

**Impact of Low Emission Engines
on Mine Air Quality:
Chemical and Biological
Measurements**

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OUTLINE

- **Objectives**
- **Sampling**
- **Analytical methods**
- **Results**
- **Summary**

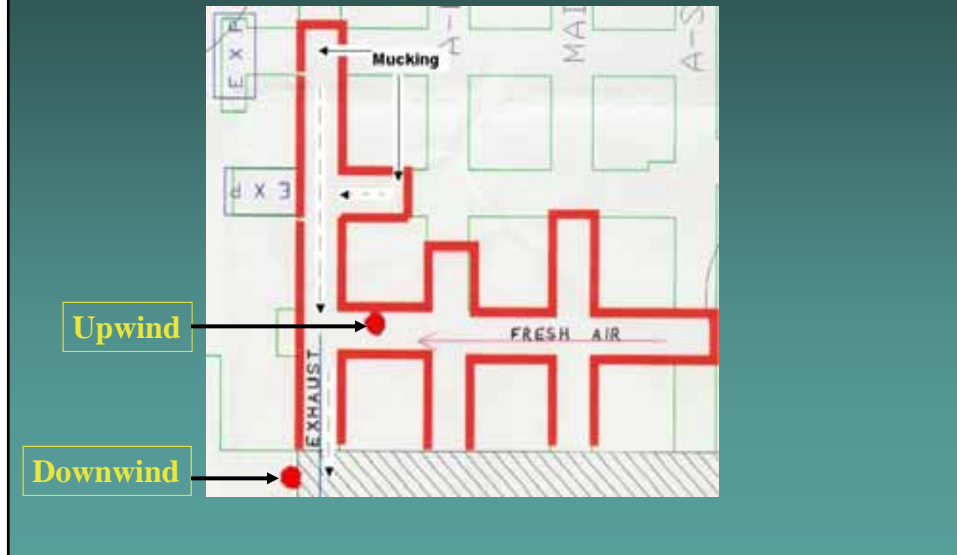
OBJECTIVES

- Evaluate the impact of low emission electronically controlled diesel engines versus older technology on mine air quality.
 - Determine diesel particulate matter (DPM)
 - Physical characteristics
 - Biological activity
 - Chemical composition
- Determine if low emission engine technology introduces any potential health concerns.

KEY QUESTIONS

- Do low emission, electronically controlled Diesel engines fueled with low sulfur (34 ppm S) fuel produce more nanoparticles than older style mechanically controlled engines?
- Do these engines introduce potentially new health concerns into the mine environment?

SAMPLING LOCATIONS



In-Mine Sampling

High Volume (HV) samplers with slotted inertial impactors, with 50% cut points at 3.5, 2.0 and 0.95 μm .
Sampling only with vehicle activity.



1998 (Model 988 F) Front End Loader with an electronically controlled engine

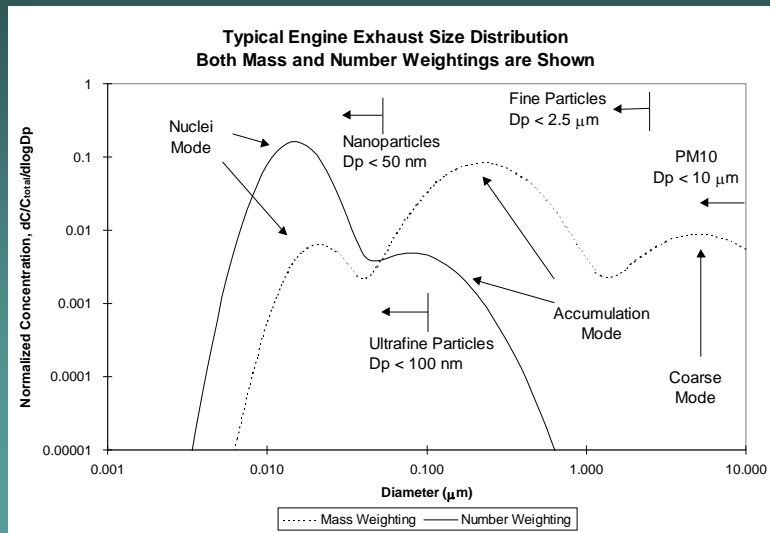


SAMPLE MATRIX

Location	Number of Days	Filters/Day	Time/ Day (hr)
Wk 1- Upwind	4	2	0.4 - 0.9
Wk 2 - Upwind	5	2	0.7 - 1.3
Wk 1 - Downwind	5	2 - 6	0.3 - 1.3
Wk 2 - Downwind	5	2 - 6	1.3 - 3.7

All samples/day pooled for chemical/biological study.

Particle Sizes Collected

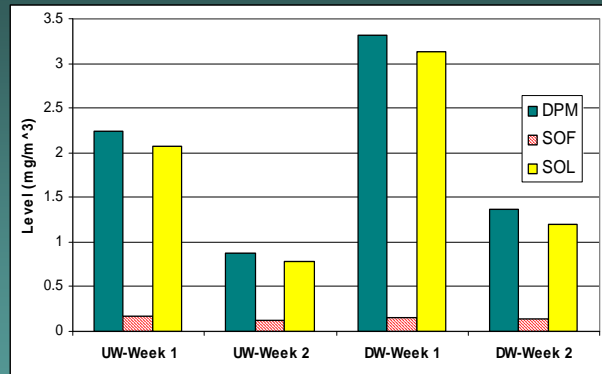


Analytical Methods

- **DPM -Gravimetric**
- **SOF - Soxhlet extraction and gravimetric**
- **Sulfates - Aqueous extraction and IC**
- **Solids - Subtraction (TPM - SOF - Sulfates)**
- **Biological Activity - Microsuspension modification of Ames Assay**
- **PAH/Nitro-PAH/Hopanes - GC/MS**

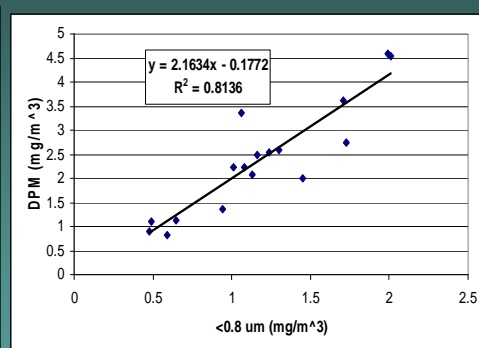
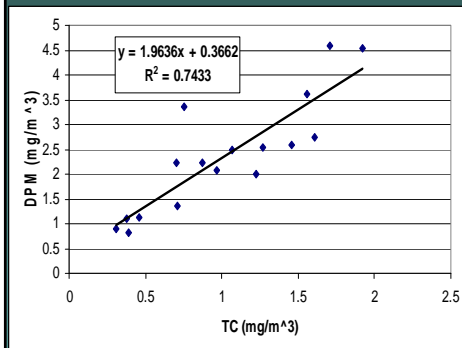
Lab blanks (unexposed Pallflex filters) also with the exposed HV filter samples.

DPM and Component Levels



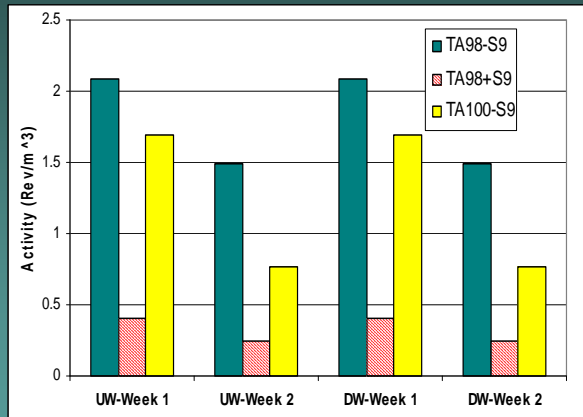
All sulfate levels were ≤ 0.01 mg/m³.
Concentrations are normalized and weighted.

DPM Correlation with TC and <0.8 μ m Particles



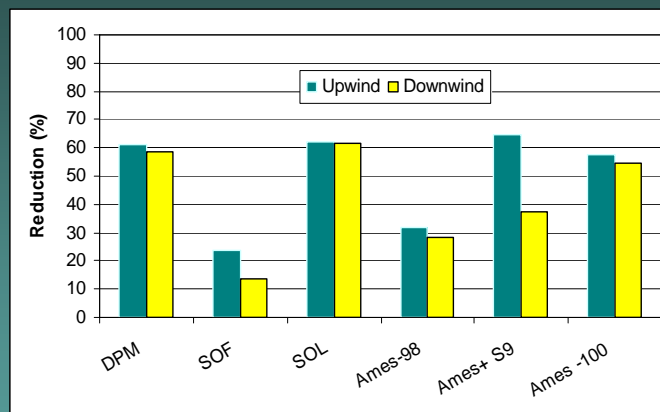
Solids and EC also strongly correlated.
OC and SOF moderately correlated.

Biological (Ames) Activity



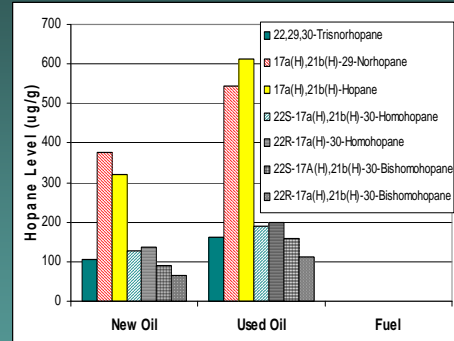
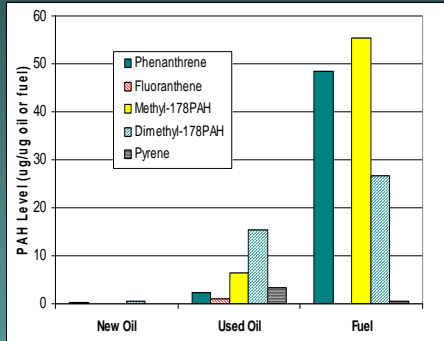
Concentrations are weighted weekly averages.

Reductions in Emissions



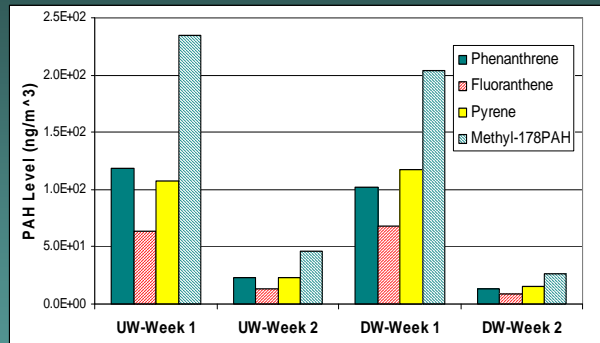
Based on weighted/normalized weekly averages (DPM, SOF, and SOL) or weighted weekly averages (Ames)

Fuel and Oil PAHs and Hopananes



Presence of PAH vs. hopanes might be used as indicators of fuel vs. lubricating oil contributions to emissions.

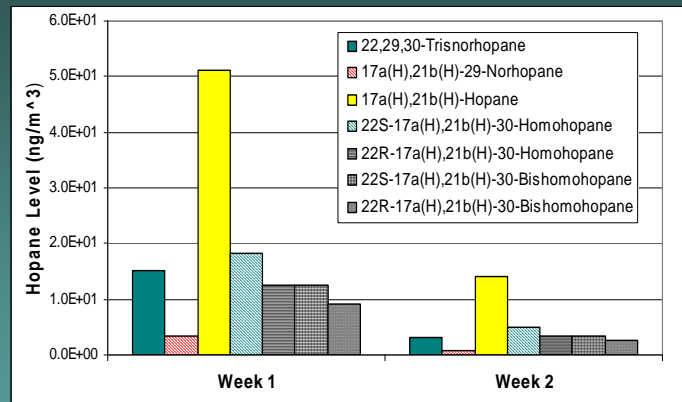
Example PAH Levels



No nitro-PAH detected.

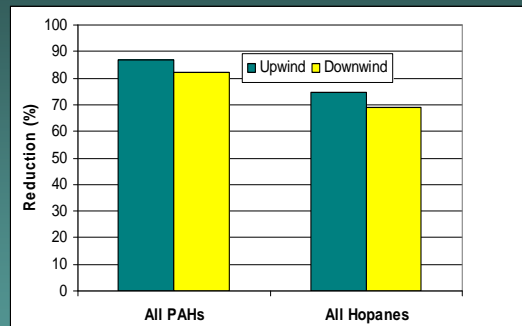
Concentrations are weighted weekly averages.

Downwind Hopane Levels



Concentrations are weighted weekly averages.

PAH and Hopane Reductions



Overall average reduction for all 22 PAH was greater than that for all 5 hopanes (both sites).

SUMMARY

- **All of the monitored emissions decreased by up to 90%) with use of the electronically controlled engines (most changes were significant).**
- **The DPM levels obtained from the HV samplers correlated well with emissions obtained using lower flow rate/full-shift samplers.**
- **There is no evidence from the chemical and biological measurements to suggest new health concerns were introduced into the mine by electronically controlled engines.**
- **The complete report is available at www.deep.org**