Memorandum

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From Scientific Officer – Air Quality, Brian Cheyne
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Monitoring of nitrogen oxides (NOx) levels in Taranaki, year 2011-12

Nitrogen oxides

Nitrogen oxides (NOx), a mixture of nitrous oxide (N2O), nitric oxide (NO) and nitrogen dioxide (NO2), are produced from natural sources, motor vehicles and other fuel combustion processes. Indoor domestic appliances (gas stoves, gas or wood heaters) can also be significant sources of nitrogen oxides, particularly in areas that are poorly ventilated. NO and NO2 are of interest because of potential effects on human health.

Nitric oxide is colourless and odourless and is oxidised in the atmosphere to form nitrogen dioxide. Nitrogen dioxide is an odorous, brown, acidic, highly corrosive gas that can affect our health and environment. Nitrogen oxides are critical components of photochemical smog – nitrogen dioxide produces the yellowish-brown colour of the smog.

Environmental and health effects of nitrogen oxides
Nitrogen dioxide is harmful to vegetation, can fade and discolour fabrics, reduce visibility, and react with surfaces and furnishings. Vegetation exposure to high levels of nitrogen dioxide can be identified by damage to foliage, decreased growth or reduced crop yield.

Nitric oxide does not significantly affect human health. On the other hand, elevated levels of nitrogen dioxide cause damage to the mechanisms that protect the human respiratory tract and can increase a person's susceptibility to, and the severity of, respiratory infections and asthma. Long-term exposure to high levels of nitrogen dioxide can cause chronic lung disease. It may also affect sensory perception, for example, by reducing a person's ability to smell an odour.

National environmental standards and guidelines
In 2004, national environmental standards (NES) for ambient (outdoor) air quality were introduced in New Zealand to provide a guaranteed level of protection for the health of New Zealanders. The national standard for the nitrogen dioxide (NO2) is set out below.

In any 1-hour period, the average concentration of nitrogen dioxide in the air should not be more than 200 $\mu g/m^3$.

Before the introduction of the national environmental standards, air quality was measured against the national air quality guidelines. The national guidelines were developed in 1994 and revised in 2002 following a comprehensive review of international and national research and remain relevant. The national guideline for the nitrogen dioxide (NO2) is set out below.

In any 24-hour period, the average concentration of nitrogen dioxide in the air should not be more than 100 µg/m³.

Measurement of nitrogen oxides

The Taranaki Regional Council has been monitoring nitrogen oxides (NOx) in the Taranaki region since 1993 using passive absorption discs. Research to date indicates that this is an accurate method, with benefits of simplicity of use and relatively low cost. To date 496 samplers of nitrogen oxides have been collected in Taranaki region. Discs are sent to EUROFINS ELS Ltd. Lower Hutt for analysis. Passive absorption discs are placed at the nominated sites. The gases diffuse into the discs and any target gases (nitrogen dioxide or others) are captured.

In the 2011-12 year, passive absorption discs were placed on one occasion at seven sites, staked about two metres off the ground for a period of 21 days, for the purpose of SEM studies.

Conversion of exposure result to standardised exposure time period

From the average concentration measured, it is possible to calculate a theoretical maximum daily or one hour concentrations that may have occurred during the exposure period. Council data on NOx is gathered over a time period other than exactly 24 hours or one hour. There are mathematical equations used by air quality scientists to predict the maximum concentrations over varying time periods. These are somewhat empirical, in that they take little account of local topography, micro-climates, diurnal variation, etc. Nevertheless, they are applied conservatively and have some recognition of validity.
One formula in general use is of the form:

$$C(t_2) = C(t_1) \times \left(\frac{t_1}{t_2}\right)^P$$

where C(t) = the average concentration during the time interval t, and p = a factor lying between 0.17 and 0.20. When converting from longer time periods to shorter time periods, using p = 0.20 gives the most conservative estimate (i.e. the highest calculated result for time period t_2 given a measured concentration for time period t_1). Using the 'worst case' factor of p = 0.20, the monitoring data reported above has been converted to equivalent 'maximum' 1-hour and 'maximum'24-hour exposure levels.

Results

Table 1 presents the actual levels found and theoretical maximum daily and hourly concentration of NOx.

Table 1 Actual (laboratory) and recalculated ambient NOx results, NES and MfE guideline.

Site code	Site description	NOx (µg/m³) Lab. results	NOx/1hr (µg/m³) (Theoretical maximum)	NOx/24hr (µg/m³) (Theoretical maximum)
AIR000016	Pohokura saddle- ("Pristine", E hill country)	0.4	1.4	0.7
AIR000017	Tariki Road- (Rural, central Tar.)	1.6	5.6	2.9
AIR000021	Watino Road- (Rural, south)	0.7	2.5	1.3
AIR000022	Pukeiti hill- ('Pristine" W site)	0.2	0.7	0.4
AIR000012	NPGHS- (Urban, road traffic)	7.1	24.7	13.1
AIR000015	Kaka Road-("Pristine", NE hill country)	0.5	1.8	0.9
AIR000025	New Plymouth central	N/R*	N/R	N/R
National Environmental Standard (NES) and MfE guideline			**200**	**100**

*no results

Discussion

The calculated 1-hour and 24-hour theoretical maximum concentrations (using a power law exponent of 0.2) ranged from 0.7 µg/m³ to 24.7 µg/m³ and 0.4 µg/m³ to 13.1 µg/m³ respectively. The highest result was obtained from the site located in New Plymouth's urban area near a busy traffic intersection. All values were within the National Environmental Standards and Ministry for the Environment Ambient Air Quality Guidelines. This continues the pattern found in previous years.

Comparison with other monitored sites in the Region

In the 2011-2012 monitoring year, the NOx component of the State of Environment Monitoring programme for air quality in Taranaki was conducted at the same time as the Fonterra Whareroa and the Downer EDI – asphalt and bitumen plant compliance monitoring programmes. This extended nitrogen oxides monitoring allowed comparison of NOx levels at 15 sites throughout the region.

The location of the NOx monitoring sites are shown in Figure 2 and the details of the NOx results are graphically presented in Figure 1.

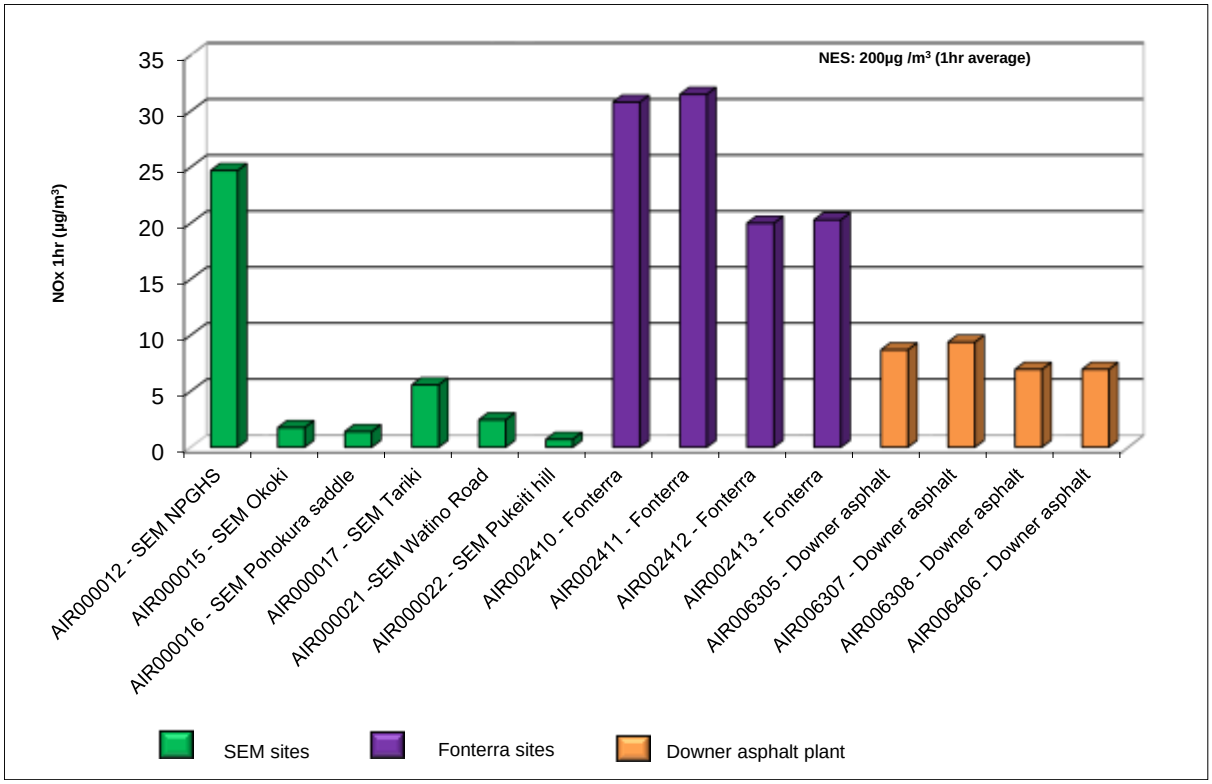

Figure 1 NOx levels at 15 sites throughout the region (year 2011-2012).

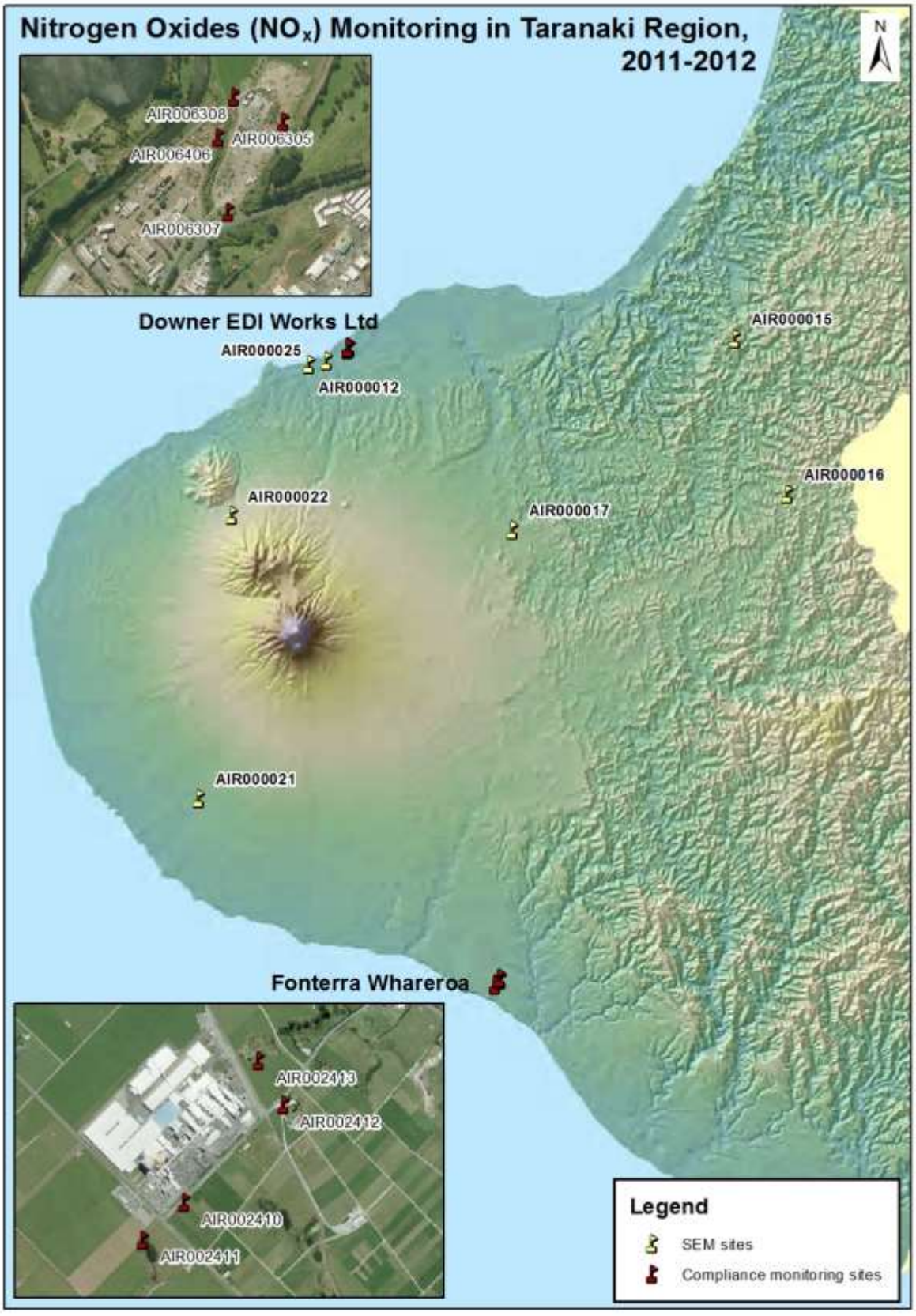

Figure 2 NOx monitoring sites in Taranaki Region, 2011-2012

Discussion
From the graph presented in Figure 1 it can be observed that the highest NOx levels recorded were obtained from the sites located around the Fonterra's Whareroa co-generation plant and from the busy traffic intersection in New Plymouth by the NPGHS. Pristine and pastoral monitoring sites showed trivial levels of nitrogen oxides. All results were below the National Environmental Standard for NOx of 200µg/m³ expressed as a 1-hour mean.

NOx results obtained from the seven SEM sites from year 1997

Figure 3 shows an entire NOx results from the seven SEM sites which have been monitored since year 1997.

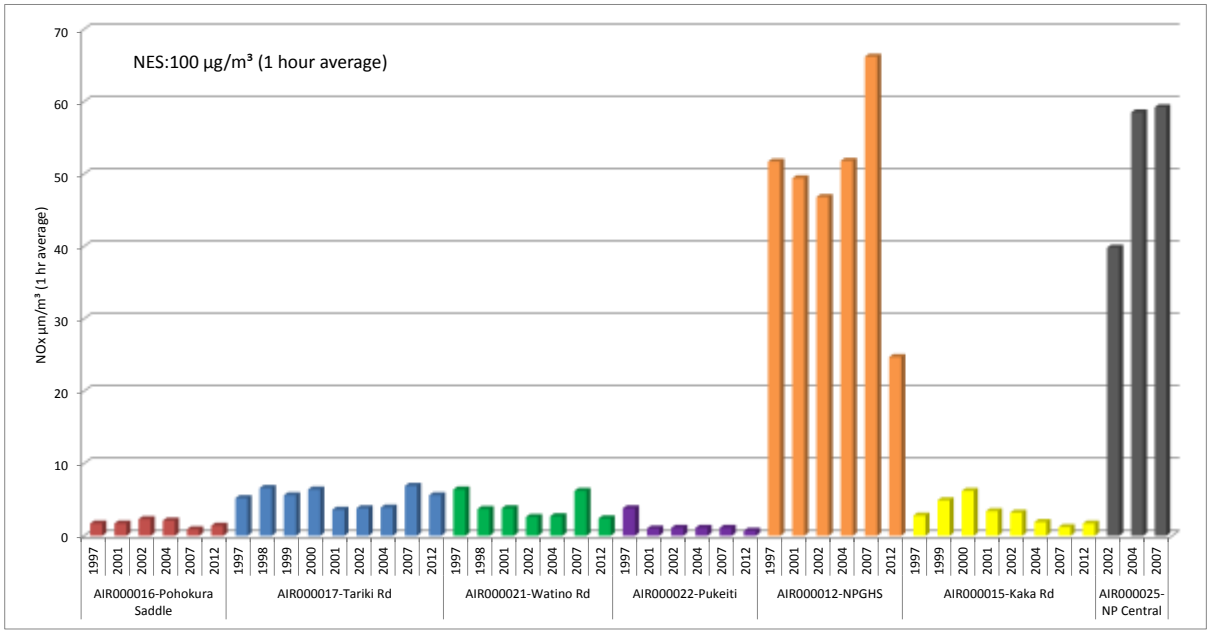

Figure 3 NOx levels at 7 SEM nominated sites since year 1997.

Ministry for the Environment uses an environmental performance indicator to categorise air quality. These categories are set out in Table 2 and further details of the entire SEM NOx results are set out in Table 3.

Table 2 Environmental Performance Indicator air quality categories

Measured value	Less than 10% of NES	10-33% of NES	33-66% of NES	66-100% of NES	More than 100% of NES
Category	*excellent*	*good*	*acceptable*	*alert*	*action*

Table 3 Categorisation of results - entire dataset (1997-2012)

National Environmental Standard for NO2 = 200 µg/m³- 1 hour average.		
Category	Measured values	
Excellent	<10% of the NES, (0-20µg/m³)	**36** (80%)
Good	10-33% of the NES, (20-66µg/m³)	**9** (20 %)
Acceptable	33-66% of the NES, (66-132 µg/m³)	**0** (0%)
Alert	66-100% of the NES, (132-200 µg/m³)	**0** (0%)
Total number of samples		**45** (100%)

Conclusion

The highest 1-hour mean NOx result from the entire SEM NOx dataset was 66µg/m³ and the mean of all results was 12.6µg/m³. The monitoring showed that 80% of the 1-hour average results fell into Ministry's 'excellent' categories and 20% of the results lay within Ministry's 'good' category. No results ever entered the 'acceptable' or 'alert' categories, i.e., no results ever exceeded the National Environmental Standard of 200µg/m³.

These results, and all regional monitoring to date, have shown that Taranaki has very clean air, and on a regional basis there are no significant pressure upon the quality of the air resource.