# Air Quality ($PM_{10}$) Monitoring Strategy for Gisborne

**NIWA Client Report: AKL2006-038**
**August 2006**

**NIWA Project: ELF06201**

# Air Quality ($PM_{10}$) Monitoring Strategy for Gisborne

Authors
Ashmita Gosai
Guy Coulson

*Prepared for*

Gisborne District Council

NIWA Client Report: AKL2006-038
August 2006

NIWA Project: ELF06201

National Institute of Water & Atmospheric Research Ltd
269 Khyber Pass Road, Newmarket, Auckland
P O Box 109695, Auckland, New Zealand
Phone +64-9-375 2050, Fax +64-9-375 2051
www.niwa.co.nz

# Contents



*Reviewed by:*

……

*Darren King*

*Air Quality Scientist*

*Approved for release by*

……

*Ken Becker*

*Regional Manager - Auckland:*

*Formatting checked*

# Executive Summary

Gisborne District Council has invited NIWA to assess the need for $PM_{10}$ monitoring in its region. There are no gazetted airsheds in the region; however, there are concerns about the air quality in Gisborne town. We have analysed available population and emissions data to identify locations where the population of Gisborne is potentially at highest risk and hence where monitoring may be appropriate.

This report assesses the need for monitoring by estimating the exposure to $PM_{10}$ encountered by the population of Gisborne using NIWA's emissions inventory and population densities from the 2001 census.

The key findings are

Population exposure to $PM_{10}$ at Gisborne Airport is higher than anywhere else in the region. The value of 0.5kg/person/day is ten times higher than the next highest locations – Matokitoki, Tarndale-Rakauroa, Tiniroto, Makaraka, Wainui and Wharekaka.

$PM_{10}$ measurements at the airport indicate that concentrations at the airport site exceeded the NES value of 50μg/$m^{-3}$ only once and exceeded guideline or alert values of 33μg/$m^{-3}$ 4 times during the monitoring period. NIWA recommends a continuous monitoring strategy be put in place for the Gisborne Airport monitoring site.

The $PM_{10}$ emissions at the airport site are mainly from industrial activities. A second site in a residential area may also be appropriate as it is expected that $PM_{10}$ from traffic and domestic heating will be the dominant sources in these areas. Gisborne District Council has approved plans for a $PM_{10}$ monitoring site at Gisborne Boys High School. Such a site should be representative of the residential areas in Gisborne.

An alternative site to the school in central Gisborne may be considered in Tamarau. Tamarau has the highest population density and emissions density of any CAU except the Airport. It is also furthest downwind of the rest of the Gisborne city. Under prevailing wind conditions traffic and heating emissions from the rest of the city will be transported over Tamarau, possibly leading to elevated $PM_{10}$ concentrations.

Some of the smaller towns in the region may be at risk of elevated $PM_{10}$ levels due to their surrounding topography. Therefore, a short-term screening programme may be helpful to eliminate any possible concerns. Design of such a programme, identifying individual sites and methods, would need to be the subject of further study.

# 1. Introduction

## 1.1 The need for a GDC monitoring strategy

High concentrations of air pollutants can have effects on human health and amenity values. In order to control the effects of pollution, the government introduced the National Environmental Standards (NES).

The NES came into effect on 1st September 2005. These standards place a legal requirement on local and regional councils to keep concentrations of certain pollutants below given thresholds. The pollutants covered by the standards and the concentration threshold values are shown in Table 1.

| Contaminant | Standard | Time Average | Allowable exceedences per year |
|---|---|---|---|
| Carbon monoxide (CO) | 10 mg/m$^3$ | 8 hours | 1 |
| Nitrogen dioxide ($NO_2$) | 200 µg/m$^3$ | 1 hour | 9 |
| Ozone ($O_3$) | 150 µg/m$^3$ | 1 hour | 0 |
| Particles ($PM_{10}$) | 50 µg/m$^3$ | 24 hours | 1 |
| Sulphur dioxide ($SO_2$) | 350 µg/m$^3$ | 1 hour | 9 |
| | 570 µg/m$^3$ | 1 hour | 0 |

**Table 1 The National Environmental Standards**

The regulations accompanying the NES state that all areas of the country must have complied with these standards by 1st September 2005. The exception is $PM_{10}$ which must be complied with by 31st August 2013. After these dates councils will not be allowed to issue resource consents for any activity that will cause the ambient concentrations of the relevant pollutants in the surrounding area to exceed the value permitted in the standards (MfE 2005). Although the NES apply to five contaminants, the principle concern in New Zealand is concentrations of $PM_{10}$.

Councils are required to produce plans of how they intend to manage air pollution covered by the NES and to monitor concentrations of pollutants in areas where a breach of the standards is likely to occur.

The NES (Clause 14) states that the standards apply at any place –

*a) that is in an airshed; and*
*b) that is in the open air; and*
*c) where people are likely to be exposed to the contaminant.*

*There is also a requirement for monitoring (Regulation 15) where;*

*If it is likely that [a standard] will be breached … the regional council must*
*a) monitor the …contaminant; and*
*b) conduct the monitoring –*
- *in that part of the airshed where there are one or more people…*

Given these developments, the GDC is required to manage air quality in its territory. The first step is to identify locations where a breach of the NES may occur and begin monitoring in those locations. This report is intended to help with that first step by identifying any areas of concern and suggesting sites where monitoring may be helpful.

## 1.2 ENVIROLINK Funding

The funding for this strategy reporting was made available by ENVIROLINK. The ENVIROLINK scheme funds research organisations such as Crown Research Institutes, universities and some non-profit research organisations to provide advice and support to the regional councils on environmental topics.

## 1.3 Scope

This report is intended to aid GDC in their decision making by identifying areas where a breach of the NES may occur and/or where the population may be at the highest risk and to prioritise locations for monitoring. It deals only with $PM_{10}$, which is the major pollutant of concern for most regional councils in New Zealand.

The need for monitoring is assessed by estimating the exposure to $PM_{10}$ encountered by the population using existing monitoring data, NIWA's National $PM_{10}$ emissions inventory and population densities from the 2001 census.

# 2. Current state of the environment

## 2.1 National Environmental Standards (NES) Airshed Definitions for GDC

The NES (2004) defines 'airshed' is "*the region of a regional council excluding any area specified in a notice as a part of region of a regional council specified by the Minister by the notice in the Gazette to be a separate airshed*" (NES, 2004). This applies to all regions of New Zealand and the standards apply to open air where people may be exposed.

Under the terms of the act, anywhere in NZ is effectively an airshed, however, places where breaches of the NES occur, or are likely to occur, are required to be recorded in the New Zealand Gazette. In August 2005, the Minister for the Environment identified 38 airsheds by notice in the New Zealand Gazette. A gazetted airshed is regulated through monitoring, reporting and consent decision requirements.

At present, there are no gazetted airsheds in the Gisborne region but there are areas of concern in Gisborne city where the principle $PM_{10}$ sources are more likely derived from domestic heating and traffic.

## 2.2 Summary of Gisborne emissions – location and sources of $PM_{10}$

In 2005, Endpoint Consultants was contracted to update the 1996 Gisborne emissions inventory (Sherman and Fisher, 2005). This study included five major source categories – transport, area, industry, agricultural, and natural. Transport emissions include on-road motor vehicles, aircraft, shipping and working harbour vessels. The area emissions are from domestic and commercial fuel combustion, surface coatings and thinners, aerosols and solvent products, service station refuelling, lawn mowing, farm or off-road vehicles and domestic waste combustion. Industrial emissions include combustion and process, while agricultural and natural include bush fires, geothermal, soil, grassland, forests and wetlands.

Few industries in Gisborne require resource consents to discharge to the air and most of those that do are situated in the industrial zone to the west of Gisborne Town in the area around the airport.

The results of the emissions inventory showed that for period 1996-2005 carbon dioxide, carbon monoxide, and sulphur dioxide have increased while nitrogen oxide has decreased. Prior to 1997 $PM_{10}$ was included in the total suspended particles rather than being differentiated. Estimated total emissions of $PM_{10}$ are given in Table 2.

| Source | Transport | Area | Industry | Natural and Agricultural | Total |
|---|---|---|---|---|---|
| $PM_{10}$ (T/y) | 60 | 104 | 96 | 22 | 282 |

**Table 2 Estimated $PM_{10}$ emissions in Gisborne District by source (Sherman and Fisher, 2005)**

## 2.3 Existing $PM_{10}$ monitoring in Gisborne

Currently, there is one $PM_{10}$ monitoring site in the Gisborne region – Oates St (Gisborne Airport), which has been in operation since 1993. Due to problems with data collection, 1999 and 2001 were excluded. GDC has approved plans to install another $PM_{10}$ monitoring site at Gisborne Boys High School (Gisborne City).

The sampling has been carried out using a HiVol method on a one day in six sampling regime. Samples are 24 hour, midnight to midnight. Although the NES requires 24 hour averages from continuous monitoring, these HiVol values are 24 hour ones and so are in comparable units.

In all the measurements at Gisborne Airport since 1993, there has only been one measurement above the limit value (50 $\mu g/m^3$) of the standard (69.5 $\mu g/m^3$ on 21$^{st}$ October 1998). There have been four other measurements above 33 $\mu g/m^3$, which is the limit value for many guidelines or targets (e.g. ARC, MfE). This falls into the "Alert" category. The highest of these four alert values was 36.7 $\mu g/m^3$ on 13$^{th}$ October 2003. Aside from one unusual exceedence measurement, concentrations of $PM_{10}$ at Gisborne Airport just reach the Alert category. However, any locations where concentrations fall into the Alert category require monitoring under the NES.

The maximum values for each of the years 1993 to 2004 are shown in Figure 1.

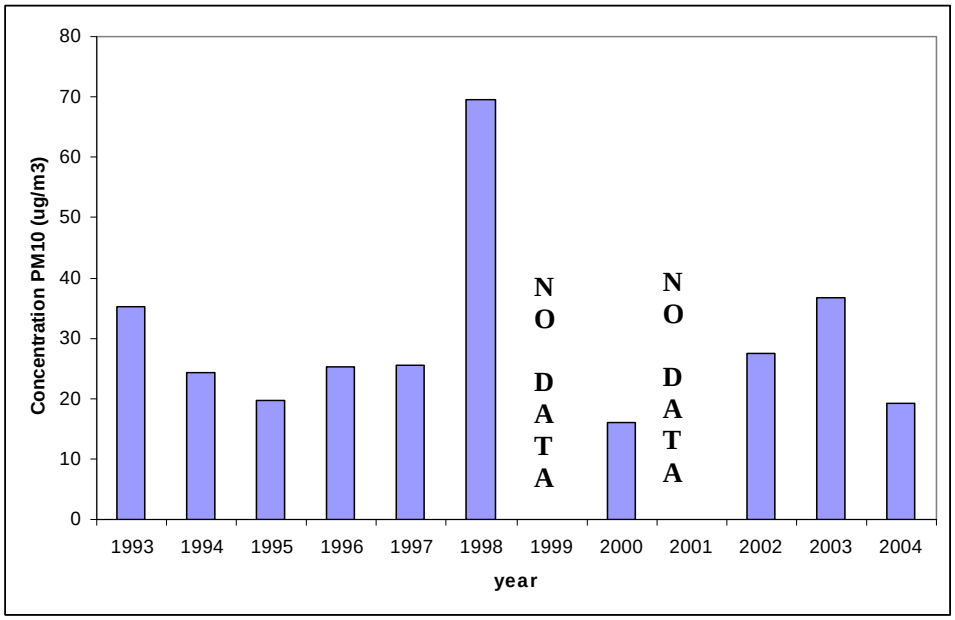


**Figure 1 Maximum 24 hour $PM_{10}$ concentrations ($\mu g/m^3$) measured at Oates Street - Gisborne Airport (one day in six monitoring).**

### 2.3.1 Annual and seasonal cycles of $PM_{10}$

Overall the trend in annual average $PM_{10}$ concentrations is decreasing at the Gisborne Airport. On seasonal time scales, the winter and spring tend to exhibit higher concentrations of $PM_{10}$ compared to summer and autumn (Figures 2 and 3). This seasonal variability is most likely due to $PM_{10}$ emissions from home heating but could also be attributed to the shifts in wind patterns during the winter/spring in comparison to summer/autumn. It is difficult to test this hypothesis without more monitoring sites in the vicinity.

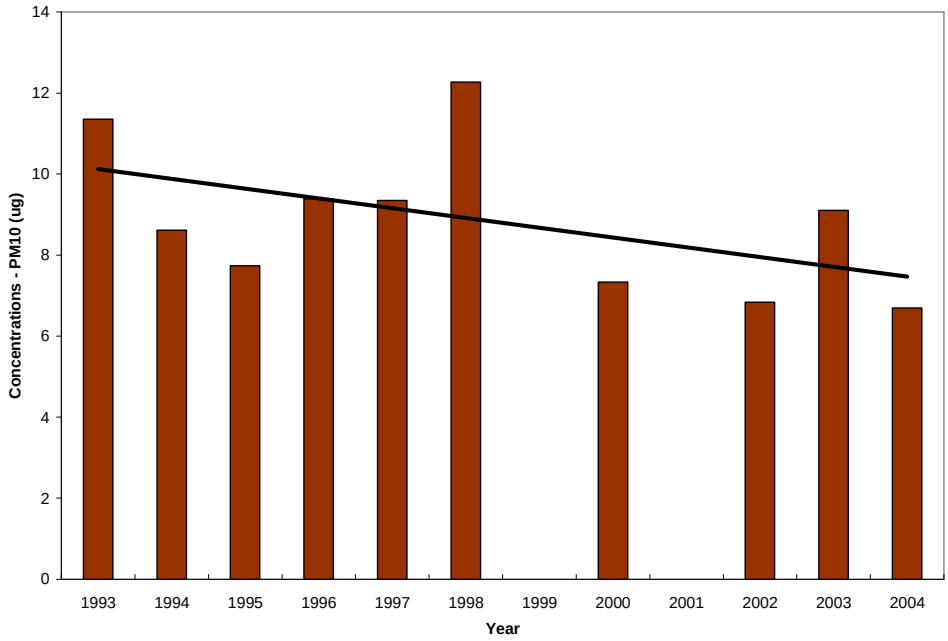


**Figure 2 Annual average $PM_{10}$ concentrations at Oates Street (Gisborne Airport)**

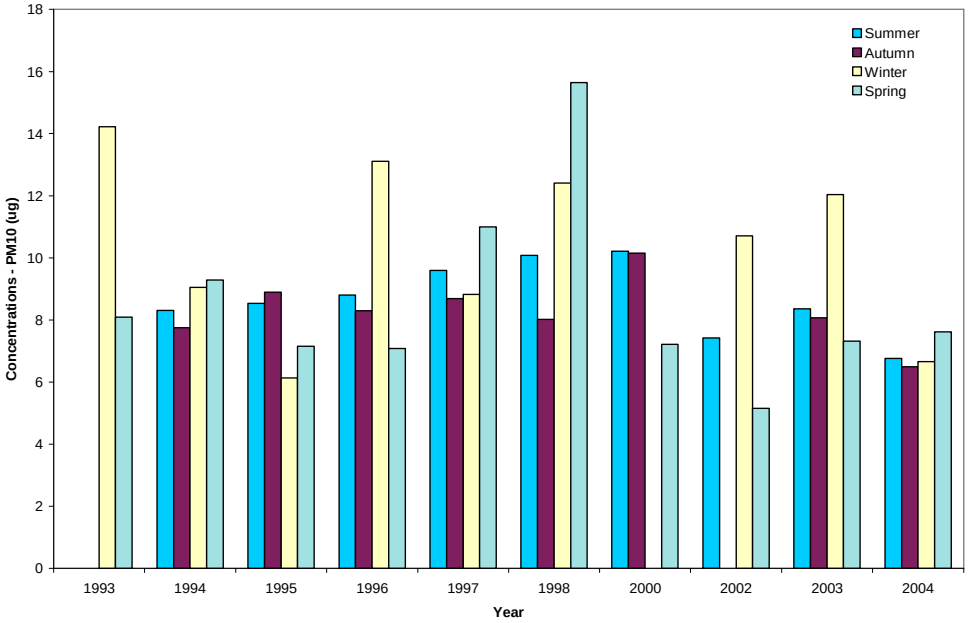


**Figure 3 Seasonal average $PM_{10}$ concentrations at Oates Street (Gisborne Airport)**

## 2.4 Meteorology

Gisborne is sheltered by high country to the west therefore enjoys a dry, sunny climate. During summer warm dry settled weather predominates while frosts may occur in winter with the majority of rainfall occurring in the winter months. Typical summer day time maximum air temperatures range from 20°C to 28°C, occasionally rising above 30°C. High temperatures are frequent in summer, which may be accompanied by strong dry foehn* winds from the northwest. Winter is mild in the north of this region and cooler in the south. Typical winter daytime maximum air temperatures range from 10°C to 16°C. Monthly average rainfall and temperatures as recorded at Gisborne Airport are shown in Figure 4.

Annual hours of sunshine average about 2200 in Gisborne. Heavy rainfall can occur from the east or southeast. North and North Westerly winds prevail (Figure 5). Sea breezes often occur in coastal areas on warm summer days.

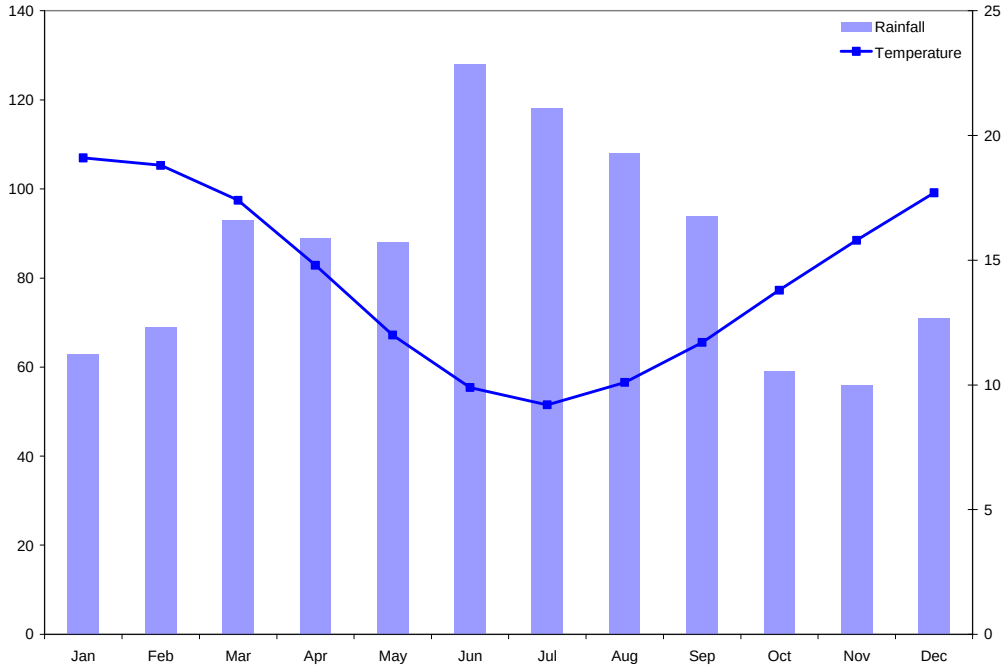


**Figure 4 Long term average rainfall and temperature at Gisborne Airport**

* A warm, dry wind on the lee side of a mountain range. When the humid air goes over a mountain it loses its moisture and cools down, but when it descends down the slope the temperature rises because of the compression. The result is a strong, warm and dry wind.

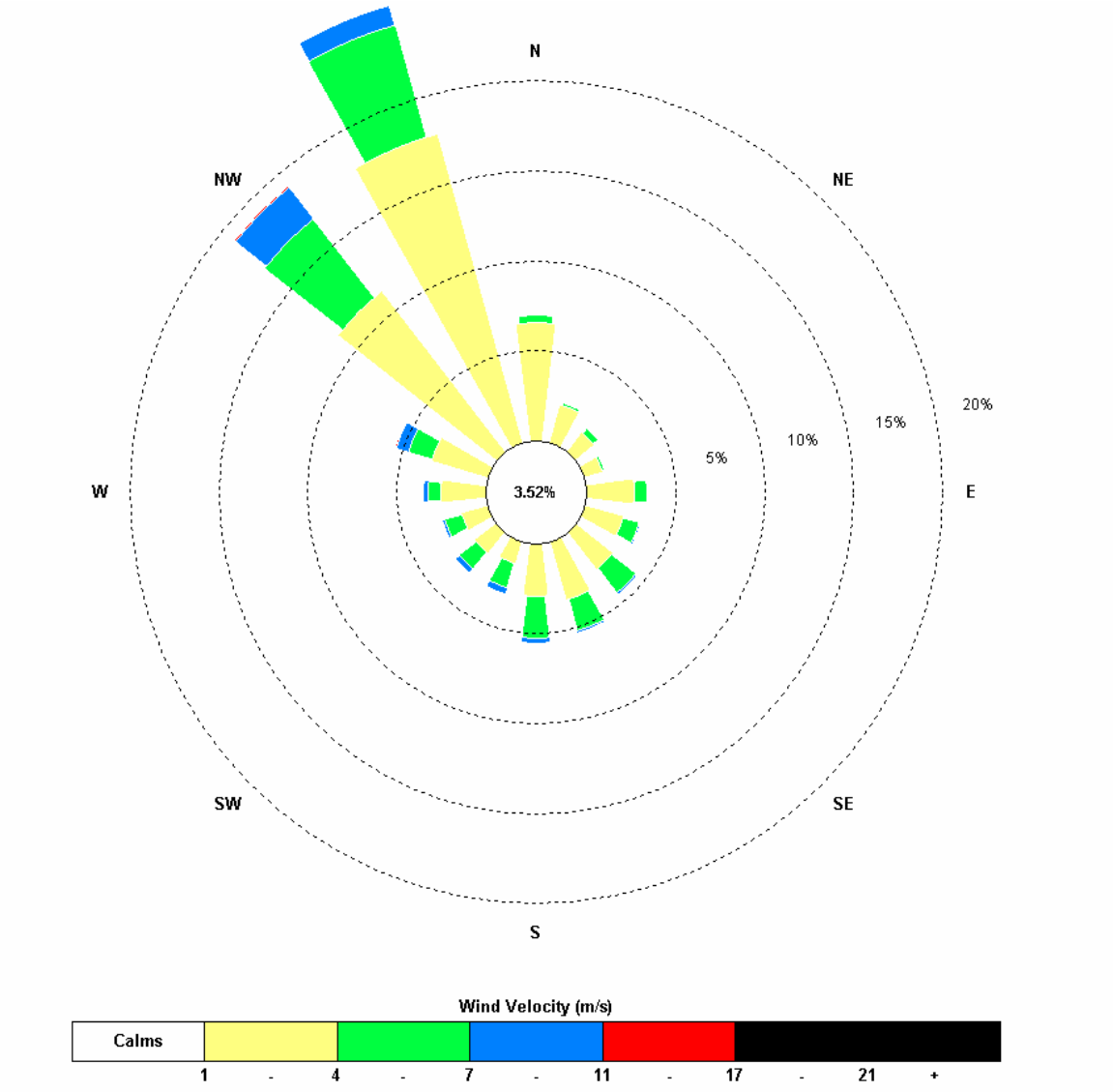


**Figure 5 Wind rose for Gisborne Airport**

### 2.4.1 Summary of location and availability of data

Gisborne Airport lies on eastern part of the Waipaoa River Valley near the western side of Gisborne city. The site is 4m above sea level and surrounded by hills to the north, south and west, while open sea and Poverty Bay lie southeast of the site.

The site has been in operation since 1905 but has moved 8 times previously (Figure 6). The present weather station has been in use since May 1989 and is located at the

observatory on Oates Street which is on the eastern edge of the airport. In past the site movement has always been within the airport limits.

The Gisborne Airport weather station is a synoptic site. This means that it collates information based on 3 hourly monitoring of wind, temperature, rainfall, sunshine, pressure, radiation, evaporation, and upper winds.

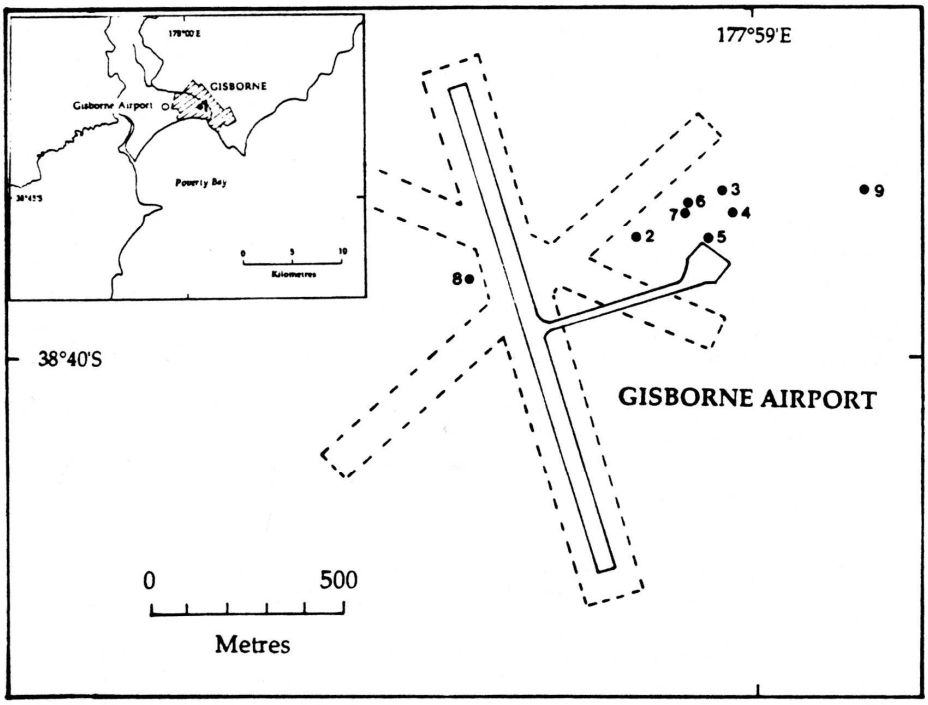


**Figure 6 Gisborne Airport site (Fouhy et al, 1992)**

# 3. Gisborne Region

## 3.1 Location

Gisborne region extends from Morere thermal springs (north of Mahia) and Mahia Peninsula to the East Cape and Potaka Township to the east of Opotiki. This represents approximately 8,265 $km^2$ or 4.9% of New Zealand's total land area. The Gisborne District Council administers this region as both a regional and district council.

## 3.2 Population

In 2001 the population in Gisborne region was 43,971 (2001 census), a change of -4.0% since 1996. In comparison, the population for New Zealand as a whole had changed by +3.3% between 1996 and 2001. However, the preliminary 2006 census data for Gisborne indicate a +0.6 percent increase in population since the 2001 census. The major centre is Gisborne City with population of about 30,000 with other outlying towns like Ruatoria, Tokomaru, Tolaga Bay and Te Karaka accommodating rest of the population. The Population and population density for all the census area units in Gisborne region are shown in Table 3 and the population density depicted in Figures 7 and 8.

| Census Area Unit | Population | Population Density (per km$^2$) |
|---|---|---|
| Te Hapara | 4290 | 1601 |
| Mangapapa | 4263 | 1407 |
| Whataupoko | 3654 | 1072 |
| Gisborne Central | 3222 | 939 |
| Gisborne Airport | 2760 | 530 |
| East Cape | 2748 | 1 |
| Kaiti South | 2736 | 714 |
| Outer Kaiti | 2427 | 1674 |
| Tamarau | 2337 | 2068 |
| Tiniroto | 2139 | 1 |
| Kaiti North | 2061 | 1561 |
| Wharekaka | 1950 | 2 |
| Tarndale-Rakauroa | 1695 | 1 |
| Wainui | 1410 | 99 |
| Riverdale | 1242 | 618 |
| Makaraka | 918 | 45 |
| Tolaga Bay | 870 | 30 |
| Ruatoria | 837 | 39 |
| Manutuke | 636 | 21 |
| Te Karaka | 552 | 191 |
| Tokomaru Bay | 462 | 46 |
| Matokitoki | 393 | 17 |
| Patutahi | 360 | 66 |

**Table 3 Population and population density for all census area units in Gisborne region**

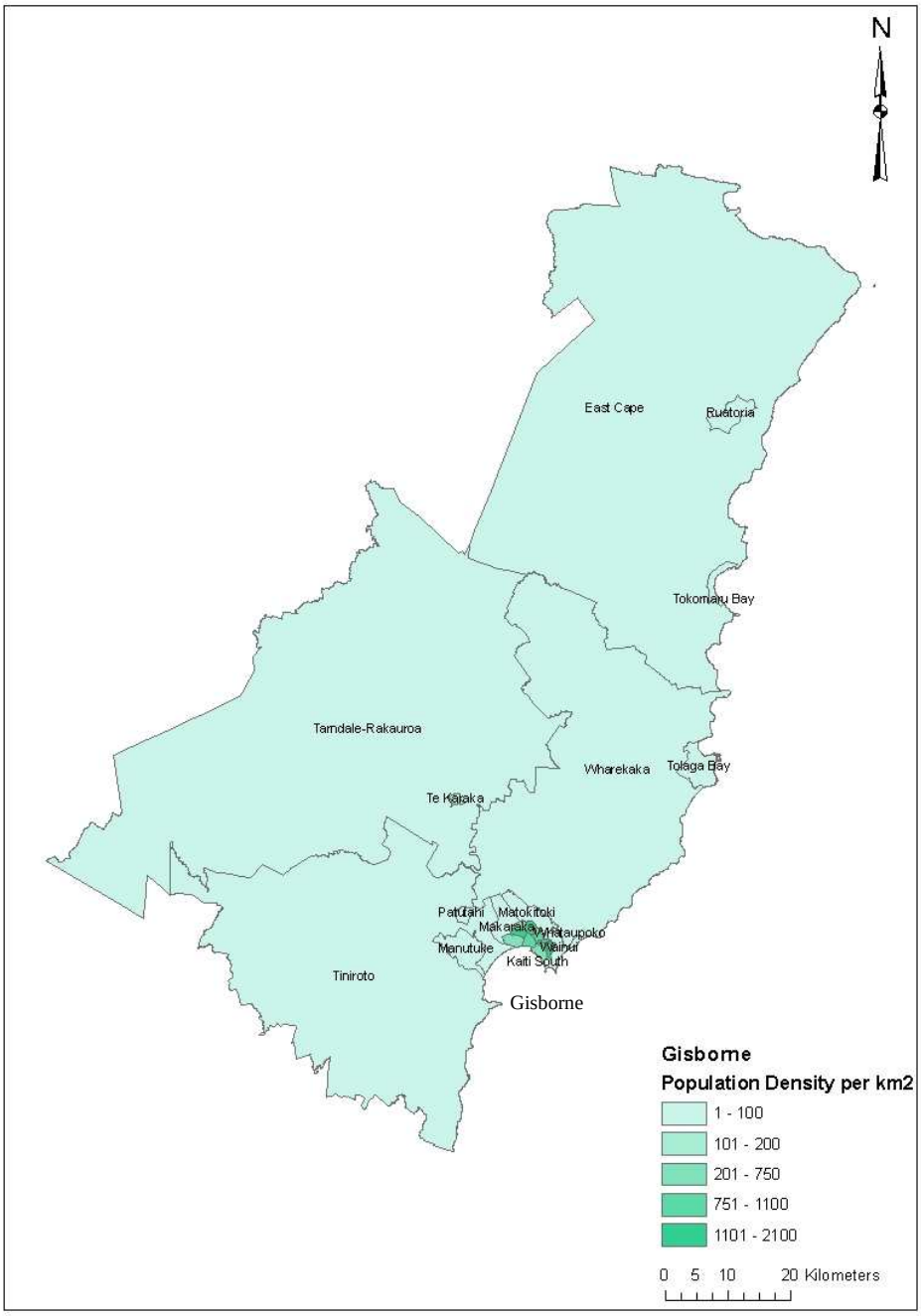


**Figure 7 Population density for Gisborne region (2001 Census)**

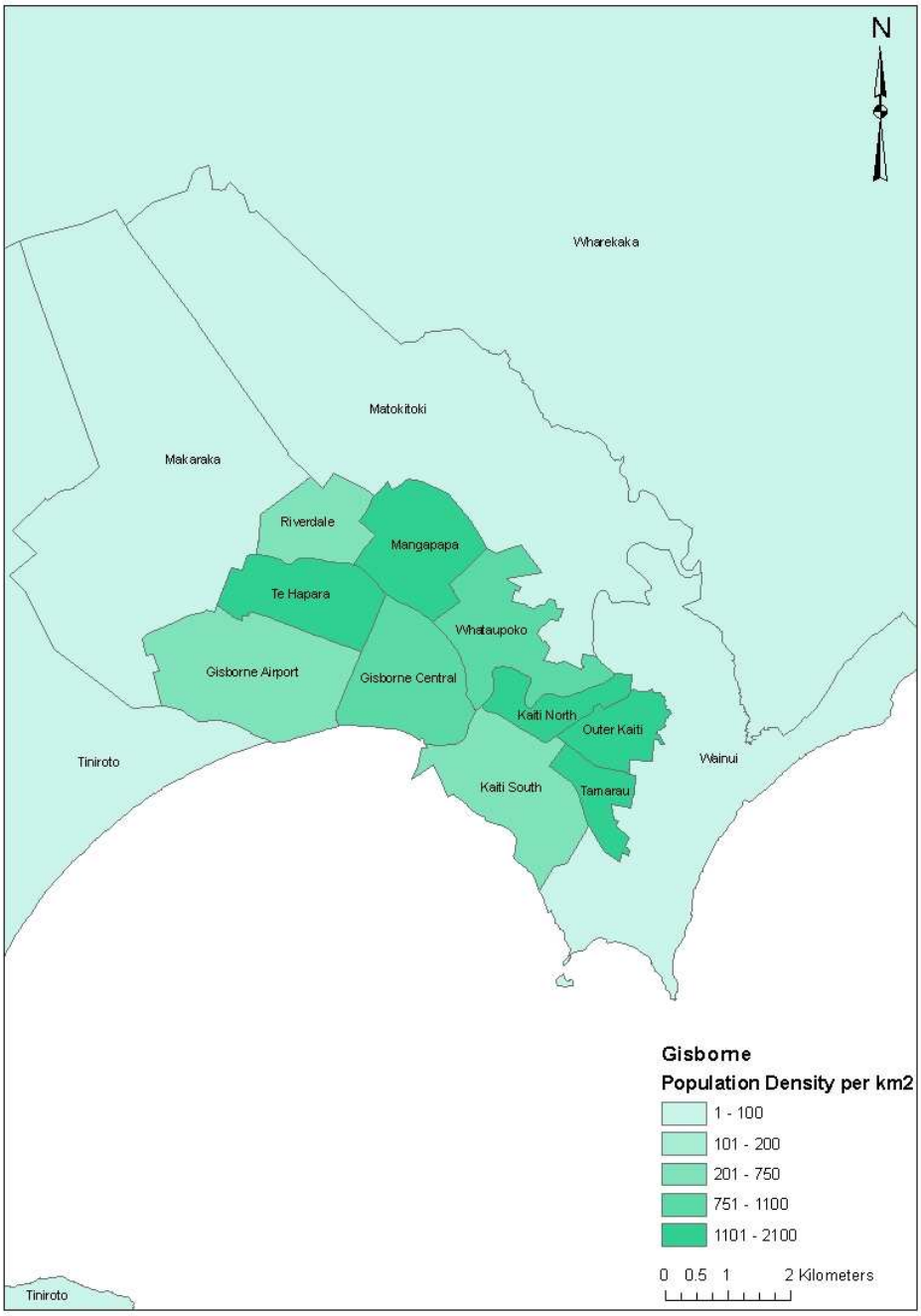


**Figure 8 Population densities by CAU of Gisborne town and surrounding areas**

# 4. Assessment of relative air pollution exposure

The first step in producing an air quality management strategy is to assess the potential risk posed by air pollution to the population of a specified area. This is generally accomplished by estimating the exposure of the population to the pollutants of interest. In terms of the NES, "exposure" is defined as concentration of a pollutant in a place where people are likely to be exposed to it.

The NES do not state how long the exposure should be but it is implicit in the averaging time that the exposure should be of a similar order. For example, the NES for $PM_{10}$ specifies that results should be reported as a 24 hour average. Therefore it is implicit that the measurements should be in places where people are likely to be exposed for 24hours. This will be principally, although not exclusively, in residential areas

In order to assess the relative exposure risk experienced by the population a quantitative measure is required. Direct measurements of $PM_{10}$ concentrations are not available anywhere in the GDC region except Gisborne Airport, other proxy measures must be used. In this study we use estimated emissions per person per day as a proxy for exposure.

The emissions of $PM_{10}$ in each CAU of the Gisborne Region were obtained from NIWA's National $PM_{10}$ emissions inventory (2004). These are given as an *Emissions Density* in units of $Kg/km^2/day$. If this value is divided by the population density we get the emissions per person per day per CAU. These emissions values are shown in Table 4.

$$\textbf{Exposure (kg/person/day)} = \frac{\textbf{Emissions Density (kg/km}^2\textbf{/day)}}{\textbf{Population Density (person/ km}^2\textbf{)}}$$

| Census Area Unit | Population Density (person/ $km^2$) | Emissions Density $PM_{10}$ ($kg/km^2/day$) | Exposure $PM_{10}$ (kg/person/day) |
|---|---|---|---|
| Gisborne Airport | 530 | 264.99 | 0.50 |
| Matokitoki | 17 | 0.87 | 0.05 |
| Tarndale-Rakauroa | 1 | 0.03 | 0.05 |
| Tiniroto | 1 | 0.07 | 0.05 |
| Makaraka | 45 | 2.14 | 0.05 |
| Wainui | 99 | 4.51 | 0.05 |
| Wharekaka | 2 | 0.07 | 0.05 |
| Patutahi | 66 | 2.94 | 0.04 |
| Manutuke | 21 | 0.89 | 0.04 |
| Tokomaru Bay | 46 | 1.94 | 0.04 |
| Te Karaka | 191 | 7.81 | 0.04 |
| Ruatoria | 39 | 1.52 | 0.04 |
| East Cape | 1 | 0.04 | 0.04 |
| Tolaga Bay | 30 | 1.11 | 0.04 |
| Mangapapa | 1407 | 51.69 | 0.04 |
| Kaiti North | 1561 | 56.63 | 0.04 |
| Gisborne Central | 939 | 33.76 | 0.04 |
| Whataupoko | 1072 | 38.16 | 0.04 |
| Tamarau | 2068 | 69.88 | 0.03 |
| Te Hapara | 1601 | 53.84 | 0.03 |
| Riverdale | 618 | 20.21 | 0.03 |
| Kaiti South | 714 | 21.82 | 0.03 |
| Outer Kaiti | 1674 | 48.43 | 0.03 |

**Table 4 $PM_{10}$ exposure per person for all Gisborne census area units**

The results show that the highest exposure risk of people in the Gisborne region to $PM_{10}$ is at Gisborne Airport. This is most likely due to the concentration of industry in the industrial zone around the airport.

This exposure risk is ten times higher than anywhere else in the region. Given these finding, there is potential for Gisborne Airport to suffer a breach of the NES. However if the emissions per person can be translated into relative concentrations, (i.e. ten times less) then we would not expect any other CAU in the Gisborne district to be at risk of breaching the NES.

Results also suggest that Tamarau has the highest population density and emissions density of any CAU except the Airport. It is also the part of Gisborne furthest downwind of the rest of the town. Under prevailing wind conditions (Figure 6), traffic and heating emissions from the rest of the town will be transported over Tamarau, possibly leading to elevated $PM_{10}$ concentrations.

Of the smaller towns in the region, although none stand out from this analysis, some, such as Ruatoria, and Te Karaka are situated in valleys. These situations, especially in winter, could lead to conditions where $PM_{10}$ pollutant levels could build up. Identifying individual sites is beyond the scope of this report as a more detailed assessment would be required.

# 5. Monitoring strategy and summary

Currently there is a monitoring site at Oates Street - Gisborne Airport and plans are in place to install another $PM_{10}$ monitoring site in central Gisborne at the Gisborne Boys High School.

Monitoring data indicate that $PM_{10}$ concentrations at the Airport site may exceed the NES value of 50μg/$m^{-3}$ occasionally and guideline or alert values of 33μg/$m^{-3}$ more frequently. The $PM_{10}$ at the airport site is mainly from industrial activities. $PM_{10}$ monitoring at Gisborne Airport is necessary for compliance with the NES even though it falls under the industrial zone as it is a work place for a large number of people and also major port of entry for people coming into and out of Gisborne region. Therefore, NIWA recommends that a continuous monitoring strategy be put in place for the Airport site. This is critical for obtaining baseline and continuous data for evaluation of $PM_{10}$ trends.

Our initial assessments of the Gisborne region suggest that both population exposure to $PM_{10}$ and the risk of a breach of the NES are low everywhere except the airport. However, as the $PM_{10}$ at the airport are largely from industrial activities, it is appropriate to consider a second site, which is representative of the residential and commercial parts of the town.

The proposed Gisborne Boys High School monitoring site in central Gisborne will likely be subject to some of the highest traffic densities in the region and being surrounded by residential areas should experience $PM_{10}$ emissions from home heating as well. Although estimated emissions per person are low, the high population density in this and surrounding areas means that total emissions are relatively high, making

this a suitable choice of site. An alternative monitoring site to central Gisborne may be considered in Tamarau.

In the smaller towns, a short-term screening programme may be helpful to eliminate any possible concerns. Design of such a programme, identifying individual sites and methods, would need to be the subject of further study.

## References

Fouhy E, Coutts L, McGann R, Collen B, and Salinger J (1992). South Pacific Historical Climate Network: Climate Station Histories – Part 2: New Zealand and Offshore Islands. New Zealand Meteorological Service, Wellington.

Ministry for the Environment (2005). Updated Users Guide to Resource Management (National Environmental Standards Relating to Certain Air Pollutants, Dioxins and other Toxics) Regulations 2004 (including Amendments 2005). Ministry for the Environment, Wellington.

Sherman M and Fisher G (2005). Air Emissions Inventory for the Gisborne District. Endpoint Consulting Partners. Report for Gisborne District Council.