

Sulphur dioxide concentrations

This factsheet presents indicators of sulphur dioxide concentrations at monitoring sites in Aotearoa New Zealand, between 2005 and 2020. Concentrations are measured against the National Environmental Standard for Air Quality (NESAQ) and a WHO guideline for sulphur dioxide exposure.



While concentrations of sulphur dioxide have consistently been far higher in industrial areas, exceedances of NESAQ regulations in recent years have been rare.



Between 2005 and 2020, three out of eight monitoring stations exceeded the lower NESAQ threshold for SO₂ concentrations, though none had more than the nine permitted exceedances of 350µg/m³ in a single year. No exceedances of the lower threshold have occurred since 2016.



Two of those three stations also (in Christchurch and Mt. Maunganui) exceeded the upper NESAQ threshold twice. The upper limit of 570µg/m³ may not be exceeded even once per year.



Between 2005 and 2020, four out of eight stations exceeded the latest (2021) WHO recommendation for daily average SO₂ concentrations, and six exceeded the previous (2005) guideline. In 2020, three stations, all in Tauranga, exceeded the 2021 guideline.

How sulphur dioxide may affect health

Sulphur dioxide (SO₂) is a colourless gas with a pungent smell, which may be produced from the combustion of sulphur-bearing coal or fossil fuels, particularly the kinds of low-quality ‘bunker fuel’ used in maritime transport. Industrial activities such as smelting certain mineral ores and fertiliser manufacture are also sources of SO₂. It may also be generated naturally in areas of geothermal or volcanic activity (Ministry for the Environment and Stats NZ 2021).

SO₂ readily reacts with other substances to form harmful compounds, e.g. with water to form sulphuric acid (‘acid rain’). It can also react with other air pollutants to form more harmful particles or cause atmospheric haze. SO₂ exposure is associated with the following:

- respiratory problems such as bronchitis
- aggravation of asthma or chronic lung disease
- irritation of the eyes.

Sulphur dioxide standards and guidelines

SO₂ air quality standards and guidelines have been developed to provide some level of protection against health risks. One-hour average SO₂ concentrations are measured against an upper and lower threshold value contained in the National Environmental Standards for Air Quality (NESAQ).

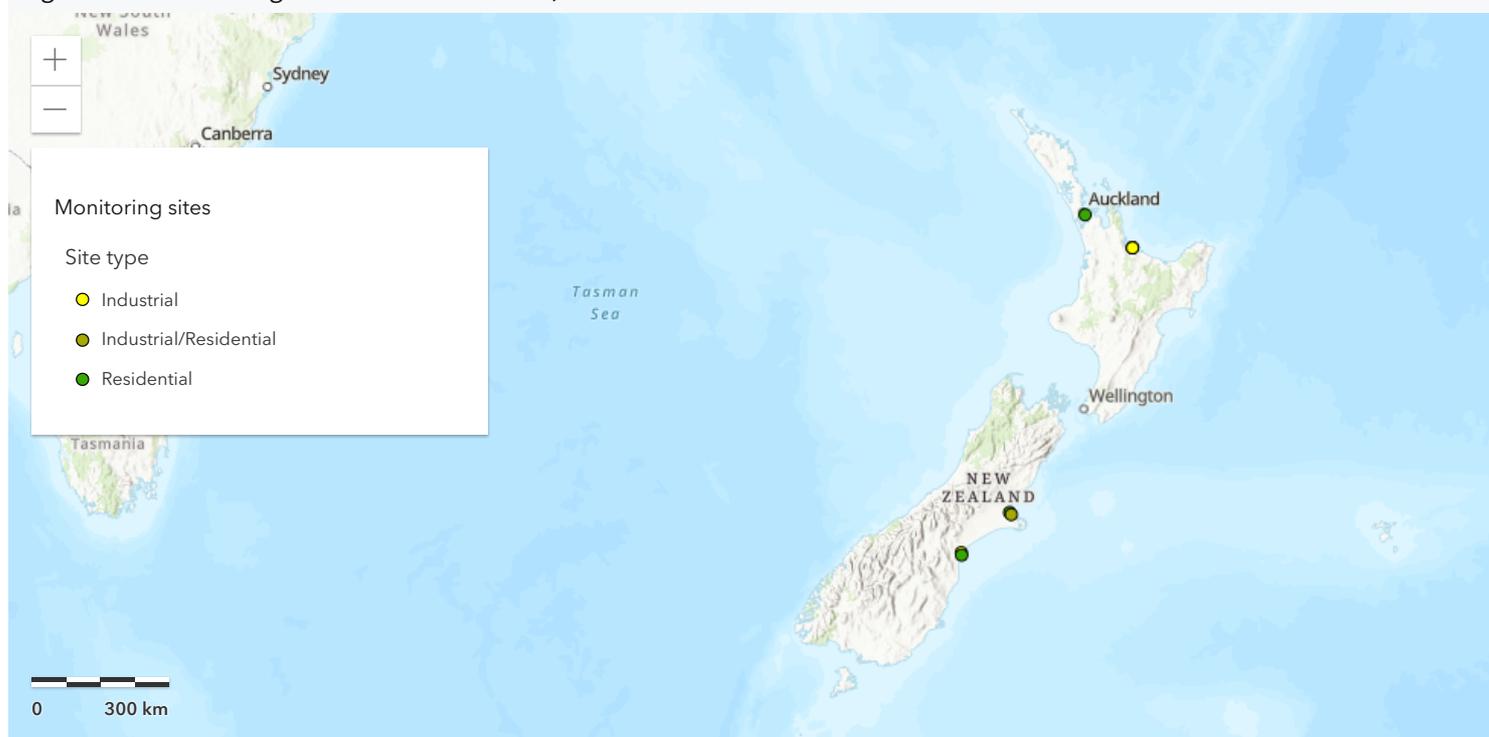
- The lower threshold of 350µg/m³ may be exceeded no more than nine times in a calendar year.
- The upper threshold of 570µg/m³ may not be exceeded even once per year.

Additionally, daily concentrations (a 24-hour average) are assessed against international WHO guidelines issued in 2021 of 40µg/m³. This value is only a recommendation and carries no regulatory weight in New Zealand.

Sulphur dioxide monitoring is limited to coastal cities

Between 2005 and 2020, eight monitoring sites across four coastal cities had valid data for SO₂ exposure (Figure 1). Three were in Mount Maunganui (Tauranga), with others in Auckland, Christchurch and Timaru. While the spatial coverage is limited, there is good rationale for siting stations in port cities, as maritime transport was responsible for 79% of the SO₂ emitted by domestic transport sources in New Zealand in 2018/19 (Kuschel, 2022). Nonetheless, some major ports such as New Plymouth and Wellington are not included in the source data for this factsheet.

Figure 1 Monitoring stations with valid data, 2005–2020



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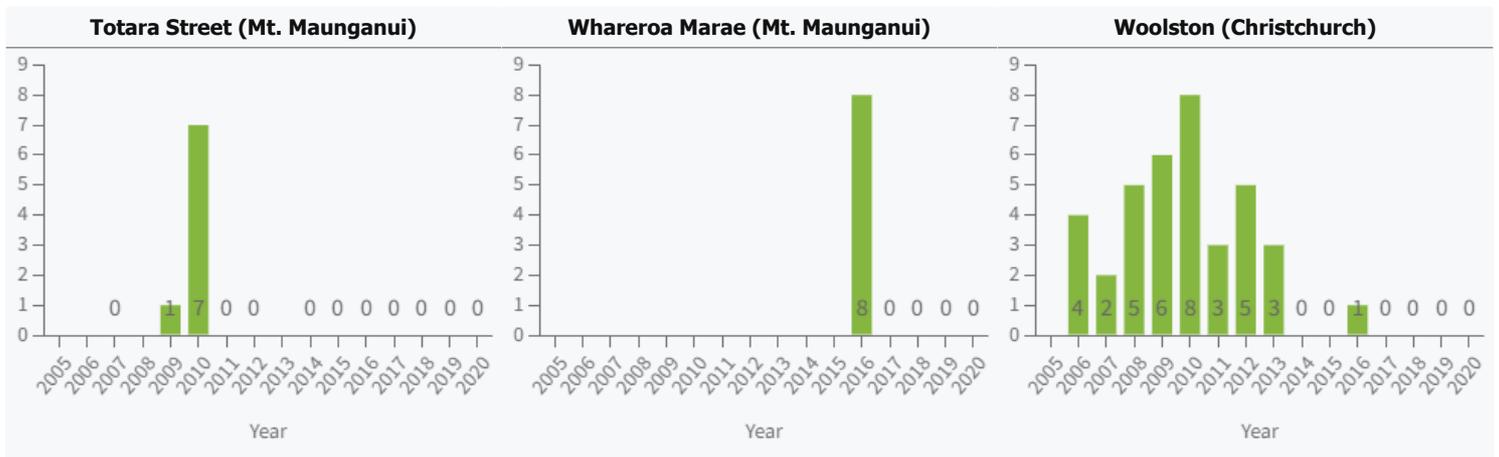
Source: Ministry for the Environment and Statistics New Zealand, 2021

Exceedances of the lower NESAQ threshold do not often occur

Three out of eight sites exceeded the lower 350 µg/m³ threshold of the national one-hour average standard between 2005 and 2020 (Figures 2a–c). The Christchurch-based station at Woolston recorded the most exceedances across this 16-year period (37 exceedances) and was the only station to record exceedances for more than two years running (Figure 2c). Woolston and Mount Maunganui’s Whareroa Marae monitoring station (Figure 2b) both had the most exceedances in a year (8 exceedances). The only other station to exceed the lower threshold was also in Mount Maunganui, north of the Marae, along Totara Street (Figure 2a). Both stations in Mount Maunganui are within 500 metres of the port of Tauranga.

None of the monitoring stations exceeded the lower NESAQ threshold more than the allowed nine times in a year.

Figures 2a–c Number of exceedances of the NESAQ’s lower threshold, 2005–2020



Note: The lower threshold is 350 µg/m³, and up to nine exceedances of this threshold in a 12-month period are allowed. Years without labels indicate 'no data' as the data for that year was either invalid or unavailable.

Source: Ministry for the Environment and Statistics New Zealand, 2021

Exceedances of the upper NESAQ threshold are rarer

The monitoring stations at Whareroa Marae and Woolston exceeded the national one-hour average standard's upper 570µg/m³ threshold twice between 2005 and 2020 (Table 1). No exceedances of the upper threshold are permitted.

Table 1 Date and recorded SO₂ concentration of NESAQ upper threshold exceedances

| Whareroa Marae (Mt. Maunganui) | | Woolston (Christchurch) | |
|--------------------------------|----------------------|-------------------------|-----------------------|
| 27 February 2016 | 5 March 2016 | 26 July 2009 | 2 June 2013 |
| 628µg/m ³ | 751µg/m ³ | 852g/m ³ | 576 µg/m ³ |

An investigation by the Bay of Plenty Regional Council suggests that the exceedances at Whareroa Marae (which occurred within eight days of each other) likely resulted from discharges by a nearby fertiliser manufacturing plant (Bay of Plenty Regional Council 2017). No specific source for the exceedances at Woolston has been identified, though the site is positioned in a busy industrial area with several potential emitters nearby.

Exceedances of the daily average WHO guideline are declining

Four out of eight monitoring stations exceeded the 2021 WHO guideline (40µg/m³) for daily average SO₂ concentration between 2005 and 2020 (Table 2). Totara Street (in Mount Maunganui) recorded the most exceedances – 142, closely followed by Woolston (in Christchurch) with 135 exceedances. However, most of these occurred before 2013, after which the number of exceedances drops. If considering only the last five years of data, nearly all exceedances were recorded in Mount Maunganui – at Whareroa Marae (38), Totara Street (16) and Tauranga Bridge Marina (5). Just four exceedances were recorded elsewhere: at Woolston in 2016, with no more recorded thereafter.

The station at Whareroa Marae was established in response to complaints about air quality from users of the Marae – the 22 exceedances in its first year of operation suggest these were well-founded. The drop in exceedances in the following years may be the result of regulatory action taken against certain emitters of SO₂ in the vicinity as a result.

While the Woolston station has historically had some of the worst concentrations of SO₂ in New Zealand, it appears that levels of the gas were greatly reduced from around 2014 onwards. Emissions in this area are mainly the result of industrial processes, so the change may be due to improvements in these processes, such as the replacement of old coal-fired boilers with more efficient models.

Table 2 Number of exceedances of the 2021 WHO daily average guideline (40µg/m³), 2005-2020

| | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|--|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| Penrose (Auckland) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Totara Street (Mt. Maunganui) | | | 14 | | 40 | 50 | 12 | 5 | | 0 | 5 | 4 | 3 | 6 | 3 | 0 |
| Tauranga Bridge Marina (Mt. Maunganui) | | | | | | | | | | | | | 0 | 1 | 1 | 3 |
| Whareroa Marae (Mt. Maunganui) | | | | | | | | | | | | 22 | 5 | 5 | 5 | 1 |
| St. Albans (Christchurch) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 |
| Woolston (Christchurch) | | 7 | 8 | 8 | 16 | 25 | 16 | 23 | 21 | 3 | 4 | 4 | 0 | 0 | 0 | 0 |
| Washdyke (Timaru) | | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| Timaru | | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Note: Blank cells indicate 'no data' as the data for that year was either invalid or unavailable.

Source: Ministry for the Environment and Statistics New Zealand, 2021

However, the 2021 WHO guideline is less stringent than the previous 2005 WHO guideline threshold of $20\mu\text{g}/\text{m}^3$. Using the 2005 threshold, the number of sites that recorded exceedances rises to six out of the eight monitoring stations (Table 3). Totara Street's total exceedances between 2005 and 2020 rise to 829 and Woolston's to 500.

Table 3 Number of exceedances of the 2005 WHO daily average guideline ($20\mu\text{g}/\text{m}^3$), 2005-2020

| | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|--|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| Penrose (Auckland) | 1 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Totara Street (Mt. Maunganui) | | | 62 | | 146 | 121 | 82 | 76 | | 6 | 47 | 57 | 39 | 93 | 100 | 0 |
| Tauranga Bridge Marina (Mt. Maunganui) | | | | | | | | | | | | | 9 | 16 | 27 | 6 |
| Whareroa Marae (Mt. Maunganui) | | | | | | | | | | | | 80 | 49 | 51 | 48 | 13 |
| St. Albans (Christchurch) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 |
| Woolston (Christchurch) | | 55 | 42 | 38 | 55 | 61 | 50 | 54 | 67 | 33 | 25 | 19 | 1 | 0 | 0 | 0 |
| Washdyke (Timaru) | | | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 5 | 3 | 1 | 0 | 0 | | |
| Timaru | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Note: Blank cells indicate 'no data' as the data for that year was either invalid or unavailable.

Source: Ministry for the Environment and Statistics New Zealand, 2021

Data for this indicator

This indicator analyses data from the most recent (2021) 'Our Air' report, part of New Zealand's environmental reporting series, published by the Ministry for the Environment and Statistics New Zealand in December 2021.

Monitoring sites exceeding the national environmental standard (one-hour average) for sulphur dioxide

Hourly average SO_2 concentration data comes from the Ministry for the Environment and Statistics NZ (Ministry for the Environment and Statistics NZ 2021) as part of New Zealand's Environmental Reporting Series. These concentrations (in $\mu\text{g}/\text{m}^3$) are compared with the National Environmental Standard for Air Quality for sulphur dioxide. The lower threshold is exceeded when concentrations exceed $350\mu\text{g}/\text{m}^3$ and the upper threshold is exceeded when concentrations are greater than $570\mu\text{g}/\text{m}^3$. The lower threshold can be exceeded nine times in a calendar year, whereas the upper threshold cannot be exceeded even once.

Monitoring sites exceeding the WHO daily guideline for sulphur dioxide

The one-hour average sulphur dioxide concentrations are used to calculate 24-hour averages, which are measured against the 2021 WHO daily average guideline. Exceedances occur when concentrations are above $40\mu\text{g}/\text{m}^3$. The previous WHO guideline of $20\mu\text{g}/\text{m}^3$ (issued in 2005) is also included for comparison.

For additional information, see the metadata link below.

References

Bay of Plenty Regional Council. 2017. *2015/2016 Regulatory Compliance Report*. Whakatāne: Bay of Plenty Regional Council Toi Moana.

Kuschel G, 2022. *Public Health Risks associated with Transport Emissions in NZ - Part 1 Stocktake and Gap Analysis as at 30 June 2021*. Report prepared by Emission Impossible Ltd for ESR, March 2022.

Ministry for the Environment and Statistics NZ. 2021. *Our Air 2021*. Wellington: Ministry for the Environment.

WHO. 2021. *WHO global air quality guidelines: particulate matter ($\text{PM}_{2.5}$ and PM_{10}), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide*. Bonn: WHO European Centre for Environment and Health.

Previous factsheet(s):
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Citation

Environmental Health Intelligence NZ, 2023. *Sulphur dioxide concentrations*. {Factsheet}. Wellington: Environmental Health Intelligence NZ, Massey University.

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