# Hazelwood Coal Mine Fire

## Lessons learnt from responding to a large-scale brown coal open-cut mine fire

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## About this publication

On 9 February 2014, embers from a bushfire ignited the open-cut Hazelwood Coal Mine near the town of Morwell, Victoria Australia. The fire, which burned for 45 days, was an unprecedented event due to the large scale of the fire in an open cut brown coal mine, the length of time that the fire burned and its proximity to the town. The response was a multi-agency effort, which required input of knowledge and expertise from around the world.

This publication has been produced as a resource that may assist other organisations involved in emergency management, environmental protection, or the public health aspects of responding to a similar large scale brown coal open-cut mine fire event. It covers:

- knowledge from different agencies about the types of information required during the fire
- processes of how agencies went about identifying and filling knowledge gaps
- improvements to emergency response and recovery processes that have been made since the fire, or are in progress.

This publication is part of a series of eight publications, and is supplemented by a database containing the raw data collected during the event.

This publication has been produced in collaboration with the Department of Health & Human Services (DHHS), Emergency Management Victoria (EMV), Metropolitan Fire Brigade (MFB), Country Fire Authority (CFA) and the Department of Environment, Land, Water and Planning (DELWP).

It is intended that this publication will be useful to emergency-response science personnel and others that may be involved in responding to an open-cut brown coal mine fire event in the future to protect the community.

This document was produced in 2017, does not constitute formal guidance and does not cover all actions that should be undertaken during a similar event; but reflects the views and experiences at the time of some of the staff who responded to the Hazelwood Mine Fire. For further details about any aspect of this report, please contact EPA Victoria on 1300 372 842 or contact@epa.vic.gov.au.

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## 1. Brush up on your history – what has happened before?

**Maintaining professional relationships is important for quick access to knowledge**

**There was no information on similar open-cut brown coal mine fire events available at the time of similar scale**

It is important to consider whether this type of event had happened before and, if so, what information can inform this incident. For this process it was critical to have already developed and maintained professional relationships with other agencies to gain swift access to their knowledge and experience.

We engaged locally, nationally and internationally, and reached out to agencies to gather insights. Our research during and after the fire found no information was available on open-cut brown coal mine fires that lasted for a long time next to a community. Most literature and experience related to existing events and studies focused primarily on long-term underground coal fires.

Smaller fires have occurred in open cut coal mines in the Latrobe Valley over the years. These fires were either managed as part of a mine's operation or through emergency services and the majority were extinguished quickly without smoke impacting the community.

The 2014 Hazelwood mine fire was a unique situation.

For more information about other research please see sections 3.6 and 4 of the Hazelwood Analysis Final Report (publication 1647).

## 2. Understand the smoke

**Not all coal is the same.**

**To understand the smoke you need the amount, makeup and burn conditions of the coal.**

A key concern during the fire was the nature of pollutants in the smoke, the potential community and firefighting exposure and what this means for people health.

Coal is formed from the build-up of layers of vegetation over thousands of years. Brown coal is young coal, in other words it hasn't had as much time for the vegetation to decay, for the water content to reduce and for the coal to harden as would be the case with black coal.

Not all brown coal is the same. The chemical elements present in the coal will change depending on their location.

Literature was available on brown coal from the Latrobe Valley and current information was available from the mine operator. Victoria's brown coal generally contains a high amount of water, a low amount of sulfur and is less contaminated with other elements compared to other brown or black coals in Australia. For example, Latrobe Valley brown coal has lower levels of sulfur compared to Anglesea and Bacchus Marsh brown coals, which means there is likely to be less sulfur emitted from the Hazelwood fire than would happen with a similar fire burning Anglesea or Bacchus Marsh brown coal.

We reviewed available data on Victorian brown coal and designed a monitoring program to cover the most likely pollutants. There was no available data in the literature at the time regarding the specific content of emissions from open-cut coal mine fires. This made estimating the exact emission rates difficult for modeling the transport of smoke, likely exposure rates and forecasting where the local smoke impacts were likely to occur.

Victoria has a number of open cut coal deposits which are mined and used for power generation. Coal-fired power generation includes controls to manage emissions and reduce ground level impacts such as: efficient combustion at high temperatures ; electrostatic participators to capture particle emissions; discharge through tall stacks at high velocity to maximise dispersion; and using continuous stack monitoring to adjust power generation to ensure stack emission levels meet EPA licence limits. The stack emissions from the power station are therefore not directly useful indicators of likely emissions from an uncontrolled fire in a coal mine.

To help understand the smoke, we needed data on the amount of coal being burnt, the makeup of the coal and the conditions (e.g. oxygen levels, combustion temperature). Estimating how much coal was burnt was difficult as the fire was deep within the coal seams. Digital scans of the size of the burn area and observations by the fire-fighters and the mine operator were used.

Simultaneous thermal imagery and video using a forward-looking infrared camera was used to find hotspots, estimate the conditions and resulting smoke production. In this case, the temperature, depth of the fire in the coal seam and addition of suppressants meant the fire was often smoldering. A fire that is smoldering will typically produce more airborne particles compared to a burning fire due to incomplete combustion. This was evident in the observed thick black smoke. A review was also conducted into fire-fighting activities, such as applying foam suppressants, to try to estimate what activities contributed to excessive levels of smoke in an attempt to manage smoke generation and impacts. However, no specific activity could be identified to help manage adverse smoke impacts to air.

Some modelling was attempted to estimate pollutant exposure of smoke on the local community, however the lack of validated emission rates meant there was much uncertainty in the estimates. The best indication of the nature and level of pollutants in the smoke was from monitoring in the community township. Monitoring of air, ash, soil and water was essential for linking theoretical assessments with on-ground observations. The monitoring data from the Hazelwood mine fire was made available as part of this series of reports.

For details on air monitoring and results please see:

- Summarising the air monitoring and conditions during the Hazelwood mine fire, 9 February to 31 March 2014 (publication 1598)
- EPA Hazelwood Recovery Program air quality assessment – Morwell and surrounds, February 2014 to May 2015 (publication 1601)
- DHHS Factsheet Air quality testing in Morwell - Volatile Organic Compounds
- Analysis of air quality during the Hazelwood mine fire (publication1648)
- Hazelwood Open-Cut Coal Mine Fire. Air Quality and Climate Change 49 (1) Feb 2015.pp 23-27
- Characteristics of an open-cut coal mine fire pollution event. Reisen, F.; Gillett, R.; Choi, J.; Fisher, G.; Torre, P. Atmospheric Environment. 151. (2017) 140-151.."

For details on water, soil and ash monitoring, results and typical composition of brown coal from the Hazelwood coal mine please see:

- EPA Hazelwood Recovery Program water, soil and ash assessment – Morwell and surrounds, February 2014 to May 2015 (publication 1600)
- DHHS Factsheet Ash fall-out – Hazelwood open cut mine fires
- Hazelwood Analysis Final Report (publication 1647)

For details about effects of smoke and your health please see:

- DHHS Factsheet Smoke and your health – Hazelwood open cut mine fire
- EPA website Effects of smoke

For more information on the data available and access to the raw data please see:

- Hazelwood database (publication 1649)
- Raw data

## 3. Tracking and monitoring the smoke

**A tiered approach to monitoring was necessary.**

**You can't monitor everywhere, so supplementary tools are needed.**

The air monitoring data, on the ground observations, satellite images, Bureau of Meteorology (BOM) weather forecasts and intelligence from the fire behaviour analysts about smoke generation from the mine and fire-fighting activities provided the key information sources used by the air quality (smoke) forecasters to understand local smoke impacts and issue smoke advisories and alerts.

### Monitoring equipment and location

The southern edge of the Morwell Township was only 200 - 300m from the fire. Traralgon, Moe, Churchill and several other small residential centres were within 20 km of the fire.

With a limited number of monitoring instruments, varying levels of smoke and a large area to cover, a tiered approach to monitoring was necessary. For particle and carbon monoxide (CO) monitoring a three-tiered approach was used including:

1. mobile roving air monitoring instruments to provide indicative particle and CO levels and the spatial extent of smoke impact
2. portable sentinel air monitors located across the local area to measure general indicative particle and CO levels
3. primary monitors to provide data with a high level of confidence, representative of the Morwell township and generally representative of higher levels near the mine.

Determining the location of monitoring equipment was dependent on the purpose of the monitoring and equipment requirements such as access to the location, power connections, length of deployment and security. For example, Morwell Bowling Club provided a good place to monitor as it was an open area, had security, access to power and generally represented the community areas where the highest smoke levels were observed.

Other locations were chosen to ensure spatial coverage and the maximum opportunity to assess community exposure and included places such as child care centres, community halls, churches and universities in areas where there were sensitive community groups, large population areas and private houses.

Community monitoring was supplemented with carbon monoxide data collected by MFB and CFA at the fire ground with personal and sentinel monitors. This was where the highest levels of smoke occurred and provided insight into potential air quality impacts in the community. These same types of fire service sentinel instruments were also used extensively in the community particularly in the early stages of the fire and the data was critical in establishing carbon monoxide as a key smoke component of potential risk.

### Areas of low impact

Identifying areas with a low likelihood of smoke impact was essential for establishing appropriate staging areas for firefighting personnel, control centres for emergency staff, and respite areas for community and emergency personnel.

It was also vital to inform the community of any potential smoke-free periods so they could air out their houses, do activities they couldn't do during high-smoke-level days and have general respite from smoke.

### Other monitoring tools

Other tools were needed to monitor and track the smoke such as satellite images, visual observations and modelling. The following provides some explanation of the various tools used during the fire.

### Satellite imagery

Satellite imagery from NASA's MODIS satellites were used extensively during the fire. The satellite passed over twice a day, which provided two high resolution snapshots of the smoke plume. However, satellite photos are ineffective when there is cloud cover.

Since the fire, in mid-2015 images from Japan's Himawari-8 satellite have been made available online, providing another source of information for tracking smoke plumes. The Himawari satellite imagery is a lower resolution compared with MODIS, but updates more frequently, at 10 minute intervals. The Japan Meteorological Agency has also successfully launched another satellite, the Himawari-9. In conjunction with the Himawari-8, the satellite will establish a more stable and continuous satellite observation system.

### Photo, video and first hand observations

Agency scientists gathered valuable information about the community's exposure to smoke through examining photos and videos of the smoke, and experiencing the event first hand. Many observations were provided by the local community, officers on the ground and the media. The visual and physical observations were valuable in providing the context for the scientific assessment and in identifying other impacted areas in the region.

Intelligence from the fire-behavior analysts about smoke generation from the mine and firefighting activities was particularly useful for surveillance and forecasting smoke alerts. For example, where intelligence showed there was:

- a greater firefighting effort resulting in more smoldering, lower heat and buoyance of smoke, poorer plume dispersion and potential for greater smoke impact.
- high winds fueling the spreading of the burning across a larger area of the north embankment resulting in greater generation of smoke.
- areas of on-going smoldering within the mine producing smoke.

### Meteorological modelling

There was limited smoke modelling forecasting available during the Hazelwood mine fire. The BOM provided forecasts of smoke transport using the Hysplit smoke model available at the time. This model quickly provided a general indication of the likely direction and extent of the smoke. The Hysplit model did not use emission factors or emission characteristics associated with coal mine fires.

The CFA ran a program called ARGOS, which is a modelling system tailored to emergency management situations. It is a chemical transport model and uses current meteorological data and predictions from BOM to forecast plume direction up to five days. ARGOS is designed for modelling a single point-source of pollution so an approach of adding a number of single point sources along the face of the fire to create a more accurate representation of the smoke source area was undertaken. At the time of the fire, ARGOS was a new tool to the emergency response team and there were only a few personnel that had access and could operate the model. Since the fire, ARGOS capability has increased and is now available to all agencies via Emergency Management Victoria (EMV). Future versions of the system will allow authorised users access via Emergency Management Common Operating Picture (EM-COP).

A key limitation of the modelling was not having representative smoke emission factors from the coal mine fire.

Two approaches have been investigated post fire to estimate the coal mine smoke emissions, one involves directly measuring smoke generated from controlled burning of brown coal and the other is to estimate from back trajectory modeling with monitoring data to guide and ground truth the estimates. The first approach has been put forward as an opportunity to fill a gap in knowledge. The latter technique is being used by Commonwealth Scientific and Industrial Research Organisation (CSIRO) as part of the Hazelwood long term health study to model and estimate ambient air smoke exposure to complement the available air monitoring data. CSIRO has made preliminary estimates of how the smoke from the Hazelwood mine fire travelled.

### Smoke from other areas

It was necessary to consider additional sources of smoke in the area during the Hazelwood mine fire to enable an estimate of total community exposure. Due to the weather conditions at the time, there were a number of other bushfires also burning nearby in the Yallourn coal mine, in grass and forest immediately west of the Hazelwood mine, in the pulp stack at the Maryvale papermill, in forest north of Yarram and in East Gippsland. These nearby fires could have contributed to increased smoke levels in the area, and agencies needed to consider this when interpreting monitoring results and making predictions about possible impacts to air quality. Most of these fires were put out quickly and an easterly wind blew most of the bigger East Gippsland bushfire plume away from Morwell across the Latrobe Valley towards Melbourne, which experienced poor air quality over the four days from 11-14 February 2014.

For more information on the East Gippsland bushfire please see section 2.1 of the Analysis of air quality during the Hazelwood mine fire (publication 1648).

## 4. Weather is a key variable

**Weather is highly influential in both smoke creation and where it goes.**

Weather plays a significant part in all fire events. Fuel, oxygen and temperature are key aspects in a fire. Sudden changes in weather and wind patterns can alter the fire and smoke paths in an instant. Weather forecasts from the Australian Bureau of Meteorology helped to predict the extent of the smoke plume. It was also critical for water scientists to plan sampling to align with rain periods, which could potentially wash ash into waterways.

Concentrations of pollutants in the air during the fire were highly variable, with the highest concentrations measured in the populated areas of Morwell during south-westerly winds. Sudden frontal wind-shifts from northerly to southerly directions were of particular concern as they happened in minutes. This provided more oxygen to the fire and sent the plume towards the nearby populated areas.

The topography of the surrounding area, being in a valley led to a lack of dispersion and an accumulation of 'trapped' smoke. In addition, the fire was below ground level and low in the mine. As a result the smoke plume started off quite low leading to more of the smoke being trapped in the morning within the air lower boundary layer and therefore more smoke at ground level.

The EPA air forecasting team used basic meteorological-based models to determine the presence and impact of the smoke over time. Most of the meteorological data needed for this modelling was easily accessed from the BOM and some EPA monitoring equipment.

## 5. Use appropriate monitoring equipment for the job

**Portability is important to generate data quickly.**

**Telemetry is important to effectively transfer the data for use.**

### Rapid deployment

Portability of equipment is particularly important during the fire because:

- it is crucial to get the monitoring equipment on site as swiftly as possible
- some of the more-accurate monitoring instruments can take a few hours to more than a day to set up and calibrate onsite
- the equipment will be moved around to multiple locations over the course of the fire.

The complexity of the logistics involved in sourcing and moving equipment added more time to travel and reduced the time available for monitoring in the field at the start of the fire, which in this case was when most of the smoke impact was occurring.

A fundamental requirement for future events is to have appropriate equipment and resources available to rapidly deploy and monitor air quality within 24 hours of escalation triggers anywhere within Victoria. The Rapid Deployment of Air Quality Monitoring for Community Health guideline was developed to assist incident controllers and agency commanders to determine when and how community air monitoring should be triggered to manage health and safety impacts on affected communities during large, complex incidents with airborne emissions in the outdoor environment.

EPA has built two mobile air quality monitoring stations in 2016, with more sensitive, higher quality instrumentation, will be built for longer-term deployment to complex smoke events of extended duration where there is expected to be a significant impact upon communities.

In 2017 EPA is procuring ten smoke detection monitors, which will be pre-deployed to high risk areas in regional Victoria, enabling the commencement of monitoring during the early hours of a smoke event and the provision of smoke related information to first responders, DHHS and EPA. EPA will partner with Victorian State Emergency Services to maintain the smoke monitors in a state of readiness for quick relocation and activation, as necessary, to fire events in the area.

For more information on rapid response please see the Hazelwood Mine Fire Inquiry: Implementation of recommendations and affirmations - Annual report.

### Understand the uncertainty of data

High-accuracy air monitors take more time to move, calibrate and to produce data, while lighter, more-portable monitors can be deployed quickly, immediately produce data and have lower power requirements.

The tradeoff for portability is often accuracy of the data. This is because the more portable instruments generally provide an indirect measure of particle concentration (generally using light-scattering technology), while more-sophisticated monitors provide a measurement that is covered by an Australian Standard methodology. For this reason, portable monitors have a level of uncertainty in the data they produce that is slightly greater than the standard instruments.

One way that this uncertainty can be reduced is with performance and correlation testing against higher-accuracy monitors.

EPA recently did smoke-chamber testing, using controlled smoke from wood, coal and diesel. In-field trials have also been done to compare the data outputs of different monitors under different conditions such as planned burns. This research is ongoing and by understanding the correlations between different monitors, corrections can be applied to the data to improve its accuracy.

For more information about the air measurement and analysis methods please see Appendix A of the Hazelwood Analysis Final Report (publication 1647).

### Speedy transfer of data

During the Hazelwood mine fire, data needed to travel fast and go to a central location for all parties to access. Telemetry systems are essential for effective data transfer. For some instruments used during the fire it was necessary to manually download data from each machine and physically pass on the raw data between people and agencies. This was labor-intensive and increased the risk of transcription error.

Streaming the data live from all emergency response equipment is a much more desirable option. EPA now has the capacity to near-live-stream data to the EPA AirWatch website during an emergency.

EMV has also launched Emergency Management Common Operating Picture EM-COP, which provides emergency management agencies with better access to real time information through a web-based information gathering, planning and collaboration tool.

### Understand the laboratory analysis process

A high volume of water, ash, land and air samples underwent laboratory analysis during the fire. An understanding of laboratory locations, availability, facilities, accreditation, analysis capabilities and limitations was essential for gaining quick and reliable results.

Laboratory results generally go through two quality assurance processes. The first is built into the testing procedures and provides an interim result. The second is usually done by another analyst. This can take hours, days or weeks to complete depending on the type and volume of data being analysed. During the fire, an early awareness of potential risks was needed. Even with some potential for inaccuracies there was a greater risk in waiting for results. In the end, interim results gave a good indication of actual results and assisted in speeding up response times.

## 6. Identify relevant standards and trigger actions for pollutants

**Relevant standards/criteria should be identified early and response systems decided upon.**

**In the absence of local standards, look to relevant standards developed in other jurisdictions.**

**Document everything.**

### Identifying appropriate standards

To be able to interpret data from environmental monitoring during an event, appropriate standards must first be identified. Standards and guidelines are generally used to trigger further action once certain concentrations are reached. Actions might include further investigation or actions, advice, or warnings to protect the health of people and the environment.

During the Hazelwood mine fire the fire services used occupational exposure standards. A chlorine generating fire in Footscray a number of years prior to the Hazelwood mine fire led fire agencies to conduct a comprehensive review of the ‘shelter in place’ advice aimed at protecting the community from exposure to chemical releases during a hazardous materials emergency. In 2011, the Protective Action Decision Guide for Emergency Services during Outdoor Hazardous Atmospheres was released. This document outlines the protocol to be followed by fire agencies in selecting air quality guideline values (such as for carbon monoxide) for community protection. During the Hazelwood fire this approach was further developed to extend to significant and potentially longer term smoke events.

During the Hazelwood mine fire, the State Environment Protection Policy (Ambient Air Quality) and the National Environment Protection (Ambient Air) Measure were primarily used to assess the concentration of pollutants in the air. A graduated air quality and health protocol for airborne particles in bushfire smoke had been in place between DHHS and EPA for eight years and was revised for the 2013/14 summer fire season. This was an agreed working arrangement for communicating health risks of community exposure to bushfire smoke, developed by the EPA, the Department of Health and Human Services (DHHS) and the Chief Health Officer. During the Hazelwood mine fire this protocol underwent a further review to include significant and potentially longer term smoke events, providing advice on actions to protect health and a threshold to guide voluntary temporary relocation and return to normal.

During the Hazelwood fire, standards were applied from state, national and international sources. More-specific graduated standards were set for particles and carbon monoxide as the two main air pollutants. These were compared to international standards and guidelines, which are not always consistent due to different policy setting in each country. This made it difficult to compare. For fine particles as $PM_{2.5}$, the graduated air quality and health protocol for airborne particles in bushfire smoke was further developed to adjust from $PM_{10}$ to $PM_{2.5}$ measurements with consideration of the intent of the Californian wildfire guide. California has well established protocols for impacts from bushfire smoke and are leaders internationally in research into smoke impacts. The carbon monoxide standard for community applied the Protective Action Decision Guide (2011). It was adapted for the unique setting of a significant large scale fire with emissions of a longer time-period. The joint standard operating procedures for fine particles and carbon monoxide from smoke and the Community smoke, air quality and health standard are available through EMV's website.

For some pollutants, a standard did not exist, or the concentration could not be linked to an acute health or environmental impact. This was the case for some soil and water assessments. For example, zinc, boron and strontium are naturally present in soil, therefore determining a concentration that would indicate 'pollution' or require further action had to include consideration for the naturally occurring levels, which was problematic.

Standards can be set for naturally occurring compounds – for example, EPA sets standards for salinity and nutrients that occur naturally in all waters, but this had not been done for many common compounds. Because of this, EPA sampled water and soils outside of the affected areas to help to understand the natural variability of a number of compounds in the soil in the area.

In water three main standards were used including the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*, *Guidelines for Managing Risks in Recreational Water* and the *Australian Drinking Water Guidelines (2011) - Updated December 2013*.

In soil the main standard used was the *National Environment Protection (Assessment of Site Contamination) Measure 1999*.

It is recommended that in preparing and practicing for a possible event, emergency managers should proactively identify appropriate standards and trigger levels and actions for likely pollutants.

### Systems to manage data and respond when standards are triggered

Once monitoring data demonstrates that certain criteria or guidelines values have been reached, actions are triggered. To be able to implement these actions confidence systems need to already be in place such as:

- quality assurance checks of the data
- effective data management
- decision-making processes, action plans and responsibilities.
- methods to communicate information
- the actual health or environmental protection messages to be issued.

These systems should be predictable and repeatable with a clear logic and justification. Building systems from scratch is a difficult task during a fire emergency, as they require significant efforts to build, check, communicate and action these systems. A proactive approach should establish these systems ahead of time.

A State Smoke Framework has been set up to provide a more integrated approach to manage the short and long-term risks of smoke and other emissions. The framework is a strategy for Victoria that identifies the types of events, tools and processes that facilitate coordinated planning, decision-making and management of significant or prolonged events that generate smoke or other emissions.

Quality assurance of data is paramount in managing an integrated data set. A quality assurance system must have documented processes in line with data quality management plans, and calibrations and analysis processes accredited by independent authorities.

Data only provides a snapshot in time, and a single high reading may not necessarily warrant action. An appropriate decision-making process must be established drawing on a network of information sources to inform an understanding of potential environmental and health impacts. Decision-making can be difficult when there a lack of sample duplication and and/or very few samples. It is critical therefore to understand the data limitations and how other information could be used to supplement the data for decision making such as visual observations. It is also critical to understand how you will communicate such uncertainties and limitations to the community or other interested parties.

## 7. Understand when a change is happening in the environment

**Baseline monitoring is needed to understand when a change has occurred in the environment.**

**Comparison with other similar events is valuable.**

### Gathering background information

For the Hazelwood mine fire, background air quality information from a long-term EPA air monitoring station was available for the area going back to the 1980's. EPA prepares an annual air monitoring report that assesses our compliance with state and national standards. This provided a good indication of existing ambient air quality.

Soil and water sampling in the area had not been occurring in the same way as the air monitoring over time before the Hazelwood mine fire event. To provide an indication of what natural/background levels may be in the area, samples can be taken outside of the affected area, but still within the same waterways or soil profiles. Water and soil have a high level of variability over time and space and this must be considered when sampling occurs outside of the affected zone during an incident. To see if the ash was causing a demonstrable effect to the local soil or waterways, soil and water samples were taken in similar types of places outside the affected zone and compared to those taken within the zone.

At the time of sampling it was difficult to find samples of the ash. It is really important to collect ash samples as soon as possible as they can be difficult to find later on.

### Impacts

**Impact in air**

Based on our air monitoring results the pollutants that, to varying degrees, exceeded the relevant National Environment Protection (Ambient Air Quality) Measure air quality standards at different times during the mine fire were: airborne particles ($PM_{2.5}$ and $PM_{10}$) and carbon monoxide. Visibility reduction also exceeded the State Environment Protection Policy (Ambient Air Quality) standard at various times during the fire.

As expected, pollutants that did not exceed the Ambient Air NEPM standards during the fire were: sulfur dioxide; nitrogen dioxide; and ozone.

All of the compounds tested during the incident returned to background, or low and stable concentrations shortly after emissions from the fire ceased.

A comparison of concentrations of air pollutants measured during the Hazelwood mine fire and the Victorian 2006/07 Eastern Victoria Great Divide bushfires show that peak $PM_{2.5}$ concentrations were similar, however the peak (i.e. maximum) carbon monoxide and benzene concentrations measured during the Hazelwood mine fire were higher.

For details on air monitoring results and analysis please see:

- Summarising the air monitoring and conditions during the Hazelwood mine fire, 9 February to 31 March 2014 (publication 1598)
- EPA Hazelwood Recovery Program air quality assessment – Morwell and surrounds, February 2014 to May 2015 (publication 1601)

- Analysis of air quality during the Hazelwood mine fire (publication 1648)
- Hazelwood Analysis Final Report (publication 1647)

**Impact of ash on soil and water**

The fly ash from the power generation plant was analyzed and compared to ash samples collected in the community area in attempt to understand the difference.

A number of metals (for example, boron, barium, manganese, strontium and zinc) and polycyclic aromatic hydrocarbons were identified in ash samples collected while the fire was still burning. However, the ash deposition on the soil was not sufficient to change the topsoil chemical composition.

While it is almost certain that some ash made its way into surrounding waterways, the volumes were likely to be very low, and water testing showed no chemical impact of ash in waterways of the Morwell region during the sampling period, which includes both during and post incident. We note though it is common that urban waterways are not pristine to begin with and contain pre-existing contaminants derived from other sources and activities.

As the fire was in a mine pit, there was already a built-in stormwater capture and treatment system in place, for waters generated from firefighting activities, and therefore there was a low risk of runoff from the mine contaminating waterways.

Monitoring continued to provide the community with confidence that the water environment was still safe post the fire as a part of the Hazelwood Recovery Program, despite evidence that there had been no impact on waterways.

Overall, the comparison of water and soil sampling data collected during the response and recovery phases showed that water and soil quality in the region did not appear to have been changed by the Hazelwood mine fire.

For details on water, soil and ash results please see:

- EPA Hazelwood Recovery Program water, soil and ash assessment – Morwell and surrounds, February 2014 to May 2015 (publication 1600)

For more information and access to the raw data collected please see:

- Hazelwood database (publication 1649)
- Raw data

## 8. Communicating scientific and technical information in an emergency

**Building trust with the community is an essential part of effective science communication.**

**It is important to quickly establish trust with the community as a reliable, responsive and consistent information source.**

**Effective science communication can help alleviate community concerns and avoid misinformation.**

### Understand and acknowledge the community's concerns

A key part of meeting the information needs of the community during an emergency event is to be aware of the nature and level of community concern. As well as providing useful insights into the community member's emotional and physical state during an event, acknowledging and responding to people's needs and concerns is also a key step to building trust. Once trust is established, community members are more likely to see scientific information as credible and reliable.

Some issues voiced by the community may be unrelated to the event or may seem un-scientific to technical staff. Despite this, it is important to acknowledge and respond to these valid concerns.

There are a variety of communications and engagement methods that can help agencies to understand and respond to community concerns and establish trust, such as community meetings, drop in sessions, door knocking, one-on one conversations and social media. The most appropriate method will vary, depending on the situation.

### There will be social, economic and environmental implications

Communication relating to the response and recovery phases of an emergency should address both the health and wellbeing for individuals and also consider the recovery and livability of the whole community. For example smoke and ash from a mine fire may increase people's concerns about a variety of issues, some of which may include:

- access to clean drinking water
- food safety
- impacts on their health, or their family and friends' health
- impacts on pets and livestock or agriculture
- access to a reliable power source (if a power line is impacted)
- access to telecommunications
- not being able to work and provide an income for their family
- smoke affecting their wellbeing

In our experience, we found that it was important to remember that people may have limited resources to change their situation, such as being unable to move out of the area to avoid exposure to smoke.

Our experience during the Hazelwood mine fire demonstrated that there are three key components to effectively communicate scientific and technical information in an emergency – be clear, be timely and be responsive.

## Be clear

**Make scientific information as understandable as possible**

Community feedback during the Hazelwood mine fire clearly indicated that many people did not understand the air monitoring information provided to them. This was a source of great frustration, which further contributed to the overall sense of community distrust of "government" during this time.

Clear communication of technical information should not be thought of as 'dumbing down' the science. Rather, the communication of science and potential environmental and health risks can be thought of as 'repackaging' the information to tell a clear story in language that is accessible for audiences without a science or medical background. The presentation of scientific data needs to be part of that clear story.

Some ways to improve the accessibility of scientific information may include the following:

- Don't assume prior knowledge – introduce all technical terms and abbreviations the first time they are used.
- Remember emergencies are a stressful time for everyone involved and potentially affected, therefore it is important to write in a non-ambiguous way and if actions are required they are clearly understandable to be followed by everyone.
- Aim for an appropriate level of 'readability' to ensure written content is easy to understand. Remember that there are people with a broad range of literacy and numeracy levels in the general population.
- Use labels on graphs to highlight high or low levels of substances, or unusual levels.
- Make it easy for people to compare data to the relevant guidelines.
- Avoid using long, wordy sentences. Consider using dot points when appropriate.
- Use tables and graphics whenever possible to convey information.
- Use subheadings to make it easier for people to quickly scan a page or screen for the information they are interested in.
- Speak clearly when presenting or talking to people face to face. Keep presentations short and succinct and always revisit the key points.
- Listen and address any questions.

**Information should be accessible**

An essential part of building up trust is to ensure the transparency of all activities, information and decision-making related to the event. Effective ways to do this include the following:

- Make scientific information available in different levels of detail, so people can start with a high-level summary. If they then want more information, they can click through to another web page or see another document for further detail. The last level of detail might be to make raw data available.

- Ensure data and contaminant levels are provided in context. On their own, numbers have no real meaning , so it is important to include:
  - a plain-English interpretation of the data where possible
  - relevant criteria or standards to compare the data with
  - an explanation of why certain data has been collected (e.g. why certain contaminants have been assessed and not others).

**Speak with one voice, with one message**

There must also be consistency in messaging from all response agencies working on the incident to build community trust and to avoid confusion or ill-informed actions. When different agencies are responsible for providing information, having agreed communications protocols ensures consistency in voice and content.

## Be timely

**Information needs to travel fast and be freely available**

During an emergency, the demand for information will come from the community, media, government and other emergency response agencies, and it needs to be delivered quickly and on time as promised.

Structured, logical processes for communicating information help people to understand where to find the information they need and when to expect it.

If information is late, or not easily accessed, there is a risk of speculation or misinformation from other sources.

During the Hazelwood mine fire, information was requested in four forms:

1. Raw data – delivered as live as possible.
2. Interpreted information – both for technical audiences and also packaged as a plain-English explanation.
3. Guidance – logical plans and actions to be followed.
4. Clear direction – actions advised to take (e.g. cautionary advice to protect health).

Consideration should be given to being proactive and having general background advice on potential impacts from fires reviewed and tested in the community and ready to be circulated.

**Keeping people informed on a regular basis, even when there is 'nothing' to report**

Sometimes there may be significant periods of time when there has been no change to information or updates, or agencies refrain from reporting due to uncertainty about the data or the potential impacts of an event. It is far better to update the community explaining why this is the case, rather than saying nothing at all. It's important to reiterate what you do know and what you don't know, keep people informed and don't wait until you have the 'perfect' information. For example:

- We are waiting for the confirmation of results from the laboratory.
- The information from our monitors remains unchanged.
- We are not yet certain what the impacts of this event will be on the environment.
- We are conducting more testing to investigate this matter further.

Regular updates are the best way to avoid communication 'black spots'. Silence from authorities during events can lead to anxiety and potential misinformation.

## Be responsive

**Use of appropriate communication channels**

Choosing the most appropriate communication tool is essential to increase the likelihood of the information reaching its intended audience. Common tools include: news media, maps, tables, fact sheets, pictures, videos, website updates, the phone and face to face.

For example, the air quality pages on EPA's website received 580,000 hits during February and March 2014, with the highest daily rate ever recorded of 60,000 on 24 February. This was ten times the normal rate.

**Tailoring the level of detail and type of information for different communication channels**

The data provided in different channels of communication needs to be tailored according to the audience and communication channel used.

For example, the presentation of data or information for a Tweet or hourly web update will often be different to the way it should be presented in a community report or used at a public meeting.

**Seek feedback to assess effectiveness of communications**

Once communications have been released, it is then important to gather feedback on the success of the communication tool used – did it reach the intended audience and did they understand the message?

Informal feedback during the early stages of the fire indicated that information on EPA's website wasn't clear and effective. As a result, changes were made to the format and presentation of information.

**Keep going, even after the emergency is over**

Once the emergency is over (i.e. the fire is controlled or put out), community based emergency recovery continues. This recognises an ongoing need in the community for communications and engagement resourcing. Communities will often have just as many questions about the longer-term health or environmental impacts of an emergency such as:

- Are we safe? How do we know?
- How do we clean up?
- Are there any lasting health impacts?
- Who can we go to for more information?
- Will this happen again?

For more information of the Hazelwood Recovery Program please see:

- EPA Hazelwood Recovery Program air quality assessment – Morwell and surrounds, February 2014 to May 2015 (publication 1601)
- EPA Hazelwood Recovery Program water, soil and ash assessment – Morwell and surrounds, February 2014 to May 2015 (publication 1600).

For more information on clean up please see:

- DHHS factsheet Cleaning up a smoke and ash affected home – Hazelwood open cut mine fire.

For more information on long-term health study please see:

- Hazelwood Mine Fire Health Study

Plain-English summaries of data and useful information need to be delivered quickly after the event to address these questions, using appropriate communication tools and techniques.

**Plan to reduce exposure**

People will make personal decisions about their health and well-being, so it is necessary to identify a range of activities and actions that people could take to protect their health and the health of anyone in their care.

A proactive approach could be to assist households to develop smoke plans through understanding, preparing for and managing risks from smoke events, which could form part of people's fire response or asthma plans for example. This includes understanding community information sheets for smoke and ash from coal mine fires particularly in the first 24 hours.

For community fact sheets on smoke and ash please see:

- DHHS Factsheet Smoke and your health – Hazelwood open cut mine fire
- DHHS Factsheet Ash fall-out – Hazelwood open cut mine fires

For more information on face masks please see DHHS Face masks – questions and answers.

## 9. Draw on networks – science groups across agencies

**Specialists will be in high demand.**

**Only use experts when you really need them.**

Having a multi-agency science advisory group was effective during the Hazelwood mine fire. Scientists from different disciplines and teams worked together to produce daily reports to inform decisions by Emergency Management Teams. The links between human health and environmental science was particularly critical in building a body of knowledge for decision making. The supportive relationship between all agencies and experts was crucial under challenging circumstances to keep the community safe. It is important that these relationships and connections are fostered outside of just emergency situations. This is particularly important for staff that may not do emergency management everyday as part of their job.

Because this fire lasted for 45 days there was a high demand for scientific expertise over this period, often in highly specialised areas of expertise. Experts were called on to create new methods and ways of doing things in response to this unprecedented incident. In addition, these experts also had to manage some normal day to day service delivery during this period.

Understanding expectations about demand for expertise was important. There is always a tendency for people to be “all hands on deck” in these types of events. During the fire there were a number of instances where experts spent a lot of time in transit to and from monitoring points, in meetings and providing other support such as changing batteries in monitoring instruments, manually downloading data, responding to individual calls from concerned community members and cleaning monitoring equipment. This impacted on their ability to be available for other business, highlighting the need to manage the amount of time towards crucial activities.

## 10. Peer reviews help get the monitoring and reporting right

**Independence helps process and focus.**

**Use other agencies and institutions.**

Independent review of data, interpretations and recommendations for actions is a good way to make sure advice and decisions are sound.

Independent experts from local institutions, interstate and overseas were contacted during the fire to assess sampling techniques, review reports and procedures, and to seek alternative views and options.

These experts were from varying fields and disciplines, such as those working in:

- modelling and forecasting
- laboratory analysis
- monitoring
- impact assessment.

To streamline the peer review process and focus the review, a set of key questions and requests were developed such as:

- advise if anything missing.
- assist in defining what was needed.
- increase our understanding of potential impacts.
- increase our understanding potential health impacts.
- review data analysis and monitoring strategies.
- check assumptions of monitoring

At the time, EPA had also just established its own Science and Engineering Advisory Committee (SEAC) made up of independent advisors whose purpose is to support EPA in the improvement of the quality and relevance of its science and engineering capability by providing strategic leadership, challenging its thinking and promoting the professionalism of its people. SEAC supported in:

- examining the process to identify right risks
- quality assurance of peer review process
- reviewing lists of peer reviewer and suggesting others in their networks
- acting as a sounding board for decisions
- providing an independent review process
- assessing the quality management plans.

Maintaining and drawing upon professional networks was key to eliciting the help from external reviewers, and should be a consideration in preparing for future emergency events.

Establishing formal expert networks and arrangements during emergency incidents should also be considered to provide support and assist in developing key personnel.

Effective independent reviewers may also be those working within the response agencies, but not involved in the incident response itself.

For more information on external expert peer reviews please see Appendix 2.

## 11. Filling gaps in available data

There is still an overall lack of publicly available data sets that characterise emissions from open-cut brown coal mine fires. One of the lessons from the meta-analysis was that it would have been useful to have captured a sample of the smoke and ash directly from the fire to act as a control or true comparison point for community ash sampling. In the absence of this data being collected to help fill this gap it is possible to conduct a series of experimental burns that replicate as closely as possible the conditions under which the mine fire occurred, such experimental burns would provide:

- air pollution emission factors generated by the burning
- concentrations and types of hazardous pollutants in the smoke
- the signature of chemical compounds
- composition of the residue after complete and incomplete combustion.

Emission factors will enable confident modelling of smoke transport from brown coal fires to estimate downwind smoke impacts in nearby townships, assisting with issuing local community smoke advisories/alerts and guiding emergency management planning and response.

Measuring levels and identifying the types of hazardous air pollutants will confirm the appropriate pollutants are monitored during these events to estimate community exposure for potential health impact studies in the future. For ash deposition it is necessary to determine:

- the chemical signature
- ash composition and particle size distribution

Determine if a signature can be found to identify brown coal ash generated from open burning as compared to other fires, such as bushfires. This would assist with environmental impact assessments and identification of how far the ash residue has been transported in the surrounding areas.

Because it was not possible to collect a large number or a large volume of ash, the ash emitted from the Hazelwood mine fire has also not been well characterised in terms of its particle size distribution. In order to better understand how ash was dispersed in the environment and deposited outdoors and indoors, it is important to understand the physical characteristics of the ash. The particle size of ash also provides some understanding of the potential pathway for human exposure such as breathing in via lungs, though skin or inadvertently ingesting dust from hands, food or drinks.

Transmission electron microscopy (TEM) in combination with energy dispersive X-ray spectroscopy (EDS) could be used to investigate the elemental distribution, morphology, crystalline phases and electronic structure of individual coal mine fire ash particles. This would have an emphasis on the ultrafine particles that may have the greatest impact on human health.

For more information on knowledge gaps please see Hazelwood Analysis Final Report (publication 1647)

## Contact

For further details about any aspect of this report, please contact EPA Victoria on 1300 372 842 or contact@epa.vic.gov.au

## Appendix 1

Along with this report seven other meta-analysis information reports have been released including:

- A consolidation of the measured air quality data and conditions to provide a general summary of the Hazelwood Mine Fire's impact on air quality in February and March 2014 (publication 1598)
- An examination of air quality data in the early stages of the Hazelwood Mine Fire to develop an understanding of the scientific correction factor that should be applied to indicative data generated by rapid response air monitoring equipment, enabling more accurate estimates of air quality in future emergency events (publication 1599)
- An assessment of air quality during the Hazelwood Mine Fire and through recovery (February 2014 to May 2015) (publication 1601)
- An assessment of water, soil and ash samples taken during the Hazelwood Mine Fire and through recovery (February 2014 to May 2015) (publication 1600)
- Hazelwood Analysis Final Report (publication 1647)
- Analysis of air quality during the Hazelwood mine fire (publication 1648)
- Hazelwood Analysis Database (publication 1649)
- Raw data

## Appendix 2

Peer review elements and organisations

| Program Element | Organisation |
|---|---|
| CO Protocol and health effects | Menzies Health Research Institute, Tasmania |
| | Toxikos Pty Ltd |
| | Kings College, London, UK |
| Smoke fine particle protocol - health effects and health protection advice | Australian Health Protection Principle Committee<br>enHealth (Environmental Health Standing Committee)<br>Monash University – School of Public Health & Preventive Medicine<br>Office of Environmental Health Hazard Assessment, Californian Environment Protection Agency<br>Californian Department of Public Health<br>Toxikos Pty Ltd |
| Air Quality Monitoring Program | University of Newcastle |
| | University of West of England, UK |
| Water Quality Monitoring Program | Centre for Aquatic Pollution Identification and Management University of Melbourne |
| Soil/Ash Quality Monitoring Program | RMIT Centre for Disaster Research, NZ |
| Air Quality Forecasting methods | University of British Columbia, Canada |
| | University of West of England, UK |
| Data Interpretations – Ash, Soil and Water samples - toxicology | RMIT School of Applied Sciences. Focus areas: Toxicology; Health Based Risk Assessment |
| Data Interpretations – PM 2.5 | University of Tasmania |
| | Canterbury University, NZ |
| Data Analysis - air monitoring | Air Quality Professionals Pty Ltd Melbourne |
| What is in the smoke document? | RMIT School of Applied Sciences |
| Dioxins and Furans Advice | RMIT School of Applied Sciences. Focus areas: Toxicology; Health Based Risk Assessment |
| Health advice and precedence | Californian Office of Environment and Environmental Health<br>Department of Health – Health Protection Branch<br>Australian Health Protection Principle Committee<br>enHealth (Environmental Health Standing Committee)<br>Monash University – School of Public Health & Preventive Medicine<br>Office of Environmental Health Hazard Assessment, Californian Environment Protection Agency<br>Californian Department of Public Health<br>Air quality professionals Pty Ltd |