WHY CONTROL DUST?

For thousands of communities, unpaved roads play an essential role in the transportation infrastructure. Nearly 2 million miles of U.S. roads are unpaved and approximately 365,000 miles of roadway are unpaved in Canada. Relatively inexpensive to build and maintain, unpaved roads provide thousands of people with vital access to work and schools, to the grocery store, and to health care facilities. And they link farms, forests, mines and wells – as well as manufacturers and product distributors – with the markets they serve.

Effective dust control is essential to keep unpaved roads drivable and safe. It is also an important way for road authorities to reduce annual maintenance, extend aggregate life and cut overall expense.

IMPROVED ROADS

Road experts will tell you, a dusty road is a deteriorating road. Dust is comprised of fine particles which, when they turn to dust, no longer serve as binding agents that hold road surfaces together. This leaves the load-bearing aggregate exposed, unstable and vulnerable—subject to degradation and loss with every passing vehicle, or to washout with every hard rain. Ruts, potholes and washboards form. The need for spot repairs increases. Blading with grading equipment must be performed more frequently. And, ultimately, the aggregate must be replaced.

LOWER ROAD MAINTENANCE EXPENSE

Budgets for road maintenance and improvement are under constant pressure, yet motorists, residents and businesses demand quality roads that are safe and comfortable to drive on. Solutions that reduce the cost of labor and materials spent keeping roads in acceptable condition can provide significant relief to road commissions and the taxpayers they serve. Use of effective dust suppression products is one such solution. Effective dust control can reduce the overall cost of unpaved road maintenance by 30% or more. Field trial results have shown that when calcium chloride is used on unpaved road surfaces to suppress dust, blading frequency decreased by 50% and aggregate life doubled.[1] Field trials in South Africa revealed that the anticipated interval between regraveling was extended from 7 to 14 years

when roads were treated with calcium chloride. The cost of paving gravel roads is significant, particularly when traffic volume is relatively low. For most counties, maintaining existing gravel roads is the only realistic option. Effective dust control enables road authorities to maintain roads in safe, drivable condition at significantly lower cost than when roads are untreated.

[1] *The Incorporation of Dust Palliatives as a Maintenance Option in Unsealed Road Management System,* D. Jones, E. Sadzik and I. Wolmerans: Paper from 20th ARRB Conference, 19-21 March, 2001.

INCREASED DRIVING SAFETY

Controlling dust improves visibility and results in greater rural driving safety. According to the Insurance Institute for Highway Safety-Highway Loss Data Institute, sixty-three percent of passenger vehicle occupant deaths occurred in rural areas. Although there are many reasons for rural traffic fatalities, reduced visibility due to road dust on unpaved roads can be a contributing factor in many accidents.

A loose dusty surface can also reduce vehicle traction. When brakes are applied suddenly on a deteriorating unpaved road, tires can fail to grip on the loose, unstable gravel. Stopping distances are extended and vehicles can skid out of control, endangering drivers and vehicle occupants. Loose gravel on a deteriorating road may also pose a hazard to others. As fine particles in the road surface turn to dust, aggregate loosens and these coarse solids can become projectiles that pose a danger to other motorists, pedestrians, and neighboring residents and business employees.

REDUCED VEHICLE DAMAGE

Even if you operate a car wash or a windshield glass or other automotive repair business, it is unlikely you are happy about the filth and damage caused to your personal vehicle by dusty, deteriorating roads. How much damage is caused to vehicles as gravel roads degrade? If just a portion of the more than $1 billion in annual revenue generated by over 7,000 U.S.[1] auto glass repair shops results from loose aggregate in gravel roads, the total tab for vehicle damage due to poor unpaved road conditions is steep. Loose aggregate not only damages windshields, it also takes its toll on paint, chrome, headlights, suspension systems and other components. Dust can clog filters, erode seals, and form abrasive grit between moving parts. The

harsh vibration caused by washboards and the impact of potholes can harm steering systems, tires and rims while loosening other components and contributing to long-term vehicle wear and tear, as well as potential vehicle safety issues.

[1] U.S. Census Bureau's *Statistics of U.S. Businesses.*

BETTER HEALTH

Scientific studies have linked airborne particulate pollution with significant health problems. People exposed to dust can experience respiratory symptoms including irritation, coughing or difficulty breathing. Exposure to particulates can also decrease lung function and aggravate asthma or hay fever. Dust can convey diseases like tetanus that are harbored by soil. Some health experts suggest that chronic bronchitis and irregular heartbeat can also result from exposure to particle pollution, and premature death is possible if individuals already have lung or heart disease. The effects of dust inhalation can have a particularly serious effect on children, the elderly or others who are vulnerable to health issues.

Dust is considered a coarse particulate, 10 microns or smaller in size, and subject to the 2006 U.S. Environmental Protection Agency (EPA) 24-hour primary and secondary standard calling for concentrations not to exceed 150 micrograms per cubic meter of air.[2] Concerns about the health effects of dust pollution have resulted in federal and state air-permitting regulations to control the amount of “fugitive dust” emitted by industrial and transportation facilities such as mines, railroads, and agricultural and manufacturing locations, where unpaved surfaces and traffic levels combine to create high concentrations of airborne dust.

[2] EPA National Ambient Air Quality Standards (40 CFR part 50).

PROTECTING THE ENVIRONMENT

Effective dust control can protect the environment from dust by preventing fine materials from becoming air- or waterborne. What’s more, by helping to preserve thousands of tons of roadway gravel, dust control also reduces the environmental impact of gravel mining and transportation of gravel needed to replenish aggregate in unpaved roadways.

The effect of road dust on natural scenery and fresh air is unmistakable. But dust is also a harmful pollutant in ways that are less obvious. Dust from

roadways can drift or wash into streams and other waterways, increasing sediment load and harming aquatic plants and animals. Dusty, deteriorating roads require more frequent blading to maintain safe, drivable conditions, which, according to the United States Department of Agriculture (USDA) Forest Service, can increase the amount of sediment that reaches streams and other surface water.

Airborne dust can also be damaging. Crops and vegetation near unpaved roads can become coated with dust, stunting their growth due to shading effect and clogged plant pores.[1]

Dust is an airborne pollutant that can degrade regional air quality. According to a 1992 study cited by researchers at Colorado State University, nearly 34 percent of the particulate matter in the atmosphere in the U.S. originates from unpaved roads nationwide.[1] Dust is considered a coarse particulate, 10 microns or smaller in size, and subject to the 2006 U.S. Environmental Protection Agency (EPA) 24-hour primary and secondary standard calling for concentrations not to exceed 150 micrograms per cubic meter of air.[2] Missouri air pollution control regulations prohibit dust from private roads in commercial operations from leaving the property. Businesses must apply some form of dust control to comply with this regulation. Other state, provincial and local regulations may also apply across the U.S. and Canada.

[1] Road Dust Suppression: Effect on Maintenance Stability, Safety and the Environment, Phases 1-3; Jonathan Q. Addo, Thomas G. Sanders, Melanie Chenard, 2004.

[2] EPA National Ambient Air Quality Standards (40 CFR part 50).

HIGHER QUALITY OF LIFE

Effective dust control can significantly improve the quality of life for those who live and work near unpaved roads, and those who travel on those roads. It is difficult to put a price tag on the simple pleasure of working or playing in the yard, walking or bicycling along a country road, hunting or fishing, bird watching, or just basking in the sun. But all of those experiences can be diminished by choking clouds of road dust.

What’s more, that same dust can cut into leisure time, increasing the need to clean windows and siding, sweep sidewalks and porches, and wash outdoor furniture. It can also render outdoor clothes lines almost useless, forcing homemakers to machine dry laundry even on the warmest and sunniest days – and tolerate resulting higher energy bills – to avoid dust contamination of sheets and towels. Dust that penetrates the interior of homes can coat walls,

floors and furnishings, imposing an additional housekeeping burden. Trying to block the dust by closing windows and doors is only partially effective, and it increases the use air of conditioning, contributing to still higher energy bills.

HOW TO CONTROL DUST

Effective dust prevention measures are essential to preserve the drivability and durability of unpaved roads, minimize impact on the natural environment, and protect the health, safety, property and quality of life of those who live on, work near, or travel on gravel roads. Dust control has been widely practiced by road authorities across North America. A wealth of field experience has demonstrated the effectiveness of calcium chloride for thorough, long-lasting dust suppression across a wide range of gravel and climate conditions.

CHOOSING THE RIGHT DUST SUPPRESSANT

Suppressants used to control dust on unpaved roads can range from water to palliative materials including brine solutions based on sodium chloride (NaCl), calcium chloride ($CaCl_2$), and magnesium chloride ($MgCl_2$). While lignin and asphalt emulsions, as well as natural clays and plant oils may also be used, chloride solutions are the predominant dust control option in most regions. Water is most commonly used as a temporary dust suppressant on construction sites and in gravel pits and quarries. Although water moisture helps bind fines to gravel to prevent dust, it must be applied frequently to maintain adequate moisture. This means high labor and equipment costs, particularly under arid conditions where water evaporates quickly.
The two most frequently used dust suppressant options are calcium chloride and magnesium chloride, which are hygroscopic (moisture attracting) materials that draw moisture from the air to provide extended dust suppression.

Calcium Chloride

Calcium chloride ($CaCl_2$) is a hygroscopic salt that draws moisture from the air to form a solution in road gravel that keeps road surfaces constantly damp, even in hot, dry conditions. The moisture helps to bind particles together to create a hard and compact road surface. Because it penetrates several inches into the road base, calcium chloride also contributes to overall road surface stability. It depresses the freezing point of the moisture in the road surface, to help minimize frost heave damage in the winter.

Magnesium Chloride

Magnesium chloride ($MgCl_2$) is also a hygroscopic salt. It is most commonly supplied in liquid form at a concentration of about 30%. Liquid magnesium chloride and liquid calcium chloride exhibit similar water attraction properties. However, under hot, dry conditions, $CaCl_2$ remains liquid, while $MgCl_2$ does not, resulting in lower dust suppression capabilities under these conditions. Application rates and environmental profiles of the two materials are very similar.

Comparing the Effectiveness of $CaCl_2$ and $MgCl_2$

Calcium chloride and magnesium chloride are often the two dust suppressant materials considered by road authorities. While, calcium chloride and magnesium chloride are similar materials, differences in the concentration of active ingredients in commercially available products can make a significant difference in how efficiently and economically they can be used to control dust.

Similar solution forming characteristics – The dust control performance of both $CaCl_2$ and $MgCl_2$ is based on their ability to keep road surfaces damp. When applied to a gravel road, calcium chloride and magnesium chloride suppress dust by attracting moisture from the air, creating a solution that dampens the road surface. Once $CaCl_2$ and $MgCl_2$ are applied to a gravel road surface, the solution volume in the road surface changes as it seeks equilibrium with the moisture content of the air. If relative humidity is high, the solution volume grows. If conditions are dry, the opposite occurs. Calcium chloride remains liquid in hot, dry weather, extending dust control under conditions when magnesium chloride solidifies and provides little if any dust protection.

Higher Concentration of $CaCl_2$ Products is a Critical Advantage – The chemical action of $CaCl_2$ and $MgCl_2$ may be similar, but the actual performance of commercially available products can be very different. Commercial calcium chloride products are available in higher concentrations than magnesium chloride dust suppressants, which means a crew using the same amount of each material can treat more road using $CaCl_2$ than with $MgCl_2$. Or, less calcium chloride than magnesium chloride will be required to control dust on the *same* length of roadway. The tables below illustrate calcium chloride's concentration advantage in comparisons of liquid and of dry products.

When comparing the performance of liquid products, it is important to note that Calcium Chloride Solution is available in concentrations of calcium chloride ranging from 28% to 42% and that the concentrations used for dust

control are typically 35% to 38%. In contrast, commercial liquid magnesium chloride products are typically supplied at a concentration of 30%. This is a significant distinction as shown in the table below:

Coverage Comparison of Commercial Liquid Dust Control Products

	Calcium Chloride	Typical Commercial $MgCl_2$
Product Concentration (commercially available products)	38%	30%
Lane Miles Covered by typical 4,000 Gallon Talk truck Load**	1.6	1.1
Actual Gallons Required per Lane Mile (to achieve same dust control effect)	2,464	3,520

Third-party Application Recommendations Confirm $CaCl_2$'s Potency Advantage – Application rate recommendations of government authorities in the U.S. and Canada reflect the greater concentration and higher resulting dust suppression potency of calcium chloride solutions compared to commercial solutions of magnesium chloride. Environment Canada has published best practices that recommend an application rate of 1.4 to 2.3 l/m^2 of magnesium chloride to achieve the same dust suppression capability as calcium chloride applied at a rate of 0.9 to 1.6 l/m^2.[1] The USDA Forest Service found that a magnesium chloride application rate of 0.30 to 0.50 gal/yd^2 was necessary to achieve the same dust suppression performance as 0.20 to 0.35 gal/yd^2 of calcium chloride.[2]

$CaCl_2$ Provides Additional Concentration-Related Savings – Lower application rates for calcium chloride can also translate into transportation, man hour and equipment cost-savings, as well as reduced impact on the environment.

Environmental, Health & Safety Profiles are Similar – Independent research into the environmental, health and safety impact of calcium chloride and magnesium chloride in dust control applications has found that concerns related to the use of these materials are similar and can be effectively managed through proper handling and application procedures and by adhering to recommended application rates.

The U.S. Department of Agriculture Forest Service reported that soil samples taken after multiple dust control test projects using calcium chloride and magnesium chloride showed similar effects for both chemicals: increases in chloride levels in soils were below thresholds for concern. Data from tree samples taken as part of the same studies showed increased chloride levels but chloride levels were not deemed a significant long-term threat to vegetation survival. One of the tests, involving application of calcium chloride

on roadway adjacent to the Tucannon River in Southeast Washington, resulted in “no significant change in calcium- or chloride-ion levels in the water”.[3]

Environment Canada application recommendations for liquid calcium chloride and magnesium chloride are the same for both materials, supporting similar impact and management requirements.[1] The U.S. Department of Agriculture Forest Service also provides identical management recommendations for magnesium chloride and calcium chloride.[2]

Product Availability – Product availability may also be a factor in choosing between $CaCl_2$ and $MgCl_2$.

[1] Best Practices for the Use and Storage of Chloride-based Dust Suppressants, Environment Canada, February 2007.

[2] Dust Palliative Selection and Application Guide, USDA Forest Service, P. Bolander and A. Yamada, November 1999.

[3] Surface-Aggregate Stabilization with Chloride Materials, U.S. Department of Agriculture Forest Service, December 2006.

Well Head Brines

Well head brine solutions – also referred to as mineral well or oil well brines – are sometimes applied to unpaved roads under the mistaken belief that they offer the same dust suppressant advantages as commercially available calcium chloride and magnesium chloride, yet at lower cost. While the hygroscopic performance of defined concentrations of pure calcium chloride and magnesium chloride are well known, the moisture attraction and resulting dust control effectiveness of other brine solutions is less certain. The lower concentrations of hygroscopic material typically found in well head brines means far more material can be required to achieve dust control, increasing transportation and application expense.

Inadequate dust suppression – The two factors that determine dust suppressant capabilities are the composition and the concentration of brine material. Composition is important because some salts are highly hygroscopic (calcium chloride and magnesium chloride) and others, such as sodium chloride, are not. Well head brines tend to contain higher levels of sodium chloride and low levels of $CaCl_2$ and $MgCl_2$. Sodium chloride is a solid under most summer climate conditions and offers no dust suppression capability. In one study on a ¾ mile section of gravel road, 38% calcium chloride was compared to an oil field brine containing 15% sodium chloride and only 12% calcium chloride and magnesium chloride combined. Controlled sampling over seven weeks found that calcium chloride – with more than three times as much hygroscopic salt – controlled dust three times better than the brine.

Environmental Issues – By using more brine to achieve dust control, the amount of dust suppressant material introduced into the environment is increased, potentially increasing impact. The varying content of brines can also pose a concern. In some jurisdictions, regulations may require permits for the use of well head brine to treat roadways.[1] What's more, the relatively high concentrations of sodium chloride in well head brines can be detrimental to soil structure and soil permeability, posing additional environmental risk.

Higher overall treatment costs – Well head brine composition can vary widely depending on the local source and is often significantly lower in hygroscopic salt content compared to calcium chloride or other commercial $CaCl_2$ or $MgCl_2$ solutions. The concentration of hygroscopic salts in the brine is important because the lower the concentration, the more material required to effectively suppress dust and the higher the transportation costs and the application cost per mile of treated road. In one comparison, 0.46 gal/yd^2 of well head brine was required to achieve the same hygroscopic capacity as 0.28 gal/yd^2 of 38% Calcium Chloride. A 3,700 gallon truck making three trips per day could treat 3.4 miles per day with 38% Calcium Chloride and only about 2.1 miles per day with the well head brine. These costs can quickly offset any per-gallon cost savings on the material itself.

[1] Guidelines for Selecting Dust Suppressants to Control Dust and Prevent Soil Erosion, Michigan Department of Natural Resources and Environment, Office of Pollution Prevention and Compliance Assistance, 2010.

Impact on Waterways

The threat posed by calcium chloride contamination of ground and surface water supplies is low. Calcium chloride is classified as practically non-toxic to aquatic organisms according to U.S. Environmental Protection Agency (EPA) criteria. In fact, the calcium component of the material is a natural component of nearly all natural waters. In excessive amounts, chloride salts can be harmful, but ground and surface waters are not likely to be impacted by calcium chloride applied for dust suppression as long as proper application procedures and application rates are used.

Unlike winter ice control applications of chloride materials which can wash from the surface of the road as snow and ice melt, properly applied dust control treatments tend to remain bound in the stabilized road surface for extended periods of time. Quantities washed into the environment are typically very dilute. Magnesium chloride and calcium chloride, as well as sodium chloride (road salt) are all soluble in water and therefore can dissolve in wet weather and be transported into ground or surface waters. The tendency of

salts to migrate from roads to ground and surface water depends on the application rate of the chloride; the composition and type of soil; the type, intensity and amount of precipitation; and the drainage of the road system.[1] This underscores the importance of using quality gravel and proper application procedures.

While many studies of salt concentrations in ground and surface water near roadways have been related to highway deicing, a United States Department of Agriculture (USDA) Forest Service sponsored study of dust control in the western U.S., included measurement of chloride levels in the Tucannon River in western Washington before and after calcium chloride was applied on the adjacent Tucannon River Road. The study found there was no significant change in calcium- or chloride-ion levels in the river. Soil samples taken before and after treatment showed increases in chloride levels remained below thresholds for concern.[2]

Impact on Health and Safety

When properly handled and applied, calcium chloride does not pose a significant risk to health and safety. Calcium and chloride are considered essential constituents in the bodies of all animals and the acute oral toxicity of calcium chloride is classified as low. However, concentrations of chloride ions in drinking water are considered a health risk and subject to EPA regulation when they exceed 250 mg/l (based on U.S. EPA National Recommended Water Quality Criteria: 2002, EPA-822-R-02-047, November 2002). In most situations, the potential for contamination of drinking water supplies from calcium chloride dust suppression treatments is small as long as proper application procedures and recommended product application rates are followed. Concentrations of chloride ions detected in cased wells near treated roads are typically well below the EPA limit.

Impact on Vegetation

Calcium is a plant nutrient and a structural component of cell walls comprising 1-2 percent by weight of dry leaf matter. However, the accumulation of salts in soil can adversely affect plant physiology and morphology and over exposure to chlorides of any kind – $MgCl_2$, NaCl, or $CaCl_2$ – can injure trees and other foliage. Leaf scorch and other injuries to trees and vegetation have been reported along roadsides where calcium chloride and magnesium chloride were sprayed for dust control.[1 3] The likelihood of damage to vegetation can be significantly limited if dust control applications follow current recommended and standard practices. On four projects studied by the USDA Forest Service,

samples taken from conifers close to treated roads showed some increase in chloride levels but not in an amount posing a long-term threat to vegetation survival. Photos of the trees taken over a period of two years revealed no discernible difference in the trees.[2]

Impact on Vehicles and Equipment

Noticeable corrosion of vehicles and equipment is unlikely to occur when the vehicles are driven on unpaved surfaces treated with calcium chloride. The calcium chloride is present in small amounts and tends to stay bound to the soil in the road, so there is little chance for significant contact with metal on a passing vehicle. Calcium chloride is readily soluble in water and vehicles can be easily cleaned after exposure to the material. Dust control application equipment should be thoroughly cleaned of calcium chloride residue after use as a preventative measure.

Impact on Pets & Wildlife

Animals are more tolerant of high salinity water than humans. Water with chloride levels as high as 1,500 – 2,000mg/l has been designated as suitable for livestock and wildlife in the western U.S and in some other areas of the world. Far higher levels are deemed acceptable for sustaining domestic animals.[1] This suggests that levels of chlorides released into adjacent water under properly administered road dust treatment programs do not pose a significant threat to pets and wildlife.

[1] Road Dust Suppression: Effect on Maintenance Stability, Safety and the Environment Phases 1-3, J.Q. Addo, T.G. Sanders, M Chenard, May 2004.

[2] Surface-Aggregate Stabilization with Chloride Materials, USDA Forest Service, S. Monlux and M.R. Mitchell, December 2006.

[3] Condition of Soils & Vegetation Along Roads Treated with Magnesium Chloride for Dust Suppression, B.A. Goodrich, R.D. Kiski, W.R. Jacobi, September 2008.