Estimating air quality in the early stages of the 2014 Hazelwood mine fire

Air quality summary report

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At the start of an emergency, air monitoring is undertaken with mobile monitoring equipment – we call this 'rapid-response' monitoring. It provides a good indication of air quality until more sophisticated and accurate instruments can be set up.

This report shows how EPA Victoria has used the indicative data from rapid-response monitoring conducted during the Hazelwood coal mine fire to gain a more reliable estimate of air quality in the early stages of the fire.

Gathering early data

When an emergency event occurs that could cause pollution, it's EPA Victoria's job to gather data about the types, levels and sources of pollution. In smoke, one key pollutant is $PM_{2.5}$ consisting of very small particles with a diameter of less than 2.5 μm (micrometers) which are harmful to human health as their very small size means they can be breathed deep into the lungs.

When the Hazelwood mine fire broke out on 9 February 2014, EPA deployed a type of rapid-response air monitoring instrument called a DustTrak™, which can be set up quickly to give indicative levels of very small particles in the air. The data from rapid-response monitoring is used to help EPA and other authorities decide on what to do next.

While a DustTrak can provide fast, indicative data, a different instrument – called a 'BAM' (beta attenuation monitor) – gives a more accurate reading and is accepted under the Australian Standards for measuring particles against the air quality standards set out in the Australian *National Environment Protection Measure (Ambient Air Quality*), commonly known as the 'Air NEPM'.

However, a BAM can't be set up fast enough in an emergency situation, so a DustTrak is the most practical option to monitor air quality until a BAM can be installed. This means that, at the start of the Hazelwood emergency, there was a period when only the DustTrak was available to collect data.

Because the DustTrak isn't as accurate as a BAM, this publication explains how EPA has corrected the DustTrak data to produce an estimate of what a BAM is likely to have recorded had it been in place in the earlier stages of the fire.

This estimate provides a more accurate understanding of what the air quality was like early on in the fire emergency.

This publication may be useful to other authorities operating this equipment in similar circumstances.

This report is intended to be read alongside the EPA publication *Summarising the air monitoring and conditions during the Hazelwood mine fire, 9 February to 31 March 2014* (publication 1598).

Differences between instruments

The primary reason why the DustTrak and the BAM give slightly different values is because they measure particles using different methods. However, variations in measurements may also result because the makeup of the smoke is variable, and because there will always be inherent differences even between instruments of the same type.

A **DustTrak** is used for rapid-response monitoring. It provides a fast indication of $PM_{2.5}$ levels, but is not accepted in the Australian Standards for assessing air quality against standards.

A DustTrak measures $PM_{2.5}$ particles through a 'light scattering' method, which determines how many particles of a certain size are passing through its sample chamber, but it doesn't actually measure the mass of the particles.

A **BAM** gives a more accurate measure of $PM_{2.5}$ particles because it collects the particles and calculates their mass – this is important because air quality standards are based on mass.

Data from BAM monitors are accepted under the Australian Standards for measuring and assessing $PM_{2.5}$ particles against air quality standards.

Figure 1: The inlet for a DustTrak™ instrument – a number of these rapid-response monitoring instruments were used by EPA during the Hazelwood mine fire.

Figure 2: Air quality station housing a BAM – two of these stations were installed in Morwell during the Hazelwood mine fire.

Estimating data to fill a gap

To produce an estimate of what the BAM is likely to have recorded in the early stages of the fire, EPA Victoria undertook the following steps:

1. DustTrak monitors began collecting data on 13 February, *before* a BAM was installed.
2. Once the BAM was installed and operating at Morwell (South) (from 21 February), EPA also continued to collect data using the DustTrak monitor. The BAM and the DustTrak were collecting data side by side.
3. Because the DustTrak and the BAM were monitoring the same thing ($PM_{2.5}$) in the same place, the data from each could be later compared using 'correlation analysis' – a statistical test to determine how strongly two sets of data are related. Because the two sets of data were found to be strongly related (see breakout box on page 3), the DustTrak data was mathematically corrected to produce an 'estimate' that more closely resembled the actual BAM data.

   For the early stages of the fire when only the DustTrak was operating (13–21 February), this estimate provides the best available indication of what the BAM is likely to have recorded, had it been in place at that time (shown as dotted lines in Figure 3).
4. To check the accuracy of the estimated data, we looked at how closely the estimate matched the actual BAM measurements from 21 February onwards (see Figure 3).
5. As an extra measure to confirm that the DustTrak was working properly, EPA compared DustTrak $PM_{2.5}$ data to 'visibility' data from another instrument called a nephelometer (see breakout box on page 3). We expected that visibility and $PM_{2.5}$ would be strongly related because they're measured by the same 'light scattering' technique; and in the environment, when visibility is low, it's often because $PM_{2.5}$ levels are high.

What does the estimate tell us?

Figure 3 shows the estimated and measured levels of $PM_{2.5}$ at Morwell (South) during the Hazelwood mine fire, which is the location that was most affected by smoke during the emergency.

Our estimated results indicate the following:

- There is an estimated $PM_{2.5}$ peak of around 800 μg/m^3 between 16 and 17 February, which is 32 times higher than the air quality standard (25 μg/m^3) set out in the Air NEPM. This indicates that air quality at Morwell (South) was poorest during this time.
- Once the BAM was installed and began recording data from 21 February, the estimated levels from this time follow a similar pattern to the actual BAM measurements. However, when the BAM reading is very high, the estimate doesn't mirror the BAM as closely as it does for lower BAM readings (see figure 3). This may be because the DustTrak instrument (on which the estimate is based) is not as well equipped to measure very high levels of $PM_{2.5}$, but is more accurate at measuring lower levels. This suggests that the estimated peak towards the start of the fire may have actually been higher in reality. Therefore our estimates are considered to be conservative.

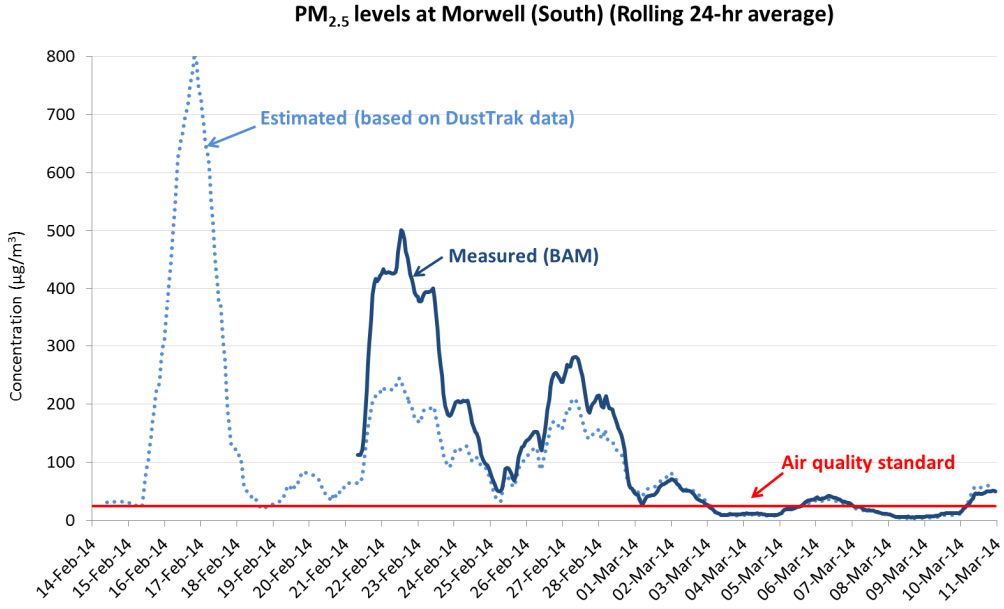

Figure 3: Measured (solid line) and estimated (dotted line) levels of $PM_{2.5}$ at Morwell (South) throughout the Hazelwood mine fire emergency.

Estimated data is based on actual DustTrak measurements that have been corrected to be more accurate. Measured data is measured by a BAM instrument.

A rolling 24-hour average is the average of the previous 24 hours calculated at each hour as the day goes on. This allows us to see when changes in air quality occurred, and how fast they were occurring.

How accurate is the estimated data?

Figure 4 compares the accuracy of the different sources of air quality data used by EPA in Morwell during the Hazelwood mine fire.

We consider the estimated data (generated from measured DustTrak data) to be more reliable than the measured DustTrak data, but less reliable than an actual BAM measurement.

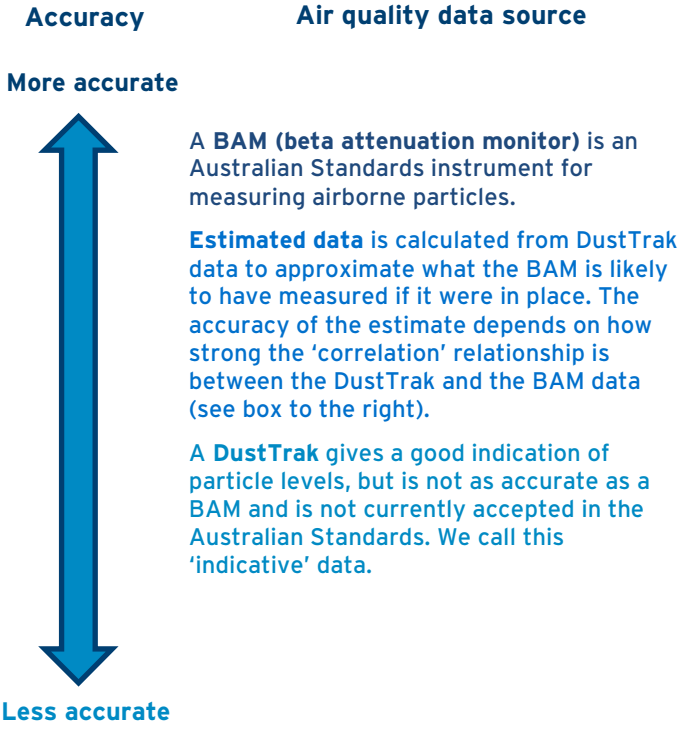

Figure 4: Comparing the different sources of air quality data used during the Hazelwood mine fire and their relative accuracy.

Considerations in using estimated data

No air monitoring instrument is 100 per cent accurate. Even when using sophisticated instruments of the same type – such as two BAMs in the same location – there are likely to be inherent differences between the instruments in the way they measure the air.

The air itself also differs across locations. Similarly, smoke from the same source can change in composition at various times and locations as it spreads. There may even be differences in the smoke over a few metres.

These issues add additional levels of complexity and uncertainty to estimated data.

Because of these complexities and site-specific differences, it's not possible to accurately apply the same data corrections used in this instance to estimate air quality elsewhere. However, this information may help inform decision making and air monitoring design in similar circumstances.

It is also important to note that this kind of estimated data can only be generated in hindsight, after a more accurate instrument (such as a BAM) is set up for comparison.

Generating the estimate from correlation analysis

The test

We can use a statistical test called a 'correlation analysis' to compare two sets of data to find out whether there's a relationship between them, and how strong that relationship is. In other words, how consistently do they follow the same mathematical 'rule'?

The result of a correlation analysis is an 'r^2' number between 0 and 1 which tells us about the strength of the relationship:

$r^2 = 1$	**Perfect relationship**
$r^2 = 0.7–0.9$	**Strong relationship**
$r^2 = 0.4–0.6$	**Moderate relationship**
$r^2 = 0.1–0.3$	**Weak relationship**
$r^2 = 0$	**No relationship**

The results

Is there a relationship between DustTrak data and BAM data at Morwell (South)?

Yes. The correlation gave **$r^2 = 0.8$**, which means there is a **strong relationship** between the DustTrak and the BAM.

The relationship can be described in a mathematical equation or 'rule', which we applied to the DustTrak data to generate an estimate of what the BAM would have measured (dotted line in Figure 3).

Checking that the DustTrak was working properly.

When we compared the DustTrak data with visibility data – which is measured by a similar instrument using the same 'light scattering' method – we got a correlation of **$r^2 = 0.99$**, which is an **almost perfect relationship.**

This indicates that the two instruments were functioning in almost the same way to measure two aspects of air quality that we usually expect to be closely related. This result gives us added confidence that the DustTrak instrument was working properly.

Generating estimates for other locations around Morwell

Using the same method for estimating $PM_{2.5}$ levels at Morwell (South), EPA has also generated estimated levels for three other locations that were affected by smoke during the fire: Traralgon, Kernot Hall (Morwell) and St Luke's Church (Morwell).

These estimated values are shown as dotted lines in Figure 6. Figure 5 shows the locations of these estimated monitoring points.

The solid lines in Figure 6 show the $PM_{2.5}$ levels that were measured by two separate BAM monitors – the first at Morwell (South) and the other at Morwell (East). Their locations are also shown in Figure 5.

As the graph in Figure 6 demonstrates, the estimated $PM_{2.5}$ levels (both measured and estimated) were highest at Morwell (South). Other locations experienced comparatively lower levels but were still occasionally above the air quality standard set out in the Air NEPM.

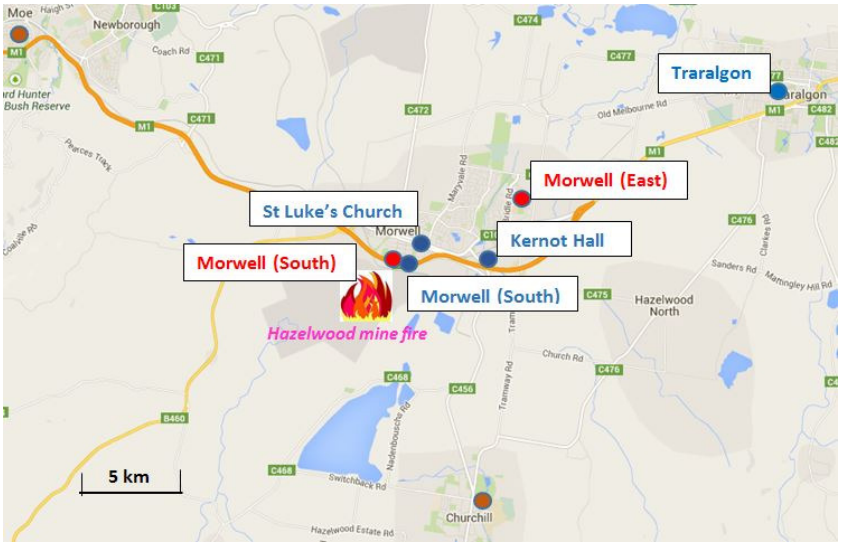

Figure 5: Map of the Morwell area and monitoring locations where BAMs (red) and DustTraks (blue) were gathering data on $PM_{2.5}$ levels. The location of the Hazelwood mine fire is also shown.

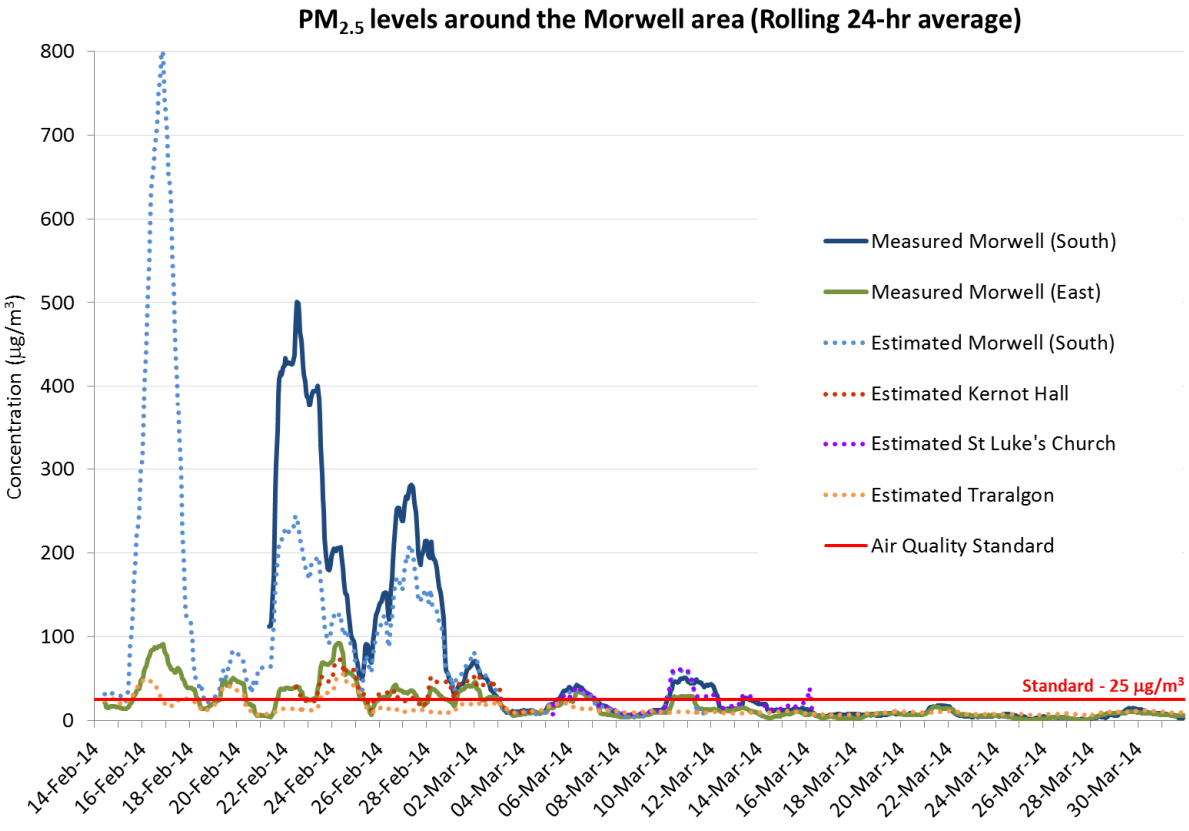

Figure 6: Estimated and measured $PM_{2.5}$ levels at locations around Morwell during the Hazelwood mine fire. Highest levels (measured and estimated) were recorded at Morwell (South). The location of each monitoring point is shown in the map in Figure 5.

Conclusions about rapid-response monitoring and estimated data

Rapid-response monitoring plays an important role in identifying air pollution and working out the appropriate next steps in addressing the issue.

While there will always be some corrections needed for air quality data generated by the DustTrak instrument used for rapid-response monitoring – particularly when pollution levels are very high – this publication has shown how EPA has been able to retrospectively correct the data to provide the best available estimate of $PM_{2.5}$ particles in the air.

This exercise has provided us with a more accurate picture of the fire's impact on air quality in the early stages of the Hazelwood fire mine (prior to the set-up of more accurate monitoring instruments). It also provides us with a greater level of confidence in understanding how the DustTrak instrument operates and how its data might be interpreted and used in future events.

For further information on this publication and the methods used, please contact EPA Victoria on 1300 372 842 or email contact@epa.vic.gov.au