# The Use of Paper Sludge for Dust Stabilization on Mine Haul Roads and Tailing Impoundments

**Stanley J. Vitton**

**Michigan Technological University**

**Houghton, Michigan**

*2008 Road Dust Management Conference*

*San Antonio, TX*

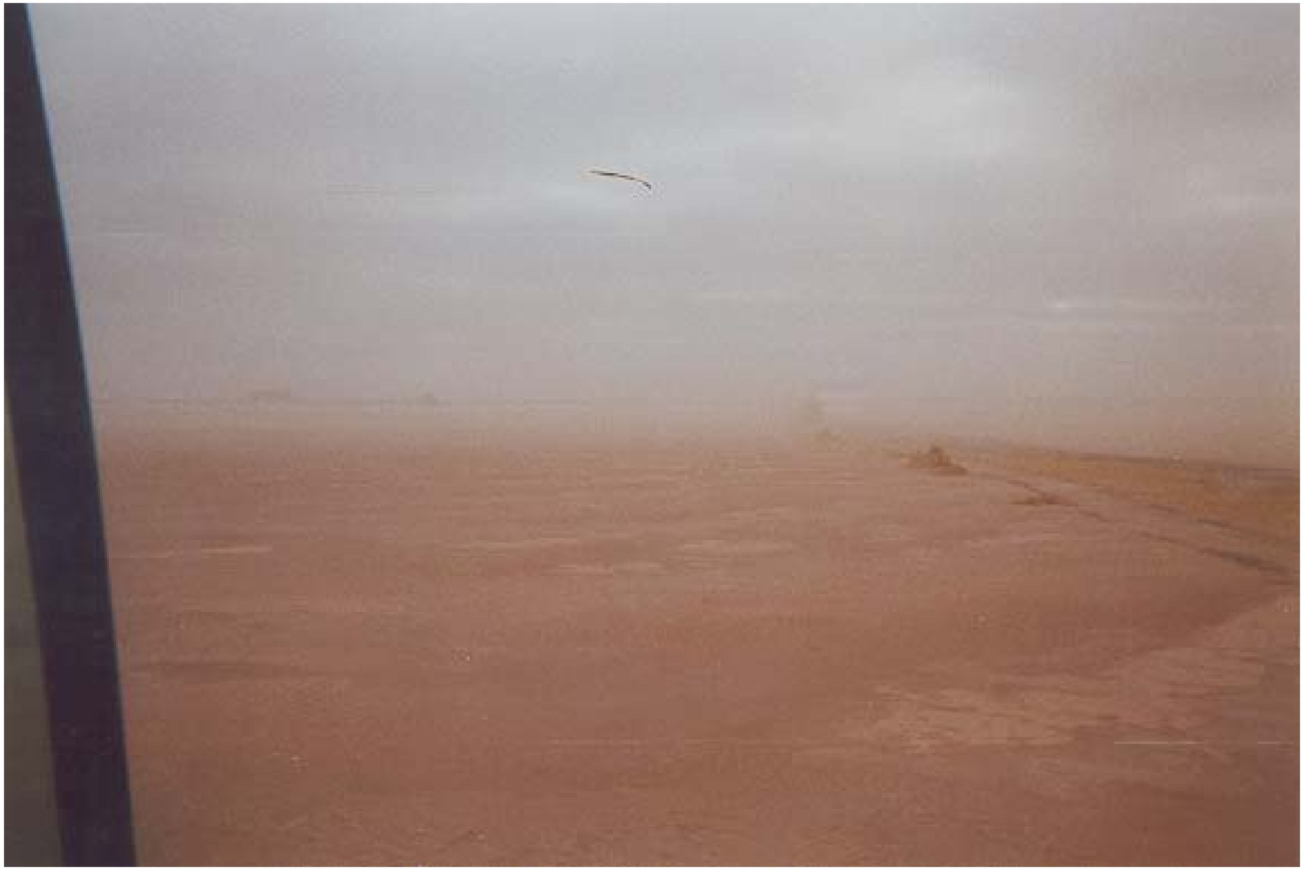
*November 13-14, 2008*

# Residuals for Mine Tailings Area Dust Control

- Introduction
- Warm and Cold Weather Dusting
- Fugitive Dust Studies
- Conclusions

# *Paper Waste Utilization in Mining Application:*

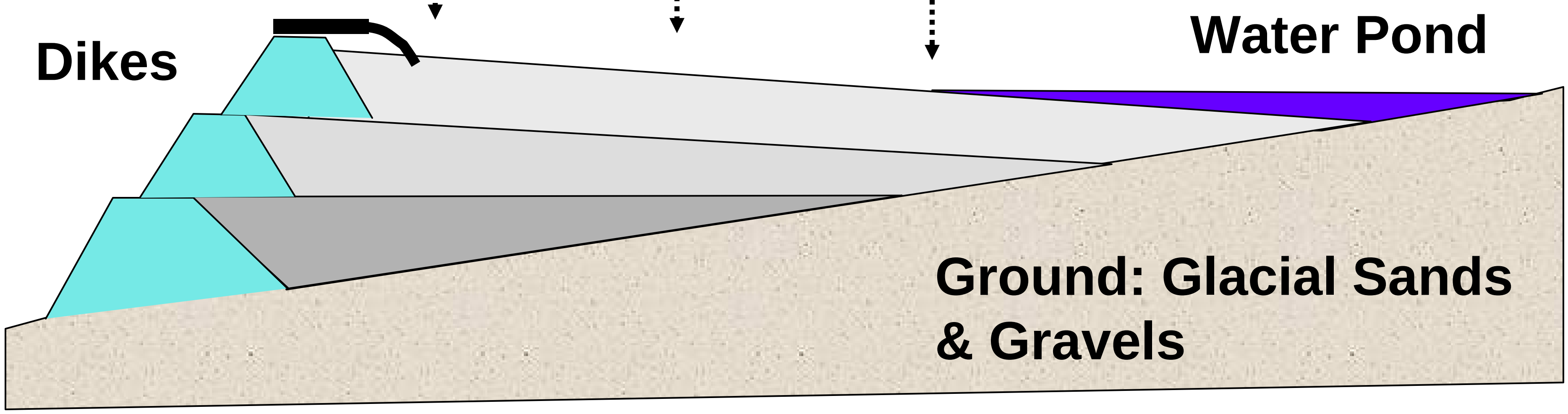
- Dust Control



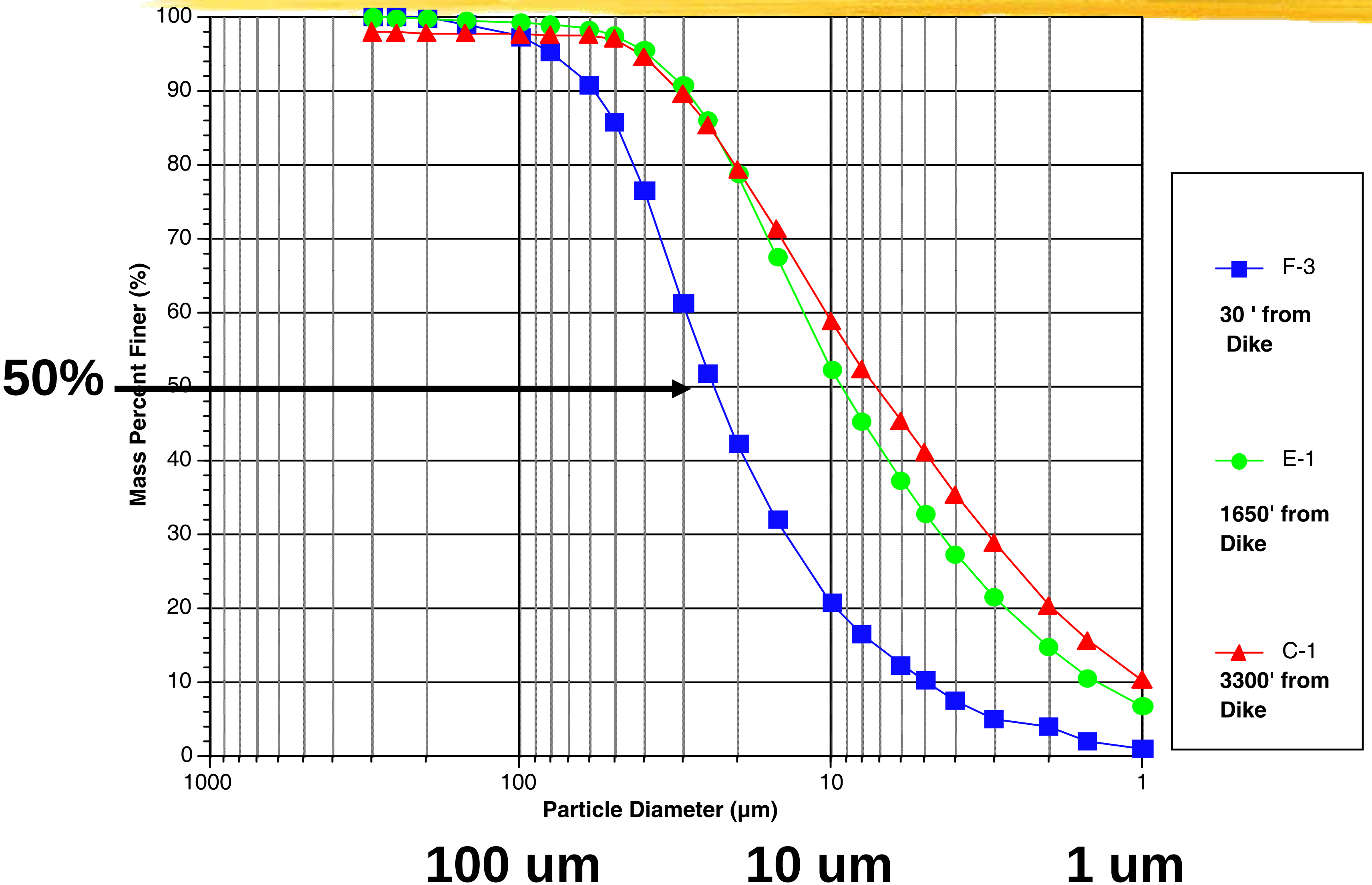
# *Upstream-Dike Construction*

**Particle Size**

| | | | |
|---|---|---|---|
| **Tilden:** | **Beach** | **11 um** | **1 um (40%)** |
| **Empire:** | **Beach** | **20 um** | **1 um (20%)** |



# Grain Size Distribution



# *Dusting Conditions*

- **Warm Weather Dusting**
- **Caused by lack of water**
- **Primarily a problem for non-point sources such as mine haul roads**

- **Cold Weather Dusting**
- **Dry Freeze, i.e., Sublimation**
- **Primarily a problem for saturated silt materials**

# *Traditional Solutions*

- **Water inundation (water pond management)**
- **Vegetative cover**
- **Mulching cover**
- **Crusting agents**
- **Binding agents**
- **Wind fence**
- **Snow Compaction**

# *Types of Active Controls*

- Controls
  - Crusting agents
    - Binding (oil emulsions)
    - Crust (Elmers Glue)
  - Coverage control
    - Vegetation
    - Hay-Mulch
    - Paper-Sludge
    - Wood Chips

# 2 Year Old Vegetation

# Chemical Refill Station

# Crusting Agents

# *Is Accessibility a Problem?*


ZR8723


4460

# Tire Fence Materials

# Paper Waste Sludge in the Control of Fugitive Dust

- Introduction
- Cold Weather Dusting
- Fugitive Dust Studies
- Conclusions

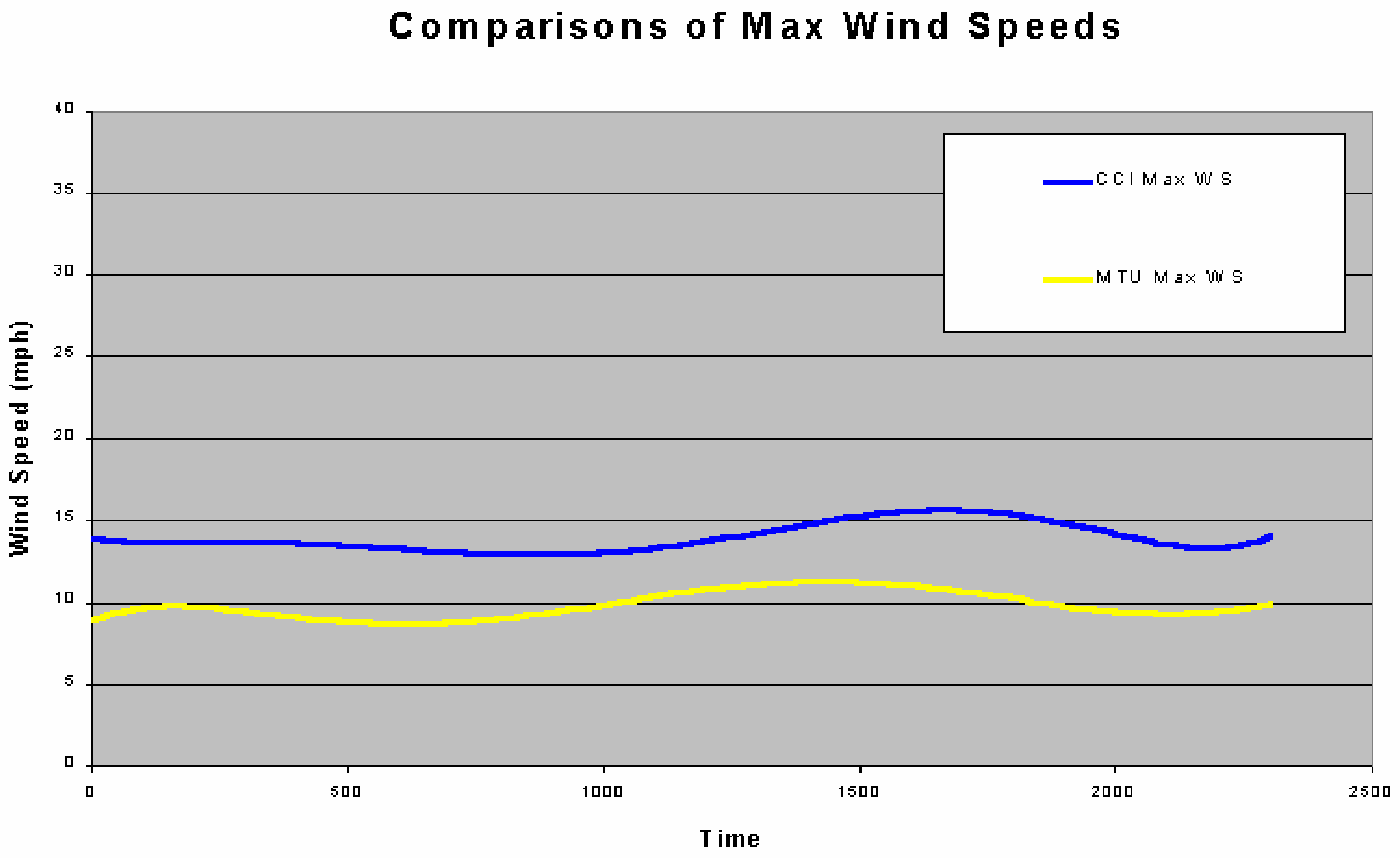
# *Wind Erosion Studies*

- **Passive**
  - **Long-term passive monitoring techniques**
  - **Show trends**
  - **Measure natural erosion**
- **Active**
  - **Short-term active monitoring techniques**
  - **Compare erosion control at a given time**
  - **Create erosion to measure**

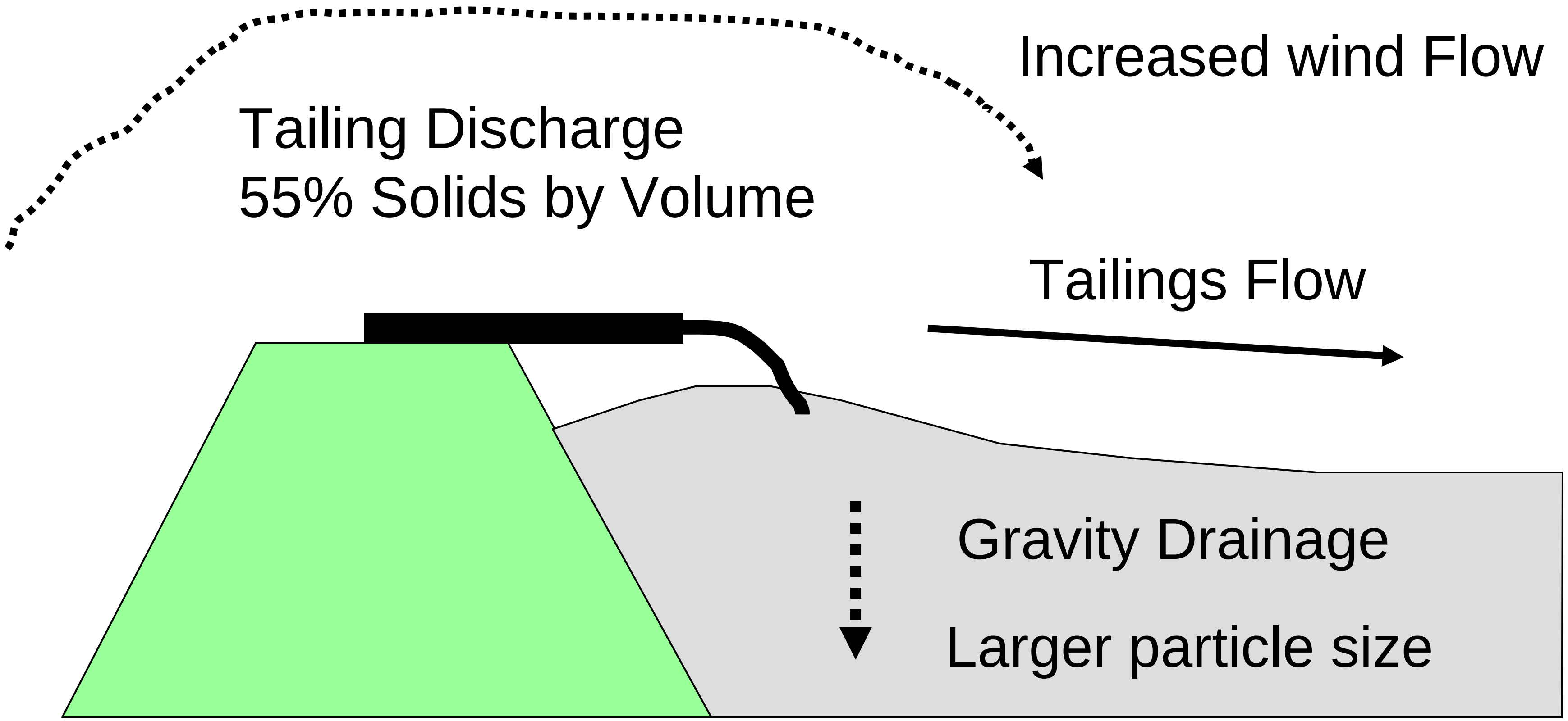
# Measuring Lift-Off Velocities

# Weather Monitoring

# Wind Speed Comparison



# *Warm Weather Dusting*



# *Cold Weather Dusting*

- Key Elements
  - No snow on the basin
  - Below freezing temperatures
  - Sublimation of pore ice
- Controls
  - Antifreeze agents
  - Cover controls
- Problems with controls
  - Accessibility

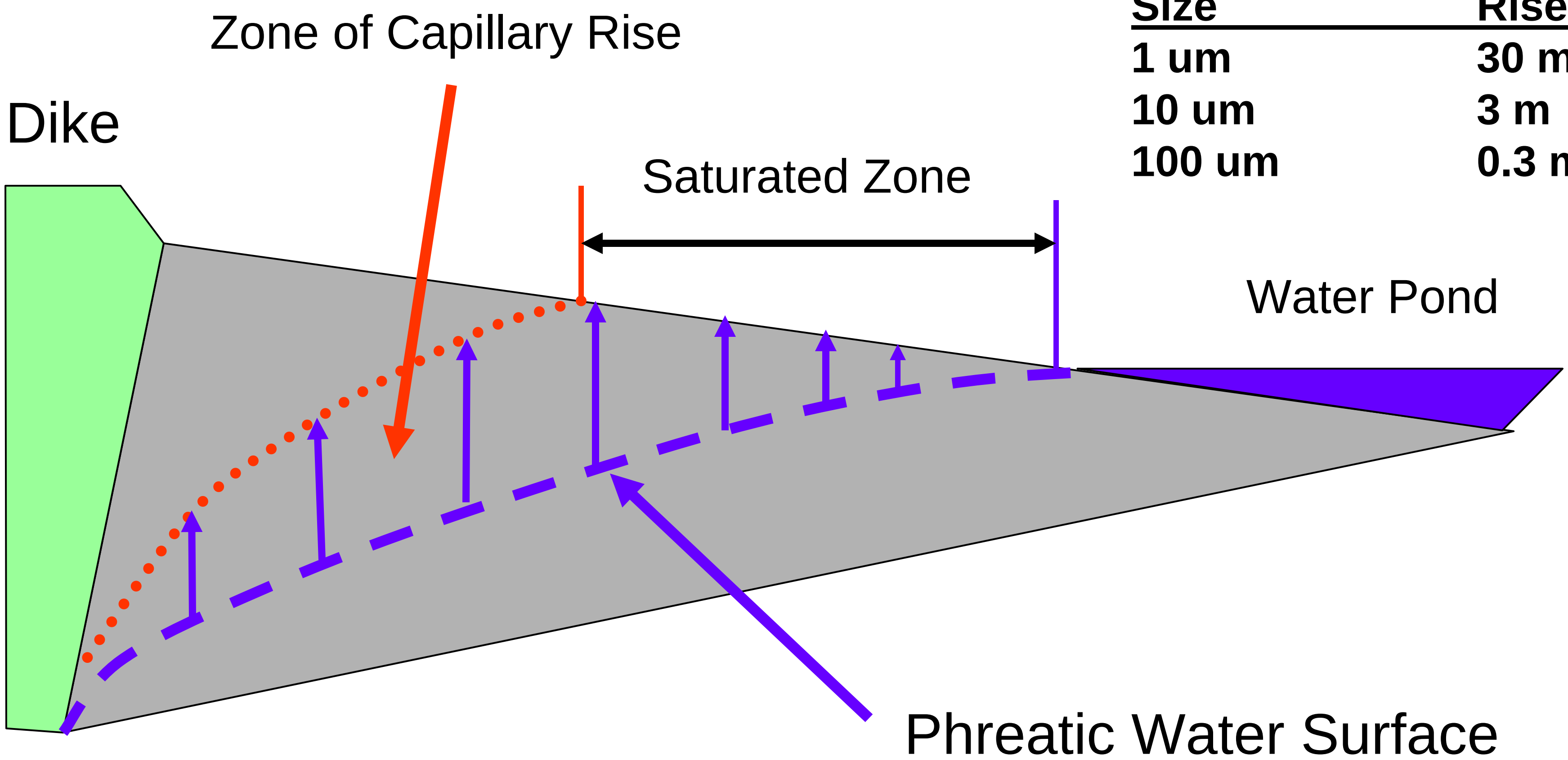
# *Dry Freeze (Sublimation)*

**Ref: Sublimation and aelian sand movement from a frozen surface: experimental results from Presqu'ile Beach, Ontario**
**by D.D. Dijk & J. Law**

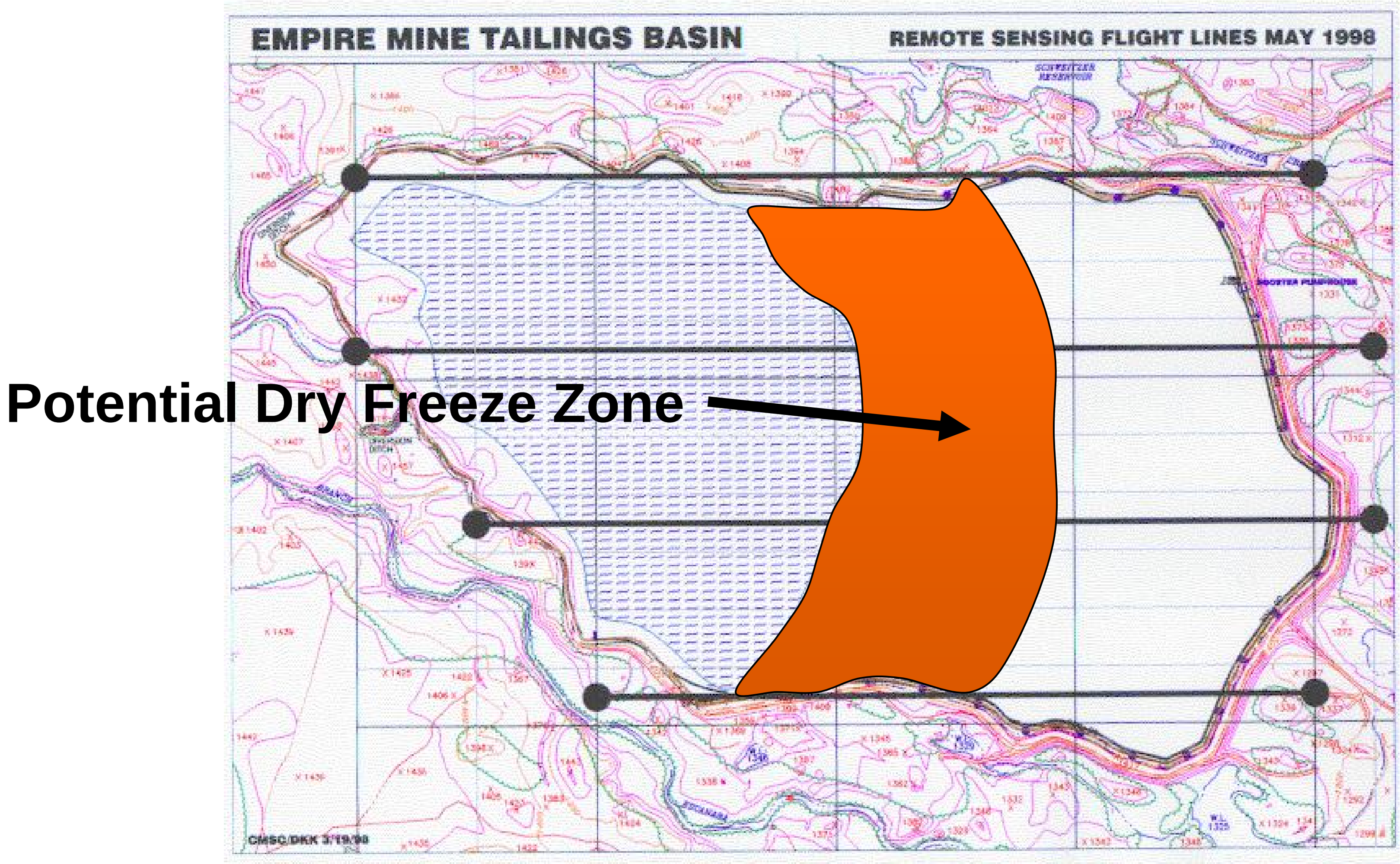
- **Temperature most influential variable**
- **A combination of low moisture content, high wind speed and low relative humidity result in greatest sublimation**

# *Capillary Action*

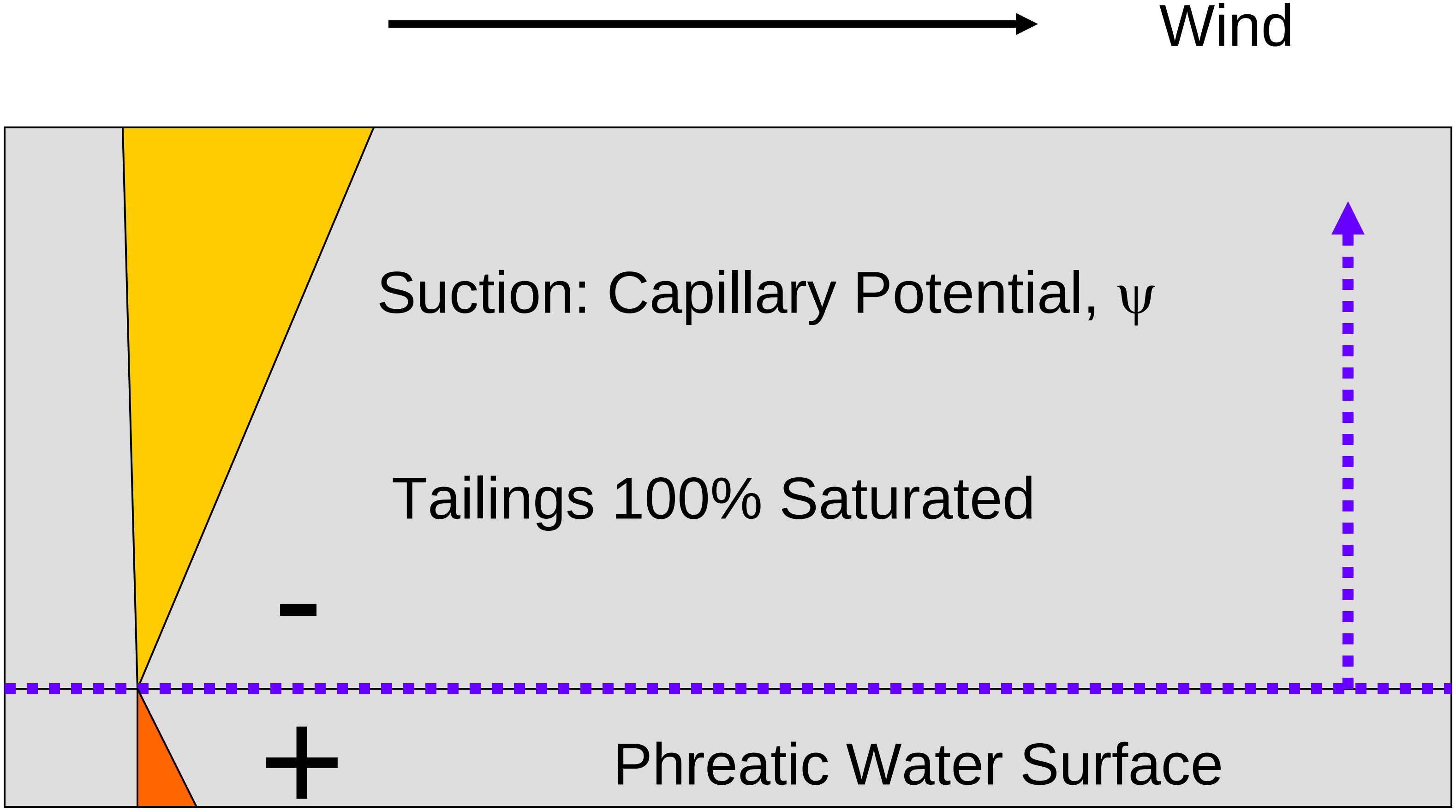
| Size | Rise |
|---|---|
| 1 um | 30 m |
| 10 um | 3 m |
| 100 um | 0.3 m |



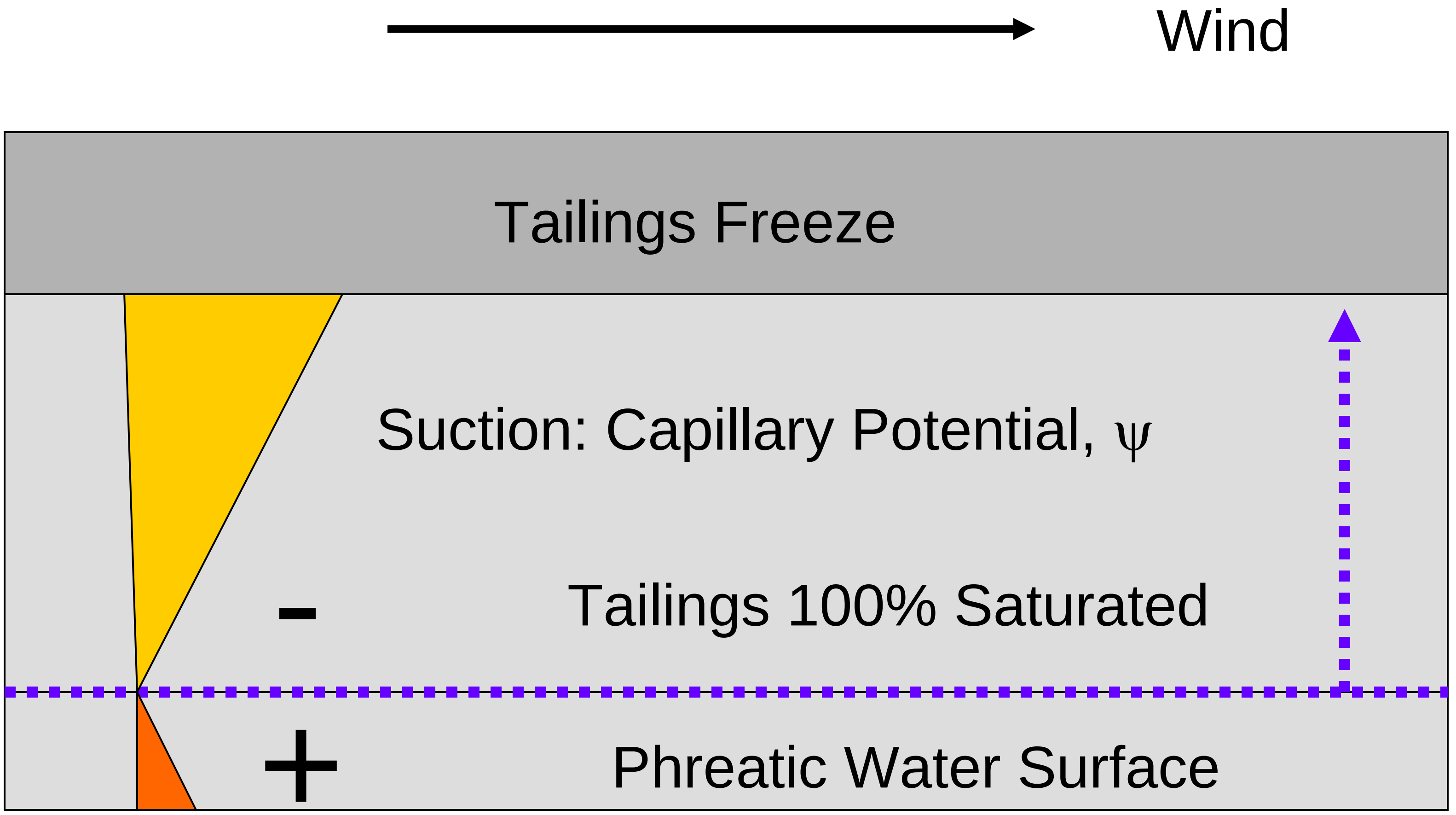
# Empire Basin: Saturated Zone



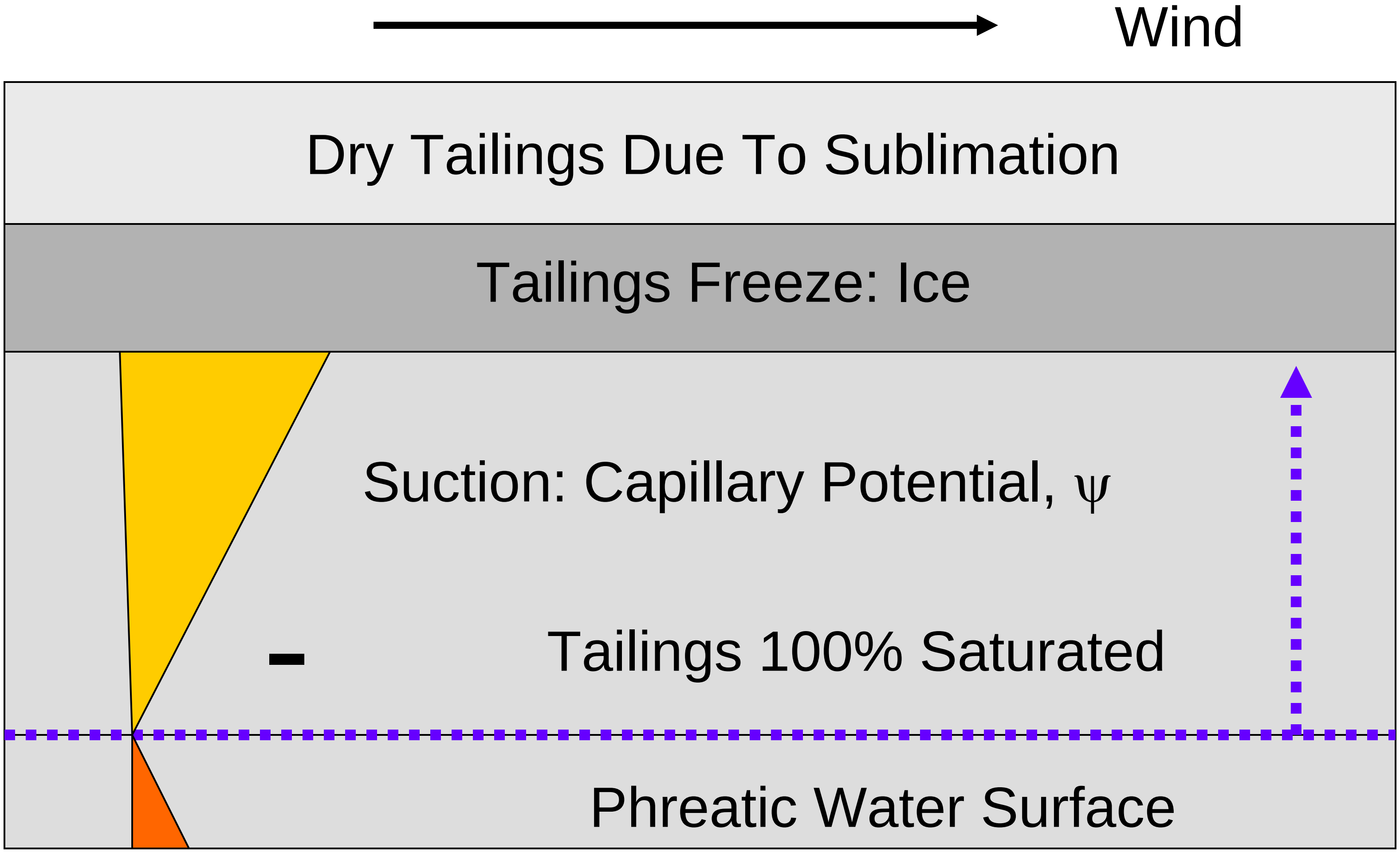
# *Freeze-Thaw Conditions*



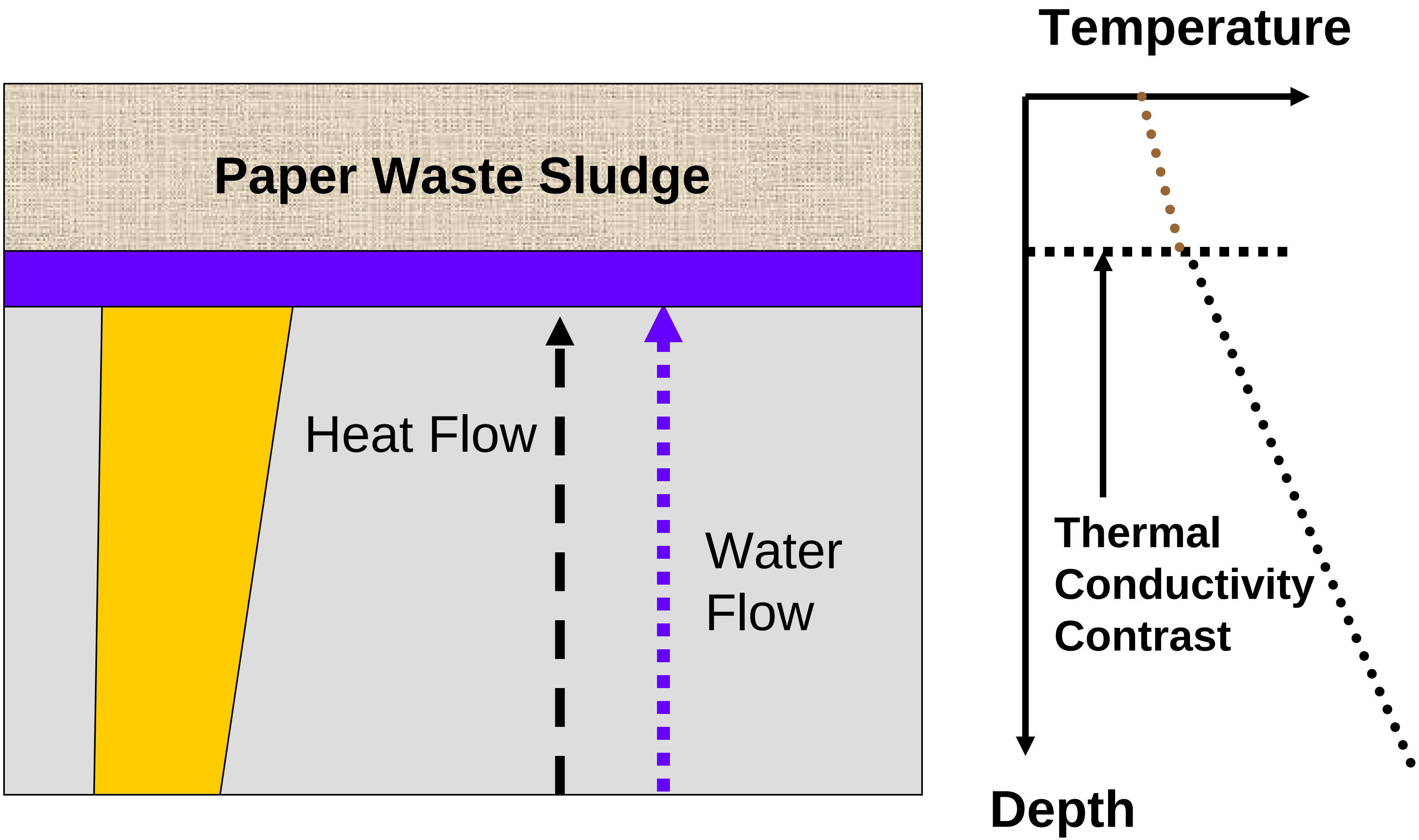
# *Freeze-Thaw Conditions*



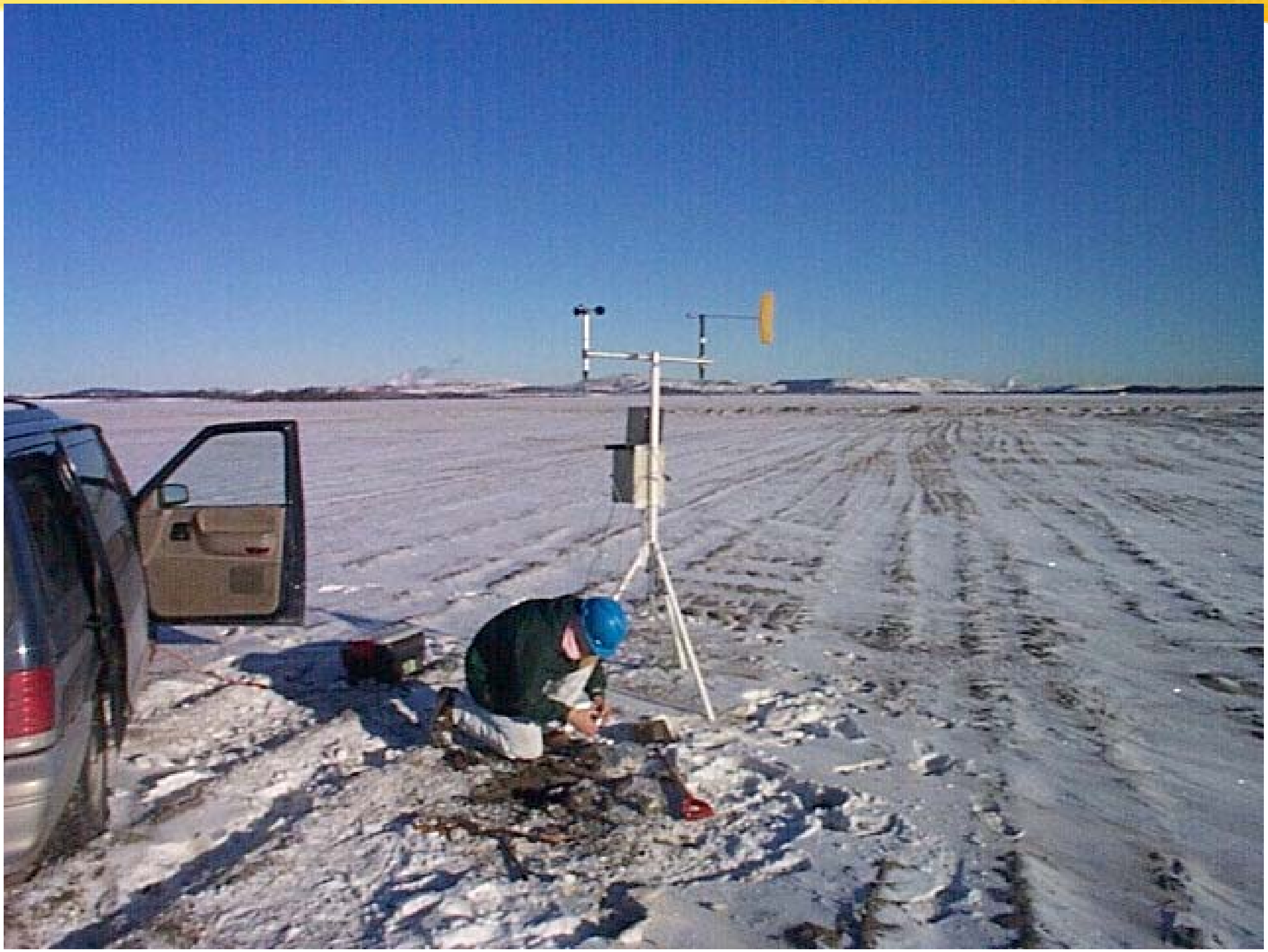
# *Freeze-Thaw Conditions*



# Freeze-Thaw Conditions



# Obtaining Frozen Samples



# MTU's Portable Wind Tunnel

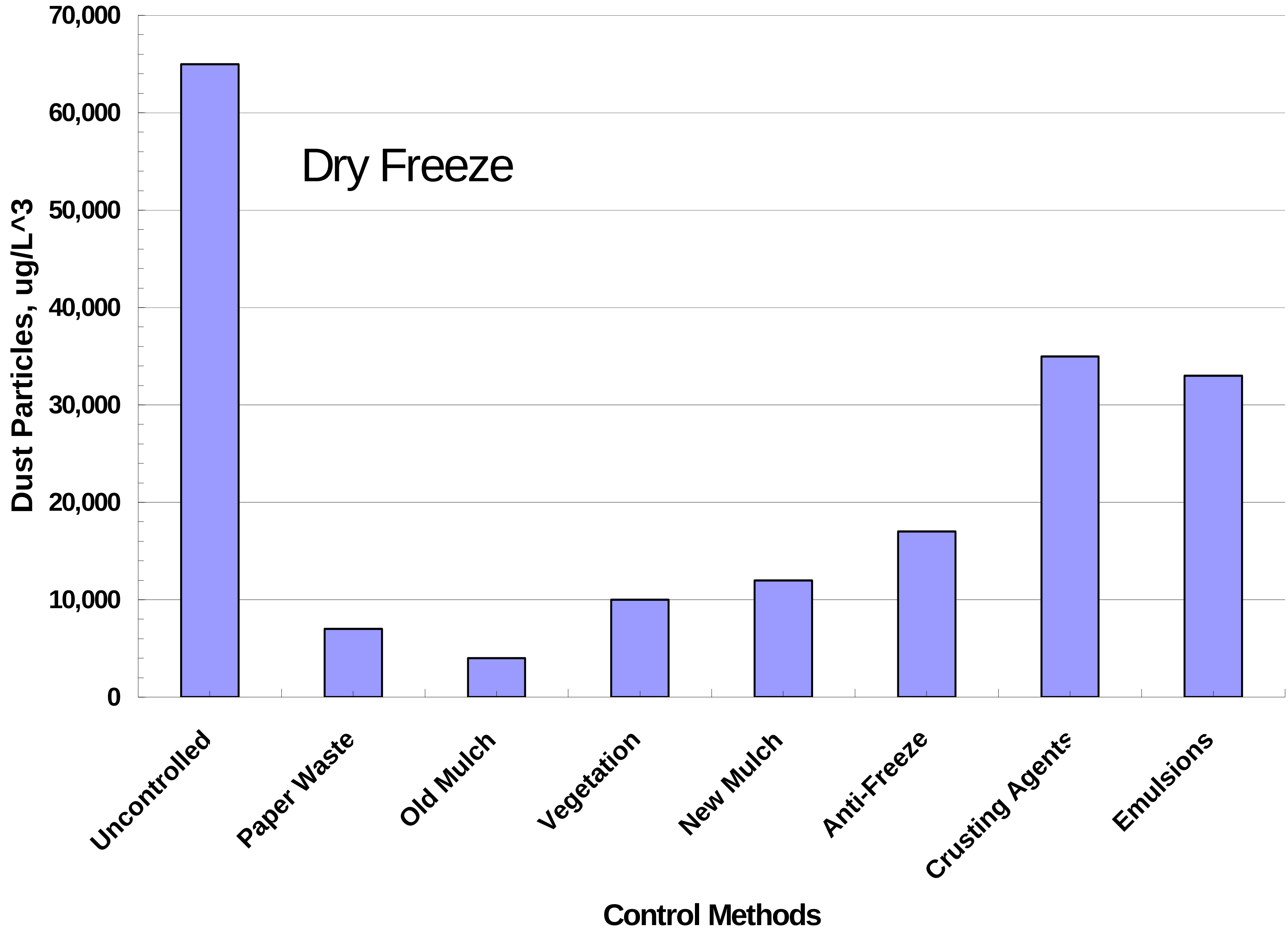
SHAFT

Super High Air Flow Tunnel

# Dust Generation Prior to SHAFT

# SHAFT Data

- Built by MTU's Facilities
- Power:  85 Hp Detroit Diesel
- Fan:  1.8 m Dia. Industrial Fan from Sound Fighter, Inc.
- Gear Reduction:  Eng : Fan = 2.62 :1
- Working Section:  1.2 x 1 x 7.6m
- Air Conditioning:  2 Sheets of Plastic Drinking Straws
- Wind Speeds:  3-16 m/sec (7-35 mph)
- Approximate Weight:  2,200 Kg (5000 lbs.)
- Mounted on 5.5 m Tandem Axle Trailer

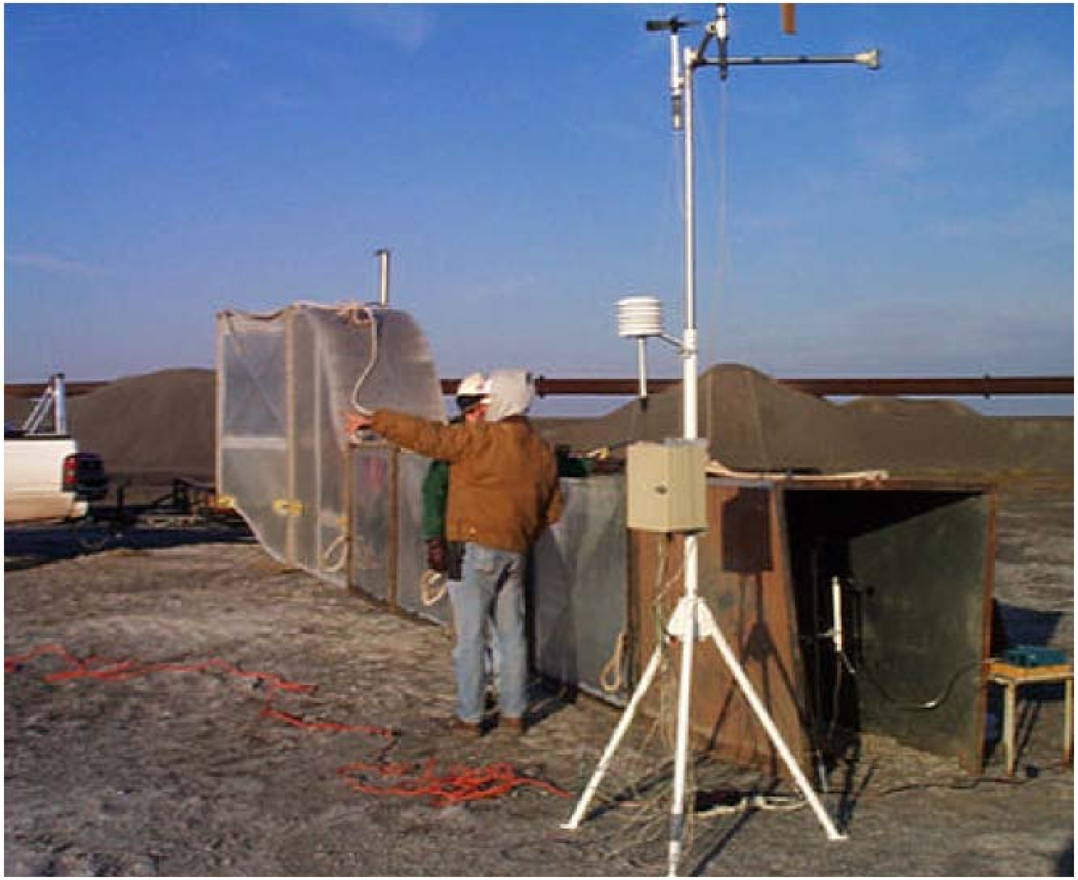


Dry Freeze
Dust Particles, ug/L^3
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
Uncontrolled
Paper Waste
Old Mulch
Vegetation
New Mulch
Anti-Freeze
Crusting Agents
Emulsions
Control Methods

# *Table 1 - Moisture and density measurements for paper sludge, tailing and old hay mulch*

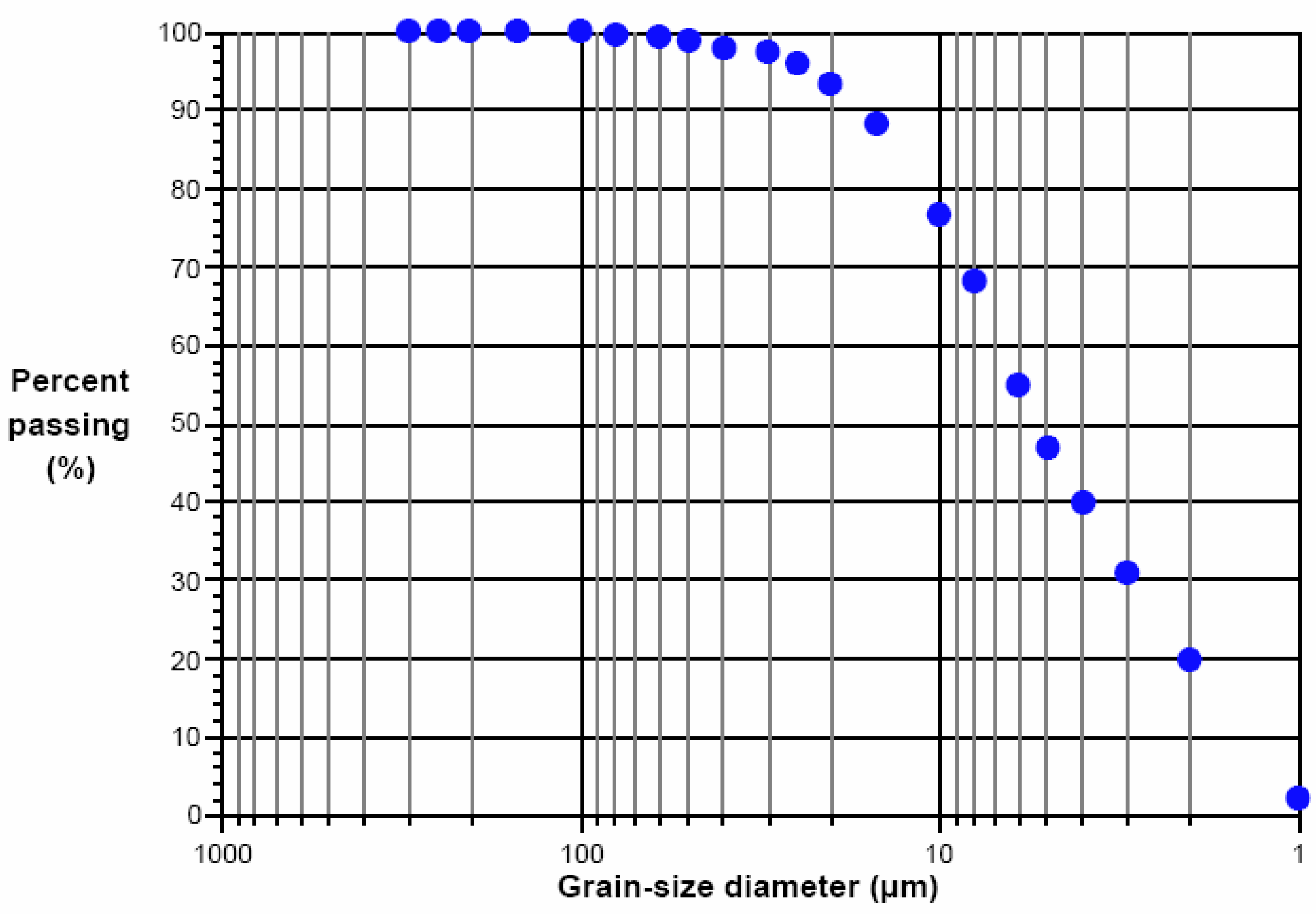
| Treatment Method | Average Moisture Percent | Particle Density ($g/cm^3$) |
|---|---|---|
| Light paper sludge application | 9.4% | 1.917 |
| Light paper sludge application with compaction | 5.4% | 1.930 |
| Heavy paper sludge application | 8.0% | 1.929 |
| Old hay mulch | 13.3% | - |
| Tailings | 10.2% | 3.093 |

*Mobile wind tunnel deployed on field plot with compacted light paper sludge application.*

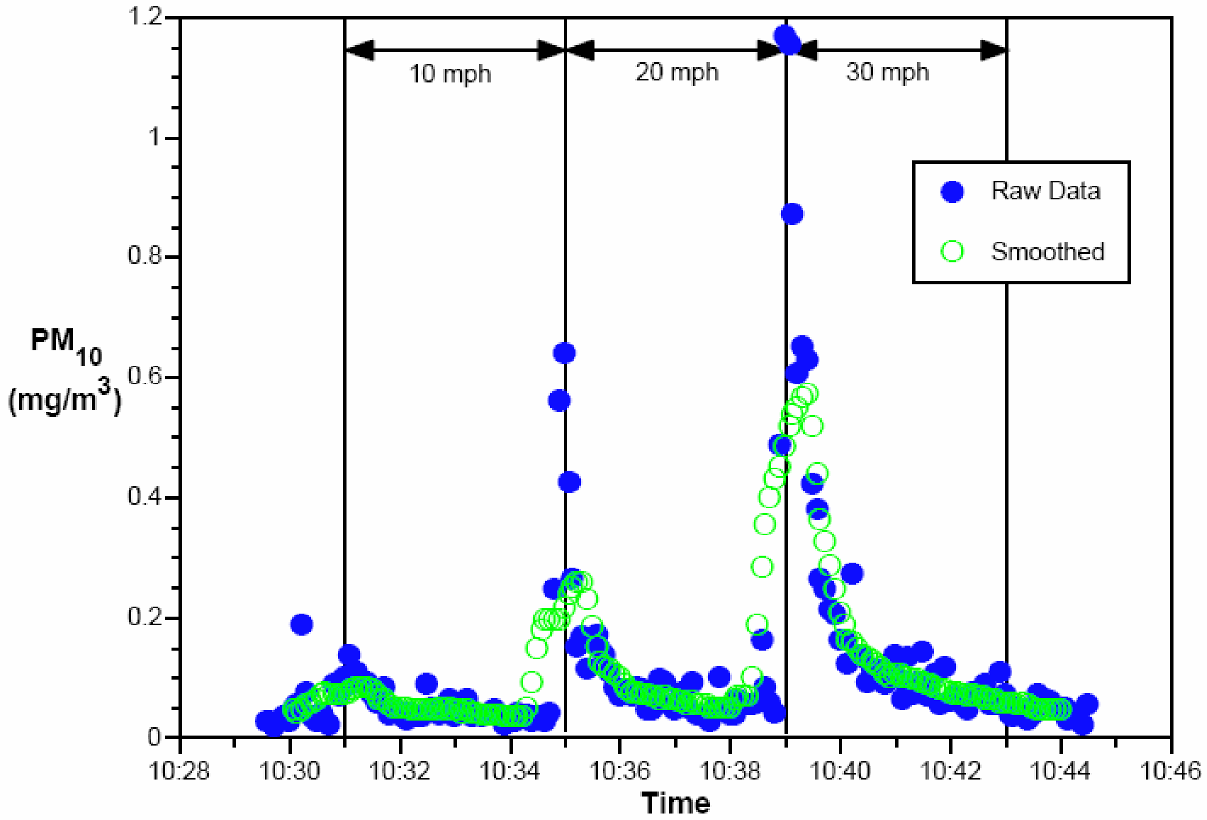


The sampling equipment is set up in the foreground end of the tunnel

# Average grain-size analysis of the tailings



# *Field test results of a plot with compacted light paper sludge application.*



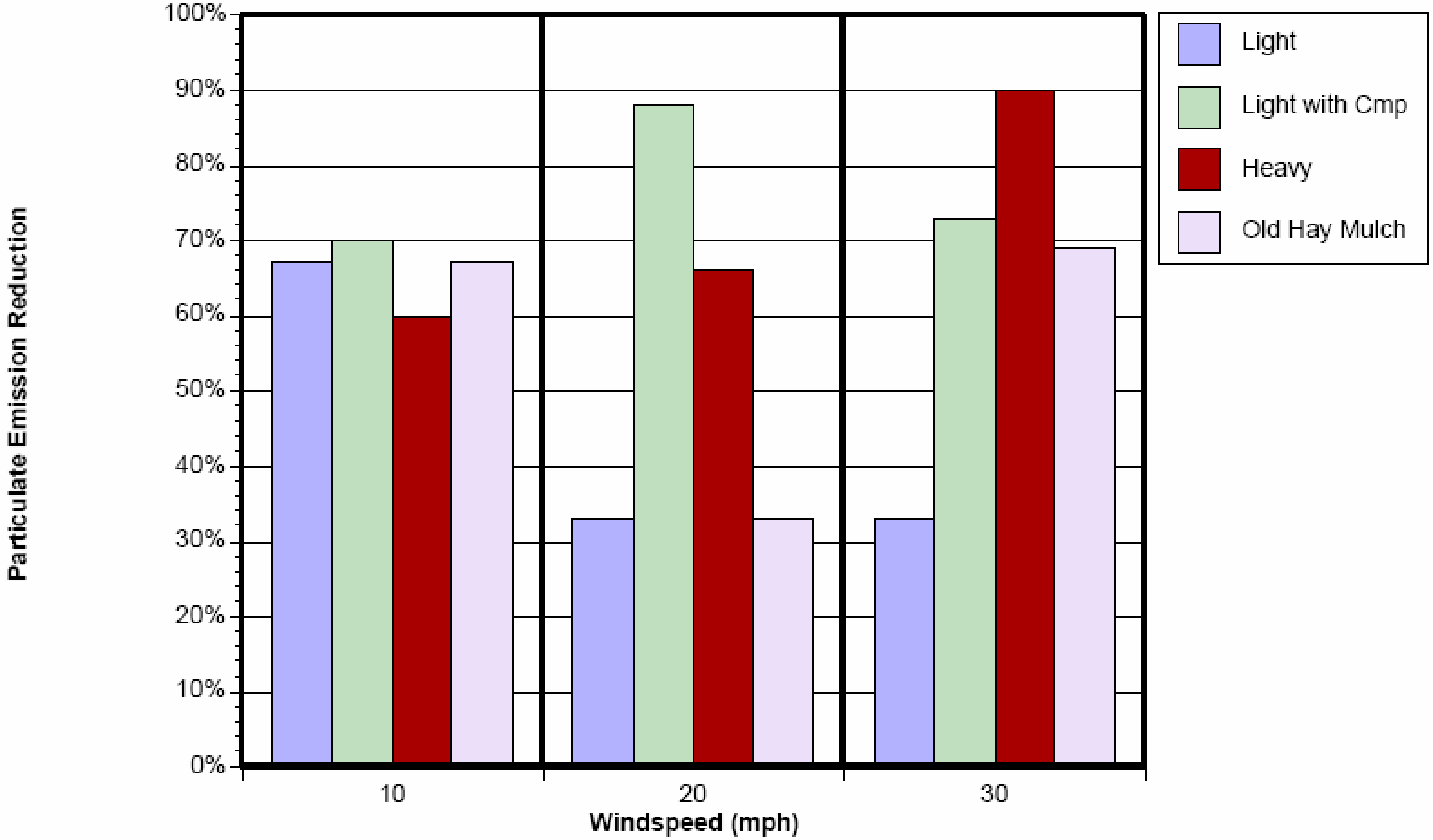

The five second (raw) PM10 data are shown by solid circles, the one-minute running average transformed (smoothed) data are shown by hollow circles

*Table 2 - Comparison of average mean and maximum PM10 concentrations produced at each wind speed during all treatment tests*

| Wind speed (mph) | Overall Average Mean $PM_{10}$ Concentration ($\mu g/m^3$) | Overall Average Maximum $PM_{10}$ Concentration ($\mu g/m^3$) |
|---|---|---|
| 10 | 9.9 | 171.8 |
| 20 | 121.4 | 524.7 |
| 30 | 158.8 | 971.3 |

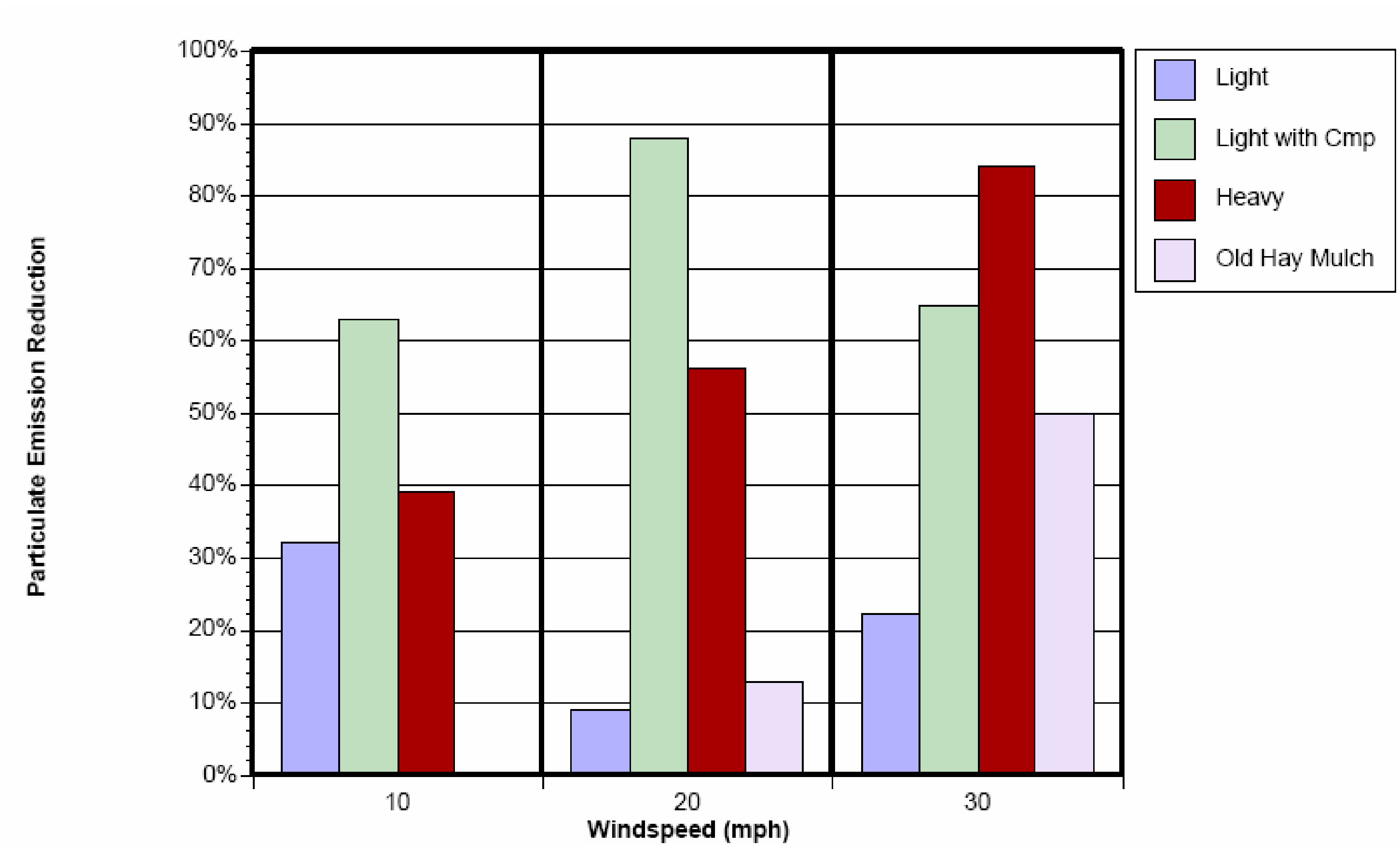
**Note: Background concentrations have been removed**

# *Average particulate emission reductions of four treatment methodologies*




**(1) Light paper sludge application, (2) light paper sludge application with compaction, (3) heavy paper sludge application, and (4) old hay mulch, at three wind speeds (10, 20, and 30 mph)**

# *Maximum particulate emission reductions of four treatment methodologies*




**(1) Light paper sludge application, (2) light paper sludge application with compaction, (3) heavy paper sludge application, and (4) old hay mulch, at three wind speeds (10, 20, and 30 mph)**

# *Table 3 - Average particulate emission reduction of four treatment methodologies for all wind speed conditions*

| Treatment Method | Mean Emission Reduction | Maximum Emission Reduction |
|---|---|---|
| Light paper sludge application | 44% | 21% |
| Light paper sludge application with compaction | 77% | 72% |
| Heavy paper sludge application | 72% | 60% |
| Old hay mulch | 56% | 21% |

**Reductions are based on average and maximum PM10 concentrations produced during testing. Reduction percentage is calculated using the uncontrolled (no treatment) field tests as the reference.**

## *Table 4 - Total particulate emission reduction of four treatment methodologies for all wind speed conditions*

| Treatment Method | Mean Emission Reduction | Maximum Emission Reduction |
|---|---|---|
| Light paper sludge application | 19% | 34% |
| Light paper sludge application with compaction | 72% | 79% |
| Heavy paper sludge application | 70% | 79% |
| Old hay mulch | 33% | 54% |

**Reductions are based on average and maximum PM10 concentrations produced during testing. Reduction percentage is calculated using the uncontrolled (no treatment) field tests as the reference and weighted by the relative concentrations provided in Table 2.**

# Residuals for Mine Tailings Area Dust Control

- Introduction
- Cold Weather Dusting
- Fugitive Dust Studies
- Conclusions

# Conclusions

- Dust regulations are becoming more stringent
- Dusting can be categorized into two situations: Dry weather and Cold Weather dusting
- Conventional dust control methods are difficult and costly to apply
- Paper waste sludge appears to be a very effective method of controlling cold weather dusting