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Effectiveness of Dust Control Agents Applied to Tank Trails and Helicopter Landing Zones

by
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Operating wheeled and tracked vehicles on dry, unsurfaced roadways creates tremendous amounts of dust as soil particles are dislodged and carried into the atmosphere through wind action. Numerous products are available for controlling dust on unsurfaced roadways, but very little data exists from large-scale field experiments designed to evaluate their effectiveness, durability over time, and cost. To help installation public works, environmental, and natural resources managers select durable and cost-effective dust control products, a research/demonstration project on unsurfaced roadways was initiated at Fort Campbell, KY, during the summer of 1996. Products evaluated included calcium chloride, proprietary polyvinyl acrylic emulsion, and soybean processing by-products. At Fort Campbell, each dust control product was applied to recently graded unsurfaced roadways according to the manufacturers' recommendations. Dust control data were then collected at monthly intervals. Levels of dust control associated with each product and the untreated control area were evaluated using dust collection pans and photographic images captured after controlled vehicle traffic. Cost and performance data suggest that calcium chloride provides good levels of dust control for periods exceeding 90 days. Conversely, polyvinyl acrylic emulsion and soybean processing by-products were exhibiting deterioration after 60 days, especially on road surfaces completely covered with limestone aggregates.

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Foreword

This study was conducted for the Directorate of Public Works, Fort Campbell, KY, under; Reimbursable Order No. RPM27-95, "Tank Trail and Landing Zone Dust Control at Fort Campbell." The technical monitor was Ted Reece, AFZB-DPW-R-B.

The work was performed by the Resource Mitigation and Protection Division (LL-R) of the Land Management Laboratory (LL), U.S. Army Construction Engineering Research Laboratories (USACERL). The USACERL principal investigator was Dr. Dick L. Gebhart. Robert E. Riggins is Chief, CECER-LL-R; and Dr. William D. Severinghaus is Operations Chief, CECER-LL. The USACERL technical editor was Gloria J. Wienke, Technical Resources Center.

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COL James T. Scott is Commander and Dr. Michael J. O'Connor is Director of USACERL.

Contents

1 Introduction

Background

Operating wheeled and tracked vehicles on dry, unsurfaced landscapes creates tremendous amounts of fugitive dust as soil particles are dislodged and carried into the atmosphere through wind action. During wet weather, dislodged particles that have settled on the soil surface are subject to water erosion, which has the potential to carry them into surface waters, thereby reducing water quality and creating sedimentation problems for area streams and wetlands (Cowherd, et al. 1990).

Fugitive dust generated from helicopter, wheeled, and tracked vehicle training exercises has the potential to create many other problems. Most notable of these are associated with safety, air quality, increased military vehicle maintenance requirements, and tactical considerations (Armstrong 1987). Dust clouds generated from helicopter landing pads and tank trails impair the visibility of military vehicle operators, increasing the likelihood of accidents and injury. Excessive dust from tank trails acts as a respiratory irritant to military vehicle operators and is considered both a safety and air quality hazard when it drifts into nearby housing and administrative areas or onto adjacent highways and streets. Excessive wear and tear on military vehicles and aircraft results from the intrusion of dust into engine and turbine compartments, air filtering systems, and other sensitive mechanical and electrical components (Hass 1986). Finally, dust generated from helicopter and tank movement provides an unmistakable signature to enemy forces in a tactical scenario.

Although not directly related to the mission and training problems mentioned above, dust also has adverse effects on vegetation near helicopter pads, roads, and trails. A covering of dust on leaf surfaces increases leaf temperatures (Eller 1977; Hirano, Kiyota, and Aiga 1995) and water loss (Ricks and Williams 1974; Fluckinger, Oertli, and Fluckinger 1979), while decreasing carbon dioxide uptake (Fluckinger, Oertli, and Fluckinger 1979; Thompson, et al. 1984; Hirano, et al. 1990; Hirano, Kiyota, and Aiga 1995). These physiological changes suggest that vegetation around helicopter pads, roads, and trails is susceptible to chronic decreases in photosynthesis and growth, which may eventually lead to accelerated erosion problems resulting from the lack of adequate roadside vegetative stabilization.

Since the 1940s, numerous products have been developed and used to control dust on unsurfaced landing zones, roads, and trails. Some products, such as used motor oils, industrial manufacturing wastes, and other petroleum-based derivatives, have damaging environmental effects and their use is now prohibited. However, recent developments in dust control technology have provided a number of environmentally safe materials that are similar in cost, efficacy, durability, and maintenance requirements, especially on unimproved roadways where somewhat rougher terrain may make traditional road maintenance more difficult and costly.

The relative merits of various agents for controlling dust on helicopter landing pads, tank trails, and unsurfaced roadways have long been the subject of heated debate. At one time or another, nearly every conceivable material has been sprayed onto unsurfaced roadways in an attempt to control dust, stabilize the road surface, and reduce vehicle maintenance costs (Kirchner 1988). Manufacturer's claims are abundant, yet Department of Army public works, safety, and environmental managers have very little actual data upon which to base product selection. An aggressive dust control program requires a systematic evaluation of dust control agents, application rates, and maintenance requirements in order to be labor and cost effective. Therefore, large scale, field oriented, comparative product testing under carefully controlled and replicated experimental conditions is a necessary prerequisite for informed decisionmaking.

Objectives

The primary objective of this report is to evaluate the effectiveness, cost, and maintenance requirements associated with several different dust control agents when used on tank trails and helicopter landing zones at Fort Campbell, KY. This information will provide guidance to Fort Campbell environmental and safety managers in developing an aggressive and cost effective dust control program.

A secondary objective associated with this project is to use video imaging technology to develop a user-friendly, semi-quantitative method for evaluating the degree of dust control afforded by the various dust control agents. Development of this technology has significant safety implications in that the level of dust obscuration (visibility) resulting from training exercises can be readily ascertained and corrective actions taken if necessary. This capability was developed by researchers at the U.S. Army Construction Engineering Research Laboratories (USACERL) and used on this project; it will be available to other installations for this purpose. Continued development of this technology may also have the potential for further use in quantifying which combinations of dust control agent, application rates, and soil types afford the greatest reductions in military vehicle signatures.

Approach

The first task in this research project was to divide tank trails selected for treatment into sections with similar soil types, surface characteristics, aspects, and slopes. Further discussion of this process is presented in Chapter 2.

Applying selected dust control agents to tank trails and helicopter landing pads represented the next task. Details concerning the various dust control agents as well as application methods and rates also are presented in Chapter 2.

Collecting, analyzing, and interpreting data obtained from video imagery and dust samplers represented the final task of this research project. Chapter 3 summarizes the results associated with each dust control agent in terms of effectiveness, cost, and maintenance requirements.

Scope

The results of this project have applicability to most U.S. Army installations conducting helicopter, wheeled, and tracked vehicle exercises.

Mode of Technology Transfer

The information in this report will provide guidance to public works, environmental, and safety managers at Fort Campbell and other military installations when they are developing aggressive and cost-effective dust control programs. The guidance is based on large-scale field evaluations of promising dust control materials.

Metric Conversion Factors

U.S. standard units of measure are used throughout this report. A table of metric conversion factors is presented below.

1 acre	=	0.407 hectare
1 ft	=	0.305 m
1 sq yd	=	0.836 m^2
1 cu yd	=	0.764 m^3
1 ton	=	907 kg
1 lb	=	0.453 kg
1 gal	=	3.78 L

2 Project Details and Data Collection

Selection and Characteristics of Dust Control Agents

Criteria against which potential dust control agents should be evaluated include previous performance, applicability to a wide range of soil and climatic conditions, prewetting requirements, ease of application, soil surface penetrability, environmental friendliness, and curing time. Based on these criteria, three products, calcium chloride, polyvinyl acrylic polymer emulsion, and soybean feedstock processing by-products, were selected for use on helicopter landing pads and tracked and wheeled vehicle roadways at Fort Campbell, KY.

Contracts to supply and distribute calcium chloride and polyvinyl acrylic polymer emulsions were awarded to Midwest Industrial Supply, Canton, OH. These products are marketed under the trade names Dust-Fyghter and SoilSement, respectively. A contract to supply and distribute soybean feedstock processing by-products was awarded to Valley Products, Memphis, TN. This product is marketed under the trade name of SoyaSeal6. Throughout the remainder of this report, products will be referred to by their trade names but this does not imply endorsement by the U.S. Army to the exclusion of other chemically similar materials marketed under different trade names. Appendix A provides a list of vendors capable of providing dust control products and related services. It should be noted that the performance of many of these vendors' products has not been established and potential customers are encouraged to consult environmental researchers at USACERL before purchasing dust control products or services.

Dust-Fyghter, a 38% calcium chloride solution, is a hygroscopic surface penetrant that binds fine soil particles together by absorbing moisture from the air. Dust-Fyghter has been used effectively on gravel roads throughout the United States by state Departments of Transportation for dust control on unsurfaced roads. This extensive use indicates its ease of application and adaptability to a wide range of soil types and climatic conditions. Dust-Fyghter also offers good soil surface penetrability, especially if soils are somewhat damp from recent precipitation or application is preceded by prewetting. Curing times are relatively short (0 to 4 hours) depending on weather conditions. Dust-Fyghter can be applied with a water truck or asphalt distributor capable of metered application at rates generally between 0.45 and 0.55 gal/sq yd.

SoilSement, a polyvinyl acrylic polymer emulsion, produces a soil surface binding film that retards dust formation. It has been extensively used throughout the United States by various mining industries for dust control on haul roads and stockpiles. The product is supplied as a concentrate and must be diluted with water before application. Manufacturers' testing indicates that with slight variations in dilution (1:1 to 1:7 volume ratios of SoilSement to water) and application rates, SoilSement is suitable for use under all types of soil and climatic conditions. SoilSement provides good soil surface penetrability. Although penetrability is improved by prewetting soil surfaces, SoilSement does not require prewetting of surfaces to be an effective dust control agent. Curing time is minimal and the road can be used immediately following application. SoilSement can be applied with a water truck or asphalt distributor capable of metered application at rates generally between 0.45 and 0.65 gal/sq yd.

SoyaSeal6, a soybean feedstock processing by-product, binds soil particles together and forms a solid, long-lasting, non-dusting surface. It is a relatively new proprietary soybean manufacturing by-product that has been used on a wide variety of soils with good results by Iowa, Minnesota, and Kentucky Departments of Transportation for dust control on unsurfaced county roadways. SoyaSeal6 has somewhat limited soil surface penetrability (1 to 1.5 inches), which is offset by very good soil surface particle binding properties. Prewetting is not necessary for good performance. SoyaSeal6 is applied at rates between 0.4 and 0.5 gallons per square yard. For ease of application and best results, it must be applied at temperatures exceeding 135 °F with an asphalt type distributor. Curing times following application are minimal (0 to 1 hour). One of the potential drawbacks to widespread use of this product is its limited geographic availability. SoyaSeal6 is manufactured in Tennessee; a similar product is manufactured in Iowa. Costs for supplying and distributing these products on roadways is relatively reasonable ($4000-$5000 per mile) within a 100 mile radius of Memphis, TN, or Des Moines, IA. Beyond this distance, transportation costs associated with heated distribution trailers become excessive and may limit wide geographic use.

Site Preparation and Research Design

Fort Campbell Directorate of Public Works personnel selected Patton/West Perimeter Roads, Rose Hill Road, and Indian Mound 8 Landing Zone for treatment with dust control agents. Patton/West Perimeter Roads are approximately 20 miles long and were divided into eight 2.5-mile segments based on general similarities in surface characteristics, slope, aspect, and underlying soil types. Rose Hill Road is about 3 miles long and was divided into four 0.75-mile segments. Surface samples collected from Patton, West Perimeter, and Rose Hill Roads were analyzed and classified as silty gravels with sand using the Unified Soil Classification System. Before the dust control agent was applied, Patton/West Perimeter and Rose Hill Roads were graded to remove excess surface material, potholes, and washboarding. Magnetic traffic counters were then installed under each road to record traffic volume and relate it to the effectiveness and durability of the dust control agent. Following grading and installation of the traffic counters under Patton/West Perimeter and Rose Hill Roads, each road segment received one of the randomly assigned dust control treatments: Dust-Fyghter, SoilSement, SoyaSeal6, or received no treatment. This arrangement resulted in three segments receiving each dust control treatment. For the purpose of statistical analyses, this arrangement was classified as a randomized complete block experimental design with three replications.

Indian Mound 8 Landing Zone is about 4000 feet long and 90 feet wide. It was blacktopped about 10 years ago but occasional saturated soil conditions and lack of adequate base preparation has resulted in extensive surface breakdown. The landing zone is periodically used as a helicopter landing pad but significant dust generated from this activity creates safety problems and limits potential use. Indian Mound was divided into three equal areas. One area recieved no treatment (control), one area received Dust-Fyghter treatment and the third area received SoilSement treatment. Perimeters 16-ft wide along the outside borders of the areas treated with Dust-Fyghter and SoilSement were sprayed with SoyaSeal6 for the purpose of controlling dust on the apron areas of Indian Mound 8 Landing Zone.

Field Demonstration

In collaboration with Range Control, arrangements were made to apply dust control materials to Patton/West Perimeter Roads, Rose Hill Road, and Indian Mound 8 Landing Zone during the week of 29 April to 02 May, 1996. Dust-Fyghter was applied at a rate of 0.50 gal/sq yd using tanker trailers equipped with 12-ft spray bars. SoilSement was diluted with water (1:7 volume ratio of SoilSement to water) and applied at a rate of 1.0 gal/sq yd using tanker trailers equipped with 12-ft spray bars. SoyaSeal6 was applied at a rate of 0.4 gal/sq yd using heated (140 °F) tanker trailers equipped with 12-ft spray bars. All dust control materials were applied in a manner that prevented surface puddling and provided for a 6-in. overlap with previously treated areas. Only half the width of each road segment was treated at a given time to allow for continued traffic and to provide adequate curing times following application. Patton/West Perimeter and Rose Hill Roads receive enough traffic that compaction using pneumatic rubber-tired or steel-wheeled rollers was not required. The rough, broken surface characteristics of Indian Mound 8 Landing Zone, in combination with a lower volume of wheeled vehicle traffic precluded the use of pneumatic rubber-tired or steel-wheeled rollers for compaction.

Dust Control Evaluation Techniques

Following application of dust control agents to Patton/West Perimeter Roads and Rose Hill Road, normal traffic was allowed to resume and dust control/traffic test evaluations began. Dust control/traffic test evaluations of each treatment in each replicate were conducted immediately following application and at monthly intervals for 3 months. Between each monthly traffic test, counters were used to estimate traffic volume, which was then related to product durability over time. Data from these counters was recorded monthly by USACERL researchers.

During each traffic test, dust control was evaluated using two different techniques. On each side of treated tank trails, tared, oil-coated dust collection pans (Vallack and Chadwick 1992; Vallack 1995) were placed between 15 and 20 ft from the center of the road in positions that avoided possible contamination from adjacent treatments. After 24 hours, dust collection pans were retrieved, reweighed, and the amount of collected dust was determined. To supplement data from the dust collection pans, videographic images were also used during every traffic test to evaluate and quantify the degree of dust control afforded by the different agents. On respective sides of each treatment in each replicate, a video camera and a white 1-sq yd backdrop were set up opposite one another at a height of 3 ft to capture video images of the relative dust obscuration levels immediately preceding and at 5 seconds after controlled vehicle traffic traveling at 40 miles per hour. These images were digitized and analyzed for level of obscuration using computer image processing techniques to determine changes in the mean value level of images due to dust. Indices derived from video images captured during controlled traffic tests on tank trails were used to provide semi-quantitative data concerning the relative effectiveness of each dust control agent. Video image indices and data from the dust collection pans were analyzed using analysis of variance procedures and treatment means were separated using Student-Newman-Keuls test (Steel and Torrie 1980). Indices from video images were also correlated with dust pan data to determine if a reliable relationship between level of obscuration and amount of pan dust could be established and used in future studies.

3 Results and Discussion

Patton, West Perimeter, and Rose Hill Roads

Dust deposition pan data collected on 03 May, 23 May, 21 June, and 18 July 1996 are presented in Table 1. Dust-Fyghter provided the greatest levels of dust control for each evaluation date, followed by SoyaSeal6, and SoilSement. When compared to the control, Dust-Fyghter, SoyaSeal6, and SoilSement reduced dust levels by about 96%, 93%, and 84%, respectively, at the first evaluation. At the final evaluation on 18 July 1996, Dust-Fyghter, SoyaSeal6, and SoilSement continued to reduce dust levels by about 87%, 63%, and 38%, respectively, when compared to the control. Product deterioration from the first to the last evaluation period was most pronounced for SoilSement, followed by SoyaSeal6. Conversely, Dust-Fyghter exhibited the lowest degree of product deterioration over time (Table 1). Beginning about 45 days after product application, road sections treated with SoilSement started to develop noticeable potholing due to traffic-induced breakdown of the treated road surfaces. Over time, this potholing became more pronounced as vehicle traffic shifted to and concentrated on stabilized sections of the roadway surface, thereby resulting in further product breakdown and roadway destabilization. Similar trends were also observed for road sections treated with SoyaSeal6, but potholing and surface breakup was much less pronounced. Potholing and washboarding of road surfaces treated with Dust-Fyghter was minimal throughout the evaluation period.

During the evaluation period, some differences between Patton, Rose Hill, and West Perimeter Roads were noted, which have significant impacts on product performance. First and foremost of these differences were in traffic volumes. Traffic volumes on Patton and West Perimeter Roads between 03 May and 20 June 1996 and between 20 June and 18 July 1996 were approximately 8400 and 5300 vehicles, respectively. Traffic volumes on Rose Hill Road during these same time periods were about 4800 and 3100, respectively. When compared to Patton and West Perimeter Roads, lower traffic volumes on Rose Hill Road resulted in increased durability and reduced potholing of both SoilSement and SoyaSeal6.

A second factor that caused noticeable differences in product performance between Patton, West Perimeter, and Rose Hill Roads was vehicle speed. Subjective observations suggested that vehicle speed was much greater on Patton and West Perimeter Roads than on Rose Hill Road. Increased vehicle speed on treated road surfaces results in increased rates of product deterioration (Armstrong 1987) and may account for differences observed between Patton, West Perimeter, and Rose Hill Roads.

A third factor that caused noticeable differences in product performance between Patton, West Perimeter, and Rose Hill Roads was the amount of limestone aggregate material on road surfaces. West Perimeter Road had substantially more surface aggregate material than Patton or Rose Hill Roads, which reduced the effectiveness and durability of SoilSement and SoyaSeal6. SoilSement and SoyaSeal6 are surface sealers/binders that require relatively smooth, stable road surfaces to maximize performance. Vehicle movement across limestone aggregate surfaces causes surface abrasion and shifting, which can quickly destroy the sealing/binding characteristics associated with SoilSement and SoyaSeal6. Within

Table 1. Dust deposition (lb/ac/day) at Fort Campbell, KY.

	Date of Measurement			
Treatment	03 May 1996	23 May 1996	21 June 1996	18 July 1996
Control	7.52a*	7.87a	10.05a	9.95a
Dust-Fyghter	0.27b	0.75b	1.01b	1.34b
SoilSement	0.52b	2.28c	4.42c	6.17c
SoyaSeal6	1.23c	1.35b	2.37b	3.36d

* Treatment means within columns followed by the same lowercase letter are not significantly different at the 0.05 level of probability as determined by Student-Newman-Keuls test.

45 days of application, dust levels on West Perimeter Road sections treated with SoilSement and SoyaSeal6 approached those of the untreated control section. Dust-Fyghter, on the other hand, is not a surface sealer/binder and performed well on West Perimeter Road.

Product costs on a square yard basis are presented in Table 2. Dust-Fyghter was the least expensive product, followed by SoilSement and SoyaSeal6. Costs presented in Table 2 include labor, equipment, and all materials necessary for application. Product costs will vary, however, due to transportation distances and product volumes required. For example, square yard costs associated with a 10,000-sq-yd area will be higher than those associated with 20,000 square yards. Analysis of video images collected from controlled vehicle passes on each treated road segment support the results from the dust deposition pan (Table 1) and also indicate that Dust-Fyghter provided the greatest level of dust control. Levels of dust obscuration were lowest for Dust-Fyghter, intermediate for SoyaSeal6 and SoilSement, and highest for the untreated control sections on Patton, West Perimeter, and Rose Hill Roads (Table 3).

Indian Mound 8 Landing Zone

On 22 May 1996, three Chinook helicopter landings were conducted on the Indian Mound 8 Landing Zone. All dust control materials effectively controlled dust during helicopter landing, takeoff, and hovering exercises when compared to the untreated (control) area. Very little dust was generated from landing zone aprons treated with SoyaSeal6 and there was no evidence of product breakdown due to rotor downblast.

Table 3. Differences in levels of dust obscuration (mean change ratio) at Fort Campbell, KY, as determined by video image analysis.

	Date of Video Imaging Measurements			
Treatment	03 May 1996	23 May 1996	21 June 1996	18 July 1996
Control	100.00	100.00	100.00	100.00
Dust-Fyghter	-24.37	49.23	-25.51	41.47
SoilSement	24.70	111.84	66.13	99.94
SoyaSeal6	3.45	68.15	30.44	75.66

* Mean change ratios below 100 indicate that levels of dust obscuration were less than those for the control treatment. The lowest mean change ratios are associated with the most effective treatments.

Table 2. Dust control materials costs at Fort Campbell, KY.

Treatment	Cost ($/sq yd)
Control	$0.00
Dust-Fyghter	$0.28
SoilSement	$0.33
SoyaSeal6	$0.34

On asphalt surfaced landing zones such as Indian Mound 8, it appears that all treatments were equally effective at reducing dust obscuration levels; cost should dictate product selection. For unsurfaced landing zones, the results from Patton, West Perimeter, and Rose Hill Roads should help guide product selection.

Although not tested in this evaluation, several other methods for controlling dust on helicopter landing zones should be considered. First among these is vegetative stabilization of the landing surface. This can be accomplished by planting grass to stabilize the soil surface. Perennial grass species are the most desirable for soil stabilization but require some maintenance in terms of mowing and periodic fertilization. Perennial grasses are best suited for infrequently or moderately used landing zones because of their inability to persist under constant disturbance. Under heavy use and constant disturbance, annual grasses such as ryegrass, wheat, and oats may be better suited. Unfortunately, these species offer the greatest degree of soil stabilization during wetter, cooler times of the year when dust problems are probably reduced. The quick germination and rapid establishment characteristics associated with these species, however, makes them ideal candidates for stabilizing helicopter landing zone soil surfaces before periods of heavy use.

Another method for controlling dust on helicopter landing zones involves incorporating polyacrylamide (PAM) materials into surface soils. PAM materials have been extensively used in the horticultural industry to help retaining soil moisture in potting mixtures. Incorporating PAM materials into landing zone surface soils will retain soil moisture for longer periods of time, thereby minimizing soil particle detachment and dust formation.

4 Conclusions and Recommendations

All treatments remained effective for 30 days following application on Patton, West Perimeter, and Rose Hill Roads. When compared to the control, Dust-Fyghter, SoyaSeal6, and SoilSement reduced dust levels by about 96%, 93%, and 84%, respectively, 30 days following product applications. Between 30 and 90 days following application, road sections treated with SoilSement and SoyaSeal6 began to deteriorate; SoilSement exhibited the most significant decline. At 90 days after product application, Dust-Fyghter, SoyaSeal6, and SoilSement continued to reduce dust levels by about 87%, 63%, and 38%, respectively, when compared to the untreated control.

Cost and performance data suggest that Dust-Fyghter provides good dust control under a wide range of conditions for periods exceeding 90 days. Because of differences in traffic type and volume, soil types, and roadway/trail surface characteristics, product performance will vary. Where road surfaces have substantial limestone aggregate covering, Dust-Fyghter performs better than SoilSement or SoyaSeal6. On roads with less aggregate covering, differences in performance between SoyaSeal6, SoilSement, and Dust-Fyghter are much less pronounced. This variation makes it impossible to provide blanket recommendations concerning one or two products. However, based on data presented here, the performance and durability of Dust-Fyghter is much greater than that of SoilSement and SoyaSeal6 across a wide range of road surface characteristics, clearly indicating that it can be successfully used for dust control purposes at Fort Campbell. Regardless of the dust control product used, maintaining a given level of dust control on tank trails will require more frequent applications than for roadways supporting primarily wheeled vehicle traffic.

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Appendix A: Vendors of Dust Control Products and Services

Calcium Chloride and Related Products

Actin
1102 E. Columbus Drive
East Chicago, IN 46312
219-397-5020

All Construction
4327 Franklin, Suite 103
Michigan City, IN 46360
219-874-9474

Ashland Chemical Company
P.O. Box 10298
Jackson, MS 39209

Cargill Solarchem Resources
P.O. Box 364
Newark, CA 94560

Dust Pro
725 S. 12th Place
Phoenix, AZ 85034
602-251-3659

Midwest Industrial Supply, Inc.
P.O. Box 8431
Canton, OH 44711
708-941-0205

Sicalco Ltd.
5240 W. 123rd Place
Alsip, IL 60658
800-942-4893

W&W Sales and Leasing Co.
P.O. Box 485
Edwardsville, IL 62025
618-656-5070

SoilSement and Related Polyvinyl Acrylic Emulsions

Bartlett Services, Inc.
60 Industrial Park Road
Plymouth, MA 02360

Benetech, Inc.
1750 Eastwood Drive
Aurora, IL 60506

Dust Pro
725 S. 12th Place
Phoenix, AZ 85034
602-251-3659

Earth Systems International
28259 Dorothy Drive
Agoura Hills, CA 91301

Energy Systems Associates
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