



Hokitika PM_{2.5} monitoring network

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1 INTRODUCTION

1.1 Background

12 air quality monitors measuring particles with an aerodynamic diameter of 2.5 and 10 microns (PM_{2.5} and PM₁₀) were deployed in Hokitika between 31 May and 24 September 2025 as part of a high-resolution air quality monitoring network. The purpose of the network was to measure the concentration of particulate matter across Hokitika and determine what variations in particulate matter concentration occurred across the town.

Another key project objective involved the comparison of 24-hour concentrations of both PM₁₀ and PM_{2.5} concentrations with relevant national and international standards and guidelines.

1.2 Project methodology

Prior to deployment a series of 15 minimotes were co-located at the Reefton air quality monitoring station between 2 and 27 May to check instrumental precision between the minimotes and enable the instrumental accuracy to be verified against the certified optical monitor used by the West Coast Regional Council.

On 31 May a selection of 12 minimote were removed from Reefton and transported to Hokitika. These 12 monitors were installed in representative locations intended to provide good spatial coverage of the town.

Three additional monitors were kept in Reefton at the ambient air quality monitoring station. The purpose of these three monitors was to provide spares in the event of an instrumental failure during the monitoring period and to verify that the relationship between the minimotes and certified optical reference device used at Reefton did not change during the investigation. This was achieved by:

1. Verifying that the three spare monitors maintained close agreement with the reference device throughout the monitoring period.
2. Returning the 12 minimote instruments at the conclusion of the monitoring to verify that the original co-location verification remained valid.

1.3 Instrumentation

The instruments used in this study – minimotes consist of dual Nova SDS011 optical sensors in conjunction with ambient temperature and relative humidity measurements. Each particle sensor has an individual inlet heater fitted. All minimotes used in this study had the inlet heaters set to maintain an inlet relative humidity concentration of 35% or less. This threshold was chosen specifically to maintain parity with the T640x. The relative humidity control is necessary to minimise the impact of water droplets (fog or mist) that may generate false positives.

The particle sensors transmit both PM₁₀ and PM_{2.5} concentrations every second. The minimote averages these values along with the temperature and humidity information to provide 1-

minute averages which are transmitted every 10 minutes using a privately provisioned cellular network to a secure-online data repository.

It is important to note that the minimote does not meet the requirements of [Schedule 2 of the National Environmental Standards for Air Quality](#). This schedule specifies the instrumentation that can be used to evaluate compliance with the ambient air quality standards for New Zealand. The current list of instruments is presently limited to High-volume filtration devices, Tapered Element Oscillating Microbalances and Beta Attenuation Monitors.

Schedule 2 was drafted in 2004 and is widely recognised as needing updating as the standard does not address the use of certified optical monitors including the Teledyne T640x.

The minimote uses global positioning system (GPS) to collect positional information and timing information. This information forms the basis of the time stamping used by the instrument and is usually accurate to within 40 microseconds.

While the instruments can be remotely triggered to collect particle filter samples for either gravimetric correction and/or particle speciation, those features were not used as part of this investigation.

The devices were powered using a battery pack which was recharged using a small solar panel. The devices were mounted on lighting poles at heights of between 2.5 and 3.5 metres above the ground level.

Real-time algorithms compare sensor data from both individual optical monitors and then also compare this data with other nearby units to assess the reliability of the particle information. These algorithms include a variety of statistical tests such as Kolmogorov-Smirnov, moving average, changes in orthogonal regression between instrumental data while taking into consideration the impact of meteorology.

These tests enable quantification of sensor variance and provide differentiation between instrumental and environmental anomalies which can form the basis of timely email and/or text alerts in the event of instrumental anomalies or anticipated predicted instrumental faults.

1.3.1 Instrumental evaluation

Prior to deployment, data from each instrument was averaged and compared with the other instruments. **Figure 1** below depicts the results of this intercomparison for the period from 2 to 8 May 2025. This figure demonstrates good agreement between instruments prior to deployment in Hokitika and means that any spatial variation observed between instruments while deployed in Hokitika is likely due to differences in ambient particulate concentration rather than variation in instrumental precision.

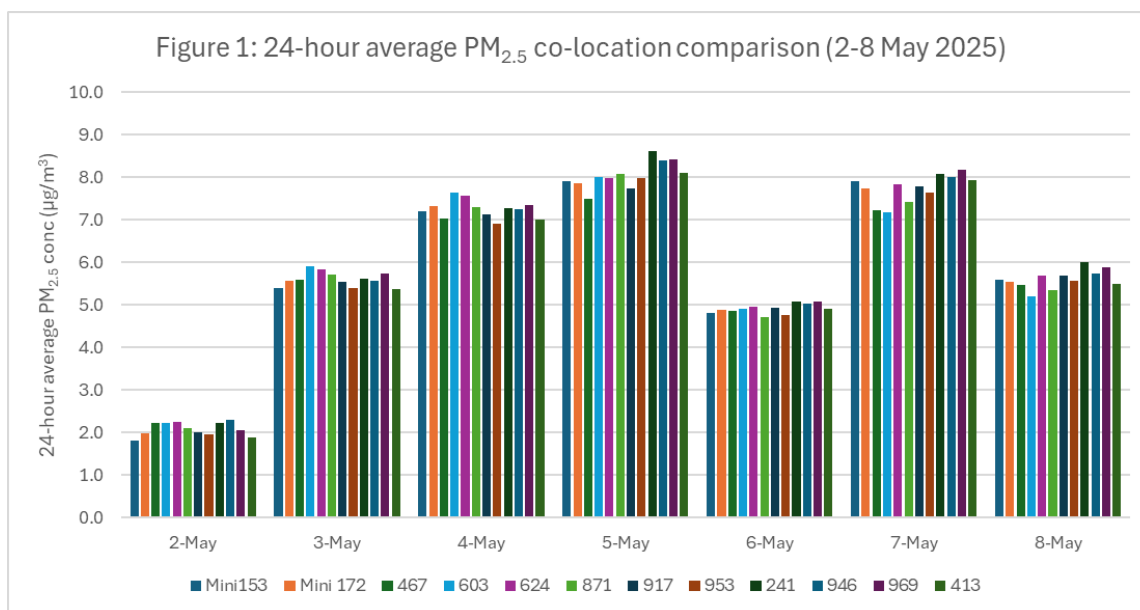


Figure 1: Comparison of the 24-hour average PM_{2.5} concentration from each of the 12 Hokitika minimotes for the period from 2 to 8 May 2025.

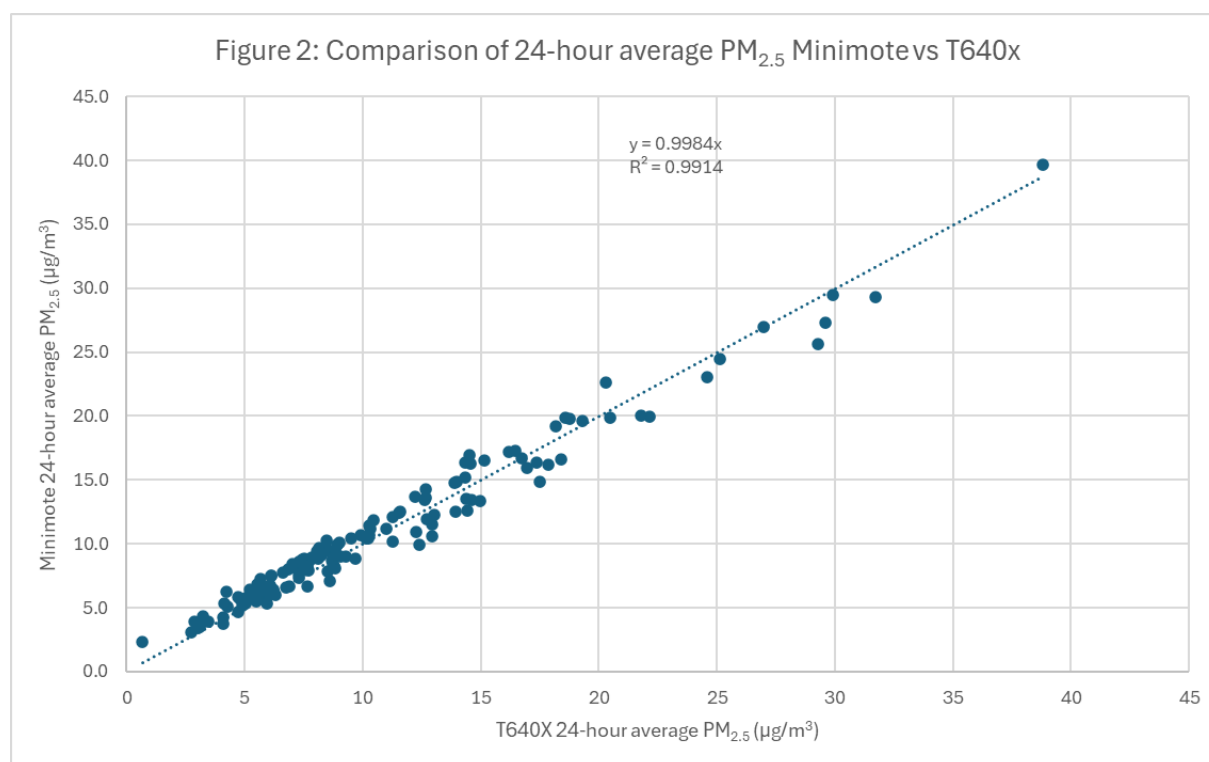


Figure 2: Scatterplot of the 24-hour average PM_{2.5} concentration from a minimote co-located with the Teledyne T640x at Reefton.

Figure 2 compares the 24-hour average PM_{2.5} concentration for the three minimotes co-located at Reefton with the Teledyne T640X instrument operated by the West Coast Regional Council. The results demonstrate good agreement between the two instruments for the duration of the intercomparison and means that the results from the minimotes deployed in Hokitika are likely to be similar to those collected by the T640x.

2 MONITORING METHODOLOGY

2.1 Monitoring Locations

Various criteria were used to select the proposed site for this investigation. Firstly, sensitive sub-populations who are particularly sensitive to elevated concentrations of particulate matter include the very young, the elderly and the infirm. For this reason, several of the sites were located alongside early learning centres, schools, retirement villages and medical facilities. Other priorities included residential and commercial zones, significant industrial sources and major road networks.

Figure 1 below displays a typical minimote instrument deployed in Hokitika. The instrument is pole mounted and positioned well above the footpath to avoid disturbing pedestrians. The solar panel is orientated to face due north, and the monitors are usually positioned on the southern side to minimise the impact of solar heating on the batteries. Instruments were usually positioned between 2.5 and 3.5 metres above ground level.



Figure 1: Image of a minimote positioned on the corner of Hall and Tudor street in Hokitika. (image taken 29/05/2025)

A map showing the location of minimotes deployed for the Hokitika survey are shown in **Figure 2** below.



Figure 2: Location of minimote instruments in Hokitika (yellow dots).

2.2 Data analysis

Data from the instrumental network was assessed each day to identify any faults or issues within the network. **Figure 3** below is a typical comparative plot of the real-time data from the 12 minimotes in Hokitika and the 3 minimotes in Riefton.

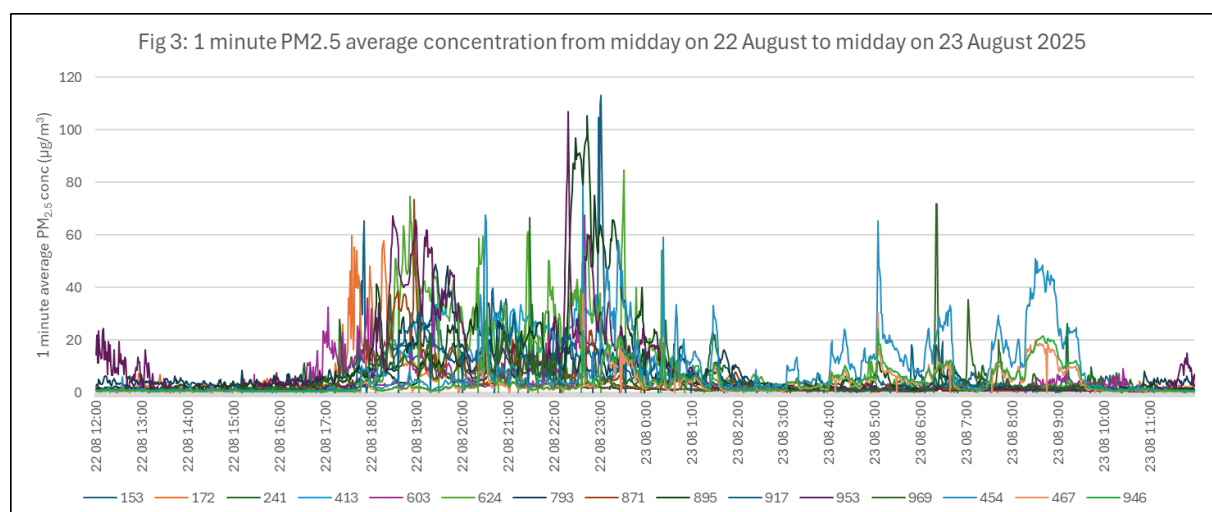


Figure 3: Plot of the 1-minute average $PM_{2.5}$ concentration from each of the deployed minimotes in Hokitika and Riefton from midday on 22 August to midday on 23 August 2025.

The 1-minute data was used to calculate hourly and 24-hourly averages for both PM_{10} and $PM_{2.5}$ for each of the 12 monitoring sites. A spreadsheet containing the 1-hour and 24-hour

averages for each of the sites is provided with this report as an excel spreadsheet entitled **Hokitika_2025_PMData.xls**.

3 SAMPLE RESULTS

3.1 Data capture

The sampling period commenced at 11am on 31 May and continued through until 2pm on 24 September, representing a total of 2788 hours of monitoring.

Collectively the network of 12 monitors in Hokitika had an average data collection rate of 98.7% with individual monitors ranging from 95.2 and 100% data capture. The lowest data capture rate of 95.2% was recorded by the monitor adjacent to the Hokitika library and the solar panel was stolen on 21 September which impacted the data capture rate for this instrument.

3.2 PM_{2.5} results

The figures below extrapolate data from each monitoring site assuming linear changes in concentrations between sites. In reality, changes in concentrations of particulate matter are unlikely to be linear, particularly where significant changes in concentration between sites occurs. These extrapolations are included for illustrative purposes to visually depict the variation in PM concentration between sites in Hokitika during the 2025 winter monitoring period.

Figure 4 below depicts the highest 24-hour average PM_{2.5} concentrations at each of the 12 sites. This is a constructed image – that is, the 95th percentile concentrations did not all occur on the same day at all sites. The purpose of **Figure 4** is to illustrate the variation in PM_{2.5} concentrations across Hokitika. As can be seen, the highest concentration (14 micrograms per cubic meter as the 95th percentile) occurred near the western end of Tudor Street. Elevated concentrations were also observed near the commercial area in Sewell Street with a smaller peak located near the southern end of Rolleston Street.

The World Health Organisation 24-hour guideline for PM_{2.5} is 15 µg/m³ and all monitoring sites in Hokitika complied with this guideline during the 2025 winter monitoring period.

Maximum 24-hour PM_{2.5} concentration measured at each site in Hokitika between 31 May and 24 September 2025

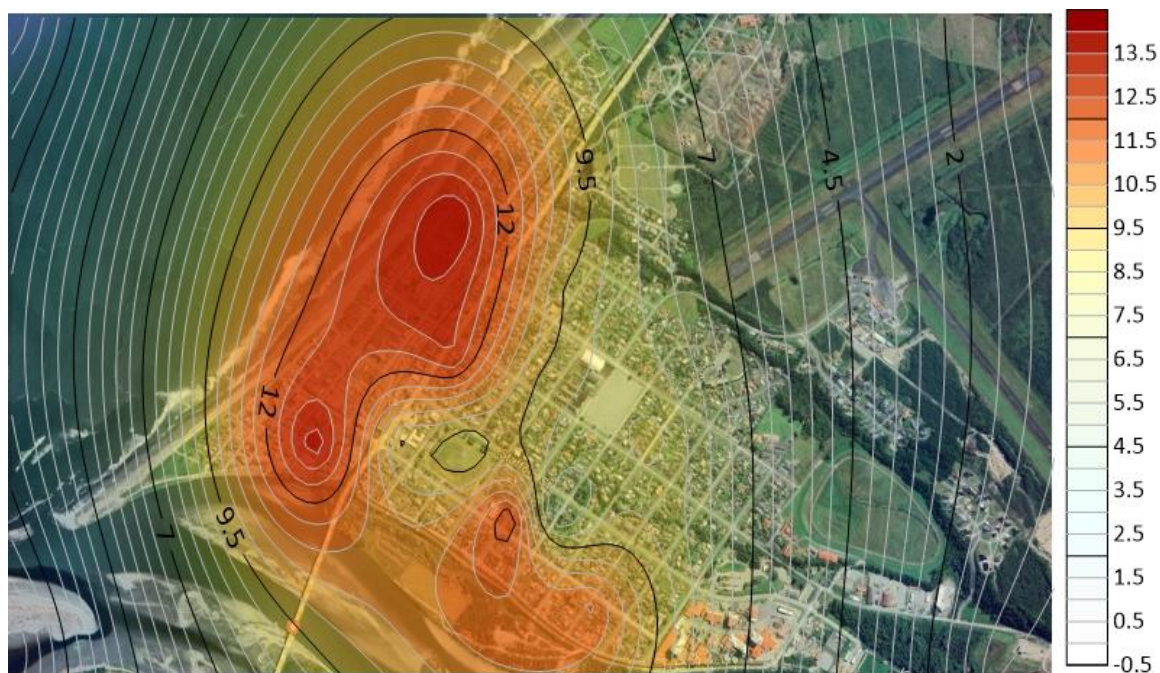


Figure 4: Isopleth map of highest PM_{2.5} concentration (95th percentile) as measured across 12 sites in Hokitika between 31 May and 24 September 2025

This study only monitored the PM_{2.5} concentrations during the winter of 2025 which is typically when particulate concentrations are elevated due to reduced atmospheric circulation during boundary level capping inversions enabling pollutants from domestic fires to accumulate. **Figure 5** below displays the geometric mean concentration for the entire winter monitoring period. This image represents the “average” PM_{2.5} concentration across Hokitika as measured during the 2025 winter (31 May to 24 September).

Most of Hokitika experienced relatively modest concentrations of below 5 µg/m³. Slightly higher average concentrations of between 5.5 and 6.0 µg/m³ were observed around the commercial areas in Hokitika, with a smaller peak of 6.5 µg/m³ recorded in the southern section of Sewell Street. The black contour line in **Figure 5** represents the 5 microgram per cubic meter isopleth. A comparison of the geometric mean against the World Health Organisation annual guideline of 5 µg/m³ is not appropriate as the data from this study only covers the winter period.

In reality, lower levels of particulate matter during the warmer months mean that average annual concentrations will be much lower than the values displayed in **Figure 5** and likely indicate that Hokitika township would comply with the annual World Health Organisation PM_{2.5} guideline.

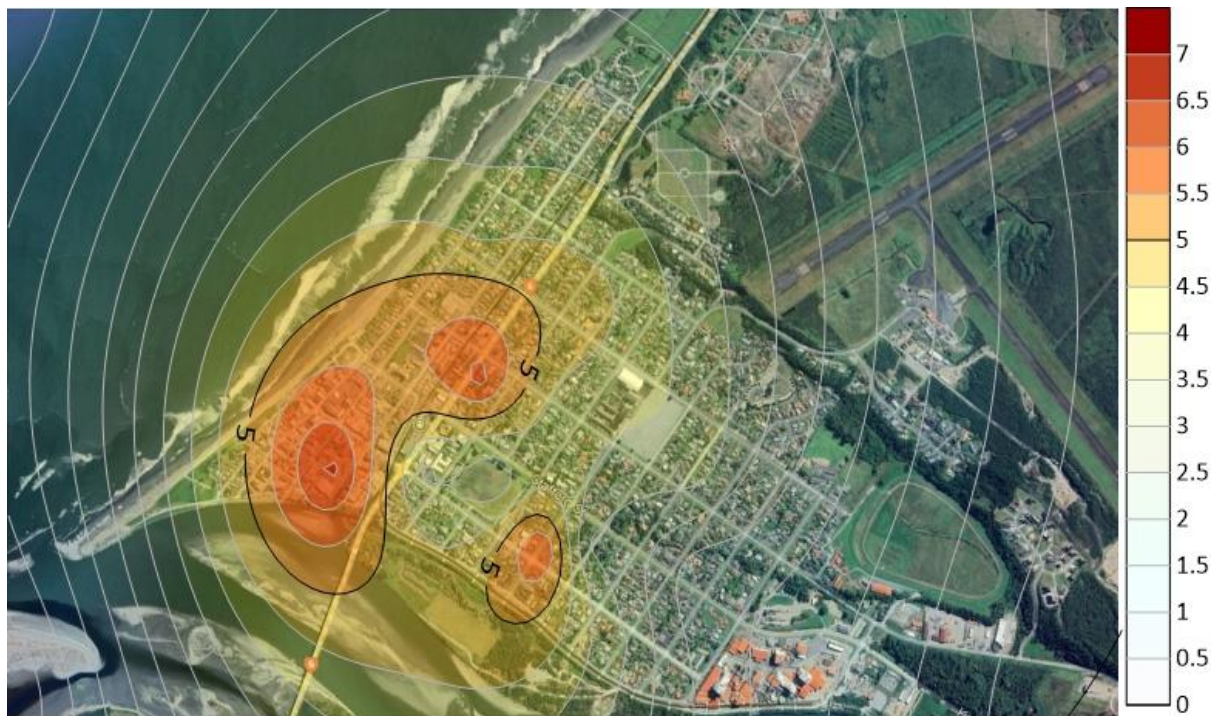


Figure 5: Isopleth map of the geometric mean of all measured 24-hour average PM_{2.5} concentrations at each of the 12 sites in Hokitika between 31 May and 24 September 2025.

3.3 PM₁₀ results

While the primary purpose of this project was to identify the variation in PM_{2.5} concentrations in Hokitika, the minimotes also recorded PM₁₀ concentrations and the following plots display the variation in 24-hour average PM₁₀ concentrations in Hokitika during the 2025 winter study. The proximity to the coastline suggests that sea salt may be a significant component of particulate concentrations – especially in western areas. There may be some benefit in performing some source apportionment work in this area to distinguish between anthropogenic and natural sources of particulate matter.

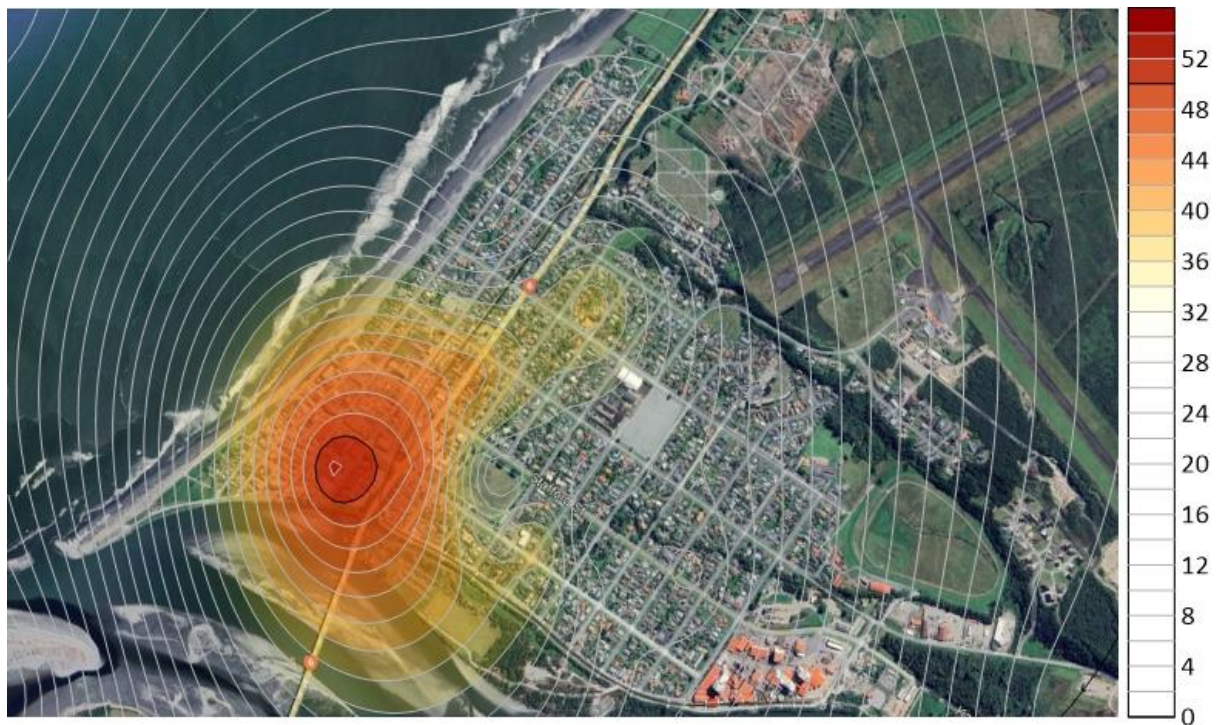


Figure 6: Isopleth map of highest PM₁₀ concentration as measured across 12 sites in Hokitika between 31 May and 24 September 2025

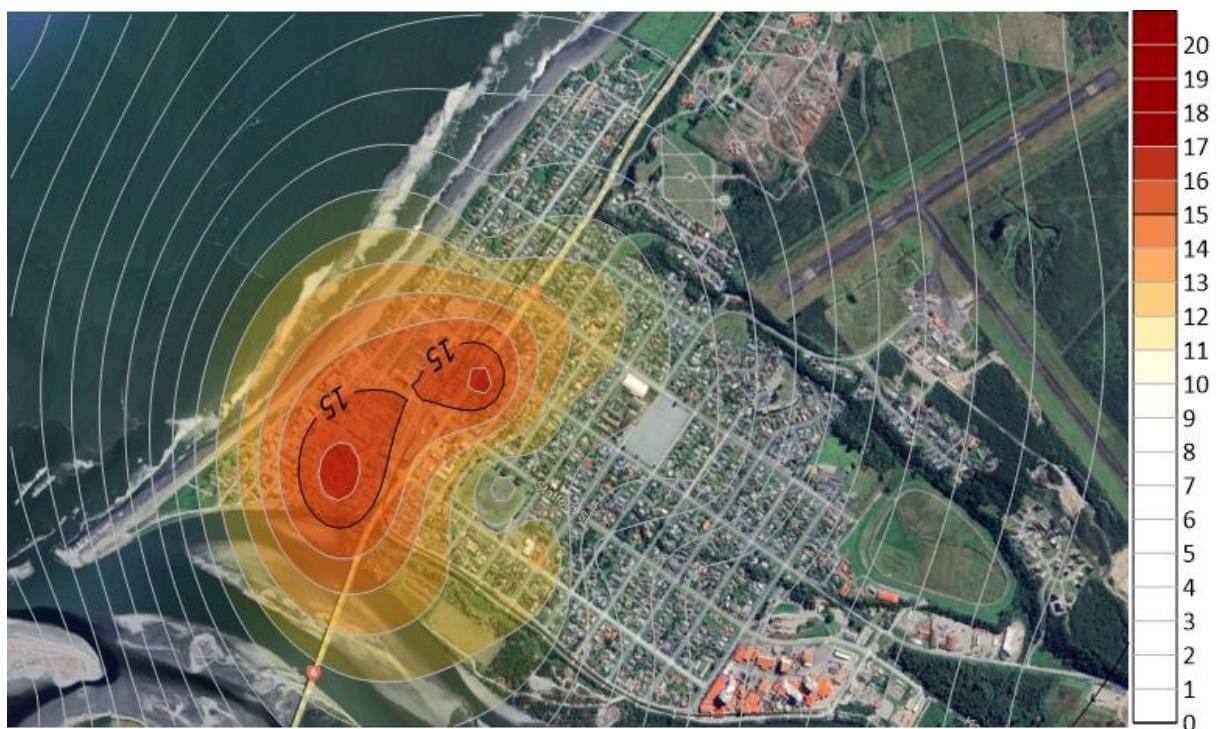


Figure 7: Isopleth map of the geometric mean of all measured 24-hour average PM₁₀ concentrations at each of the 12 sites in Hokitika between 31 May and 24 September 2025.

The variation in PM₁₀ concentration is broadly similar to the PM_{2.5} plots indicating related sources. The highest concentrations were observed in the western parts of Hokitika with lower concentrations generally observed at eastern sites. As noted above, these results could be impacted by contributions from sea salt.

Previous work by NIWA¹ indicated that the T640x over-reports PM₁₀ data and that an adjustment to the data was recommended to correct the data. The West Coast Regional Council (WCRC) performed a similar comparison to the Teledyne T640x in Westport during 2023. The more recent Westport co-location results were used to adjust both the PM_{2.5} and PM₁₀ data collected during the 2025 Hokitika investigation. The 2023 Westport co-location adjustments were selected in preference to the 2021 NIWA investigation for several reasons including:

1. Being coastal, some particulate matter in Westport is likely to include marine sea salt which is less likely to be present in Reefton. It is possible that addition of marine sea salt as particulate material could result in small differences in the optical instrumental response from the T640x device.
2. The airshed components in Westport will include both coal and wood particulate matter from domestic home heating while Reefton has a much higher proportion of coal particulate matter. It is possible that this difference in combustion particle origin could result in small differences in the optical instrumental response from the T640x device.
3. The Westport data includes adjustments for both PM₁₀ and PM_{2.5} while the 2021 NIWA investigation encountered an instrumental issue with the collection of coarse particulate matter and derived an interim adjustment factor to account for this.

The adjustment factors used for the PM_{2.5} and PM₁₀ datasets were based upon the RMA regression equations developed by the West Coast Regional Council based upon the 2023 monitoring period.

PM_{2.5} – RM = 0.42 T640x

PM₁₀ – RM = 0.60 T640x

When this adjustment was made to the PM₁₀ data collected by the minimotes in this investigation, it confirmed that all but one site in Hokitika met the 24-hour PM₁₀ National Environmental Standard of 50 µg/m³ for PM₁₀ during the 2025 winter study. The Sewell Street monitoring site recorded a peak 24-hour concentration of 52.7 µg/m³ on 18 September and 50.6 µg/m³ on 28 June. The standard allows for one exceedance of the national standard in any 12-month period. A second exceedance of the standard within the 12-month period is potentially a breach of the standard. There are several important points to note in relation to the Sewell street monitor.

1. As will be noted in Section 4 below, the minimotes used in this investigation do not meet the instrumental requirements specified in Schedule 2 of the National Environmental Standards for Air Quality. There is a higher level of uncertainty associated with the use of these instruments which means that care needs to be taken when directly comparing the results with any national standard or guideline.
2. The estimated level of uncertainty associated with the instruments used in this investigation is estimated to be +/- 5 µg/m³. Both exceedances measured at the Sewell Street site are within the expected level of uncertainty for this type of instrument.
3. Based upon the monitoring data collected from the monitoring instruments deployed in Hokitika, all remaining monitors complied with the relevant national environmental standard. This suggests that even if the instrumental measurements were correct, the

¹ An investigation of the performance of different PM monitors in Reefton, NIWA 2021

elevated concentrations are likely to be restricted to a relatively small area and are not representative of air quality in the wider Hokitika community.

Despite these observations, it is evident that elevated concentrations of PM₁₀ occur during winter conditions and that there is merit in periodically checking the PM₁₀ concentrations to verify that PM₁₀ concentrations in Hokitika are reducing over time.

A similar comparison with PM_{2.5} data confirmed that all monitoring sites during the 2025 winter monitoring programme complied with the WHO 24-hour guideline value of 15 µg/m³. The highest 24-hour PM_{2.5} concentration 14 µg/m³ was measured at Tudor Street. The Sewell Street site which was noted above as having potentially exceeded the PM₁₀ National Environmental Standard for Air Quality recorded a maximum 24-hour PM_{2.5} concentration of 13.9 µg/m³.

4 LIMITATIONS

The major limitation of the minimotes used in this investigation is that they do not meet the requirements of Schedule 2 of the 2004 National Environmental Standards for Air Quality. However, the instruments do compare favourably with the Teledyne T640x certified optical instrument used by the West Coast Regional Council to monitor air quality.

A comparison of both the $PM_{2.5}$ and PM_{10} 24-hour average concentrations with the T640x monitor confirmed that the coefficient of determination was 0.99 and 0.98 respectively. These values mean that the data collected by the instruments is likely to be similar to those measured by the Teledyne T640x monitor.

5 SUMMARY

An investigation into the variation in ambient particulate matter concentrations of PM_{2.5} and PM₁₀ were monitored during the 2025 winter (31 May – 24 September) using a network of 12 small, distributed monitors. The overall data capture rates for these instruments were 97.3%. There was a small loss of data resulting from the theft of a solar panel at one site.

The recorded data was adjusted based upon co-location information between gravimetric and optical particle monitors located at Westport during 2023.

All monitoring sites in Hokitika were found to comply with the World Health Organization 24-hour PM_{2.5} guideline of 15 µg/m³. The highest 24-hour concentrations of 14 and 13.9 µg/m³ occurred on the western section of Tudor Street and the southern section of Sewell Street respectively.

One monitoring site (southern end of Sewell Street) was found to have exceeded the National Environmental Standard for PM₁₀ of 50 micrograms per cubic metre. The Sewell Street monitoring site recorded a peak 24-hour concentration of 52.7 µg/m³ on 18 September and 50.6 µg/m³ on 28 June. The standard allows for one exceedance of the National Environmental Standard in any 12-month period. A second exceedance of the standard within the 12-month period is potentially a breach of the standard. However, it is important to note that the monitoring instruments do not meet the requirements of Schedule 2 of the National Environmental Standards. Also, both exceedances are within the margin of error of the instrumentation. Finally, only one of the 12 monitoring sites actually recorded a breach of the standard suggesting that any breach is probably localised and could be impacted by close proximity to an emission source (although no obvious sources were identified during installation).

6 REFERENCES

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