# Managing Fugitive Dust On Roads and Airports

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# Road Map Part 1

- Understanding fugitive dust
- Impacts of Dust
- Methods to manage dust
- Road Preparation
- Selecting and Applying Palliatives
- Performance Testing

# Unpaved Roads in the US


- 1.3 million miles of unpaved road in US
- 97% located in rural areas
- Source of 10.5 million tons particulate matter <10μm (PM10)

# An Example of the Magnitude of the Problem

- Consider: -> 2-mile stretch of unpaved road,
- -> 20 vehicles/day,
- -> average speed= 30 mph.

- Result: 10,920 lbs of dust (PM10) per month

- (Roberts et al., 1975)

# Impact of Loss of Particulate Matter from Unpaved Roads

- Degradation of road surface
- Driver safety
- Health and Quality of life

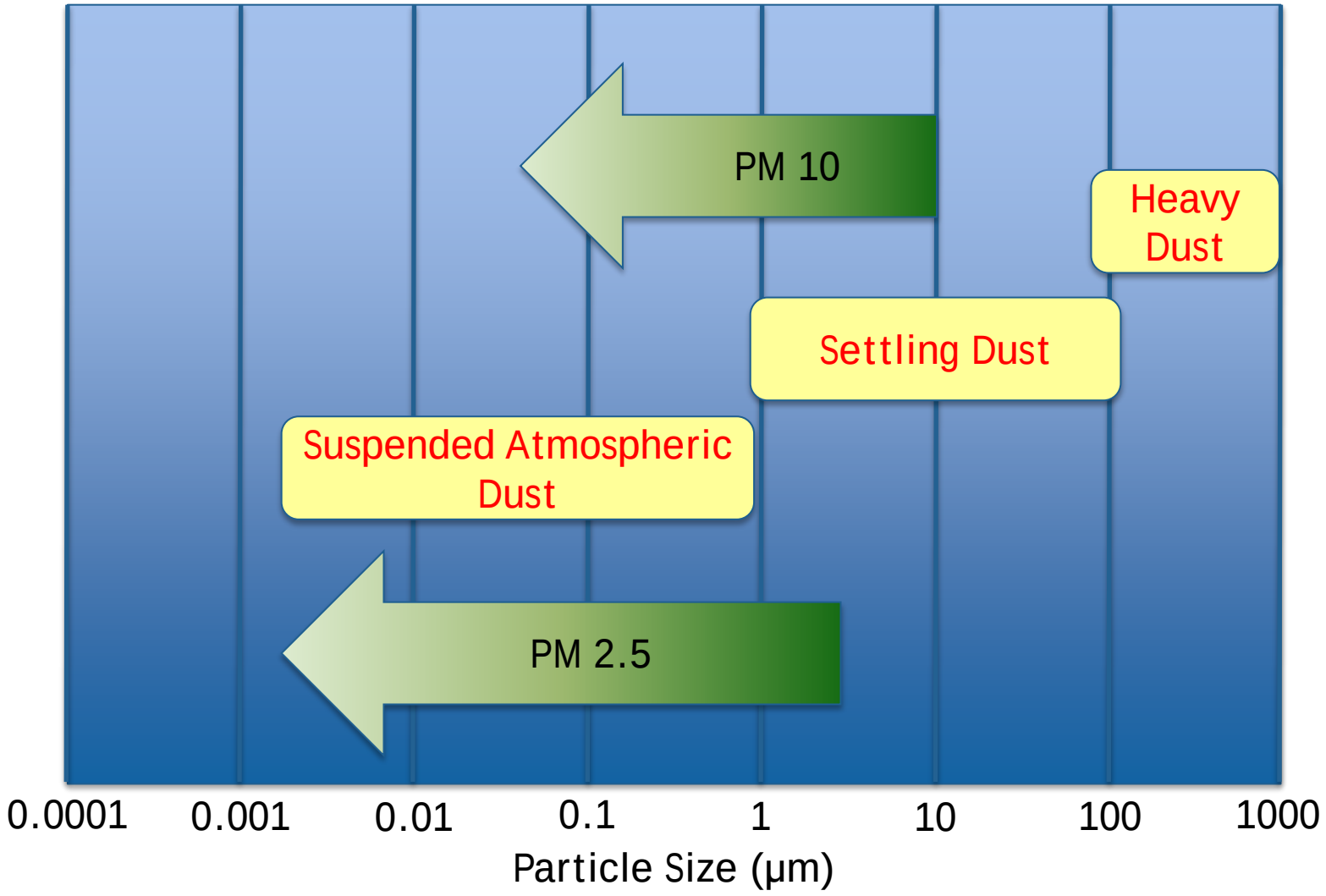
# Soil Vocabulary

- **Surface course:** the top layer of the road that is directly driven on
- **Aggregate:** a mixture of different sized crushed rock that makes up the road surface
- **Fines:** the smaller (fine) pieces of crushed rock material that is part of the aggregate and makes up the road surface
- **Plasticity:** a measure of the quality of the binding particles in a clay soil; higher clay content of soil generally indicates higher plasticity
- **Dust suppressant / dust palliative:** substances applied to the surface of a road to control and reduce the generation of dust
- **Chip seal/high float:** a road type made up of one or more layers of asphalt and aggregate

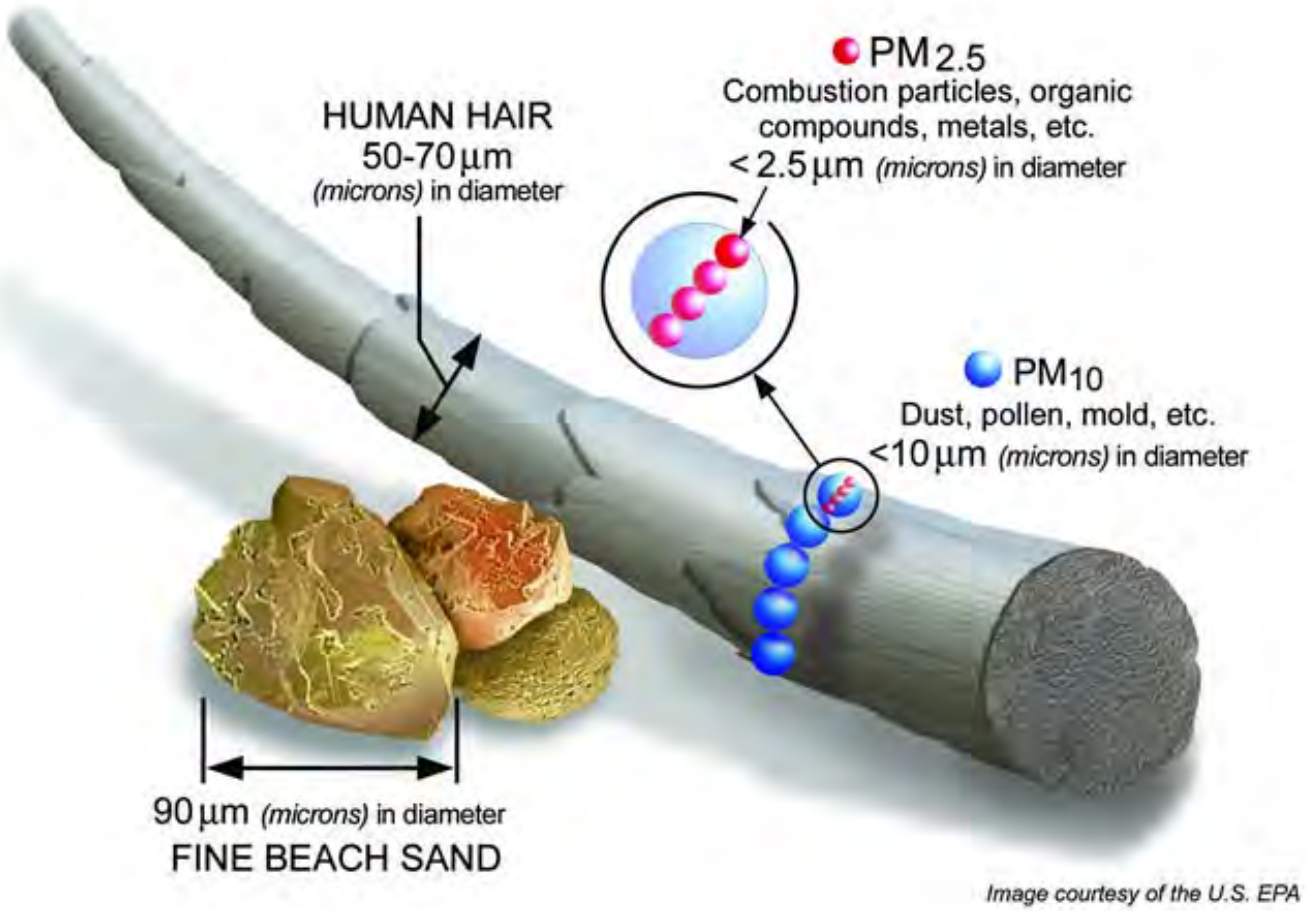
# Dust Definitions

- Loftable material: any material that can be placed in the air due to wind or vehicles. Usually <0.75mm
- Suspended material: Any material that stays in the air for an extended period of time. Usually <PM30
- Harmful to Health <PM10

# How Small are These Particles We Are Working With?



# Really Small!



# Health Issues

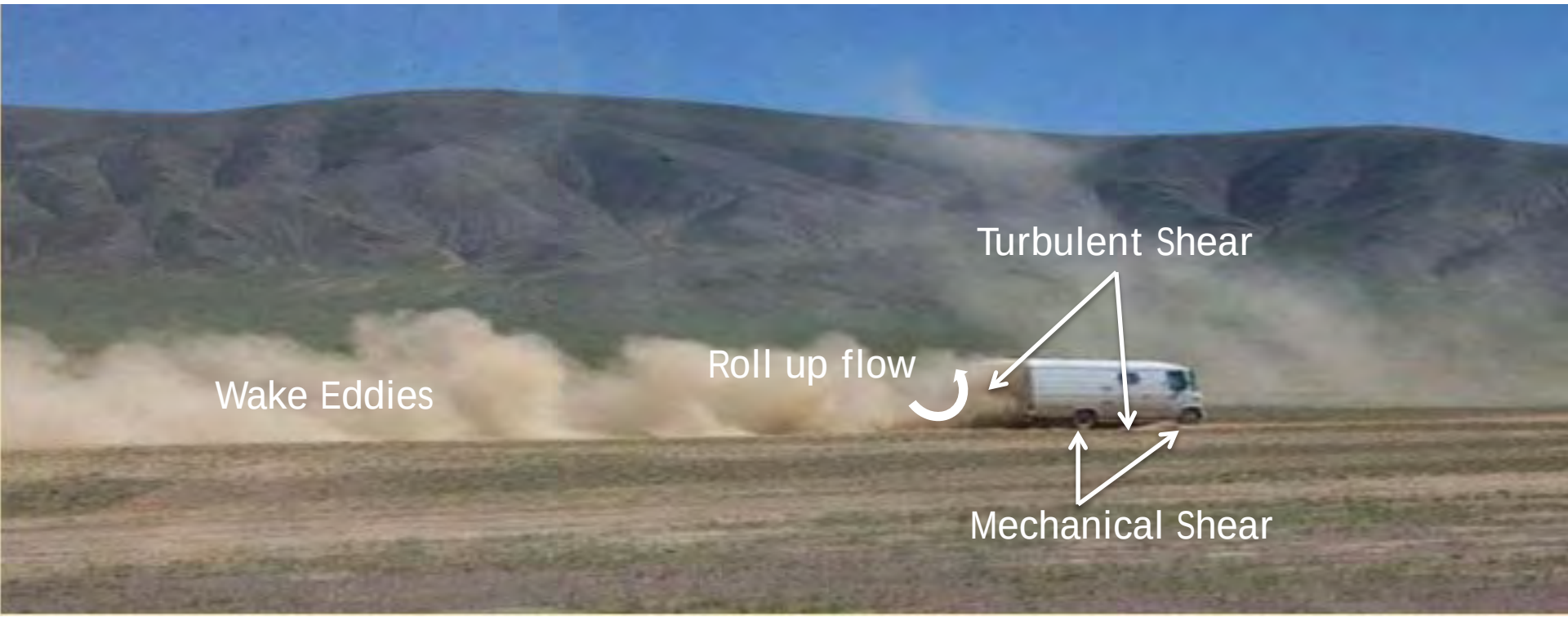
- Impacts children, elderly, and those with respiratory aliments the most
- Mortality rates increase 4.3% to 10% per 10 $\mu gm^{-3}$ PM10
- PM2.5 may penetrate into the alveoli of the lungs reducing transfer of oxygen
- 1 micron may enter the bloodstream

# Prioritize Areas for Dust Suppression

- Roads that are used the most
- Roads near places where people congregate (school, community hall, store, clinic, etc.)
- Roads outside of homes where individuals with respiratory issues live (young, elderly)
- Roads close to environmentally sensitive areas
- Roads near subsistence and food preparation areas

# What Causes This?

# We Need a Mechanical Means of Lofting Particles into The Air



# Moving Dust


Advective Transport
Turbulent Diffusion
Settling
Mechanical and Convective Lofting
STOP

# Settling time from a 2m loft

~3 sec

0.1 mm

~11 sec

0.05 mm

~4 minutes

0.01 mm
PM10

~1 hour

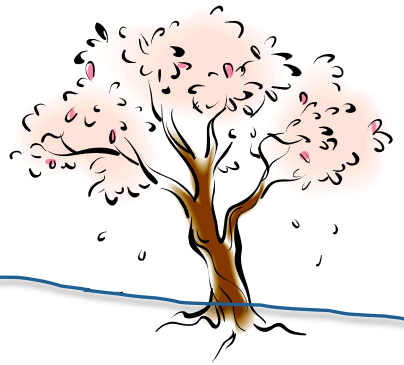


0.0025 mm
PM2.5

5.9 hours



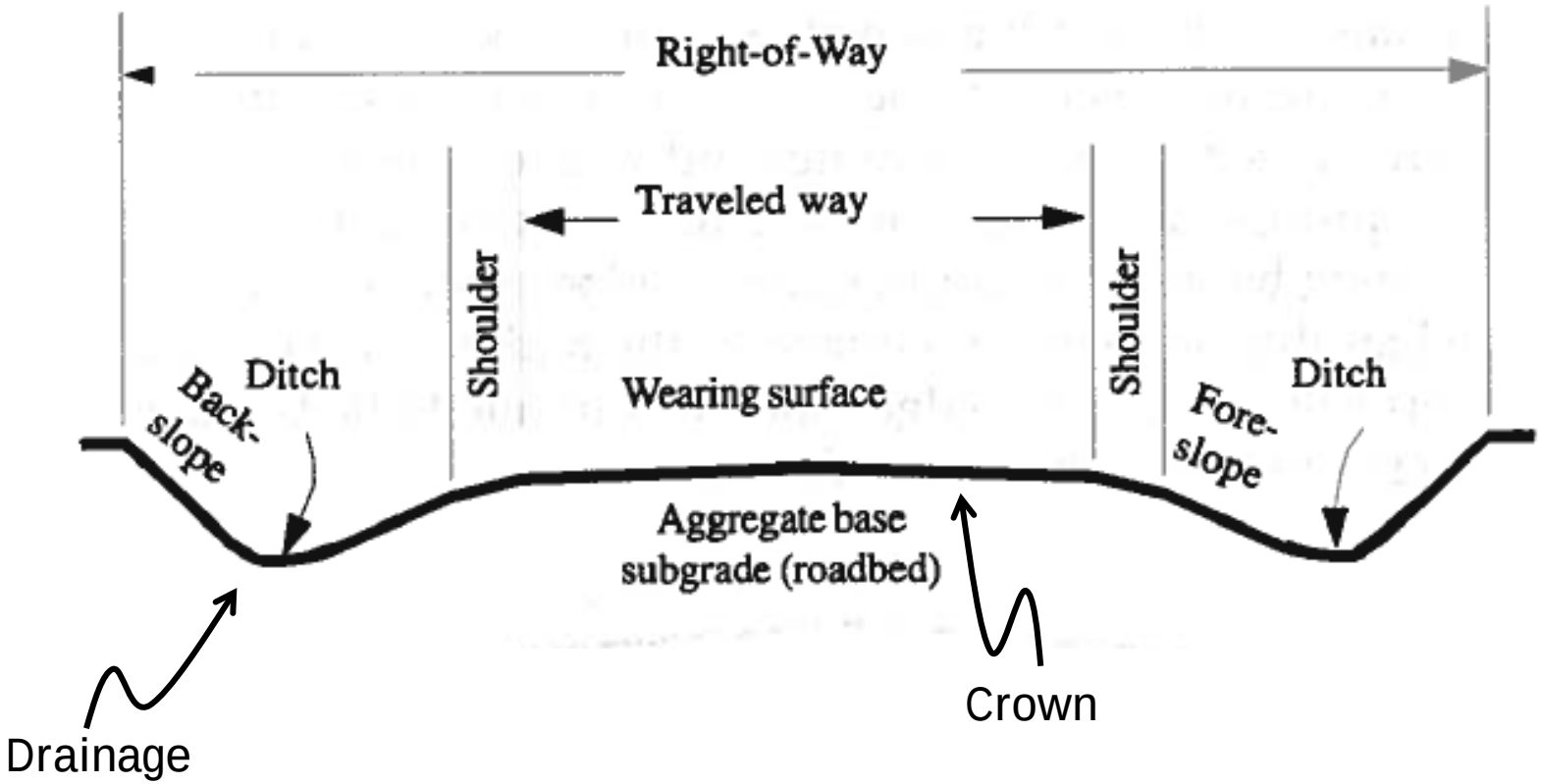
0.001 mm



# Methods to Manage Dust


Good Dust Management
Starts with a Good Road

# Control Dust through Proper Design and Construction



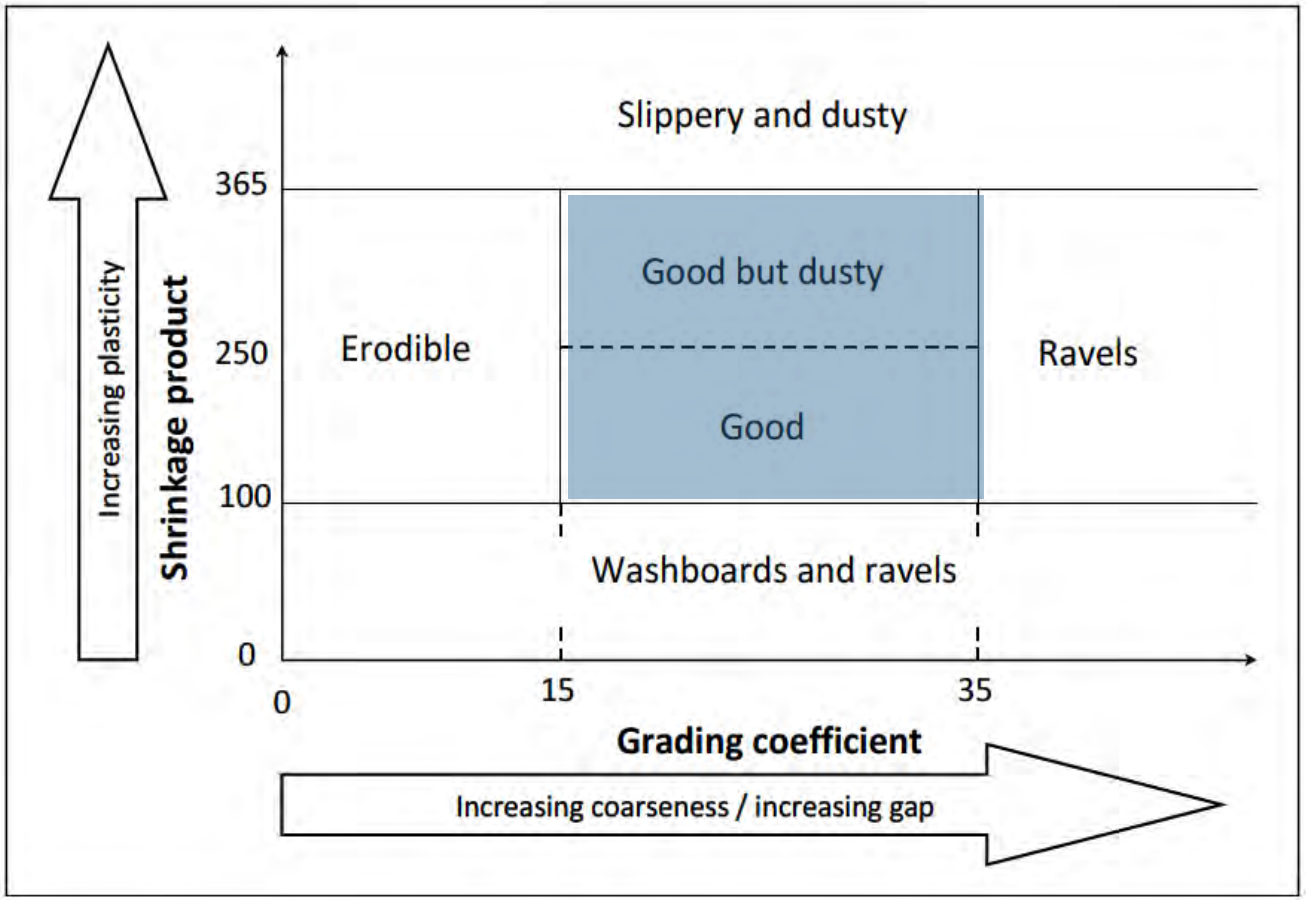

FHWA, 1998

# Suggested Dust Management Approaches

| Based on Rainfall | Suggested Dust Management Level | | Based on Road Usage |
|---|---|---|---|
| 12-20 dusty days (May-Sept) | **Level 1:** Institutional Controls (i.e. changes to driving behavior) | | < 25 vehicles/day |
| 21-30 dusty days (May-Sept) | **Level 2:** Institutional Controls + Road Watering | | 25-75 vehicles/day |
| 31-50 dusty days (May-Sept) | **Level 3:** Institutional Controls + Chemical Stabilization (i.e. palliatives) | | 75-500 vehicles/day |
| 51-61 dusty days (May-Sept) | **Level 4:** Aggregate Stabilization | (ex. chip seals) | 500-1,500 vehicles/day |
| | | (ex. pavement) | > 1,500 vehicles/day |

# Proper Fines is Critical

Proper fines content (passing the #200 sieve) is between 8 and 15% for untreated roads.

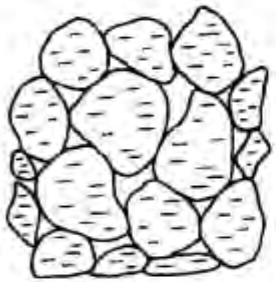
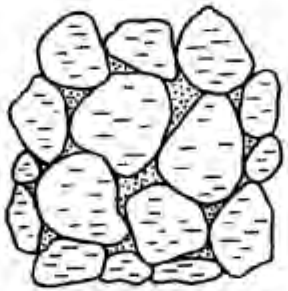
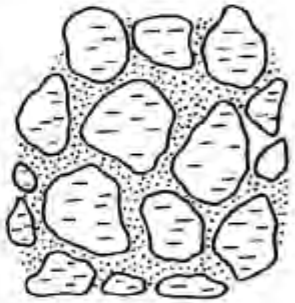



# Using the Right Building Material is Critical

**Too Many Fines Causes Muddy Roads**

# Float


Too Few Fines
Float
Washboard
Loose Fines

|  |  |  |
|---|---|---|
| ***Aggregate With No Fines*** | **Aggregate With Sufficient Fines For Maximum Density** | **Aggregate With Great Amount Of Fines** |
| **Grain-to-grain contact** | **Grain-to-grain contact with increased resistance against deformation** | **Grain-to-grain contact destroyed, aggregate "floating" In soil** |
| **Variable density** | **Increased to maximum density** | **Decreased density** |
| **Pervious** | **Low permeability** | **Low permeability** |
| **Non-frost susceptible** | **Frost susceptible** | **Frost susceptible** |
| **High stability if confined, low if unconfined** | **Relatively high stability In confined or unconfined conditions** | **Low stabllity and low strength** |
| **Not affected by adverse water conditions** | **Not greatly affected by adverse water conditions** | **Greatly affected by adverse water conditions** |
| **Difficult to compact** | **Moderately difficult to compact** | **Not difficult to compact** |
| **Ravels easily** | **Good road performance** | **Dusts easily** |

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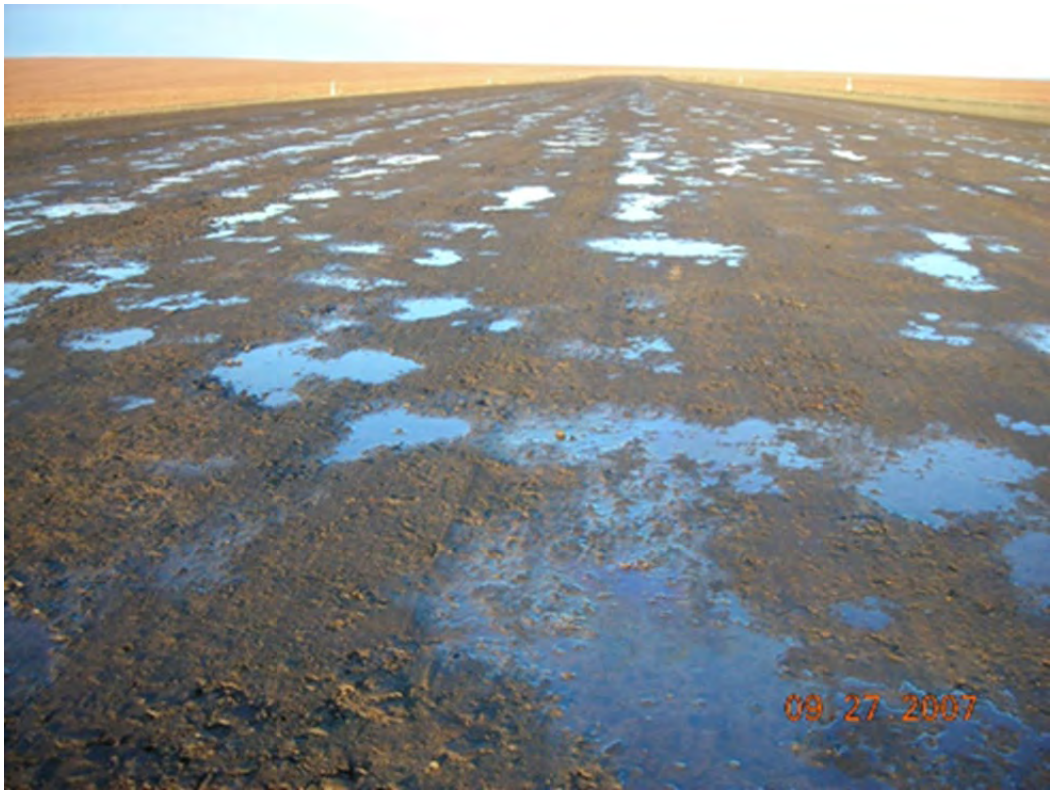
# Proper Crown is Critical

- Should be between 4% and 5%

# A Good Crown is Critical

- Too Flat Causes ponding



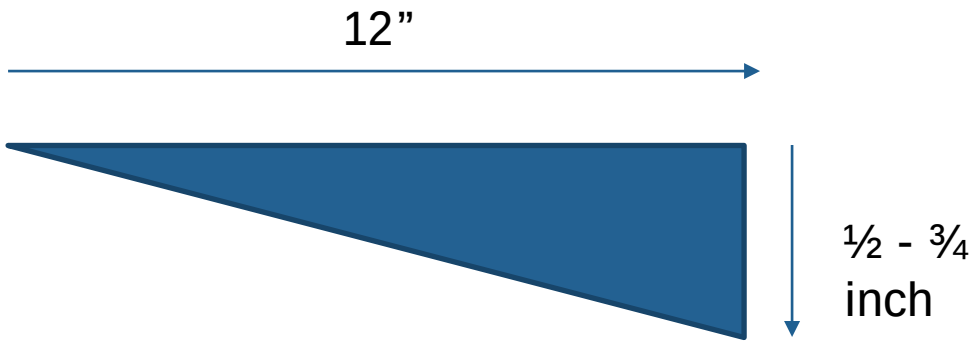
# A Good Crown is Critical

- Too Steep Causes Erosion

Courtesy of Dave Jones

# Commercial Slope Meter

# Measuring Crown

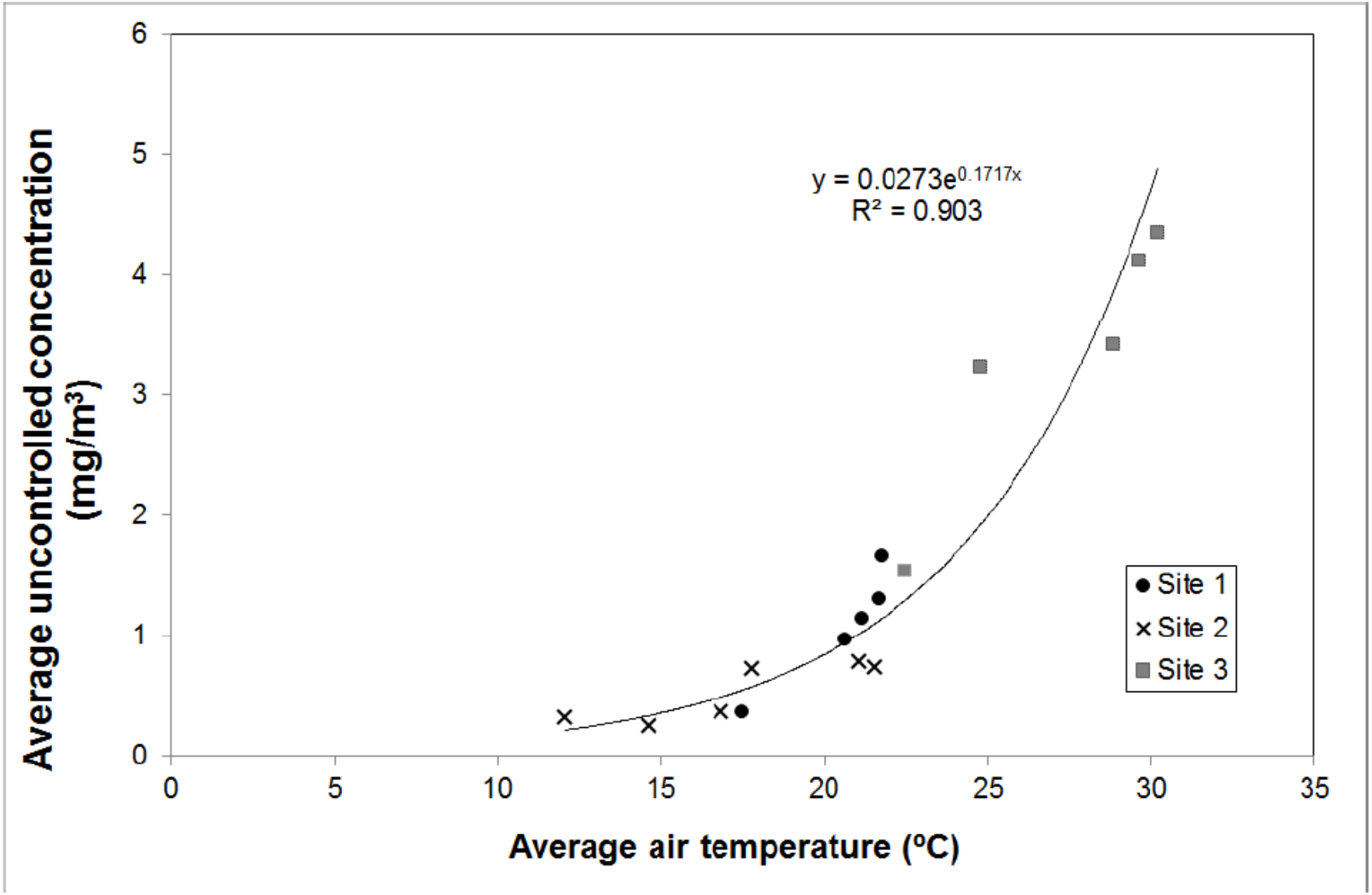



Material feathered to eliminate water ponding
Gap under blade indicates crown
Blade rolled forward to feather material
CATERPILLAR

# Limiting Fugitive Dust by Limiting Speed

15 MPH

30 MPH

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# Types of Dust Suppressants

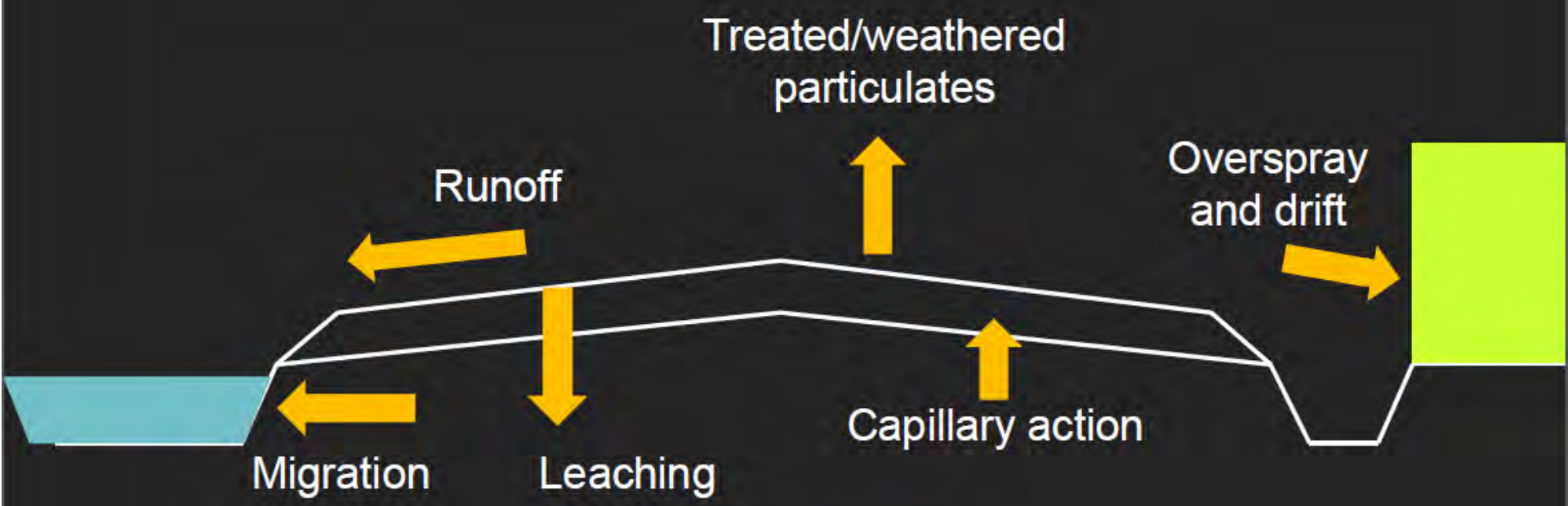
> 250 on the market!

- **Water**
- **Water-attracting salts:** *calcium chloride, magnesium chloride, sodium chloride*
- **Organic non-bituminous binders:** *lignosulfonates, tall oil, pine tar*
- **Synthetic oils:** *proprietary formulations*
- **Electrical-chemical stabilizers:** *enzymes, sulfonated oils, ionic*
- **Bitumen asphalt and tar:** *cutback asphalts, emulsified asphalts*
- **Synthetic polymer emulsions:** *polyvinyl acetate, vinyl acrylic*

# General Considerations for Dust Suppressants

- **Plan, assess, prioritize, budget**
- Start with a good base road
- Consider track on / track off
- Chemical Palliatives
  - Requires periodic reapplication
  - Consider recompacting every few weeks
  - Wear and abrasion is minimized with good driving habits
- Pavements
  - Requires annual maintenance
  - Encourages increased use for skateboards, bicycles, and those in wheelchairs (Alaska villages)

# Environmental endpoints—ecological pathways



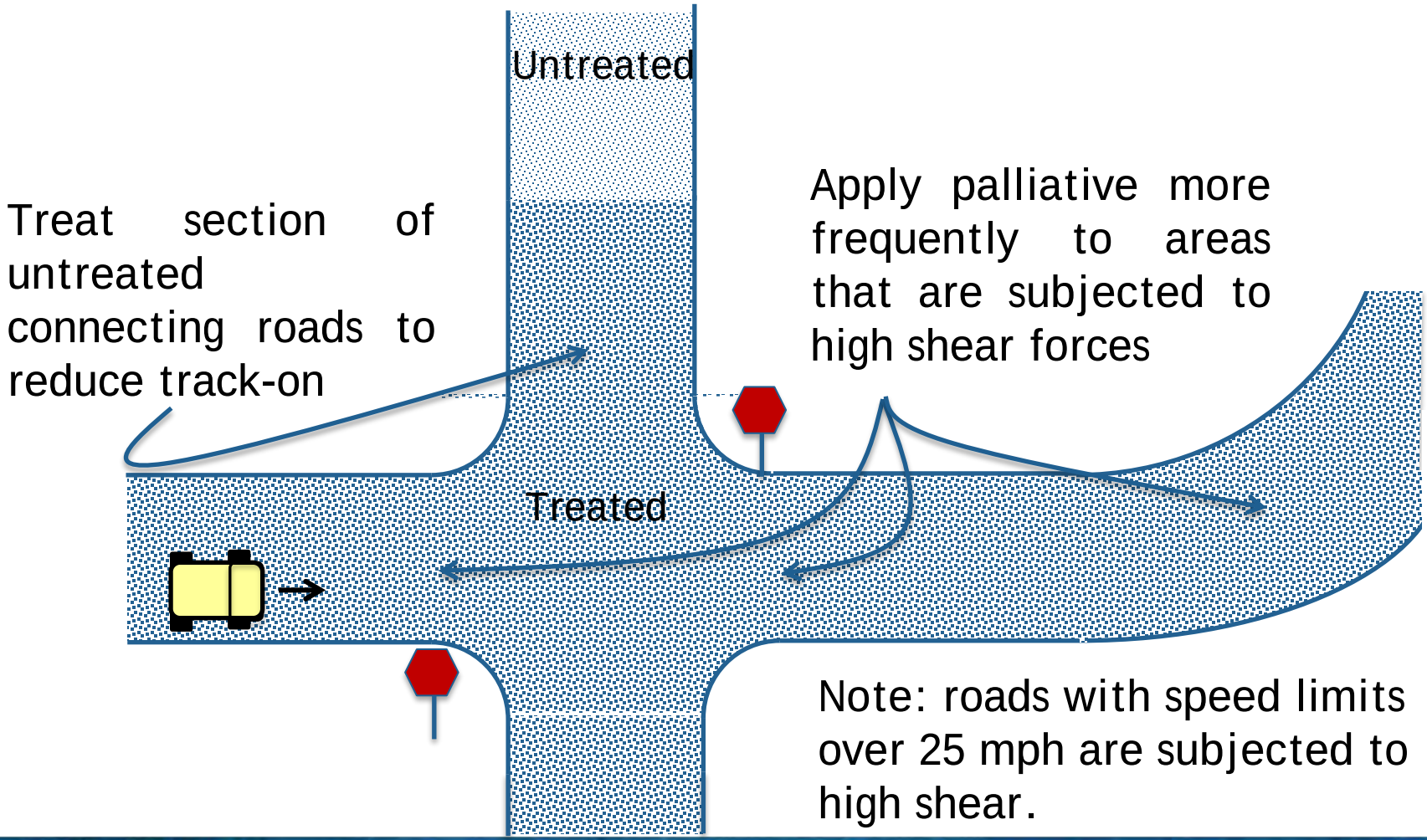

**Possible receptors**

**Birds**
**Mammals**
**Herptiles**
**Invertebrates**
**Plants**
**Fish**

USGS science for a changing world

Modified from SD LTAP 2000 and Steevens et al. 2007

# Synthetic Fluid Considerations
# Product Application and Maintenance



# 1999 US Forest Service Guide

| Dust Palliative | Traffic Volumes, Average Daily Traffic | | | Surface Material | | | | | | | | Climate During Traffic | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Plasticity Index | | | Fines (Passing 75μm, No. 200, Sieve) | | | | | | | |
| | Light <100 | Medium 100 to 250 | Heavy >250 (1) | <3 | 3–8 | >8 | <5 | 5–10 | 10–20 | 20–30 | >30 | Wet &/or Rainy | Damp to Dry | Dry (2) |
| Calcium Chloride | ✓✓ | ✓✓ | ✓ | ✗ | ✓ | ✓✓ | ✗ | ✓ | ✓✓ | ✓ | ✗ (3) | ✗ (3,4) | ✓✓ | ✗ |
| Magnesium Chloride | ✓✓ | ✓✓ | ✓ | ✗ | ✓ | ✓✓ | ✗ | ✓ | ✓✓ | ✓ | ✗ (3) | ✗ (3,4) | ✓✓ | ✓ |
| Petroleum | ✓ | ✓ | ✓ | ✓✓ | ✓ | ✗ | ✓ (5) | ✓ | ✓ (6) | ✗ | ✗ | ✓ (3) | ✓✓ | ✓ |
| Lignin | ✓✓ | ✓✓ | ✓ | ✗ | ✓ | ✓✓ (6) | ✗ | ✓ | ✓✓ | ✓✓ | ✓ (3,6) | ✗ (4) | ✓✓ | ✓✓ |
| Tall Oil | ✓✓ | ✓ | ✗ | ✓✓ | ✓ | ✗ | ✗ | ✓ | ✓✓ (6) | ✓ (6) | ✗ | ✓ | ✓✓ | ✓✓ |
| Vegetable Oils | ✓ | ✗ | ✗ | ✓ | ✓ | ✓ | ✗ | ✓ | ✓ | ✗ | ✗ | ✗ | ✓ | ✓ |
| Electro-chemical | ✓✓ | ✓ | ✓ | ✗ | ✓ | ✓✓ | ✗ | ✓ | ✓✓ | ✓✓ | ✓✓ | ✓ (3,4) | ✓ | ✓ |
| Synthetic Polymers | ✓✓ | ✓ | ✗ | ✓✓ | ✓ | ✗ | ✗ | ✓✓ | ✓✓ (6) | ✗ | ✗ | ✓ | ✓✓ | ✓✓ |
| Clay Additives (6) | ✓✓ | ✓ | ✗ | ✓✓ | ✓✓ | ✓ | ✓✓ | ✓ | ✓ | ✗ | ✗ | ✗ (3) | ✓ | ✓✓ |

# Additive Selection Table

Jones 2013

| Additive Category/ Sub-Category | Traffic: Average Daily Traffic <100 | Traffic: Average Daily Traffic 100-250[1] | Traffic: Average Daily Traffic >250[1] | Climate: Humidity/Storm Intensity Dry[2] | Climate: Humidity/Storm Intensity Damp | Climate: Humidity/Storm Intensity Wet[3,4,5] | Wearing Course Material: Plasticity Index <3[6] | Plasticity Index 3-5[6] | Plasticity Index 6-15 | Plasticity Index >15[6,7] | Fines (% Passing #200 [75 µm] Sieve) <5[1] | Fines 5-10[1] | Fines 11-20 | Fines 21-30[7,8] | Fines >30[6,7,8] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Water and Water plus Surfactant** | | | | | | | | | | | | | | | |
| Water | Not cost effective as a long-term fines preservation strategy | | | | | | | | | | | | | | |
| Water + surfactant | Not cost effective as a long-term fines preservation strategy | | | | | | | | | | | | | | |
| **Water absorbing** | | | | | | | | | | | | | | | |
| Calcium chloride | 1 | 1 | 7 | 50[9] | 1 | 50 | 7 | 1 | 1 | 50 | 50 | 7 | 1 | 7 | 50 |
| Magnesium chloride | 1 | 1 | 7 | 7[9] | 1 | 50 | 7 | 1 | 1 | 50 | 50 | 7 | 1 | 7 | 50 |
| Sodium chloride brine | 1 | 7 | 50 | 50[9] | 7 | 50 | 50 | 1 | 1 | 50 | 50 | 7 | 1 | 7 | 50 |
| **Organic Non-Petroleum** | | | | | | | | | | | | | | | |
| Glycerin based | 1 | 1 | 50 | 1 | 1 | 50 | 7 | 1 | 1 | 50 | 50 | 7 | 1 | 7 | 50 |
| Lignosulfonate | 1 | 1 | 7 | 1 | 1 | 50 | 7 | 1 | 1 | 50 | 50 | 7 | 1 | 1 | 7 |
| Molasses/sugar | 1 | 50 | 50 | 1 | 1 | 50 | 50 | 1 | 1 | 50 | 50 | 50 | 1 | 7 | 50 |
| Plant oil | 1 | 7 | 50 | 1 | 1 | 50 | 50 | 1 | 1 | 50 | 50 | 7 | 1 | 1 | 50 |
| Tall oil pitch resin | 1 | 7 | 50 | 1 | 1 | 7 | 7 | 1 | 1 | 50 | 50 | 7 | 1 | 1 | 50 |
| **Organic Petroleum** | | | | | | | | | | | | | | | |
| Asphalt emulsion | 1 | 7 | 50 | 1 | 1 | 1 | 7 | 1 | 7[4] | 50 | 7 | 1 | 1 | 50 | 50 |
| Base oil | 1 | 1 | 7 | 1 | 1 | 7 | 7 | 1 | 1 | 50 | 50 | 7 | 1 | 1 | 7 |
| Petroleum resin | 1 | 1 | 50 | 1 | 1 | 7 | 7 | 1 | 1 | 50 | 7 | 7 | 1 | 7 | 50 |
| Synthetic fluid | 1 | 1 | 7 | 1 | 1 | 7 | 7 | 1 | 1 | 50 | 50 | 7 | 1 | 1 | 7 |
| Synthetic fluid + binder | 1 | 1 | 7 | 1 | 1 | 7 | 7 | 1 | 1 | 50 | 7 | 1 | 1 | 1 | 7 |
| **Synthetic Polymer Emulsion** | | | | | | | | | | | | | | | |
| Synthetic polymer[7] | 1 | 1 | 50 | 1 | 1 | 7 | 7 | 1 | 1 | 50 | 50 | 1 | 1 | 7 | 50 |
| **Conc. Liquid Stabilizer** | | | | | | | | | | | | | | | |
| Conc. Liquid Stabilizer | 7 | 50 | 50 | 7 | 7 | 7 | 50 | 50 | 50 | 7 | 50 | 50 | 7 | 7 | 7 |
| **Clay Additive** | | | | | | | | | | | | | | | |
| Bentonite | 1 | 1 | 7 | 1 | 1 | 7 | 1 | 7 | 50 | 50 | 1 | 1 | 7 | 50 | 50 |

| Additive Category/ Sub-Category | % trucks >10[1] | Geometry: Steep Grades[4,5] | Geometry: Sharp Curves[1,5] | Rel. Life Cycle Cost |
|---|---|---|---|---|
| Water | Not cost effective as a long-term fines preservation strategy | | | |
| Water + surfactant | Not cost effective as a long-term fines preservation strategy | | | |
| Calcium chloride | 1 | 7 | 7 | 1 |
| Magnesium chloride | 1 | 7 | 7 | 1 |
| Sodium chloride brine | 1 | 7 | 7 | 2 |
| Glycerin based | 1 | 7 | 7 | 1 |
| Lignosulfonate | 1 | 7 | 7 | 1 |
| Molasses/sugar | 7 | 7 | 7 | 3[10] |
| Plant oil | 7 | 7 | 7 | 1 |
| Tall oil pitch resin | 1 | 7 | 7 | 2[13] |
| Asphalt emulsion | 7 | 1 | 7 | 2[13] |
| Base oil | 1 | 1 | 1 | 1 |
| Petroleum resin | 1 | 1 | 7 | 2[13] |
| Synthetic fluid | 1 | 1 | 1 | 2[13] |
| Synthetic fluid + binder | 1 | 1 | 1 | 2[13] |
| Synthetic polymer | 7 | 7 | 7 | 2[13] |
| Conc. Liquid Stabilizer | 1 | 1 | 1 | 1 |
| Bentonite | 7 | 7 | 1 | 1 |

| Key to Colors and Explanation Notes in Selection Charts | |
|---|---|
| 1 | No significant influence on performance |
| 7 | Some influence on performance |
| 50 | Significant influence on performance |
| 1 | Cars and trucks at higher speeds may break surface crust and accelerate washboarding and raveling, if so more frequent rejuvenation will be required |
| 2 | More than 20 days with less than 40% relative humidity |
| 3 | High intensity storms |
| 4 | Likely to leach out and/or down into lower layers during storm events |
| 5 | Soaked California Bearing Ratio (CBR) and abrasion resistance must be checked / increased with increasing number of trucks to ensure all-weather passability |
| 6 | Materials have little or no effective binder content and are prone to washboarding and raveling. Treatments may leach down into road structure |
| 7 | May become slippery when wet |
| 8 | High fines content may require higher application rates to be effective |
| 9 | Requires a minimum humidity level to perform effectively |
| 10 | May leach down into layer, but dry back of the material plus a light water spray / rejuvenation will return it to surface |
| 11 | Generally not suitable as a spray-on application. A "skin" can form on the surface which is damaged by traffic |
| 12 | Requires frequent rejuvenation |
| 13 | Relatively high initial product cost price, but life-cycle cost could be lower than other treatments |

# Selection Based on Performance

| Treatment | Traffic | Climate | PI | Fines | | Perf | Rank |
|---|---|---|---|---|---|---|---|
| | 125 | Damp | 7 | 8 | | | |
| Water | 50 | 50 | 50 | 50 | | 200 | NS |
| Calcium chloride | 1 | 1 | 1 | 7 | | 10 | 2 |
| Mag. chloride | 1 | 1 | 1 | 7 | | 10 | 2 |
| Sodium chloride | 7 | 7 | 1 | 7 | | 22 | 4 |
| Glycerin based | 1 | 1 | 1 | 7 | | 10 | 2 |
| Lignosulfonate | 1 | 1 | 1 | 7 | | 10 | 2 |
| Molasses/sugar | 50 | 1 | 1 | 50 | | 102 | NS |
| Plant oil | 7 | 1 | 1 | 7 | | 16 | 3 |
| Tall oil | 7 | 1 | 1 | 7 | | 16 | 3 |
| Asphalt emulsion | 7 | 1 | 7 | 1 | | 16 | 3 |
| Base/mineral oil | 1 | 1 | 1 | 7 | | 10 | 2 |
| Petroleum resin | 1 | 1 | 1 | 7 | | 10 | 2 |
| Synthetic fluid | 1 | 1 | 1 | 7 | | 10 | 2 |
| Synthetic polymer | 1 | 1 | 1 | 1 | | 4 | 1 |
| Conc. Liquid Stabilizer | 50 | 7 | 50 | 50 | | 157 | NS |
| Bentonite | 1 | 1 | 50 | 1 | | 53 | NS |

# Types of Dust Suppressants

> 250 on the market!

- **Water**
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- **Synthetic oils:** *proprietary formulations*
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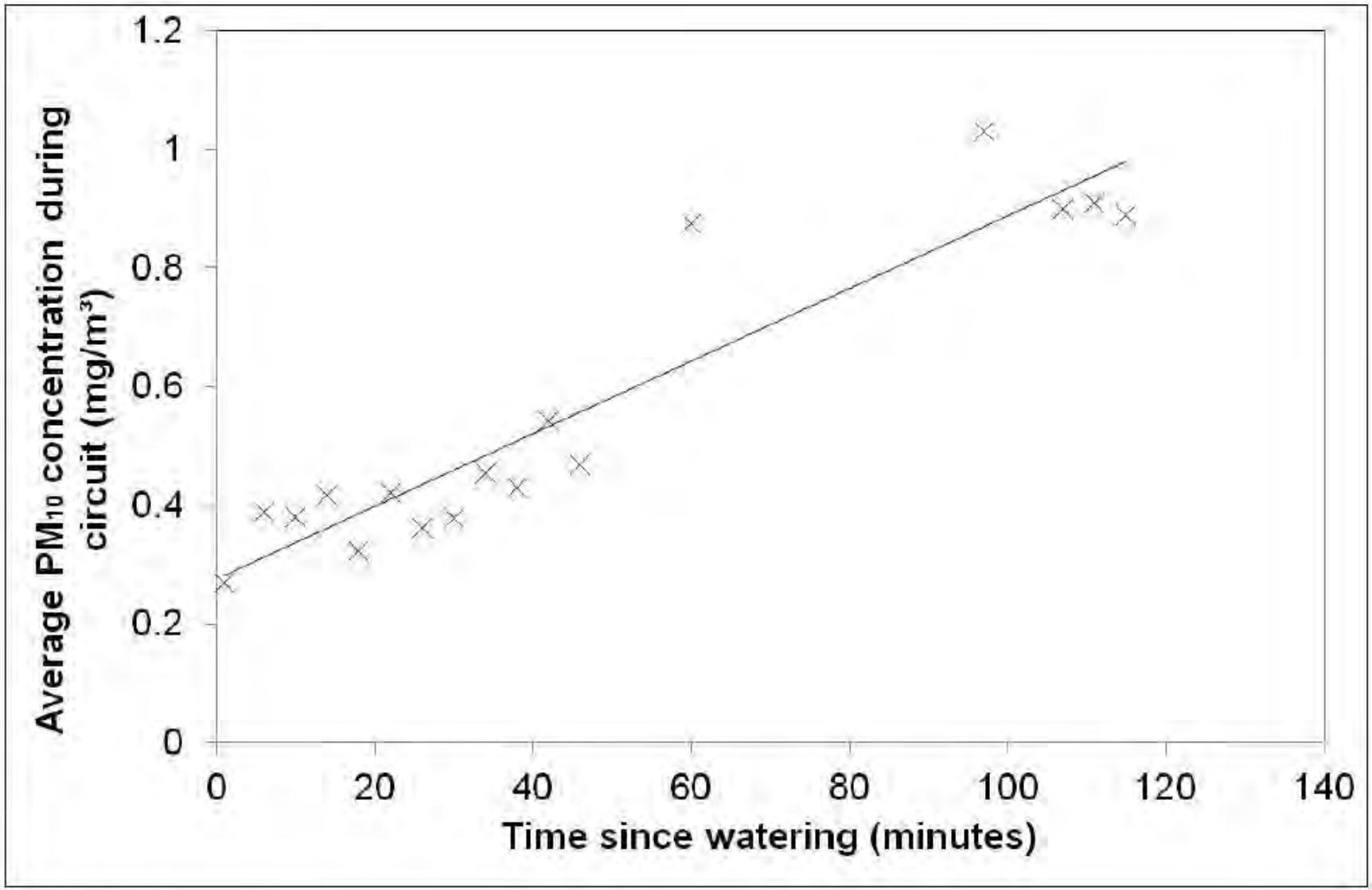


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# What is Calcium Chloride

Calcium Chloride is a salt similar to sodium chloride but tends to be stronger.

It is used as a deicing/anti-icing chemical as well as a dust palliative.

# How does it work as a palliative?

- Calcium chloride has a strong affinity for water. It will attach to moisture in the air or soil and hold it.

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# $CaCl_2$ Characteristics


- Most commonly used
- Requires high fines (10 – 14%)
- Ineffective when RH falls below 35%
- Can be slippery during and after a rainfall
- Has a bitter taste
- A mucus irritant
- Can impact water quality

# Why use Calcium Chloride

- It is the second most common palliative besides water.
- Except for water, it is the most cost-effective palliative.
- It requires minimal equipment to put down.
- Workforce development is minimal.
- It has proven to be safe when used as a palliative.

# Why use Calcium Chloride

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- It has proven to be safe when used as a palliative.

# Ideal Road and Materials

- Define project limits
- Establish drainage
- If necessary, refresh surface course
  - Ideally ¾ dense graded material with 8 to 15% passing 200 sieve.
  - Ideally a minimum of 4” thick for grading
- Establish grade
- If you have silt or clean sand, calcium chloride is not a good choice.

# Application of Calcium Chloride

- Topically Applied
  - Liquid
  - Solid
- Mixed into Soil
  - Liquid
  - Solid
- Application rate
  - 1 to 1.5% by weight

# Required Equipment

- Applied as a solid
  - Grader
  - Spreader
  - Water truck
  - Compactor (optional)
- Applied as a Liquid
  - Grader
  - Water Truck
  - Compactor (optional)
  - Forklift (optional)

# Steps to Apply Solid Topical Application

- Shape Road
- Compact
- Loosen upper 2 inches
- Add Salt
- Water
- Compact

# Steps to mix (2 to 4 inches)

- Windrow to centerline
- Add salt to windrow
- Blend
- Shape
- Water
- Compact

# Steps to Topically Applied Brine

- Shape Road
- Apply Brine
- Compact


# Steps to Blending Brine (2 to 4 inches)

- Loosen roadway to desired depth
- Apply Brine
- Blend
- Shape
- Compact

# Worker Safety

- Provide coveralls, gloves, safety vests and safety glasses to all workers.  Calcium chloride is a strong irritant.
- Provide plenty of drinking water.
- Provide showers at the end of the work shift.
- Consider providing hand creams and body lotions.

# Equipment

Prevent corrosion by washing equipment at the end of every shift.

Thoroughly rinse brine tanks

Lubricate more frequently.

# How much calcium chloride Should I use?

The target is 1% to 1.5% by weight of treated soil.

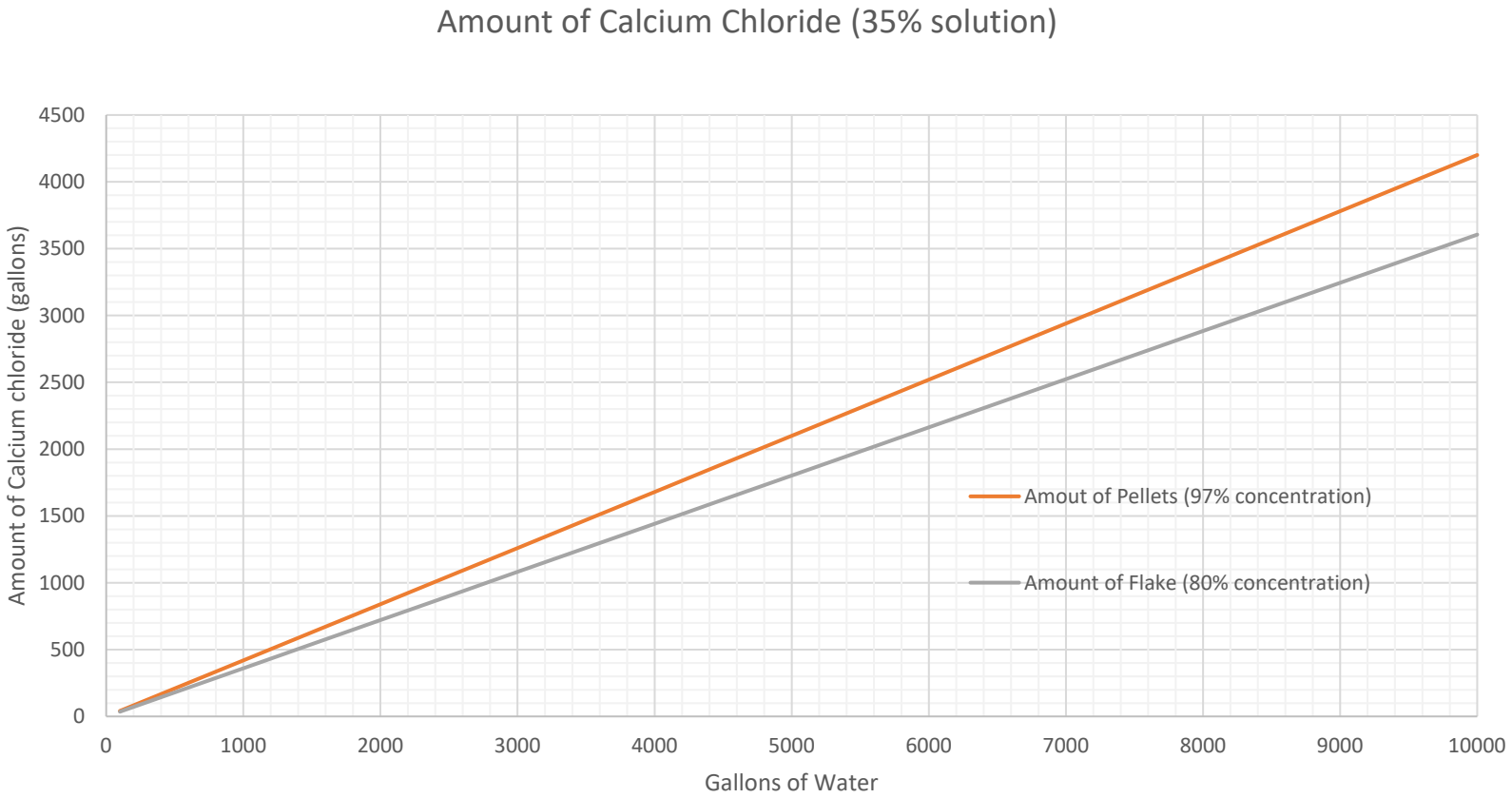
Assuming the surface course weighs 3,500 lbs/cy you would use

Between 35 lbs and 53 lbs, (3,500 x .01), calcium chloride per yard of surfacing material.

# Road Dust Control with Calcium Chloride Topically Applied

**Equivalent Rates of Application**

| Flake | Pellet | Liquid (Concentrations) | | |
|---|---|---|---|---|
| | | 38% | 35% | 32% |
| lbs./sq.yd. | lbs./sq.yd. | gal./sq.yd. | | |
| 0.5 | 0.41 | 0.09 | 0.1 | 0.11 |
| 0.75 | 0.61 | 1.13 | 0.15 | 0.16 |
| 1.00 | 0.82 | 0.17 | 0.19 | 0.22 |
| 1.25 | 1.02 | 0.22 | 0.24 | 0.27 |
| 1.50 | 1.23 | 0.26 | 0.29 | 0.33 |


Amount of Calcium Chloride (35% solution)
Amount of Calcium chloride (gallons)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
Gallons of Water
Amout of Pellets (97% concentration)
Amount of Flake (80% concentration)

# Parting thoughts

- There are several ways to apply calcium chloride.  Choose the way that fits the equipment you have.
- Plan where you are going to apply calcium chloride carefully.  Generally, focus on the higher trafficked areas.
- Plan early. Order early.
- Order bags if you can’t handle super sacks.
- Keep the product dry.
- Protect your people and your equipment.

# Types of Dust Suppressants

> 250 on the market!

- **Water**
- **Water-attracting salts:** *calcium chloride, magnesium chloride, sodium chloride*
- **Organic non-bituminous binders:** *lignosulfonates, tall oil, pine tar*
- **Synthetic oils:** *proprietary formulations*
- **Electrical-chemical stabilizers:** *enzymes, sulfonated oils, ionic*
- **Bitumen asphalt and tar:** *cutback asphalts, emulsified asphalts*
- **Synthetic polymer emulsions:** *polyvinyl acetate, vinyl acrylic*

# Synthetic Fluids

- **Petroleum Products with all aromatics removed**
- **Meet all EPA/DEC toxicity requirements**
- **Naturally clear liquid but may have additives**
- **Non-corrosive**
- **Considerably more expensive than $CaCl_2$**
- **Liquid below -40 F**


Applying Synthetic Fluid


It has to be done right


It has to be done right

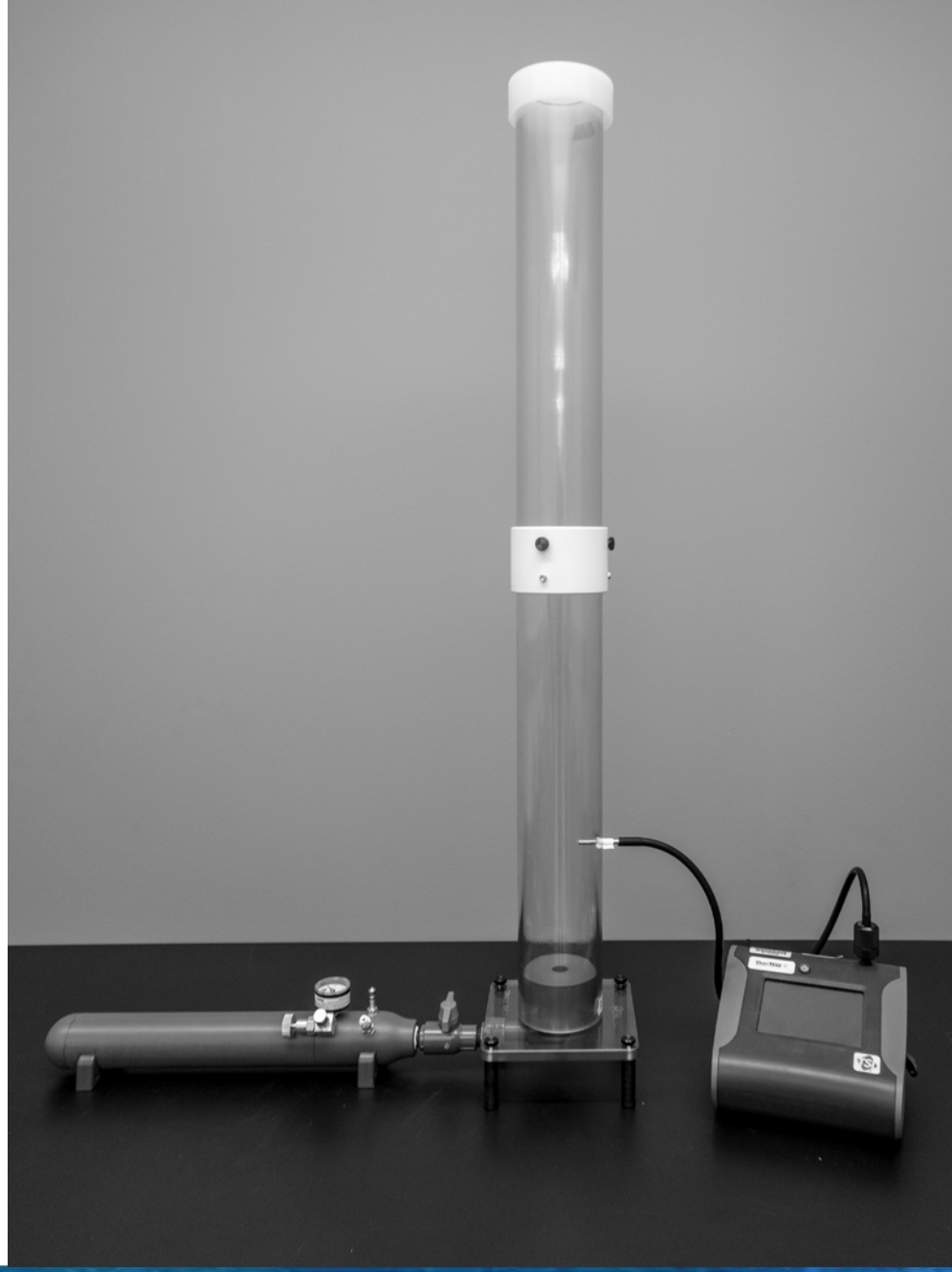
# It has to be done right

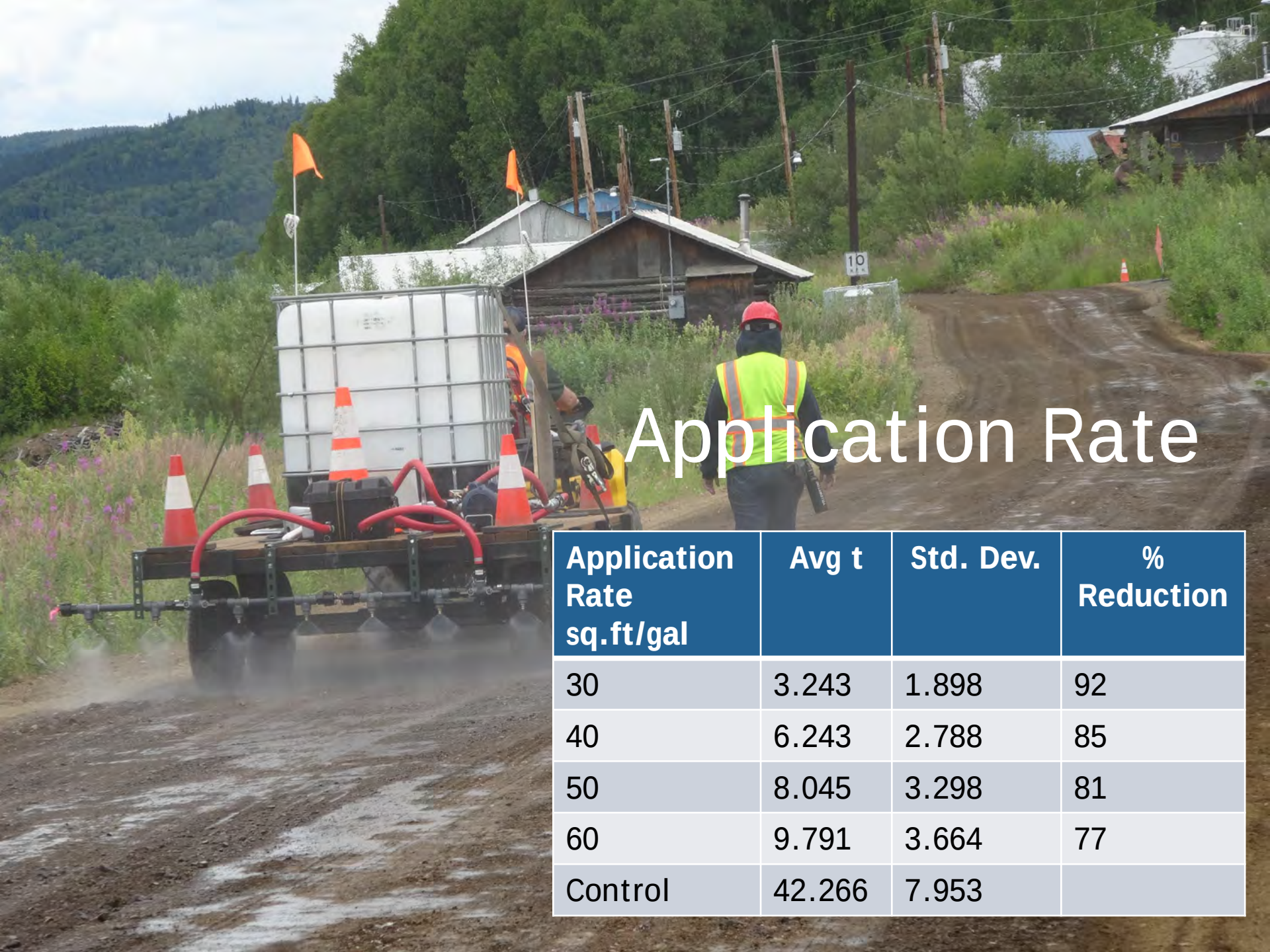
- Good Equipment is Not Expensive

# Synthetic Fluid Considerations
## Product

- Types – **Be sure product has been tested and has a good reputation** – do your homework!
- Best to have a product that can withstand storage down to -50$^{o}$F.
- Application rates – Too much wastes expensive product, too light results in poor performance. Determining the right rate requires testing.

Mini Dust Column used to test palliative





# Application Rate

| Application Rate sq.ft/gal | Avg t | Std. Dev. | % Reduction |
|---|---|---|---|
| 30 | 3.243 | 1.898 | 92 |
| 40 | 6.243 | 2.788 | 85 |
| 50 | 8.045 | 3.298 | 81 |
| 60 | 9.791 | 3.664 | 77 |
| Control | 42.266 | 7.953 | |

# Synthetic Fluid Considerations
# Product Application

Application – use appropriate spraying equipment –**NO WATER TRUCKS!!**

# Synthetic Fluid Considerations
# Product Application

Application may require multiple passes. **Be patient!**

# Synthetic Fluid Considerations
# Product Maintenance

- Re-compact treated roads every few weeks.
- Protect your expensive treated road by controlling speed and aggressive driving.

# Proper Fines is Critical

Proper fines content (passing the #200 sieve) is between 8 and 15% for untreated roads.


# UAF-DUSTM Used for Monitoring Field Performance

# The system is versatile

# Reasons for Poor Performance

- Surface too sandy (low fines)
- Material too dense to allow penetration of the selected product
- Weather
- Too little product applied


http://AIDC.UAF.EDU/TTAP

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- **ADEC**
- **Midwest Industrial Supply, Inc**
- **Soil Works, Inc.**

# Part 2 Overview May 23, 2024

- Use of clay additives
- Polymer Stabilizers
- Chip Seals
- Recycled Asphalt
- Hot Asphalt Pavement

# Questions?


Image courtesy of Subaru of America, Inc.

Available: http://www.subaru.com/enthusiasts/rally/article.html?uri=/rally/posts/08212012_085321/