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Alaska Rural Dust Control Alternatives

prepared for:

Alaska Department of Environmental Conservation

January 2006

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1. INTRODUCTION

Air quality monitoring data collected in several rural Alaska communities over the past few years reveals elevated levels of PM_{10}. The high readings are coupled with complaints of heavy dust conditions reported to the Alaska Department of Environmental Conservation (ADEC) from residents of these communities together with anecdotal information from local hospitals of increases in health problems and visits during these periods. (Trost, 2003)

Review of information collected from emission inventories and interviews of rural community residents has led ADEC to conclude that unpaved road use is a significant contributor to elevated PM_{10} levels in these communities. ADEC is interested in evaluating alternative methods for control of dust emissions from unpaved road use to assist the communities in air quality improvement. ADEC also believes that control measures that reduce emissions from unpaved road use will also reduce emissions from unpaved airfield use and from windblown dust emissions from these surfaces.

ADEC has requested that a study be conducted of these control measures that would:

1. develop a matrix of feasible dust control strategies for reducing road and airport dust emissions;
2. identify costs and benefits of various dust control materials and strategies, and
3. identify and prioritize needs for identifying, selecting, and implementing effective, economic, and environmentally sound dust control measures.

Sierra Research (Sierra) was selected by ADEC to prepare this study. Sierra has significant experience in the evaluation of dust control measures and has conducted similar studies for a number of regional governments and air quality regulatory agencies. For this study, Sierra performed a literature search on dust control from unpaved roads and collected specific data relative to dust problems in two rural Alaska communities and promising dust control measures.

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2. LOCAL CONDITIONS

Due to the limited budget and schedule for completing this study, Sierra was not able to evaluate the feasibility of implementing dust control measures throughout rural Alaskan communities. Instead, we collected data from two communities that were deemed to be somewhat representative of those with elevated PM_{10} impacts. The communities selected by ADEC for focused study were Kotzebue and Noatak.

Climate

The region in which Kotzebue and Noatak are located experience long, cold winters and short, cool summers.(ADCA. 2006) In Kotzebue, the average low temperature during January is -12ºF; the average high during July is 58ºF. For Noatak, temperatures average -21ºF to 15ºF during winter; 40ºF to 60ºF during summer. Snowfall averages 40 to 48 inches, with total precipitation of 9 and 12 inches per year in Kotzebue and Noatak, respectively. Kotzebue Sound is ice-free from early July until early October. Relative humidities in the region average over 60% for each month of the year.(Teck Cominco, 2005) The relatively cold temperatures in the region, however, mean that absolute humidities, or the total quantity of water in the air, is low except on the warmest of days. At Kotzebue, mean wind speeds range from 9 miles per hour in May to 13 miles per hour in January.(Trost, 2004) Extreme gusts exceed 34 miles per hour every month of the year. At these levels, Kotzebue is considerably windier than the average of all other monitored American communities.(City-Data, 2006) The combination of frequent wind and low absolute humidity means that exposed soil surfaces dry quickly after precipitation occurs and remain dry until the next precipitation event.

Demographics

Kotzebue and Noatak are rural communities located north of the Arctic Circle on or near the Kotzebue Sound in northwestern Alaska. Kotzebue lies on the Baldwin Peninsula bordering the Sound, while Noatak is approximately 55 miles north of Kotzebue on the Noatak River, which feeds into the Kotzebue Sound. Kotzebue, with a population of 3,130 people, is a coastal community and regional service and transportation center for smaller communities in the region. Noatak, with a population of 448, is an inland community representative of the fishing and subsistence economies of the region in general.

Roadways

Both communities depend on unpaved roads for intracommunity travel. Unpaved roads are used by a combination of light duty passenger vehicles, all-terrain vehicles, and snow machines. Both communities have access to limited gravel supplies, which are found in sporadic deposits and are used to construct and periodically resurface unpaved roads. Kotzebue, for example, imports gravel by barge from a commercial pit approximately 30 miles away.

Soils

The general geology of the region in which Kotzebue and Noatak lie consists of glacial alluvium deposited on the southern flank of the Brooks Range and redeposited by forces of water and wind.(Schoephorster, 1965; Furbush, 1971) The alluvium contains high levels of finely ground dust that contributes to dust emissions during disturbances of soil surfaces, either from mechanical abrasion or wind entrainment. Permafrost underlies most soils in this region, and limits the depths to which excavations can be undertaken for the recovery of fill material or gravel.

Kotzebue – The surface soils on most of the Kotzebue spit are poorly drained with high organic contents. The organic content derives from partially decomposed peat and the many roots of grasses, shrubs, and sedges. Because of the organic content and the lack of clay, these soils are nonplastic, or not cohesive, and not suitable for roadway structural sections or surfaces.(Furbush, 1971) The structural sections of roadways are best constructed from materials excavated from the limited deposits of gravelly sand located in the old beach ridges on the spit. Although these soils lack cohesion, their surfaces can be consolidated with appropriate treatment to reduce the release of fines and the generation of fugitive dust under vehicle travel.

Noatak – No soil survey has been conducted in Noatak. However, surveys are available for other rural communities in the area of Noatak that lie along rivers. Two such surveys were conducted in the Kobuk and Deering communities, which are 128 miles northeast of Kotzebue on the Kobuk River and 57 miles southwest of Kotzebue at the mouth of the Inmachuk River, respectively.(Schoephorster, 1965; Hinton, 1967) The soils in these communities are primarily sandy loams that are nonplastic.

PM_{10} Levels

PM_{10} measurements have been collected in Kotzebue and Noatak on a seasonal basis in the past several years. These measurements have shown exceedances of the federal 24-hour PM_{10} ambient air quality standard of 150 ug/m^3 during the dry period of the year between breakup in early May and the arrival of increased rainfall in late July.

Kotzebue – In 2002, PM_{10} concentrations were monitoring by five filter-based samplers and one continous sampler at five locations in Kotzebue. Four of the locations were located adjacent (two upwind, two downwind) of a major unpaved road in the community, and the fifth was located within the community but not adjacent to roadway.

The monitoring period spanned from June 29 to September 25, 2002, and no exceedances of the federal 24-hour standard were recorded. These concentrations were lower than was expected, perhaps because of the late project start, missing the dry months of May and June, and the location of the continuous sampler at an upwind roadway site.(Trost, 2004)

In 2003, PM_{10} monitoring was conducted at the same five locations between May 31 and July 24. During this monitoring effort, a continuous PM_{10} monitor was located at one of the downwind roadway sites. During this period, several exceedances of the federal 24-hour standard were measured. PM_{10} measurements correlated with precipitation, meaning that 24-hour averages declined on days when precipitation fell, but an analysis of the data with respect to wind speed and direction did not yield any conclusive results.(Trost, 2004) A correlation of average daily PM_{10} with diurnal traffic counts also did not reveal a simple relationship.

In 2004, PM_{10} monitoring was conducted only at the pair of roadway sites recording the higher traffic counts and PM_{10} measurements in 2003. Filter-based samplers were used at each of the two sites and one continous sampler was co-located at the downwind roadway site. The monitoring period spanned between May 26 to July 20, and several exceedances of the federal 24-hour standard were recorded. As in 2003, no distinct correlations could be found between PM_{10} measurements, wind speeds, and wind directions. During one of the exceedance days, however, all of the monitors recorded elevated measurements while the community was impacted by smoke from wildfires as verified by decreasing visibility as reported by the National Weather Service. (Trost, 2004)

Average and maximum 24-hour average PM_{10} values recorded in Kotzebue during these three monitoring periods are presented in Table 1. Values are reported separately for filter-based samplers and the continuous sampler as the continuous sampler usually reported higher measurements than the co-located filter samplers.

Table 1
Kotzebue PM_{10} Monitoring Data

	2002	2003	2004
Filter-Based Measurements			
No. of Sampling Days	14	28	28
No. of Exceedance Days	0	5	10
Max. 24-Hour PM_{10}, µg/m^3	121	220	351
Highest Avg. 24-Hr. PM_{10}, µg/m^3	50	55	131
Continuous Monitoring			
No. of Sampling Days	89	48	50
No. of Exceedance Days	1	10	10
Max. 24-Hour PM_{10}, µg/m^3	172	560	371
Average 24-Hr. PM_{10}, µg/m^3	28	94	93

These data indicate that 24-hour average concentrations of PM_{10} exceed the national ambient air quality standard, and that mitigation of fugitive dust emissions in areas proximate to the monitoring sites is warranted.

Noatak – PM_{10} monitoring was conducted in Noatak at a single monitoring site in 2003 and 2005. The monitoring site was located adjacent to a major unpaved road in the community and the community school. No monitoring of traffic or meteorological conditions was conducted in this community during these years.

In 2003, one filter-based sampler was operated intermittently between February 27 and September 12 in Noatak. One exceedance of the national 24-hour PM_{10} was recorded during ten acceptable monitoring days. Data collected during 7 of 17 monitoring days could not be used due to failure to satisfy federal monitoring criteria with respect to run times. Monitoring was not conducted between May 13 and July 2, when precipitation levels are the lowest of the year and when Kotzebue measured some of its highest PM_{10} measurements of 2003.

During the summer of 2005, two co-located filter-based samplers were operated in Noatak. Monitoring commenced on May 28, 2005, and data has been reported through November 6, 2005. During this period, several exceedances of the national 24-hour standard were recorded. Summaries of the Noatak monitoring data from 2003 and 2005 are presented in Table 2.

Table 2
Noatak PM_{10} Monitoring Data

	2003	2005
Filter-Based Measurements		
No. of Sampling Days	10	25
No. of Exceedance Days	1	9
Max. 24-Hour PM_{10}, µg/m^3	152	601
Average 24-Hr. PM_{10}, µg/m^3	38	177

These data indicate that 24-hour average concentrations of PM_{10} periodically exceed the national standard and that mitigation of fugitive dust emissions proximate to the monitoring sites are warranted.

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3. DUST CONTROL MEASURES

Controls for dust emissions from unpaved roads take several forms. These forms can include:

- reducing the numbers of vehicles using unpaved roads;
- reducing vehicle speeds on unpaved roads;
- correcting road design problems;
- increasing the moisture content of unpaved road surface soils;
- binding smaller particles to larger particles in unpaved road surface soils;
- covering unpaved road surface soils with gravel; and
- sealing unpaved road surface soils with pavement or other impermeable materials.

In the following sections, general information on each of these categories of control are presented. More detailed information is provided in Appendix A on controls that involve the application of dust palliatives applied to road surfaces. A list of controls considered to be technologically infeasible in northwestern Alaska, together with the reasons for infeasibility, are presented in Table 3 at the end of this section.

Reducing Numbers of Vehicles

PM_{10} emissions from unpaved road travel are directly proportional to the number of vehicles traversing an unpaved road section. Emissions can be reduced by reducing the numbers of vehicles using an unpaved road, and this can be achieved by imposing weight or vehicle use restrictions, or by removing an unpaved road from service, among other methods. An example of this type of control was enacted recently by the City of Kotzebue, which now prohibits anyone under 14 years of age from operating an offroad vehicle (snowmachine and all-terrain vehicle) on city streets unless accompanied by an adult on the same machine.(Kotzebue, 2006) Closing a unpaved road to traffic may not be practical in rural Alaskan communities as restrictions imposed or induced on one unpaved road will simply divert traffic to other unpaved roads in affected communities.

Reducing Vehicle Speed

Studies show that PM_{10} emissions are proportional to vehicle speed. Based on an initial speed of 40 miles per hour, a reduction in the speed limit to 20 miles per hour results in a 65% reduction in dust emissions.(Succarieh, 1992) Vehicle speeds can be reduced

through road postings and enforcement, or by altering the road surface to install waterbars (drainage channels) or speed bumps. Depending on the availability of law enforcement resources and community social cohesion, the enforcement of speed limits on unpaved roads may be practical method of reducing PM_{10} emissions on heavily traveled unpaved roads. Roughing a roadway surface by installing speed bumps or waterbars to reduce speeds is of limited practicability as speeds creating dust emissions will be reduced only within a relatively short distance of the vertical disturbance.

Correcting Road Design Problems

The long term performance of any dust suppressant applied to a road surface will depend on the ability of road to shed water and provide a smooth driving surface. If the road surface is not well drained through crown and crossflow improvements, water will puddle either on the road surface or in adjacent low spots. Surface water will float soil fines from the underlying soil and distribute them across the roadway surface with passing traffic. Standing water adjacent to a roadway has the potential to saturate the road sub-base, resulting in structural failure as evidenced by potholes. Aggregate in a roadway surface reduces tire forces on fine materials that increases the release of dust from a roadway. The loss of fines in the roadway surface leaves the aggregate unanchored and vulnerable to being pushed to the side of the road by tire forces. The success of palliatives to reduce dust depends on the repair and maintenance of good drainage on and adjacent to the road. (CPWA, 2005)

Increasing Moisture Content

Moisture in the surface soils of unpaved roads causes particles to adhere to each other through the surface tension of connecting water droplets and the adhesion of droplets to dust particles. The moisture content of surface soils can be increased either through direct application of water to roadway surfaces, or through the attraction of water to deliquescent salts added to surface soils.

Water is available in significant quantities in almost all rural Alaskan communities. Methods of conveying this water economically to unpaved roads for application as a dust control agent is problematical in smaller communities. Some larger communities, like Kotzebue, have water trucks in the fleets of roadway maintenance vehicles, and can take advantage of local water supplies for use in dust control efforts. Smaller communities do not have access to such equipment and have only limited capacity to apply water in sufficient quantities to effectively control dust emissions. Watering provides short term reductions in dust generation depending on surface evaporation rates. Regular, light watering is more effective than less frequent, heavy watering.(Bolander, 1999)

Unpaved road dust control can also be implemented by the application of deliquescent salts to roadway surfaces. Calcium chloride and magnesium chloride asbsorb moisture from the air to keep surface soils in which these chemical have been mixed at higher moisture contents than untreated soils. At 77ºF and 90% humidity, for example, calcium chloride will absorb more than 17 times its own weight in water.(CPWA, 2005) The

performance of chlorides depends on the percent of surface soil passing a 200-mesh screen, with recommendations between 10 and 20 percent.(Morgan, 2005) Potential disadvantages to the use of these salts are that roads may become slippery when wet and vehicle corrosion may occur. Additionally, prolonged rainfall will leach the salts from the roadway. The practical utility of an application of one of these salts is no more than one year.(Morgan, 2005) Sodium chloride, or common rock salt, is also deliquescent, and has been tested in a limited number of studies, but it is not as effective as calcium or magnesium chloride.

Calcium chloride has been tested and used as a dust control palliative in several locations in Alaska over the past several years. These locations include Kotzebue, Teck Cominco's Red Dog Mine, and Haines, among other locations. The general experience has been that calcium chloride produced visible reductions in fugitive dust generation and remained somewhat effective for a summer season without any problems or adverse environmental impacts. (Baxter, 2001)

Binding Particles Together

The largest group of dust palliatives used on unpaved roads and airfields consists of chemicals that are designed to bind fine soil particles together or to larger particles. These chemicals fall into several subgroups, such as:

- petroleum-based binders,
- organic nonpetroleum dust suppressants,
- electrochemical stabilizers, and
- synthetic polymer products.

Petroleum-based Binders – Petroleum-based binders used for dust suppression include emulsified asphalts, cutback asphalt, and Bunker C. These agents are used to coat surface soil particles with a thin layer of asphalt that increases their mass and decreases their likelihood of becoming airborn. Some of these binders exhibit no adhesive properties, however, but instead increase the mass of fine particles, reducing their ability to become airborne.(Nevada DOT, 2003) Emulsified asphalt, because it is a mixture of asphalt and water in very small droplets, has the capability to penetrate unpaved road surfaces to coat more than just the surface particles, especially if the product is mechanically mixed into the top inch or two of road surface with a grader. Because of their petroleum base, these products can contaminate waterways if any migration due to runoff occurs.

Organic Nonpetroleum Dust Suppressants – Organic nonpetroleum dust suppressants include lignosulfonates, resins, and vegetable oils. Lignosulfonates derive from the manufacture of paper during which lignin is extracted from wood fibers. Lignin binds wood cells together and is a natural polymer. As a byproduct of paper manufacture, it occurs in solution with sodium, calcium, ammonium, or magnesium bisulphate. Lignosulfonates bind soil particles together due to a combination of chemical and physical interactions. Resins are usually synthesized as combinations of lignosulfonates

and additives designed to neutralize adverse effects. Lignosulfonates are water soluable and will leach out of, or deeper into, roadway surface with rainfall. These products are also corrosive to aluminum and its alloys unless calcium carbonate is added. Lignosulfonates have a useful duration of six months and work best with surface materials that have high fine contents and high plasticity indices in a dry environment.(CPWA, 2005) Because glacial tills contain low levels of clay and have low plasticity indices, lignosulfonates may be of limited value in controlling dust emissions from these soils.

Electrochemical Stabilizers – Electrochemical stabilizers include sulphonated petroleum, ionic stabilizers, and bentonite. These products are intended to neutralize hydrophilic soils and allow for the formation of water tension bonds between particles to bind them. To be effective, electrochemical stabilizers need to be worked into the road surface, requiring equipment that may not be available in remote rural communities.

Synthetic Polymer Products – Synthetic polymer products include polyvinyl acrylics and acetates that are designed to bind soil particles together and form a semi-rigid film on the road surface. These products are formulated as either water soluable liquids or dry powders intended to be mixed with water. Because the products are applied in liquid form and required to dry in binding soil particles together, care needs to be taken after application to assure that temperatures during the curing period will not approach freezing and that traffic will be diverted from application areas until curing is completed. Curing periods typically extend from 12 to 24 hours. Synthetic polymer products have been used for dust control and improved soil strength on a number of airfields in Northern Canada and Alaska.

Covering of Unpaved Road Surface Soils With Gravel

The abrasion of unpaved road surface soils and release of fugitive dust by unpaved road traffic can be reduced by the application of gravel to the road surface. Gravel provides a hard wearing surface that protects soils from the abrasive forces of vehicle wheels. Gravel will not reduce the strength of vortex airflows behind passing vehicles from entraining loose soil particles into the air, however. In the absence of a well constructed roadbase using crushed aggregate, surface gravel will be pushed down into the road surface by traffic, especially during wet conditions. If the road surface does not contain a sufficient quantity of fine material of high plasticity (cohesion) to hold surface gravel in place, traffic can also cause surface gravel to be expelled laterally from the road's driving lanes. To be effective over more than a short period of time, new gravel applied to a road must be anchored to the road surface by incorporation into a cohesive surface layer, whether by use of well graded aggregate mixes or by use of soil adhesives.

In the event that gravel is lost to the roadway surface through vertical migration into noncohesive soils in the subbase, the use of geotextile fabrics may be of benefit. These fabrics are constructed of polymer threads that are very high in tensile strength, and are available in designs that either form water barriers or allow water, but not fine soil, to migrate through. (Hopkins, 1989)

Sealing of Unpaved Road Surface Soils With Pavement or Other Impermeable Materials

The most effective, and expensive, method of controlling fugitive dust emissions from unpaved road surfaces is the application of pavement or other impermeable materials to the road surfaces. Asphalt concrete and Portland concrete wear courses, when applied to road surfaces, provide durable and effective traffic surfaces that prevent the abrasion of soil surfaces. Except for roadways carrying more than 250 to 500 vehicles per day, the use of paving to control dust emissions may not be cost-effective.(Bolander, 1999) In the past few years, several roads in Kotzebue that carry more than 500 vehicles per day have been paved.(Hadley, 2006) Thin pavements, such as chip seals, have been applied to roads in southern Alaska, but these surfaces have fallen apart completely during the first breakup. (Reckard, 1988)

Fiberglass plates are used in cold climate oilfields to provide temporary road surfaces over native soil. These interlocking plates are typically manufactured in sections that are 14 feet long by 8 feet wide by 2 inches thick. The plates are designed to carry very heavy loads over short distances without the need to construct structural roadbeds in areas like northwestern Alaska where construction aggregate is in very limited supply. The plates are expensive, costing about $2,000 per plate, but appear to have an almost indefinite lifespan. (Compositech, 2005)

Control Methods Deemed Infeasible

From analysis of the studies cited in this section, several methods for controlling dust emissions from unpaved roads in rural Alaskan communities were deemed to be technologically infeasible. A list of those methods, together with the reasons for infeasibility, is presented in Table 3.

Table 3
Control Methods Deemed Technologically Infeasible in Northwestern Alaska

Dust Control Category	Specific Product	Reasons for Infeasibility
Petroleum-Based Binders	Cutback Asphalt	Petroleum products that are non-biogradable will contaminate runoff during breakup
	Bunker C	

Selection Guides

Several publications found in the literature search for this study contain selection guides for choosing chemical dust palliatives on the basis of road traffic levels, soil type, and other parameters. These guides are presented in Appendix B.

Bibliography

An extensive bibliography of unpaved road dust control literature has been compiled by Temple Stevenson for a report on dust control methods for unpaved mining roads in Wyoming's Powder River Basin.(Stevenson, 2004) This bibliography is reproduced in Appendix C.

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4. COSTS AND BENEFITS

The costs of dust control on unpaved roads in rural Alaskan communities can be calculated on the basis of available market data, but the benefits of each control method will vary depending on the soil type, traffic level, and road design, among other factors. As a result, approximate costs for various control methods are presented here on the basis of delivery to and application in Kotzebue. The control methods included in the cost analysis are limited to those that are technologically feasible in northwestern Alaska. The ranges of control effectiveness for each of the control methods derive from the literature, not from studies conducted in cold climates.

The costs of dust control methods, per mile of treated roadway in northwestern Alaska, are summarized in Table 3. Labor and equipment costs are based on data provided by the Alaska Department of Transportation and Public Facilities (ADOT&PG). (Adler, 2006) Detailed cost calculations are presented in spreadsheet format in Appendix C.

Table 3
Dust Control Method Costs and Effectiveness
($ per mile of road treated)

Dust Control Category	Specific Product	Control Cost ($ per mile of road treated)	Control Effectiveness Range	Control Duration
Moisture Increase	Watering	$32	0% - 50%*	1-2 hours
	Calcium Chloride	$26,000	0% - 70%**	6 months
Particle Agglomeration	EK-35	$20,000	0% - 99%***	1 year
	Lignosulfonate	$22,000	0% - 90%*	2 months
Soil Coverage	Gravel	$84,000	0% - 30%*	3 months
	Geotextile	$27,000	N/A	10 years
	Asphalt Paving	$2,700,000	90% - 99%	15 years
	Fiberglass Plates	$2,800,000	90% - 99%	10 years

*Orlemann, 1983
**Morgan, 2005
***MRI, 2002

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5. RECOMMENDATIONS

Dust Control Measures

In the context of rural Alaskan communities, unpaved road dust control is expensive. This outcome is due to the transportation costs of dust palliatives, the scarcity of aggregate, and the limited equipment available for road improvement and maintenance. Because of these conditions, dust control in these communities should start with the least expensive options first. These options include speed controls and restrictions on vehicle use in sensitive areas (i.e., near schools, hospitals, and residential areas).

The next least expensive control method is the reconstruction of unpaved roads to provide good drainage and a solid base. The use of geotextiles to support a road surface over poor quality soils is a reasonably cost-effective method of improving road structure in areas where underlying soils impose requirements for frequent maintenance. Without good drainage and road base, the benefits of additional dust control measures will be limited. Where useful, rural community representatives should enlist assistance from the ADOT&PG Local Technical Assistance Program to identify the causes of unpaved road structural failures and evaluate the options for resolving deficiencies.

Depending on the availability of equipment and manpower, the watering of roads during high dust periods is an available if not wholly effective method of dust control. Because monitoring data suggest that high dust generation rates occur sporadically during the two month period following breakup, short term control measures like watering can provide limited benefits provided that impacted communities have access to water trucks.

The optimization of benefits from the application of dust palliatives is dependent on local soil and traffic conditions that require site-specific investigations. While some categories of palliatives can quickly be ruled out due to technological infeasibility, such as the use of liquid products that cannot tolerate freezing or petroleum-based products that are toxic to aquatic life, the selection of the most effective product of those that remain cannot be made without knowledge of the site in which dust control is to be achieved. Upon request, ADOT&PF can assist rural communities with soil analyses useful in the palliative selection process.

Depending on local soil and traffic conditions, some deliquescent salts and synthetic polymer products may provide adequate levels of dust control on rural community unpaved roads. These products, which include calcium chloride and EK-35, have been tested in several locations in Alaska and have been demonstrated to control dust emissions without adversely impacting sensitive environments. Because the successful use of these products is dependent upon a number of factors that vary from community to

community, pilot tests of selected products for a summer season should be undertaken in affected communities before community-wide application is pursued.

Further Research

Better characterizations of unpaved road structural conditions and soil characteristics are needed in rural communities with elevated PM_{10} levels in order to identify the most cost effective methods of dust control. This work could be undertaken by appropriate staff of ADOT&PF on a single visit basis to assist communities requesting help in reducing dust emissions.

Pilot project testing of dust palliatives and other methods of reducing emissions from unpaved road use should be undertaken in communities desiring to invest in dust control. The selection of dust control methods for testing should be based on an analysis of local road conditions. The benefits of dust palliative use should be measured with simple monitoring technology like the University of Colorado Dustometer, which can be quickly mounted in the bed of a pickup and uses common 8 inch by 10 inch fiberglass filters to collect dust samples while the pickup traverses either treated or untreated road sections. The results of pilot testing should be documented and published on a website for review by rural community representatives.

Finally, additional research on innovative control measures should be undertaken. The budget and duration of this study allowed for a limited review of the literature available on unpaved road dust control research. Given the challenges of climate and resource limitations in rural Alaskan communities, especially those in the northern portion of the state that are remote and accessible only by air, the standard solutions to unpaved road dust are not available. More work needs to be done in investigating and developing solutions that rely primarily on limited local resources.

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APPENDIX A

Summary Information on Dust Palliatives

(from Bolander, 1999)

APPENDIX B

Dust Palliative Selection Guides

(from Bolander, 1999; CPWA, 2005; and U.S. Army, 2006)

APPENDIX C

Bibliography

(from Stevenson, 2004)

APPENDIX D

Detailed Cost Calculations of Dust Control Methods