Smoke from hazard reduction burning from 2 to 3 September 2017

Air pollution due to smoke
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Cover photo: Smoke plumes from coastal hazard reduction burn Diggers Camp. John Lugg/OEH
Contents

Analysis of typical exceedance event in Sydney due to PM$_{2.5}$ pollution from hazard reduction burning, 2-3 September 2017 5

Event description 5

Event analysis 7
  Day 1, Saturday, 2 September 2017 7
  Day 2, Sunday, 3 September 2017 8
  Day 3, Monday, 4 September 2017 8

Smoke-indicator timeseries plots of visibility, as nephelometer readings 14

The role of wind speed and direction in determining particle levels 15

Summary 16

References 16
List of figures

Figure 1  Hazard Reduction Burns and other fire incidents in the Sydney region on Friday, 1 September 2017. Locations of larger hazard reduction burns shown in circles. 6

Figure 2  PM$_{2.5}$ daily average concentrations at Sydney sites, showing that five sites exceeded the daily PM$_{2.5}$ NEPM standard on Saturday, 2 September, and two sites exceeded the standard on Sunday, 3 September 2017 7

Figure 3  Synoptic charts for Saturday-Monday, 2-4 September 2017. Source: BOM (2017) 9

Figure 4  Spatial distribution of PM$_{2.5}$ 24-hour average concentrations in the Greater Sydney Region on Saturday, 2 September 2017 10

Figure 5  NSW Rural Fire Services Smoke Dispersion Model incremental particle prediction for 1pm, Saturday, 2 September 2017 11

Figure 6  OEH Chemical Transport Modelling of PM$_{2.5}$ concentrations for 1pm, Saturday, 2 September 2017 11

Figure 7  MetEye forecast for wind speed and direction, for 1pm, Saturday, 2 September 2017, showing offshore air flows and onshore progression of the afternoon sea breeze, across Sydney. Source: Bureau of Meteorology 12

Figure 8  OEH HYSPLIT in NSW back trajectories for Saturday, 2 September 2017 13

Figure 9  Time series plot of Nephelometer (visibility) exceedances for Sydney north west and Sydney south west (top), Sydney east (middle), and Illawarra and Central Coast (bottom), during 2-3 September 2017 14

Figure 10 Panel plot of Nephelometer (visibility) (top), wind direction (middle) and wind speed (bottom) at Chullora, from 31 August-4 September 2017 15
Analysis of typical exceedance event in Sydney due to PM$_{2.5}$ pollution from hazard reduction burning, 2-3 September 2017

This analysis provides insight into the occurrence of typical high PM$_{2.5}$ pollution in Sydney, due to the impact of hazard reduction burns (HRB). The results are useful for understanding HRB-related fine particle pollution in Sydney.

Event description

Over the weekend of 2-3 September 2017, 24-hour (daily) average PM$_{2.5}$ levels exceeded the National Environment Protection (Ambient Air Quality) Measure (AAQ NEPM) standard at six monitoring stations in Sydney, on the east coast of New South Wales. This was due to smoke from large hazard reduction burns (HRB), west of Sydney.

Figure 1 shows two large HRBs to the north west of Sydney in the Hawkesbury area; one large HRB to the south west of the Sydney near Warragamba dam; and numerous smaller HRBs near Sydney’s western suburbs. The three major HRBs covered a total area of approximately 2600 hectares.

Elevated PM$_{2.5}$ pollution in the region exceeded the NEPM PM$_{2.5}$ 24-hour standard at five air quality monitoring stations in the Greater Sydney Region on 2 September and at two stations on 3 September 2017, as shown in Figure 2. This event was associated with calm conditions and light north-westerly winds on 2 September, ahead of stronger south-westerly winds and the passage of a cold front on 3 September 2017.
Figure 1  Hazard Reduction Burns and other fire incidents in the Sydney region on Friday, 1 September 2017. Locations of larger hazard reduction burns shown in circles.
Figure 2: PM$_{2.5}$ daily average concentrations at Sydney sites, showing that five sites exceeded the daily PM$_{2.5}$ NEPM standard on Saturday, 2 September, and two sites exceeded the standard on Sunday, 3 September 2017

**Event analysis**

**Day 1, Saturday, 2 September 2017**

A high-pressure system over the east coast of Australia brought relatively calm conditions and light north-westerly winds to the Greater Sydney Region (Figure 5, top left and right). These conditions, combined with a strong temperature inversion, caused smoke from HRBs to be transported across the city.

Exceedances of the NEPM PM$_{2.5}$ 24-hour standard were recorded at air quality monitoring sites in Sydney east (Chullora, Earlwood and Rozelle), Sydney north west (Prospect) and Sydney south west (Oakdale). Chullora and Prospect recorded the highest levels (Figure 2, Figure 4). Sydney’s more eastern suburbs recorded relatively lower impacts of HRB emissions (Randwick, Figure 4).

Sydney east experienced a north-easterly sea breeze on Saturday, 2 September 2017 (Figure 10). This suggested that the afternoon north-easterly sea breezes may have suppressed the offshore transport and dispersion of particles. This would account for Chullora and Prospect having the highest daily PM$_{2.5}$ levels, while Randwick (Sydney east) recorded no PM$_{2.5}$ exceedance (Figure 4). The spatial distribution of PM$_{2.5}$ daily averages recorded across Sydney suggested a build-up of smoke between Prospect and Chullora.

This interpretation was supported by information presented in Figure 5 to Figure 8:
• Smoke dispersion modelling, by the NSW Rural Fire Service, and PM$_{2.5}$ dispersion modelling, by Office of Environment and Heritage (OEH) (CCAM-CTM)$^1$, predicted higher smoke levels in Sydney’s western and central areas, than in the eastern suburbs (Figure 5 to Figure 6).
• The Bureau of Meteorology, MetEye forecast for wind speed and direction, for 1pm, Saturday, 2 September 2017, showed prevailing offshore air flows and the onshore progression of the afternoon sea breeze, across Sydney (Figure 7).
• HYSPLIT in NSW back trajectory analysis by OEH showed smoke flowing into the Greater Sydney Region from the north west, where two major HRBs were burning (Figure 8).

**Day 2, Sunday, 3 September 2017**

A strong temperature inversion overnight and calm conditions with very light north-westerly air flows meant minimal dispersion of smoke from the HRBs on the previous day. Typically, HRBs occur on Saturdays and then smolder over the remainder of the weekend. These conditions may account for the exceedances of the NEPM PM$_{2.5}$ daily standard at St Marys and Prospect (Sydney north west) on Sunday (Figure 2). These monitoring sites were closest to the HRBs near Sydney’s western suburbs.

Dispersion conditions improved, with northerly winds after midday and moderate south-westerly winds in the evening, associated with the passage of a cold front (Figure 3).

**Day 3, Monday, 4 September 2017**

Particle levels in Sydney returned to low levels on Monday, 4 September 2017, due to consistent westerly to south-westerly winds and the absence of active HRBs (Figure 3).

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$^1$ The CCAM-CTM air quality model is a meteorological model, the Conformal Cubic Atmospheric Model (CCAM) and a dispersion model called the Chemical Transport Model (CTM). CCAM and CTM were developed by CSIRO (McGregor et al., 2008, Cope et al., 2009)
Figure 3  Synoptic charts for Saturday-Monday, 2-4 September 2017. Source: BOM (2017)
Figure 4  Spatial distribution of PM$_{2.5}$ 24-hour average concentrations in the Greater Sydney Region on Saturday, 2 September 2017
Figure 5  NSW Rural Fire Services Smoke Dispersion Model incremental particle prediction for 1pm, Saturday, 2 September 2017

Figure 6  OEH Chemical Transport Modelling of PM$_{2.5}$ concentrations for 1pm, Saturday, 2 September 2017
Figure 7 MetEye forecast for wind speed and direction, for 1pm, Saturday, 2 September 2017, showing offshore air flows and onshore progression of the afternoon sea breeze, across Sydney. Source: Bureau of Meteorology
Figure 8  OEH HYSPLIT in NSW back trajectories for Saturday, 2 September 2017
Smoke-indicator timeseries plots of visibility, as nephelometer readings

Nephelometer readings of reduced visibility are a good indicator of fine smoke particles.

Figure 9 shows a timeseries plot of the visibility readings, for Thursday-Monday (31 August-September 2017), for sites in Sydney, the Illawarra and the Central Coast that exceeded the OEH visibility standard, on Saturday-Sunday (2-3 September 2017).

The highest readings for hazardous visibility were at Oakdale (Sydney south west) and Chullora (Sydney east). The higher reading at Oakdale was due to the proximity of the HRBs to the monitoring site. The second highest reading at Chullora was consistent with the spatial distribution of PM$_{2.5}$ (Figure 4) and the HYSPLIT in NSW back trajectory (Figure 8).

Figure 9 Time series plot of Nephelometer (visibility) exceedances for Sydney north west and Sydney south west (top), Sydney east (middle), and Illawarra and Central Coast (bottom), during 2-3 September 2017
The role of wind speed and direction in determining particle levels

Chullora was chosen for a panel plot to show the role of wind speed and direction in determining particle levels.

Figure 10 presents a panel plot for the nephelometer readings, wind speed and wind direction at Chullora, from 31 August to 4 September 2017. This plot identifies the following key associations between meteorological conditions and particle levels.

- Before and during the period of high nephelometer readings (low visibility), there were very calm conditions (wind speed less than two metres per second) with air flows from the north west. These conditions, combined with a strong temperature inversion and smoke from HRBs north west of the Greater Sydney Region, resulted in high particle levels in across the city.

- On Saturday afternoon, the north-easterly sea breezes most likely blocked the dispersion of smoke within the Sydney region, causing a build-up of smoke and the highest PM$_{2.5}$ readings at Chullora and Prospect.

- After midday on Sunday, the stronger north-westerly to south-westerly winds, associated with passing of a cold front late in the evening, helped to disperse smoke (particles) over the ocean waters.

- On Monday, 4 September 2017, low levels of particles were recorded.

The evidence provided by the panel plot (Figure 10) was consistent with the analysis based on Figure 3 to Figure 9, above.
Summary

The Greater Sydney Region, experienced reduced visibility and exceedances of the PM$_{2.5}$ 24-hour NEPM standard at six monitoring stations, on 2 to 3 September 2017. This was due to smoke from hazard reduction burning to the north and west of the region. A high-pressure system over the east coast of Australia brought calm conditions, a strong temperature inversion and light north-westerly air flows to the Sydney region. Smoke from HRBs in the west was transported across the city, reducing visibility and elevating PM$_{2.5}$ levels. The afternoon north-easterly sea breeze blocked the dispersion of smoke, causing the build-up of smoke and exceedances of the PM$_{2.5}$ 24-hour standard across the city. Smoke continued to elevate PM$_{2.5}$ levels in calm conditions, especially closer to the HRBs near western Sydney, until the passage of a cold front with stronger south-westerly assisted dispersion of smoke.

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