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Monitoring of nitrogen oxides (NOx) levels in Taranaki near major NOx sources, year 2019-2020

From 2014 onwards, the Taranaki Regional Council (TRC) has implemented a coordinated region-wide monitoring programme to measure nitrogen oxides (NOx), not only at individual compliance monitoring sites near industries that emit NOx, but simultaneously at urban sites (the Council regional state of the environment programme) to determine exposure levels for the general population. The programme involves deploying all measuring devices on the same day, with retrieval three weeks later. This approach will assist the Council to further evaluate the effects of local and regional emission sources and ambient air quality in the region.

Nitrogen oxides

NOx, any mixture of nitrous oxide (N_2O), nitric oxide (NO) and nitrogen dioxide (NO_2), are produced from soil, motor vehicles and industrial fuel combustion processes. Indoor domestic appliances (gas stoves, gas or wood heaters) are significant localised sources of nitrogen oxides.

Environmental and health effects of nitrogen oxides

NO and NO_2 are of interest to air scientists and public health authorities because of potential effects on human health when present in high concentrations (eg as found in high density industrialised cities).

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 brown colour of the smog.

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, particularly in areas that are poorly ventilated. 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 nitrogen dioxide (NO_2) 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 existing 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 nitrogen dioxide (NO_2) 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/m^3.

Nitrogen dioxide limits are included in the special conditions of resource consents issued by the Council. The consents limits reflect those imposed under the NES and MfE's guideline.

Measurement of nitrogen oxides

The Taranaki Regional Council has been monitoring NOx in the Taranaki region since 1993 using passive absorption discs. These discs are placed at the nominated sites. The gases diffuse into the discs and any target gases (whether nitrogen dioxide or others) are captured. Research to date indicates that this is a reliable screening method for measuring average exposure, with benefits of simplicity of use and relatively low cost. To date more than 780 samplers of nitrogen oxides have been collected in Taranaki region. Discs are sent to an independent laboratory for analysis.

In the 2019-2020 year, passive absorption discs were placed on one occasion at 30 sites, staked about two metres off the ground for a period of 21 days, for the purpose of compliance monitoring.

Conversion of exposure result to standardised exposure time periods

Sampling is conducted over various lengths of time. The issue is therefore that of estimating an indicative equivalent exposure concentration over alternative time periods of interest (eg as referenced in guidelines or other criteria). For comparison with the Ministry for the Environment short-term guideline for BTEX, from the average concentration measured, it is desirable to consider what an indicative theoretical maximum one-hour or 24-hour concentration might be. There are mathematical equations used by air quality scientists to predict equivalent concentrations over varying time periods. These are somewhat empirical, in that they take little account of local topography, micro-climates, variations in activity processes, diurnal variation, etc. Nevertheless, they are conservative (they tend to over-estimate) for a steady-state source. The Council uses these as a screening tool. 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 t2 given a measured concentration for time period t1).

Using the 'worst case' factor of p = 0.20, the monitoring data reported herein have also been converted to equivalent 'maximum' one hour and 24-hour exposure levels. These should not be considered accurate estimates of what actually occurred, but can give an indication of a risk of exceedance of criteria levels.

Results

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

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

	Survey at	Site code	NOx(µg/m3) Lab. results	NOx 1/hr (µg/m3) Theoretical max.	NOx 24/hr (µg/m3) Theoretical max.
Petrochemical	McKee PS	AIR007901	4.2	14.4	7.7
		AIR007902	3.6	12.4	6.6
	Turangi PS	AIR007822	16.7	57.4	30.4
		AIR007824	5.0	17.2	9.1
	Kaimiro PS	AIR007817	2.1	7.2	3.8
		AIR007818	5.3	18.2	9.6
	Sidewinder PS	AIR007831	9.4	32.3	17.1
		AIR007832	3.3	11.3	6.0
	Maui PS	AIR008201	1.8	6.2	3.3
		AIR008214	3.0	10.3	5.5
	Kupe PS	AIR007827	1.5	5.2	2.7
		AIR007830	2.0	6.9	3.6
	Kapuni PS	AIR003410	5.5	18.9	10.0
		AIR003411	4.3	14.8	7.8
	Cheal PS	AIR007841	5.2	17.9	9.5
		AIR007842	4.1	14.1	7.5
	Waihapa PS	AIR007815	2.1	7.2	3.8
		AIR007816	4.2	14.4	7.7
	Ballance AUP	AIR003401	14.7	50.5	26.7
		AIR003404	17.1	58.8	31.1
	Pohokura PS	AIR003101	2.0	6.9	3.6
		AIR003102	2.4	8.2	4.4
	Rimu PS	AIR012501	2.4	8.2	4.4
		AIR012502	4.3	14.8	7.8
Dairy factory	Fonterra	AIR002410	6.9	23.7	12.6
		AIR002411	7.1	24.4	12.9
		AIR002412	3.4	11.7	6.2
		AIR002413	2.5	8.6	4.5
SEM	NPGHS	AIR000012(SW)	10.7	36.8	19.5
		AIR000012(NE)	8.3	28.5	15.1
National Environmental Standard (NES) and MfE guideline				**200 (NES)**	**100 (MfE)**

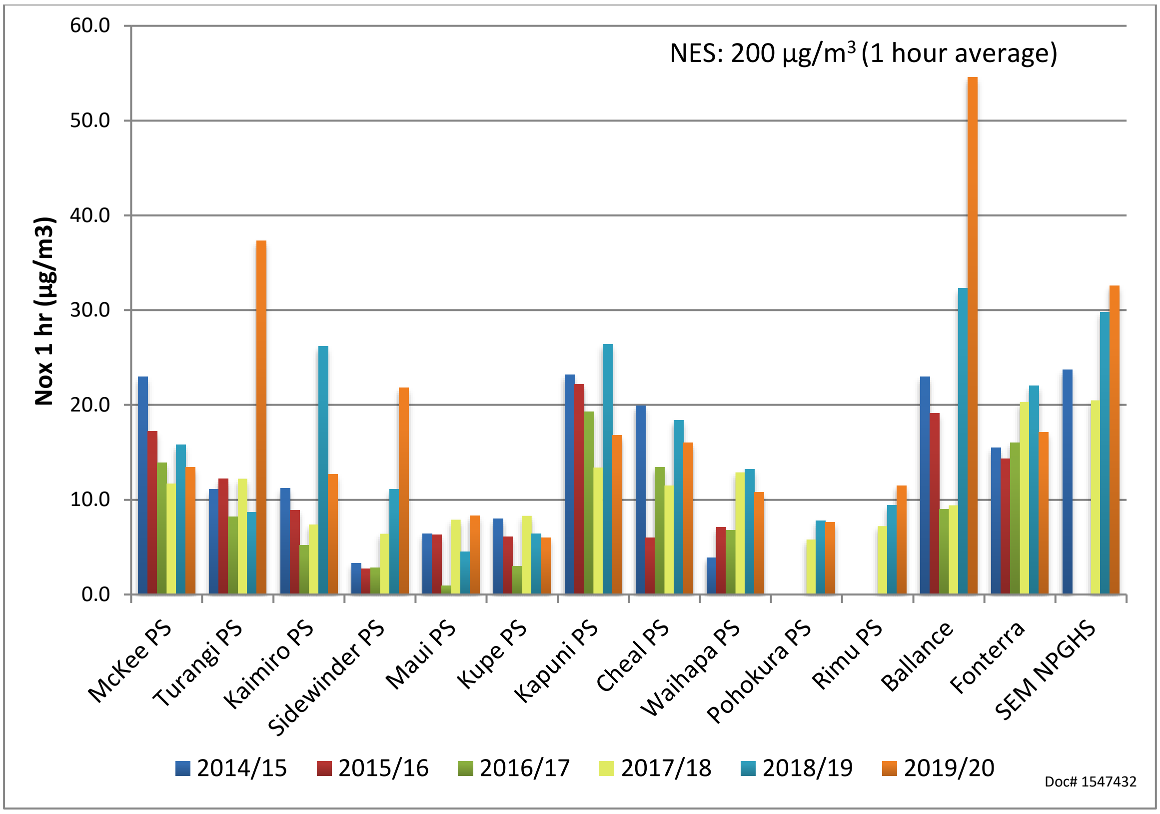

Figure 1 Average NOx levels at 14 surveyed locations throughout the region (year 2019-2020)

Discussion

The calculated 1-hour and 24-hour theoretical maximum concentrations (using a power law exponent of 0.2) ranged from 5.2 µg/m³ to 58.8 µg/m³, and from 2.7 µg/m³ to 31.1 µg/m³ respectively (Table 1). The highest results in the 2019-2020 monitoring year were obtained at five different locations:

1. In the Kapuni heavy industrial area around the 'Balance' Agri-Nutrients.
2. From the site at Turangi production station.
3. From the site at Sidewinder production station.
4. And In New Plymouth's urban area near a busy traffic intersection.

All values were well within the National Environmental Standards, Ministry for the Environment Ambient Air Quality Guidelines and the respective resource consents limits. This continues the pattern found in previous years.

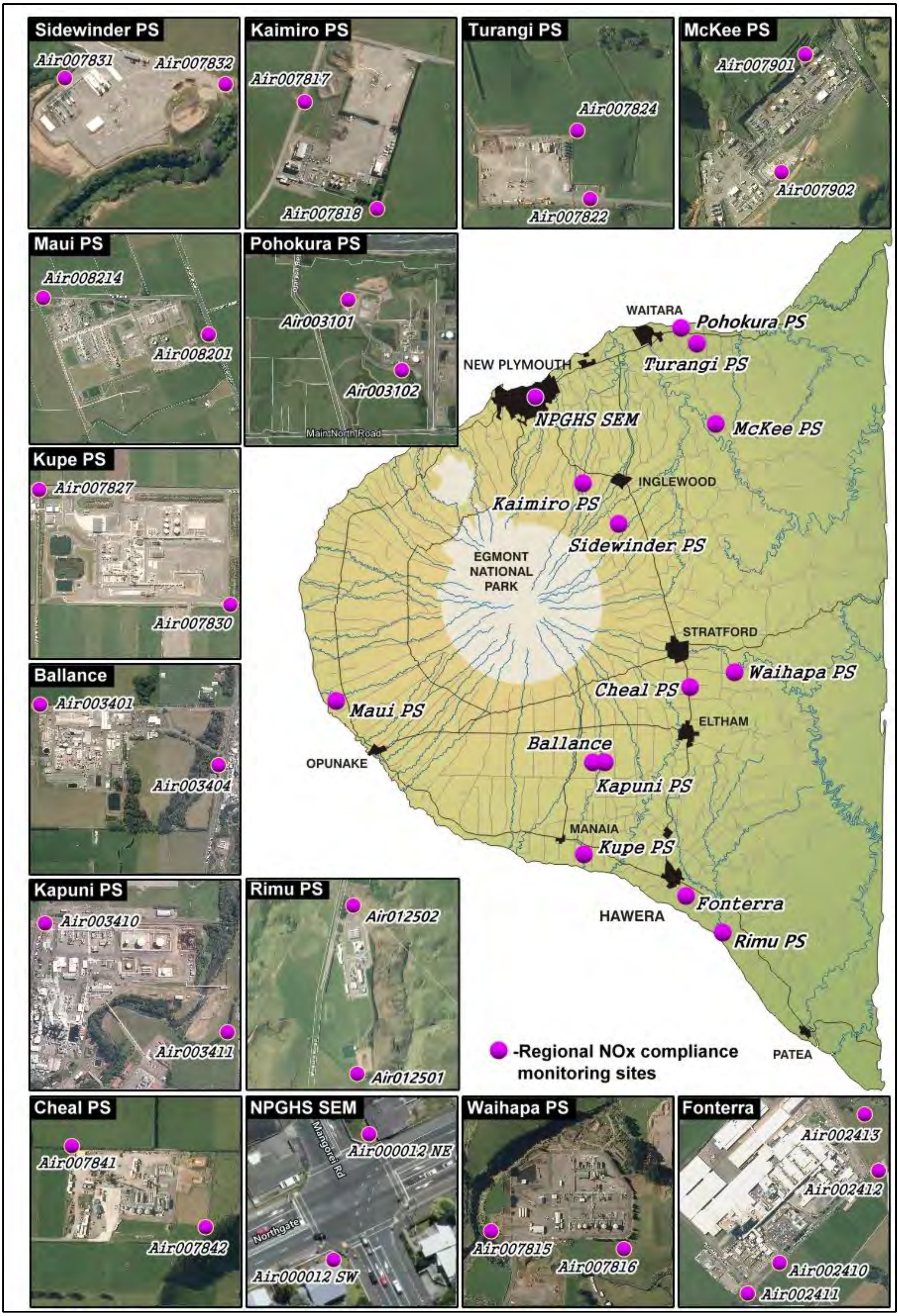

Figure 2 NOx monitoring sites in Taranaki Region, 2019-2020

Ministry for the Environment environmental performance indicator

Ministry for the Environment uses environmental performance indicator to categorise air quality. Their categories are set out in Table 2. Further details of the entire NOx results for 2019-2020 in Taranaki are set out in Table 3.

Table 2 MfE 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 regional results (2019-2020 monitoring year)

National Environmental Standard for NO2 = 200 µg/m3- 1 hour average.		
Category	**Measured values**	
Excellent	<10% of the NES, (0-20µg/m^3)	**22** (73%)
Good	10-33% of the NES, (20-66µg/m^3)	**8** (27 %)
Acceptable	33-66% of the NES, (66-132 µg/m^3)	**0** (0%)
Alert	66-100% of the NES, (132-200 µg/m^3)	**0** (0%)
Total number of samples		**30** (100%)

Conclusion

The monitoring showed that across all sites monitored, 73% of the calculated 1-hour average results fell into the Ministry's 'excellent' categories and the remaining 27% of the results lay within the 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/m^3.

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 pressures upon the quality of the air resource.