Alaska Department of Transportation & Public Facilities
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Construction Dust Amelioration Techniques

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Dust produced on seasonal road construction sites in Alaska is both a traffic safety and environmental concern. Dust emanating from unpaved road surfaces during construction severely reduces visibility and impacts stopping sight distance, and contributes to the local burden of PM 2.5, small particulates that present an important environmental air quality concern. This research aims to assist ADOT&PF in developing safe, efficient techniques for short-term dust suppression. Experts believe applying a dust-control palliative like calcium chloride, Enviroclean, Durasoil, or EK35 to the unpaved surface during road construction will solve the dust problem. This research will gather necessary information to determine when, what type, in what concentration, and how often the dust-control palliative should be applied. The amount and size of the dust particles, the time the surface is to remain unpaved, the makeup of the unpaved road surface, local environmental conditions, and the availability and cost of the dust control palliatives are factors to consider. The project is especially valuable because measurement systems used in other states involve special equipment and/or certification of observers, neither of which may be practical in Alaska with our remote locations and short construction season.

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
^oF	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	^oC
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
^oC	Celsius	1.8C+32	Fahrenheit	^oF
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380. (Revised March 2003)

Executive Summary

Many road construction projects require that traffic must be maintained during construction. This requires that public and construction vehicles drive on unpaved road surfaces. The duration that the vehicles have to drive on the unpaved road surface varies from hours to several months depending on size of the project and construction schedule. Dust generated from the traffic during road construction can impact traffic safety. The dust can significantly reduce sight visibility below the AASHTO minimum stopping sight distance and also pose a health hazard to workers in the vicinity of the construction project.

Current Alaska DOT/PF practice for temporary dust control on highway construction projects is to periodically apply water to the gravel road surface. For relatively hot dry (70 degrees F & 40% relative humidity) weather, the road needs to be watered every 20-25 minutes to maintain acceptable visibility for traffic safety. The primary disadvantages of this practice are the high cost and the difficulty in scheduling construction equipment for the application frequency necessary to minimize the level of dust for adequate sight distance.

The primary objective of this research project is to evaluate the feasibility and effectiveness of using long term dust palliatives at a reduced application rate to provide temporary dust control on road construction projects. Nine test sections were constructed to evaluate three dust palliatives (*Freedom Binder 400, Durasoil, and Soiltac*) at three different application rates required for three different performance periods – 1 week, 2 weeks and 1 month.

In addition, the hand held *DustTrak II Model 8532* and the UAF-DUSTM aerosol monitors were evaluated as tools to determine the levels of dust concentration for enforcement of construction contract specifications.

The conclusions of this project are:

- Watering is more cost effective than *Durasoil, Soiltac* and the *Freedom Binder 400* for temporary (1-4 weeks) dust control for construction projects.
- The *Durasoil, Soiltac* and the *Freedom Binder 400* are more difficult to apply than water as a dust palliative. The *Soiltac* and *Freedom Binder 400* require mixing with water. All three palliatives tested required that the lane be closed to apply the palliative. The *Soiltac* also required a 20 minute cure time between each of the four applications.
- The *Durasoil, Soiltac*, and *Freedom Binder 400* palliatives were not successful in providing the desired 7 day, 14 day and 28 days of acceptable temporary dust control using the following application (undiluted) rates.

Performance Period	***Freedom Binder 400***	***Durasoil***	***Soiltac***
1 week	.008 (125 sft/gal)	.014 (70 sft/gal)	.013 (80 sft/gal)
2 week	.0125 (80 sft/gal)	.020 (50 sft/gal)	.017 (60 sft/gal)
3 week	.025 (40 sft/gal)	.025 (40 sft/gal)	.020 (50 sft/gal)

Application Rates (gal/sft)

- The additional 200-250 trucks per day due to the construction activities had a significant impact on the performance of the dust control measures.
- An alternative to reducing the amount of watering required to control dust is to lower the speed limit through the construction zone.
- The quantity of dust generated by a vehicle is dependent on the vehicle size and speed. A large truck traveling at 45 MPH generates significantly more dust than a smaller passenger vehicle traveling 30 MPH.
- It was not practical to measure the dust concentrations on a high volume high speed road with the UAF-DUSTM.
- It was not practical to reliably measure the dust concentrations with the handheld *DustTrak II Model 8532*. The vehicles would slow down and move to the other lane when they see a person standing on the road taking dust concentration measurements.

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Introduction

Many road construction projects require that traffic must be maintained during construction. This requires that public and construction vehicles drive on unpaved road surfaces. The duration that the vehicles have to drive on the unpaved road surface varies from hours to several months depending on size of the project and construction schedule.

Dust generated from the traffic during road construction can impact traffic safety. The dust can significantly reduce sight visibility below the AASHTO minimum stopping sight distance. (The sight stopping distance is the distance that a vehicle travels from the time that the driver identifies a hazard to the time that the vehicle stops and is primarily dependent on vehicle speed.) The dust can also pose a health hazard to the workers and the public in the vicinity of the construction project.

Current Alaska DOT/PF practice for temporary dust control on highway construction projects is to periodically apply water to the gravel road surface. For a relatively hot dry (70 degrees F, min. humidity – 40%) day, the road needs to be watered every 20-25 minutes to maintain acceptable visibility for traffic safety. (Appendix B) The water is commonly applied to the road surface with tanker trucks equipped with splash plates that are also used to facilitate compaction of the roadway embankment. The water can usually be obtained in either streams, lakes or fire hydrants located near the project. The *Alaska DOT/PF Standard Specifications for Highway Construction* has provisions for using calcium chloride for dust control (Section 634 – Calcium Chloride for Dust Control). However, calcium chloride is primarily only used at the end of the first construction on multi-season projects to provide dust control during winter shutdown.

The primary advantages of watering for temporary dust control are: 1) equipment (water truck) that is commonly used for other construction activities on the project; 2) applied with minimal impact to traffic; 3) does not require special traffic control or lane closures during application; 4) frequency of application can be adjusted for weather conditions, traffic levels and project requirements; and 5) can be applied quickly on short notice. The primary disadvantages of this practice are the high cost and the difficulty in scheduling construction equipment for the application frequency necessary to maintain a minimal level of dust. If the water is not applied in a timely manner, there are periods when the dust reduces the sight distance below acceptable levels.

For long term dust control on gravel roads, the Alaska DOT/PF primarily uses calcium chloride. Although calcium chloride is a relative inexpensive and effective long term dust control palliative, it requires significant effort with graders and compaction equipment to blend the calcium chloride into the top 4 inches of the road surface. Calcium chloride is also is corrosive to vehicles and equipment.

Due to the corrosive nature to aircraft, calcium chloride can not be used on gravel runways. For long term dust control on rural airports, Alaska DOT/PF has used a variety of non-corrosive dust palliatives including *EK-35, Permazyme, Soilsement and Durasoil.*

The University of Alaska Fairbanks in-conjunction with Alaska DOT/PF is currently conducting the related research project – "*Development of an Alaskan Specification for Palliative Application on Unpaved Roads and Runways*" - to evaluate the effectiveness of these non-corrosive dust palliatives on rural gravel roads and runways.

Objective

The primary objective of this research project is to evaluate the feasibility and effectiveness of using dust palliatives to provide temporary dust control on road construction projects. If this study determines that dust palliatives are a viable alternative to the current practice of watering, a performance specification will be developed for the use of dust palliatives as temporary dust control for construction projects.

In addition, this research project also:

- Evaluated the use of the hand held *DustTrak II Model 8532* and the UAF-DUSTM aerosol monitors as tools to determine the levels of dust concentration for enforcement of construction contract specifications.
- Determine the duration that watering is effective in controlling dust.

Project Scope

The scope of this project is to:

1. Construct test sections to evaluate three dust palliatives at three different application rates required for three different periods – 1 week, 2 weeks and 1 month.
2. If dust palliatives are a viable alternative for temporary dust control, develop a construction specification that will permit a contractor to use a dust control palliative on the Alaska DOT/PF Approved Product List with an approved application rate for the appropriate dust suppression period.
3. Evaluate practicality of the *DustTrak II Model 8532* and UAF-DUSTM aerosol monitors to be used on construction projects to quantify fugitive dust levels for contract enforcement.

Factors Affecting the Quantity of Dust Generated by Vehicles

Vehicles traveling on unpaved roads generate significant dust plumes by pulverizing the gravel surface material and lofting the material into the air. Key factors that affect the dust emission rates include:

- Fine particle content of the road surface material - Based on the EPA Compilation of Air Pollutant Emission Factors (AP-42, Section 13-2-2), a road surface with 15% silt (<.075mm) generates approximately 3.75% more dust emission than a road surface with 4% silt. (Cowheard et al., 1990; MRI, 2000; AP-42, EPA)

- Soil moisture content – Based on the EPA *Compilation of Air Pollutant Emission Factors* (AP-42, Section 13-2-2), a road surface with a moisture content of 0.5% generates approximately 82% more dust than a road surface with 15% moisture content. (AP-42, EPA)

- Vehicle speed – Based on studies by Gilles, the dust emission factor increased at different rates for different size vehicles traveling at different speeds. For a small car (Neon), the dust emission factor increased at a rate of .83 km/hr. The dust emission factors for larger vehicles - Tarus, GMC van, and Dodge Caravan – increased at a rate of 6.00, 8.98 and 9.61 km/hr., respectively. For larger military vehicles (M977 HEMMTT &

M923A2 {5 ton}), the dust emission factor increased at a rate of 48.3 and 47.4 km/hr. (Nicholoson et al., 1989; Etyemezian et al., 2003; MRI, 2001; Gilles et al, 2005)

This is consistent with a study conducted as part of this research project and presented in Appendix A. For this study, the maximum measured dust concentration for a 2005 Ford F-150 pickup truck increased by 123% between 30 MPH and 45 MPH.

- Vehicle height – The height of the dust plume generated by a vehicle is 1.7 times the height of the vehicle. The higher that the dust particles are ejected into the air, the longer it takes for them to settle to the ground and the farther the dust travels. The vehicle shape and the angle of the ambient wind with respect to the direction of vehicle travel also affect the height of the dust plume. (Gilles et al, 2005)

- Vehicle weight – Based on the EPA Compilation of Air Pollutant Emission Factors (AP-42, Section 13-2-2) a truck weighing 90,000 lbs. generates approximately 5.5 times more dust than a vehicle weighing 2,000 lbs. Figures #4 and #B-4 illustrate the difference in dust generated by two different size vehicles. (US EPA, 1996, 2003; MRI, 2001; Gilles et al, 2005)

- Number of vehicle Wheels – The amount of dust generated by a vehicle is proportional to its number of wheels. (Saccarieh, 1992) Figures #4 and #B-4 illustrate the difference in dust generated by a vehicle with 4 tires vs. 18 tires.

- Tire Width – Wider tires generate a larger amount of dust emissions per tire. In addition, dual tires also generate more dust than a single tire. (Saccarieh, 1992)

Dust Palliative Test Section

To evaluate the economic feasibility, construction feasibility and effectiveness of using dust palliatives for temporary dust control on road construction projects, a series of test sections were incorporated as part of the Tok Cutoff; MP 0-2 and MP 5-24 project. Three dust palliatives (*Freedom Binder 400, Soiltac and Durasoil*) were applied to the unpaved surface at three different application rates. The application rates were selected by the respective palliative suppliers to provide dust control for 1 week, 2 weeks and 1 month periods.

Dust Palliatives

<u>Freedom Binder 400</u> - Freedom Binder 400 is a tall-oil pitch emulsion. The *Freedom Binder 400* can be applied by a water truck with either a splash plate or a spray bar. Application with a spray bar provides a more uniform application and minimizes the overspray.

To facilitate uniform application, the *Freedom Binder 400* is mixed with water at a 4:1 ratio. The rate of application of the *Freedom Binder 400* was controlled by a flow meter and the speed of the distributor.

The cost of the *Freedom Binder 400* FOB Palmer is approximately $8.22 per gallon. The supplier is located in Palmer, Alaska. The *Freedom Binder 400* can be shipped in 275 gallon totes.

The manufacturer's recommended undiluted application rate for secondary roads with light traffic is .028 gal/sft (36 sft/gal). For roads with heavy truck traffic the undiluted application rate is .04 gal/sft (25 sft/gal) or two separate applications of .028 gal/sft (36 sft/gal). For the test sections, the *Freedom Binder 400* was placed in four equal coats at the following undiluted application rates:

Test Section	**Performance Period**	**Application Rate**		**Material Cost**	
		Gal/sft	**Sft/gal**	**$/SFT**	**$/Test Section**
3C	1 week	.008	125	$.066	$1,973
2C	2 week	.0125	80	$.103	$3,083
1C	4 week	.025	40	$.206	$6,165

Table 1 – Application Rates for *Freedom Binder 400*

<u>Durasoil</u> - Durasoil is synthetic organic liquid that can not be diluted with water. The *Durasoil* does not cure and can be applied and reworked in freezing or wet conditions. The *Durasoil* can be applied by a water truck with either a splash plate or a spray bar. Application with a spray bar provides a more uniform application and minimizes the overspray. The road surface must be dry and below optimum moisture content to the desired treatment depth to ensure full penetration, proper coating of the aggregate and to prevent flooding. The *Durasoil* is placed in two equal applications. No cure time is necessary prior to applying the second coat of *Durasoil*. The rate of application of the *Durasoil* was controlled by the speed of the distributor. Traffic can travel on the *Durasoil* immediately after it is applied.

The cost of the *Durasoil* FOB Anchorage is approximately $9.75 per gallon and can be shipped in 275 gallon totes. The *Durasoil* is shipped from Arizona and requires approximately 2 week transit time before application.

The manufacturer's recommended undiluted application rate for unpaved roads is .030 gal/sft (30 sft/gal) and .050 gal/sft (20 sft/gal) for unpaved tank trails. For the test section, the *Durasoil* was placed in two equal coats with the following total application rates:

Test Section	Performance Period	Application Rate		Material Cost	
		Gal/sft	Sft/gal	$/SFT	$/Test Section
3A	1 week	.014	70	$.139	$4,170
2A	2 week	.020	50	$.195	$5,850
1A	4 week	.025	40	$.244	$7,313

Table 2 – Application Rates for *Durasoil*

<u>*Soiltac*</u> – *Soiltac* is an environmentally safe biodegradable copolymer based emulsion. The copolymer coalesces to form bonds that bind the aggregates and fines together to form a durable and water resistant matrix. To facilitate uniform application, the *Soiltac* is normally mixed with water at a 6:1 ratio for topical road application. The *Soiltac* can be applied by a water truck with either a splash plate or a spray bar. Application with a spray bar provides a more uniform application and minimizes overspray.

The *Soiltac* was placed in four equal coats. Each successive coat of *Soiltac* dilution should be applied in a timely manner to ensure that the surface always stays wet. The *Soiltac* cannot be allowed to dry between applications – approximately 20 minutes. However, due to traffic considerations, the *Soiltac* cured only approximately 5 minutes before the succeeding coats were applied. The last coat was allowed to cure approximately 2 hours prior to opening the road for traffic.

The cost of the *Soiltac* FOB Anchorage is approximately $9.25 per gallon. Since there currently is no supplier in Alaska, the *Soiltac* is shipped from Arizona and requires approximately 2 week lead time before applying the product. The *Soiltac* is typically shipped in 275 gallon totes.

The manufacturer's recommended undiluted application rate is .0154 gal/sft (65 sft/gal) for roads with high traffic; .0167 gal/sft (60 sft/gal) for heavy haul roads and mining roads; and .0067 gal/sft (150 sft/gal) for temporary roads and detours. For the test sections, the undiluted application rates were:

Test Section	Performance Period	Application Rate		Dilution Ratio	Material Cost	
		Gal/sft	Sft/gal		$/SFT	$/Test Section
3B	1 week	.013	80	1:9.3	$.137	$4,179
2B	2 week	.017	60	1:6.8	$.195	$5,850
1B	4 week	.020	50	1:5.7	$.244	$7,313

Table 3 – Application Rates for *Soiltac*

Test Site Description

The test sections were incorporated into the Tok Cutoff MP 0-2 and MP 5-24 Resurfacing project. The test sites were located between MP 22 to 24 of the Tok Cutoff Highway – approximately 35 miles northeast of Glennallen. The scope of this construction project is to reconstruct the Tok Cutoff Highway by:

- Milling the existing pavement
- Blending the milled pavement with the top 6” of existing base course
- Place Crushed Aggregate Base Course (CABC) of varying thickness to establish profile grade
- Construct two layers of Asphalt Surface Treatment (“B” & “C” chips) in accordance with Section 405(3) of the *Alaska Standard Specifications for Highway Construction.*

Control Section	Section 3C	Section 3B	Section 3A	Section 2C	Section 2B	Section 2A	Section 1C	Section 1B	Section 1A
Water	FB 400 (.008 gal/sft)	*Soiltac* (.013 gal/sft)	*Durasoil* (.014 gal/sft)	*FB 400* (.0125 gal/sft)	*Soiltac* (.017 gal/sft)	*Durasoil* (.02 gal/sft)	*FB 400* (.025 gal/sft)	*Soiltac* (.02 gal/sft)	*Durasoil* (.025 gal/sft)
	1 week			2 week			4 week		

Glennallen ←   Tok →

FB 400 = Freedom Binder 400

Figure 1 –Layout of Test Sections

Test Section Construction

Prior to applying the dust palliatives, the Crushed Aggregate Base Course (CABC) on the road surface was scarified and graded to a 2% - 3% cross slope. The CABC was compacted to 98% to 100% density. The moisture content ranged from 1.9% to 3.4%. Although it had rained the previous day, the road surface had dried sufficiently to require watering to control dust.

The CABC is a non-plastic 1” minus material. The percentage of CABC passing the #200 sieve varied from 3.7% to 4.9%. The CABC was in conformance with the following gradation specification:

Sieve Size	Percent Passing
1”	100%
¾”	70%-100%
#4	35%-65%
#8	20%-50%
#50	8%-30%
#200	0%-6.0%

Table 4 – CABC Gradation Specification

The test sections were located at the east end of the project. The material source was located east of the project. The placement of the CABC started at the east end and moved to the west. This resulted in approximately 200 to 250 gravel trucks (80-85 tons) traveling daily through the test sections.

All of the dust palliatives were transported to the project in 275 gallon totes. The dust palliatives were transferred to a 2,000 gallon tank on a flatbed truck where the *Soiltac* and *Freedom Binder 400* were mixed with water (Figure 2). All of the palliatives were placed on the road surface with a 15 long spray bar (Figure 3).

To allow application of the palliatives and sufficient time for curing, one lane was closed to traffic. A pilot car was used to direct traffic around the test sections. Since the lane closure would disrupt the hauling of the CABC material, the installation of the test sections was done on Sunday – when the trucks were not hauling CABC. (Note: If the placement of the CABC had started at the west end of the project and moved east, the gravel trucks would not have had to travel through the single lane closure area which would have allowed the application of the palliatives to occur at any time - independent of the truck haul.)

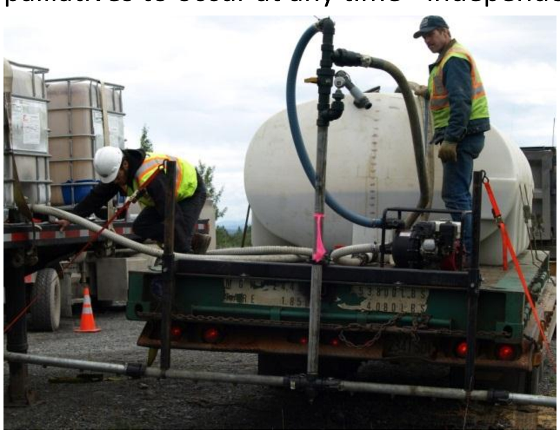

Figure 2 – Mixing palliative with water

Figure 3 – Applying the palliatives with a 15’ spray bar.

Placement of the palliatives was started at 8:00 AM and was completed at 11:20 PM. Single lane traffic was maintained until 12:30 AM the next day for a total of 16.5 hours of pilot car traffic control required to construct the nine 1,000 fo0ot long test sections.

Performance

Within hours after the test sections were opened to traffic, the *Durasoil* was picked up by vehicle tires and tracked on to the adjacent *Soiltac* and *Freedom Binder 400* test sections. The only portions of the test sections not tracked by the *Dursoil* were the eastbound lanes of test sections 3C and 3B. It is not known why the *Durasoil* tracked.

Test sections 3A, 3B and 3C with the lowest application rate needed to be watered within 2 days after the initial application instead of the projected 7 days. (Figures #4 - #6) The test sections for the medium (2A, 2B and 2C) and the high application rates (1A, 1B and 1C) needed to be watered 4 days after the initial application - significantly quicker than the projected 14 & 28 days.

Figure 4 –Section 3A – 7/18/2011 –One day after application of *Durasoil.* (Note the difference in levels of dust generated by the two vehicles traveling at the same speed)

Figure 5 - Section 3B – 7/18/2011 – One Day after application of *Soiltac*

Figure 6 - Section 3C - 7/18/2011 – One Day after application *of Freedom Binder 400*

Cost Comparison

The Alaska DOT/PF pays the Contractor $20 per 1,000 gal for watering as a Contingent Sum Item. For Contingent Sum Items, the price is set by the Alaska DOT/PF prior to bidding. The Alaska DOT/PF directs the Contractor on when and how often to apply water based on weather and traffic conditions. For a relatively hot (70 degrees) dry day, the road needed to be watered every 20-25 minutes to maintain acceptable visibility for traffic safety. (Appendix B) For the Tok Cut-off MP 0-2 and 5-24 Resurfacing project, a total of 9,210,000 gallons of water (219,285 gallons per lane mile) was used for temporary dust control during the 2011 construction season. The total cost is $184,190 ($4,385 per lane mile).

The following table compares the cost of watering and the material cost of one application of the palliatives at the three application rates used for the test sections. The cost of the equipment and traffic control for applying the palliatives was not included in the cost comparison. For comparison, the cost of applying Calcium Chloride as a dust palliative is $6,000 per lane mile.

Palliative	Application Rate		# of Applications	Total Qty. (gallons)	Cost	
	Gal./sft	Gal./lane mile			Lane/mile	Project Total
Water	2.8	219,285	All	9210,000	$4,385	$184,190
Freedom Binder 400	.008	634	1	26,611	$ 5,280	$218,744
Durasoil	.014	1109	1	46,570	$10,811	$454,054
Soiltac	.013	1030	1	43,243	$ 9,524	$400,000
Freedom Binder 400	.0125	990	1	41,580	$ 8,138	$341,788
Durasoil	.020	1584	1	66,528	$15,444	$648,648
Soiltac	.017	1346	1	56,549	$12,454	$523.076
Freedom Binder 400	.025	1980	1	83,160	$ 16,276	$683,575
Durasoil	.025	1980	1	83,160	$19,305	$810,810
Soiltac	.020	1584	1	66,528	$14,652	$615,384

Table 4 – Cost Comparison of Watering and Palliatives

Evaluation of Aerosol Monitors for Contract Enforcement

The feasibility of two aerosol monitors were evaluated for contract enforcement – hand held *DustTrak II Model 8532* and UAF-DUSTM with the *DustTrak II Model 8530*.

The *DustTrak II* aerosol monitors measure the concentration of particulate matter 10 microns in diameter or smaller (PM10). Concentrations of PM10 are determined based on the sampled airstream's opacity. Concentrations are measured every second and recorded to the internal memory. Each test period is automatically logged into a separate file.

For the UAF-DUSTM, the aerosol monitor is enclosed in a protective case attached to the rear of an ATV. Flexible plastic tubing connects the aerosol monitor to an intake structure positioned 14 inches behind the tire and 14 inches above the ground surface. The intake is held in place by three rigid aluminum tubes to resist longitudinal, lateral, and vertical motion. As the ATV is driven across the test section, the concentration of PM10 generated by the rear tire is recorded every second. Environmental conditions during testing are recorded using a *Kestrel 4500 Weather Meter*. A GPS data logger tracks the location and speed of the ATV.

Conclusions

- Watering is more cost effective than *Durasoil, Soiltac* and the *Freedom Binder 400* for temporary (1-4 weeks) dust control for construction projects.

- The *Durasoil, Soiltac*, and *Freedom Binder 400* palliatives were not successful in providing the desired 7 day, 14 day and 28 days of acceptable temporary dust control using the following application (undiluted) rates.

Performance Period	***Freedom Binder 400***	***Durasoil***	***Soiltac***
1 week	.008 (125 sft/gal)	.014 (70 sft/gal)	.013 (80 sft/gal)
2 week	.0125 (80 sft/gal)	.020 (50 sft/gal)	.017 (60 sft/gal)
3 week	.025 (40 sft/gal)	.025 (40 sft/gal)	.020 (50 sft/gal)

Application Rates (gal/sft)

- The additional 200-250 trucks per day due to the construction activities had a significant impact on the performance of the dust control measures.

- The *Durasoil, Soiltac* and the *Freedom Binder 400* are more difficult to apply than water as a dust palliative because:

- The palliatives require a spray bar instead of a splash plate to control overspray
    - The *Soiltac* and *Freedom Binder 400* require mixing with water
    - Traffic control and lane closures are required during application of the *Soiltac* and *Freedom Binder 400*.
    - The *Soiltac* required a 20-30 minute cure time between each of the four applications

- The quantity of dust generated by a vehicle is dependent on the vehicle size and speed. A large truck traveling at 45 MPH generates significantly more dust than a smaller passenger vehicle traveling 30 MPH.

- An alternative to reducing the amount of watering required to control dust is to lower the speed limit through the construction zone.

- It was not practical to measure the dust concentrations on a high volume high speed road with the UAF-DUSTM because:
    - It is not safe to operate a four wheel ATV traveling 25 MPH with the rest of the traffic traveling at higher speeds.
    - A correlation has not been established between the amount of dust generated by a truck traveling 45 MPH and a four wheel ATV traveling 25 MPH.

- It was not practical to reliably measure the dust concentrations with the handheld *DustTrak II Model 8532*. The vehicles would slow down and move to the other lane when they see a person standing on the road taking dust concentration measurements.

Recommendations for Future Research

- Investigate other palliatives such as glycerine or soap to determine potential benefits of extending the performance of watering for dust control.
- Develop speed/dust relationships for construction vehicles including the commonly used semi belly/side dump trucks.
- Track the change in moisture content vs. generation of dust using a continuous monitor during normal watering operations.
- Develop an understanding of why trucks loft more dust than light vehicles and the size of particles lofted.

- Investigate the effects of the height of the dust plume. The height is important for environmental concerns.
- Investigate the use of stationary monitors, such as those used by EPA to determine compliance with PM10 regulations (EBAMs, TEOMs, Hi-Vols, etc.), for use in contract enforcement.
- Establish an acceptable level of emissions, based on either opacity, concentration, or moisture content as predicted by AP-42

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Appendix A

Vehicle Speed Effects on Dust

Dust concentration levels generated by a pickup truck traveling at 15 MPH, 20 MPH, 25 MPH, 30 MPH, 35 MPH, 40 MPH and 45 MPH were measured. The tests were conducted on Dawson Road in North Pole (Figures B1-B6) which had not had any form of dust control within the past year. For comparison, the dust concentration generated by the same pickup traveling at 25 MPH and 35 MPH were also measured on an adjacent road (Sharon Rd.) which had been treated with *Durasoil* the previous summer (Figures B-7 & B-8).

The test vehicle was a 2005 Ford-150 pickup. The maximum and average (1 minute) PM-10 were measured using a handheld *DustTrak II Model 8532* taken 10' and 12' from the center of the vehicle. The *DustTrak II* was approximately 3 feet from the ground surface. The PM-10 measurements are summarized in Table 1.

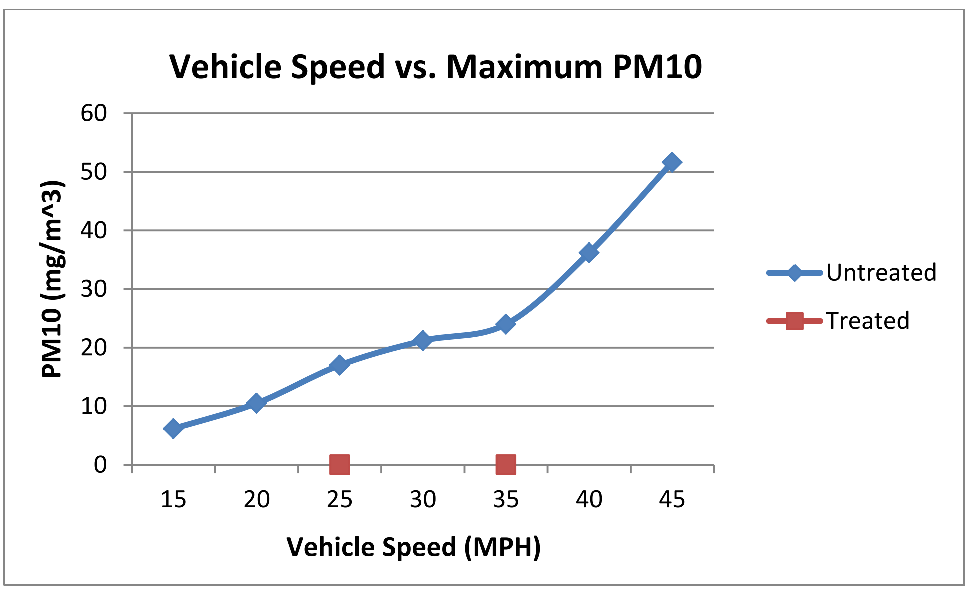

Figure A-1 – Vehicle Speed vs. Maximum PM10 at 12'

Figure #A-1 – 15 MPH (Max. PM10 = 6.3; Avg. PM 10 = .7)

Figure #A-2 –25 MPH (Max. PM10 = 17.0; Avg. PM 10 = 2.3)

Figure #A-3 – 30 MPH (Max. PM10 =21.2; Avg. PM 10 = 4.0)

Figure #A-4 – 35 MPH (Max. PM10 = 24.0; Avg. PM 10 = 4.2)

Figure #A-5 – 40 MPH (Max. PM10 = 36.2; Avg. PM 10 = 5.0)

Figure #A-6 – 45 MPH (Max. PM10 = 51.6; Avg. PM 10 = 7.4)

Figure #A-7 – Max. PM10 = .09; Avg. PM 10 =.01 (25 MPH)

Figure #A-8 – 35 MPH - Max. PM10 =.03; Avg. PM 10 = .01

Road	Dust Palliative	Speed (MPH)	Dist from CL (ft)	Average PM10	Max PM10	Min PM10	Avg Avg PM10	Avg. Max PM10	Avg. Min PM10
Dawson	No	15	10	1.210	13.900	0.007	1.032	9.435	0.007
Dawson	No	15	10	0.854	4.970	0.006			
Dawson	No	15	12	0.095	2.400	0.007	0.381	2.870	0.006
Dawson	No	15	12	0.667	3.340	0.005			
Dawson	No	20	10	1.650	6.430	0.011	1.615	6.295	0.011
Dawson	No	20	10	1.58	6.16	0.01			
Dawson	No	20	12	1.510	15.100	0.006	1.865	14.700	0.006
Dawson	No	20	12	2.220	14.300	0.006			
Dawson	No	25	10	2.760	18.900	0.012	2.000	20.500	0.010
Dawson	No	25	10	1.240	22.100	0.008			
Dawson	No	25	12	3.020	10.000	0.038	3.020	10.000	0.038
Dawson	No	30	10	1.990	15.200	0.005	1.990	15.200	0.005
Dawson	No	30	12	2.840	10.900	0.012	4.733	23.167	0.008
Dawson	No	30	12	5.330	34.600	0.005			
Dawson	No	30	12	6.030	24.000	0.006			
Dawson	No	35	10	5.210	24.200	0.082	5.210	24.200	0.082
Dawson	No	35	12	3.130	23.800	0.118	3.130	23.800	0.118
Dawson	No	40	10	4.240	53.400	0.006	6.525	49.550	0.006
Dawson	No	40	10	8.810	45.700	0.006			
Dawson	No	40	12	6.120	25.200	0.028	4.520	29.000	0.028
Dawson	No	40	12	2.920	32.800	0.028			
Dawson	No	45	12	10.100	87.200	0.017	7.350	51.633	0.019
Dawson	No	45	12	7.210	33.600	0.018			
Dawson	No	45	12	4.740	34.100	0.021			
Sharon	Yes	25	12	0.015	0.060	0.005	0.013	0.092	0.006
Sharon	Yes	25	12	0.011	0.124	0.006			
Sharon	Yes	35	12	0.012	0.028	0.006	0.011	0.028	0.006
Sharon	Yes	35	12	0.010	0.027	0.005			

Table A-1 – Summary of PM -10 Measurements

Appendix B

Watering for Dust Control

The Alaska DOT/PF pays $20 per 1,000 gal for watering as a Contingent Sum Item. For Contingent Sum Items, the price is set by the Alaska DOOT/PF prior to bidding. The Alaska DOT/PF directs the Contractor on when and how often to apply water based on weather and traffic conditions.

The following pictures illustrate that for a relatively hot (70 degrees) dry day, the road needed to be watered every 20-25 minutes to maintain acceptable visibility for traffic safety. To illustrate the differences in visibility, a sign was placed at 500’ (sight distance for 55 MPH), Type II barricade was placed at 350’ (sight distance for 45 MPH) and a Type II barricade was placed at 200’ (sight distance for 30 MPH). The speed of the trucks were not measured, but it is assumed that all of the trucks in the photos were traveling at the posted speed limit of 45 MPH.

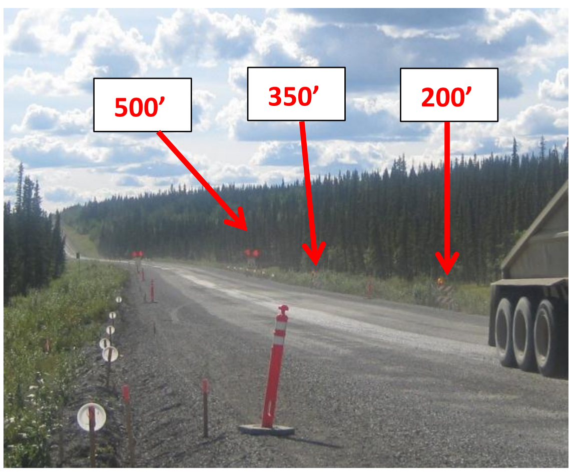

Figure #B-1 – Taken shortly after watering

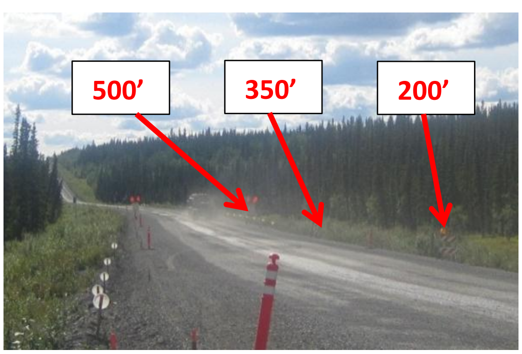

Figure #B-2 – Six minutes after watering

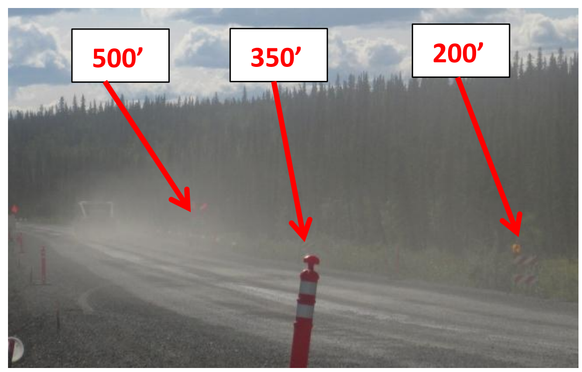

Figure #B-3 – 9 minutes after watering

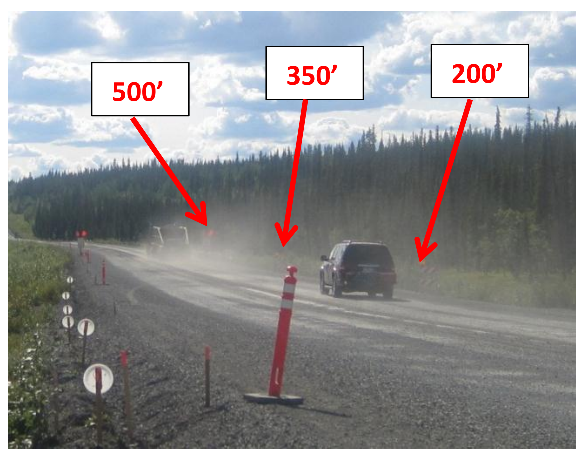

Figure #B-4 – 17 minutes after watering

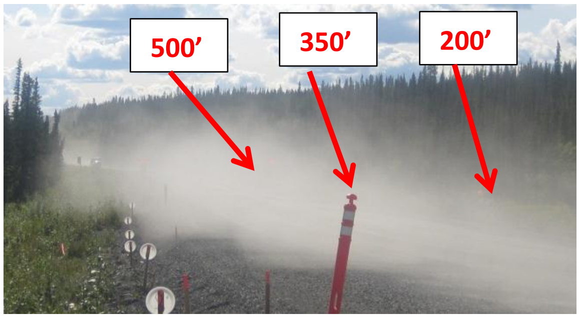

Figure #B-5 – 21 minutes after watering

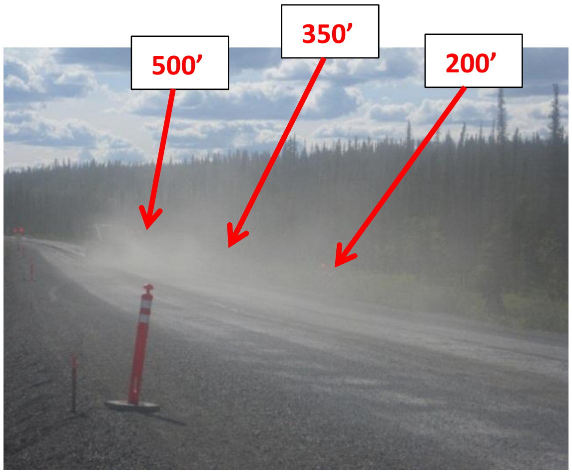

Figure #B-6 – 24 minutes after watering