Best Practices for Dust Control in Metal/Nonmetal Underground Mining

Greg Chekan
Mining Engineer
NIOSH

CDC Workplace Safety and Health

National Institute for Occupational Safety and Health NIOSH

Overview

- **Case studies of dust control in large-opening mines:**
  - **Dump/crusher**
  - **Production shots**
  - **Haulage cycle**
  - **Other sources**

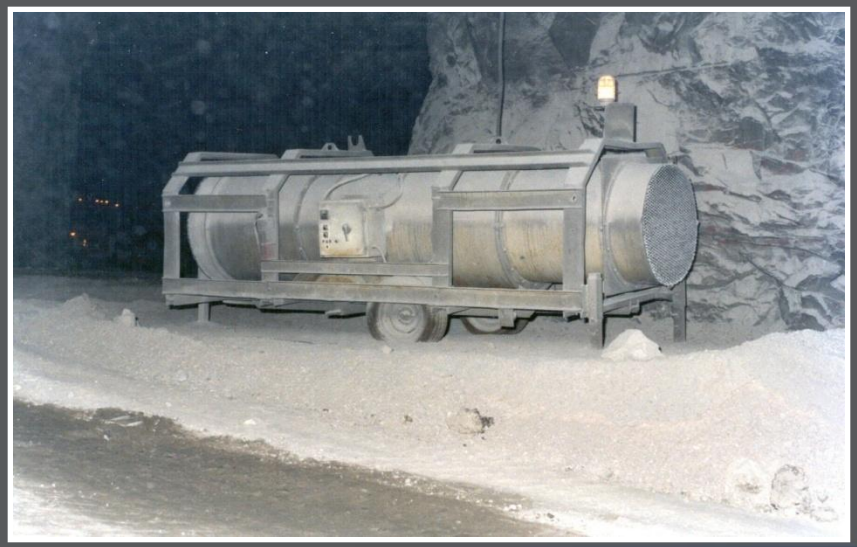
Dust Control in Large-opening Mines

Ventilation

- **Dilute and transport dust from mine atmosphere**
- **Direct dust away from workers**

Improvements in Ventilation to Remove Harmful Particulate

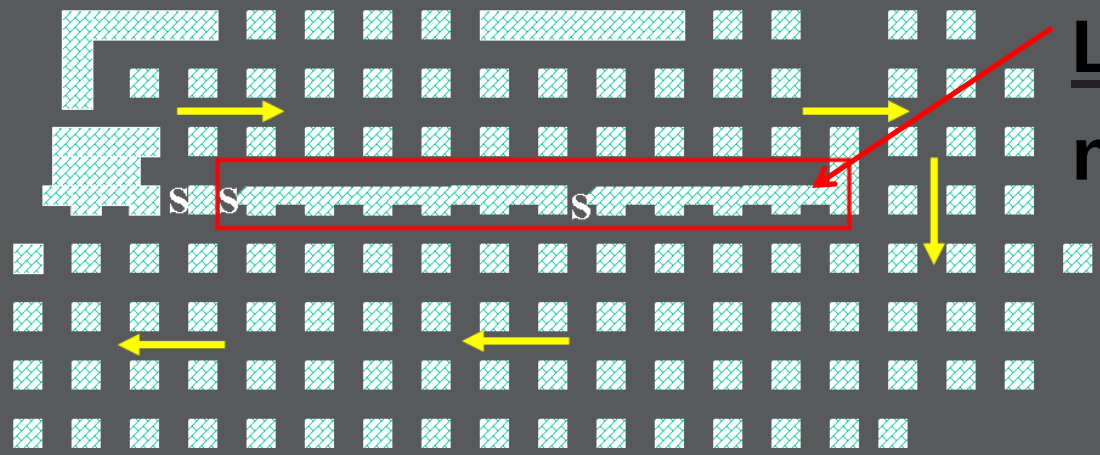
<u>Mine-wide</u> – Main fan to establish airflow on a mine-wide basis



<u>Local</u> – Booster fans for more direct and controlled air volume

Improvements in Ventilation to Remove Harmful Particulate

Stoppings – in key locations to more efficiently direct and control airflow



Long Pillars – reduce number of stoppings

Controlling Dust with Ventilation

Dump/Crushing Facility – Local Ventilation

UNDERGROUND CRUSHERS

- As mines become larger, crusher facilities are located underground
- Major point source of silica dust requiring engineering controls

Isolate crusher from general mine air using curtain stoppings.

Use booster fans to transport and dilute dust.

Evaluated Two Types of Fans

Axial Vane Fan

- 36-inch diameter
- 50 hp electric
- 50,000 cfm

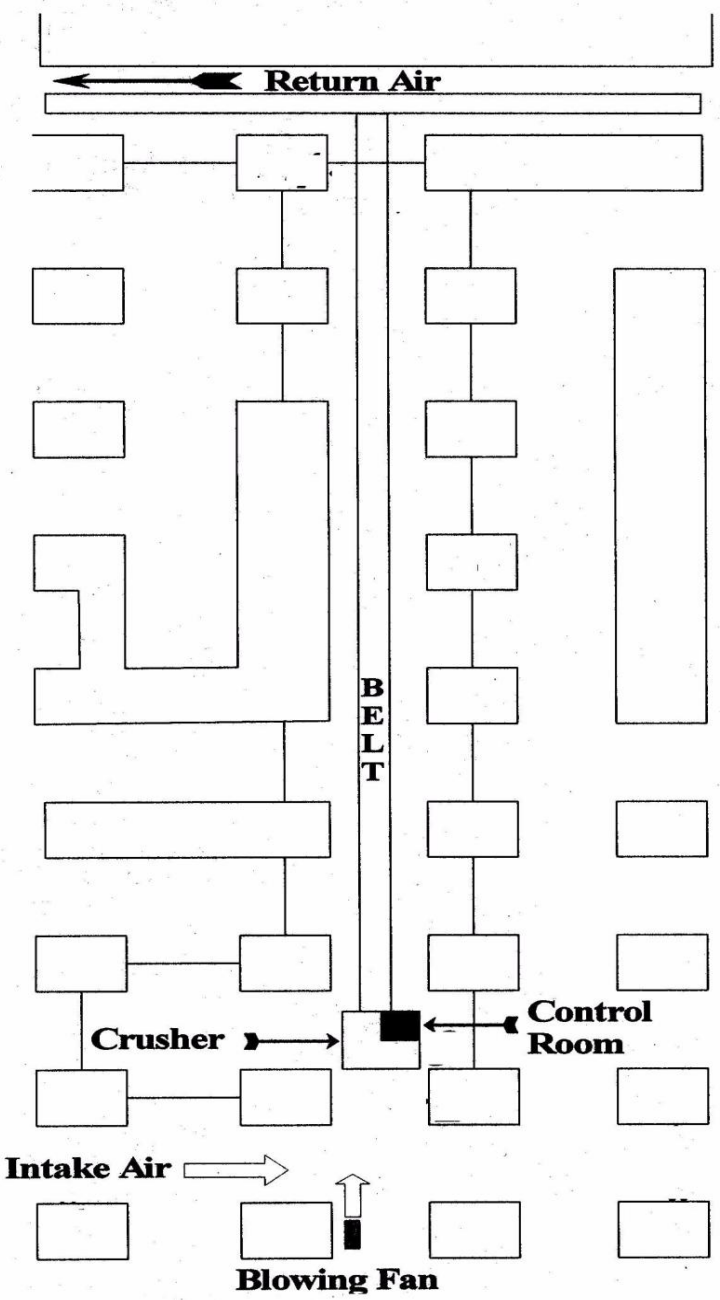
Propeller Fan

- 60-inch diameter
- 27.2 hp diesel engine
- 50,000 cfm

Main Air Return

Location of Crusher, 15 Stoppings, and Fans

Axial Vane or Propeller Fan



Sampling Strategy

Fan approximately
100 ft from dump

Characterize dust levels and distribution around the crusher by area sampling at six key locations

Sample for three days for each fan

Area Sampling

1- Intake/crusher side

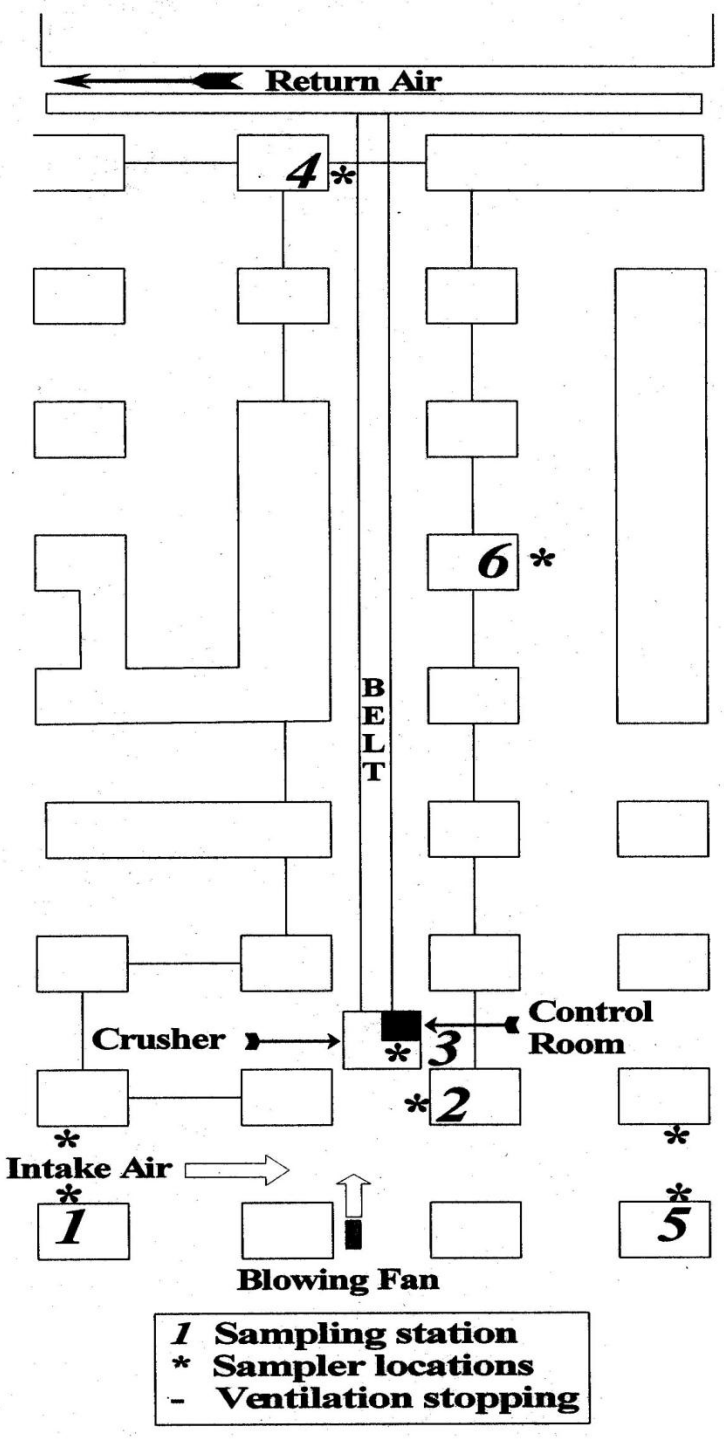
2 - Dump

3- Crusher: outside/inside booth

4- Belt

5- Return/crusher side

6- Adjacent entry

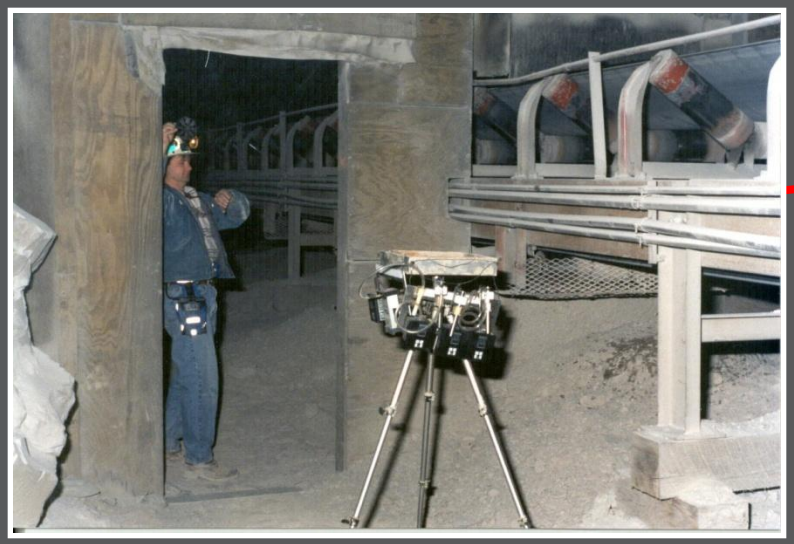


Pressurization and Dust Filtration System

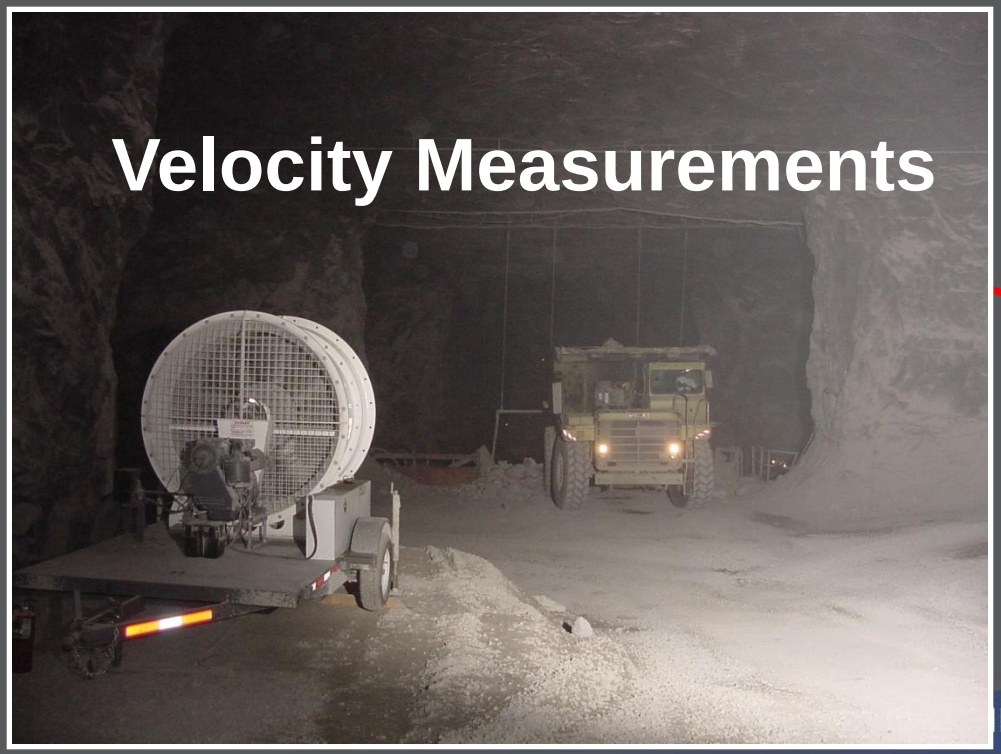
Crusher: 300 hp – 1,000 tph

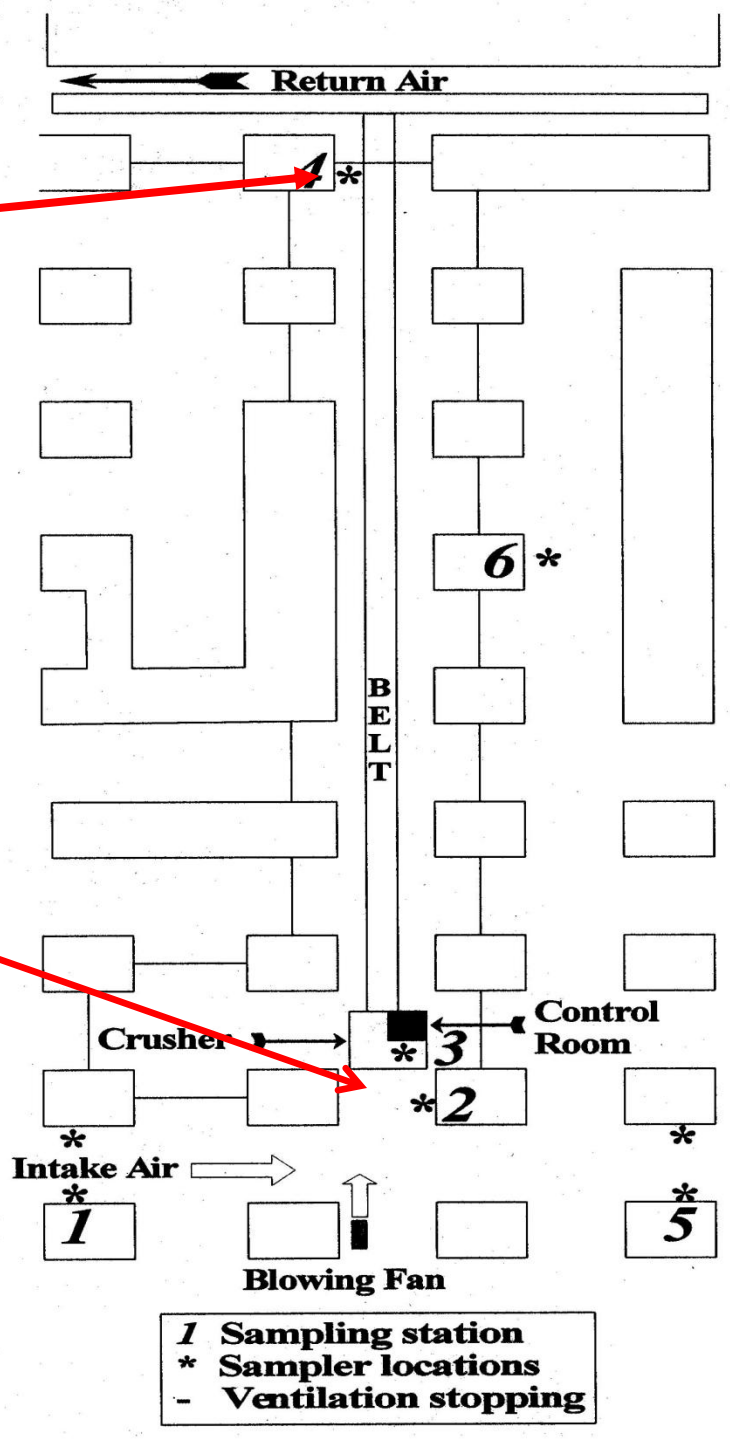
Daily Production Per Sampling Shift

	Axial Vane Fan			Propeller Fan		
Shift number	1	2	3	1	2	3
Gravimetric sampling time, min	316	322	298	325	312	297
Measured tonnage	3780	3890	3890	3820	3785	3820

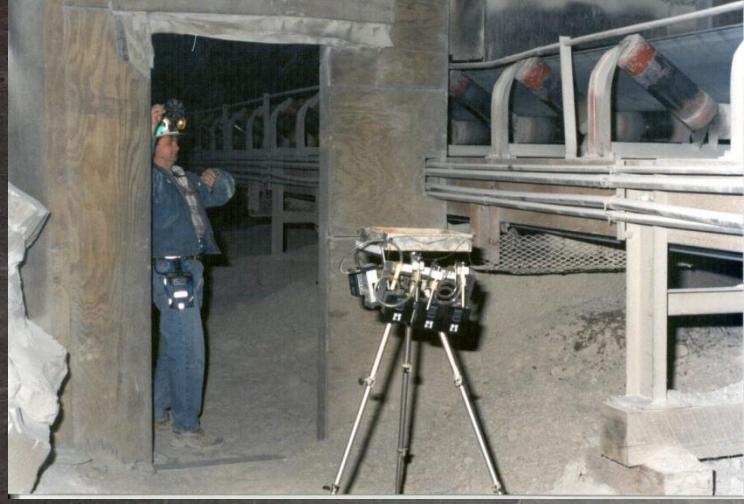


Velocity Measurements





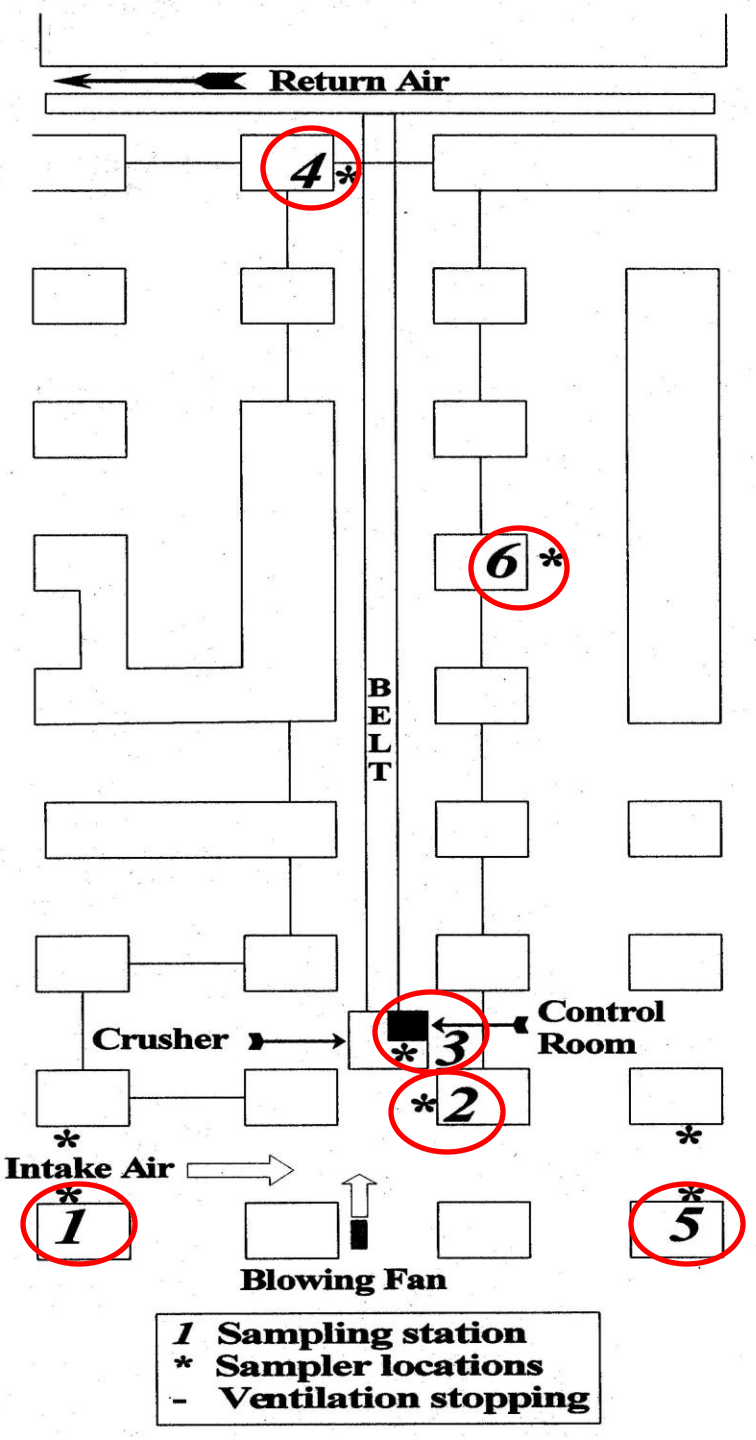
Fan type	Axial Vane	Propeller
Average air velocity at regulator, fpm	690	725



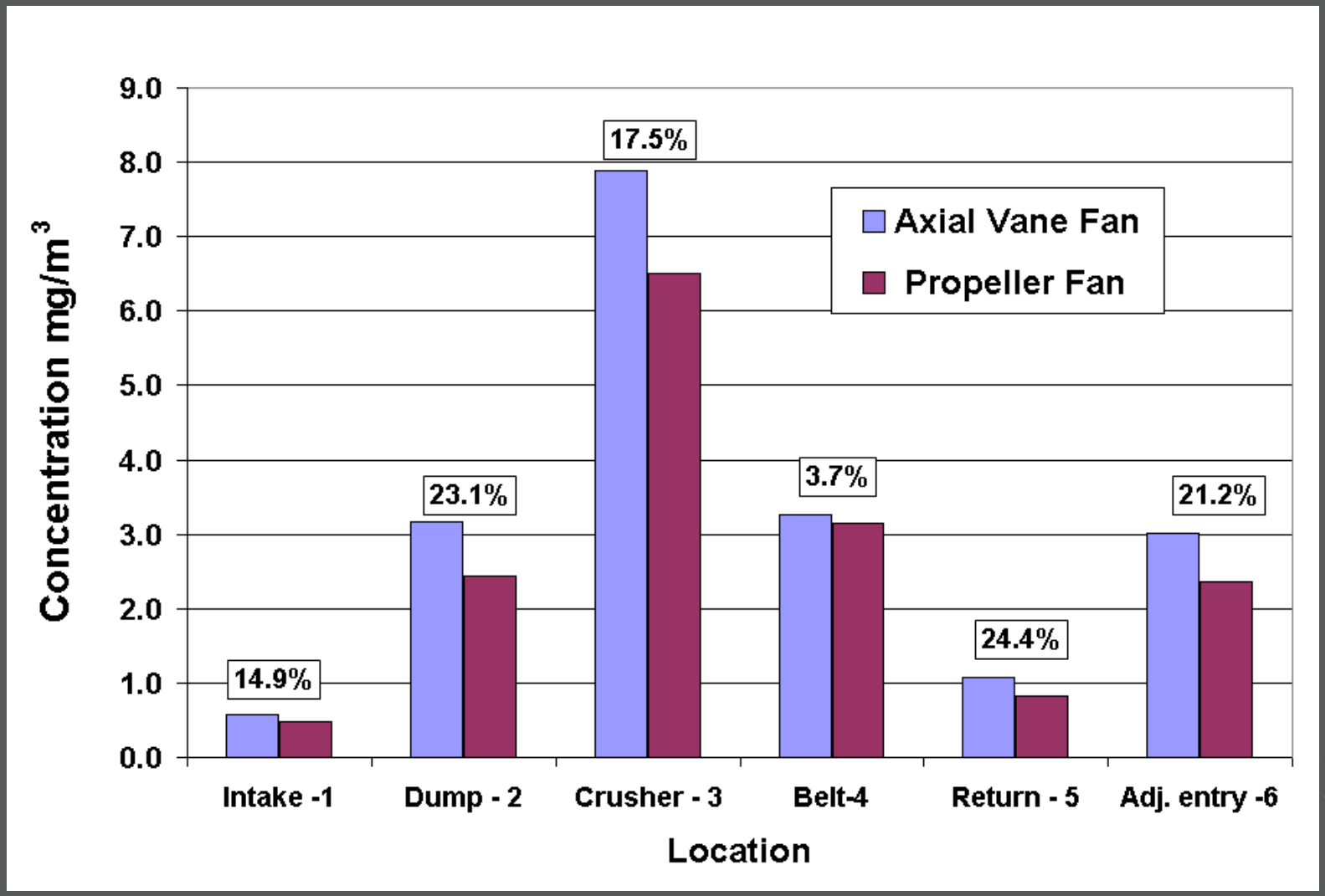
Average Air Velocity Across Dump, fpm

	Left Side	Center	Right Side
Avial Vane	240	0	0
Propeller	240	140	100

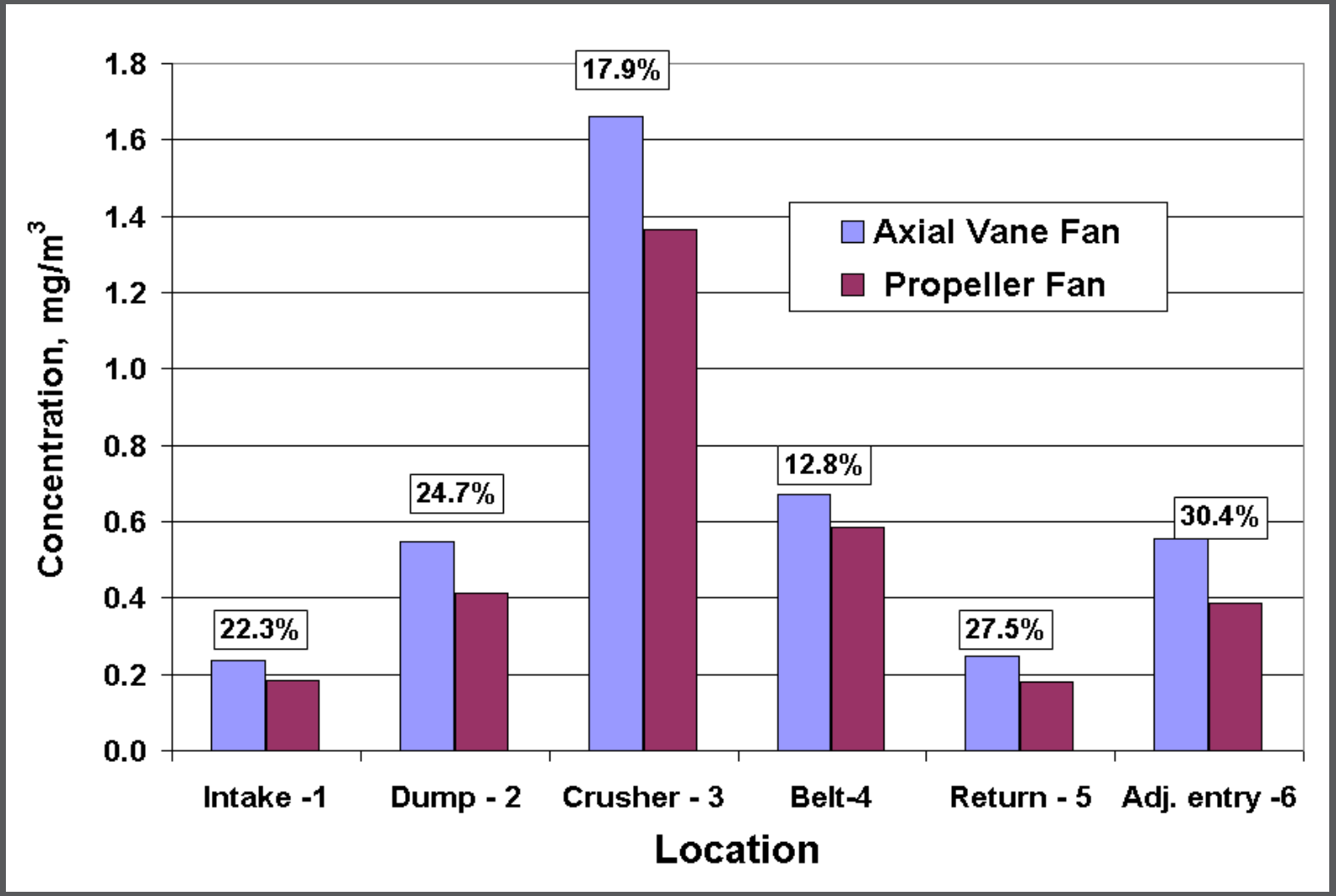
Results:
Gravimetric Samplers



Respirable Dust Concentrations
Gravimetric Sampling: 3-Day Average



Respirable Silica Dust Concentrations
Gravimetric Sampling: 3-Day Average



Propeller Fan
vs.
Axial Vane Fan

Reductions in Dust
3-Day Average

Respirable Dust
Averaged 16% Reduction

Respirable Silica
Averaged 21% Reduction

Best Practices

1. Isolate the dump/crusher/belt from the general mine air

2. Provide ventilation to move dust to return air

3. Locate booster fans as close to the dump as possible for better air movement

<u>To protect operator</u>

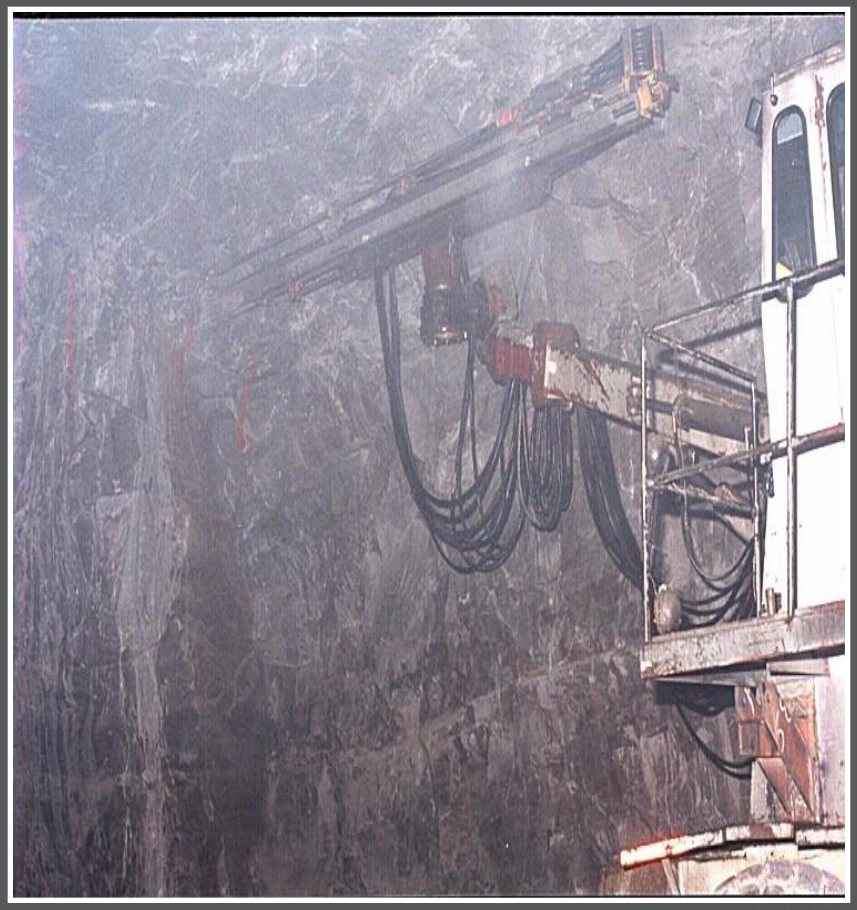
Equip booth with a filtration/pressurization system

Controlling Dust with Ventilation

Production Shots: Mine-wide Ventilation

Dust Generated by Production Shots

- Can generate high quantities of dust depending on number of shots
- Inadequate ventilation may cause dust clouds to break up and disperse in mine
- Leads to higher background levels of silica that can recirculate in mine atmosphere



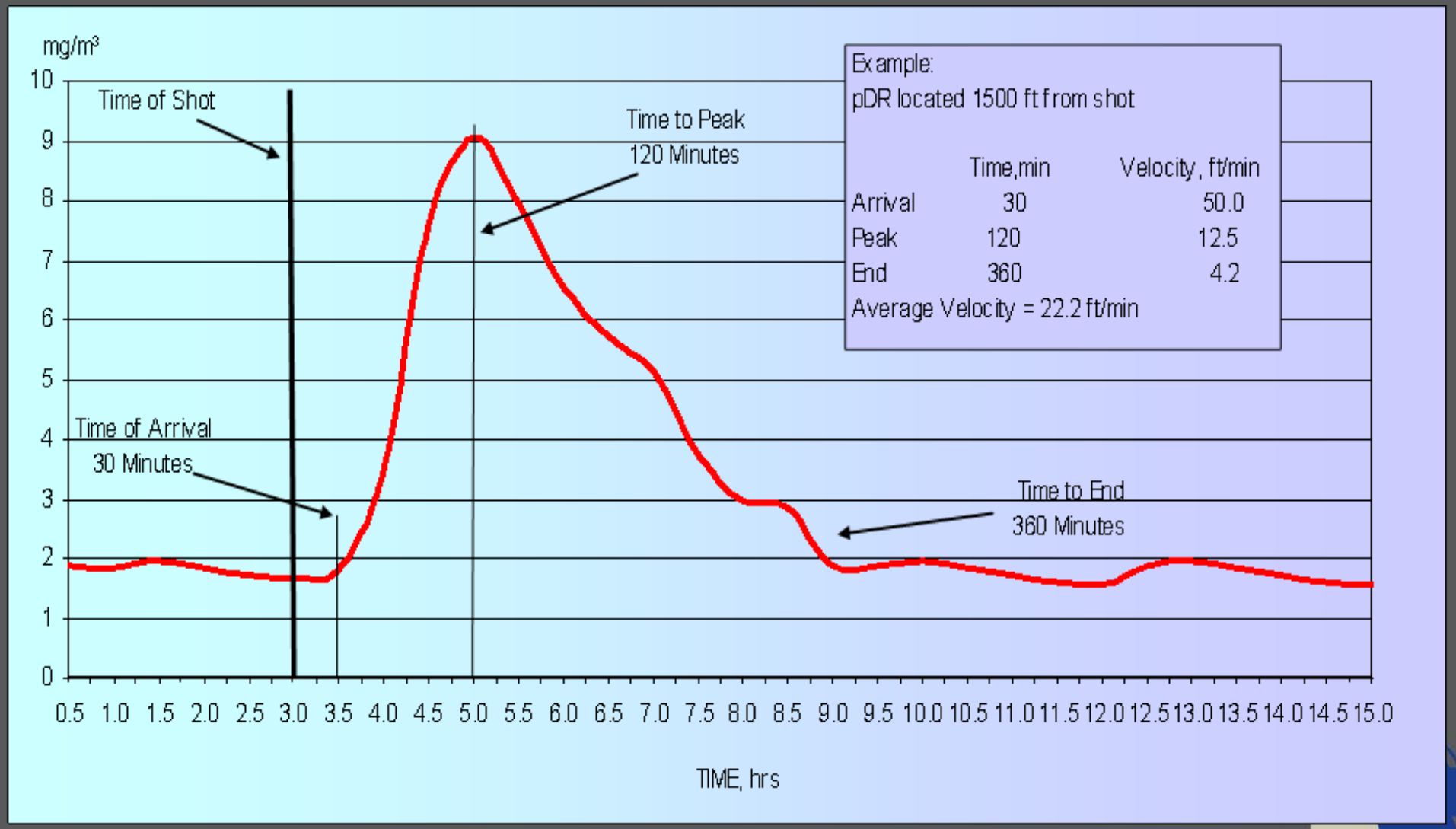
Thermo Scientific's *personal*DataRam (pDR)

- The movement of shot dust through the mine can be monitored and evaluated using pDRs
- pDR gives the time and average concentration over logged period

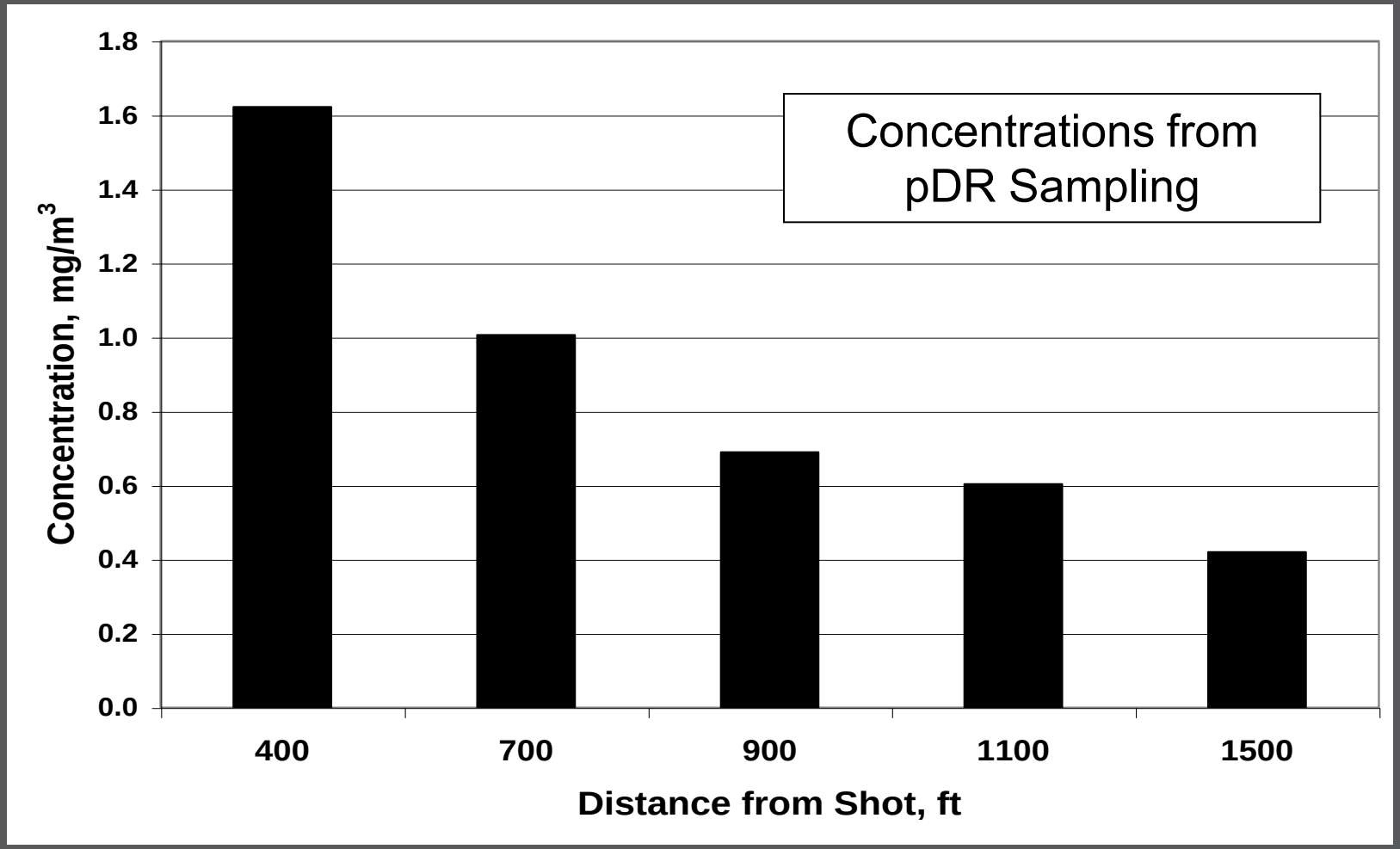
Point Source of Dust

Dust Cloud Signature

Logged time, known distance, estimate velocity



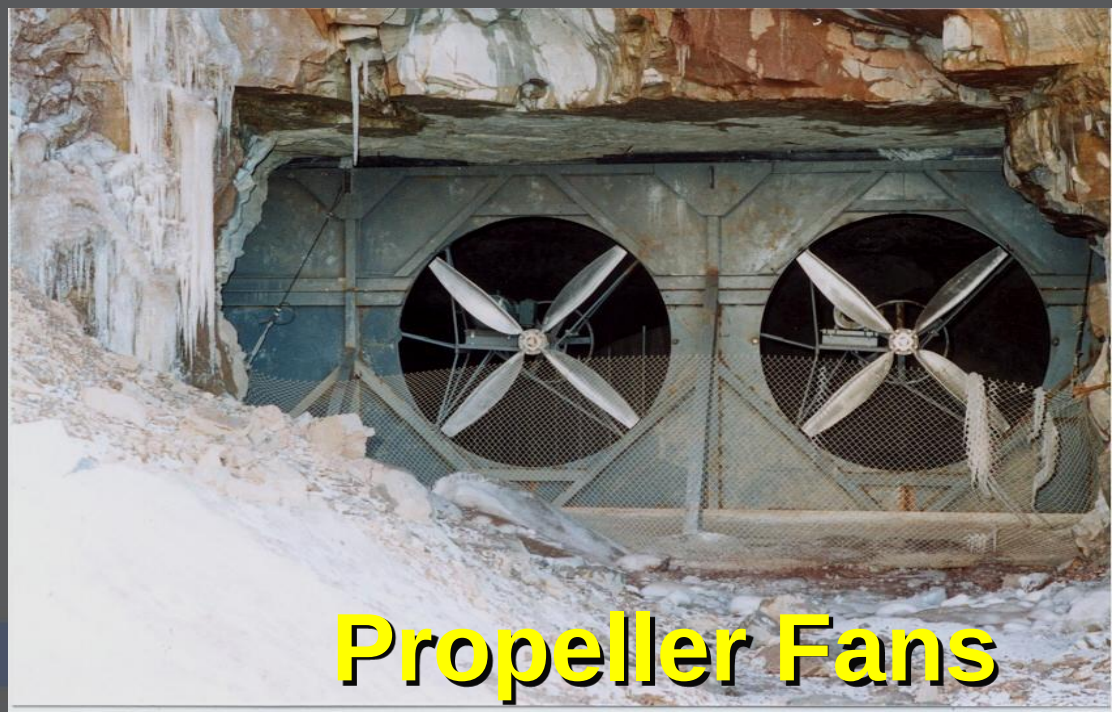
Typical Results of Dilution of Respirable Dust from Shot Source



Case Study

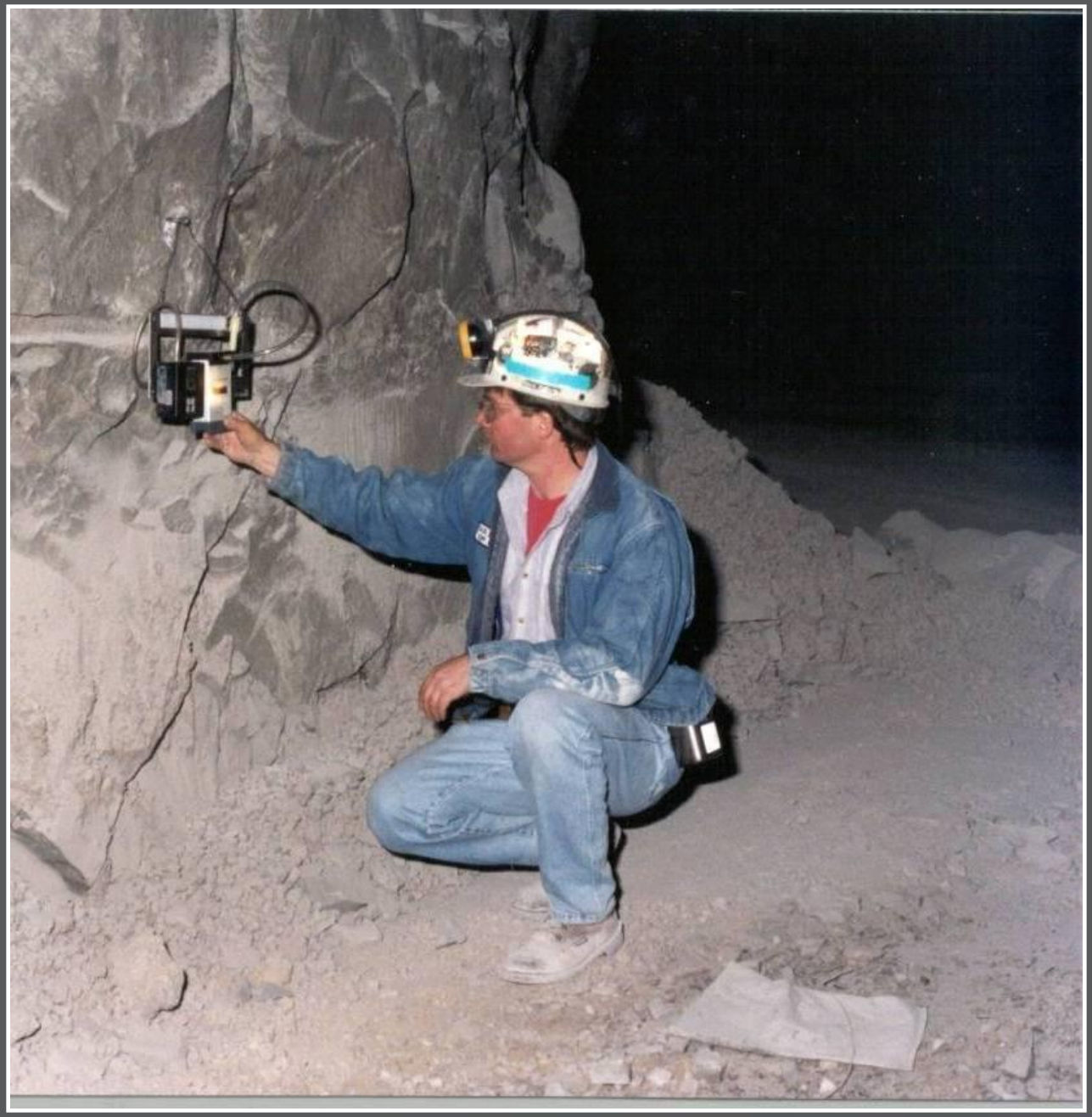
Determine influence of fan and curtain installation for improving both ventilation and shot dust removal from mine

Improving Mine-wide Ventilation



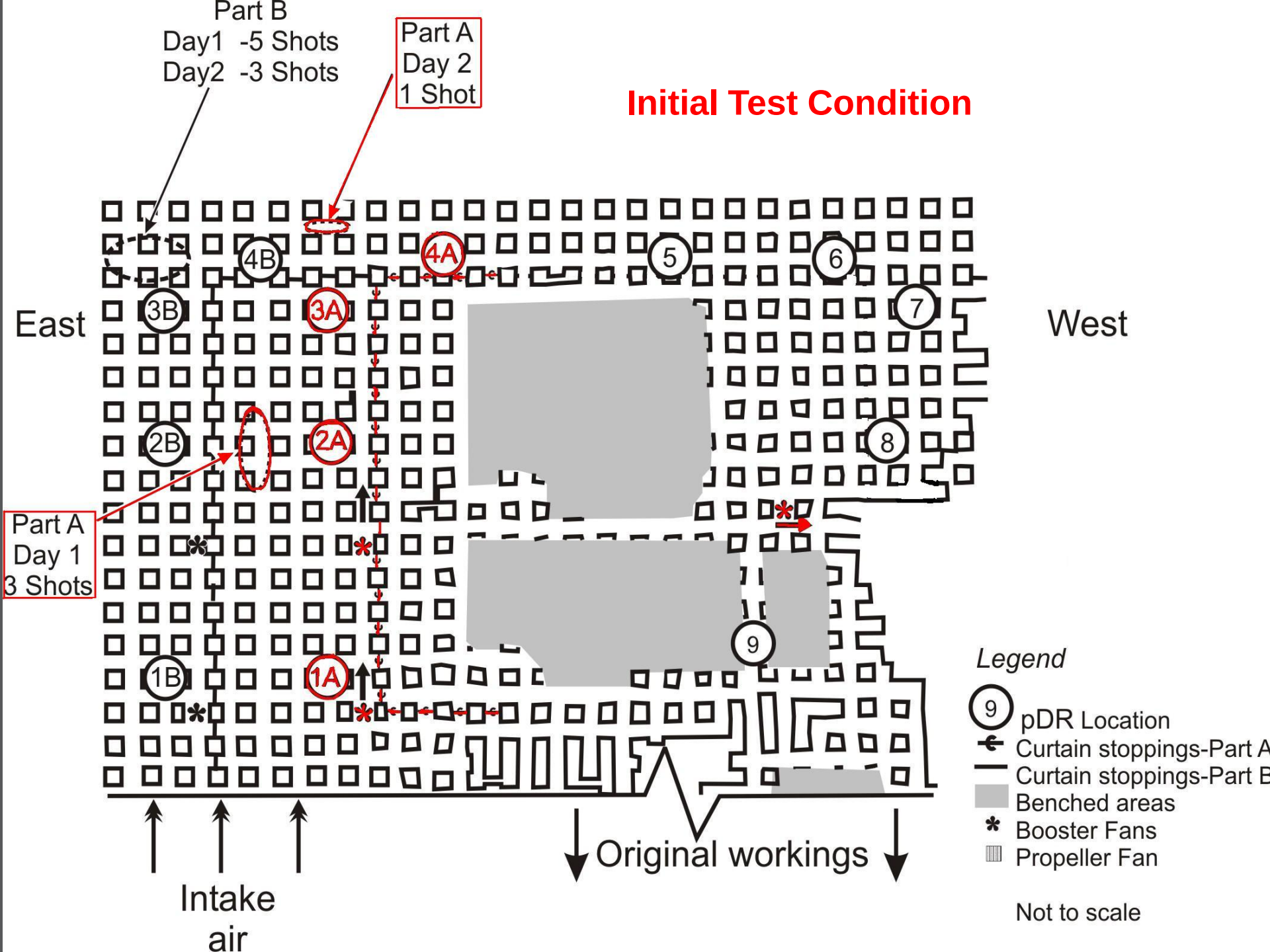
Objectives

- Monitor travel path of the dust cloud
- Determine average air velocity based on time-to-station dust data
- Establish the in-mine dust retention time
  - Time required to clear dust from the mine

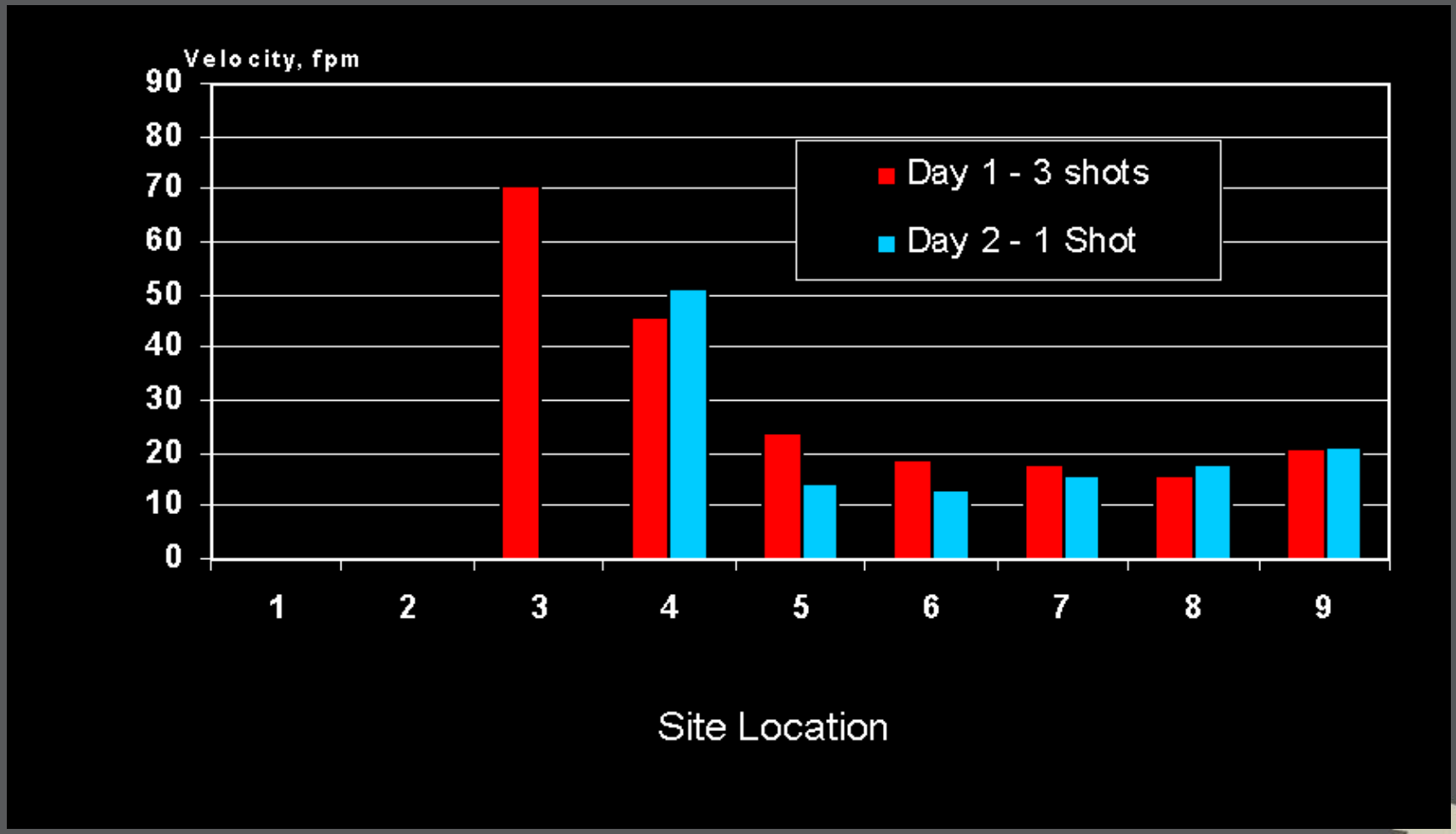


Dust Sampling

Position pDRs around curtain perimeter to monitor dust


Part B
Day1 -5 Shots
Day2 -3 Shots
Part A
Day 2
1 Shot
Initial Test Condition
East
West
4B
4A
5
6
3B
3A
7
2B
2A
8
Part A
Day 1
3 Shots
9
1B
1A
Legend
9 pDR Location
Curtain stoppings-Part A
Curtain stoppings-Part B
Benched areas
Booster Fans
Propeller Fan
Not to scale
Original workings
Intake
air

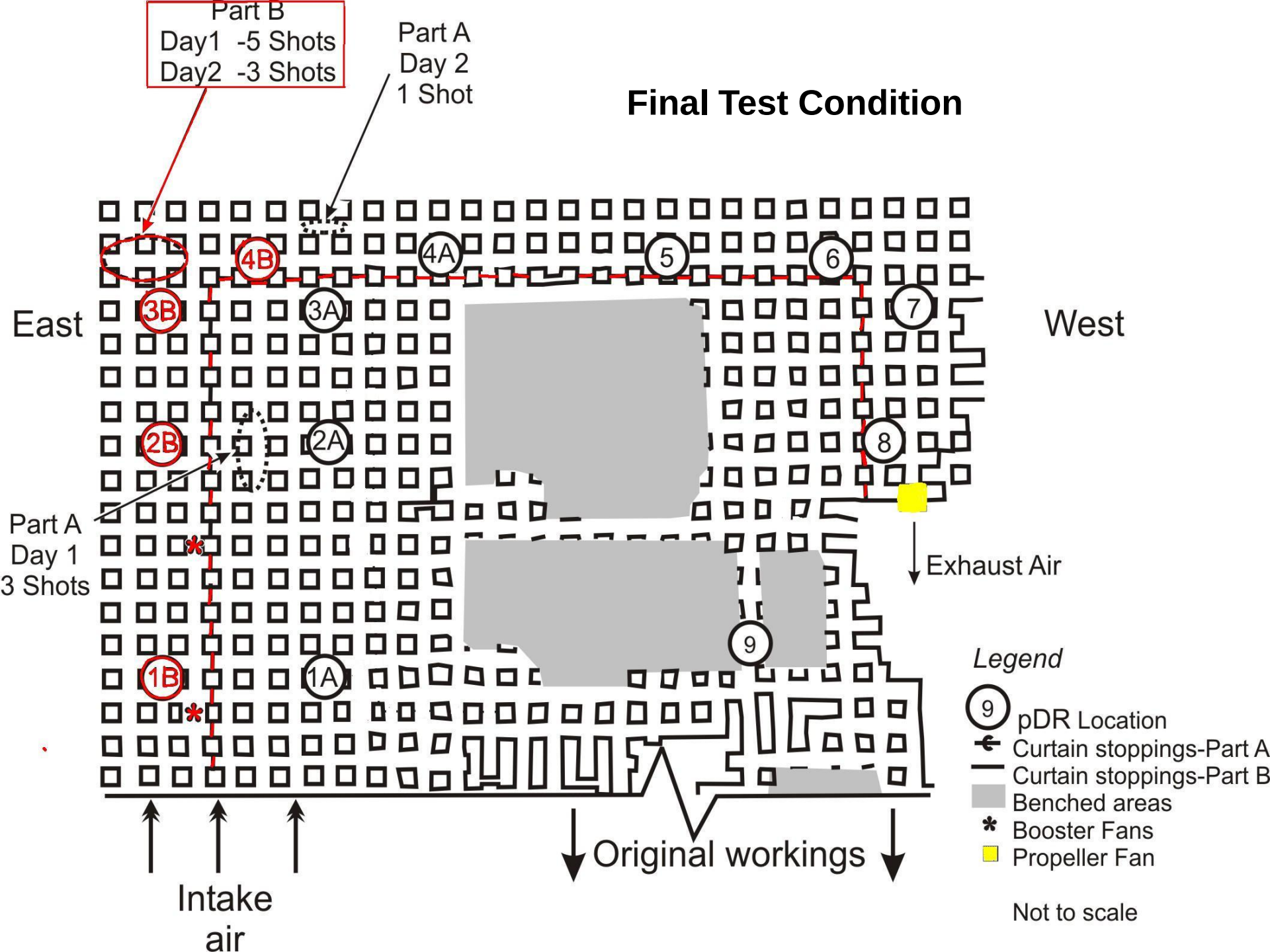
Estimated Air Velocities



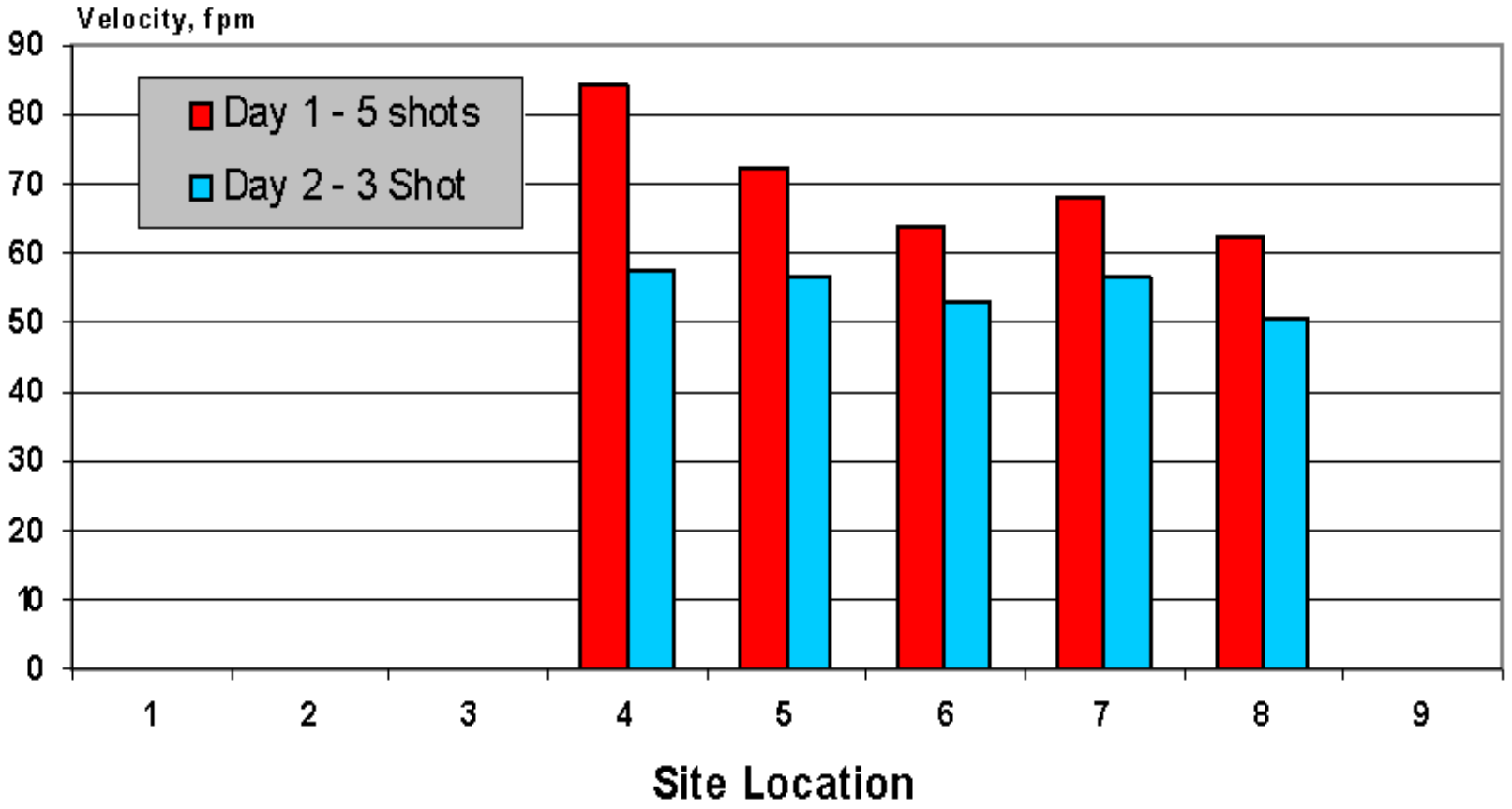
Two Hartzell high volume/low pressure propeller fans each rated at 500,000 cfm

Over 40 curtain stoppings around perimeter of faces

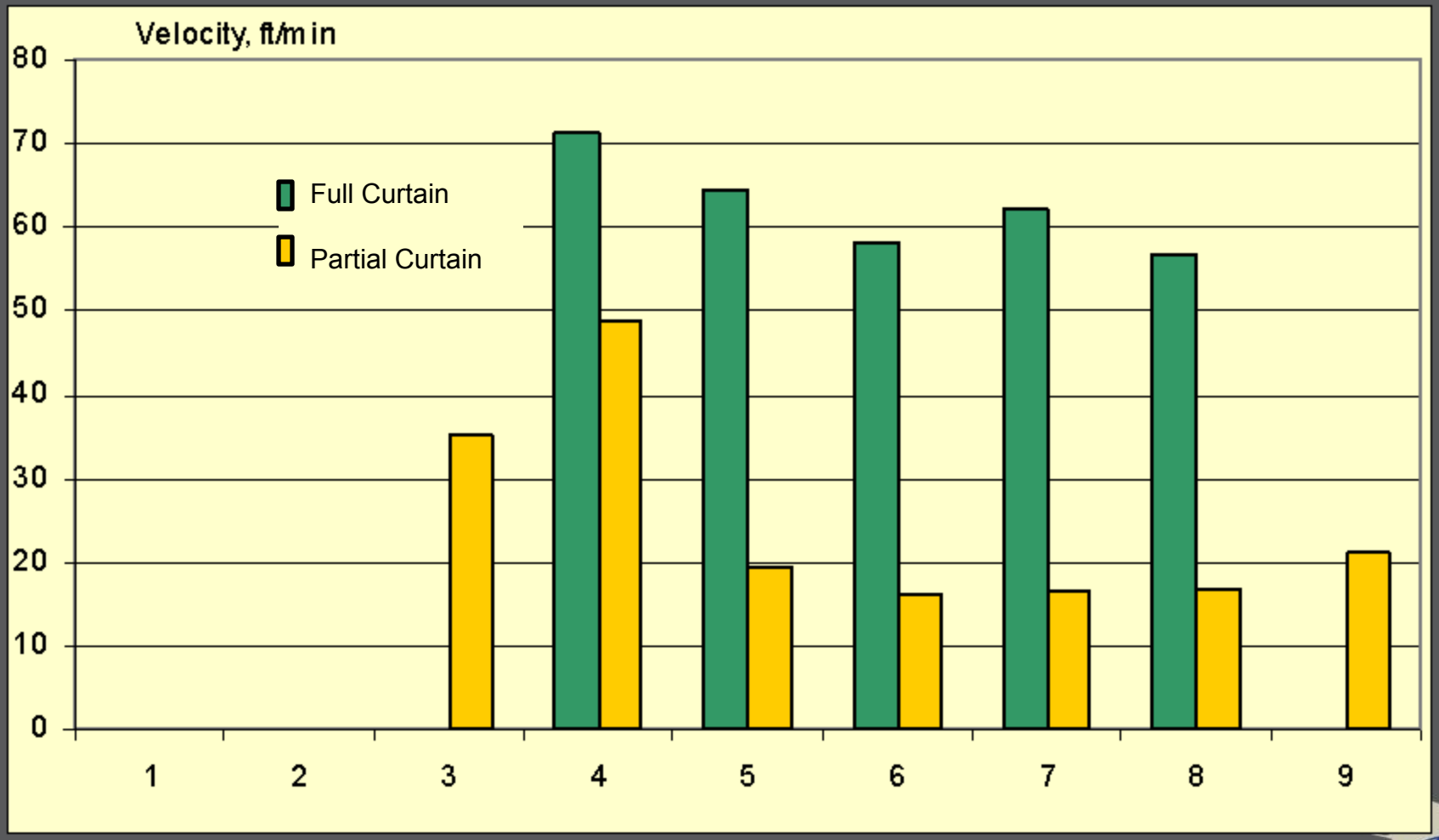
Final Test Condition



Estimated Velocities After Installation of Propeller Fans and Curtain Line



Propeller Fan and Curtain Line Air Velocity Enhancement



Dust Retention Time

120 min
No Propeller Fans and Partial Curtain Line

20 min
Propeller Fans and Completed Curtain Line

Best Practices

- **Install a main fan to establish air circuits on a mine-wide scale**
- **Install permanent or brattice stoppings or long pillars in key locations throughout the mine to more efficiently direct and control airflow**
- **Use booster fans to assist main fan if needed**

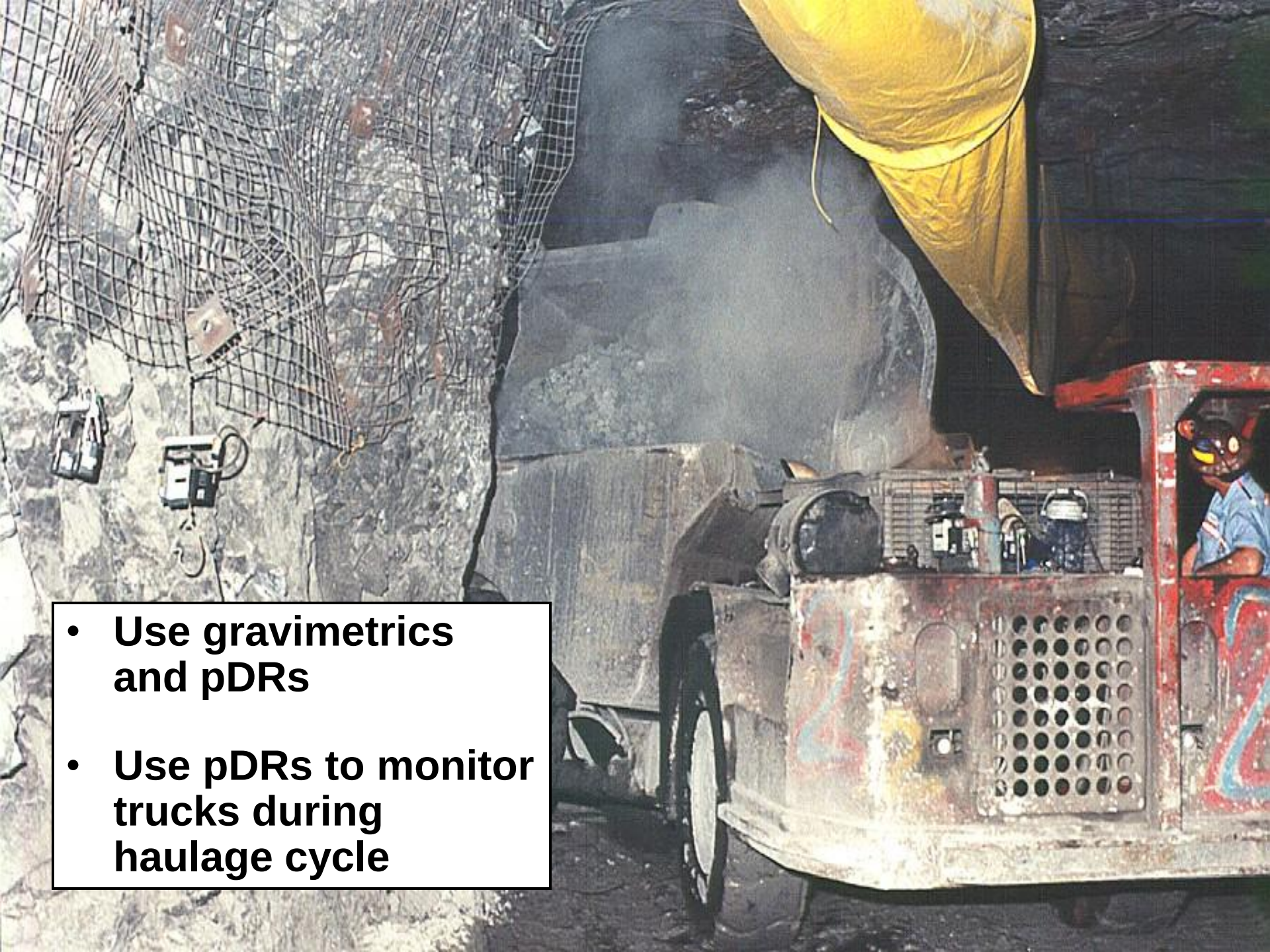
UNDERGROUND GOLD MINE

SAMPLING TRUCKS DURING THE HAULAGE CYCLE

CDC Workplace Safety and Health
National Institute for Occupational Safety and Health NIOSH

OBJECTIVE: BASELINE STUDY

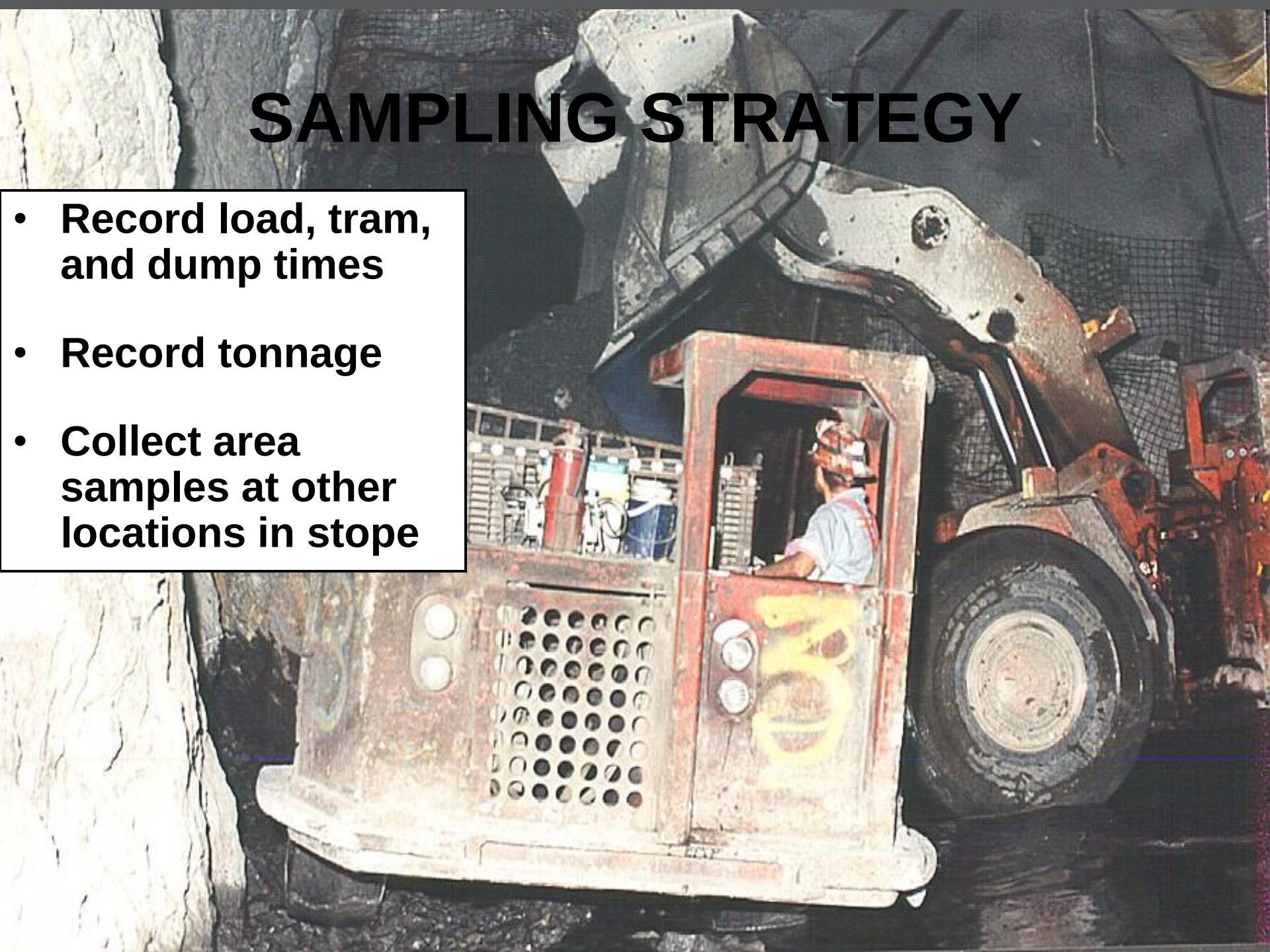
- Evaluate truck driver dust exposure during haulage cycle
- Determine the difference in silica dust levels between dry and wet stopes



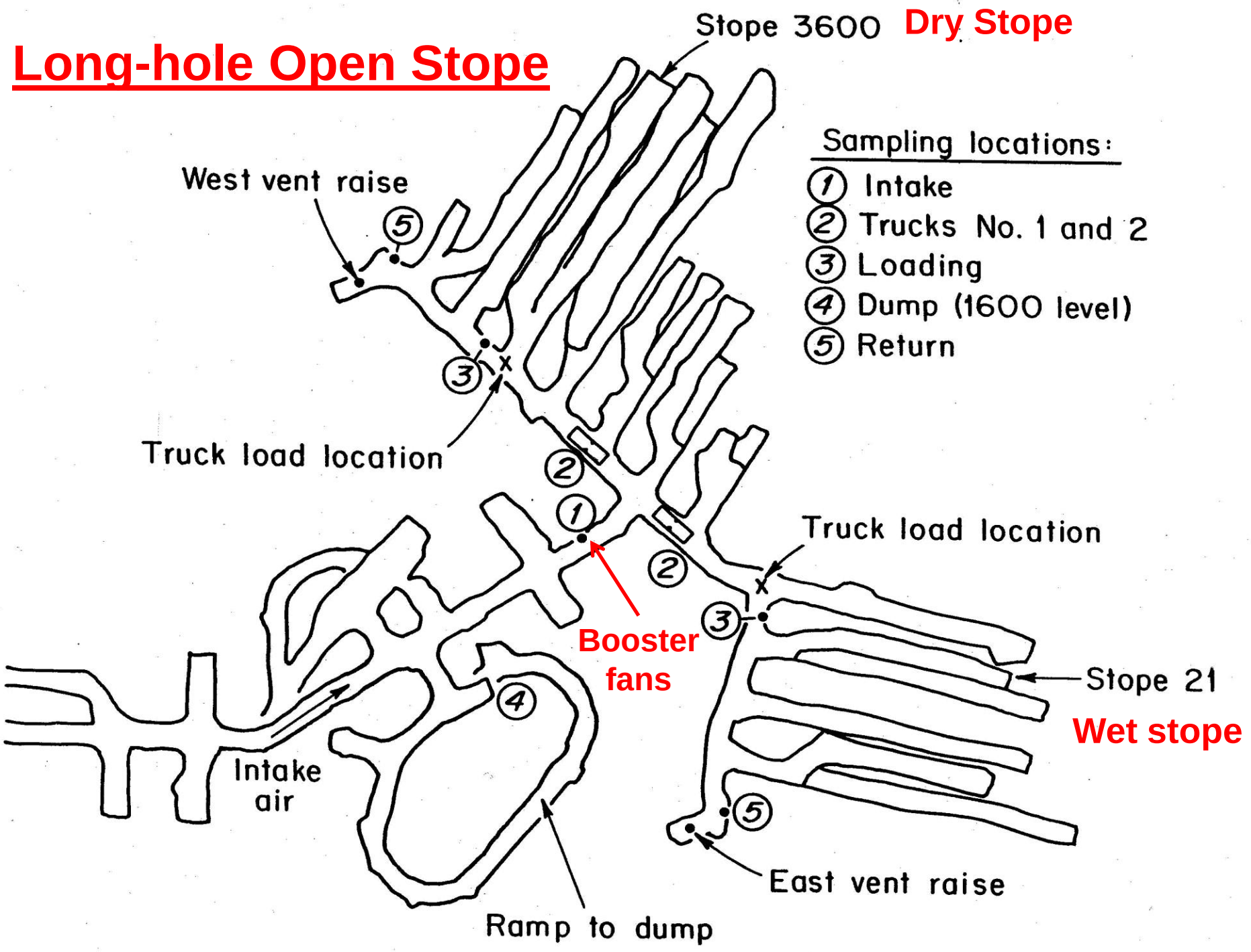
- **Use gravimetrics and pDRs**
- **Use pDRs to monitor trucks during haulage cycle**

SAMPLING STRATEGY

- **Record load, tram, and dump times**
- **Record tonnage**
- **Collect area samples at other locations in stope**



Long-hole Open Stope

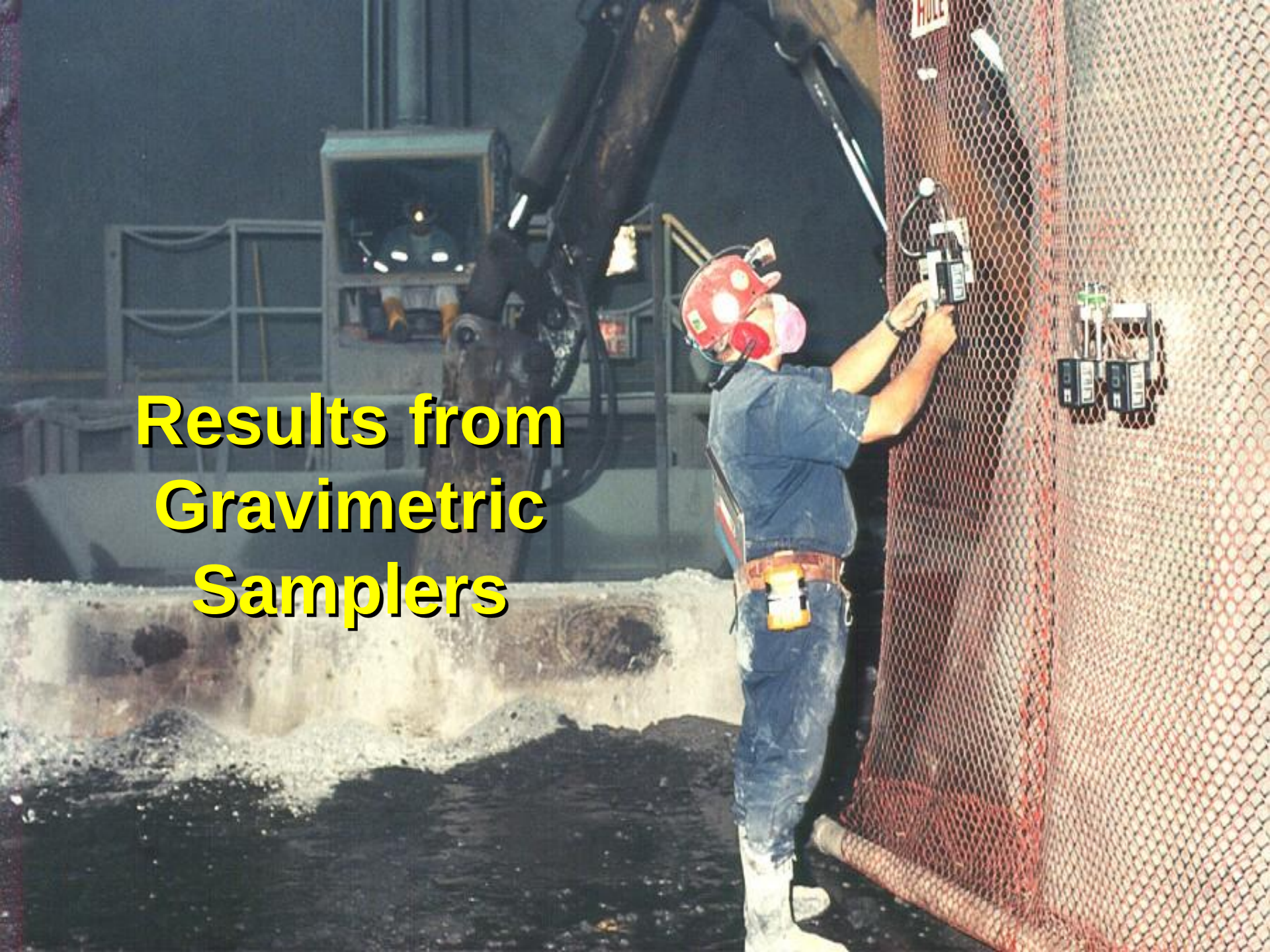


Intake air:
560 fpm
180,000 cfm

Intake air supplemented by booster fans

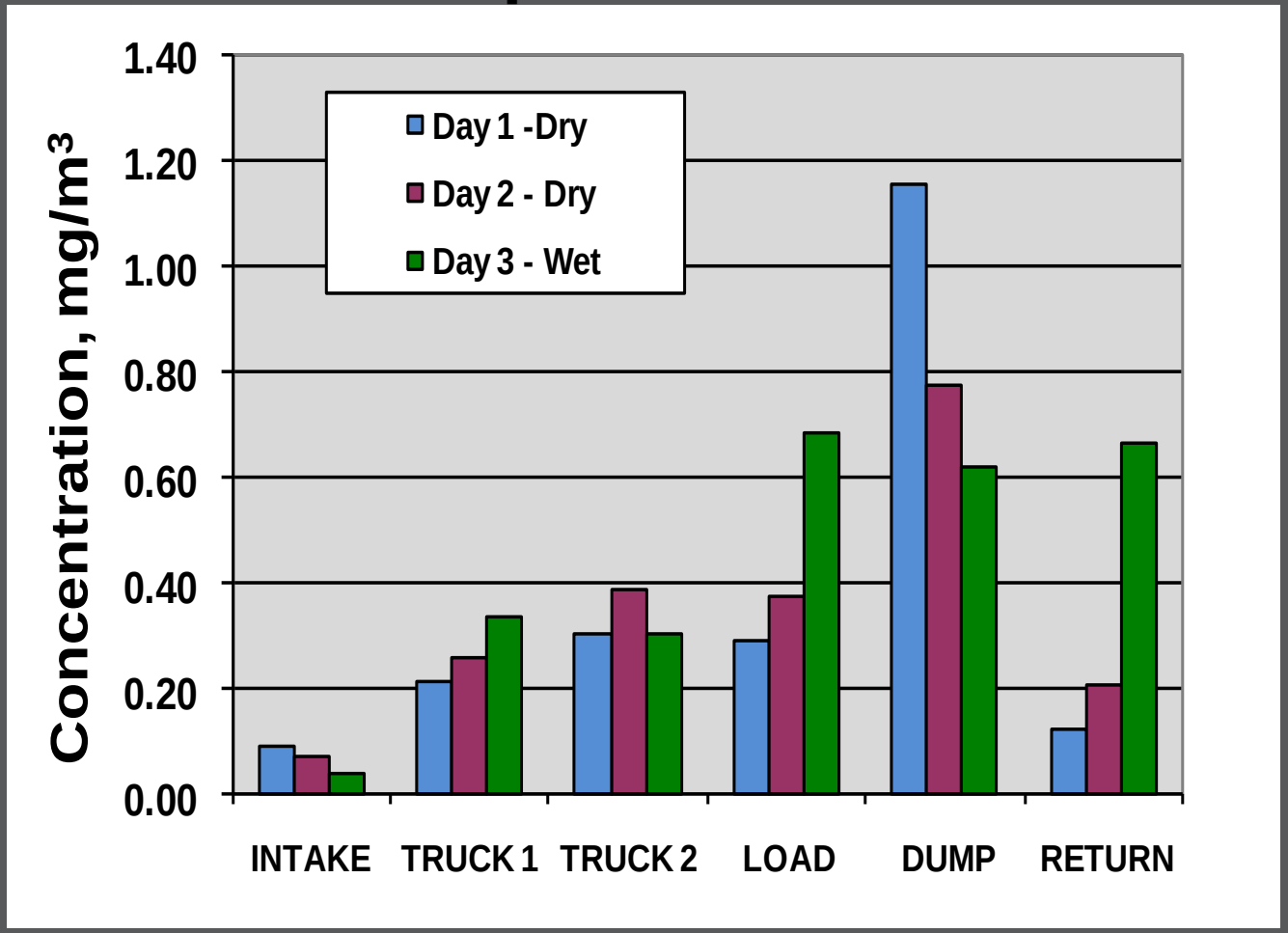
Axial vane fan:
30,000 cfm


Loading Samplers
Truck Samplers


Results from
Gravimetric
Samplers

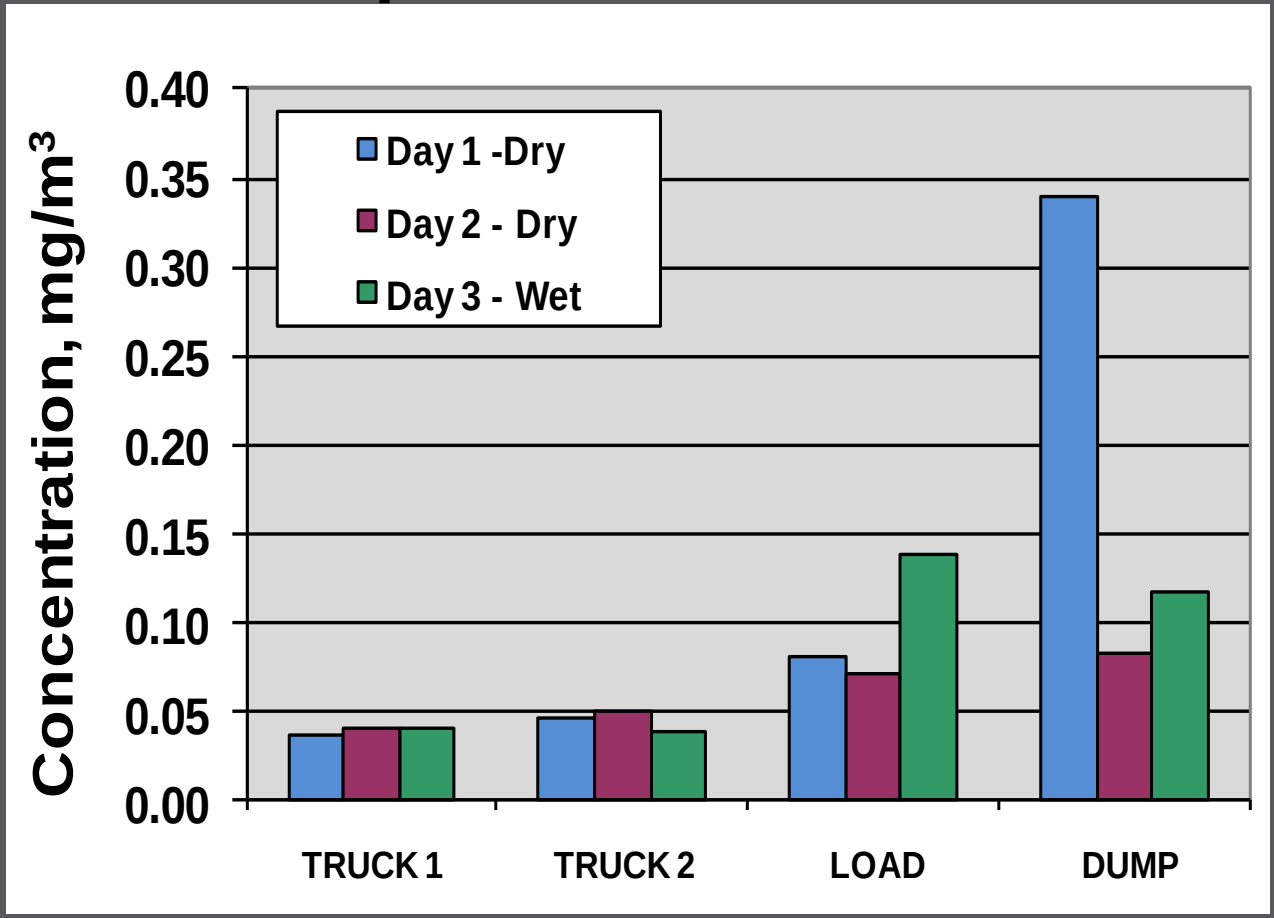
Respirable Dust

- Intake low indicating clean air
- Trucks 1 and 2 very similar for three days
- Load and dump locations were highest
- Day 3: Wet muck, high concentration at some locations



Respirable Quartz Dust

- Trucks 1 and 2 similar; little decrease on day 3
- Quartz concentrations highest at dump
- No consistent pattern



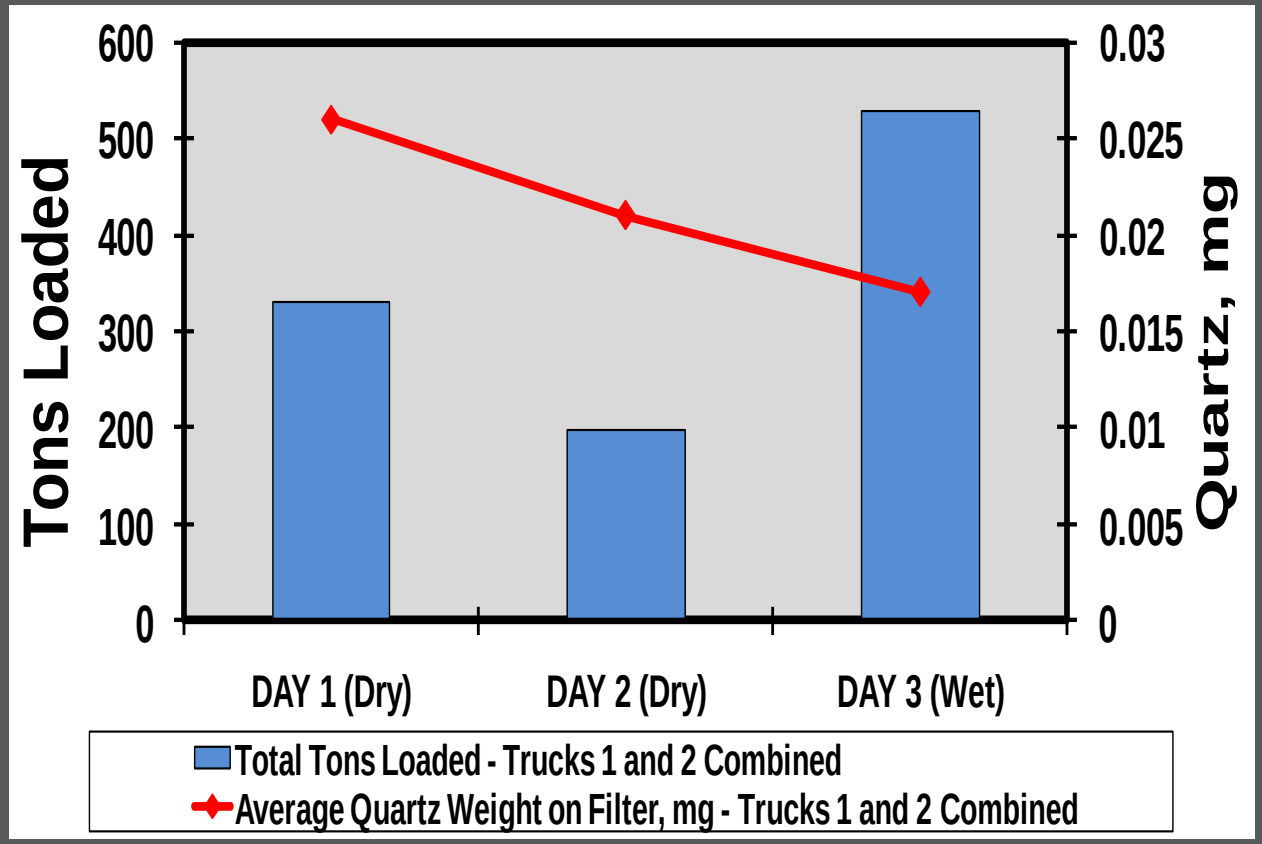
Tonnage Per Sampling Period

Tonnage loaded on day 3 was almost twice the tonnage on days 1 and 2

Day	Trucks 1 and 2 Combined Tons
1 - Dry	330
2 - Dry	198
3 - Wet	528

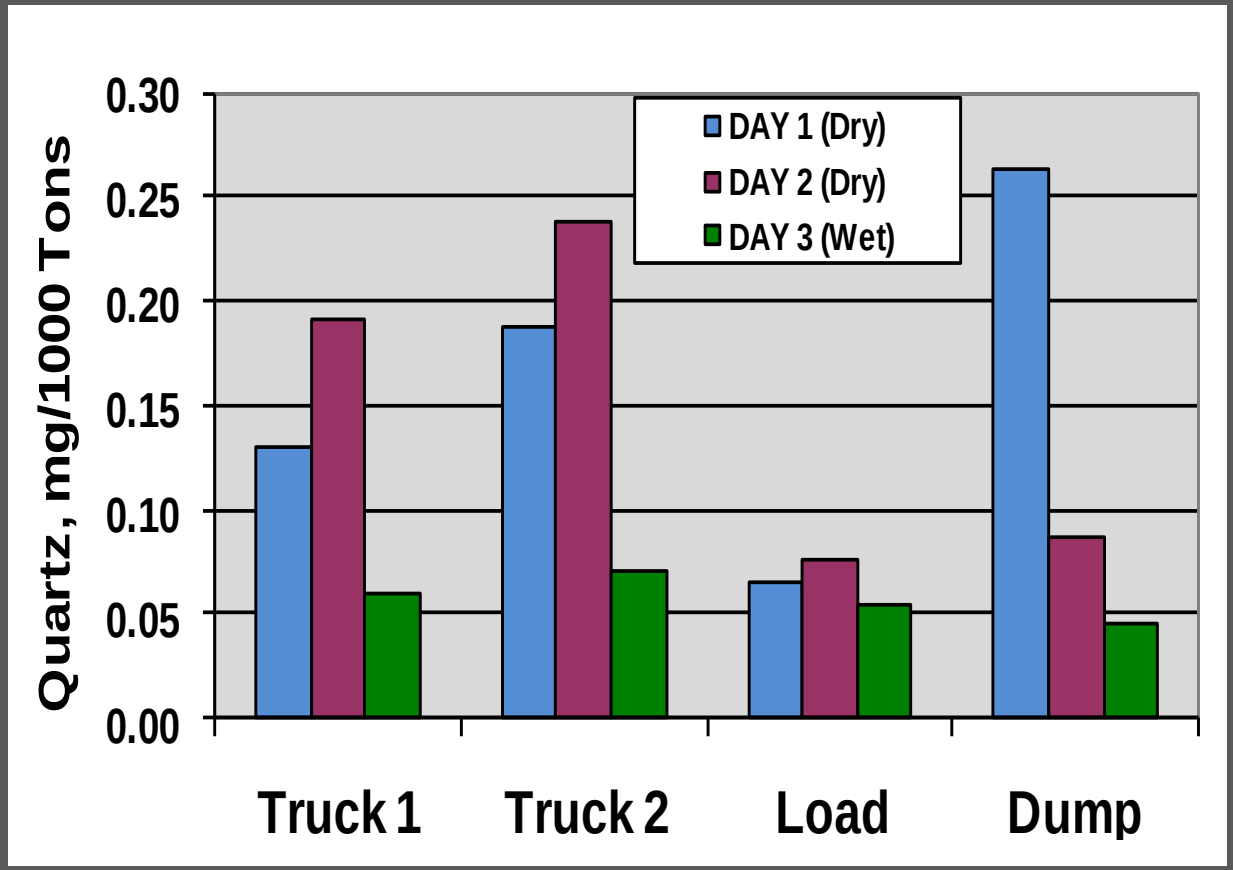
Dry Versus Wet Muck – Respirable Quartz, mg

- Quartz weight, (mg) vs. tonnage
- Trucks 1 and 2: 40% more tonnage on day 3
- Wet stope produced 28% less quartz by weight on filter



Respirable Quartz mg per 1,000 Tons

- Quartz generation normalized to 1,000 tons
- Wet muck: lower values at all locations
- Percent Decrease:
  - Truck 1 – 170%
  - Truck 2 – 200%
  - Load – 30%
  - Dump – 280%



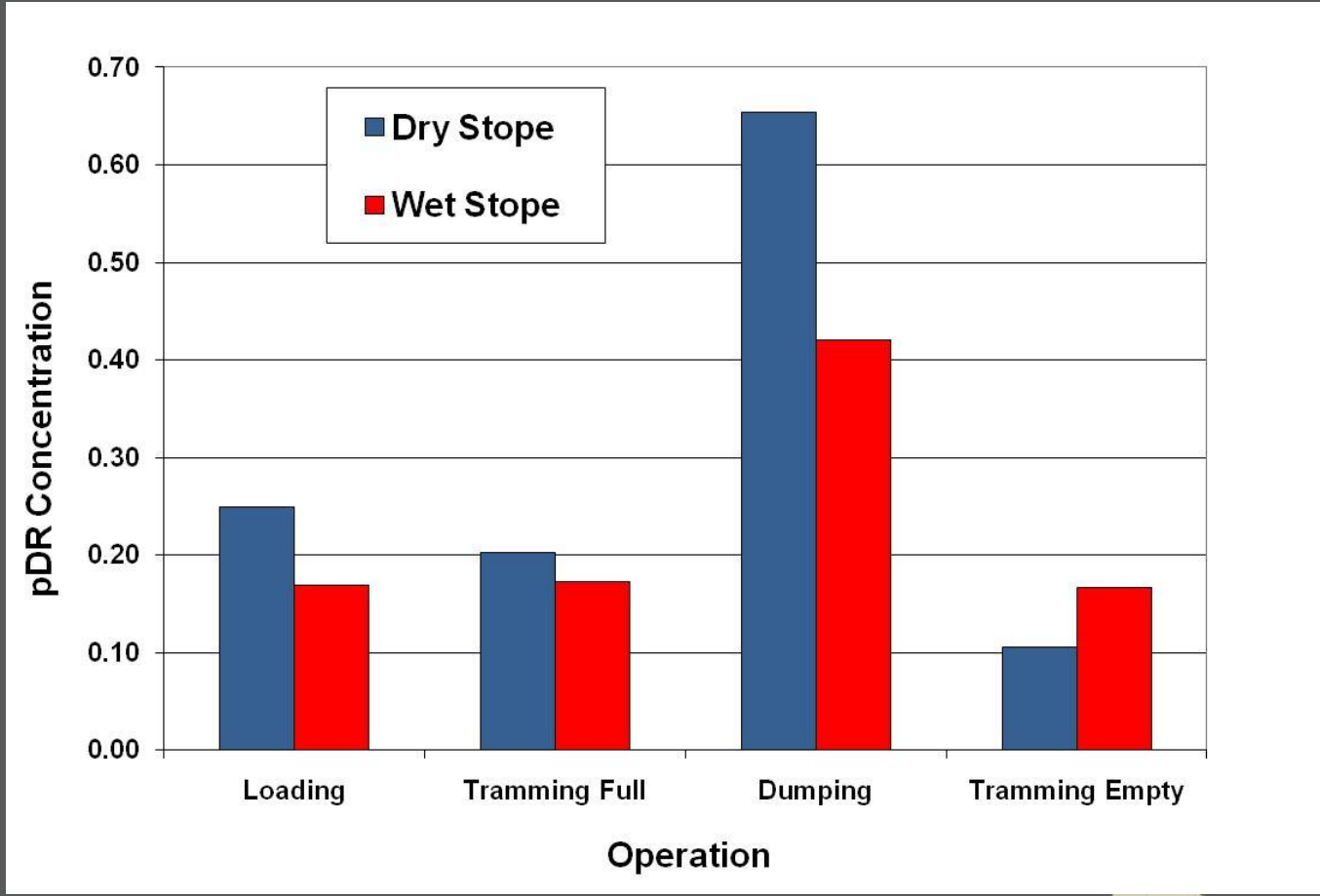
HAULAGE CYCLE

1) Loading
2) Tramming full
3) Dumping
4) Tramming empty

Results from pDR

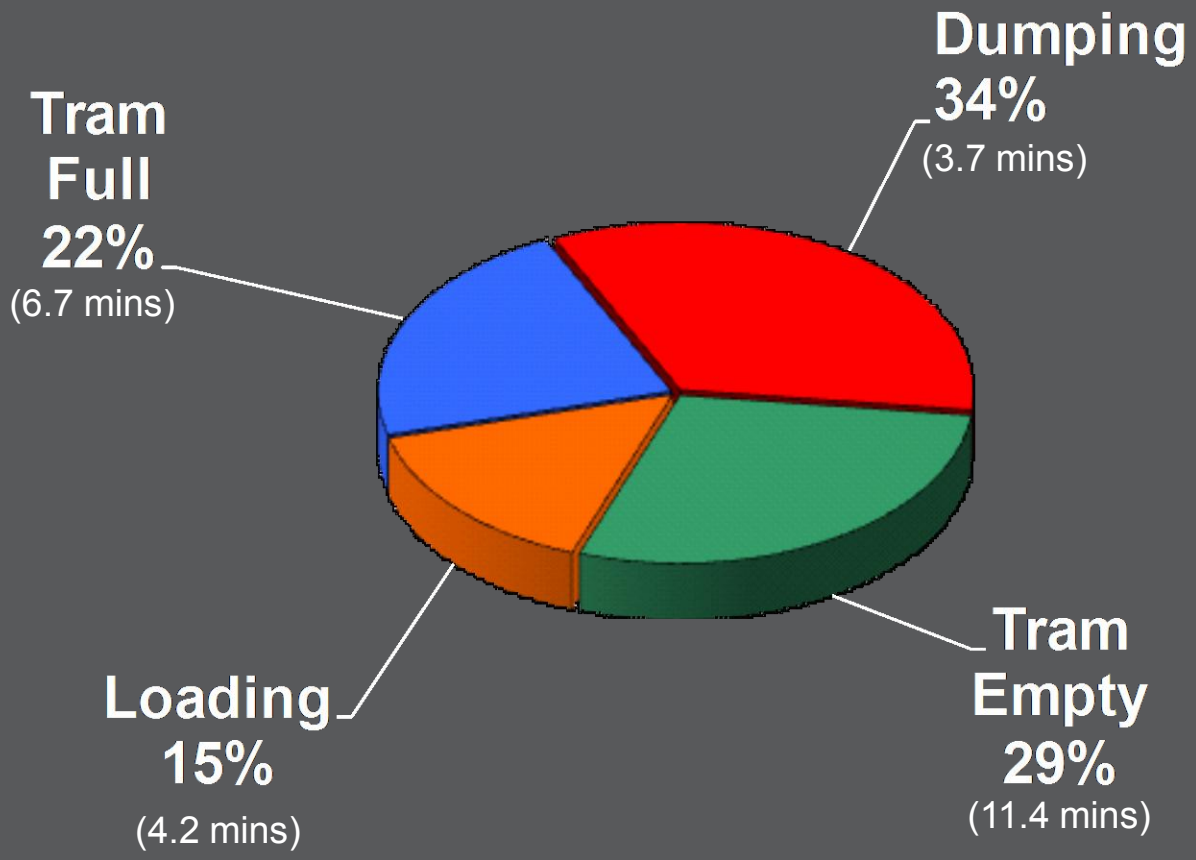
Time Study Using pDRs
Dry vs. Wet Stope

- Truck 1 and 2 combined
- Wet stope – lower dust at loading, tramming full and dumping
- <u>Trucks 1 and 2</u> 32% and 35% reduction in dust levels, respectively



Time-weighted-average Dust Contributions

Dump location had highest dust contribution despite having the shortest duration… (14% time vs. 34% dust)



Best Practices

To reduce quartz levels:

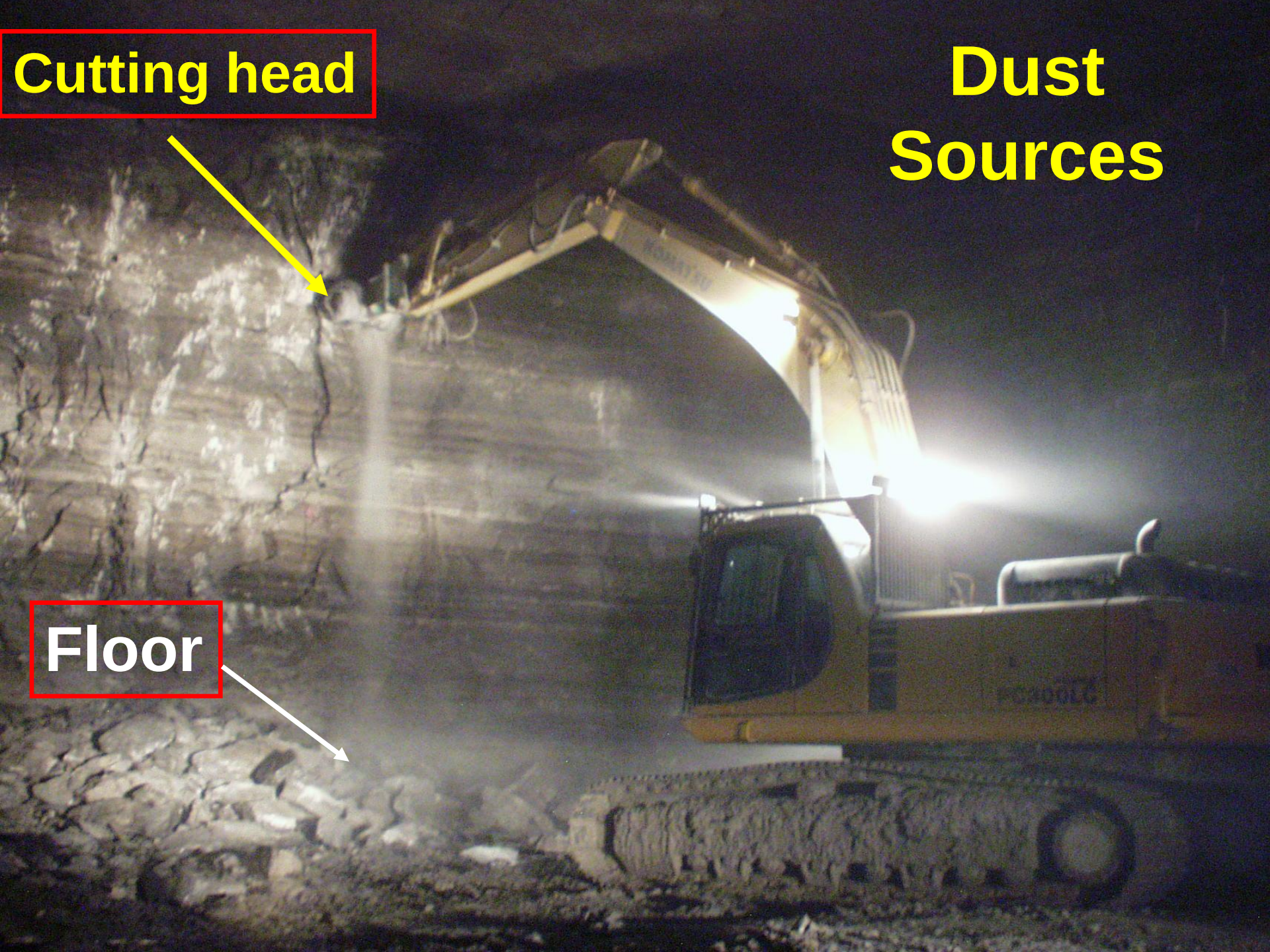
- Establish an air circuit with main mine fan
- Use auxiliary air keeping it as close to the loading area as possible
- Keep muck wet when loading
- Control haul road dust

Other Dust Sources

- Scalers
- Haul road dust
- Down-hole drills

Pick type
harder rock

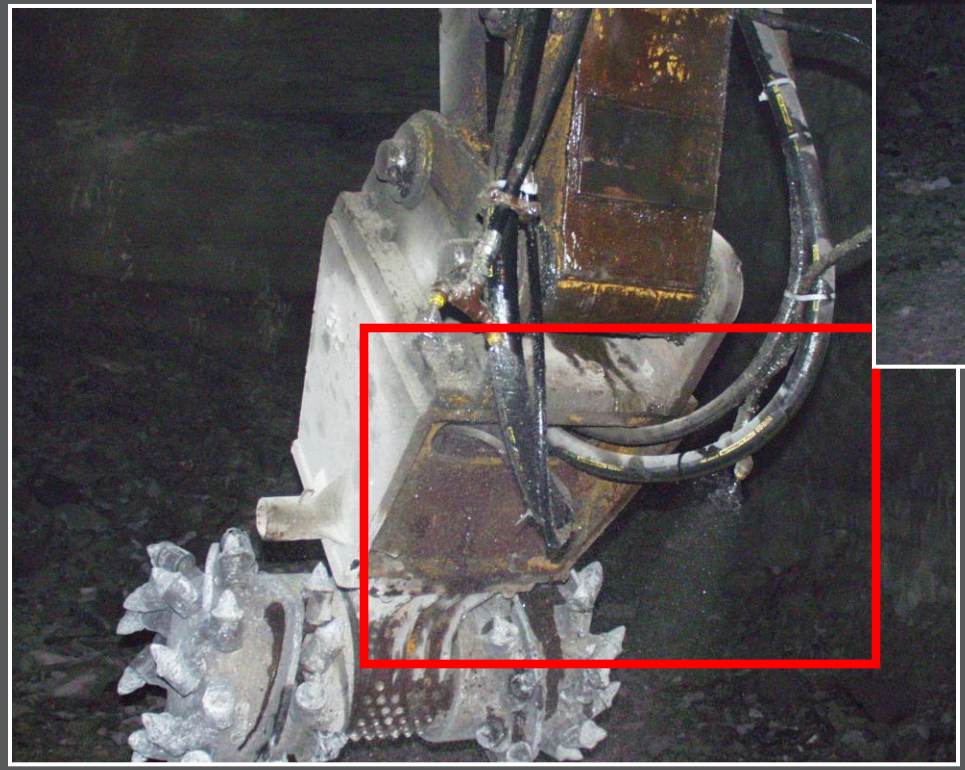
Rotary head
softer rock

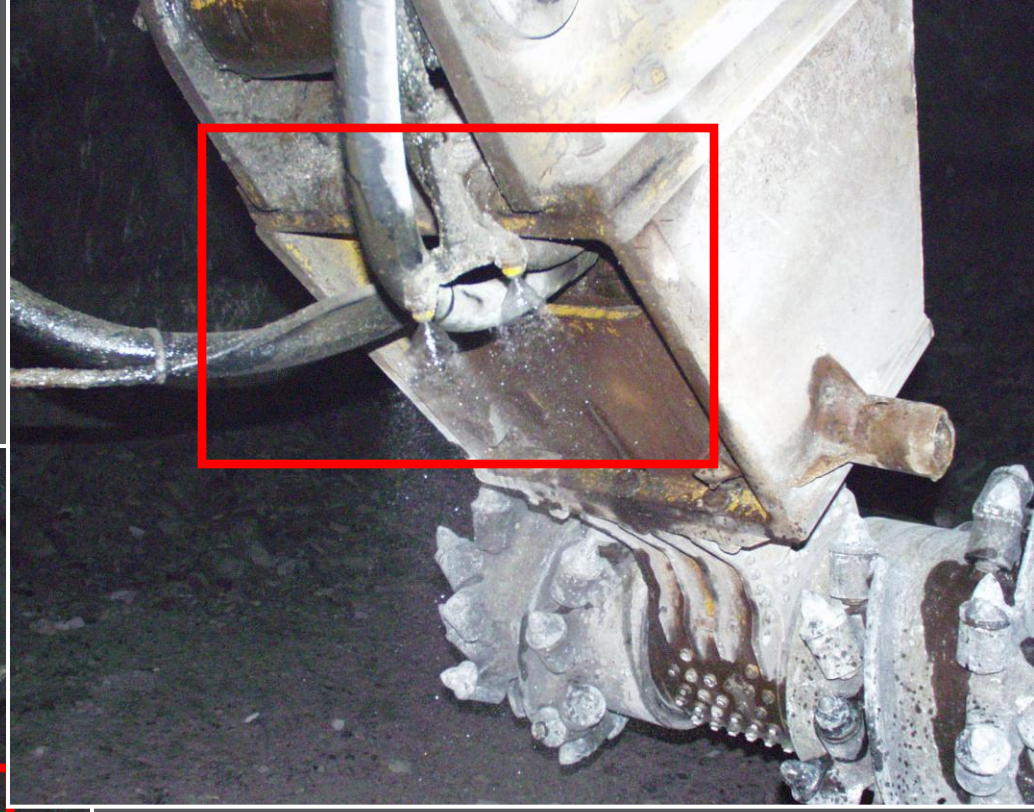

Cutting head
Dust Sources
Floor

Dust Issues

- Visibility
- Nuisance dust >10 microns

Spray Systems





Sprays must be located as close to dust source as possible

500 Gallon Tank

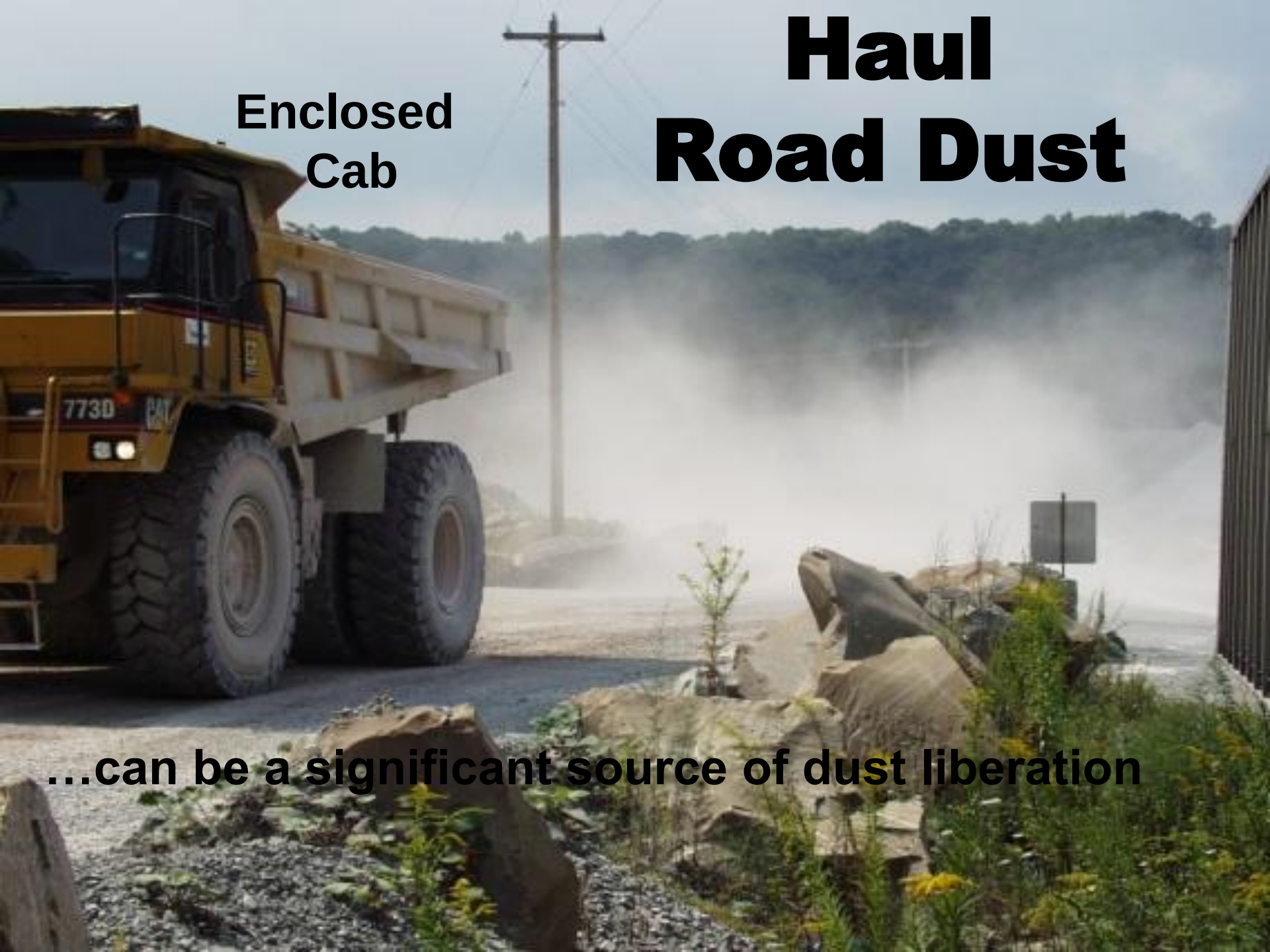
Refill 2.5 hrs

Move and dilute dust with booster fan

Fan placement: Location of face

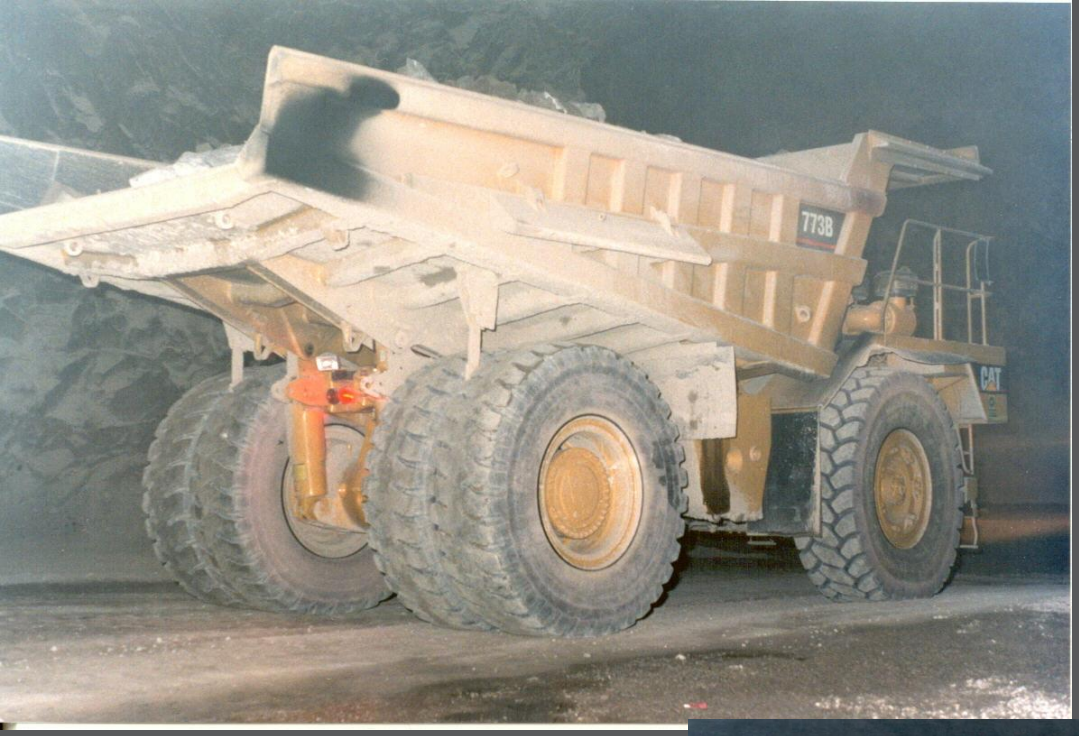
Other Dust Sources

- **Scalers**
- **Haul Road Dust**
- **Down-hole drills**


Enclosed
Cab
Haul
Road Dust
773D
CAT
…can be a significant source of dust liberation

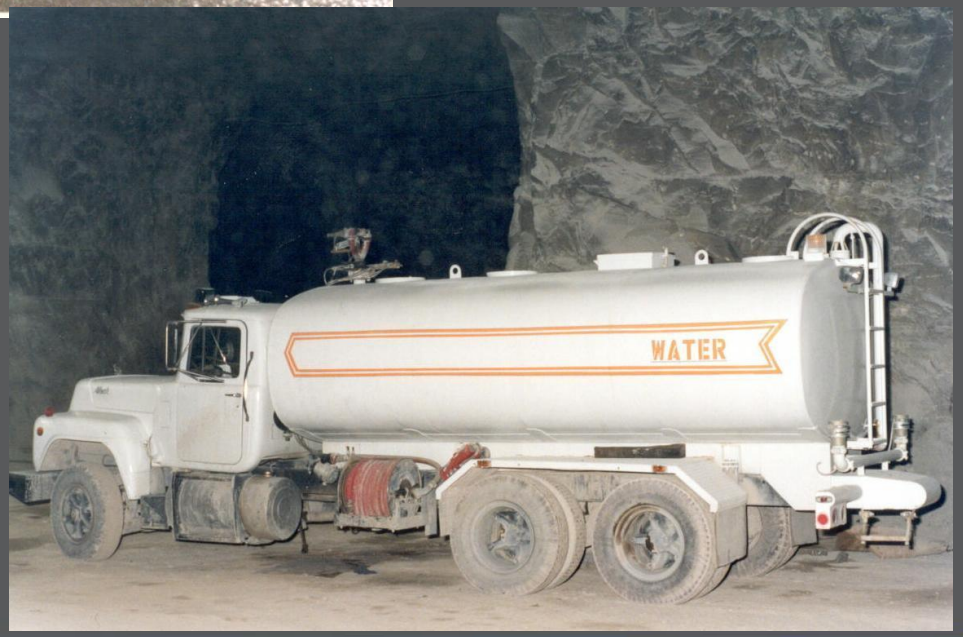
Safety Hazards:

Impair operator's visibility

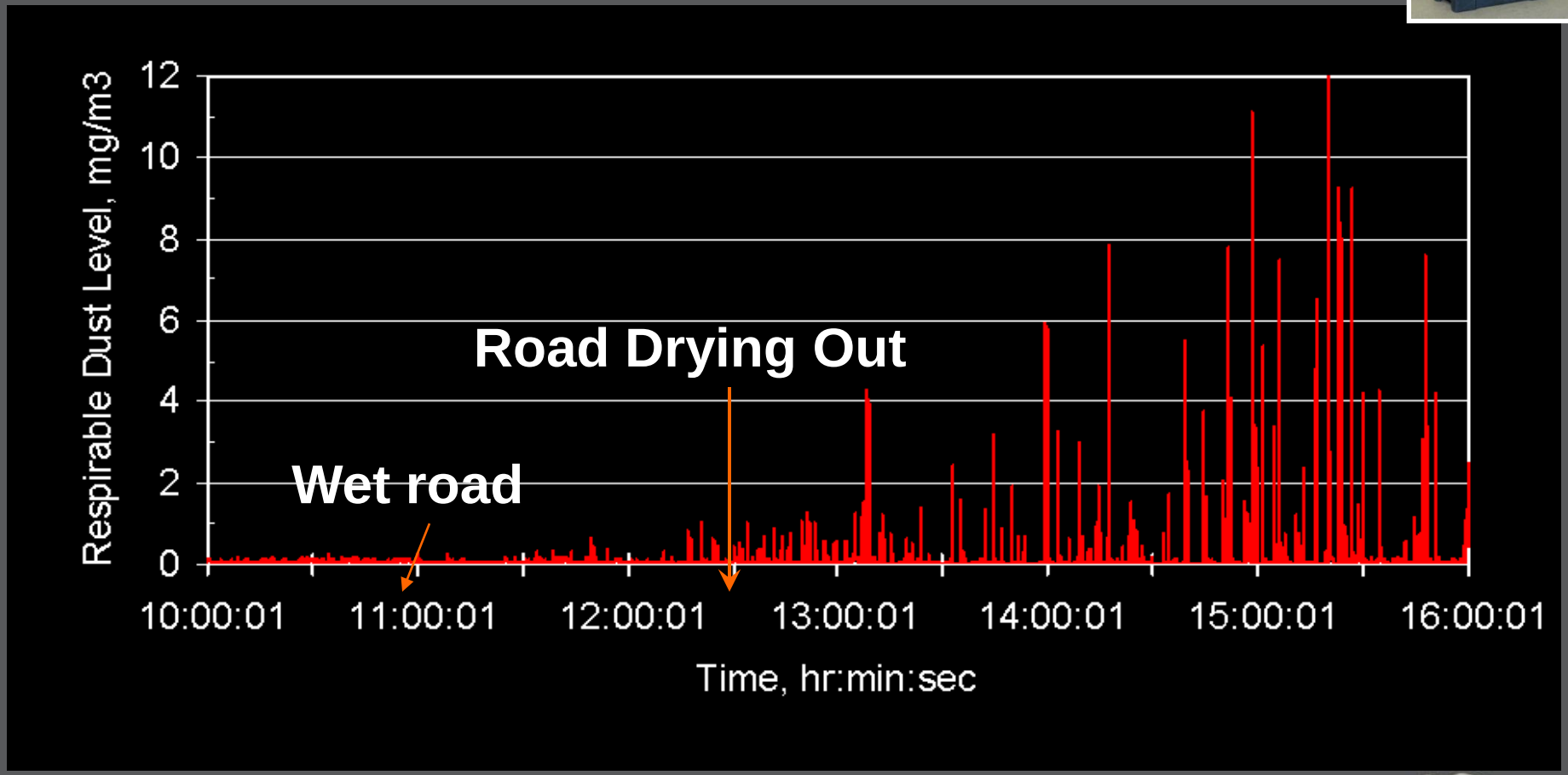


Summer
High humidity

Winter
Road wetting to control dust generation



ROAD WETTING EFFECT
Sampling with pDR



Haul Road Dust Research

- 80% of dust is not respirable, > 10 microns
- Dust levels diminish approximately 50 feet from source
- Sampling shows that road wetting is an effective technique when practiced as required

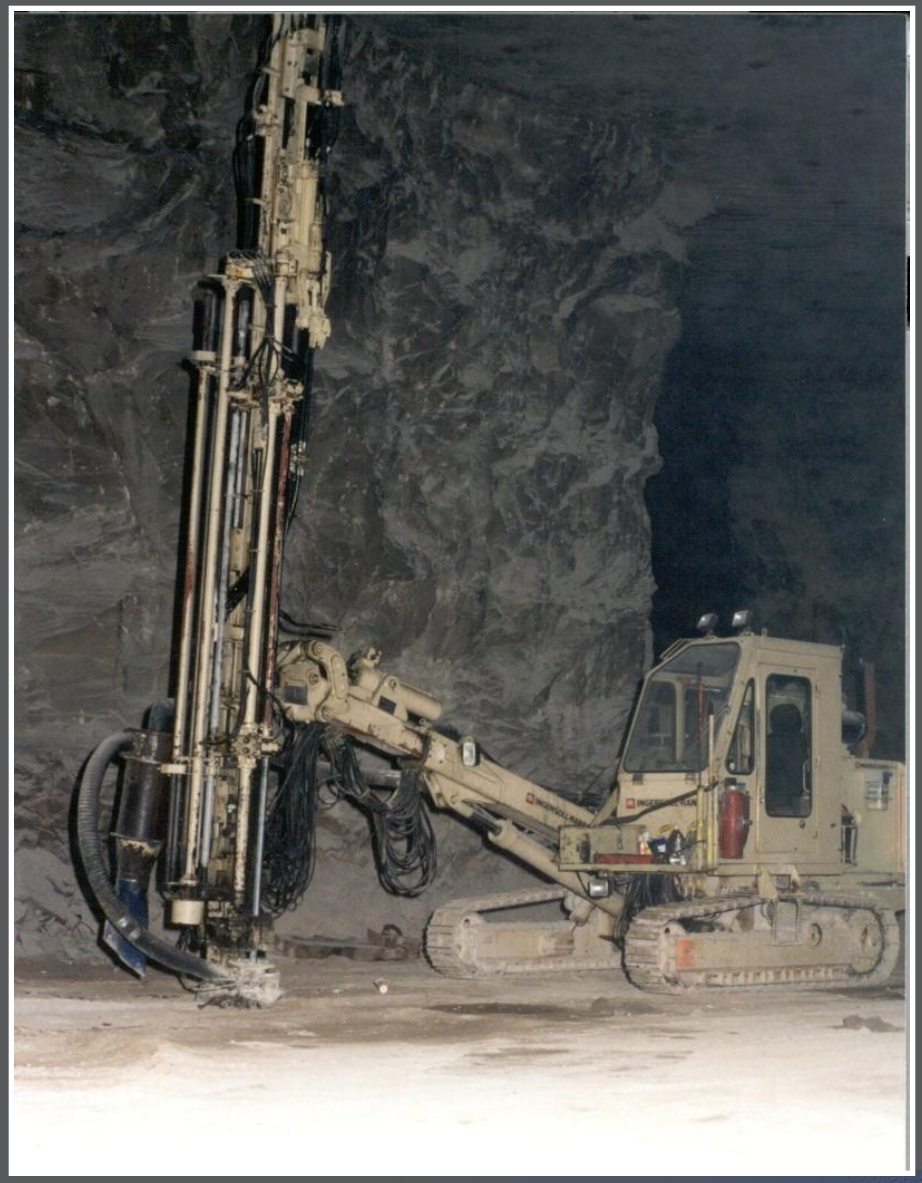
Best Practices

- Road wetting is effective, but continual maintenance must be practiced
- Use traffic control as a dust control technique:
  - Max exposure occurs within 4–15 seconds behind a haul truck
  - Require trucks to maintain more than 20 seconds of separation
  - May result in a 40%–50% reduction in respirable dust exposure to the following truck

Other Dust Sources

- Scalers
- Haul road dust
- Down-hole drills

Down-hole Drills

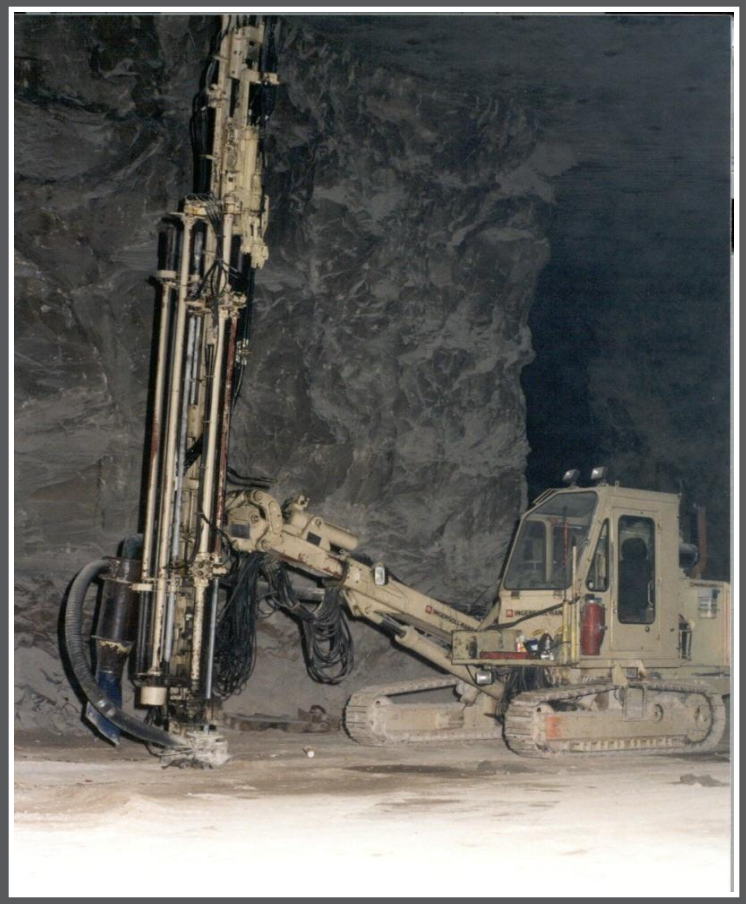


<u>Ninety percent of dust emissions from:</u>

- **Drill shroud leakage**
- **Drill stem bushing leakage**
- **Dust collector dump discharge**

To Reduce Dust Exposure

Use booster fans to remove dust in poorly ventilated benches



Best Practices

- **Maintain a tight drill deck shroud enclosure with the ground**
- **Maintain a collector-to-bailing airflow ratio of at least 3:1**
- **Maintain the dust collector as specified by the manufacturer**

Disclaimer

The findings and conclusions in this presentation are those of the authors and do not necessarily represent the views of NIOSH. Mention of any company or product does not constitute endorsement by the National Institute for Occupational Safety and Health (NIOSH). In addition, citations to Web sites external to NIOSH do not constitute NIOSH endorsement of the sponsoring organizations or their programs or products. Furthermore, NIOSH is not responsible for the content of these Web sites. All Web addresses referenced in this presentation were accessible as of the date the presentation was originally delivered.

Thank You

Greg Chekan

E-mail: gcc8@cdc.gov

412-386-6676

Questions?