Office of Environment & Heritage

NSW EPA Environment Protection Authority

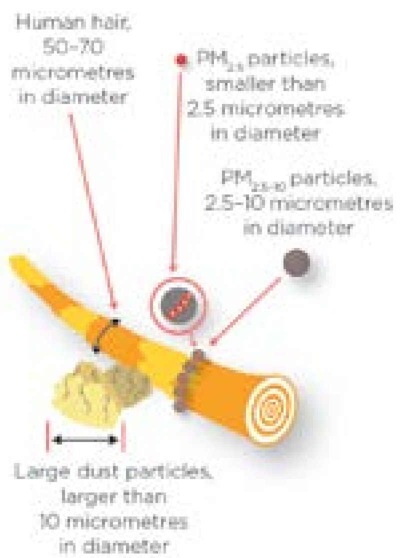
Our local air quality

Findings from the Lower Hunter Particle Characterisation Study

Air quality in the Lower Hunter is generally good by world standards, but airborne particle levels can exceed national standards at times.

Higher particle levels measured near the Port of Newcastle have also raised community concerns.

There are health benefits to improving air quality. Reducing long-term exposure of communities to fine particles can deliver the greatest health benefits.



What are airborne particles?

Airborne particles are a suspended mixture of solid and liquid particles in the air. $PM_{2.5}$ particles have diameters of less than or equal to 2.5 micrometres and include combustion particles, organic compounds and metals. $PM_{2.5–10}$ particles have diameters of 2.5–10 micrometres and include dust and pollen.

Where do particles come from?

Particles come from human and natural sources. Natural sources include sea salt, bushfires, soil and pollen, and are often not feasible to regulate. Measures to control bushfire smoke and soil dust include managed burns, and soil conservation and cover techniques. Human sources can be regulated and include vehicles, industry, commercial activities, household sources such as wood heating, non-road diesel equipment and transport, and hazard-reduction burning.

Airborne particles include:

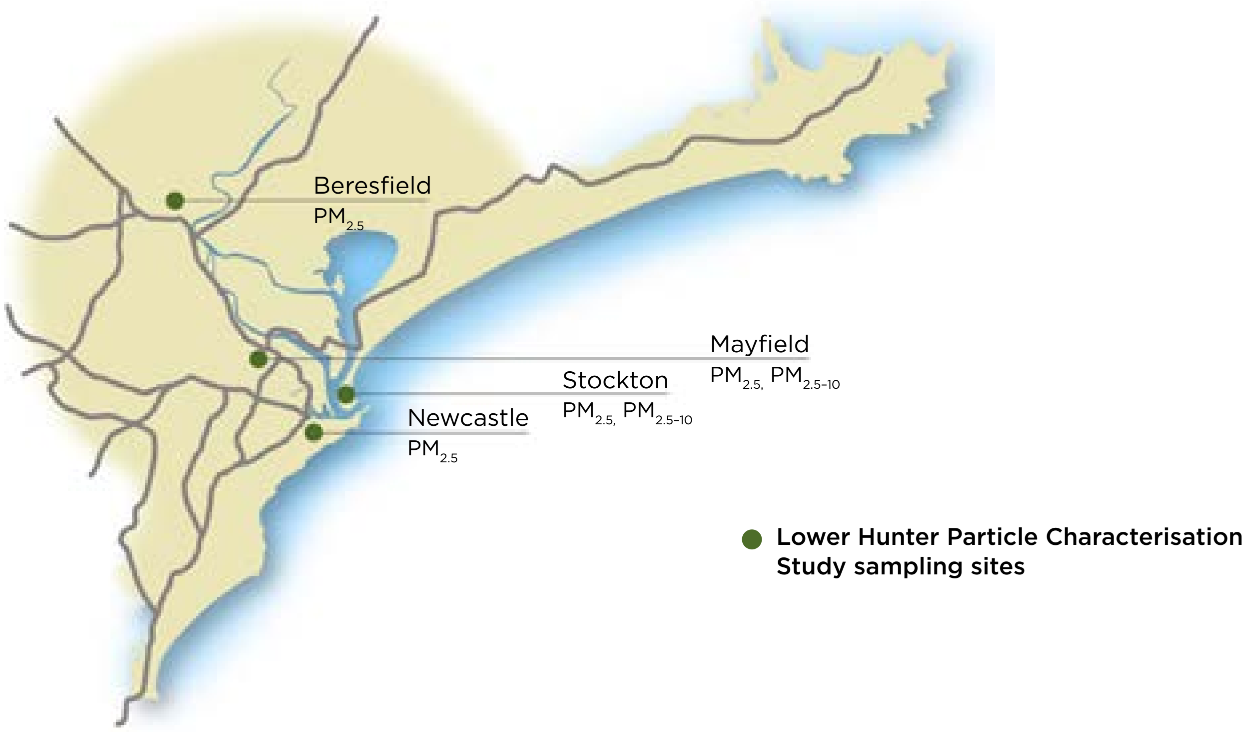
- primary particles emitted directly into the air
- secondary particles which form in the air from chemical reactions between gases, or between gases and particles.

What was the Lower Hunter Particle Characterisation Study?

The Lower Hunter Particle Characterisation Study was a three-year scientific study commissioned by the NSW Environment Protection Authority (EPA) to investigate the composition and major sources of particles in the Lower Hunter.

The study was conducted by scientists from the NSW Office of Environment and Heritage (OEH), CSIRO, and the Australian Nuclear Science and Technology Organisation (ANSTO), with oversight from NSW Health, and looked at $PM_{2.5}$ and $PM_{2.5\text{–}10}$ particles.

$PM_{2.5}$ particles were monitored at four sites, including two sites representative of regional population exposures (Newcastle, Beresfield) and two sites near the Port of Newcastle (Mayfield and Stockton). $PM_{2.5\text{–}10}$ particles were monitored at Mayfield and Stockton, sites closest to the Port of Newcastle.



How was the study conducted?

Scientists measured $PM_{2.5}$ and $PM_{2.5\text{–}10}$ particles over one year, from 1 March 2014 to 28 February 2015. Samples were collected over a 24-hour period, every third day, with filters sent for laboratory analysis to find out the chemical composition of the particles collected.

Mathematical methods were used to analyse the particle composition data and identify source 'factors' based on the types and ratios of chemicals that occur together. These chemical 'fingerprints', seasonal trends in source factors, and wind analysis were used to identify the likely source or sources in each factor. Source factors may come from one source (e.g. vehicles), or may be a mixture of sources (e.g. mixed shipping and industry).

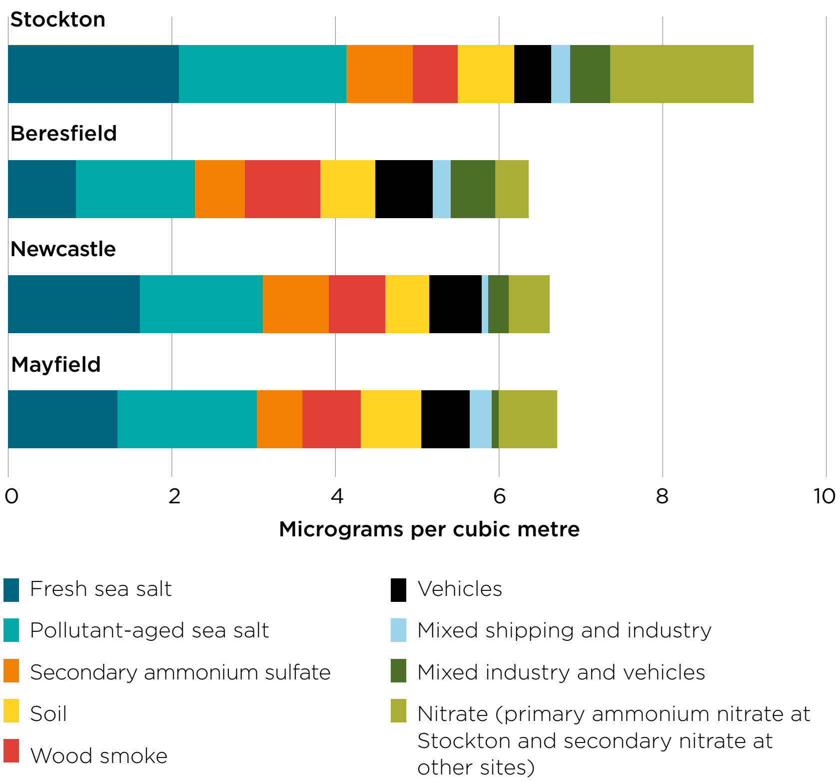
What did the study find out about $PM_{2.5}$ particles?

Newcastle, Mayfield and Beresfield had similar annual average $PM_{2.5}$ particle concentrations in the range 6.4–6.7 micrograms per cubic metre ($\mu g\ m^{-3}$), with a 50:50 split between primary and secondary particles. The annual average $PM_{2.5}$ particle level was higher at Stockton (9.1 $\mu g\ m^{-3}$) with a 65:35 split between primary and secondary particles at this site.

The study identified nine source factors for $PM_{2.5}$ particles at all four sites.

All four sites had similar levels of $PM_{2.5}$ particles from each source factor, except Stockton, which recorded primary ammonium nitrate and higher sea salt levels.

$PM_{2.5}$ particles: annual averages



The nine source factors contributing to $PM_{2.5}$ particles in the Lower Hunter

Primary particles

Fresh sea salt
Particles blown from breaking ocean waves.

Wood smoke
Particles from residential wood heating with some contribution from vegetation fires.

Soil
Soil dust emitted as primary particles; some carbon in the soil dust at Mayfield and Stockton possibly due to coal particles or soot.

Vehicles
From on-road and non-road sources (including locomotives).

Nitrate
Primary ammonium nitrate at Stockton (industry).

Secondary particles

Pollutant-aged sea salt
Sea salt that has reacted chemically in the air with pollution from other sources such as industry and vehicles.

Secondary ammonium sulfate
Secondary particles from sources of sulfur dioxide (fossil fuel burning) and ammonia (agriculture, industry, vehicles, non-road equipment, soils, the ocean).

Nitrate
Secondary sodium nitrate at Mayfield, Newcastle and Beresfield from nitrogen oxide sources (vehicles, non-road equipment, industry).

Primary and secondary particles

Mixed shipping and industry
Primary and secondary particles from shipping and industry.

Mixed industry and vehicle
Primary and secondary particles from industry, vehicles and non-road sources.

How do $PM_{2.5}$ particle sources vary across sites?

At Stockton primary ammonium nitrate made up:

- 19% of the annual $PM_{2.5}$ particle mass
- about 40% of the mass in winter when off-shore winds prevail and the Stockton site is downwind of ammonium nitrate manufacturing on Kooragang Island.

At Newcastle, Mayfield and Beresfield, the nitrate occurred as secondary sodium nitrate formed in the air due to reactions between the nitrous oxide emitted from various sources (such as vehicles, non-road diesel equipment, industry) and sea salt. Secondary nitrate accounted for 6–11% of the annual $PM_{2.5}$ particle mass at these sites.

Fresh sea salt decreased away from the coast, from 24% at Newcastle to 13% at Beresfield on an annual basis.

Wood smoke increased with distance from the coast, and was much higher in cooler months, when it contributed up to 45% of the $PM_{2.5}$ particles at Beresfield and up to 12% at Stockton on a monthly average basis.

About 10% of all $PM_{2.5}$ particles were from vehicles at Newcastle, Mayfield and Beresfield over the year and 5% at Stockton.

Industrial emissions contribute to several source factors including mixed industry and vehicles, mixed shipping and industry, nitrate, pollutant-aged sea salt, secondary ammonium sulfate, vehicles and soil.

How does $PM_{2.5}$ particle pollution vary seasonally?

Particle concentrations and sources vary during the year due to changes in weather patterns and human activities, such as wood heater use in winter. In summer frequent on-shore winds blow particles inland. In winter off-shore winds are dominant transporting particles from inland sources towards the coast.

The proportion of fresh sea salt and pollutant-aged sea salt was highest during October–February due to frequent on-shore winds.

Wood smoke and vehicles generally contributed more to $PM_{2.5}$ particles during cooler months (May–July) when wood heaters are in use and north-westerly off-shore winds prevail. Cool air stays closer to the ground, trapped by warmer air above (called a temperature inversion) resulting in poorer dispersion of air pollution.

Due to its inland location wood smoke contributed more to $PM_{2.5}$ particle levels at Beresford and seasonal variations in $PM_{2.5}$ particles from vehicles were also less apparent.

Soil contributed least to $PM_{2.5}$ particle levels during summer because of the frequent on-shore winds.

Dominant off-shore winds in winter means that emissions from ships are blown seaward rather than towards the coast.

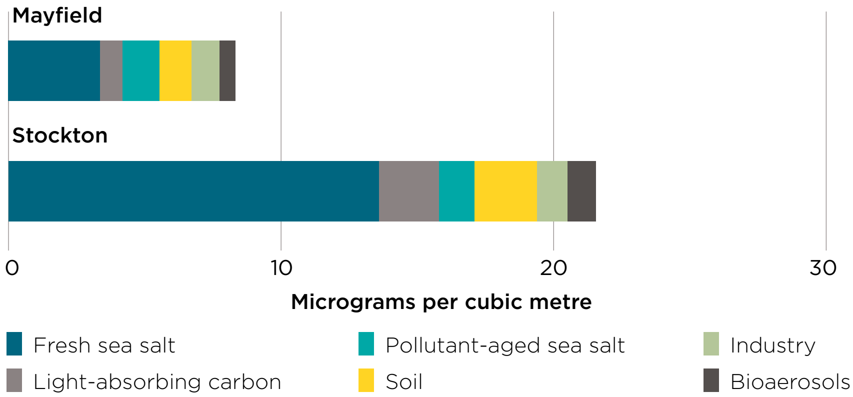
In Newcastle secondary ammonium sulfate and nitrate contributions were greater during warmer months when air chemistry is enhanced, and lowest during winter months when winds blow off-shore.

Stockton received higher amounts of primary ammonium nitrate in cooler months with off-shore winds, when it contributed about 40% of $PM_{2.5}$ particles. Wind analysis identified the ammonium nitrate manufacturing facility on Kooragang Island as the most likely source.

What did the study find out about $PM_{2.5\text{–}10}$ particles?

$PM_{2.5\text{–}10}$ particle composition and sources were determined at the sites near the Port of Newcastle, which are Mayfield and Stockton. The study identified six source factors for $PM_{2.5\text{–}10}$ particles. The annual average $PM_{2.5\text{–}10}$ particle concentration was two and a half times higher at Stockton (21.5 µg m^{-3}) compared to Mayfield (8.3 µg m^{-3}), mainly due to fresh sea salt.

$PM_{2.5\text{–}10}$ particles: annual averages



The six key factors contributing to $PM_{2.5\text{–}10}$ particles in the Lower Hunter

Primary particles

Fresh sea salt
Primary particles blown from breaking ocean waves.

Light-absorbing carbon (with some sea salt)
Coal particles may contribute to this source.

Soil
Comprises soil dust emitted as primary particles.

Industry
Related to industrial emissions.

Bioaerosol
Fungal spores and pollens combined with industrial emissions and sea salt.

Secondary particles

Pollutant-aged sea salt
Sea salt that has reacted chemically in the air with pollution from other sources, e.g. industry, vehicles.

Most $PM_{2.5\text{–}10}$ particles were primary particles, but there is evidence of chemical reactions in the pollutant-aged sea salt factor.

In addition to the main study, computer modelling was used to understand the distribution of particles over the broader region. This chemical transport modelling confirmed that the levels and composition of $PM_{2.5}$ particles across the region, including at Lake Macquarie and Maitland, are similar to those at the sites studied. This is because $PM_{2.5}$ particles stay in the air for long periods and can travel long distances.

How do $PM_{2.5–10}$ particles vary between sites?

Levels of industry and pollutant-aged sea salt in $PM_{2.5–10}$ particles were similar at Mayfield and Stockton. However Stockton experienced higher fresh sea salt due to its location near the ocean and higher light-absorbing carbon, soil and bioaerosol concentrations.

How do $PM_{2.5–10}$ particle levels vary seasonally?

$PM_{2.5–10}$ particle levels and their sources showed greater seasonal changes than $PM_{2.5}$ particles. Similar seasonal patterns were evident for Mayfield and Stockton due to wind patterns, but higher $PM_{2.5–10}$ particle concentrations occurred at Stockton.

During October to April, on-shore winds were prominent and fresh sea salt made up 73% of the $PM_{2.5–10}$ particles at Stockton. With pollutant-aged sea salt, the contribution increases to almost 80% because the narrow Stockton peninsula lies between the Pacific Ocean and the northern arm of the Hunter River. Fresh sea salt and pollutant-aged sea salt were also dominant at Mayfield during the October to April period. $PM_{2.5–10}$ particle concentrations were significantly lower during late autumn and winter when off-shore winds prevailed and the contribution of sea salt was reduced.

Soil and industrial contributions were relatively consistent throughout the year at Mayfield, but were more prominent at Stockton during late autumn and winter when off-shore winds prevailed.

Bioaerosols were highest in autumn and summer when fungal spore concentrations peaked.

Light-absorbing carbon was found to account for about 10% of the $PM_{2.5–10}$ particle mass at Mayfield and Stockton. Coal particles could contribute to light absorbing carbon, and so contribute up to 10% of the $PM_{2.5-10}$.

2799

Photography
Cover: International Imaging/Hunter Development Corporation.
Page 4: Hunter Development Corporation.
All other photographs: J. Spencer/OEH.

More information

www.environment.nsw.gov.au/aqms/lowhunterparticle.htm

Published by:
Office of Environment and Heritage and Environment Protection Authority
59 Goulburn Street, Sydney NSW 2000
Phone: +61 2 9995 5000 (switchboard)
Email: info@environment.nsw.gov.au
Websites: www.environment.nsw.gov.au and www.epa.gov.au
OEH 2016/0256 ISBN 978 1 76039 348 9
April 2016