

# TECHNICAL NOTES

U.S. DEPARTMENT OF AGRICULTURE

NATURAL RESOURCES CONSERVATION SERVICE

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## WA NRCS DUST SUPPRESSION SELECTION AND APPLICATION GUIDE for UNPAVED ROADS



## INTRODUCTION

The purpose of this Technical Note (TN) is to help NRCS employees understand and correctly choose and apply the dust suppressant that is appropriate for a particular site, traffic conditions, and climate. In addition, this TN describes the expected performance, limitations, and potential environmental impacts of various treatments.

This guide examines most of the commonly available dust suppressants currently available and does not endorse any particular product.

## DUST ABATEMENT BASICS

Fine particles, including dust, act to help hold the surface of unpaved roads together. With a loss of fine particles from the roadway, there is an increase in roadway surface raveling and maintenance costs. These fines are smaller than what the eye can see and pass through the 75  $\mu\text{m}$  (No. 200) sieve.

How can dust emissions from the roadway be reduced or eliminated? Since the fines act as a binder that holds the surface of the unpaved road together, removing them is not a good option. Sealing the surface with an asphalt or concrete pavement or Bituminous Surface Treatment eliminates the dust problem; however, the low traffic on most non-paved access roads does not justify the cost of sealing the road with asphalt, concrete, or a surface treatment. Another alternative is to apply a dust suppressant product. These products are not a permanent solution and will require further applications as the effectiveness of the product decreases with time. Dust suppressants are one of many possible methods to control dust.

Dust suppressants work by either agglomerating the fine particles, adhering and binding the surface particles together, or increasing the density of the road surface material. They reduce the ability of the surface particles to be lifted and suspended by either vehicle tires or wind.

To properly select the appropriate suppressant one must understand the primary factors that generate dust. They include the following:

- Vehicle speed
- Number of wheels per vehicle
- Number of vehicles
- Vehicle weight
- Particle size distribution (gradation) of the surface material
- Restraint of the surface fines (compaction, cohesiveness/bonding, durability)
- Surface moisture (humidity, amount of precipitation, amount of evaporation).

Selection of the proper dust abatement program must include an understanding of not only the above factors, but the total long-term cost and environmental impacts of that program. Long-term costs include road improvement, road preparation, application of the suppressant in conjunction with the number of times the suppressant needs to be applied, and expected change in maintenance practices. Environmental considerations typically include impacts to the water quality, aquatic habitat, and plant community.

## DUST SUPPRESSION BASICS

There are a wide variety of dust suppressants available on the market. They can be divided into six basic categories: water, hygroscopic (water absorbing products), petroleum, nonpetroleum (lignosulfonates), polymer emulsion, and clay additive products.

Typical suppressants in each category are:

- Water (Generally not recommended due to high labor cost for repeated applications)

- Water Absorbing Suppressant (Hydroscopic) Products (Generally not recommended due to environmental risk)
  - calcium chloride brine and flakes
  - magnesium chloride brine
  - sodium chloride (salt)
- Petroleum Emulsion (Generally not recommended due to environmental risk)
  - asphalt emulsions
  - cutback asphalt (liquid asphalt)
  - dust oils
  - modified asphalt emulsions
  - Bituminous Road Oil
- Adhesive (Nonpetroleum) Products
  - Lignosulfonate
  - animal fats
  - molasses/sugar beet
  - tall oil emulsions
  - vegetable oils
- Polymer Emulsion Products
  - polyvinyl acetate
  - vinyl acrylic
- Clay Additives
  - bentonite
  - montmorillonite

## ENVIRONMENTAL IMPACTS

The primary environmental concern with dust suppressants is how they impact the groundwater quality, freshwater aquatic environment, and plant community. Take all necessary precautions to keep dust suppressant material out of water drainages and roadway ditches leading to streams.

The impact of dust suppressants on groundwater quality is based on how the suppressant migrates to the local groundwater table in conjunction with the chemicals used in the suppressant. Knowing the depth to groundwater and the permeability of the native soil will assist in determining how and if the chemicals will leach to the groundwater table. The impact of dust suppressants on the freshwater aquatic environment is measured by both the toxicity to fish and the availability of oxygen. Each state sets its own standards and they may vary by watershed and the type and age of the fish population. There are no standard tests for measuring how dust suppressants impact the plant community; however, some tests have been performed that simply observe the impact on plant life.

## DUST SUPPRESSANT SELECTION CONSIDERATIONS

Important benefiting factors of dust suppressants that should be considered when evaluating and selecting the proper dust suppressant product include:

- Cohering the dust particles to themselves or to larger particles.
- Resisting wear by traffic.
- Remaining on the road.
- Resisting aging.

The dust suppressant evaluation checklist (Appendix 1) can be used to inventory the unpaved roadway. Table 1 provides guidelines and information about dust suppressant limitations, application methods, and environmental impacts, which helps further in selecting the best dust suppressant. The Web Soil Survey "Report-Engineering Properties" for the practice location may be helpful in determining characteristics of surface soil material in lieu of an onsite analysis.

Table 1 – Suppressant Selection Chart<sup>1</sup>

| Dust Suppressant                                   | Traffic Volumes, Average Daily Traffic |                         |                      | Surface Material <sup>2</sup> |     |     |                                      |      |       |       |       | Climate During Traffic |                |            | Environmental Hazardous |        |                 |
|----------------------------------------------------|----------------------------------------|-------------------------|----------------------|-------------------------------|-----|-----|--------------------------------------|------|-------|-------|-------|------------------------|----------------|------------|-------------------------|--------|-----------------|
|                                                    | Light<br><100                          | Medium<br>100 to<br>250 | Heavy<br>>250<br>(1) | Plasticity Index              |     |     | Fines (Passing 75 m, No. 200, Sieve) |      |       |       |       | Wet<br>&/or<br>Rainy   | Damp<br>to Dry | Dry<br>(2) | Water Quality           | Plants | Aquatic Animals |
|                                                    |                                        |                         |                      | <3                            | 3–8 | >8  | <5                                   | 5–10 | 10–20 | 20–30 | >30   |                        |                |            |                         |        |                 |
| Water (6)                                          | (1)                                    | (1)                     |                      |                               |     |     |                                      |      |       |       |       |                        |                |            |                         |        |                 |
| Water Absorbing (Hygroscopic) – Calcium Chloride   |                                        |                         |                      |                               |     |     |                                      |      |       |       | (3)   | (3,4)                  |                |            |                         |        |                 |
| Water Absorbing (Hygroscopic) - Magnesium Chloride |                                        |                         |                      |                               |     |     |                                      |      |       |       | (3)   | (3,4)                  |                |            |                         |        |                 |
| Petroleum Emulsion Based                           |                                        |                         |                      |                               |     |     |                                      |      | (5)   |       |       | (3)                    |                |            |                         |        |                 |
| Adhesive (non-Petroleum) - Lignosulfonate          |                                        |                         |                      |                               |     | (5) |                                      |      |       |       | (3,5) | (4)                    |                |            |                         |        |                 |
| Polymers                                           |                                        |                         |                      |                               |     |     |                                      |      | (5)   |       |       |                        |                |            |                         |        |                 |
| Clay Additives (5)                                 |                                        |                         |                      |                               |     |     |                                      |      |       |       |       | (3)                    |                |            |                         |        |                 |

<sup>1</sup> Information was derived from the information in Appendix 3.

<sup>2</sup> Soils analysis may be necessary to determine the percent (%) fines and the plasticity Index of the soils.

 = Good
  = Fair
  = Poor

Notes:

- (1) May require higher or more frequent application rates, especially with high truck volumes
- (2) Greater than 20 days with less than 40% relative humidity
- (3) May become slippery in wet weather
- (4) SS-1 or CSS-1 with only clean, open-graded aggregate
- (5) Road mix for best results.
- (6) Generally the most expensive and labor intensive due to the required repeated applications.

## DUST SUPPRESSANT APPLICATION GUIDELINES

Any suppressant ingredient may migrate due to carelessness in application, run-off, leaching, dust particle migration, or adhesion to vehicles. A careful review of the product literature, Material Safety Data Sheet, and manufacturer's instructions is essential before purchase and use. All safety precautions and manufacturer's directions must be followed when handling, mixing, and applying dust suppressants. Application of all dust suppressants must comply with federal, state, and local laws and regulations. These vary by locality and need to be checked prior to implementing the dust abatement program. The applicable Washington State Laws and Regulations can be found in Appendix 2.

Once a suitable product is selected, the next step is to determine the appropriate application rate and frequency. Manufacturer's literature and past experience be used to help determine the appropriate application rate. Generally, higher application rates or increased frequency (see Appendix 2) are required when the following conditions are present:

- High traffic volumes with high speeds and a larger percentage of truck traffic
- Low humidity conditions, especially when using calcium chloride
- Low fines content in road surface, typically when there is less than 10 percent passing through the 75  $\mu\text{m}$  (No. 200) sieve
- Poorly bladed surface and/or loose wearing surface.

The performance of any dust suppressant is related to many application factors. Application method, rate, frequency, and product concentration are a few of these factors. A stable, tight surface that readily sheds surface water is another. If properly applied and constructed, a longer life and higher level of service can be expected from the dust abatement efforts. Since dust suppression and road maintenance efforts are usually combined, it is prudent to include the following practices in the maintenance and rehabilitation of road surfaces prior to applying a dust suppressant:

- Repair unstable surfacing and/or subgrade areas
- Adequately drain (crown and cross fall) the road surface
- Remove boney (poorly graded) surface material
- Grade sufficient depth of roadway to remove ruts, potholes, and erosion gullies
- Compact the roadway (depending on treatment and sequence of operations).

Maximum benefits can also be achieved by adequate penetration of the liquid dust suppressant. This penetration should be on the order of 10 to 20 millimeters (3/8 to 3/4 inches). Proper penetration mitigates loss of the suppressant resulting from surface wear. Adequate penetration also resists leaching, imparts cohesion, and resists aging. Application tips that apply to all liquid dust suppressant products include:

- Apply suppressants, especially salts, immediately following the wet season.
- If possible, apply after rain so materials are moister (aids mixing) and more workable. If applied just before a rain, the material may wash away.
- Adhere to manufacturers' recommendations on minimum application rate, compaction and curing time prior to allowing traffic.
- If the surface material is dry, dampen, except when using cut-back asphalt products.
- If a hard crust is present, break up and loosen the surface.
- Use a pressure distributor to uniformly distribute the dust suppressant.
- Ensure that the necessary "residual" of the product is obtained. The residual is the amount of product that remains after the evaporation of water from the concentrate, as well as that used to dilute the product prior to application. The residual (sometimes called solids or binder) is the portion of the product that is responsible for the binding and/or agglomeration of the particles.

## REFERENCES

Washington State Department of Ecology, Publication Number 96-433, Revised March 2003 ***"Techniques for Dust Prevention and Suppression"***.

USDA Forest Service, November 1999, 9977 1207-SDTDC ***"Dust Suppressant Selection and Application Guide"***.

Appendix 1

| DUST SUPPRESSANT EVALUATION CHECKLIST (DSEC)                                                                                                                                                             |                                                                                                 |                                      |                    |                                                                                                     |                          |                                   |      |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------|--------------------------------------|--------------------|-----------------------------------------------------------------------------------------------------|--------------------------|-----------------------------------|------|
| Inventoried Road                                                                                                                                                                                         | SITE INVENTORY QUESTIONS                                                                        |                                      | CIRCLE BEST CHOICE |                                                                                                     |                          |                                   |      |
|                                                                                                                                                                                                          | Traffic Volumes, average daily traffic                                                          |                                      | Light (<100)       | Medium (100 to 250)                                                                                 |                          | Heavy (>250)                      |      |
|                                                                                                                                                                                                          | % Fines Passing the No. 200 Sieve (surface material)                                            |                                      | <5                 | 5-10                                                                                                | 10-20                    | 20-30                             | >30  |
|                                                                                                                                                                                                          | Plasticity Index of Fines (surface material)                                                    |                                      | <3                 |                                                                                                     | 3-8                      |                                   | >8   |
|                                                                                                                                                                                                          | Climate Conditions During Traffic                                                               |                                      | Wet and/or Rainy   |                                                                                                     | Damp to Dry              |                                   | Dry  |
|                                                                                                                                                                                                          | Environmental Considerations                                                                    |                                      | Potential Impact   |                                                                                                     |                          |                                   |      |
|                                                                                                                                                                                                          | Water Quality                                                                                   |                                      | Low                |                                                                                                     | Medium                   |                                   | High |
|                                                                                                                                                                                                          | Plants                                                                                          |                                      | Low                |                                                                                                     | Medium                   |                                   | High |
|                                                                                                                                                                                                          | Aquatic Animals                                                                                 |                                      | Low                |                                                                                                     | Medium                   |                                   | High |
|                                                                                                                                                                                                          | Road Condition                                                                                  |                                      |                    | Condition Response                                                                                  |                          |                                   |      |
|                                                                                                                                                                                                          | Is the surfacing and/or subgrade in need of repair?                                             |                                      |                    | Yes                                                                                                 |                          | No                                |      |
|                                                                                                                                                                                                          | Does the road surface lack adequate crown and/or cross fall?                                    |                                      |                    | Yes                                                                                                 |                          | No                                |      |
|                                                                                                                                                                                                          | Is there poorly graded surface material?                                                        |                                      |                    | Yes                                                                                                 |                          | No                                |      |
|                                                                                                                                                                                                          | Does the road surface have ruts, potholes, or erosion gullies?                                  |                                      |                    | Yes                                                                                                 |                          | No                                |      |
|                                                                                                                                                                                                          | All road condition issues should be addressed prior to the application of the dust suppressant. |                                      |                    |  Yes Responses |                          |                                   |      |
|                                                                                                                                                                                                          | Alternatives                                                                                    | Dust Suppressants (refer to Table 1) |                    |                                                                                                     |                          | Suitable Alternatives (check Box) |      |
| 1                                                                                                                                                                                                        | Water                                                                                           |                                      |                    |                                                                                                     | <input type="checkbox"/> |                                   |      |
| 2                                                                                                                                                                                                        | Water Absorbing (Hygroscopic) (Not Recommended)                                                 |                                      |                    |                                                                                                     | <input type="checkbox"/> |                                   |      |
| 3                                                                                                                                                                                                        | Petroleum Emulsion/Based (Not Recommended)                                                      |                                      |                    |                                                                                                     | <input type="checkbox"/> |                                   |      |
| 4                                                                                                                                                                                                        | Adhesive (Non-Petroleum) - Lignosulfonate                                                       |                                      |                    |                                                                                                     | <input type="checkbox"/> |                                   |      |
| 5                                                                                                                                                                                                        | Polymer Emulsion                                                                                |                                      |                    |                                                                                                     | <input type="checkbox"/> |                                   |      |
| 6                                                                                                                                                                                                        | Clay Additive                                                                                   |                                      |                    |                                                                                                     | <input type="checkbox"/> |                                   |      |
| Suitable alternatives must be discussed with the landowner. The benefits, costs and potential negative impacts must be clearly communicated while considering the alternative dust suppression products. |                                                                                                 |                                      |                    |                                                                                                     |                          |                                   |      |

Completed by: Name \_\_\_\_\_

Date: \_\_\_\_\_

## **Appendix 2 – Relevant Washington Laws and Regulations**

### **Chapter 70.94 RCW Washington Clean Air Act and Chapter 173-400 WAC**

These statutes require owners and operators of fugitive dust sources to prevent fugitive dust from becoming airborne and to maintain and operate sources to minimize emissions.

### **Chapter 70.95I RCW Used Oil Recycling**

This law prohibits the use of used oil as a dust suppressant. Used oil includes any oil that has been refined from crude oil, used, and as a result of such use, is contaminated by physical or chemical impurities. If you plan to use a chemical suppressant, verify that it does not contain any used oil as an ingredient. Also be certain that if the product contains fuel oil ingredients that the fuel oil does not contain used oil. Note that federal regulation 40 CFR Part 279, Standards for the Management of Used Oil, Subpart I prohibits the use of used oil as a dust suppressant in all 50 states.

### **Chapter 90.48 RCW, Water Pollution Control**

Section .080 prohibits the discharge of any material into surface or ground waters that could cause pollution as defined in WAC 173-200-020(22). If your site is near surface or ground water, use dust control measures that have zero or minimal aquatic impact. If you decide to use a chemical dust suppressant, select a product with no aquatic toxicity.

### **Chapter 70.105 RCW, Hazardous Waste Management**

This statute prohibits the disposal to the ground of any dangerous (hazardous) waste. If you are planning to use a chemical dust suppressant, make sure it does not contain any dangerous waste ingredients.

### **Chapter 70.105D RCW Hazardous Waste Cleanup - Model Toxics Control Act (MTCA)**

This law requires the identification and cleanup of hazardous sites. The Department of Ecology can investigate reports of releases or the presence of hazardous substances. If a hazardous product is used as a dust suppressant and Ecology later receives a complaint of contamination, a site assessment may be conducted. A cleanup may be required if it is determined that there is a potential threat to human health or the environment. This determination depends on the hazardous substance(s) present, their concentration(s), the environmental characteristics of the site including proximity to surface and groundwater, as well as the current or proposed future use of the property.

### **Chapter 90.03 RCW Surface Water Code and Chapter 90.44 RCW Regulation of Public Ground Waters (wells)**

This regulation requires a water right permit for all surface water withdrawal and for any water from a well that will exceed 5,000 gallons per day. If you plan to use water for dust suppression at your site, be sure that you have a legal right to that water. If in doubt, check with the Department of Ecology's Water Resources Program. Temporary permits are usually obtainable in a short time period. In some instances, water may need to be obtained from a different area and hauled in, or from an existing water right holder.

### APPENDIX 3—Road dust suppressants.

| Dust Suppressant Category      | Attributes                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Limitations                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Application                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Origin                                                                                                                                                                                                                                                                                                                                           | Environmental Impact                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|--------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Water                          | <ul style="list-style-type: none"> <li>agglomerates the surface particles</li> <li>normally, readily available</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                       | <ul style="list-style-type: none"> <li>evaporates readily</li> <li>controls dust generally for less than a day</li> <li>generally the most expensive and labor intensive of the inorganic suppressants</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                         | <ul style="list-style-type: none"> <li>frequency depends on temperature and humidity; typically only effective from 1/2 to 12 hours</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                            | <ul style="list-style-type: none"> <li>any potable water source</li> </ul>                                                                                                                                                                                                                                                                       | <ul style="list-style-type: none"> <li>none</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                             |
| Hygroscopic - Calcium Chloride | <ul style="list-style-type: none"> <li>ability to absorb water from the air is a function of temperature and relative humidity; for example, at 25°C (77°F) it starts to absorb water at 29% relative humidity, and at 38°C (100°F) it starts to absorb water at 20% relative humidity</li> <li>significantly increases surface tension of water film between particles, helping to slow evaporation and further tighten compacted soil as drying progresses</li> <li>treated road can be regraded and recompacted with less concern for losing moisture and density</li> </ul> | <ul style="list-style-type: none"> <li>requires minimum humidity level to absorb moisture from the air</li> <li>doesn't perform as well as MgCl in long dry spells</li> <li>performs better than MgCl when high humidity is present</li> <li>slightly corrosive to metal, highly to aluminum and its alloys, attracts moisture, thereby prolonging active period for corrosion</li> <li>rainwater tends to leach out highly soluble chlorides</li> <li>if high fines content in treated material, the surface may become slippery when wet</li> <li>effectiveness when less than 20% solution has performance similar to water</li> </ul> | <ul style="list-style-type: none"> <li>generally 1 to 2 treatments per season</li> <li>initial application: <u>flake</u>: @ 0.5 to 1.1 kg/m<sup>2</sup> (1.0 to 2.0 lb/y<sup>2</sup>), typical application 0.9 kg/m<sup>2</sup> (1.7 lb/y<sup>2</sup>) @ 77% purity<br/>liquid: 35 to 38% residual @ 0.9 to 1.6 L/m<sup>2</sup> (0.2 to 0.35 g/y<sup>2</sup>), typical application is 38% residual concentrate applied undiluted @ 1.6 L/m<sup>2</sup> (0.35 g/y<sup>2</sup>)<br/>follow-up: apply @ 1/2 to 1/3 initial dosage</li> </ul> | <ul style="list-style-type: none"> <li>by-product in the form of brine from manufacture of sodium carbonate by ammonia-soda process and of bromine from natural brines</li> <li>three forms: <u>flake</u>, or Type I, @ 77 to 80% purity<br/><u>pellet</u>, or Type II, @ 94 to 97% purity<br/><u>clear liquid</u> @ 35 to 38% solids</li> </ul> | <ul style="list-style-type: none"> <li>water quality impact: generally negligible if the proper buffer zone exists between treated area and water</li> <li>fresh water aquatic impact: may develop at chloride concentrations as low as 400 ppm for trout, up to 10,000 ppm for other fish species</li> <li>plant impact: some species susceptible, such as pine, hemlock, poplar, ash, spruce, and maple</li> <li>potential concerns with spills of liquid concentrate</li> </ul> |

### APPENDIX 3—Road dust suppressants (continued).

| Dust Suppressant Category        | Attributes                                                                                                                                                                                                                                                                                                                                                                             | Limitations                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Application                                                                                                                                                                                                                                                                                                                                                        | Origin                                                                                     | Environmental Impact                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|----------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Hygroscopic - Magnesium Chloride | <p>starts to absorb water from the air at 32% relative humidity independent of temperature</p> <ul style="list-style-type: none"> <li>more effective than calcium chloride solutions for increasing surface tension, resulting in a very hard road surface when dry</li> <li>treated road can be regraded and recompacted with less concern for losing moisture and density</li> </ul> | <ul style="list-style-type: none"> <li>requires minimum humidity level to absorb moisture from the air</li> <li>more suitable in drier climates</li> <li>in concentrated solutions, very corrosive to steel (note: some products may contain a corrosive-inhibiting additive); attracts moisture, thereby prolonging active period for corrosion</li> <li>rainwater tends to leach out highly soluble chlorides</li> <li>if high fines content in treated material, the surface may become slippery when wet</li> <li>effectiveness when less than 20% solution has performance similar to water</li> </ul> | <ul style="list-style-type: none"> <li>generally 1 - 2 treatments per season</li> <li>initial application: 28 to 35% residual @ 1.4 to 2.3 L/m<sup>2</sup> (0.30 to 0.5 g/y<sup>2</sup>), typical application is 30% residual concentrate applied undiluted @ 2.3 L/m<sup>2</sup> (0.50 g/y<sup>2</sup>)</li> <li>follow-up: apply @ 1/2 initial dosage</li> </ul> | <ul style="list-style-type: none"> <li>occurs naturally as brine (evaporated)</li> </ul>   | <ul style="list-style-type: none"> <li>water quality impact: generally negligible if the proper buffer zone exists between treated area and water</li> <li>fresh water aquatic impact: may develop at chloride concentrations as low as 400 ppm for trout, up to 10,000 ppm for other fish species</li> <li>plant impact: some species susceptible such as pine, hemlock, poplar, ash, spruce, and maple</li> <li>potential concerns with spills</li> </ul> |
| Hygroscopic - Sodium Chloride    | <ul style="list-style-type: none"> <li>starts to absorb water from the air at 79% relative humidity independent of temperature</li> <li>increases surface tension slightly less than calcium chloride</li> </ul>                                                                                                                                                                       | <ul style="list-style-type: none"> <li>requires minimum humidity level to absorb moisture from the air</li> <li>moderately corrosive to steel in dilute solutions</li> <li>tends not to hold up well as a surface application</li> </ul>                                                                                                                                                                                                                                                                                                                                                                    | <ul style="list-style-type: none"> <li>generally 1 - 2 treatments per season</li> <li>higher dosages than calcium treatment</li> </ul>                                                                                                                                                                                                                             | <ul style="list-style-type: none"> <li>occurs naturally as rock salt and brines</li> </ul> | <ul style="list-style-type: none"> <li>same as calcium chloride</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                  |

### APPENDIX 3—Road dust suppressants (continued).

| Dust Suppressant Category        | Attributes                                                                                                                                                                                                                                                                                                                                                          | Limitations                                                                                                                                                                                                                                                                                                                                                                           | Application                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Origin                                                                                                                                                                                                                                                                                                                | Environmental Impact                                                                                                                                                                                                                                                                                  |
|----------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Petroleum Products               | <ul style="list-style-type: none"> <li>binds and/or agglomerates surface particles because of asphalt adhesive properties</li> <li>serves to waterproof the road</li> </ul>                                                                                                                                                                                         | <ul style="list-style-type: none"> <li>under dry conditions some products may not maintain resilience</li> <li>if too many fines in surface and high in asphaltenes, it can form a crust and fragment under traffic and in wet weather</li> <li>some products are difficult to maintain</li> </ul>                                                                                    | <ul style="list-style-type: none"> <li>generally 1 to 2 treatments per season</li> <li>0.5 to 4.5 L/m<sup>2</sup> (0.1 to 1 g/y<sup>2</sup>) depending on road surface condition, dilution, and product</li> <li>the higher viscosity emulsions are used for the more open-graded surface materials</li> <li>follow-up: apply at reduced initial dosages</li> </ul>                                                                                                                                                                                                                | <ul style="list-style-type: none"> <li>cutback asphalt: SC-70</li> <li>Asphalt emulsion: SS-1, SS-1h, CSS-1, or CSS-1h mixed with 5+ parts water by volume</li> <li>modified asphalt emulsions</li> <li>emulsified oils</li> <li>mineral oils</li> </ul>                                                              | <ul style="list-style-type: none"> <li>wide variety of ingredients in these products</li> <li>“used” products are toxic</li> <li>oil in products might be toxic</li> <li>need product specific analysis</li> <li>potential concerns with spills and leaching prior to the product “curing”</li> </ul> |
| Nonpetroleum: Lignin Derivatives | <ul style="list-style-type: none"> <li>binds surface particles together</li> <li>greatly increases dry strength of material under dry conditions</li> <li>retains effectiveness during long dry periods with low humidity</li> <li>with high amounts of clay, it tends to remain slightly plastic permitting reshaping and additional traffic compaction</li> </ul> | <ul style="list-style-type: none"> <li>may cause corrosion of aluminum and its alloys</li> <li>surface binding action may be reduced or completely destroyed by heavy rain, due to solubility of solids in water</li> <li>becomes slippery when wet, brittle when dry</li> <li>difficult to maintain as a hard surface, but can be done under adequate moisture conditions</li> </ul> | <ul style="list-style-type: none"> <li>generally 1 to 2 treatments per season</li> <li>10 to 25% residual @ 2.3 to 4.5 L/m<sup>2</sup> (0.5 to 1.0 g/y<sup>2</sup>), typical application is 50% residual concentrate applied undiluted @ 2.3 L/m<sup>2</sup> (0.50 g/y<sup>2</sup>) or 50% residual concentrate applied diluted 1:1 w/water @ 4.5 L/m<sup>2</sup> (1.0 g/y<sup>2</sup>)</li> <li>may be advantageous to apply in two applications</li> <li>also comes in powdered form that is mixed 1 kg to 840 liters (1 lb to 100 gallons) of water and then sprayed</li> </ul> | <ul style="list-style-type: none"> <li>water liquor product of sulfite paper making process, contains lignin in solution</li> <li>composition depends on raw materials (mainly wood pulp) and chemicals used to extract cellulose; active constituent is neutralized lignin sulfuric acid containing sugar</li> </ul> | <ul style="list-style-type: none"> <li>water quality impacts: none</li> <li>fresh water aquatic impacts: BOD may be high upon leaching into a small stream</li> <li>plant impacts: none</li> <li>potential concern with spills</li> </ul>                                                             |

### APPENDIX 3—Road dust suppressants (continued).

| Dust Suppressant Category                         | Attributes                                                                                                                                                    | Limitations                                                                                                                                                                                                                                | Application                                                                                                                                                                                                                                                                                                             | Origin                                                                                                                     | Environmental Impact                                                                                                                                                                                                    |
|---------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Organic Nonpetroleum: Molasses/Sugar Beet Extract | <ul style="list-style-type: none"> <li>provides temporary binding of the surface particles</li> </ul>                                                         | <ul style="list-style-type: none"> <li>limited availability</li> </ul>                                                                                                                                                                     | <ul style="list-style-type: none"> <li>not researched</li> </ul>                                                                                                                                                                                                                                                        | <ul style="list-style-type: none"> <li>by-product of the sugar beet processing industry</li> </ul>                         | <ul style="list-style-type: none"> <li>water quality impact: unknown</li> <li>fresh water aquatic impact: unknown</li> <li>plant impact: unknown, none expected</li> </ul>                                              |
| Organic Nonpetroleum: Tall-Oil Derivatives        | <ul style="list-style-type: none"> <li>adheres surface particles together</li> <li>greatly increases dry strength of material under dry conditions</li> </ul> | <ul style="list-style-type: none"> <li>surface binding action may be reduced or completely destroyed by long-term exposure to heavy rain, due to solubility of solids in water</li> <li>difficult to maintain as a hard surface</li> </ul> | <ul style="list-style-type: none"> <li>generally 1 treatment every few years</li> <li>10 to 20% residual solution @ 1.4 to 4.5 L/m<sup>2</sup> (0.3 to 1.0 g/y<sup>2</sup>); typical application is 40 to 50% residual concentrate applied diluted 1:4 w/water @ 2.3 L/m<sup>2</sup> (0.5 gal/y<sup>2</sup>)</li> </ul> | <ul style="list-style-type: none"> <li>distilled product of the kraft (sulfate) paper making process</li> </ul>            | <ul style="list-style-type: none"> <li>water quality impact: unknown</li> <li>fresh water aquatic impact: unknown</li> <li>plant impact: unknown</li> </ul>                                                             |
| Organic Nonpetroleum: Vegetable oils              | <ul style="list-style-type: none"> <li>agglomerates the surface particles</li> </ul>                                                                          | <ul style="list-style-type: none"> <li>limited availability</li> <li>oxidizes rapidly, then becomes brittle</li> </ul>                                                                                                                     | <ul style="list-style-type: none"> <li>generally 1 treatment per season</li> <li>application rate varies by product, typically 1.1 to 2.3 L/m<sup>2</sup> (0.25 to 0.50 g/y<sup>2</sup>)</li> <li>the warmer the product, the faster the penetration</li> <li>follow-up: apply at reduced initial dosages</li> </ul>    | <ul style="list-style-type: none"> <li>some products: canola oil, soybean oil, cotton seed oil, and linseed oil</li> </ul> | <ul style="list-style-type: none"> <li>water quality impact: unknown</li> <li>fresh water aquatic impact: some products have been tested and have a low impact</li> <li>plant impact: unknown, none expected</li> </ul> |

### APPENDIX 3—Road dust suppressants (continued).

| Dust Suppressant Category   | Attributes                                                                                                                                                         | Limitations                                                                                                                                                                                                                                                        | Application                                                                                                                                                                                                                                                                                                              | Origin                                                                                                                                 | Environmental Impact                                                                                                                                                                                |
|-----------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Electrochemical Derivatives | <ul style="list-style-type: none"> <li>changes characteristics of clay-sized particles</li> <li>generally effective regardless of climatic conditions</li> </ul>   | <ul style="list-style-type: none"> <li>performance dependent on fine-clay mineralogy</li> <li>needs time to "set-up," i.e. react with the clay fraction</li> <li>difficult to maintain if full strengthening reaction occurs</li> <li>limited life span</li> </ul> | <ul style="list-style-type: none"> <li>generally diluted 1 part product to anywhere from 100 to 600 parts water</li> <li>diluted product also used to compact the scarified surface</li> </ul>                                                                                                                           | <ul style="list-style-type: none"> <li>typical products: sulfonated oils, ammonium chloride enzymes, ionic products</li> </ul>         | <ul style="list-style-type: none"> <li>need product specific analysis</li> <li>some products are highly acidic in their undiluted form</li> </ul>                                                   |
| Polymers                    | <ul style="list-style-type: none"> <li>binds surface particles because of polymer's adhesive properties</li> </ul>                                                 | <ul style="list-style-type: none"> <li>difficult to maintain as a hard surface</li> </ul>                                                                                                                                                                          | <ul style="list-style-type: none"> <li>generally 1 treatment every few years</li> <li>5 to 15% residual solution @ 1.4 to 4.5 L/m<sup>2</sup> (0.3 to 1.0 g/y<sup>2</sup>); typical application is 40 to 50% residual concentrate applied, diluted 1:9 w/water @ 2.3 L/m<sup>2</sup> (0.50 gal/y<sup>2</sup>)</li> </ul> | <ul style="list-style-type: none"> <li>by-product of the adhesive manufacturing process</li> <li>typically 40 to 60% solids</li> </ul> | <ul style="list-style-type: none"> <li>water quality impact: none</li> <li>fresh water aquatic impact: generally low</li> <li>plant impact: none</li> <li>need product specific analysis</li> </ul> |
| Clay Additives              | <ul style="list-style-type: none"> <li>agglomerates with fine dust particles</li> <li>generally increases dry strength of material under dry conditions</li> </ul> | <ul style="list-style-type: none"> <li>if high fines content in treated material, the surface may become slippery when wet</li> </ul>                                                                                                                              | <ul style="list-style-type: none"> <li>generally 1 treatment every 5 years</li> <li>typical application rate is at 1 to 3% by dry weight</li> </ul>                                                                                                                                                                      | <ul style="list-style-type: none"> <li>mined natural clay deposits</li> </ul>                                                          | <ul style="list-style-type: none"> <li>water quality impact: unknown</li> <li>fresh water aquatic impact: none</li> <li>plant impact: none</li> </ul>                                               |