmental requirements for the ASUB project. Regarding the ambient air quality the following documents are relevant, and have been considered in this report:

- Canterbury Natural Resources Regional Plan (CNRRP) specifies regional objectives and policies, and the assessment criteria for air quality. This plan also includes AQL6 Objective and AQL38 Policy specific for Ashburton. The plan's criteria prevail, if they are more stringent than the threshold values specified in the National Environmental Standards for Air Quality and the Ministry for the Environment guidelines.

- The National Environmental Standards: Air Quality (NES). Ministry for the Environment. 2005 (including 2007 and 2011 amendments).

- The Ambient Air Quality Guidelines (AAQG). Ministry for the Environment 2002.

## 4.1 Canterbury Natural Resources Regional Plan

The Regional Plan includes a Chapter 3 considering air quality issues in the region. In Objective AQL2, the following five categories have been developed for setting Regional Ambient Air Quality Targets (RAAQT) for the Canterbury Region. Categories have been assigned in order to provide a comparative assessment of the air quality impacts and to indicate the significance of the anticipated changes in the local air quality. These five categories for air quality are shown in Table 4.1.

**Table 4.1: Air Quality Categories**

| Category | Measured (predicted) time averaged value of air contaminant concentration | Comment |
|---|---|---|
| Action | Exceeds the NES for Air Quality value* | Exceedences of the NES for Air Quality are a cause for concern and warrant action if they occur on a regular basis. |
| Alert | Between 66 % and 100 % of the NES for Air Quality value | This is a warning level, which can lead to exceedences if trends are not curbed. |
| Acceptable | Between 33 % and 66 % of the NES for Air Quality value | This is a broad category, where maximum values might be of concern in some sensitive locations, but are generally at a level that does not warrant dramatic action. |
| Good | Between 10 % and 33 % of the NES for Air Quality value | Peak measurements in this range are unlikely to affect air quality. |
| Excellent | Less than 10 % of the NES for Air Quality value | Of little concern: if maximum values are less than 10 percent of the NES for Air Quality, average values are likely to be much less. |

This approach was described and recommended by the Ministry for the Environment (MfE, 1997) in order to maintain some national consistency in the application of the standards or guideline values. The Ministry for the Environment suggests that regional councils should adopt criteria based on the monitoring results, with the aim of maintaining air quality at measured levels when it is below 66% of the AAQG value, and enhancing when it is above.

These air quality categories have been used to setup Regional Ambient Air Quality Targets (RAAQT) shown in Table 4.2. If the local ambient air quality is below the acceptable level (66%), the local authorities can use RAAQT to improve air quality.

**Table 4.2: Regional Ambient Air Quality Targets for assessed contaminants**

| Contaminant | Regional Ambient Air Quality Targets (RAAQT) -Upper Thresholds | | | | Averaging period |
|---|---|---|---|---|---|
| | Alert | Acceptable 66% | Good 33% | Excellent 10% | |
| Carbon monoxide | 30 mg/m3 | 20 mg/m3 | 10 mg/m3 | 3 mg/m3 | 8 hour |
| | 10 mg/m3 | 7 mg/m3 | 3 mg/m3 | 1 mg/m3 | 1 hour |
| Particulate matter PM10 | 50 µg/m3 | 33 µg/m3 | 17 mg/m3 | No target | 24 hour |
| Nitrogen dioxide | 200 mg/m3 | 132 mg/m3 | 66 mg/m3 | 20 mg/m3 | 1 hour |

Source: Environment Canterbury Regional Council, (2011), Canterbury Natural Resources Regional Plan, Christchurch, Chapter3: Air Quality, 2011

## 4.2 National Environmental Standards for Air Quality

The National Environmental Standards for Air Quality (AQNES) include thresholds for five air contaminants including carbon monoxide, nitrogen dioxide, PM10, ozone, and sulphur dioxide. *"The ambient standards are the minimum requirements that outdoor air quality should meet in order to guarantee a set level of protection for human health and the environment"*.

The National Environmental Standards have a special status under the Resource Management Act 1991. They are provided for by the Act and those agencies responsible for their achievement are expected to adhere to them. The National Environmental Standards have a higher statutory status than the Ministry for the Environment guidelines. For the Project, the NESAQ criteria are applicable to this assessment because the Canterbury Regional Council's Regional Ambient Air Quality Guideline threshold values are the same as the NESAQ values.

The NES threshold concentrations of carbon monoxide, nitrogen dioxide, PM10, are shown in Table 4.3 and these contaminants are relevant to the assessment as they are emitted by motor vehicles. Concentrations of carbon monoxide and PM10 have been continuously monitored in Ashburton.

**Table 4.3: Ambient Air Quality Standards relevant to the Project**

| Contaminant | Threshold concentration | Time average | Permissible excess annually |
|---|---|---|---|
| Carbon monoxide | 10 mg/m3<br>30 mg/m3 | 8 hour (running mean)<br>1 hour | 1 |
| Nitrogen Dioxide | 200 µg/m3 | 1 hour | 9 |
| $PM_{10}$ | 50 µg/m3 | 24 hour | 1 |

Source: Ministry for the Environment, 2005. National Environmental Standards for Clean Water, Air and Land. Ref. Infor 147, October 2005

Other contaminants covered by the NES, such as sulphur dioxide and ozone, have not been assessed as these are not emitted in any significant way from the transport fleet and have not been identified as an issue for the ASUB project.

## 4.3 Ambient Air Quality Guidelines

Also relevant are the AAQGs published by the Ministry for the Environment that were most recently updated in 2002 (MfE, 2002). The AAQGs that are relevant to this assessment are summarised in Table 4.4.

In addition, the effect of $PM_{2.5}$ particulates has been considered in this assessment and a criterion for these contaminants was also included in the table; however this criterion is not a standard threshold. It is specified in the Ministry for the Environment Ambient Air Quality Guidelines.

**Table 4.4 New Zealand Ambient Air Quality Guidelines**

| Contaminant | Threshold concentration | Averaging period |
|---|---|---|
| Carbon monoxide | 30 mg/m³ | 1-hour |
| Fine particles (as $PM_{10}$) | 20 µg/m³ | Annual |
| Fine particles (as $PM_{2.5}$)* | 25 µg/m³ | 24-hour |
| Nitrogen dioxide | 100 µg/m³ | 24-hour |

* NOTE: the $PM_{2.5}$ NZAAQG is a monitoring level only – that is, there is no specific requirement to achieve it (MfE, 2002).

At present, the $PM_{2.5}$ value should not be used as a target for air-shed management until more valid air quality monitoring data will be available. In this assessment the $PM_{2.5}$ value should be used as an indicative measure.

# 5 Existing Air Quality

There are a number of available reports on air quality monitoring in Ashburton. These reports include results of air quality monitoring programmes undertaken by the Environment Canterbury Regional Council (ECRC) and other technical reports containing results from different investigation programmes. The air quality monitoring data used in this assessment were obtained from the reports covering the period from 2005 to 2011.

Regular air quality monitoring in Ashburton's urban area is carried out by the Canterbury Regional Council. A permanent and continuous monitoring station is located at 14 Cambridge Street. The air quality monitoring data from this site for the period from 2005 to 2011 was in the report published by the Regional Council in March 2010 (Environment Canterbury March 2010). This report includes the data for three main indicators of air pollution from road transport: carbon monoxide, nitrogen dioxide and PM10.

The two diagrams presented below in Figures 4 and 5, show that the PM10 Air quality standard threshold of 50 µg/m³ was exceeded every year starting from 2005. Figure 4 shows 24 hour average maximum values recorded in Ashburton, and the diagram in Figure 5 shows the number of exceedences per year. Most of the air pollution is coming from domestic home heating, and there are regulations in place to control air pollution in Ashburton. Considering high air pollution levels, the contribution from road transport need to be assessed.

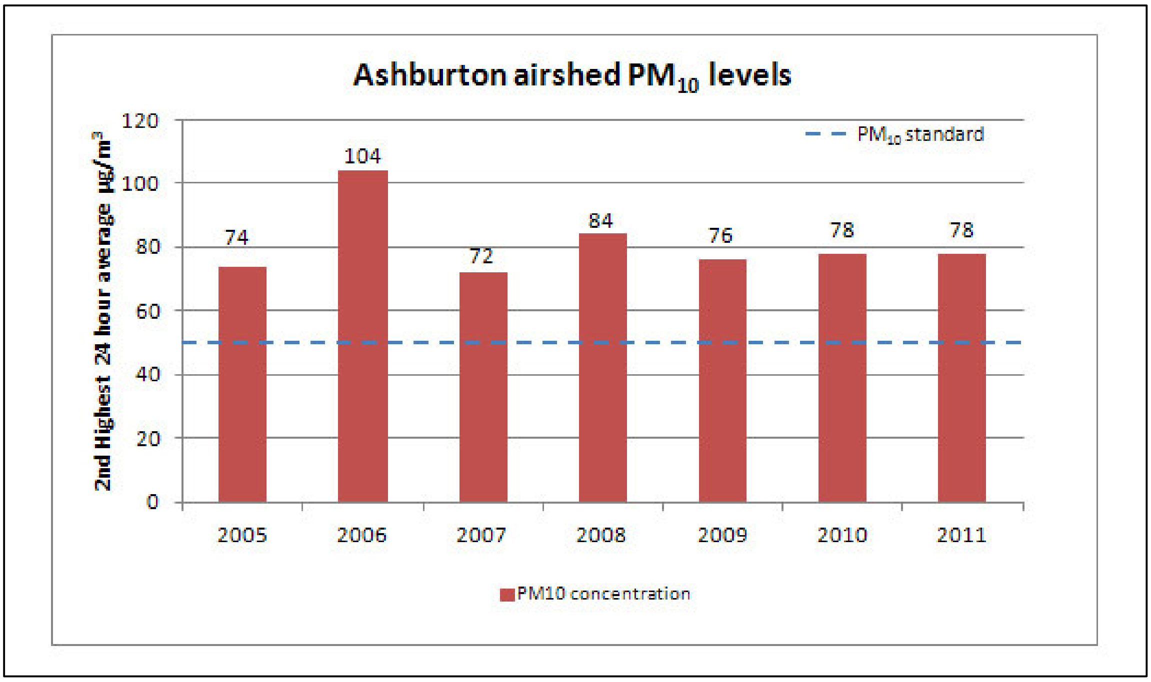



**Figure 4: Ashburton Airshed PM10 concentrations**

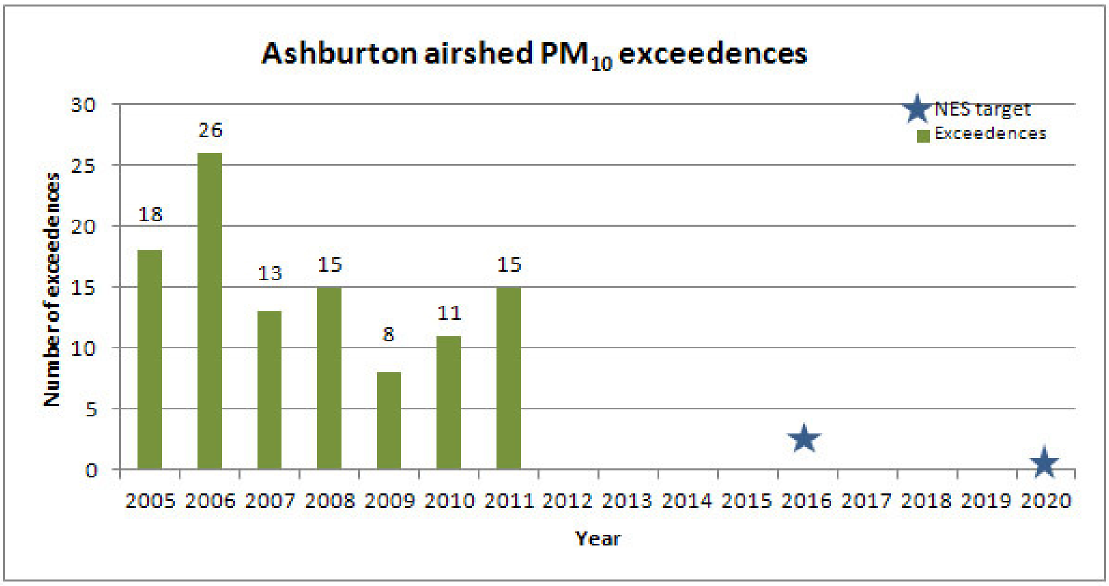
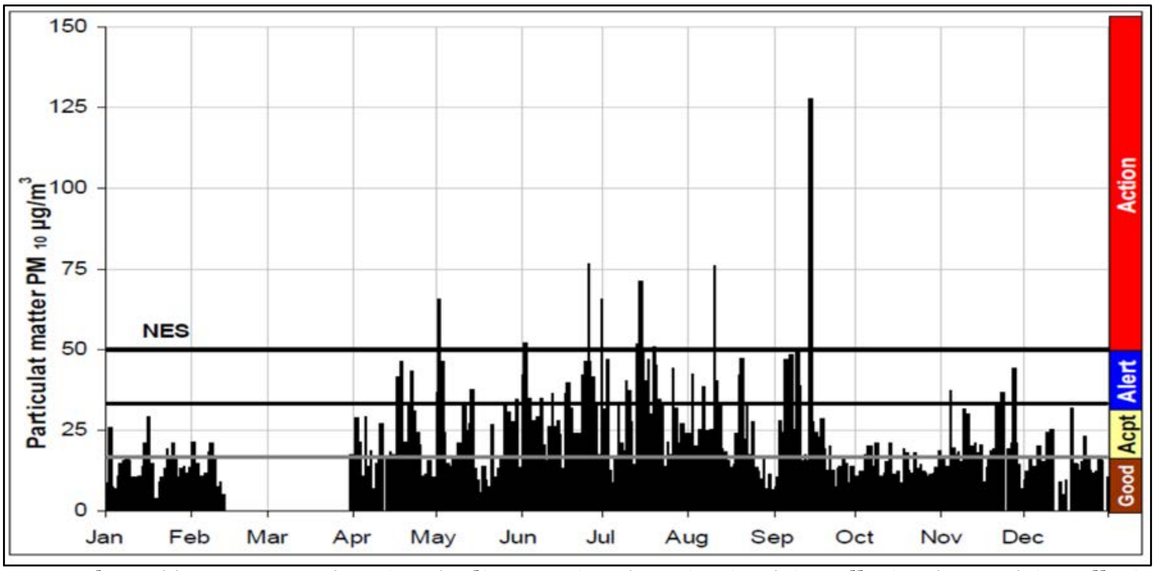



**Figure 5: Ashburton Airshed PM10 exceedences**

## 5.1 Seasonal Variations

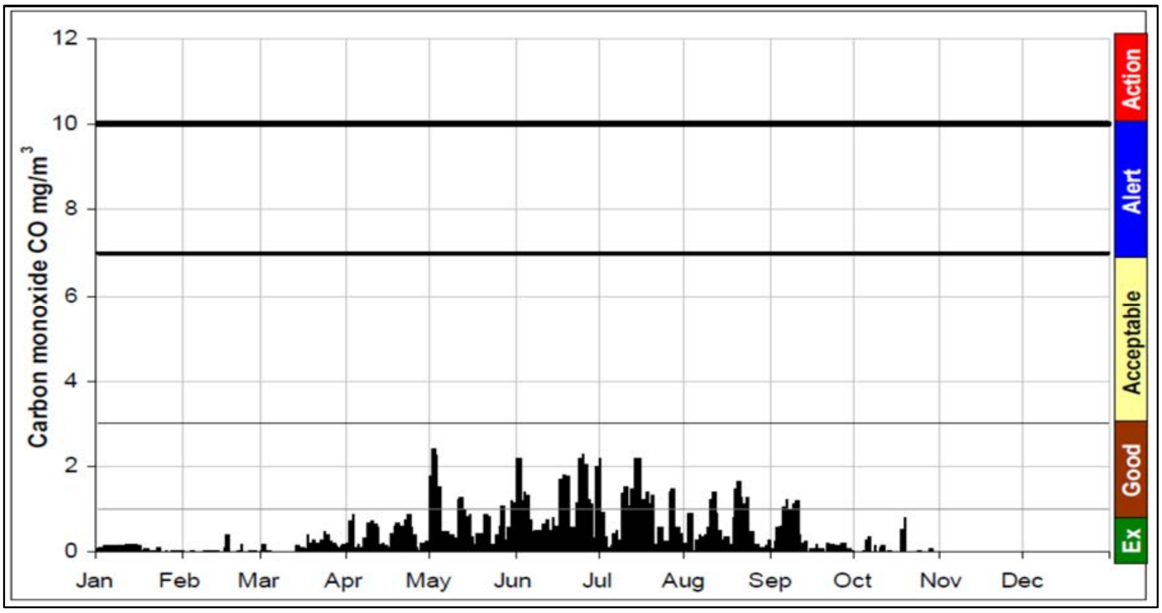
The seasonal variation of air pollution is well documented for various urban locations throughout New Zealand. For example, the air quality monitoring data from Christchurch, Dunedin, Taupo or Ashburton show well established fluctuations of air contaminants in the urban ambient air. Changes depend on seasons, with air pollution levels in winter time (June through August) higher than for the rest of the year. It was observed that similar trends are well established in Ashburton, and it can be seen in Figure 6.




Source: http://ecan.govt.nz/services/online-services/monitoring/air-pollution/Pages/air-pollution

**Figure 6: Ashburton 24 hours PM10 concentrations measured in 2009**

A further example of the ambient air quality monitoring data provided by the ECRC is shown in Figure 7. The diagram shows 8 hour average carbon monoxide concentrations measured at 14 Cambridge Street monitoring site. It can be seen that air pollution increased to higher concentrations around the period from May to October. Other air quality monitoring data not shown here also shows similar patterns in concentrations for nitrogen dioxide.




Source: http://ecan.govt.nz/services/online-services/monitoring/air-pollution/Pages/air-pollution
**Figure 7: Ashburton 8 hour average CO concentrations measured in 2009**

Figures 6 and 7 are typical of air quality data throughout New Zealand. Occasional very high readings are obtained against a background of fluctuating but consistently much lower readings. The events of high concentrations are often associated with temperature inversions. Temperature inversions in Ashburton may occur during relatively calm, cool and clear conditions and are more common in winter. Air quality monitoring shows that during such conditions dispersion of air contaminants is limited and there is a strong correlation between temperature inversions and high air pollution levels. The highest concentrations of contaminants are therefore more likely to occur during winter months from June to August, when calm weather conditions prevail and concentrations of air contaminants can build up when high traffic volumes and burning of domestic fires coincide with these atmospheric conditions.

# 6 Vehicle Emission Dispersion Modelling

The vehicle emission dispersion modelling was carried out using CALRoads model package for predicting air quality impacts of pollutants near roadways. CALRoads View combines into one integrated graphical interface the mobile source air dispersion models CALINE4, CAL3QHC, and CAL3QHCR. These United States Environmental Protection Agency (US EPA) models are used for predicting ambient air concentrations of vehicle emitted contaminants including carbon monoxide (CO), nitrogen dioxide (NO2), particulate matter (PM), and other inert gases from idle or moving motor vehicles.

## 6.1 Potentially Sensitive Areas and Receptor Sites

A number of specific discrete receptors were selected in Ashburton and along Chalmers Avenue and a new link road south of Tinwald on the basis recommended by the MfE Guideline (MfE June 2008)) that identify potentially sensitive receptors, as well as giving a representative picture of effects. These receptors are listed in Table 6.1. The receptor site is a residential dwelling or occupied facility located on the property and most exposed to vehicle emissions.

**Table 6.1: Location of receptor sites**

| Address (Site location) | Distance to the edge (m) | Features (location and topography) |
|---|---|---|
| 1 Archibald St (SH1)<br>31 Archibald St (SH1)<br>69 Archibald St (SH1)<br>121 Archibald St (SH1) | 21<br>14<br>12 | Ashburton town area close to the existing bridge and SH1 |
| 36 Chalmers Ave<br>37 Chalmers Ave<br>108 Chalmers Ave | 15<br>14<br>14 | Chalmers Avenue area |
| 59 Carters Tce (new link)<br>65 Jonstone St (new link)<br>70 Jonstone St (new link) | 14*<br>20*<br>13* | Rural area south of Tinwald along a new link road from the new bridge to Graham Road. |
| 163 West St (SH1) | 10 | Ashburton town centre |

*This distance is given to the edge of a new link road

In total 11 sites adjacent to the ASUB project areas were identified. These receptor sites cover all of the areas where people are expected could be exposed to vehicle emissions from the ASUB project. Ambient air concentrations have been assessed for all sites for the year 2026 for “do minimum” (without the bridge) and for the post construction (with the bridge) conditions.

All properties in the area are already affected by high air pollution events which have been recorded in Ashburton every year (see the previous Section 5.0) starting since 2005. Those properties located along SH1 are affected by vehicle emissions and emissions from domestic sources mainly home heating. Those located at Chalmers Avenue and a new link road are affected by home heating emissions, because vehicle emissions are negligible in this area considering low traffic volumes on the local roads.

Only 11 properties have been chosen to assess concentrations of air contaminants because, it was assumed that each dwelling is representative for other dwellings located in similar environments. The critical factor was a distance from the edge of the carriageway. If predicted concentrations at these sites meet the air quality requirements, then other houses located at the same, similar or greater distance from the ASUB roads would also comply with these requirements. The most effected sites will be those located at the shortest distance from SH1, Chalmers Avenue and the new link road.

The minimum distance between a residential dwelling and the edge of carriageway assessed by the model is 10 and 12 metres. The maximum roadside concentrations of vehicle emitted contaminants were predicted for these distances only.

## 6.2 Meteorological Input

The MfE Guideline for Dispersion Modelling (MfE June 2004) recommends a conservative approach, which was applied for this assessment. "Conservative" has that meaning that the assumptions made would tend to overestimate pollution levels compared to what would probably occur.

CALRoads View requires a set of meteorological parameters including ambient temperature, wind speed, wind direction, measured in one hour intervals, and calculated atmospheric stability classes and mixing heights. All parameters are combined in the data file, which was prepared using meteorological records from the year 2011 obtained from the Ashburton airport meteorological station.

CALRoads View uses atmospheric stability classes that were developed according to characteristics of atmospheric turbulence. There are seven classes from extremely unstable atmospheric conditions corresponding to class A to stable conditions defined as class G. The stability classes are associated with specific meteorological characteristics including wind speed, intensity of solar radiation and cloud cover. This data is not readily available from weather stations and very difficult to calculate so a conservative assumption was made for stability classes. Class D (neutral conditions) was applied for the period from 1$^{st}$ January to 30$^{th}$ June, and class F (stable) was applied for the rest of the year.

Due to limitations in Gaussian Plume modelling which is used by CALRoads View, the modelling cannot calculate emission plume spread when wind speeds are close to zero. All wind speeds that are less than 0.5 m/s are considered in the model to be equal to 0.5 m/s, and approximately 0.7 % of the 2011 meteorological wind data are affected by this assumption. This is a standard modelling methodology and it is recommended in the MfE (MfE, June 2008).

## 6.3 Background Concentrations

The dispersion model predicts the sum of dispersed vehicle emissions and the background concentration. The background concentration is a contribution from the other emission sources and needs to be determined in the modelling input. The ambient air quality monitoring data for Ashburton shows high air pollution levels of carbon monoxide and PM10 particulates specifically in winter time. The comprehensive data is provided in the Environment Canterbury Regional Council, *Annual ambient air quality monitoring report* (March 2010). The annual average concentrations from this report were used as background concentrations for the air pollution dispersion modelling.

The background concentration of air contaminants in the assessment area can be assumed as indicated in Table 6.2.

**Table 6.2: Non traffic background ambient air concentrations**

| Air contaminant | Value |
|---|---|
| Carbon monoxide (8 hours) | 0.2 mg/ $m^3$ |
| Nitrogen dioxide (1 hour) | 20 $\mu g/m^3$ |
| Particulates PM10 (24 hours) | 25 $\mu g/m^3$ |
| Particulates PM2.5 (24 hours) | 10 $\mu g/m^3$ |

Emissions of nitrogen oxides consist of nitric oxide and nitrogen dioxide (NO and NO2). Vehicle emissions of nitrogen oxides (NOx) are generally more than 90% NO, which oxidises to NO2 in the atmosphere over a few hours to a couple of days. This rate of oxidation of NO to NO2 is dependent on different parameters but the NO2: NOx ratio is often assumed to be around 0.2. A background concentration of NO2 in the assessment area is assumed to be 20 $\mu g/m^3$ based on the several years of air quality monitoring data from Christchurch. The monitoring site at St. Albans Street was considered as most appropriate for Ashburton, and has been assumed that the site and the ASUB assessment area were located in similar environment. The model's predicted concentrations are provided in ppm (the model output), and were converted to $\mu g/m^3$.

## 6.4 Input Traffic Flows and Vehicle Emission Rates

The traffic volumes counted in 2012 and predicted for 2026 are shown in Table 6.3. Some of these volumes are slightly different and exceed those counted or predicted at specific sites. It has been done to obtain the average numbers for the model input in the case when traffic counting sites do not coincide with the modelled road section. Hourly traffic flows for different sections of the local road network were calculated using the corresponding Annual Average Daily Traffic (AADT) data provided by transport modellers. The speed limit on SH1, Chalmers Avenue and a new link road was assumed as 50 km/h.

**Table 6.3: Current and predicted traffic volumes for ASUB area**

| Route | Current 2012 | | Predicted 2026 | | | |
|---|---|---|---|---|---|---|
| | vehicle/ day | Vehicle/ hour | Without bridge | | With bridge | |
| | | | vehicle/ day | vehicle/ hour | vehicle/ day | vehicle/ hour |
| Existing bridge SH1 N-bound | 9,500 | 530 | 18,100 | 1005 | 10,000 | 560 |
| Existing bridge SH1 S-bound | 10,500 | 580 | 19,800 | 1100 | 11,000 | 610 |
| Second bridge N-bound | - | - | - | - | 7,500 | 420 |
| Second bridge S-bound | - | - | - | - | 6,500 | 360 |
| New Link (Carters Tce-Manchester St) | - | - | - | - | 12,900 | 715 |
| New Link (Manchester St-Graham St) | - | - | - | - | 9,000 | 500 |
| Chalmers Ave N-bound | 2070 | 115 | 3,870 | 215 | 5,760 | 320 |
| Chalmers Ave S-bound | 1800 | 100 | 3,510 | 195 | 5,400 | 300 |
| SH1 (Moore St– Walnut Av) N-bound | 8,500 | 472 | 11,020 | 612 | 7,650 | 425 |
| SH1 (Moore St– Walnut Av) S-bound | 8,500 | 472 | 9,920 | 551 | 8,910 | 495 |
| SH1 (Wilkins St–Graham St) N-bound | 8,000 | 445 | 13,500 | 750 | 10,170 | 565 |
| SH1 (Wilkins St–Graham St) S-bound | 8,000 | 445 | 11,700 | 650 | 7,920 | 440 |

The vehicle emission rates required for the air pollution dispersion modelling were calculated using the Auckland Regional Council (ARC) Vehicle Emissions Prediction model (VEPM 5.0). The model calculates speed-dependent emission rates for the selected year based upon average speeds along the road network links and taking into account vehicle fleet composition and daily traffic volumes.

The fleet composition used in the emissions model was composed of default model values, and information on the percentage of heavy vehicles provided by the traffic modellers. According to the traffic model, traffic flow through the proposed second bridge will include from 5 - 10 % of heavy vehicles. Vehicle fleet composition used for the modelling is shown in Table 6.4.

**Table 6.4: Vehicle fleet composition (% of the total fleet registered)**

| Vehicle type | 2026 | | |
|---|---|---|---|
| | Petrol (%) | Diesel (%) | Hybrid (%) |
| cars | 62.3 | 11.8 | 2.5 |
| LCV | 2.1 | 14.0 | 0.7 |
| HCV (small) | 0 | 0.4 | 0 |
| HCV (medium) | 0 | 7.0 | 0 |
| HCV (large) | 0 | 3.7 | 0 |
| Bases (large) | 0 | 0.6 | 0 |
| Motorcycles | 0.1 | 0 | 0 |
| **Total** | **100 %** | | |

The VEPM5.0 model calculates particulates vehicle emissions for PM2.5 only. Since the assessment process used here, and the NES, needs PM10 effects, the emission rates of PM10 must be calculated and used in the modelling.

There is a considerable amount of research on the PM10/PM2.5 fraction from vehicle emissions and there is some variability in the results. This ratio can change with time (vehicle technologies), can be different for different fleet profiles, different driving conditions, for different fuels and is even dependent on ambient weather conditions. A large study in California concluded that the PM2.5 emission factor for the fleet was 79% of the PM10 (Gillis et al., 2001). An extensive review carried out in the UK has given a range that varies from 90% to 60% (Tetzel et al., 2006). A study in London found a similar range, with an overall mean value of 67% (Charron and Harrison, 2006). This last study quoted results from France, Greece and Switzerland that gave similar ratios.

For the purposes here, it would be justified to use a PM2.5 fraction anywhere from 60% up to 90%, however the most conservative factor has been used – 60%. That gives the highest (and most conservative) amount of PM10 emitted as derived from the VEPM PM2.5 emissions factors. Calculated vehicle emission rates used as an input for pollution dispersion modelling are shown in Table 6.5.

**Table 6.5: VEPM 5.0 calculated vehicle emission rates (g/mile-vehicle)***

| Driving mode | 2026 | | | |
|---|---|---|---|---|
| | CO | NO2 | PM10* | PM2.5* |
| Free flowing 50 km/h | 2.53 | 0.12 | 0.03 | 0.02 |
| Congested 20 km/h | 4.05 | 0.15 | 0.06 | 0.04 |

* Brake-wear and tyre-wear emission rates are included within the rates

# 7 Assessment of Vehicle Emission Effects

The maximum average ambient air concentrations predicted for discreet receptors (assessment sites) are shown in Table 7.1. Concentration plots assessed for the whole ASUB project area at regular intervals using grid receptors (4600 grid receptors) are shown in Appendix C, D, E and F. These plots show concentrations of carbon monoxide, PM10, nitrogen dioxide and PM2.5 in the project area after construction of the second bridge.

There is an example of the model's output file. The file is too large to be included in the report, so an extraction with modelling parameters and predicted PM10 concentrations after the second bridge construction is shown in Appendix G.

## 7.1 Modelling Results

The assessment shows that there are no significant changes in the local air quality in terms of the average values after construction of the second bridge. The highest concentrations were predicted for 163 West St due to the shortest distance from the edge of SH1 and the high traffic volume on SH1. Other highest concentrations were also predicted for sites along Archibald Road (SH1) and located close to the existing bridge. Concentrations for do minimum conditions were predicted with assumption of congested traffic on SH1 and increased emission rates (see Table 6.5).

The assessment shows that for all receptor sites, air quality in 2026 with the second bridge operational will remain in the same air quality category as current ambient air (see Table 4.2). The local air quality is considered to be "excellent" with respect to emissions of carbon monoxide, and "good" for nitrogen dioxide, and particulates.

**Table 7.1: Predicted concentrations in 2026 for "no bridge" and "bridge" options**

| Site location | | Concentration | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | CO (8-hour) mg/m3 | | $NO_2$ (1-hour) µg/m3 | | $PM_{10}$ (24-hour) µg/m3 | | $PM_{2.5}$ (24-hour) µg/m3 | |
| | | 2026 no bridge | 2026 bridge | 2026 no bridge | 2026 bridge | 2026 no bridge | 2026 bridge | 2026 no bridge | 2026 bridge |
| | *Standard/Guideline* | *10* | *10* | *200* | *200* | *50* | *50* | *25* | *25* |
| 1 | 1 Archibald St (SH1) | 1.08 | 0.78 | 62.5 | 54.7 | 22.8 | 21.1 | 15.41 | 14.08 |
| 2 | 31 Archibald St (SH1) | 1.16 | 0.81 | 64.2 | 58.3 | 23.0 | 21.2 | 15.55 | 14.13 |
| 3 | 69 Archibald St (SH1) | 1.07 | 0.80 | 62.1 | 56.4 | 22.5 | 21.2 | 15.11 | 14.11 |
| 4 | 121 Archibald St (SH1) | 0.98 | 0.79 | 59.6 | 52.6 | 22.2 | 21.1 | 15.00 | 14.08 |
| 5 | 36 Chalmers Ave | 0.75 | 0.70 | 45.4 | 41.4 | 21.9 | 21.0 | 14.86 | 13.98 |
| 6 | 37 Chalmers Ave | 0.72 | 0.69 | 41.4 | 39.5 | 22.1 | 21.1 | 14.82 | 14.09 |
| 7 | 108 Chalmers Ave | 0.74 | 0.68 | 52.7 | 37.6 | 21.9 | 21.0 | 14.82 | 13.97 |
| 8 | 59 Carters Tce | 0.62 | 0.70 | 37.9 | 41.4 | 21.5 | 21.1 | 14.40 | 14.08 |
| 9 | 65 Johnstone St | 0.66 | 0.68 | 39.1 | 37.6 | 21.6 | 21.0 | 14.48 | 13.99 |
| 10 | 70 Johnstone St | 0.65 | 0.67 | 38.7 | 35.7 | 21.5 | 20.9 | 14.46 | 13.97 |
| 11 | 163 West St (SH1) | 1.20 | 0.84 | 64.5 | 58.3 | 24.5 | 21.6 | 16.42 | 14.42 |

There will be changes in contaminant concentrations at specific locations within and near to the ASUB project area. What will be important is the extent of change at the sensitive locations and the changed levels relative to the regional guidelines. There will be areas along Chalmers Avenue and south of Tinwald where the project might make air quality slightly worse, because traffic volumes will rise in these areas.

Some reductions of air contaminants along the existing SH1 can be anticipated, because a part of traffic flow will be redirected to the second bridge and associated link roads. There will also be changes in rates of the types of contaminants emitted because of changes in vehicle flow types as congestion will be relieved after construction of a second bridge.

The model predicts ambient air roadside concentrations adding dispersed vehicle emitted contaminants to the background concentrations. When interpreting modelling results, it should be taken into account that predicted concentrations shown in Table 7.1 include maximum background values, and the predicted concentrations show the contribution of the vehicle emissions. In this case, the effect of domestic sources such as home heating is included only in the background concentrations as an average value.

Under unfavourable weather conditions including temperature inversion and light wind or no wind at all, the background concentrations specifically for particulates will increase up to the Air Quality standard threshold and sometimes exceed the standard (see Chapter 5, Figure 4 and 5). To model these conditions input background concentrations need to be increased significantly, for example up to 40 or 50 µg/m$^3$ for PM10. In this case the predicted concentrations will exceed the standard thresholds.

According to the Environment Canterbury reports (November 2008 and March 2010) domestic home heating is a main contributor to PM10 ambient air concentrations in Ashburton (see Table 2.1). The roadside concentrations in 2026 will strongly depend on the efficiency of domestic home heating emission control measures.

# 8 Assessment of Construction Emissions

## 8.1 Dust Deposition and Dispersion

The assessment of dust deposition at the boundary of road construction sites shows that the deposition rates will be variable and depend on the following factors:

- The short-term fugitive emissions during periods of dry weather;
- The duration of activities in any possible borrow area contributing dust;
- The frequency of dust emission events; and the efficiency of proposed dust emission control measures.

The reference sources suggest that properties located 100 m or more from any specific dust sources are unlikely to experience any significant dust deposition impacts due to particle settlement characteristics. The "Methodology for Estimating Fugitive Windblown and Mechanically Re-suspended Road Dust Emissions" (Countess, 2001) suggests that particles of more than 10 microns in size and greater will largely deposit within 50 metres of their source. Particles smaller than 10 microns are likely to remain suspended and travel a considerable distance.

Results of another study by Cowherd and Grelinger (2003) show that the percentage of reduction in plume mass depends on the distance from the dust source. The data was obtained from field tests of fugitive dust dispersed over land areas covered with different vegetation for light winds of 5 to 10 km/h.

The study shows that for flat terrain covered with short grass about 30 % of plume mass will be deposited within a distance of 100 metres from the source. Flat terrain covered with trees and bushes will reduce about 50 to 80 % of plume mass within 50 metres from the source, and at a distance of 100 metres from the source about 90 to 95 % of plume mass will be deposited. The dust plume over grass may spread approximately up to 200 metres.

Most references suggest that the deposition of large airborne particles appears within 100 metres from the source. There are some disagreements in the minimal distance due to wind conditions during the test, local topography, and vegetation; however the majority of the reports agreed that the deposition of dust from unpaved roads - which also can be applied to road construction sites - will take place within 50 metres to 100 metres from the source (Watson et. al., 1996).

## 8.2 Dust Management

### 8.2.1 Mitigation Measures for Construction Management Plan

A range of appropriate dust mitigation measures are available and can be implemented to prevent fugitive dust emissions from construction sites. Examples of such appropriate measures to minimise or eliminate potential fugitive dust emissions include the following:

- Construction site needs to be designed in a way to minimise top soil disturbing areas, stockpiles required and travelled distances on unpaved roads.
- The access roads should be constructed using appropriate pavement materials.
- Watering truck or some other water spraying facilities should be available on the site to keep wet soil handling areas and unpaved roads in the case of windy and dry weather conditions.
- Wind fencing can be considered as a wind control measure at the site.
- Trucks used for topsoil stripping and moving soil materials need to be watered specifically under dry and windy weather conditions.
- Earthworks should be limited as far as practical or interrupted under dry and windy weather conditions.
- Vehicle speed within the construction site and on access roads should be controlled and limited as far as practical.
- Vehicles leaving the site should be watered if required.
- Liaison with local residents in case of fugitive dust emission complaints.
- Monitoring of dust emissions should be organised, and if required, monitoring methods and a specific location of monitoring sites should be considered on the case by case basis.

The references above suggest that stockpiling sites should not be located within the distance of at least 100 metres from the sensitive receiving areas, having regard to the likely direction of strong winds.

# 9 Conclusion

The effect of the proposed second bridge on the local air quality in Ashburton is estimated as less than minor, because predicted air quality after completing of the ASUB project will remain the same in terms of the descriptive Regional Air Quality Categories.

The assessment shows that the proposed second bridge and traffic on link roads are only small contributors to the Ashburton airshed. The project will slightly reduce emissions of carbon monoxide (CO) and particulates (PM10). However, the change is negligible when compared to the total emissions of these contaminants into the Ashburton airshed from other sources, such as domestic heating and industry.

Beyond the areas adjacent to the project, air quality will approximately remain the same depending on the amount of traffic on local roads and further residential development in these areas. Some reduction in overall concentrations of carbon monoxide and particulates along SH1 should occur because the ASUB will divert traffic and reduce traffic congestion on SH1.

The assessment also indicates that ambient concentrations of air contaminants can increase up to the standard limits or exceed these limits within the project area, when calm meteorological conditions coincide with temperature inversion, calm and cold weather and the congested traffic flow. It is anticipated that maximum concentrations will remain for a short period of time from one to several hours, may be one day, rather than constant high concentrations.

## 9.1 Dust Emissions from Construction Sites

Fugitive dust emissions could potentially occur in the vicinity of the construction activities and could affect properties and residential dwellings within the distance of approximately 200 m from the source. The actual deposition rates will depend on the amount of dust and nature disturbed at the source. These dust emissions and potential effects will be controlled by a range of mitigation measures included in a Construction Management Plan.

If appropriate mitigation measures are implemented as necessary during construction, PM10 levels and fugitive dust emissions from construction activities can be kept within the acceptable thresholds and trigger levels. The effect of these emissions on the local environment will be less than minor.

# References

Countess, R. (2001). *Methodology for Estimating Fugitive Windblown and Mechanically Resuspended Road Dust Emissions Applicable for Regional Scale Air Quality Modelling*. Westlake Village, CA, April 2001.

Cowherd, C.J., and Grilinger, M.A., 2003, *Characterisation of Enhanced Dust Deposition on Vegetation Groundcover Bordering Emission Sources*. Prepared by Midwest Research Institute for U.S. Army Construction Engineering Research Laboratory. June 2003

Environment Canterbury Regional Council, (2011), *Canterbury Natural Resources Regional Plan,* Christchurch,Chapter3: Air Quality, 2011

Environment Canterbury Regional Council, (March 2010), *Annual Ambient Air Quality Monitoring report 2009,* Report No.R10/16 ISBN: 978-1-877542-78-7

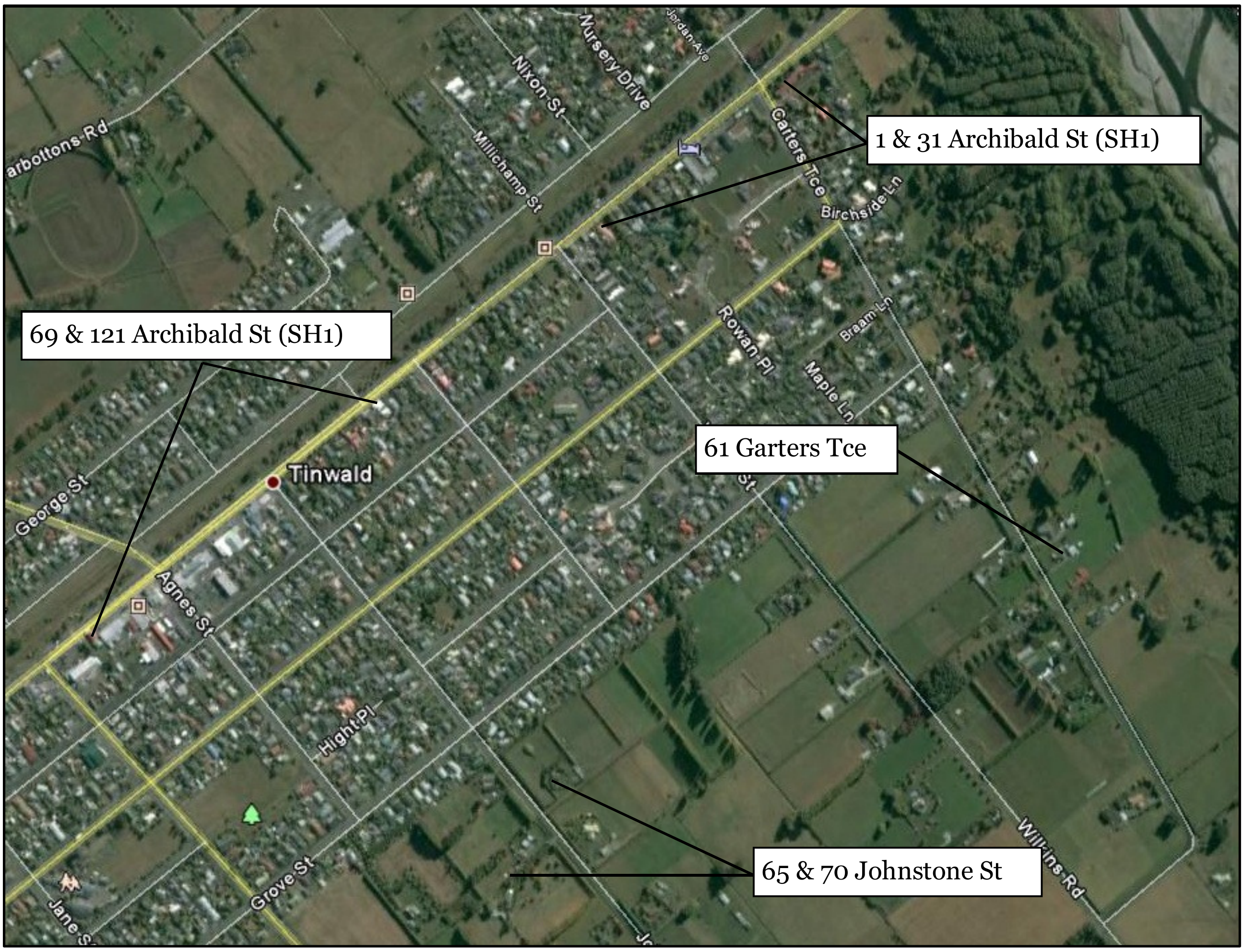
Environment Canterbury Regional Council (November 2008), *Inventory of emissions to air in regional Canterbury towns*, 2007, Report No. R08/96 ISBN 978-1-86937-944-5

Ministry for the Environment (MfE), September 2001, *Good Practice Guide for Assessing and Managing the Environmental Effects of Dust Emissions,* Wellington 2001.

Ministry for the Environment, (2004), *Good Practice Guide to Atmospheric Dispersion Modelling*. Air Quality Technical Report No 27, www.mfe.govt.nz/publications/air

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

# Appendix A

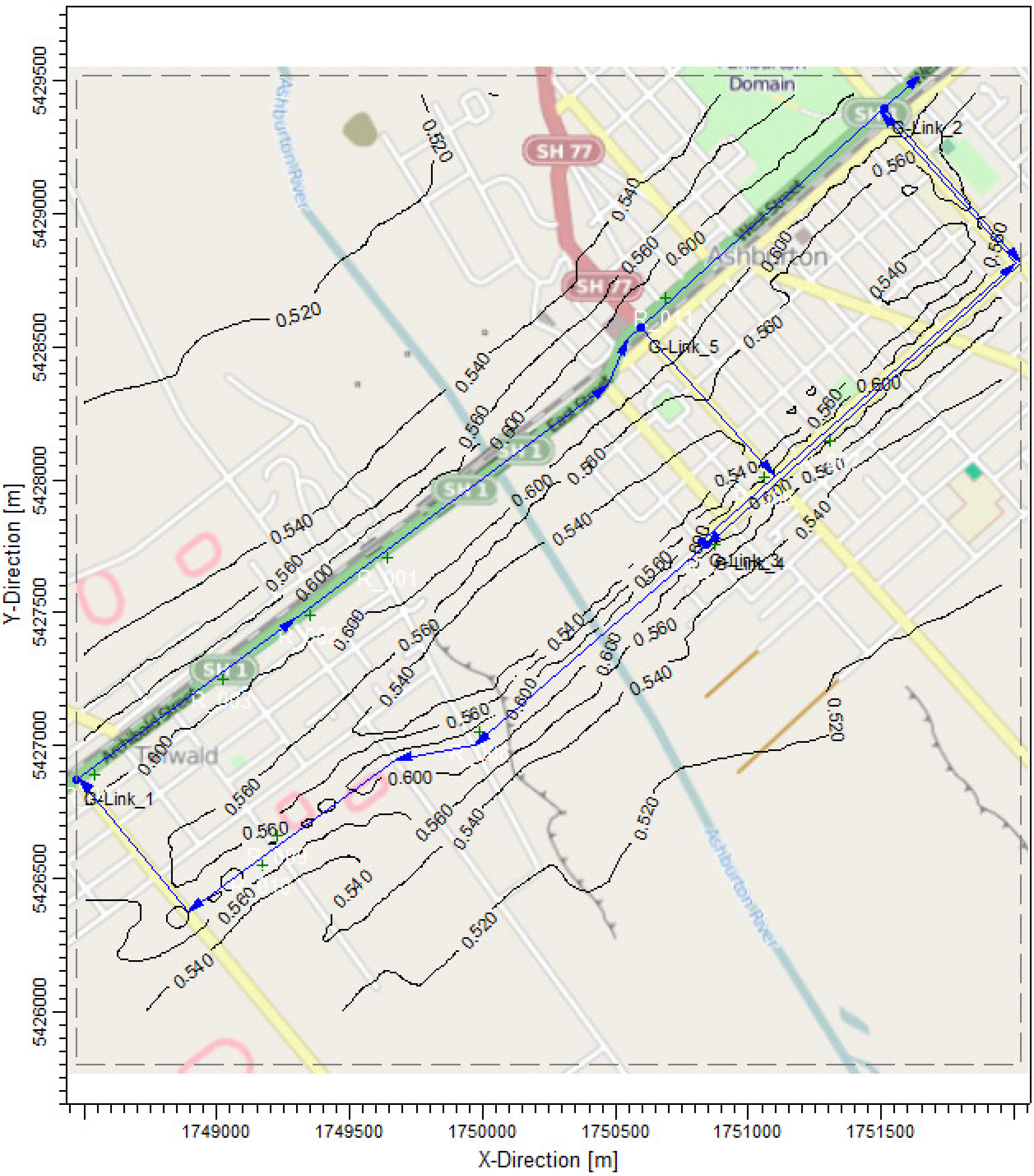

1 & 31 Archibald St (SH1)
69 & 121 Archibald St (SH1)
61 Garters Tce
65 & 70 Johnstone St
Tinwald
Carters Tce
Birchside Ln
Nixon St
Nursery Drive
Millichamp St
Rowan Pl
Braam Ln
Maple Ln
George St
Agnes St
Hight Pl
Grove St
Wilkins Rd
Jane St

# Appendix B


163 West St (SH1)
36,37, 108 Chalmers Ave
Havelock St
Walnut Ave
Chalmers Ave
Victoria St
East St
Ashburton
Dobson St
Oxford St
Beach Rd
1

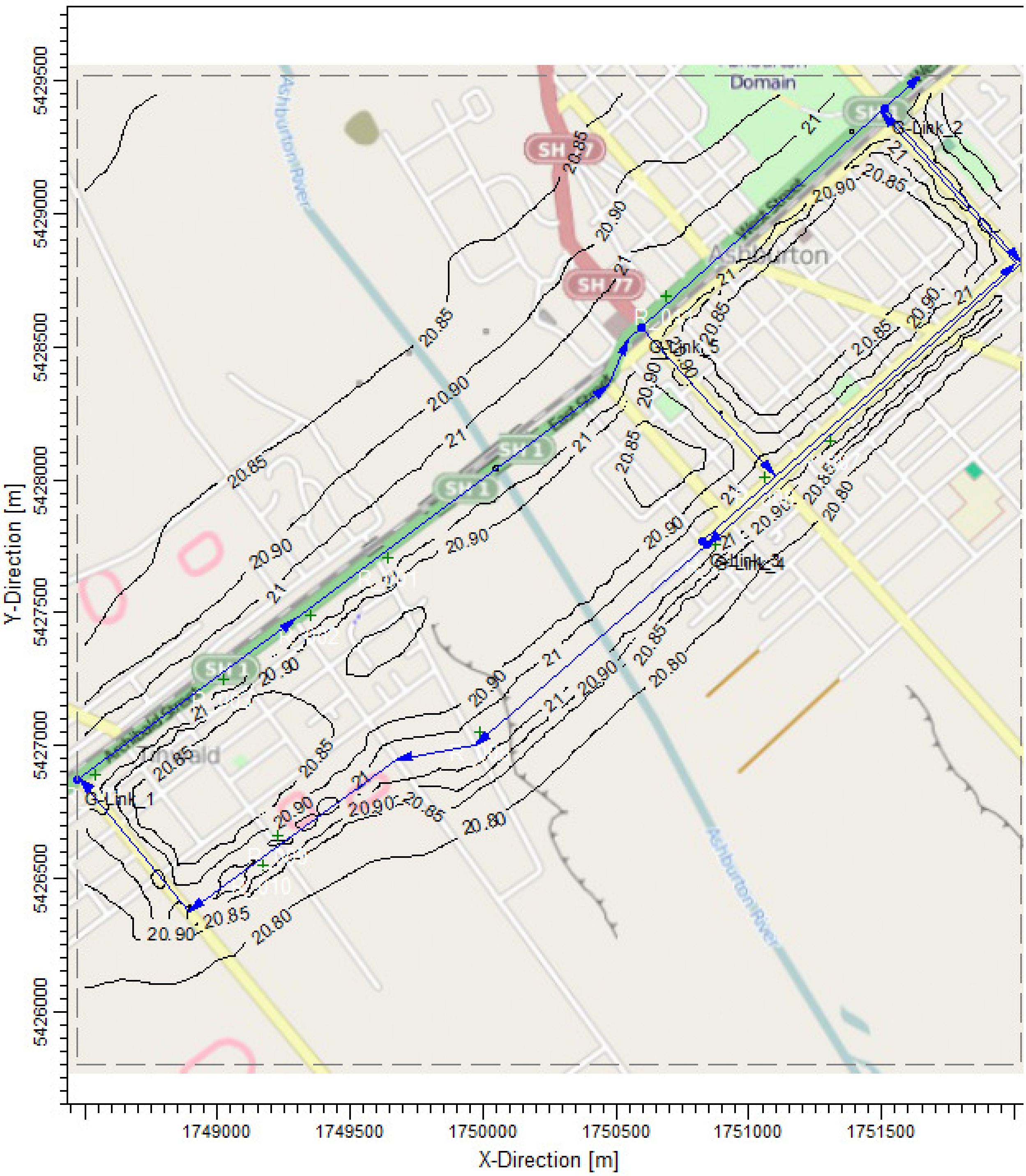
# Appendix C

### 2026 - Carbon monoxide concentrations with second bridge (NB 1ppm = 1.2 mg/m3)



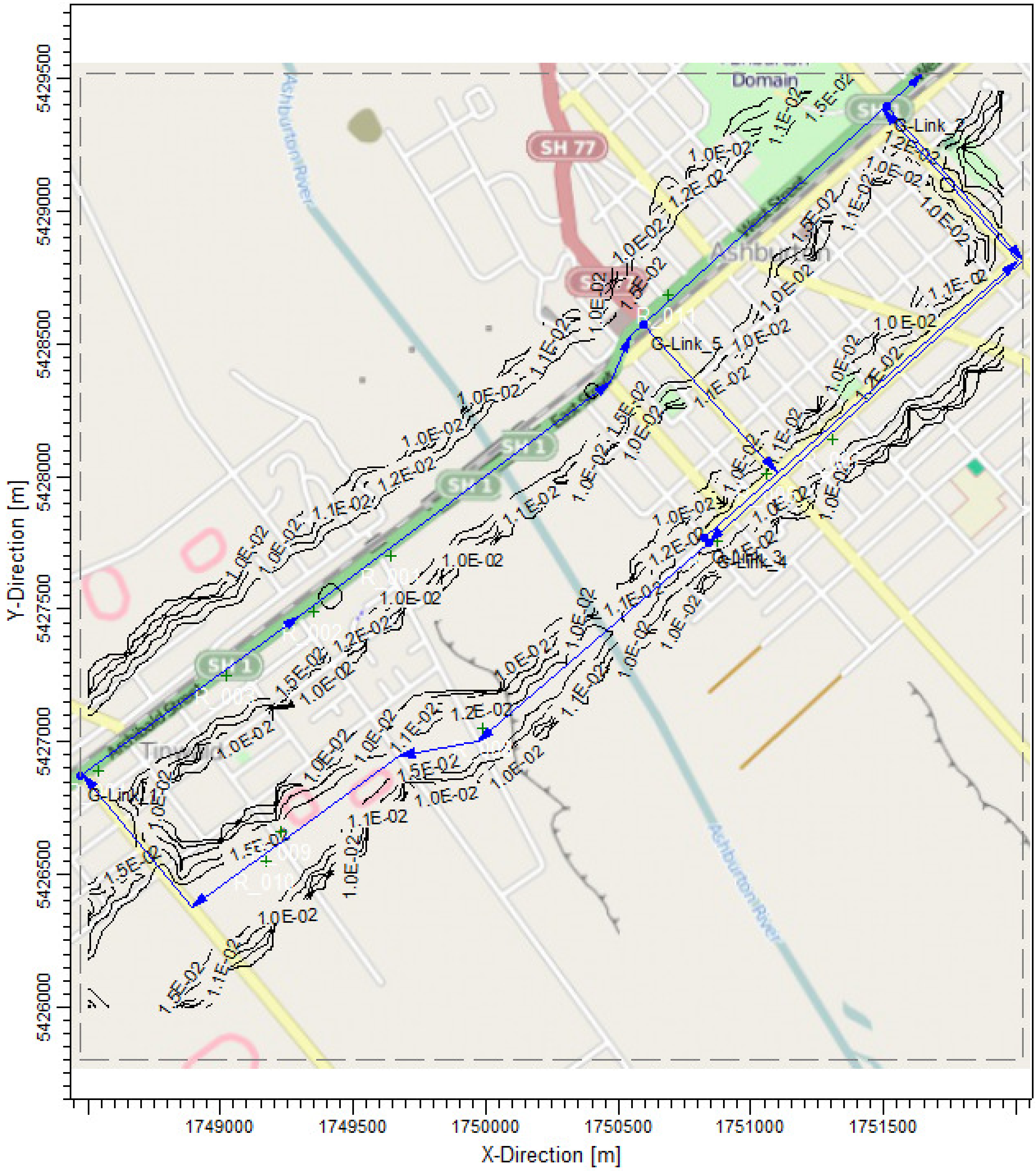
# Appendix D

## 2026 - PM10 concentrations with second bridge (µg/m3)



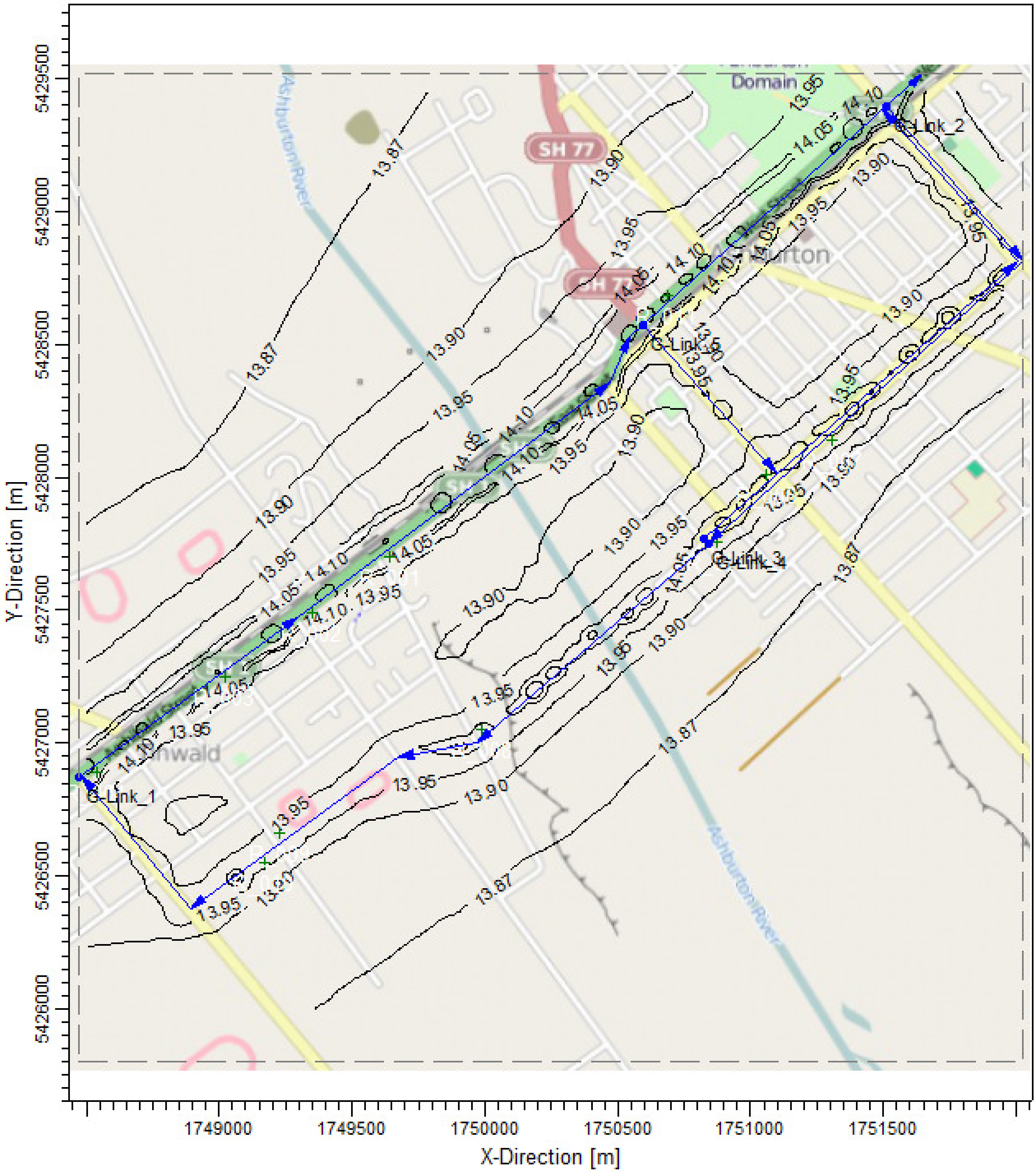
# Appendix E

### 2026 - NO2 concentrations with second bridge (NB 1 ppm = 1980 µg/m3)



# Appendix F

### 2026 - PM2.5 concentrations with second bridge (µg/m3)



# Appendix G

```
                                                           CAL3QHCR
(Dated: 12340)

     DATE :  8/25/13
PAGE:  1
     TIME : 23:31:18

     JOB:                     Ashburton
RUN:                     CAL3QHCR RUN

       ===================
       General Information
       ===================

         Run start date:  1/ 1/11    Julian:   1
               end date: 12/31/11    Julian: 365

         A Tier 2 approach was used for input data preparation.

         The MODE flag has been set to P for calculating PM averages.

         Ambient background concentrations are included in the averages
below.


       Site & Meteorological Constants
       -------------------------------
         VS =   0.0 CM/S       VD =   0.0 CM/S       Z0 =  10. CM
ATIM =  60.

           Met. Sfc. Sta. Id & Yr = 26170     8
           Upper Air Sta. Id & Yr = 93436     8

         CAUTION: The input years for the Run and Meteorological data
                  differ.  The respective values are:  11 and    8.

         Rural mixing heights were processed.

         In 2011, Julian day 1 is a Saturday.

         The patterns from the input file
         have been assigned as follows:

           Pattern # 1 is assigned to Monday.
           Pattern # 1 is assigned to Tuesday.
           Pattern # 1 is assigned to Wednesday.
           Pattern # 1 is assigned to Thursday.
           Pattern # 1 is assigned to Friday.
           Pattern # 1 is assigned to Saturday.
           Pattern # 1 is assigned to Sunday.
```

```
       Link Data Constants - (Variable data in *.LNK file)
       -------------------

                    LINK DESCRIPTION             *              LINK
COORDINATES (M)               *   LENGTH   BRG  TYPE    H       W
NLANES
                                                 *       X1           Y1
X2          Y2     *      (M)   (DEG)        (M)     (M)
      ------------------------------------------------*----------------------
----------------------------*-------------------------------------------------
       1.                        Link_1                  * 1748470.25
5426869.50  1749296.25   5427474.00 *    1024.    54.  AG    0.2    13.0
       2.                        Link_2                  * 1749296.25
5427474.00  1750470.50   5428356.00 *    1469.    53.  AG    0.2    13.0
       3.                        Link_3                  * 1750470.50
5428356.00  1750544.25   5428531.50 *     190.    23.  AG    0.2    13.0
       4.                        Link_4                  * 1750544.25
5428531.50  1751649.88   5429520.50 *    1483.    48.  AG    0.2    13.0
       5.                        Link_5                  * 1751510.88
5429397.00  1752024.00   5428815.00 *     776.   139.  AG    0.2    12.0
       6.                        Link_6                  * 1752024.00
5428815.00  1750839.50   5427752.00 *    1592.   228.  AG    0.2    12.0
```

```
                                                                CAL3QHCR
(Dated: 12340)

     DATE :  8/25/13
PAGE:  2
     TIME : 23:31:18

     JOB:                       Ashburton
RUN:                       CAL3QHCR RUN

       Link Data Constants - (Variable data in *.LNK file)
       -------------------

                    LINK DESCRIPTION             *              LINK
COORDINATES (M)               *   LENGTH   BRG  TYPE    H       W
NLANES
                                                 *      X1          Y1
X2           Y2     *     (M)   (DEG)        (M)     (M)
      -------------------------------------------*----------------------
---------------------------*-------------------------------------------
       7.                       Link_7           * 1750824.38
5427767.00  1752002.88   5428813.50 *    1576.    48.  AG    0.2    12.0
       8.                       Link_8           * 1752002.88
5428813.50  1751496.50   5429382.00 *     761.   318.  AG    0.2    12.0
       9.                       Link_9           * 1750841.00
5427753.50  1749971.38   5427000.50 *    1150.   229.  AG    5.0    13.0
      10.                       Link_10          * 1749971.38
5427000.50  1749669.75   5426948.00 *     306.   260.  AG    1.0    13.0
      11.                       Link_11          * 1749669.75
5426948.00  1748892.75   5426376.50 *     965.   234.  AG    0.5    13.0
      12.                       Link_12          * 1748892.75
5426376.50  1748481.12   5426879.00 *     650.   321.  AG    0.5    13.0
      13.                       Link_13          * 1750594.50
5428574.50  1751096.62   5428019.00 *     749.   138.  AG    0.2    13.0

       Receptor Data
       -------------

                                                  *
COORDINATES (M)
                      RECEPTOR                    *          X
Y             Z
      --------------------------------------------*--------------------
-------------------
       1.                       R_001             *    1749643.00
5427704.00        1.8
       2.                       R_002             *    1749349.00
5427490.00        1.8
       3.                       R_003             *    1749021.62
5427250.00        1.8
       4.                       R_004             *    1748537.00
5426891.50        1.8
       5.                       R_005             *    1750874.38
5427755.50        1.8
```

```
       6.                     R_006                    *     1751061.75
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       7.                     R_007                    *     1751308.88
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      14.                     G1_3                     *     1748500.00
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      15.                     G1_4                     *     1748500.00
5426150.00         1.8
      16.                     G1_5                     *     1748500.00
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      17.                     G1_6                     *     1748500.00
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      18.                     G1_7                     *     1748500.00
5426300.00         1.8
      19.                     G1_8                     *     1748500.00
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      20.                     G1_9                     *     1748500.00
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      21.                     G1_10                    *     1748500.00
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5426550.00         1.8
      24.                     G1_13                    *     1748500.00
5426600.00         1.8
      25.                     G1_14                    *     1748500.00
5426650.00         1.8
      26.                     G1_15                    *     1748500.00
5426700.00         1.8
      27.                     G1_16                    *     1748500.00
5426750.00         1.8

SIX HIGHEST 24-HOUR END-TO-END AVERAGE CONCENTRATIONS IN MICROGRAMS/M**3
         INCLUDING AMBIENT BACKGROUND CONCENTRATIONS.

                  Highest                Second Highest          Third
Highest        Fourth Highest         Fifth Highest          Sixth Highest
            Rcptr            Ending                  Ending
Ending                   Ending                  Ending                  Ending
```

```
           No.   Conc  Day Hr  Calm    Conc  Day Hr  Calm    Conc  Day
Hr  Calm   Conc  Day Hr  Calm    Conc  Day Hr  Calm    Conc  Day Hr
Calm

             1  21.1187 (289,24) C 4  21.1114 (339,24) C 2  21.0978 (
54,24) C 5  21.0806 (356,24) C 2  21.0786 (293,24) C 1  21.0752 ( 46,24)
C 5
             2  21.1820 (289,24) C 4  21.1806 (339,24) C 2  21.1638 (
54,24) C 5  21.1483 (293,24) C 1  21.1442 ( 46,24) C 5  21.1250 (356,24)
C 2
             3  21.1758 (339,24) C 2  21.1329 ( 54,24) C 5  21.1289 (
46,24) C 5  21.1282 (289,24) C 4  21.1069 (340,24) C 0  21.0951 (293,24)
C 1
             4  21.1281 (339,24) C 2  21.1017 (289,24) C 4  21.0927 (
54,24) C 5  21.0625 (293,24) C 1  21.0602 (356,24) C 2  21.0529 (340,24)
C 0
             5  21.0317 (289,24) C 4  20.9796 (119,24) C 2  20.9715
(117,24) C 4  20.9459 (118,24) C 0  20.9433 ( 54,24) C 5  20.9340
(356,24) C 2
             6  21.1374 (240,24) C 4  21.0307 (202,24) C 3  21.0176
(224,24) C 1  21.0003 (204,24) C 2  20.9929 (353,24) C 2  20.9894
(200,24) C 3
             7  21.0053 (289,24) C 4  20.9304 ( 54,24) C 5  20.9263
(117,24) C 4  20.9200 (356,24) C 2  20.9143 (119,24) C 2  20.8997
(364,24) C 2
             8  21.1211 (240,24) C 4  21.0218 (353,24) C 2  21.0196
(168,24) C 5  21.0124 (199,24) C 2  20.9968 (184,24) C 3  20.9632
(232,24) C 5
             9  20.9911 (240,24) C 4  20.9291 (353,24) C 2  20.9123
(232,24) C 5  20.9100 (231,24) C 5  20.9050 (214,24) C 3  20.9018
(168,24) C 5
            10  20.9499 (289,24) C 4  20.9227 ( 54,24) C 5  20.9200
(293,24) C 1  20.9055 (353,24) C 2  20.8960 (356,24) C 2  20.8923
(231,24) C 5
            11  21.6237 (240,24) C 4  21.4609 (224,24) C 1  21.4591
(202,24) C 3  21.3978 (204,24) C 2  21.3842 (184,24) C 3  21.3791
(200,24) C 3
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**Opus International Consultants Ltd**
138 Hutt Park Road, Gracefield
PO Box 30 845, Lower Hutt 5040
New Zealand

t: +64 4 587 0600
f: +64 4 587 0604
w: www.opus.co.nz