Managing Fugitive Dust On Alaska's Roads and Airports

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Road Map

- Understanding fugitive dust
- Methods to manage dust
- Field Research
- Laboratory Research
- Applying Palliatives in Rural Alaska

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.

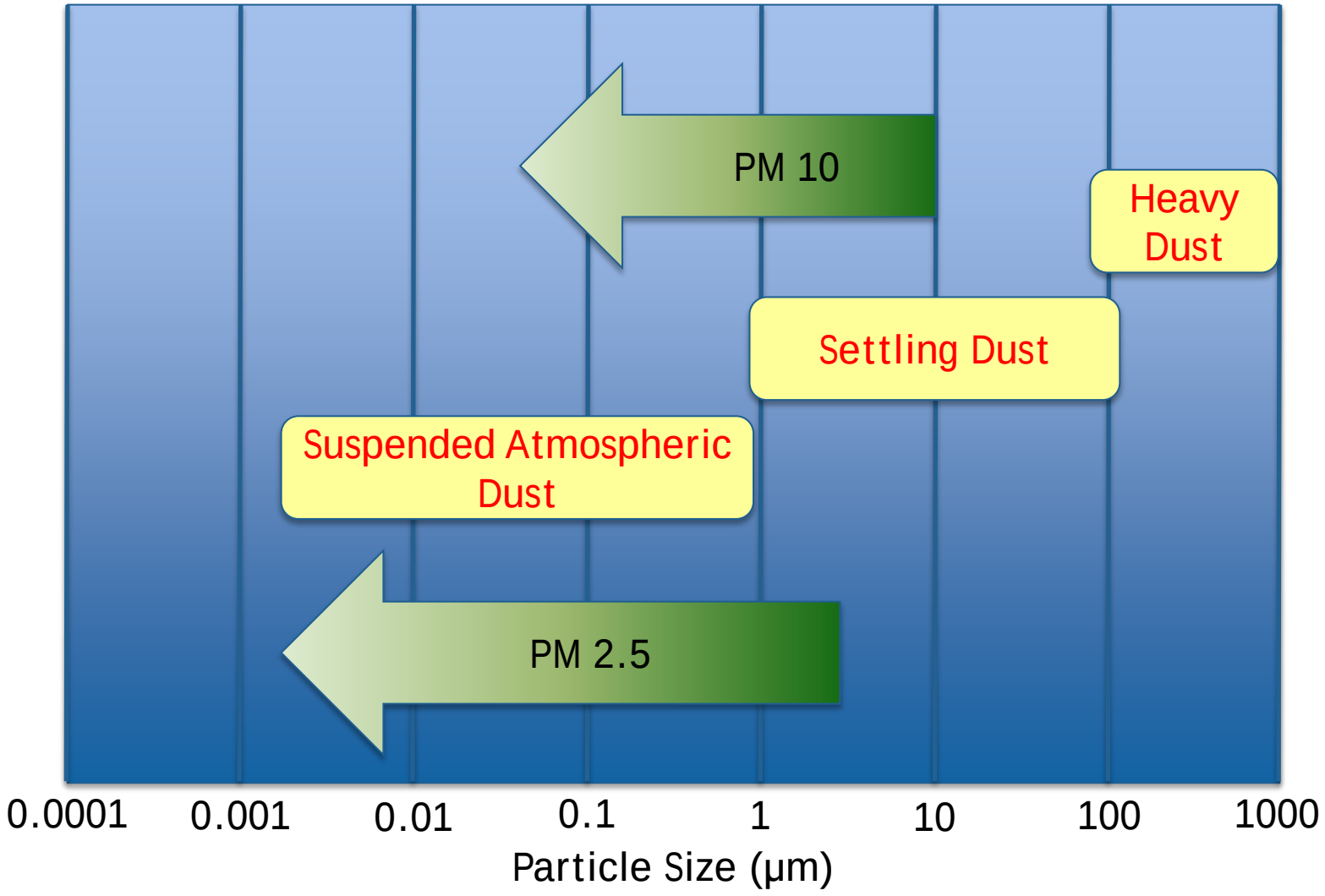
Result: 10,920 lbs of dust (PM10) per month

(Roberts et al., 1975)

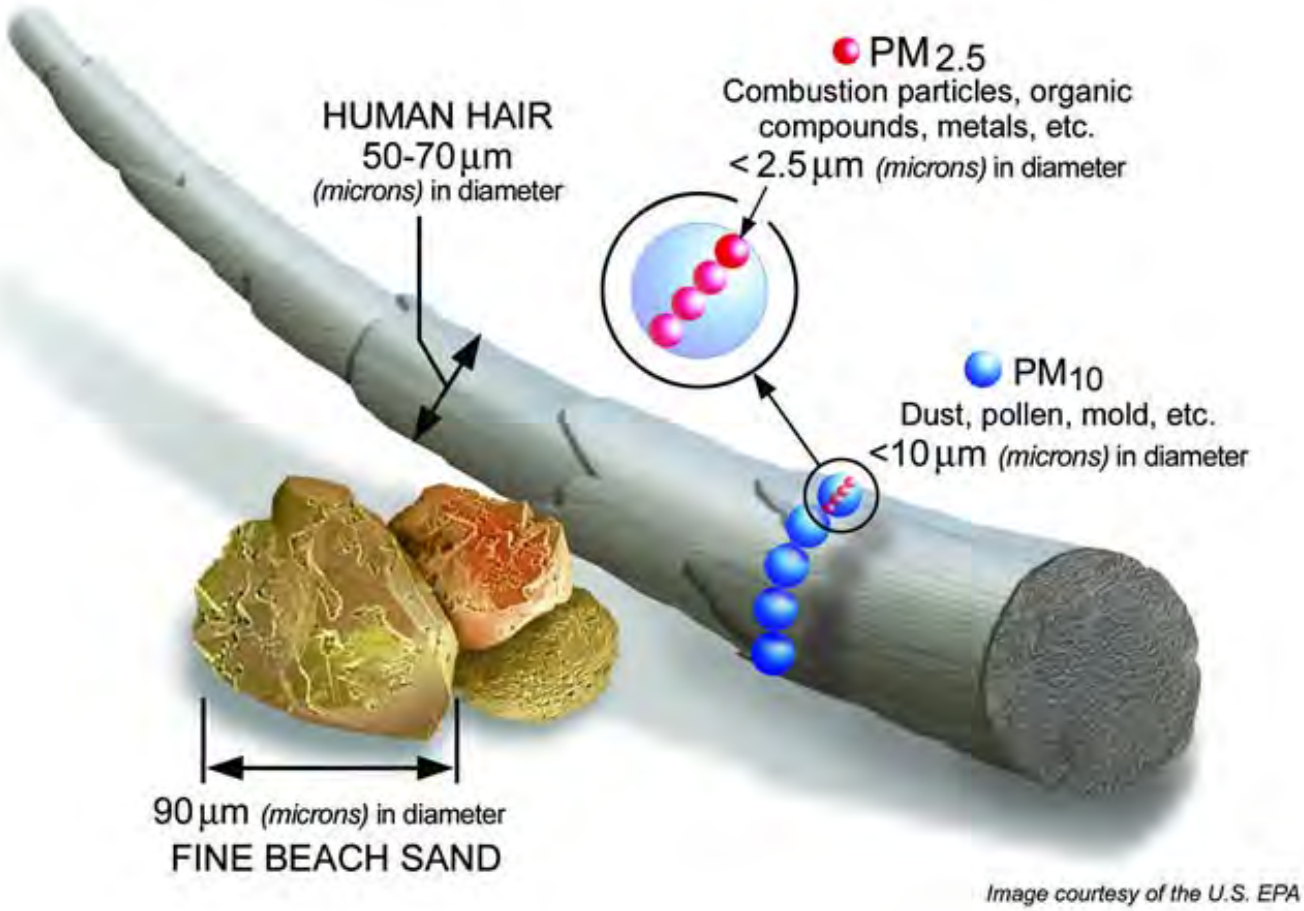
Impact of Loss of Particulate Matter from Unpaved Roads

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

How Small are These Particles We Are Working With?

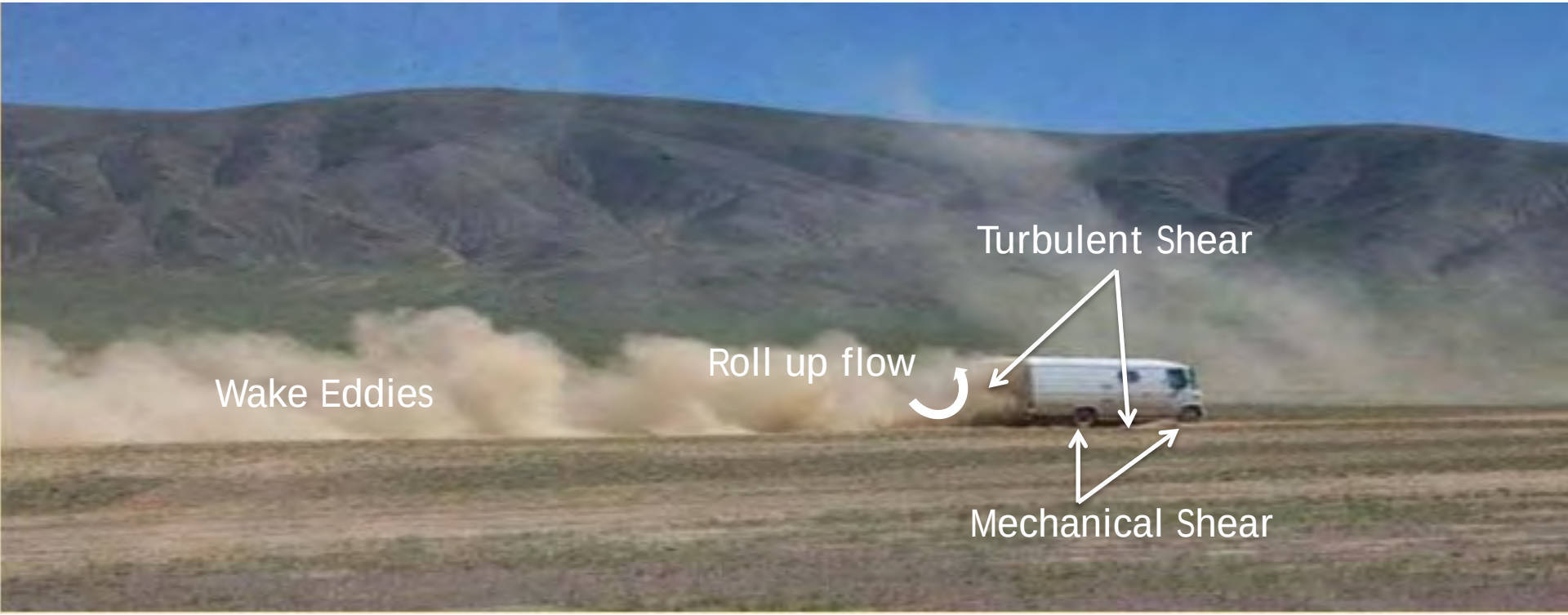


Really Small!



Tanana, Alaska Dust

Mechanical Particle Lofting Particles



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

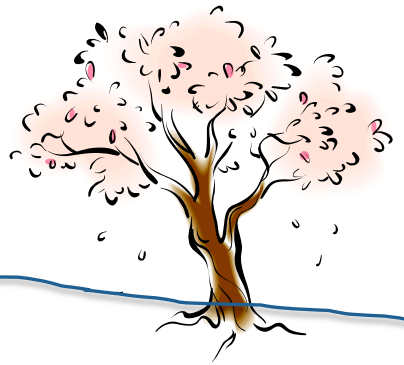
0.01 mm
PM10

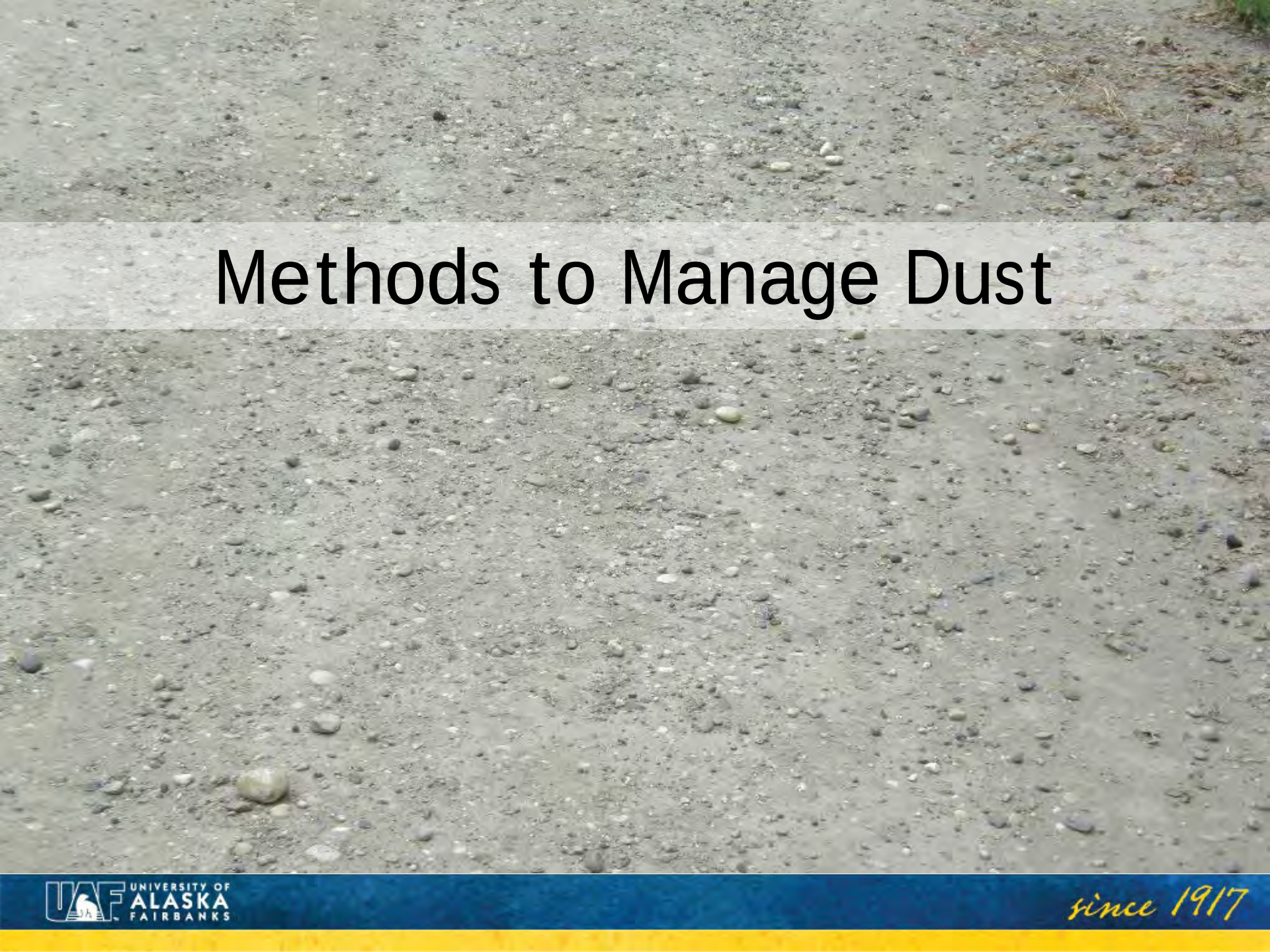
~1 hour

0.0025 mm
PM2.5

5.9 hours

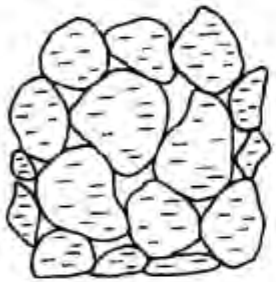
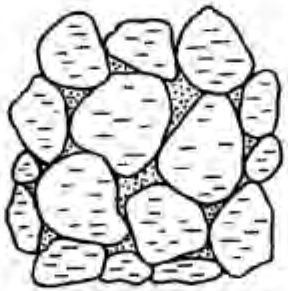
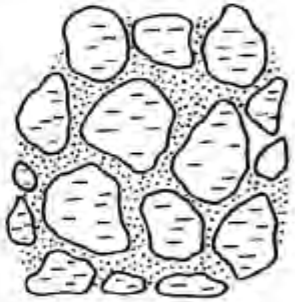
0.001 mm





Methods to Manage Dust


Good Dust Management
Starts with a Good Road

		
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**

Keller 2014 RDI Conference

Too Many Fines Causes Muddy Roads


Too Few Fines
Float
Washboard
Loose Fines

A Good Crown is Critical

- Should be between 4% and 5%


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

Limiting Fugitive Dust by Limiting Speed

15 MPH

30 MPH

Types of Palliatives

- **Water**
- **Water Absorbing Products (deliquescent/hydroscopic)**
  - **calcium chloride, magnesium chloride, brine**
- **Organic Nonpetroleum Products**
  - **vegetable oils**
  - **animal fats**
  - **lignosulfonate**
  - **tall oil emulsions**
- **Electrochemical Products**
  - **enzymes**
  - **ionic products**
  - **sulfonated oils**
- **Pavement**

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)	✓	✓✓

Types of Palliatives

- **Water**
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  - **lignosulfonate**
  - **tall oil emulsions**
- **Electrochemical Products**
  - **enzymes**
  - **ionic products**
  - **sulfonated oils**

Applying Calcium Chloride on Village Roads

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.

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.

Downsides

- Calcium Chloride is an irritant.
- Strong bitter taste.
- Corrosive.
- Improperly manage can be detrimental to the environment.

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.

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/C.Y., calcium chloride.

Road Dust Control with Calcium Chloride Topically Applied

Equivalent Rates of Application

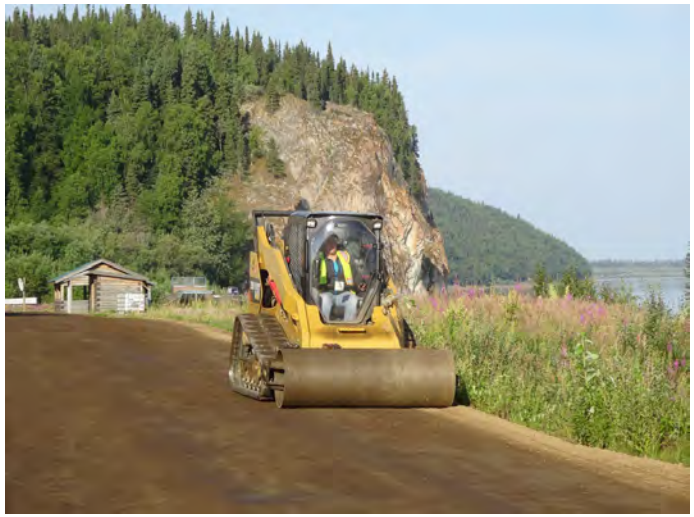
Flake (applied dry)	Pellet (applied dry)	Liquid (Concentrations)		
		38%	35%	32%
lbs./sq.yd.	lbs./sq.yd.	gal./sq.yd.		
0.5	0.41	0.09	0.1	0.11
0.75	0.61	1.13	0.15	0.16
1.00	0.82	0.17	0.19	0.22
1.25	1.02	0.22	0.24	0.27
1.50	1.23	0.26	0.29	0.33

Application of Synthetic Fluids
(Durasoil, Ek35, Envirokleen)

Application must be uniform

Required Equipment

Applicator



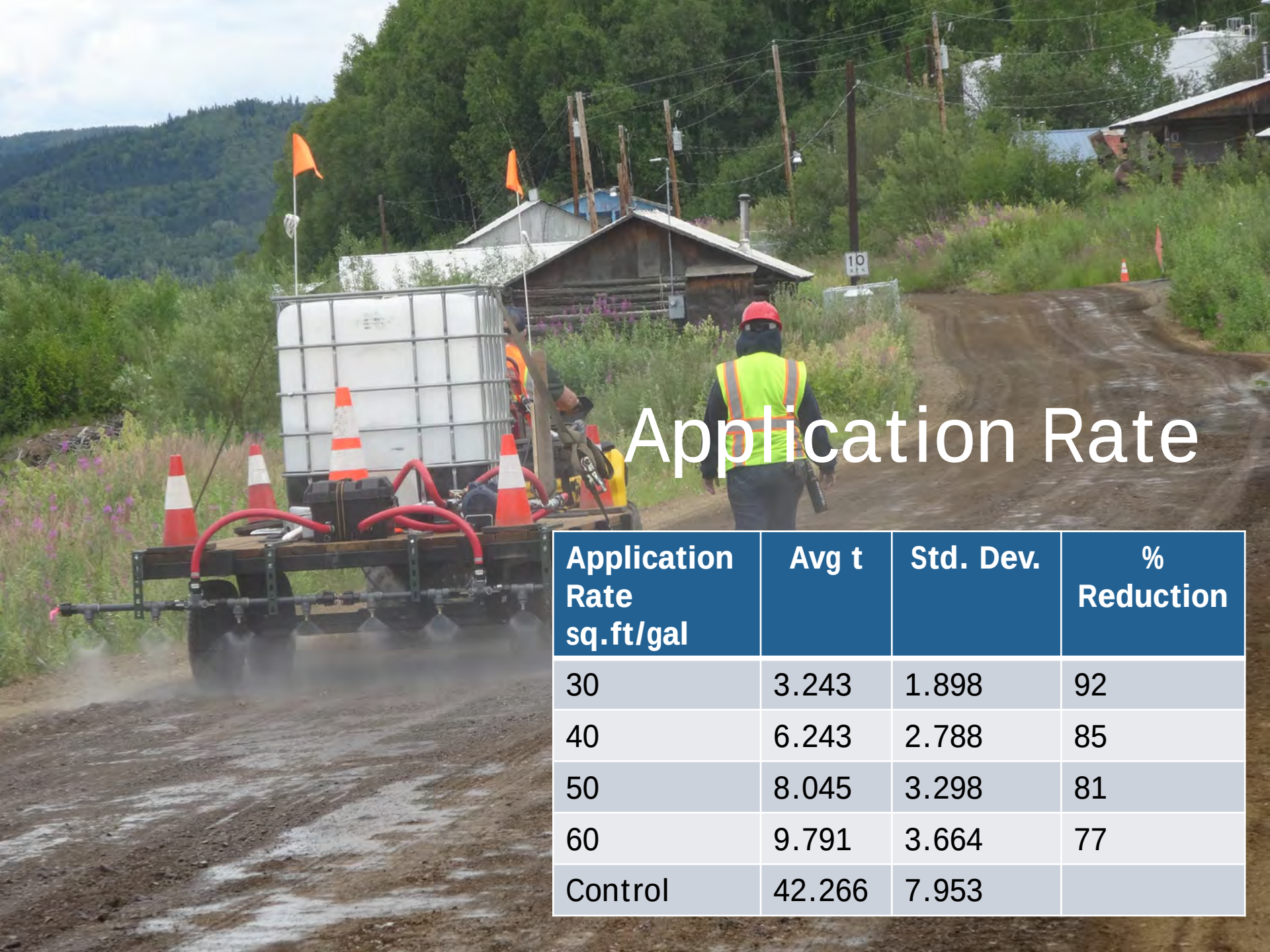
Compactor

Grader

Good Equipment is Not Expensive

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**



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	

Polymer Surfacing (Just add Water)

Equipment

Attributes of Polymers

- Available in powder or emulsion
- Requires as little as 1% by weight
- Can be applied either topically or mixed
- Provides a hard surface with a 5 plus year life if mixed. One year topical.
- Tolerant of a range of soils
- Cannot be regraded without replacing the polymer
- Expensive

Cold Mix Asphalt
No heat required

Cold mix asphalt is a mixture of asphalt and aggregate that is combined and placed without the addition of heat. The asphalt cement may be either a cutback or an emulsion.

Equipment

Pug Mill

Compactor

Pull behind Paver

Dump Truck

Asphalt Storage

Loader

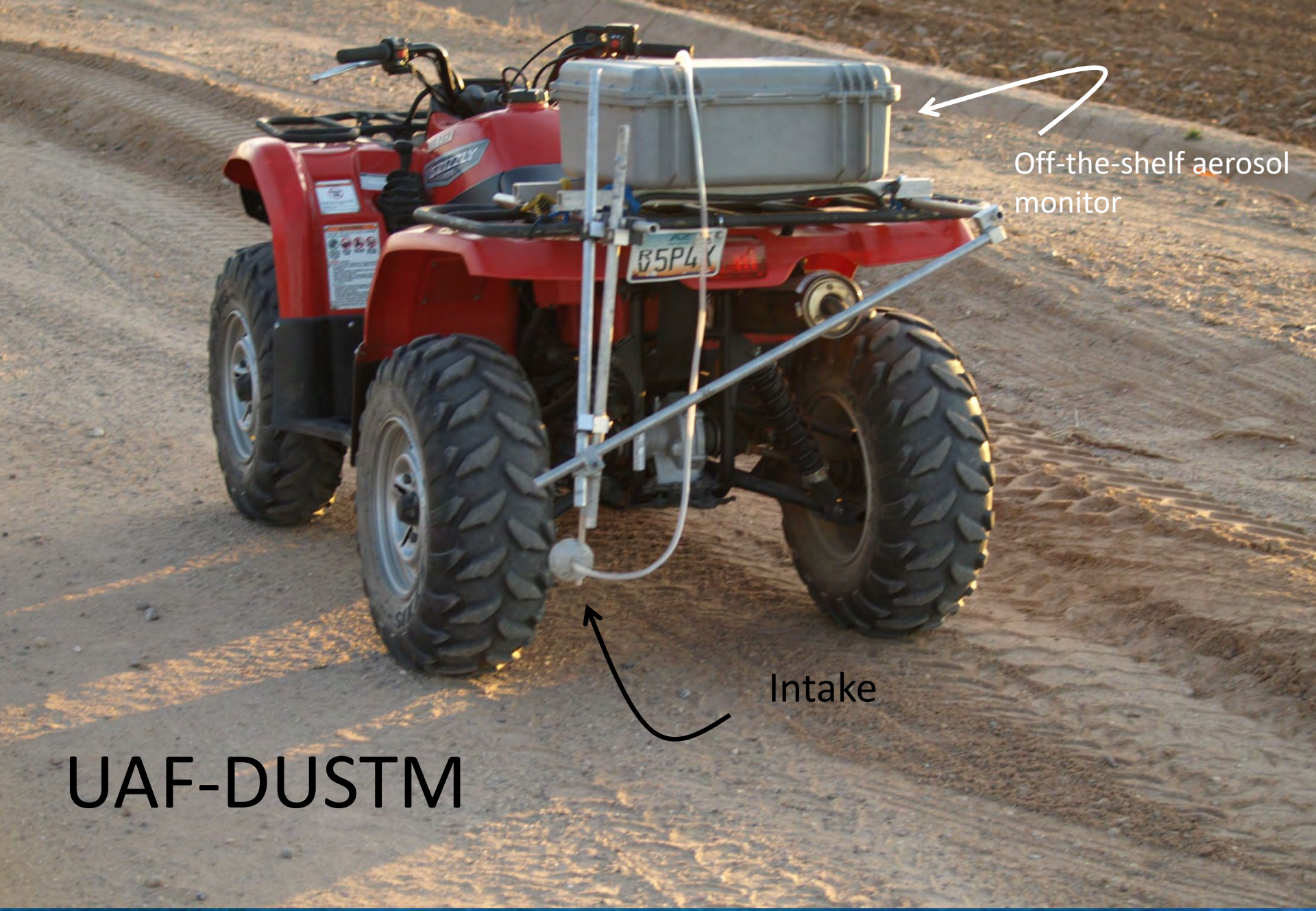
Attributes of Cold Mix

- Cure time can be tailored based on use
- Less expensive in remote areas
- Environmentally friendly
- Patch material can be left behind.
- End-product similar to hot mix asphalt.

Questions?

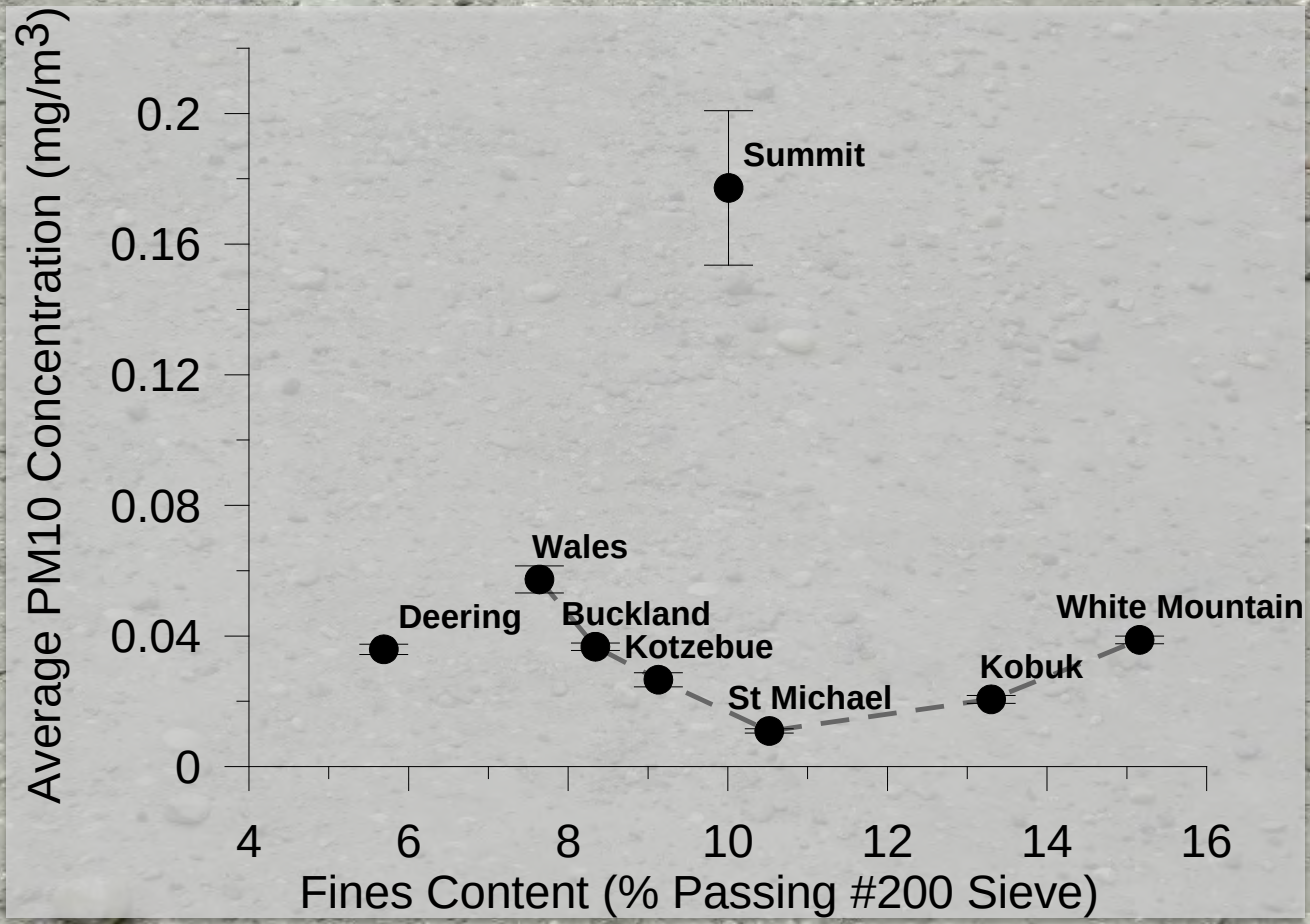
Image courtesy of Subaru of America, Inc.

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

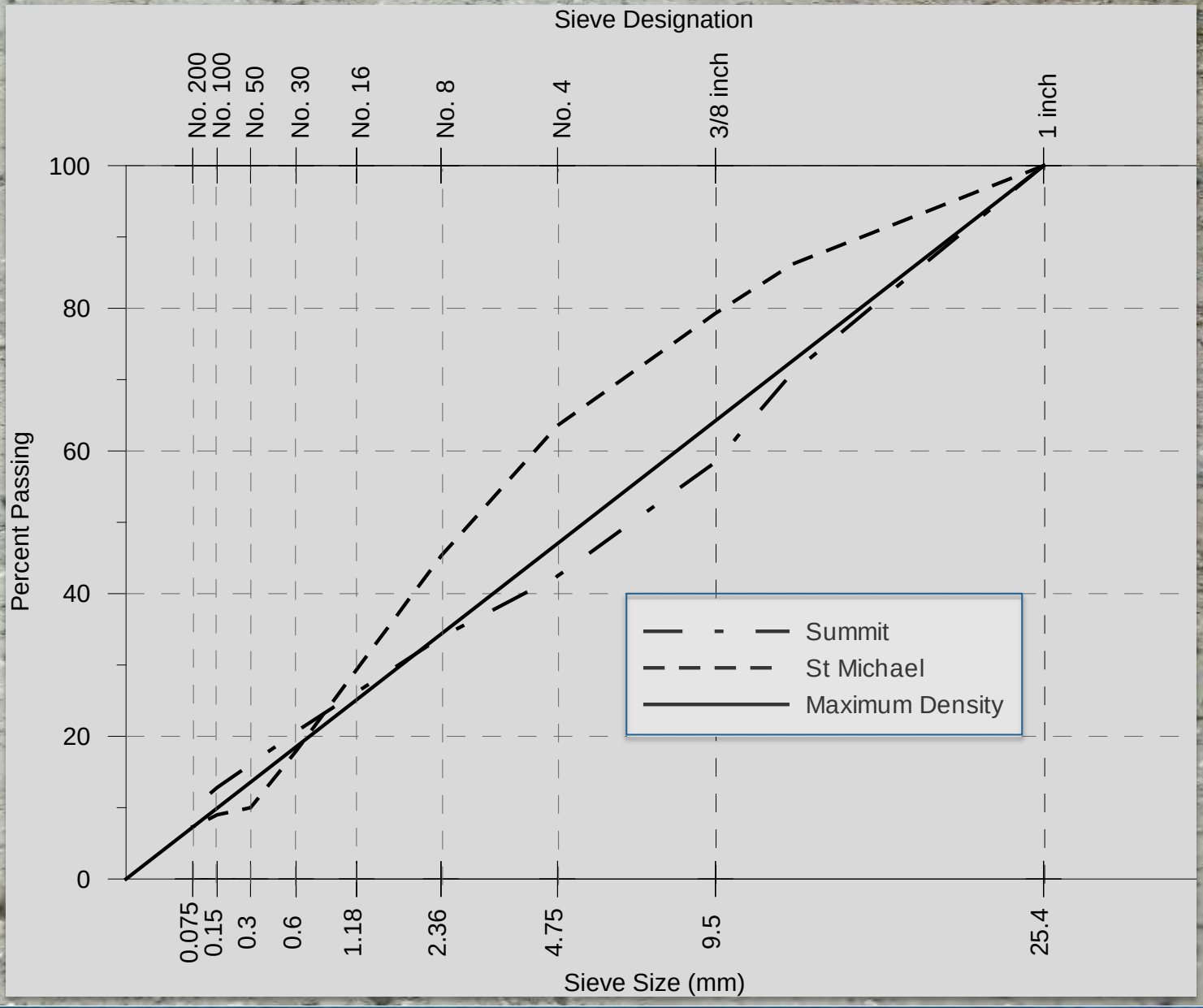


UAF-DUSTM

What we Have Learned so Far About Synthetic Fluid Performance

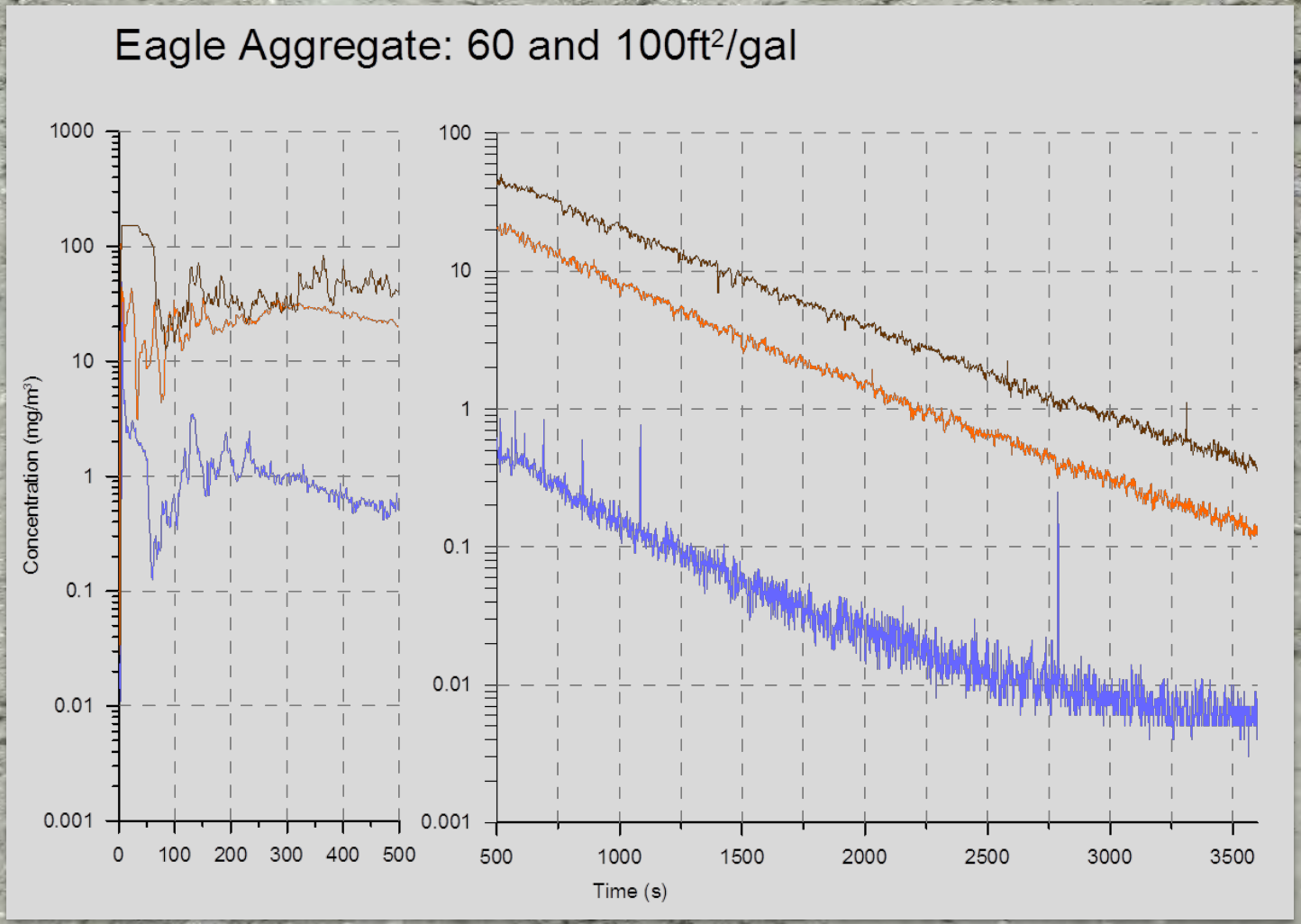


Impact of Gradation



Our Laboratory Test Methodology - UAF Dust Column

Preliminary Results from Dust Column Testing



Applying Palliative in the Village

Acknowledgements

Funding
- **AKDOT&PF**
- **AUTC**
- **Federal Highway Administration**
- **ADEC**
- **Midwest Industrial Supply, Inc**
- **Soil Works, Inc.**

The Team
- **Clark Milne**
- **Travis Eckhoff**
- **Logan Little**
- **Donovan Camp**
- **Samantha Feemster**
- **Cody Klingman**
- **Wilhelm Muench**
- **Reggie Dallaire**
- **Dr. Rich Wies**

How do I know how much a yard of material weighs?

Using a 5 gallon bucket fill with three equal lifts, compacting each lift with 50 blows. You can use a 2x4 to compact the soil.

Weigh the bucket on a bathroom scale.

A 5 gallon bucket contains 0.67 cubic feet or of volume.

Compute the weight of a cubic yard with the following equation.

Wt./c.y. = (wt. of bucket/0.67) x 27

Example: If the bucket weights 85 lbs, the

Wt./cy = (85/.67) x 27 = 3,425 lbs

Area of Road

Determine road area to be covered

Area: $yd.^2 = \frac{width\ (ft)\ x\ length\ (ft)}{9\ ft.^2(1yd.^2)}$

Length = $0.25\ mile\ x\ 5280\ \frac{ft}{mile} = 1{,}320$ ft

Thus: area = $\frac{20\ ft.x\ 1320\ ft.}{9} = 2{,}933\ yd.^2$

Calcium Chloride Flakes

Determine the quantity of flake needed for the desired application rate.

lbs. needed = area to be covered x desired application rate

lbs. of flake=$2933 yd.^2 \ x \ 1.5 \ lb/yd.^2$ = 4399.5 lbs.

Determine the number of bags required

no. of bags =$\frac{lbs.of \ flake}{100 \ lb/bag}$

no. of bags = $\frac{4399.5 \ lbs}{100 \ lb/bag}$ = 44 bags

Calcium Chloride Pellets

Determine the quantity of pellets needed at the desired application rate

lbs. of pellets = (area to be covered) x desired application rate

lbs. of pellets = 2933 $yd.^2$ x 1.23 lbs/$yd.^2$ = 3607.6 lbs

Determine number of bags required

no. of bags = $\frac{lbs\ of\ pellets}{80\ lbs/bag}$

no. of bags = $\frac{3607.6\ lbs}{80\ lbs/bag} = 45\ bags$

Calcium Chloride Concentrations (liquid)

Determine the quantity of 32% liquid needed at the desired application rate

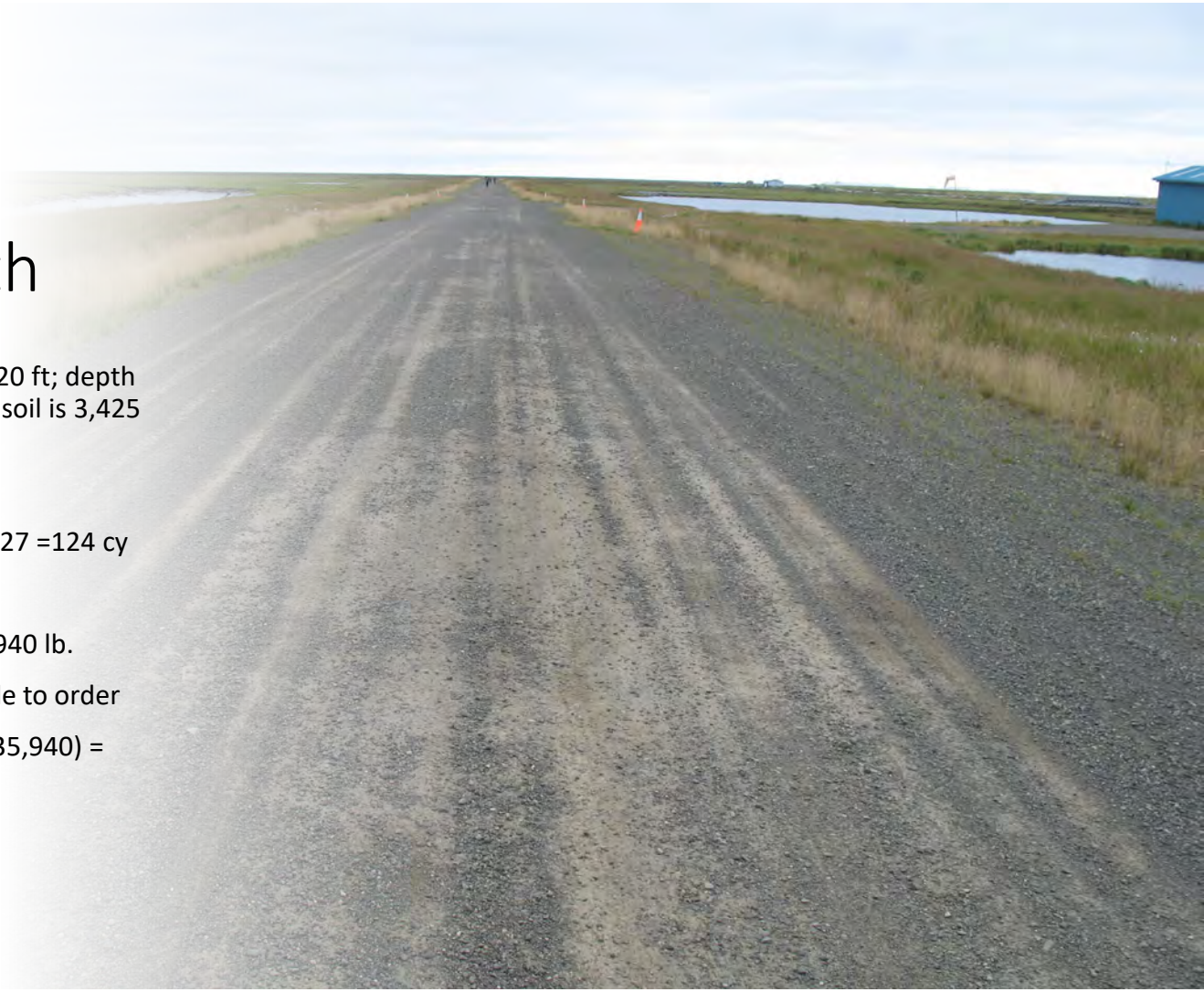
gallons of liquid = 2933 $yd.^2$ x 0.33 gal/$yd.^2$ = 967.89 gallons

Computing how much calcium chloride to order.

- First estimate the area to be treated by multiplying the distance to be treated by the width to be treated.
- Multiply the area by the depth to be treated in feet. (Depth in inches/12)
- Divide that value by 27 to get the volume in cubic yards.
- Multiply this by 0.01 – 0.015

C.Y. = 0.01 x (wt. of soil/c.y.) x (length x width x depth)/27

Example for mixing to a specified depth



Assume: length =1,000 ft; width = 20 ft; depth of treatment is 2 inches; weight of soil is 3,425 lb/cy; application rate = 1.25%

Compute volume of soil:

vol. = (1000)(20)(2/12)/27 =124 cy

Compute weight of soil

Wt. = 124(3435) = 425,940 lb.

Compute weight of calcium chloride to order

wt. of calcium chloride = 0.0125(435,940) = 5,450 lb. per 1,000 ft.

Suggest adding 10% extra