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PREPARED FOR

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Air quality management in Nelson – the potential impact of an annual average $PM_{2.5}$ NES

EXECUTIVE SUMMARY

The Ministry for the Environment is in carrying out a review how particulate matter is managed with particular focus being given to whether $PM_{2.5}$ should be monitored across the country and the value of setting rules for $PM_{2.5}$ and long term exposure. The review arises as a result of a Parliamentary Commission for the Environment Report (2015) report on the state of air quality in New Zealand.

Nelson City Council is in the process of an Air Plan review with priority being given to assessing rule options for wood burners. The objective of this report is to evaluate the possible implications of the introduction of a National Environmental Standard (NES) for annual average $PM_{2.5}$. Compliance with the WHO 24-hour average $PM_{2.5}$ guideline is also considered.

Current World Health Organisation guidelines for $PM_{2.5}$ are 10 $\mu g/m^3$ (annual average) and 25 $\mu g/m^3$ (24-hour average, three allowable exceedences). A recent report by WHO recommends a review of the $PM_{2.5}$ guidelines as a result of health impacts literature which suggest a lower long term (annual) guideline may be required.

Monitoring of $PM_{2.5}$ in Nelson is limited to Airshed A. Annual average $PM_{2.5}$ concentrations for each Airshed have been estimated based on $PM_{2.5}$ monitoring data for Airshed A, ratios of $PM_{2.5}$ to PM_{10} and integrating source apportionment data where required. Monitoring of $PM_{2.5}$ for Airsheds B1, B2 and C is required to confirm the estimates. Ongoing monitoring of $PM_{2.5}$ in Airshed A is also recommended to increase certainty around current concentrations.

The assessment does not include an evaluation for worst case year in terms of meteorology.

Annual average $PM_{2.5}$

Results suggest Airshed A and Airshed B1 are unlikely to comply with the existing WHO guideline for annual average $PM_{2.5}$ (10 $\mu g/m^3$). Airsheds B2 and C are likely to comply with the existing WHO annual average guideline for $PM_{2.5}$. If the guideline were reduced to 8 $\mu g/m^3$ Airsheds A, B1 and B2 are all likely to be non-compliant. Airshed C may be compliant.

In Airshed A, domestic heating within the Airshed is likely to contribute around 42% of the annual average PM_{10} concentrations and around 65% of the annual average $PM_{2.5}$ concentrations. A further 8% of the $PM_{2.5}$ concentrations are likely to arise from domestic heating emissions in other Airsheds. The next largest contributor to annual average $PM_{2.5}$ concentrations is estimated to be natural sources at 15%. Domestic heating would therefore need to be the focus of any reduction in $PM_{2.5}$ concentrations to meet an annual average concentration of 10 $\mu g/m^3$.

In Airshed B1 domestic heating is estimated to contribute around 22% (including other Airshed contributions) of the annual average PM_{10} and 38% of the annual average $PM_{2.5}$ concentrations. In this Airshed industry is estimated to be the main contributor to annual average concentrations for both PM_{10} and $PM_{2.5}$ based on a mass emissions approach. However, this does not account for the increased dispersion associated with some industrial sources and it is there likely that the industry contribution is overestimated. Monitoring is recommended to confirm $PM_{2.5}$ concentrations as there is more uncertainty with the method of estimation in this Airshed.

In Airshed A, a reduction in PM_{10} concentrations is required to meet the current NES for PM_{10} (24-hour average, one allowable exceedance). If PM_{10} concentrations are reduced by 14% it is likely that the annual average $PM_{2.5}$ concentrations would reduce to below 10 $\mu g/m^3$. However, more monitoring is recommended to increase certainty around current annual average $PM_{2.5}$ concentrations.

In Airshed B1 it is likely that the 24-hour average PM_{10} concentrations already meet the NES for $PM_{10.}$ The estimate of annual average $PM_{2.5}$ concentration for this Airshed is 12 $\mu g/m^3$ and was estimated based on subtracting coarse fraction sources from PM_{10} concentrations. Reductions in PM_{10} concentrations associated with the natural attrition replacement of older burners is unlikely to reduce annual $PM_{2.5}$ concentrations by sufficient amounts to achieve an annual standard of 10 $\mu g/m^3$ for $PM_{2.5}$.

24-hour average $PM_{2.5}$

Airsheds A and B1 are unlikely to comply with a 24-hour average $PM_{2.5}$ standard with reductions of around 20-30% in Airshed A and possibly up to around 15% in Airshed B1 to achieve compliance. Airshed B2 may be compliant although monitoring is required to confirm this. It is likely that Airshed C would comply with a 24-hour average $PM_{2.5}$ standard of 25 µg/m^3.

Recommendations

1. It is recommended that priority be given to monitoring of $PM_{2.5}$ in Airshed B1 and that the monitoring period include both seasons to enable calculation of annual average concentrations. A one it two day sampling regime should suffice while monitoring is investigative.

2. Investigative monitoring of $PM_{2.5}$ in Airshed A should continue to confirm existing annual average concentrations. A one day in two sampling regime should suffice. Continuous monitoring (every day) may be required in the future if a $PM_{2.5}$ NES is introduced and the Airshed is found to be non-compliant.

3. Investigative monitoring of $PM_{2.5}$ would also be required in Airsheds B2 and C (e.g., for two years in each location depending on results) if an NES for $PM_{2.5}$ was established.

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1 INTRODUCTION

A 2015 review of the state of air quality in New Zealand by the Parliamentary Commissioner for the Environment recommended that the Minister for the Environment review how particulate matter is managed with particular focus being given to whether $PM_{2.5}$ should be monitored across the country and the value of setting rules for $PM_{2.5}$ and long term exposure. The focus on $PM_{2.5}$ and annual average exposure is consistent with a recent WHO report (World Health Organization, 2013) which places priority on annual average exposure and indicates that it is likely that WHO would review both short and long term guidelines for $PM_{2.5}$ and potentially for PM_{10}.

A $PM_{2.5}$ standard or guideline was not included for New Zealand in the National Environmental Standard because it was proposed that management of PM_{10} to meet the NESAQ would result in reductions in concentrations of $PM_{2.5}$ and because it was argued that the coarse fraction did result in health impacts. This management by proxy position is unlikely to be considered robust in terms of future reviews of New Zealand guidelines and standards given the increased evidence with respect to long term exposures and impacts of $PM_{2.5}$.

The Nelson City Council's Air Plan became operative in 2008. The Plan included management measures targeting domestic home heating as the main source of winter time breaches of the National Environmental Standard (NES) for PM_{10}. The plan aimed to reduce PM_{10} concentrations in Nelson's Airshed A by 70% and in other Airsheds by lesser amounts. The measures included in the Air Plan were:

i. A ban on outdoor rubbish burning from 2004

ii. Emission limits for new installations of solid fuel burners of 1.5 g/kg and an energy efficiency of 65% (when tested to NZS 4013).

iii. A ban on the use of open fires from January 2008.

iv. A ban on the installation of solid fuel burners in new dwellings or existing dwellings using other heating methods from November 2008.

v. Airshed A and B1 - staged phase out of older burners from 2010, 2011 and 2013. The latter phase out date of wood burners installed between 2000 and 2003 was withdrawn following 2011 revisions to the NES. This resulted in approximately 120 burners in Airshed A which did not get phased out and for which no legislative replacement date currently exists.

vi. Airshed B2 – staged phase out of older (pre 1990s burners) by 2010 and pre 1995 burners by 2012.

An evaluation of the effectiveness of the Air Plan in reducing PM_{10} concentrations in Nelson to meet the NES was carried out in 2014 (Wilton, 2014). Results suggested significant reductions in concentrations in Airshed A and B1 where concentrations in breach of the NES historically occurred. Additional reductions in 2014 levels of around 14% are likely to be required for ongoing compliance with the NES in Airshed A (Wilton & Zawar Reza, 2014).

Nelson City Council are in the process of an Air Plan review. Understanding the relationship between sources of 24-hour average PM_{10} concentrations and annual average $PM_{2.5}$ concentrations will enable the Council to more effectively manage air quality.

Depending on the contributions of natural sources to PM_{10} events, it is likely that many urban areas would require more stringent management to reach a guideline of 25 $\mu g/m^3$ for $PM_{2.5}$ (as recommended in WHO (2006) than to reach a target of 50 $\mu g/m^3$ for PM_{10}. However, if an annual average $PM_{2.5}$ standard alone is adopted it may influence the extent of focus on required on solid fuel burning for domestic home heating. An understanding of the relationship between the contribution of domestic heating to a 24-hour average PM_{10} standard relative to an annual average $PM_{2.5}$ standard is necessary to future proof the outcomes of the Air Plan Review.

The objectives of this study are to advise NCC on:

- The likely annual average $PM_{2.5}$ concentrations in Nelson relative to existing and possible future WHO annual average $PM_{2.5}$ guidelines.
- The likely relative contribution of domestic heating to annual average $PM_{2.5}$ concentrations in Nelson.

- The likely implications of a 24-hour average NES for $PM_{2.5}$ (relative to the existing PM_{10} NES) in Nelson based on the current WHO value of 25 µg/m^3.
- The likely implications of an annual average NES for $PM_{2.5}$ (relative to the existing 24-hour average PM_{10} NES) in Nelson based on the current WHO value of 10 µg/m^3.
- The likely impact of management measures to reduce 24-hour average PM_{10} concentrations to meet the NES in Airshed A and B1 on annual average $PM_{2.5}$ concentrations.
- The likely impact of allowing installations of solid fuel burners in new houses and existing dwellings currently using other heating methods in Airshed B2 and C on annual average $PM_{2.5}$ concentrations.

1.1 WHO guidelines and recommendations for PM_{10} and $PM_{2.5}$

The World Health Organisation (WHO) is the directing and coordinating authority for health within the United Nations system. It is responsible for providing leadership on global health matters, shaping the health research agenda, setting norms and standards, articulating evidence-based policy options, providing technical support to countries and monitoring and assessing health trends ("World Health Organisation," 2014).

The current WHO guidelines are:

- PM_{10} - 50 µg m^{-3} (24-hour average, three allowable exceedences) and 20 µg m^{-3} annual average.
- $PM_{2.5}$ - 25 µg m^{-3} (24-hour average, three allowable exceedences) and 10 µg m^{-3} (annual average) (World Health Organization, 2006).

Technical supporting documentation indicates that particulate is considered a no threshold contaminant (there is no safe threshold) and that there is insufficient evidence for policy differentiation based on composition.

In 2013 the WHO conducted a review of evidence for air quality guidelines. The review identified new health outcomes associated with exposure to particulate concentrations, additional support for other health outcomes and makes recommendations that WHO review both short and long term guidelines for $PM_{2.5}$ and potentially for PM_{10}.

2 PM_{10} AND $PM_{2.5}$ MONITORING

Air quality in Nelson is managed based on four areas referred to as Airsheds. Figure 2.1 shows the boundaries of the existing Airsheds within Nelson. The distribution of emissions within these Airsheds is shown in Appendix A. Air quality monitoring for PM_{10} has been carried out in Airshed A using continuous monitoring since 2001 and in Airshed B1 since 2005. Air quality monitoring of $PM_{2.5}$ using gravimetric sampling based on a one day in six sampling regime has been carried out in Airshed A since 2008.

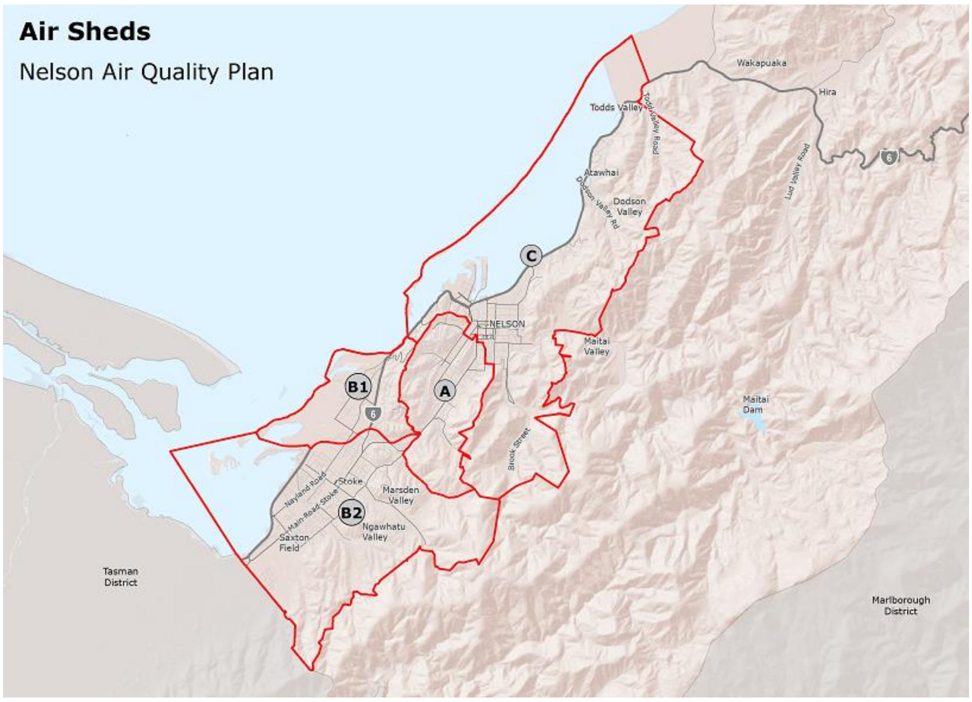

Figure 2-1: Nelson Airshed Areas

Monitoring of PM_{10} in Airsheds B2 and C has been intermittent with monitoring conducted in 2010 and 2015 in Airshed B2 and 2008, 2009, 2014 and 2015 in Airshed C. Monitoring was also carried out at a range of locations in Airshed B2 and C in the early 2000s.

An additional study of value when considering the contribution of PM_{10} and $PM_{2.5}$ and sources was a receptor modelling apportionment study carried out in Airshed A (Ancelet, Davy, & Trompetter, 2013) from 2008 to 2012 and in Airshed B1 (Ancelet, Davy, Trompetter, & Markwitz, 2010) in 2008 and 2009. The study in Airshed A included by the PM_{10} and $PM_{2.5}$ size fraction and is of value in illustrating the impact of natural sources within both size fractions. For PM_{10} a greater contribution from natural sources is expected because of the nature of the mechanism of formation. In Airshed A the average contribution of marine aerosol and soil/ dust to PM_{10} was found to be around 6.6 $\mu g/m^3$ for a sampling period from May to September. In comparison the contribution of the same sources to $PM_{2.5}$ concentrations was found to be 1.2 $\mu g/m^3$ on average. Because the majority of other sources of PM_{10} lie within the $PM_{2.5}$ size fraction, the relative contribution of natural source contributions to $PM_{2.5}$ concentrations is lower than for PM_{10} concentrations. It would therefore be expected that anthropogenic sources of particulate such as domestic heating and motor vehicles would have a greater proportional contribution to annual average $PM_{2.5}$ than annual average PM_{10}.

In Airshed B2 the receptor modelling study focused only on the PM_{10} size fraction. Two additional industry related sources (fertiliser and surface coating) were identified in this Airshed and were found to contribute 13% of the PM_{10} (Ancelet et al., 2010). These contributions are most likely to be in the coarse mode ($PM_{10-2.5}$) owing to the mechanisms of formation. Marine aerosol was found to contribute 18% and soil 16% of the PM_{10} over the duration of the sampling.

3 AIRSHED A

3.1 Annual average $PM_{2.5}$ concentrations

Monitoring of $PM_{2.5}$ has been carried out in Airshed A using a gravimetric one day in six sampling regime since 2008 at the St Vincent Street air quality monitoring site. An estimate of the likely annual average $PM_{2.5}$ concentration per year from 2008 to 2014 has been made for Airshed A using the following methodology. No $PM_{2.5}$ data were available for 2015 at the time this report was prepared.

For all years except 2013

Annual average $PM_{2.5}$ and PM_{10} concentrations were estimated based on seasonally adjusted concentrations for $PM_{2.5}$ sample days. A ratio of $PM_{2.5}$ to PM_{10} was established based on these data. The annual average PM_{10} (all sample days) was multiplied by the $PM_{2.5}$ to PM_{10} ratio for that year to give an annual average $PM_{2.5}$ concentration.

For 2013

Sample days for $PM_{2.5}$ during 2013 were limited to only eight samples for the whole of winter and 22 samples for non-winter months. Estimates of annual average concentrations of $PM_{2.5}$ were made for 2013 based on PM_{10} data using the following ratios:

- May – August – 86% (based on median annual ratio)
- Other months – 54% (based on median annual ratio)

Table 3.1 compares the annual average $PM_{2.5}$ and PM_{10} concentrations as well as the seasonal relationships and differences between data and existing WHO guidelines or NES for Airshed A. This shows the winter concentrations of $PM_{2.5}$ are much higher (22 – 40 µg/m^3) than the concentrations during the non-winter months (5-7 µg/m^3). Winter concentrations of $PM_{2.5}$ are likely to have reduced from 36-40 µg/m^3 around 2008 and 2009 to around 22-23 µg/m^3 during 2013-2014. Based on the ratio of $PM_{2.5}$ to PM_{10} for 2008 (75%) the annual average $PM_{2.5}$ concentration for 2001 is likely to have been around 26 µg/m^3. Estimated annual average $PM_{2.5}$ concentrations for 2014 exceed the annual WHO guideline for $PM_{2.5}$ of 10 µg/m^3. Data for PM_{10} for 2015 suggest an annual average $PM_{2.5}$ concentration is likely to be more similar to 2013 than 2014. The assessment does not include an evaluation for worst case year in terms of meteorology.

Table 3.1: Summary PM_{10} and estimated $PM_{2.5}$ data for Airshed A

	2008	2009	2010	2011	2012	2013	2014	2015
Annual average $PM_{2.5}$ (estimated)	16	17	13	13	13	12.5	11	
Annual average PM_{10}	21	22	18	18	17	18	17	
Average winter $PM_{2.5}$ (µg/m^3)	36	40	28	27	26	24	23	
Average (non-winter) $PM_{2.5}$ (µg/m^3)	6	7	7	7	6	7	5	
Reduction to meet annual average $PM_{2.5}$ of 10 µg/m^3	37%	40%	23%	21%	22%	20%	9%	
Second highest PM_{10} (24-hour average)	69	77	58	64	53	58	52	49
Reduction to meet 24-hour average 50 µg/m^3	28%	35%	14%	22%	6%	14%*	4%*	0%*

Winter = May to August

*note that the reduction required in 2014 PM_{10} concentrations to meet this limit has been estimated at 14% based on worst case meteorology to date.

** data from January to April only

The percentage reduction in concentrations required for the annual average $PM_{2.5}$ concentration to meet a limit of 10 µg/m^3 (WHO current annual average guideline) and the second highest daily PM_{10} concentration to meet the existing NES limit for New Zealand (50 µg/m^3 24-hour average) is also shown in Table 3.1.

It is also worth noting that there is a difference in the way year to year variability in meteorological conditions impacts on these two different exposure periods. For the 24-hour average the influencing factor is the extent of impact of meteorology on a given day. That is, how low the wind speeds are and how stable the lower atmosphere whereas for the annual average the frequency of calm stable conditions is a key variable.

3.2 Comparison of annual average concentrations to WHO guidelines

The WHO annual average guideline for PM_{10} is 20 µg/m^3. Monitoring data from St Vincent Street shows Airshed A has been compliant with this guideline since 2010.

The WHO annual average guideline for $PM_{2.5}$ is 10 µg/m^3. Recent annual average $PM_{2.5}$ concentrations have been estimated at around 11- 13 µg/m^3.

Airshed A is unlikely to comply with the current WHO annual average $PM_{2.5}$ guideline and potential future reductions in this guideline would further limit compliance.

Data suggests the reduction required to meet an annual average $PM_{2.5}$ guideline (9-20%) in Airshed A is greater than required to meet the current NES for PM_{10} (24-hour average of 50 µg/m^3) which has been estimated at around 14% (Wilton & Zawar Reza, 2014).

3.3 24-hour average $PM_{2.5}$ concentrations

Table 3.2 compares the measured daily maximum, second and third highest $PM_{2.5}$ concentrations to the WHO guidelines for 24-hour average $PM_{2.5}$. Note that $PM_{2.5}$ monitoring is carried out on a limited sampling frequency. The current WHO guideline for 24-hour $PM_{2.5}$ allows three exceedences per year. Because of missing data owing to the sampling regime the fourth highest measured concentration per year (which would be indicative of the reduction required for compliance) is unlikely to be represent the appropriate value for determining compliance. The second highest concentrations would provide a better indication of the likely values from which concentrations would have to be reduced.

Table 3.2: Summary $PM_{2.5}$ daily concentrations for Airshed A

	2008	2009	2010	2011	2012	2013	2014
Maximum measured $PM_{2.5}$ (24-hour average)	62	70	51	57	51		41
Difference compared to 24-hour average $PM_{2.5}$ of 25 µg/m^3	60%	64%	51%	56%	51%		39%
Second highest $PM_{2.5}$ (24-hour average)	55	65	43	57	37		32
Difference compared to 24-hour average 25 µg/m^3	55%	62%	42%	56%	32%		22%
Third highest $PM_{2.5}$ (24-hour average)	51	64	43	47	36		27
Difference compared to 24-hour average 25 µg/m^3	51%	61%	42%	47%	31%		7%
Reduction to meet current PM_{10}	28%	35%	14%	22%	6%	14%*	4%

NES

*note that the reduction required in 2014 PM_{10} concentrations to meet this limit has been estimated at 14% based on worst case meteorology to date.

3.4 Comparison of 24-hour average $PM_{2.5}$ concentrations to WHO guidelines

The WHO 24-hour average guideline for $PM_{2.5}$ is 25 µg/m^3. Recent 24-hour average $PM_{2.5}$ concentrations likely to represent the fourth highest concentrations[1] per year are around 30- 40 µg/m^3.

Airshed A doesn't comply with the current WHO 24-hour average $PM_{2.5}$ WHO guideline and potential future reductions in this guideline would further limit compliance.

Data suggests the reduction required to meet a 24-hour average $PM_{2.5}$ guideline in Airshed A is greater than required to meet the current NES for PM_{10} (24-hour average of 50 µg/m^3) which has been estimated at around 14% (Wilton & Zawar Reza, 2014).

[1] The fourth highest concentration represents compliance or otherwise with a guideline in an instance wherer there are three permitted exceedences

4 AIRSHED B1

4.1 Annual average $PM_{2.5}$ concentrations

No monitoring for $PM_{2.5}$ has been carried out in Airshed B1. Using the ratio of $PM_{2.5}$ to PM_{10} from Airshed A is unlikely to give a good representation for Airshed B1 owing to the differences in sources and the higher contribution of soil and marine aerosol in Airshed B1.

Estimates of annual average concentrations of $PM_{2.5}$ were therefore made for 2008 to 2014 by subtracting from the PM_{10} the monthly average source apportionment concentrations for dusts and marine aerosol from the 2008/2009 study period (excluding the small contribution in the finer $PM_{2.5}$ size fraction) and by subtracting the proportional contribution of industrial sources (fertiliser and surface coatings) identified in the source apportionment study for Tahunanui (Ancelet et al., 2010). Note that the method is indicative only and that actual monitoring of $PM_{2.5}$ should be carried out to determine compliance or otherwise with any $PM_{2.5}$ guidelines or standards.

Table 4.1 shows the estimated annual average $PM_{2.5}$ as well as the differences between these data and existing WHO guidelines or NES for Airshed B1. The percentage reduction in concentrations required for the annual average $PM_{2.5}$ concentration to meet a limit of 10 μg/m^3 (WHO current annual average guideline) and for the second highest daily PM_{10} concentration to meet the existing NES limit for New Zealand (50 μg/m^3 24-hour average) is also shown in Table 4.1.

Table 4.1: Summary PM_{10} and estimated $PM_{2.5}$ data for Airshed B1

	2008	2009	2010	2011	2012	2013	2014	2015
Annual average $PM_{2.5}$ (estimated)	14	13	10	9	11	12	12	10
Annual average PM_{10}	22	21	18	17	20	21	20	19*
Reduction to meet annual average $PM_{2.5}$ of 10 μg/m^3	26%	24%	4%		8%	15%	15%	1%
Second highest PM_{10} (24-hour average)	57	60	48	48	52	43	50	42
Reduction to meet 24-hour average PM_{10} NES of 50 μg/m^3	12%	17%			4%		0%	

*incomplete data – indicative only

4.2 Comparison of annual average concentrations to WHO guidelines

The WHO annual average guideline for PM_{10} is 20 μg/m^3. Data suggests Airshed B1 is probably non-compliant with this guideline although further monitoring it recommended.

The WHO annual average guideline for $PM_{2.5}$ is 10 μg/m^3. Recent annual average $PM_{2.5}$ concentrations have been estimated at around 10- 12 μg/m^3 although the data are indicative only and it is possible that Airshed B1 is compliant with the current WHO guideline for $PM_{2.5}$.

Data suggests the 24-hour average PM_{10} concentrations in Airshed B1 are probably compliant with the NES for PM_{10}.

4.3 24-hour average $PM_{2.5}$ concentrations

The highest daily 24-hour average $PM_{2.5}$ concentrations were estimated using PM_{10} data for Airshed B1 and assuming a winter ratio of $PM_{2.5}$ to PM_{10} of 0.8. The ratio was determined using the PM_{10} source apportionment data for the highest concentrations days. On these days marine aerosol and soil contributed 12% and fertiliser and surface coatings 8% of the daily PM_{10}. All other sources of PM_{10} were assumed to be within the fine ($PM_{2.5}$ size fraction). Table 4.2 shows the estimated fourth highest (WHO guideline allows for three exceedences per year) $PM_{2.5}$ concentration per year for Airshed B1 based on the PM_{10} data. This suggests the Airshed would be in breach of a daily guideline for $PM_{2.5}$ of 25 µg/m^3.

Table 4.2: Estimated/ indicative $PM_{2.5}$ daily concentrations for Airshed B1

	2008	2009	2010	2011	2012	2013	2014
Fourth highest PM10 µg/m3	56	57	41	44	48	42	48
Estimated fourth highest $PM_{2.5}$ (24-hour average)	45	46	33	35	38	34	38
Difference compared to 24-hour average $PM_{2.5}$ of 25 µg/m3	48%	49%	24%	31%	38%	26%	38%
Reduction to meet current PM_{10} NES	21%	12%	17%	0%	0%	4%	0%

4.4 Comparison of 24-hour average $PM_{2.5}$ concentrations to WHO guidelines

The WHO 24-hour average guideline for $PM_{2.5}$ is 25 µg/m^3. It is likely that $PM_{2.5}$ concentrations in Airshed B1 are around 30- 40 µg/m^3 for the fourth highest concentrations (with the first three highest concentrations being allowed).

It is likely that Airshed B1 doesn't comply with the current WHO 24-hour average $PM_{2.5}$ WHO guideline and potential future reductions in this guideline would further limit compliance.

Data suggests a reduction of around 26-38% would be required to meet a 24-hour average $PM_{2.5}$ guideline of 25 µg/m^3 in Airshed B1.

5 AIRSHED B2

5.1 Annual average $PM_{2.5}$ concentrations

No monitoring for $PM_{2.5}$ has been carried out in Airshed B2 and PM_{10} monitoring has been limited to the winter months only. Thus estimation of an annual average $PM_{2.5}$ concentration would be indicative only.

Estimates of annual average concentrations of $PM_{2.5}$ were made for 2010 and 2015 by multiplying winter concentrations of PM_{10} by a ratio of 86% (median ratios for Airshed A) and using an average summertime PM_{10} concentration of 5.5 µg/m^3 (Airshed A PM_{10} monitoring data for 2015 adjusted for $PM_{2.5}$ ratio). Airshed A ratios were used because the relative contributions of sources are similar in Airshed B2 to Airshed A. Summer $PM_{2.5}$ concentrations from Airshed A were used in the absence of any other Airshed data on summer concentrations of $PM_{2.5}$.

Table 5.1 shows the estimated annual average $PM_{2.5}$ for Airshed B2. This suggests $PM_{2.5}$ may be compliant with the WHO annual average guideline for $PM_{2.5}$ in Airshed B2. Monitoring of $PM_{2.5}$ in this Airshed would be required to confirm this as there are a number of assumptions used.

Table 5.1: Summary PM_{10} and estimated $PM_{2.5}$ data for Airshed B2

	2010	2015
Annual average $PM_{2.5}$ (estimated)	10	9
Annual average PM_{10}	15	14
Reduction to meet annual average $PM_{2.5}$ of 10 µg/m^3	1%	
Second highest PM_{10} (24-hour average)	40	29
Reduction to meet 24-hour average PM_{10} NES of 50 µg/m^3	0%	0%

5.2 Comparison of annual average concentrations to WHO guidelines

The WHO annual average guideline for PM_{10} is 20 µg/m^3. Data suggests Airshed B2 is likely to be compliant with this guideline.

The WHO annual average guideline for $PM_{2.5}$ is 10 µg/m^3. Data for 2015 suggests Airshed B2 is compliant with this guideline. However, a number of assumptions are used in the estimated concentrations and monitoring to clarify is recommended.

5.3 24-hour average $PM_{2.5}$ concentrations

Daily winter concentrations of $PM_{2.5}$ were estimated for 2010 and 2015 using a ratio of $PM_{2.5}$ to PM_{10} of 0.86 based on the Airshed A wintertime relationship between the two size fractions.

Table 3.2 shows the estimated fourth highest (WHO guideline allows for three exceedences per year) $PM_{2.5}$ concentration per year for Airshed B2 based on the PM_{10} data. This suggests the Airshed may comply with a daily guideline for $PM_{2.5}$ of 25 µg/m^3.

Table 5.2: Estimated/ indicative $PM_{2.5}$ daily concentrations for Airshed B2

	2010	2015
Fourth highest PM10 µg/m3	35	25
Estimated fourth highest $PM_{2.5}$ (24-hour average)	30	21
Difference compared to 24-hour average $PM_{2.5}$ of 25 µg/m3	17%	
Reduction to meet current PM_{10} NES	0%	0%

5.4 Comparison of 24-hour average $PM_{2.5}$ concentrations to WHO guidelines

The WHO 24-hour average guideline for $PM_{2.5}$ is 25 µg/m^3. It is possible that Airshed B2 complies with this guideline. Monitoring is recommended to confirm should a $PM_{2.5}$ standard be introduced.

6 AIRSHED C

6.1 Annual average $PM_{2.5}$ concentrations

No monitoring for $PM_{2.5}$ has been carried out in Airshed C. As with Airshed B2 an estimate of indicative $PM_{2.5}$ concentrations was made using the ratio of $PM_{2.5}$ to PM_{10} from Airshed A.

Estimates of annual average concentrations of $PM_{2.5}$ were made for 2008, 2009 and 2015 by multiplying winter concentrations of PM_{10} by a ratio of 86% (median ratios for Airshed A). Airshed A ratios were used because the relative contributions of sources are similar in Airshed C to Airshed A with domestic heating dominating the winter contribution. Summer $PM_{2.5}$ concentrations from the months January to April 2015 were used to estimate the average non May to August PM_{10} and $PM_{2.5}$ concentrations for the years 2008 and 2009.

Table 6.1 shows the estimated annual average $PM_{2.5}$ concentration for Airshed C. This suggests $PM_{2.5}$ is likely to be compliant with the WHO annual average guideline for $PM_{2.5}$ in Airshed C. Monitoring of $PM_{2.5}$ in this Airshed is recommended should an annual average guideline or standard be introduced.

Table 6.1: Estimated PM_{10} and $PM_{2.5}$ data for Airshed C

	2008	2009	2015
Annual average $PM_{2.5}$ (estimated)	9	9	8
Annual average PM_{10}	13	13	12
Reduction to meet annual average $PM_{2.5}$ of 10 µg/m^3	0%	0%	0%
Second highest PM_{10} (24-hour average)	35	33	35
Reduction to meet 24-hour average PM_{10} NES of 50 µg/m^3	0%	0%	0%

6.2 Comparison of annual average concentrations to WHO guidelines

The WHO annual average guideline for PM_{10} is 20 µg/m^3. Data suggests Airshed C is likely to be compliant with this guideline.

The WHO annual average guideline for $PM_{2.5}$ is 10 µg/m^3. Estimated annual average concentrations of $PM_{2.5}$ are 8-9 µg/m^3 and it is likely that this Airshed is compliant with this guideline. If the annual average $PM_{2.5}$ guideline were reviewed to less than 8 µg/m^3 Airshed C would be unlikely to be compliant.

Airshed C is compliant with the 24-hour average NES for PM_{10} with maximum concentrations consistently less than 40 µg/m^3.

6.3 24-hour average $PM_{2.5}$ concentrations

Daily winter concentrations of $PM_{2.5}$ were estimated for 2008, 2009 and 2015 using a ratio of $PM_{2.5}$ to PM_{10} of 0.86 based on the Airshed A wintertime relationship between the two size fractions.

Table 6.2 shows the estimated fourth highest (WHO guideline allows for three exceedences per year) $PM_{2.5}$ concentration per year for Airshed C based on the PM_{10} data. This suggests the Airshed may comply with a daily guideline for $PM_{2.5}$ of 25 µg/m^3.

Table 6.2: Estimated/ indicative $PM_{2.5}$ daily concentrations for Airshed C

	2008	2009	2015
Fourth highest PM_{10} µg/m3	26	25	25
Estimated fourth highest $PM_{2.5}$ (24-hour average)	22	21	21
Difference compared to 24-hour average $PM_{2.5}$ of 25 µg/m3	n/a	n/a	n/a
Reduction to meet current PM_{10} NES	0%	0%	0%

6.4 Comparison of 24-hour average $PM_{2.5}$ concentrations to WHO guidelines

The WHO 24-hour average guideline for $PM_{2.5}$ is 25 µg/m^3 with three allowable exceedences per year. It is likely that Airshed C complies with this guideline.

7 DOMESTIC HEATING CONTRIBUTION

The domestic heating contribution to annual average PM_{10} and $PM_{2.5}$ concentrations has been estimated for Airsheds A and B1. Similar estimates for Airsheds B2 and C are not possible owing to the absence of monitoring data for the non-winter months. Airshed A data are likely to be indicative of contributions for Airsheds B2 and C, however.

7.1 Airshed A

The relative contribution of different sources to PM_{10} for each month of the year was obtained from the 2014 emission inventory. The relative contributions vary with season (e.g., domestic heating is greater during the winter). Meteorological conditions also vary with season (conditions inhibiting dispersion are more prevalent during the winter months). It is therefore necessary to make an assessment of concentrations from each source for each month of the year in order to estimate the annual average contributions.

An evaluation of the source apportionment (receptor modelling) studies for Airshed A was carried out to identify the contribution of natural sources to PM_{10} and $PM_{2.5}$ concentrations. This showed an average natural source contribution of 6.5 $\mu g/m^3$ for Airshed A PM_{10} and 1.6 $\mu g/m^3$ for Airshed A $PM_{2.5}$.

To estimate the relative contribution of sources to annual average PM_{10} and $PM_{2.5}$ concentrations the average contribution of natural sources to concentrations of each was subtracted from the monthly average concentration. The resulting monthly average concentration was allocated to anthropogenic sources based on the emission inventory distribution from the 2014 inventory. The monthly average concentration allocations to each source were then averaged to give an annual estimated concentration for domestic heating, motor vehicles and industry. The contribution from other Airsheds is based on data provided by Golder and Associates (Gimson, pers com, 2015). Industry contributions are likely to be slightly over estimated owing to different dispersion characteristics for many industry sources.

Figure 7.1 shows the estimated relative contribution of sources to annual average PM_{10} and $PM_{2.5}$ concentrations.

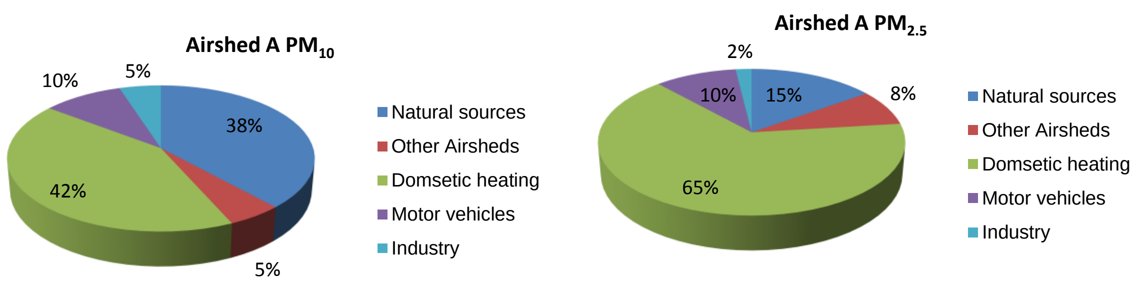

Figure 7-1: Estimated relative contribution of sources to annual average PM_{10} and $PM_{2.5}$ concentrations for Airshed A

7.2 Airshed B1

The relative contribution of different sources to PM_{10} for each month of the year was obtained for Airshed B1 from the 2014 emission inventory. As indicated above, the relative contributions vary with season. Meteorological conditions also vary with season (conditions inhibiting dispersion are more prevalent during the winter months). The annual average contribution assessment is therefore made based on the averaging of monthly concentration contributions as described for Airshed A above.

An evaluation of the source apportionment (receptor modelling) studies for Airshed B1 was carried out to identify the contribution of natural sources to PM_{10} and $PM_{2.5}$ concentrations. This showed an average natural source contribution of 6.6 µg/m^3 for Airshed B1 PM_{10} and 1.2 µg/m^3 for Airshed B1 $PM_{2.5}$.

Figure 7.2 shows the estimated relative contribution of sources to annual average PM_{10} and $PM_{2.5}$ concentrations.

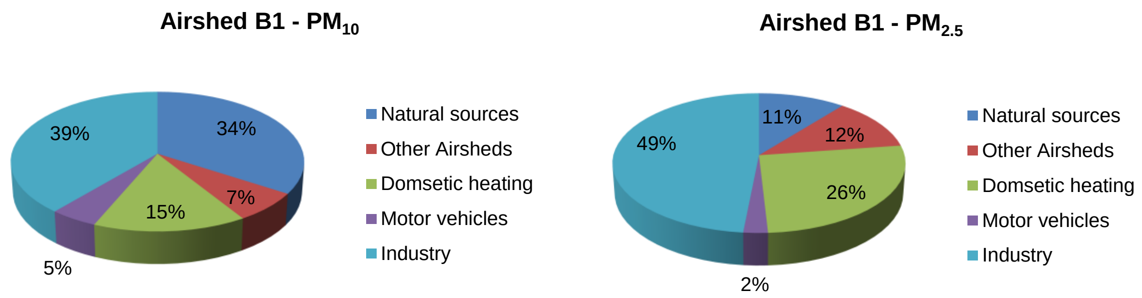

Figure 7-2: Estimated relative contribution of sources to annual average PM_{10} and $PM_{2.5}$ concentrations for Airshed B1

8 IMPACT OF MANAGEMENT OPTIONS ON ANNUAL AVERAGE $PM_{2.5}$

8.1 Impact of reductions in 24-hour average PM_{10} on annual average $PM_{2.5}$ concentrations.

A reduction of 14% in 24-hour average PM_{10} concentrations has been recommended for Airshed A for compliance with the NES for PM_{10}. The impact of reducing winter concentrations by 14% (by targeting domestic heating) on annual average $PM_{2.5}$ concentrations was assessed for the years 2013 and 2014 by applying the reduction to PM_{10} concentrations for the months May to August and estimating its impact on annual average $PM_{2.5}$.

For 2013 the estimated annual average $PM_{2.5}$ concentration reduced from around 12.5 µg/m^3 to 11.3 µg/m^3 (a 10% reduction).

For 2014 the estimated annual average $PM_{2.5}$ concentration reduced from an estimated 11.4 µg/m^3 to around 10.1 µg/m^3 (an 11% reduction).

It is possible that an annual average $PM_{2.5}$ guideline of 10 µg/m^3 may be met in Airshed A if wintertime concentrations in this Airshed are reduced by 14% as required to meet the current NES for PM_{10}. More intensive monitoring of $PM_{2.5}$ concentrations (e.g., daily or one day in two) is recommended to allow for a more robust assessment of likely compliance.

In Airshed B1 it is possible that the 24-hour average PM_{10} concentrations already meet the NES for PM_{10}. Additional reductions of around 2-3% could occur through the replacement of older more polluting wood burners (either at the end of their useful life or through regulation). However, if current annual average concentrations were 12 µg/m^3 (as estimated for 2014) a 3% reduction in wintertime PM_{10} is only likely to reduce annual $PM_{2.5}$ concentrations by around 2% and a reduction of around 15% would be required to meet a guideline/standard of 10 µg/m^3. It is possible that Airshed B1 would not meet an annual average $PM_{2.5}$ standard even with additional reductions in PM_{10} concentrations associated with the phase out of older more polluting wood burners.

8.2 Impact of allowing new installations of burners in Airshed B2 and C on annual average $PM_{2.5}$ concentrations.

Data suggests that management of PM_{10} in Airshed A to meet the current NES for PM_{10} is likely to be sufficient for the management of annual average $PM_{2.5}$ and provided the assessment of impact of allowing new installations of burners (in new dwellings or existing dwellings using other heating methods) in either Airshed A or C does not compromise attainment of that standard a $PM_{2.5}$ limit of 10 µg/m^3 should be achievable. Further monitoring is recommended however to increase the robustness of the assessment.

Airshed B1 most probably wouldn't comply with an annual average $PM_{2.5}$ standard of 10 µg/m^3. Allowing additional discharges of $PM_{2.5}$ into Airshed B1 is not recommended at this stage. Further monitoring of $PM_{2.5}$ will provide for a more robust assessment should a 10 µg/m^3 or lower $PM_{2.5}$ annual average NES be adopted.

Allowing new installations of wood burners into Airshed B2 may be possible provided the net impact is a decrease in emissions (e.g., increases in emissions associated with new installations are offset by the replacement of older more polluting burners with lower emission burners). However, given additional reductions in concentrations are likely to be required for Airshed B1 if an annual average $PM_{2.5}$ standard is introduced it is recommended that an evaluation of options for managing $PM_{2.5}$ concentrations in Airshed B1 be carried out prior to any decisions relating to allowing new burners in Airshed B2. It should be noted, however, that $PM_{2.5}$ concentrations in Airshed B1 are an estimate only and that monitoring of $PM_{2.5}$ in Airshed B1 is recommended to more accurately establish existing $PM_{2.5}$ concentrations.

9 SUMMARY

The purpose of this report was to evaluate:

- The likely annual average $PM_{2.5}$ concentrations in Nelson relative to existing and possible future annual average $PM_{2.5}$ standards.
- The likely relative contribution of domestic heating to annual average $PM_{2.5}$ concentrations in Nelson.
- The likely implications of a 24-hour average NES for $PM_{2.5}$ (relative to the existing PM_{10} NES) in Nelson based on the current WHO value of 25 µg/m^3.
- The likely implications of an annual average NES for $PM_{2.5}$ (relative to the existing 24-hour average PM_{10} NES) in Nelson based on the current WHO value of 10 µg/m^3.
- The likely impact of management measures to reduce 24-hour average PM_{10} concentrations to meet the NES in Airshed A and B1 on annual average $PM_{2.5}$ concentrations.
- The likely impact of allowing installations of solid fuel burners in new houses and existing dwellings currently using other heating methods in Airshed B2 and C on annual average $PM_{2.5}$ concentrations.

The analysis suggests that Airshed A is unlikely to comply with the existing WHO guideline for annual average $PM_{2.5}$ and it is possible that Airshed B1 may also not comply. Airsheds B2 and C are likely to comply with the existing WHO annual average guideline for $PM_{2.5}$. If the guideline were reduced to 8 µg/m^3 Airsheds A, B1 and B2 are all likely to be non-compliant. Airshed C may be compliant.

In Airshed A domestic heating within the Airshed is likely to contribute around 42% of the annual average PM_{10} concentrations and around 65% of the annual average $PM_{2.5}$ concentrations. Thus this source would need to be the focus of any reduction in $PM_{2.5}$ concentrations to meet an annual average concentration of 10 µg/m^3.

The relative contribution in Airsheds B2 and C is likely to be similar to Airshed A. In Airshed B1 domestic heating is estimated to contribute around 22% (including other Airshed contributions) of the annual average PM_{10} and 38% of the annual average $PM_{2.5}$ concentrations. In this Airshed industry is estimated to be the main contributor to annual average concentrations for both PM_{10} and $PM_{2.5}$ based on a mass emissions approach. However, this does not account for the increased dispersion associated with some industrial sources and it is there likely that the industry contribution is overestimated.

If PM_{10} concentrations are reduced by 14% in Airshed A to meet the NES, it is likely that annual average $PM_{2.5}$ concentrations would reduce to below 10 µg/m^3. However, more intensive monitoring is recommended to increase certainty around current annual average $PM_{2.5}$ concentrations.

In Airshed B1 it is likely that the 24-hour average PM_{10} concentrations already meet the NES for $PM_{10.}$ However, if current annual average $PM_{2.5}$ concentrations were 12 µg/m^3 (as estimated for 2014) reductions in PM_{10} concentrations associated with the natural attrition replacement of older burners is unlikely to reduce annual $PM_{2.5}$ concentrations by sufficient amounts to achieve an annual standard of 10 µg/m^3 for $PM_{2.5}$.

Airsheds A and B1 are unlikely to comply with a 24-hour average $PM_{2.5}$ standard with reductions of around 20-30% in Airshed A and possibly up to around 15% in Airshed B1 to achieve compliance. Airshed B2 may be compliant although monitoring is required to confirm this. It is likely that Airshed C would comply with a 24-hour average $PM_{2.5}$ standard of 25 µg/m^3.

Based on the relative risks identified, it is recommended that priority be given to monitoring of $PM_{2.5}$ in Airshed B1 and that the monitoring period include both seasons to enable calculation of annual average concentrations. Should a standard for $PM_{2.5}$ be introduced it is likely that continuous monitoring of $PM_{2.5}$ at Airshed A would also be required as well as investigative monitoring for $PM_{2.5}$ of at least two years in each of Airsheds B2 and C.

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APPENDIX A: DISTRIBUTION IN PM_{10} EMISSIONS ACROSS NELSON