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FINAL REPORT

Guidelines for Dust Control on Unsurfaced Roads in Alabama

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GUIDELINES FOR DUST CONTROL ON UNSURFACED ROADS IN ALABAMA

Final Report

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PIs: Dr. Dan A. Brown
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Synopsis

Two dust palliatives, calcium chloride and lignosulfonate, were applied to two different roads in eastern Alabama to evaluate their effectiveness. Both test roads were treated with three different treatments of each palliative. The roads, one sandy and one clayey, were monitored for over one year (two summers).

The results indicated:

⇒ all treatments were an improvement over no treatment,

⇒ the calcium chloride treatment appeared to provide effective dust control for a longer period on sandy soils, at least in the short term in our weather conditions.

⇒ in clayey soils, calcium chloride appeared to retain moisture for longer periods after a rain; while more effectively controlling dust, this section also appeared to be more susceptible to rutting from traffic and might, therefore, be best applied with the addition of some gravel for surface stability.

⇒ lignosulfonate formed a hard crust on the road that, at least initially, resisted potholing.

⇒ lignosulfonate seemed to provide some additional benefit of surface hardening, particularly on clayey soils where traffic is relatively light.

⇒ in permeable, sandy soils, rainfall appeared to remove much of the lignosulfonate after a few months.

Table of Contents

I. Introduction

Dust control on unpaved roads is needed to improve safety, reduce maintenance and improve the quality of life adjacent to the road. Historically, dust control has been pursued by applying some treatment to the road surface. Since numerous treatments been used with many conflicting assessment of effectiveness, the Alabama County Engineers desired a recommendation on an effective treatment for unpaved roads in Alabama.

II. Scope

This project evaluated two unpaved roads subject to six different dust control treatments. The conduct of the project and the evaluation of results is given below.

III. Previous Work

A. Historical solutions

Historically, liquids have been applied to the surface of unpaved roads to reduce dust. Liquids included water, petroleum products, calcium chloride solution, lignosulfonate and other proprietary chemicals. Paving the road, and using geotextiles beneath unpaved roads also reduces dust emissions.

Water is effective in reducing dust. Once applied to an unpaved road, the capillary attraction of the water to the fine dust particles aggregates the particles into flocs that are too heavy to become airborne under traffic loads. Water is effective, environmentally sound and inexpensive. However, it evaporates quickly, requiring frequent reapplication - in hot weather, perhaps several times per day. Heavy application of water is the only economic liquid surface treatment that works well on gravelly soils because other liquid treatments drain too rapidly and only function until the initial application dried (Rosbury and Zimmer, 1985). Saltwater is also used with somewhat longer lasting success because of the hygroscopic nature of salt (the dust particles aggregate into flocs that are too heavy to become airborne under traffic loads; Langdon and Williamson, 1983). Muleski, et al. (1984) compared the effectiveness of water to petroleum distillates and a proprietary product, Coherex. Water was the most expensive to deploy, because of the frequency of application required. Kestner (1988) reviews a case history of dust control using water.

Petroleum products, historically used motor oil, are not in current use. Although effective, the dispersion of petroleum products on the ground surface is prohibited by Alabama Department of Environmental Management (ADEM).

Calcium chloride, dissolved in water, is used to aggregate dust particles into flocs that are too heavy to become airborne under traffic loads. Calcium chloride is a salt which acts as a hygroscopic chemical (attracts water). This affinity for moisture can be satisfied by humidity. Calcium chloride draws moisture from the ambient air and holds it as capillary moisture in the soil. The fine particles which would otherwise loosen to form dust are held by the resulting capillarity and aggregate into flocs that are too heavy to become airborne under traffic loads. Calcium chloride is reported to have the additional attraction of improving the strength of the soil it's absorbed in. Calcium chloride is water soluble and may leach from the surface soils with rainfall. Some users report improvement in the roadway base with the application of calcium chloride (Anonymous, 1990). Hubbard (1910) noted an improvement in effectiveness if more than one calcium chloride treatment was used during dry weather periods. Conversations with drivers at the East Alabama Motor Speedway (a dirt track raceway near Phenix City) indicate that the race car drivers perceive that calcium chloride "makes the track more slippery" compared to simply watering the track to control dust. This track is composed of a clayey soil and it may be that this perception stems from the higher water content in the soil at the track surface as a result of the calcium chloride.

The Alabama Department of Environmental Management (ADEM) presently has no specific rules or regulations concerning the use of calcium chloride for dust control. However, some interpretations of the State Water Pollution Control Act appear to suggest that runoff water containing this salt could be construed as a violation and thus a permit to disperse calcium chloride on the ground surface may be required by ADEM (see Appendix A). Calcium chloride, like any road salt, is corrosive to exposed metal surfaces including cars and road grading equipment.

<u>Lignosulfonate</u> is a material composed of pulp liquor from paper processing. When applied to unpaved roads lignosulfonate forms a hard crust that traps the soil particles, reducing dust. The crust also tends to improve surface drainage, which may reduce maintenance costs. Lignosulfonate is water soluble, and may leach from the surface soils with rainfall. Langdon and Williamson (1983) found that pulp liquor that had been processed for alcohol is not as effective a dust palliative as the unprocessed form.

Rosbury and Zimmer (1985) report good success with all chemical surface treatments, as long the roadway is graded to assure good drainage.

Of course, as a long term solution to dust problems, construction of a <u>paved surface</u> should be considered as an alternative. Although paving represents a high initial cost, in some instances it may not be more expensive compared to other surface treatments. In the harsh Alaskan climate, Nordenson (1993) found that paving was the most economic alternative.

<u>Geotextiles</u> can reduce dust generation from subbase soils. The geotextile, placed under the wearing course, resists the penetration of aggregate into the subgrade and thus the penetration of dust-sized particles up through the aggregate from below. The geotextile acts like a filter, retaining fine soil particles. If the soils below the geotextile are susceptible to abrasion and the generation of dust, the geotextile can reduce the amount of that dust that is allowed to escape (Anonymous, 1991).

<u>Molex</u>, a beet processing derivative, has been used for dust control. The material is hygroscopic and acts to hold the attracted water in capillary tension. This moisture binds the dust particles in

flocs that are too heavy to become airborne under traffic loads. This material is less corrosive than salts such as calcium chloride (Anonymous 1992). However, it may have limited availability.

B. Evaluation techniques

Langdon (1980) reported on a dust collector that attached near the rear wheel of a pickup truck. The pipe shaped device had it's intake behind the rear wheel, turned upwards and led into the a cyclone-type dust particle extractor (high volume air samplers) in the bed of the truck. The dust was attracted to the device by the forward motion of the truck into the dust as well as a vacuum produced by the cyclone. The device produced fairly consistent results, but was influenced by tire conditions, vehicle condition and speed, and wind direction. Moreover, similar weather conditions are required to perform a comparison.

Langdon (1980) also used the Photo Comparison Method to evaluate dust. This method used photographs (or, now, videotapes) of vehicles passing the same roadway. The effectiveness of the treatment could be evaluated by the amount of dust raised on passing. Visual comparison of the amounts, with the same vehicle, were used to determined palliative effectiveness. The method is slow and requires similar weather conditions to perform a comparison.

The United States Forest Service (1987) reports on a road dust monitor under development. The device, similar to that described above, also mounts on the rear of a pickup truck. The dust is funneled into and up a duct where it passes in front of a light source and sensor system. Preliminary work indicates that the sensor detects differences in reflected light under differing dust conditions. However, the sensor itself rapidly becomes dusty, obscuring the measurements.

Muleski, et al. (1984) used cyclones on towers adjacent to the roadway to sample the dust from the air. These devices draw large volumes of air through a filter. Muleski's experience indicated that samplers placed on towers did not improve the measurements above samplers placed on the ground surface.

Rosbury and Zimmer (1985) report that dustfall pans are not very effective in monitoring dustfall from unpaved roads. Dustfall pans are pans left at the side of the road that dust falls into after becoming airborne. The pans are carefully weighed after a fixed amount of collection time to determine the amount of dust caught. The variability observed during their tests was too great to afford an interpretation of the report. Variability in this method arises from ambient moisture, wind direction and speed, vehicle type, tire type, airflow around and under vehicles, traffic patterns, path the vehicle takes on the roadway, and road and air temperature. Rosbury and Zimmer also report that tire size and shape affect dust generation.

IV. Research Approach

A. Important properties.

Dust palliatives need to penetrate the soil, resist evaporation, shed water, provide abrasion resistance (for cohesive palliatives), resist aging and be environmentally sound. Soil penetration is needed to keep the palliative active for a long time. Poor penetration results in rapid loss of the palliative due to traffic. Highly volatile palliatives will not remain active after evaporation. This applies to petroleum products, but also to water-based products shortly after application. Evaporation that occurs before penetration takes place reduces the lifetime effectiveness of the palliative. Palliatives that change their properties over time may lose their effectiveness. Environmental acceptability is required.

B. Choice of Chemicals

Calcium chloride and lignosulfonate were chosen for evaluation in this study. Both are readily available, relatively inexpensive, seem to have relatively little environmental impact, and are relatively easy to apply using equipment which might be readily available in county engineering offices. Currently, these are the most popular dust palliatives.

Dust palliatives need several properties to be effective. Some palliatives depend on attraction of moisture from the air to reduce dust. Other palliatives depend on adding cohesion to the soil reduce dust. Calcium chloride uses the former principle, and lignosulfonate primarily uses the latter.

Both calcium chloride and lignosulfonate had about the same surface penetration, since both were water based. Surface penetration is a measure of how long the palliative will last. Greater penetrations imply greater life. Langdon and Williamson (1983) describe a penetration test to evaluate different treatments. A standard notched specimen of soil is placed between glass plates. The notch is filled with the palliative and the depth of penetration into the soil is viewed through the glass.

C. Selection of test strips

Two unpaved test strips were selected to evaluate the dust palliative treatments. The selection criteria were:

- fairly level, straight road,
- one site primarily sandy,
- one site primarily clayey,
- adequate amount of sunshine to aid in drying roadway,
- relatively low traffic volume,
- sufficient length to accommodate all the test sections.

The two sections of roadway selected were:

- Looser Road in Chambers County (a clayey soil mixed with some gravel), and

- Russell County Road 83 (a relatively clean, sandy soil with very little cohesive binder).

The cooperation of the Chambers and Russell county highway engineers were solicited and received. The engineers agreed to assist with road preparation and laydown of the solutions. They also cooperated by not regrading the road for one year, so that the effect of the treatments could be evaluated.

D. Mixing and Application of chemicals

The test sections were divided into 7 - 500 foot segments. The first three segments were treated with different concentrations of calcium chloride, the middle section was untreated, and the last three segments were treated with different concentrations of lignosulfonate. Both chemicals were placed at a given site within 24 hours to ensure that these were subject to similar environmental conditions. The materials were applied at the Chambers Co. site on June 23-24, 1992 and at the Russell Co. site on July 1, 1992.

Calcium Chloride

The calcium chloride used in this project was obtained in "flaked" form and transported to the appropriate county engineers offices in bags. The flaked form of the material was considered easier to mix than pellets, and much cheaper than obtaining a premixed solution.

At the Chambers County site, calcium chloride was mixed and applied in a 35% solution. Mixing was accomplished in a water truck by dumping the material into the top of the tank and circulating the mixture with a high velocity pump. In theory, it would have been possible to mix this material to a 38% solution (saturation) at the time; however, in practice, mixing to a 35% solution using this method was tedious and difficult. Mixing to these relatively high concentrations would best be accomplished with an impeller-type mixer in a more controlled environment than the back of a water truck. It was noted during mixing that the tank became quite hot from the reaction of the calcium chloride with water, such that the water tank was too hot to touch.

Because of the difficulty in mixing at Chambers County, the Russell County mixture was prepared using a 29.5% solution. This was mixed in the tank of a water truck using circulating pumps in a similar fashion, and mixing was accomplished much more easily than with the higher concentration mixture used previously. It is apparent that this type of equipment is commonly available at Alabama county engineering offices, and if such is the case, a relatively low (<30%) concentration of chemical would be recommended for ease of mixing. Of course, for a given rate of application of chemical, the lower concentration therefore requires application of the solution at a higher rate and increases trucking costs.

For the Chambers County site in clayey soil, the calcium chloride was applied at 0.44 gal/yd^2 on the first (heavy) section at a 35% solution and at 0.22 gal/yd^2 on the second (light) section. Each of these sections was lightly prewetted, the surface scarified to a depth of about 2 to 3 inches and bladed, and the chemical solution mixed using a motor grader. The water truck which applied the solution made several passes in order to apply the chemical as evenly as possible and at the correct application rate. The wetted surface was bladed back into shape and the surface compacted with the water truck tires. The third section received a topcoat of calcium chloride solution at 0.22 gal/yd^2 without any scarification or mixing. Although a small amount of the solution was observed to run off the roadway, it appeared that most of the solution soaked in. Although the manufacturers recommend mixing the chemical in the roadway, a reasonable method to apply the solution as a topcoat might be to make several light applications at different times to achieve maximum penetration and avoid runoff.

For the Russell County site in sandy soil, the solution was applied similarly but at concentrations of 0.66 and 0.33 gal/yd^2 for the 29.5% solution in the heavy and light (both mixed and topcoat only) sections respectively. Scarification and mixing in place was much easier in the sandy soil, and the motor grader operator mixed the solution to a depth of about 3 to 4 inches on average. The solution soaked into the sandy soil readily, and essentially no runoff was observed in even the topcoat only section.

Lignosulfonate

The lignosulfonate used in this project was obtained in liquid form as a 50% solids solution. This solution was delivered in a tanker and was diluted to a 25% solids solution for application.

Mixing and application of the lignosulfonate was accomplished with the same water truck type distribution equipment as was used for the calcium chloride. Mixing was relatively easy since the material was already a solution. However, although the manufacturer reported that sufficient mixing would be accomplished by driving the truck to the site, it was found that mixing by circulation through a pump was necessary to obtain a well mixed product.

For both Russell and Chambers County sites, the lignosulfonate was applied to three segments of the roadway representing a heavy mixed, a light mixed, and a light unmixed section. The heavy and light sections represent a distribution rate of 1 and 0.5 gal./sq.yd. respectively. After a light prewetting with water, the mixed sections were scarified and mixed by blading similarly to the calcium chloride sections described previously. A final topcoat application (representing about 0.1 to 0.2 gal./sq.yd.) was applied after mixing was complete. The unmixed section received a topcoat without any scarification or blading. Each section received 5 to 10 passes of the sprayer to leave the required concentration of calcium chloride on the roadway.

E. Monitoring of strips

The test strips were monitored visually for two summers, and monitored with a vacuum device for the second summer. Visual observations included appearance of dust on the surface and in the air, color of roadway, appearance of road surface, appearance of potholes and/or rutting, and dust on plants adjacent to the roadway.

A vacuum device was built to measure the amount of dust on the road surface. The device consisted of a high power vacuum cleaner attached to a 2 ft. by 2.5 foot box that was placed on the road surface. The box was used to vacuum a transverse strip of the road surface. The road was vacuumed with the device for 30 seconds before the box was moved to the adjacent position, until the entire transverse section of the road was covered. The dust was collected on filter paper in the device. The filter paper and dust was dried and weighed and compared to the weight of the paper before vacuuming to get the weight of dust collected. This method was designed to reduce variability from wind direction and speed, vehicle type, tire type, airflow around and under vehicles, traffic patterns, and the path the vehicle takes on the roadway.

V. Results

Within about two weeks after placement of the chemicals, a period of unusual rainy weather ensued throughout the normally dry months of August, September, and October. Several drought years had preceded this work, with severely dry conditions during these months from 1988 to 1991. One might therefore conclude that an effective means of controlling dust is to conduct a dust control experiment, which will ensure rainy weather for the remainder of the summer!

Because of the lack of dry weather, it was decided to monitor the performance of the applied chemicals through the winter and into the next summer. This evaluation is therefore an unusually severe test in that the wet winter months (and wet summer of '92 months) will tend to leach the chemicals from the soil and diminish the effectiveness for the subsequent year. Subjective evaluations were available for the short period after application of the chemicals and prior to the start of wet weather.

A. Objective measurements

Attempts were made to "measure" the amount of dust on the roadway using the vacuum cleaner box described previously. These attempts met with poor results, with erratic measurements that did not correlate well with subjective evaluations of the dust conditions. In addition, the results were not very reproducible. It is unclear whether the vacuum was lifting particles that did not correlate with those lifted by wheel traffic or the dust in a local spot was highly variable, but the measurements were not considered sufficiently reliable to base recommendations on. Another method which was attempted involved the use of collector cans placed along the roadway to collect dust as the traffic went by. This method was considered to sensitive to local wind and other conditions to be reliable. Although there are more sophisticated techniques for measuring airborne particles, the equipment is costly and not amenable to use over a widespread area within a short time period. The objective measurement of dust is an area that needs more research in order to develop a reliable and cost effective technique.

B. Subjective measurements

Because of the difficulties in obtaining high quality measurements of dust conditions, subjective evaluations were made as the primary means of judging the effectiveness of the various dust palliatives. Typically, the observations were made from a moving vehicle by two persons in the vehicle. The passenger made most of the observations in the rear of the vehicle and recorded them in a log. The different treatments were marked with stakes beside the road. As the constant speed vehicle passed over each, differences in the amount of dust raised was observed. The use of a controlled number of passes with a specific vehicle was done primarily to eliminate the effects of weather, humidity, and traffic pattern on measurements made on a given day.

The resulting observations indicated:

- all treatments were an improvement over no treatment,
- the calcium chloride treatment appeared to provide effective dust control for a longer period on sandy soils, at least in the short term in our weather conditions.
- in clayey soils, calcium chloride appeared to retain moisture for longer periods after a rain; while more effectively controlling dust, this section also appeared to be more susceptible to rutting from traffic and might, therefore, be best applied with the addition of some gravel for surface stability.
- lignosulfonate formed a hard crust on the road that, at least initially, resisted potholing.
- lignosulfonate seemed to provide some addition benefit of surface hardening, particularly on clayey soils where traffic is relatively light.
- in permeable, sandy soils, rainfall appeared to remove much of the lignosulfonate after a few months.

VI. Conclusions and Recommendations

A. Calcium Chloride

The results of this very limited study suggest that calcium chloride can be an effective dust control treatment. With clayey subgrades some additional measures for stabilization might be needed in conjunction with calcium chloride.

Calcium chloride can be obtained in either liquid, pellet, or flaked form. Although the liquid would likely be most easily mixed, shipping costs with this form would be quite high. Given that a significant effort may be needed to properly mix the calcium chloride, it is recommended that the flake form be used; it's cheaper to ship than the solution and dissolves faster than calcium chloride pellets.

A 25% saturation by weight solution of calcium chloride solution is recommended. Although higher concentrations are discussed in the manufacturer's literature, this percentage can be readily mixed and higher concentrations can be difficult to mix. If calcium chloride is to be used on a widespread basis within a county, it would be wise to invest in or modify some existing equipment to facilitate mixing. On this project the material was successfully mixed in a large tank by circulating the solution through a high volume pump; if this approach is used, it would be desirable to mix in a tank without any baffles to hinder mixing and flow and with a large opening for dumping in the flaked material. Some type of impeller, agitator, or other mixing device would be highly desirable.

An application rate of around 0.40 gallons per square yard would be ideal, based on the observations made in this research. This material should be mixed into the upper 3 to 4 inches of subgrade in a manner so as to thoroughly mix the material and to leave the roadbed graded for good drainage. If the solution runs off the road at this laydown rate, make several passes at lower rates to allow the solution to soak in. For example, two passes at 0.20 gallons/square yard are the same as one pass at 0.40 gallons per square yard. Higher application rates may be slightly more effective at controlling dust, but it is suggested that a more modest initial rate of application may be more cost effective. If recurring dust is noted within a single summer, an effective approach might be to follow up the initial application with a subsequent light topcoat (unmixed) treatment. Final transverse grade of the road should be about 0.5 inches for every foot. Clear drainage ditches are a must.

The best application time is when the ground is moist, not dry, so as to achieve optimal penetration. If the soil is extremely dry, a light prewetting is recommended. It is also recommended that application be avoided when the ground is extremely wet or when the forecast calls for heavy rains within a day or so of treatment. Heavy rain can dilute and remove the solution.

B. Lignosulfonate

The results of this study suggest that lignosulfonate might best be used for dust control in cohesive or clayey soils, and that the cementing effects of the material might provide some additional stability for such soils for at least one dry season. The lignosulfonate was observed to be leached away by rainfall in extremely sandy soils, although this leaching might not be so severe over a single dry summer.

For lignosulfonate, a mixture that has with 25% total solids appears to be optimal for handling and placement. If purchased (as is typical) in a 50% solution, then the 25% solution would require a 1:1 mixture of the purchase product and water. Mixing this solution is relatively easy with circulation through a pump, and can commonly be performed in the tank from which the solution will be spread. Agitation does not appear to be necessary for good mixing. As lignosulfonate is not corrosive, this product may be somewhat easier on equipment than the calcium chloride.

The relatively light application at a rate of 0.50 gallons per square yard seems to be almost as effective as the heavier rates. Recommended practice is to apply one half of this (0.25 gallons per square yard), blade the road to the final geometry while the lignosulfonate soaks in, and apply the remaining half as a topcoat. As for the calcium chloride, do not apply just before or during rainstorms. The best application time is when the ground is moist, not dry, and prewetting is recommended if the subgrade is extremely dry. Grading to facilitate drainage is necessary, with the final transverse grade of the road of about 0.5 inches for every foot. Clear drainage ditches are a must.

Another strategy for utilizing lignosulfonate to control dust would be to use relatively dilute amounts of the product in conjunction with routine watering, with several applications over the course of a single dry summer. While not as effective as with a mixed-in-place application, the lignosulfonate should extend the effectiveness of the watering application.

C. Quality assurance.

The following quality assurance points should be followed when using liquid treatments:

- calibration of spray equipment,
- field sampling equipment calibration and maintenance,
- field sampling procedures to assure correct quantities are being applied,
- laboratory analysis procedures to assure material specifications are met,
- calculations and recordkeeping.

D. Recommendations for Future Research in Alabama.

Because of the limited scope of this project, these recommendations should be considered as preliminary and subject to verification in a given county based upon experience. To that end, a useful research effort would consist of coordinating and measuring the effectiveness of future dust control efforts by counties across the state with the objective of documenting the effectiveness, successes, difficulties, etc. of county engineers across the state so that all might benefit from the experiences of others. This effort could document field performance throughout a wide variety of soil types and weather conditions. Such an effort on the part of a single research team would be very large and expensive, but utilizing the efforts and resources of a number of county engineering organizations could make such a study practical.

In addition to the needed research outlined above, there is a need for a more effective means of quantitatively measuring the effectiveness of dust control. The device developed as a part of this research was not very effective, although the wet weather conditions may not have provided a suitable evaluation. Some additional research on this topic would be beneficial to allow the documentation of effectiveness across a wide area without resorting to subjective visual classification.

Acknowledgements

The writers are grateful for the financial support of the Alabama Highway Research Center, Frazier Parker, Jr., Director, for the conduct of this project. Chambers County Engineer, Charles Markert and Assistant County Engineer Henry Hawkins are thanked for their cooperation in applying the chemical to the Chambers County roadway. James McGill, Russell County Engineer, is thanked for his cooperation in applying the chemical to the Russell County roadway.

Ed Newlin of DOW Chemical is thanked for his technical help in donating a portion of the calcium chloride and technical assistance in applying it.

Dave Lechter and Rosella Jensen of Georgia-Pacific are thanked for the donation of the lignosulfonate and for their assistance in delivery of the lignosulfonate.

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Appendix A

Letter from the Alabama Department of Environmental Management (ADEM) regarding the use of Calcium Chloride on unpaved roadways.

It appears that ADEM has no regulations directly concerning this subject, even though pollution of groundwater by salts is a technical violation of the State Water Pollution Control Act. It would seem that the use of salts on paved roadways to melt ice would be a more severe test of this act with regards to the use of salts on roads, but it seems as though the State of Alabama has not resolved this issue. A letter from ADEM is attached.

ADEM

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March 11, 1992

David J. Elton, Ph.D.,P.E.
Department of Civil Engineering
Harbert Engineering Center
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Dear Dr. Elton:

Your request for information concerning dust control treatment is difficult to address. No regulations or rules specifically address the process. However, the State Water Pollution Control Act prohibits the introduction of a pollutant into a water of the state without a permit. If the substances being used for dust control were transported to a water of the state via storm water runoff, a violation of the law would occur.

Groundwater is included in the definition of a water of the state. Therefore any pollution of groundwater caused by the salts or other substances used for treatment would be a violation of the law.

By copy of this letter, I am requesting the Land Division to provide information concerning solid and hazardous wastes requirements.

Sincerely,

John A. Poole, Jr.
Chief
Industrial Branch
Water Division

cc: Stephen Jenkins, w/enc.

Appendix B

Sample calculations for mixing calcium chloride at a 25% solution

These calculations are for DOWFLAKE®, the flake form of calcium chloride manufactured by The Dow Chemical Co. Other brands may be substituted, but the concentration of calcium chloride (as a percentage of product) might differ

Note, DOWFLAKE typically consists of 78% calcium chloride, and the 25% solution refers to the amount of calcium chloride per pound of solution.

Therefore, the solution contains greater than 25% by weight of DOWFLAKE, i.e. (25%)/(0.78) = 32% by wt. DOWFLAKE.

Now, for a solution which is 32% DOWFLAKE, 68% water, add 1 pound DOWFLAKE to (68/32) = 2.125 pounds of water.

Water weighs 8.33 pounds/gal. at 60°F, so add (1/2.125)(8.33) = 3.92 pounds DOWFLAKE per gal. of water.

According to information provided by Dow, a 25% solution using DOWFLAKE would have a specific gravity of 1.247 and would thus weigh 10.39 pound per gallon (1.247 x 8.33).

Adding 8.33 pounds of water (1 gal.) and 3.92 pounds DOWFLAKE produces 12.25 pounds of solution, or 12.25/10.39 = 1.18 gallons of solution.

Therefore, 1 ton (2000 pounds) of DOWFLAKE should be added to (2000/3.92) = 510 gallons of water to produce 602 gallons of solution at 25% $CaCl_2$.

Summary to produce a 25% $CaCl_2$ solution:

- add 392 pounds DOWFLAKE per 100 gallons of water to produce 118 gallons of solution per 100 gallons of water, or

- add 510 gallons of water per ton of DOWFLAKE to produce 602 gallons of solution per ton of DOWFLAKE.

Appendix C

Dust Control Product Suppliers

SUPPLIER	PHONE NO:
<u>Lignosulfonate</u>	
Georgia-Pacific Corporation	800-876-7863
ITT Rayonier	800-221-2954
<u>Calcium chloride</u>	
Ashland Chemical	800-292-6519
Birmingham Industrial Chemical	800-476-2042
Dow Chemical Corporation	800-825-5369
Harcross Chemical Corporation	800-292-3474
Tetra Chemicals	800-327-7817