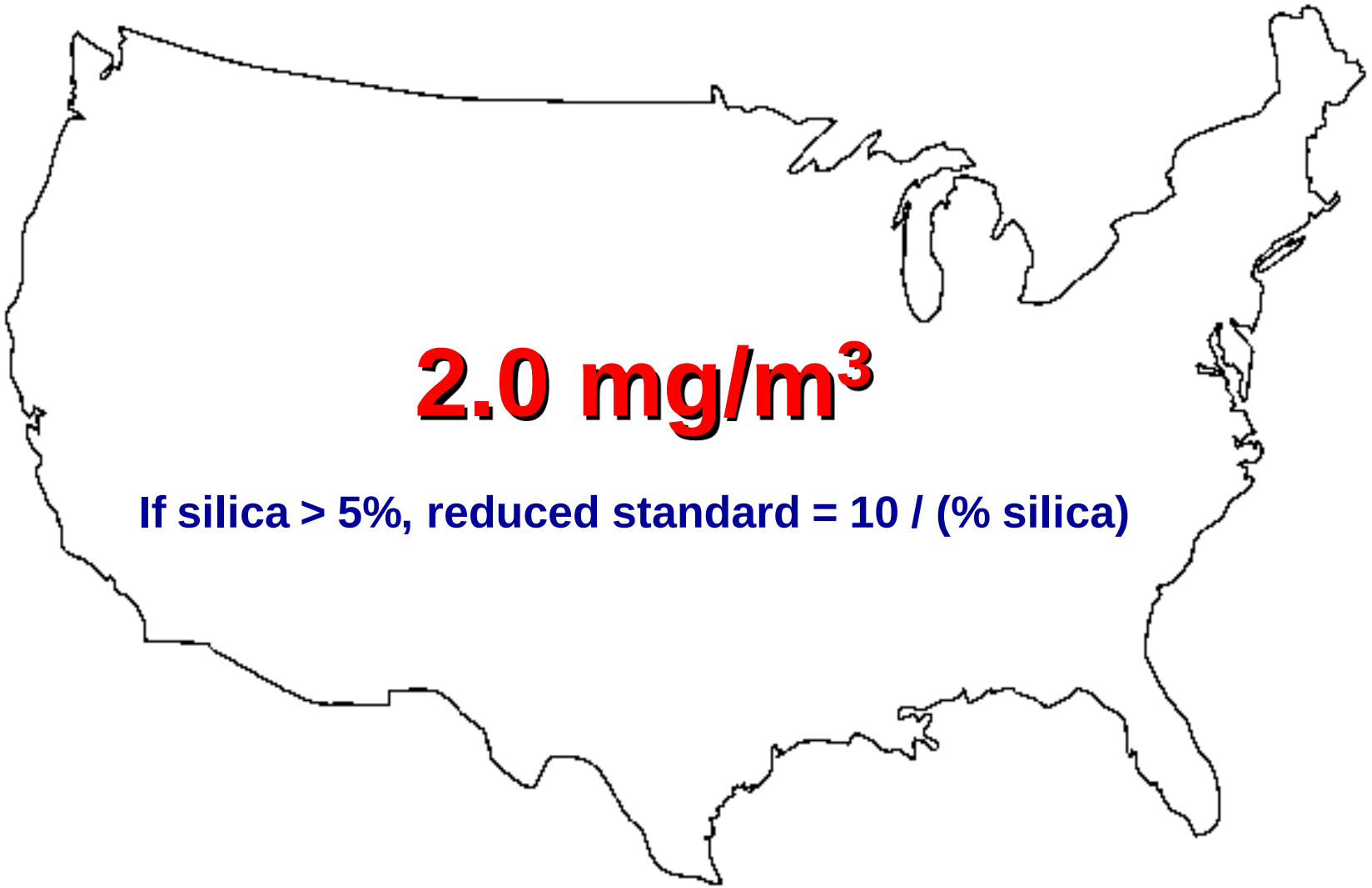
Sampling to Quantify Respirable Dust Generation

- Current respirable dust standards and sampling requirements established in 1969
- Dust sampling instruments approved for use in underground coal mines
- Sampling methods to quantify dust sources

Respirable dust standard for coal mining



2.0 mg/m^3

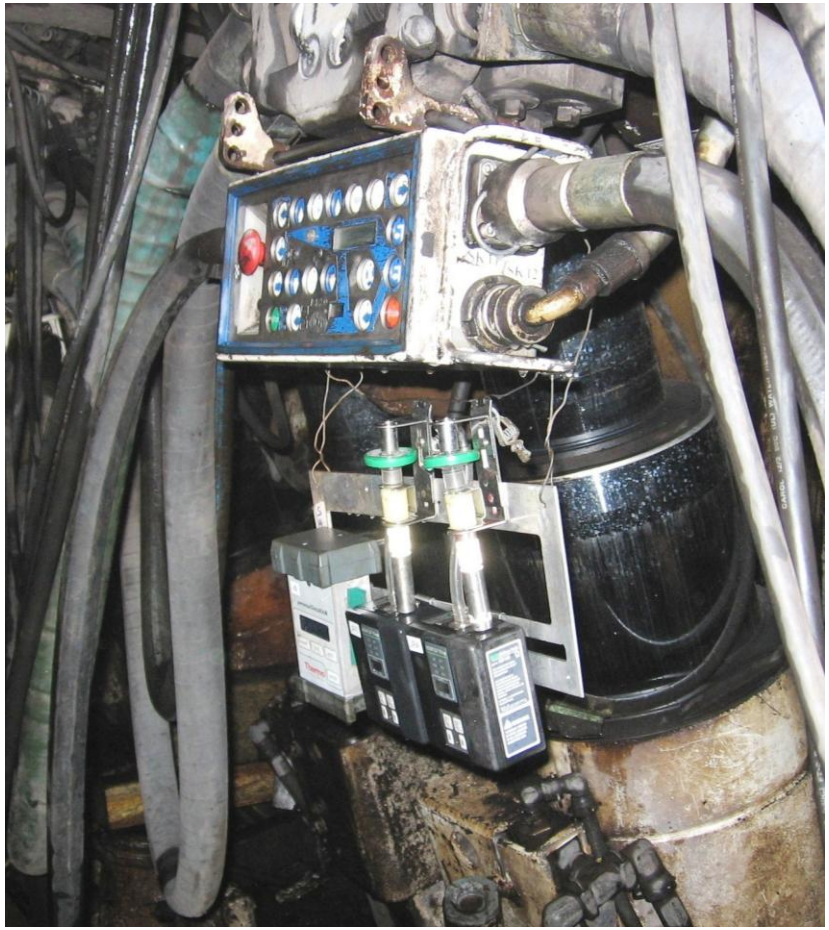
If silica > 5%, reduced standard = 10 / (% silica)

Gravimetric dust sampler

- Provides time-weighted-average respirable dust concentration
- Dorr-Oliver cyclone separates respirable and oversize dust
- Pump operated at 2.0 liters per minute in coal mines

Sampling with gravimetric sampler

- Filter is pre- and post-weighed to determine mass gain and is used to calculate an average dust concentration over sampling period
- Filter processed using MSHA P7 infrared analytical technique for silica content
- Sufficient mass must be collected to have confidence in measurement
- NIOSH typically uses multiple gravimetric samplers and averages data



Personal DataRAM (pDR)

- Uses light scattering as measurement technology
- Instantaneous readings correlated with time and stored in internal memory
- Relative concentrations impacted by:
  - size distribution of dust
  - composition of dust
  - water mist in air
- PRL adjusts readings with ratio obtained from adjacent gravimetric samplers

pDR field calibration

- Divide average gravimetric concentration by average pDR concentration for same sampling period
- Multiply all individual pDR readings by ratio
- Example:

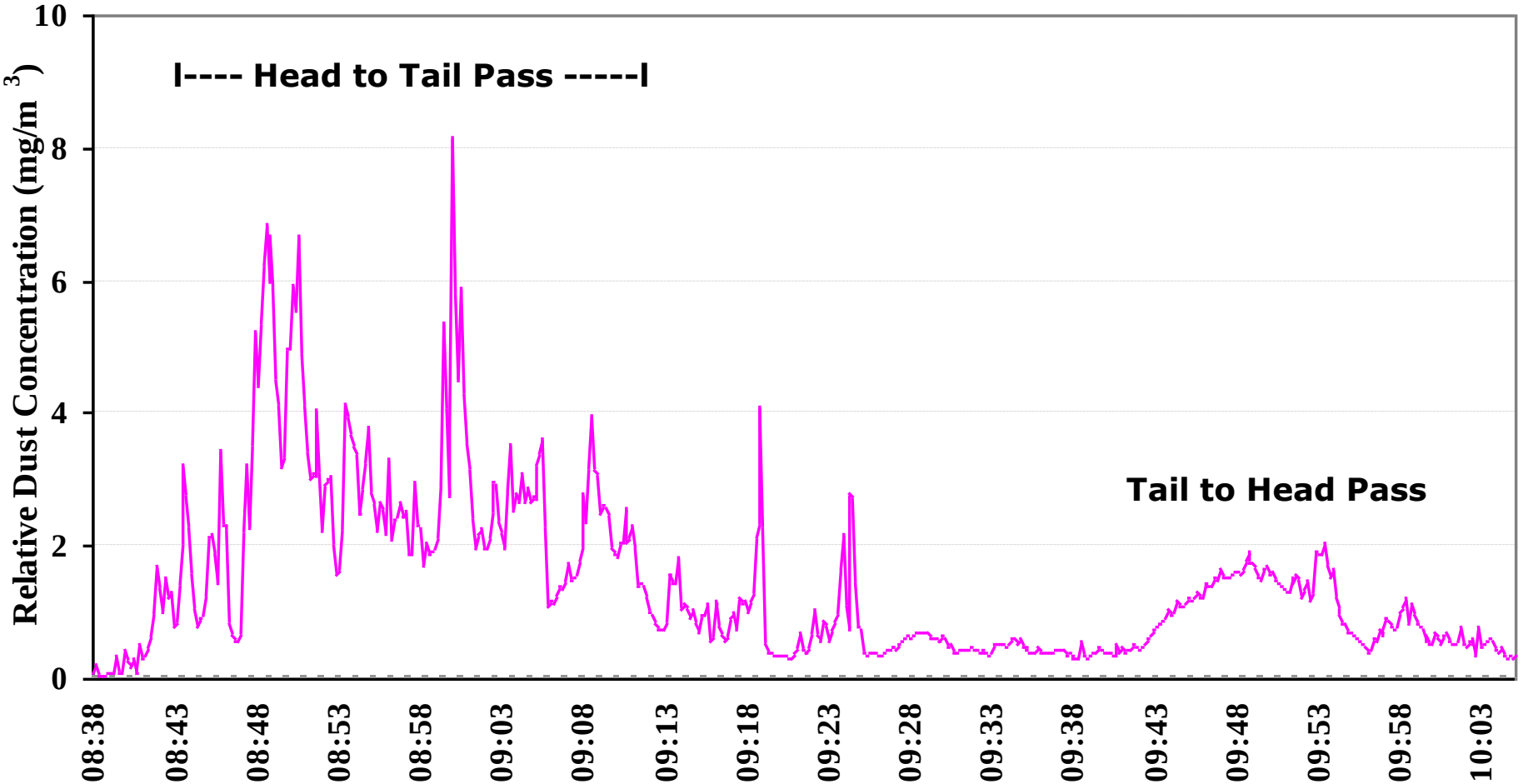
  gravimetric average = 1.4 mg/m^3

  pDR average = 1.1 mg/m^3

  grav/pDR ratio = 1.4/1.1 = 1.27

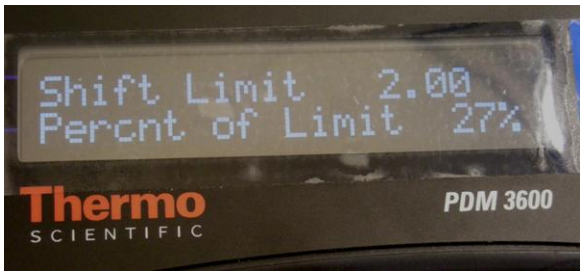
  pDR concentrations * 1.27 = adjusted pDR concentrations

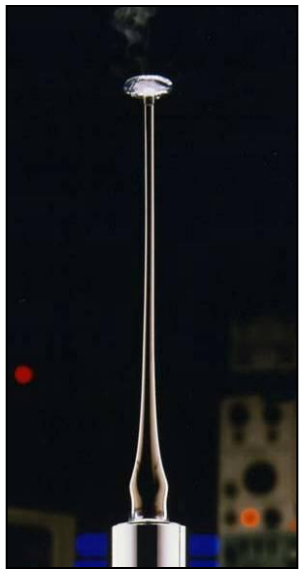
pDR provides time record of dust levels



Personal Dust Monitor (PDM)

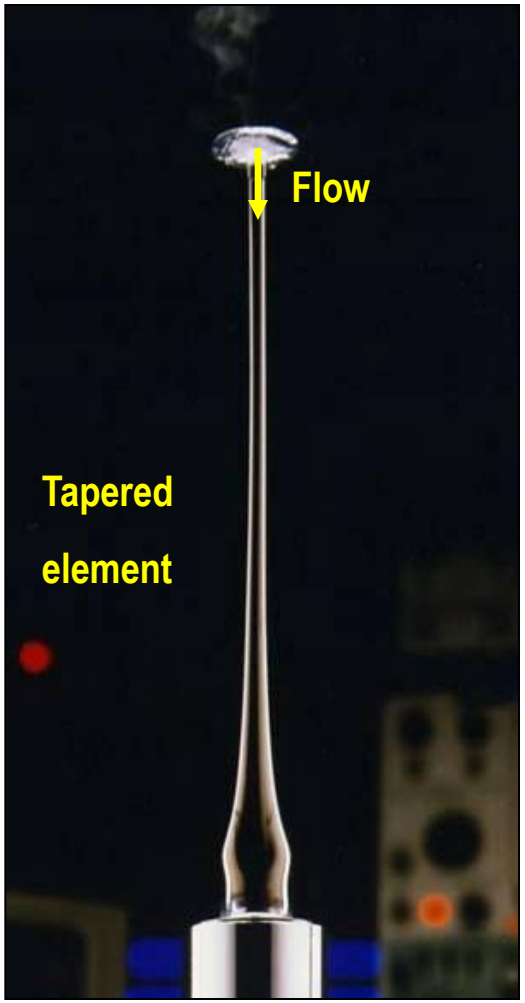
- Real-time measurement of respirable dust
- Combines dust sampler and cap lamp into one unit
- Sample inlet is mounted on cap lamp
- Utilizes mass-based measurement to quantify dust concentration (TEOM)
- Dust measurements are displayed on screen and stored internally for later analysis





Principle of operation

- Exchangeable filter cartridge mounted on the end of the tapered element collects particles as sample stream flows through hollow tube
- Tapered element oscillates at its harmonic frequency -- like a tuning fork
- Frequency changes in *direct* relation to the mass collected on the filter
- Measurement principle does *not* respond to other particle characteristics such as size distribution or composition (heated circuit removes moisture)

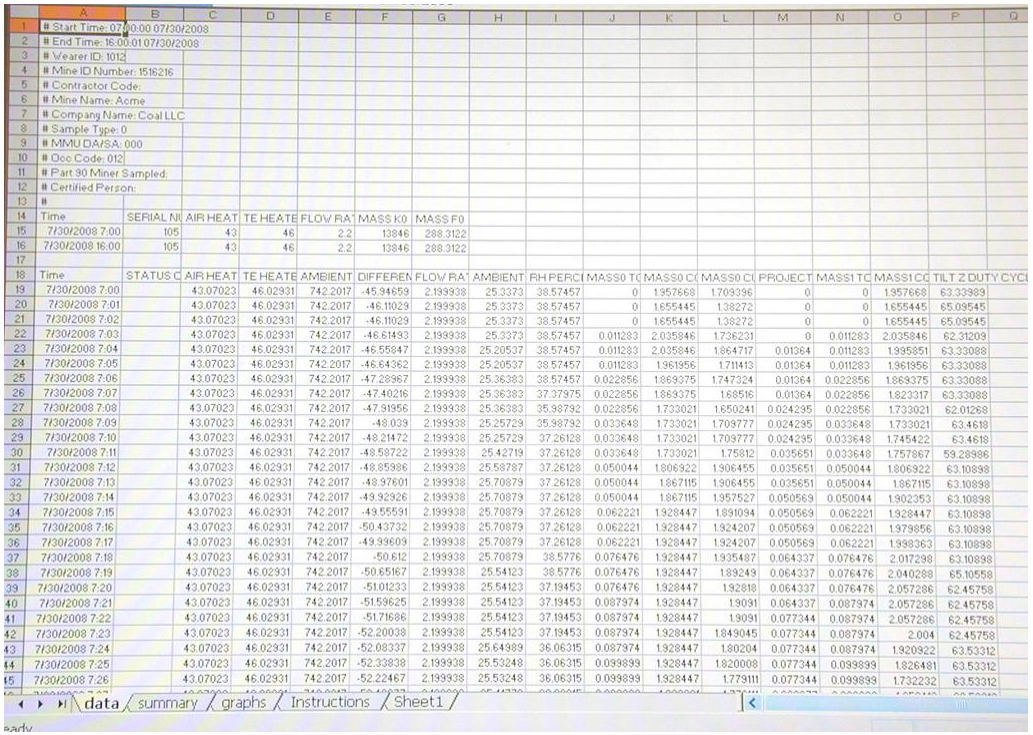


PDM status:

- Meets NIOSH sampling accuracy requirements (NIOSH RI 9669)
- Equivalency to CMPDSU (gravimetric sampler) published in peer-review journal
- MSHA IS approval granted for use in underground coal mines
- CFR 30, Part 74 modified rule is nearly finalized
- Thermo Scientific began delivery of commercial units in July 2009
- Two ongoing NIOSH research efforts (software and silica)

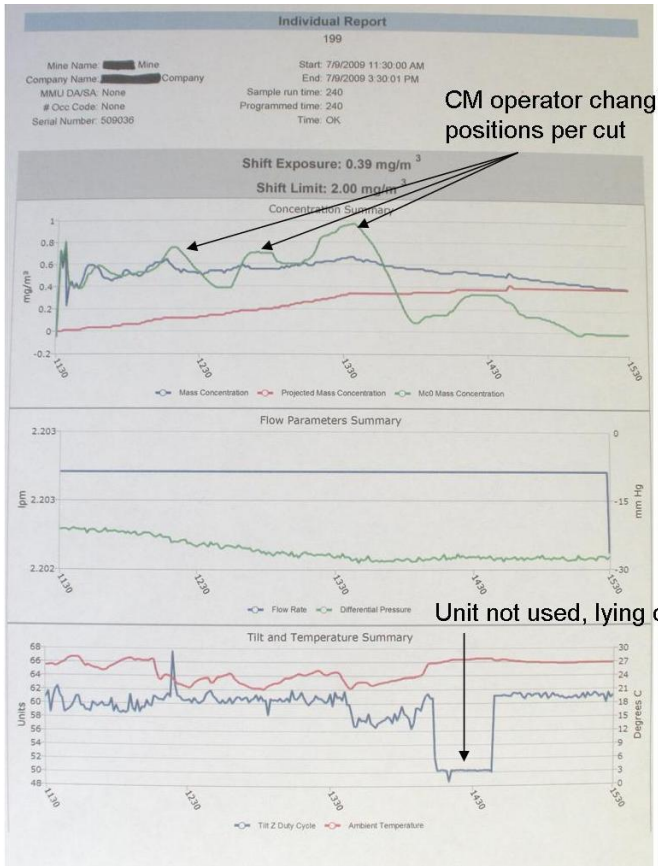
PDM analytical software

- Compile output from PDM samplers
- Provide user-selected summaries for multiple samplers (foreman, mine superintendent, etc.) or engineering evaluations
- Provide graphing capabilities



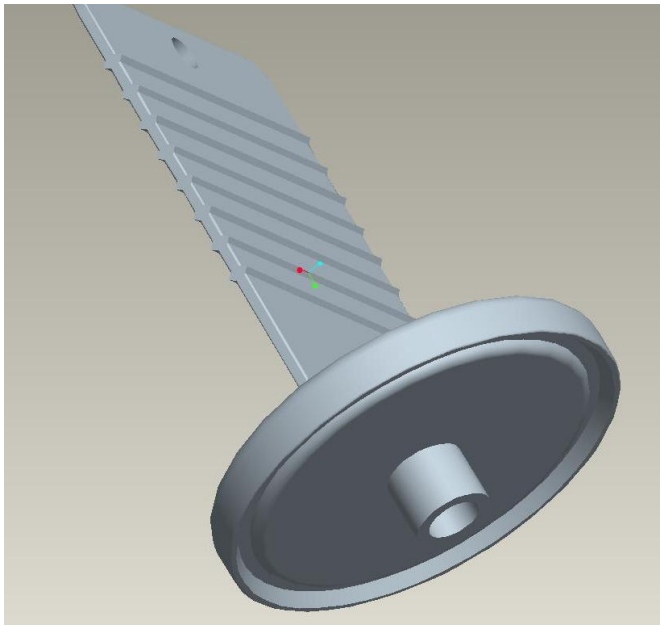
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	# Start Time: 07/30/2008 07:00:00																
2	# End Time: 16:00:01 07/30/2008																
3	# Wearer ID: 1012																
4	# Mine ID Number: 1516216																
5	# Contractor Code:																
6	# Mine Name: Acme																
7	# Company Name: Coal LLC																
8	# Sample Type: 0																
9	# MMU DA/SA: 000																
10	# Occ Code: 012																
11	# Part 90 Miner Sampled:																
12	# Certified Person:																
13	#																
14	Time	SERIAL NU	AIR HEAT	TE HEATE	FLOW RA	MASS K0	MASS F0										
15	7/30/2008 7:00	105	43	46	2.2	13846	288.3122										
16	7/30/2008 16:00	105	43	46	2.2	13846	288.3122										
17																	
18	Time	STATUS C	AIR HEAT	TE HEATE	AMBIENT	DIFFEREN	FLOW RA	AMBIENT	RH PERCI	MASS0 TC	MASS0 CC	MASS0 CU	PROJECT	MASS1 TC	MASS1 CC	TILT Z DUTY	CYCI
19	7/30/2008 7:00		43.07023	46.02931	742.2017	-45.94659	2.199938	25.3373	38.57457	0	1.957668	1.709396	0	0	1.957668	63.33989	
20	7/30/2008 7:01		43.07023	46.02931	742.2017	-46.11029	2.199938	25.3373	38.57457	0	1.655445	1.38272	0	0	1.655445	65.09545	
21	7/30/2008 7:02		43.07023	46.02931	742.2017	-46.11029	2.199938	25.3373	38.57457	0	1.655445	1.38272	0	0	1.655445	65.09545	
22	7/30/2008 7:03		43.07023	46.02931	742.2017	-46.61493	2.199938	25.3373	38.57457	0.011283	2.035846	1.736231	0	0.011283	2.035846	62.31209	
23	7/30/2008 7:04		43.07023	46.02931	742.2017	-46.55847	2.199938	25.20537	38.57457	0.011283	2.035846	1.864717	0.01364	0.011283	1.995851	63.33088	
24	7/30/2008 7:05		43.07023	46.02931	742.2017	-46.64362	2.199938	25.20537	38.57457	0.011283	1.961956	1.711413	0.01364	0.011283	1.961956	63.33088	
25	7/30/2008 7:06		43.07023	46.02931	742.2017	-47.28967	2.199938	25.36383	38.57457	0.022856	1.869375	1.747324	0.01364	0.022856	1.869375	63.33088	
26	7/30/2008 7:07		43.07023	46.02931	742.2017	-47.40216	2.199938	25.36383	37.37975	0.022856	1.869375	1.68516	0.01364	0.022856	1.823317	63.33088	
27	7/30/2008 7:08		43.07023	46.02931	742.2017	-47.31956	2.199938	25.36383	35.98792	0.022856	1.733021	1.650241	0.024295	0.022856	1.733021	62.01268	
28	7/30/2008 7:09		43.07023	46.02931	742.2017	-48.039	2.199938	25.25729	35.98792	0.033648	1.733021	1.709777	0.024295	0.033648	1.733021	63.4618	
29	7/30/2008 7:10		43.07023	46.02931	742.2017	-48.21472	2.199938	25.25729	37.26128	0.033648	1.733021	1.709777	0.024295	0.033648	1.745422	63.4618	
30	7/30/2008 7:11		43.07023	46.02931	742.2017	-48.58722	2.199938	25.42719	37.26128	0.033648	1.733021	1.75812	0.035651	0.033648	1.757867	59.28986	
31	7/30/2008 7:12		43.07023	46.02931	742.2017	-48.85986	2.199938	25.58787	37.26128	0.050044	1.806922	1.906455	0.035651	0.050044	1.806922	63.10898	
32	7/30/2008 7:13		43.07023	46.02931	742.2017	-48.97601	2.199938	25.70879	37.26128	0.050044	1.867115	1.906455	0.035651	0.050044	1.867115	63.10898	
33	7/30/2008 7:14		43.07023	46.02931	742.2017	-49.92926	2.199938	25.70879	37.26128	0.050044	1.867115	1.957527	0.050569	0.050044	1.902353	63.10898	
34	7/30/2008 7:15		43.07023	46.02931	742.2017	-49.55591	2.199938	25.70879	37.26128	0.062221	1.928447	1.891094	0.050569	0.062221	1.928447	63.10898	
35	7/30/2008 7:16		43.07023	46.02931	742.2017	-50.43732	2.199938	25.70879	37.26128	0.062221	1.928447	1.924207	0.050569	0.062221	1.979856	63.10898	
36	7/30/2008 7:17		43.07023	46.02931	742.2017	-49.99609	2.199938	25.70879	37.26128	0.062221	1.928447	1.924207	0.050569	0.062221	1.998363	63.10898	
37	7/30/2008 7:18		43.07023	46.02931	742.2017	-50.612	2.199938	25.70879	38.5776	0.076476	1.928447	1.935487	0.064337	0.076476	2.017298	63.10898	
38	7/30/2008 7:19		43.07023	46.02931	742.2017	-50.65167	2.199938	25.54123	38.5776	0.076476	1.928447	1.89249	0.064337	0.076476	2.040288	65.10558	
39	7/30/2008 7:20		43.07023	46.02931	742.2017	-51.01233	2.199938	25.54123	37.19453	0.076476	1.928447	1.92818	0.064337	0.076476	2.057286	62.45758	
40	7/30/2008 7:21		43.07023	46.02931	742.2017	-51.59625	2.199938	25.54123	37.19453	0.087974	1.928447	1.9091	0.064337	0.087974	2.057286	62.45758	
41	7/30/2008 7:22		43.07023	46.02931	742.2017	-51.71686	2.199938	25.54123	37.19453	0.087974	1.928447	1.9091	0.077344	0.087974	2.057286	62.45758	
42	7/30/2008 7:23		43.07023	46.02931	742.2017	-52.20038	2.199938	25.54123	37.19453	0.087974	1.928447	1.849045	0.077344	0.087974	2.004	62.45758	
43	7/30/2008 7:24		43.07023	46.02931	742.2017	-52.08337	2.199938	25.64989	36.06315	0.087974	1.928447	1.80204	0.077344	0.087974	1.920922	63.53312	
44	7/30/2008 7:25		43.07023	46.02931	742.2017	-52.33838	2.199938	25.53248	36.06315	0.099899	1.928447	1.820008	0.077344	0.099899	1.826481	63.53312	
45	7/30/2008 7:26		43.07023	46.02931	742.2017	-52.22467	2.199938	25.53248	36.06315	0.099899	1.928447	1.779111	0.077344	0.099899	1.732232	63.53312	

data / summary / graphs / Instructions / Sheet1

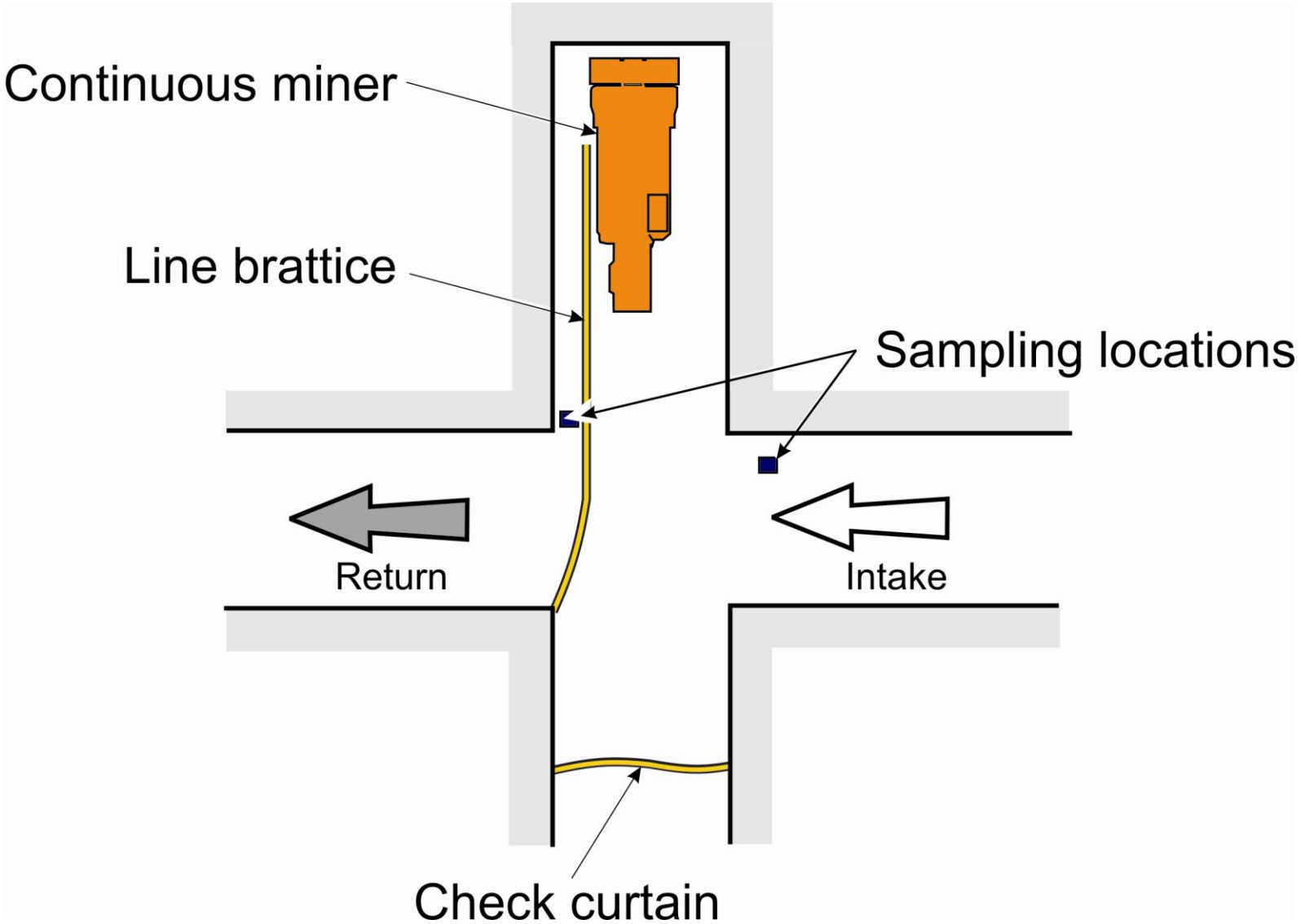


PDM filter capsule for maintaining sample integrity for quartz analysis

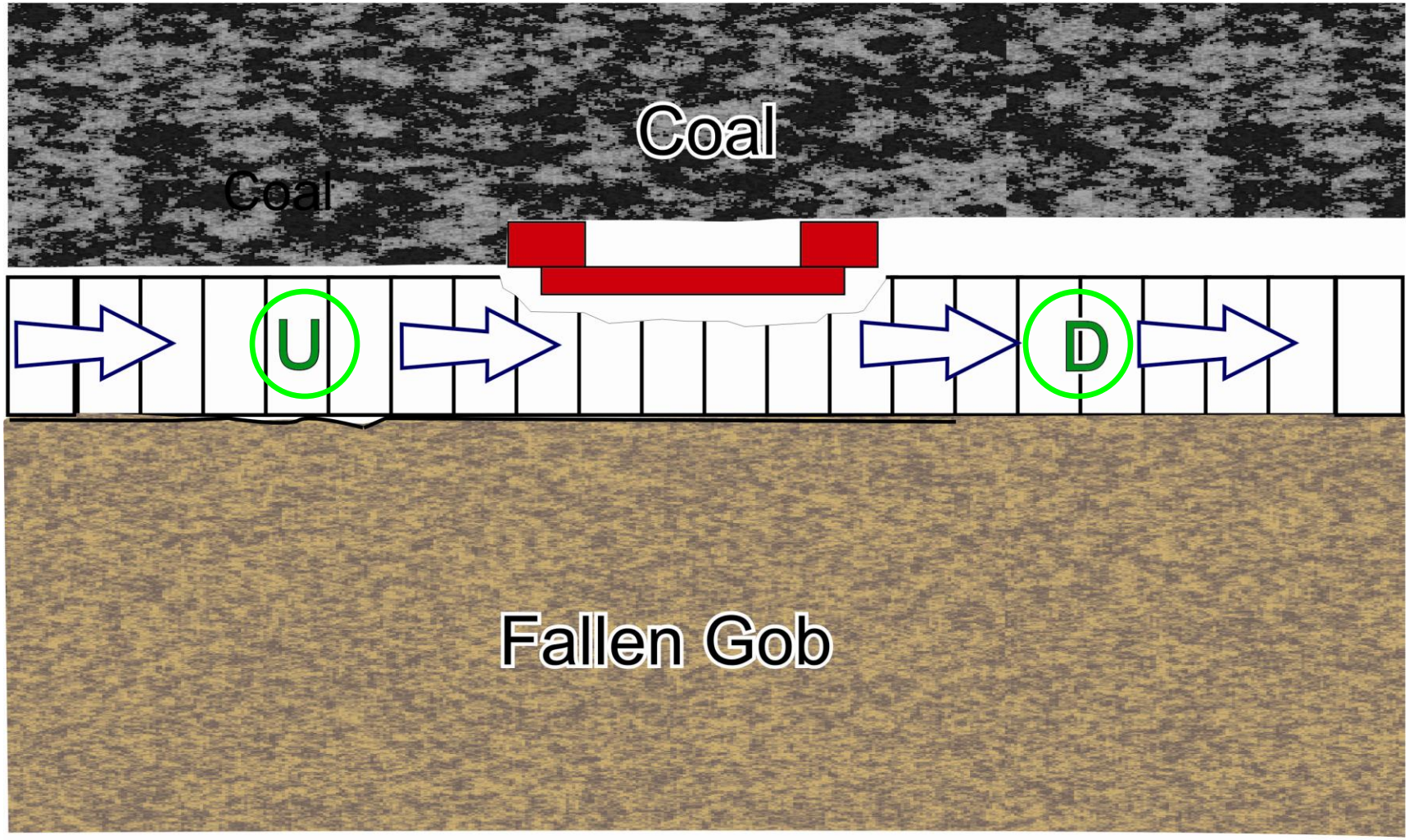
- Place capsule over PDM filter when TEOM unit removed from PDM
- Use capsule as filter removal tool and to secure dust
- Send to lab, remove finger tab, ash capsule
- Plan to conduct mine surveys to complete side-by-side testing with current silica analysis method



Sampling to isolate a fixed dust source



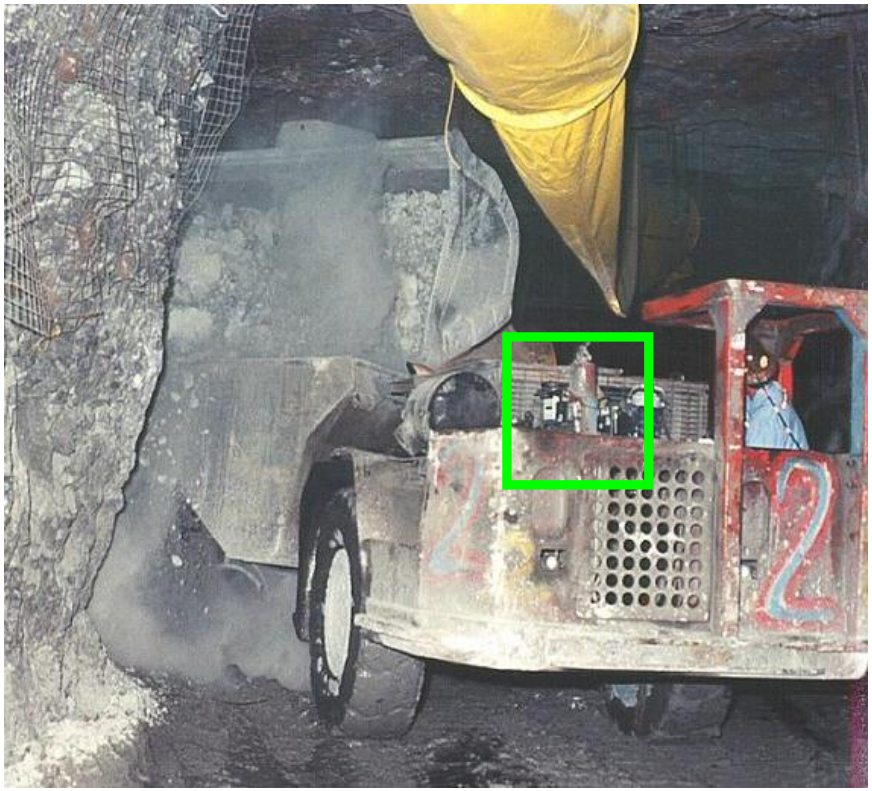
Sampling to isolate a mobile dust source



U - Upwind location D - Downwind location

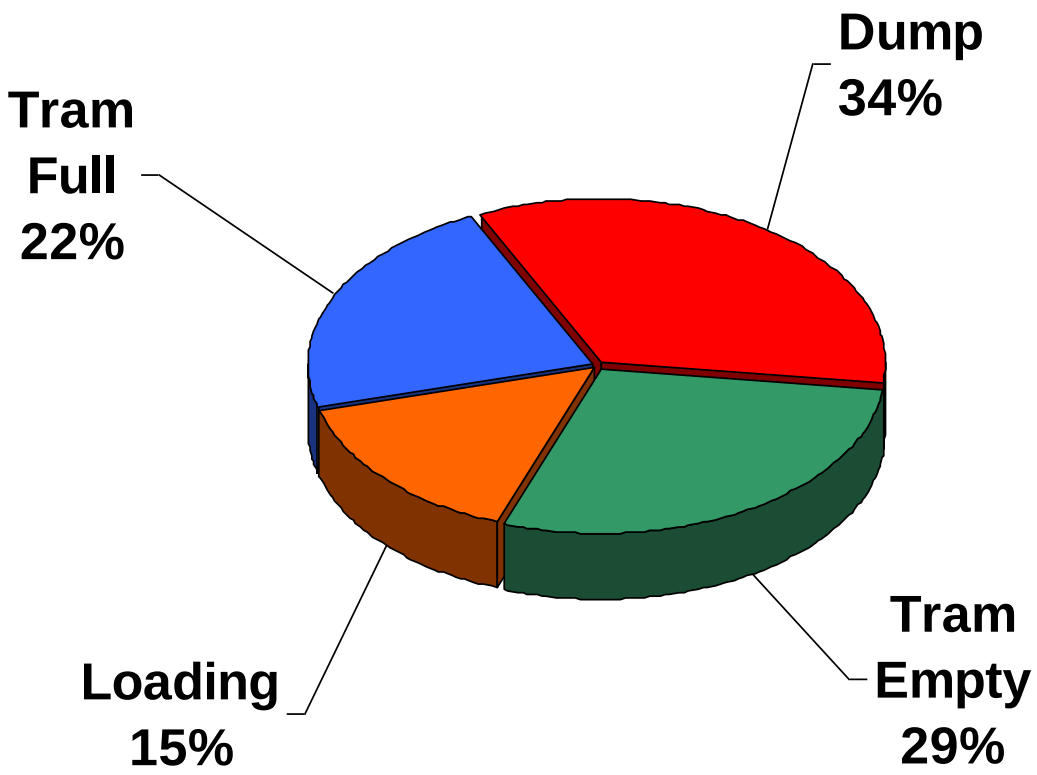
Using real-time data to quantify mobile dust sources

- Evaluate dust levels during truck haulage cycle at an underground gold mine
- Use pDR samplers and time study data to quantify dust generation for different parts of cycle
  - loading
  - hauling full
  - dumping
  - hauling empty
- Two researchers conducting time studies

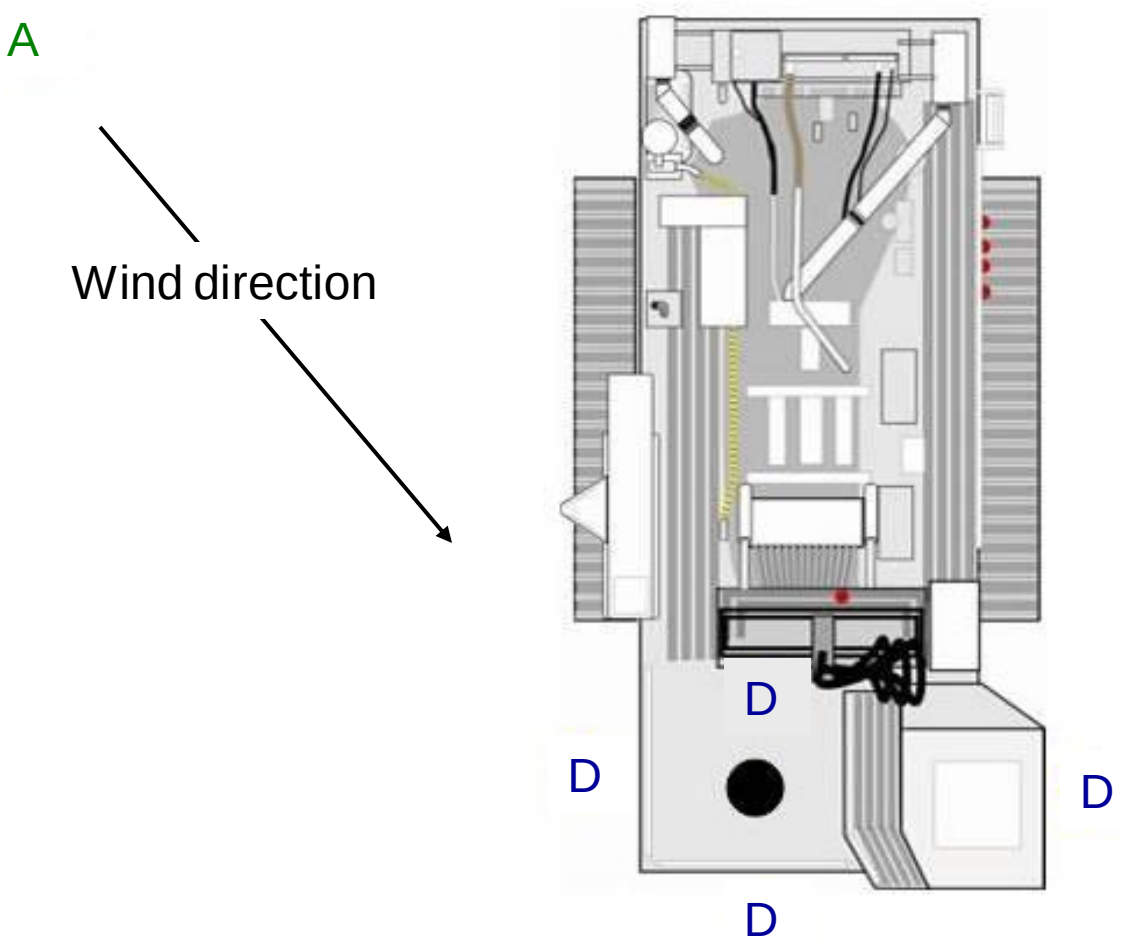


Time-weighted-average dust contributions

Dump location had highest dust liberation (despite the shortest time)



Sampling to isolate an unconfined dust source



A – Ambient sampling location

D – Drill sampling locations

Thank you!

Questions??

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