BEST PRACTICES GUIDE FOR DUST MANAGEMENT IN ALBERTA

CASA
Clean Air Strategic Alliance

June 2026

Acknowledgments

The Clean Air Strategic Alliance thanks the members of the *Best Practices Guide for Dust Management in Alberta* project team, their organizations, and the participants of engagement sessions for their contributions to the project. Corresponding members stayed diligently updated on the project and CASA staff are also acknowledged.

This project would not have been possible without operational funding provided by Alberta Environment and Protected Areas. Project funding was provided by Alberta Environment and Protected Areas and the City of Calgary.

Disclaimer

The *Best Practices Guide for Dust Management in Alberta (the Guide)* and *Best Practices Guide for Dust Management in Alberta – Technical Documentation* (Technical Documentation; Appendix 1) aim to explain the application of dust-related requirements in Alberta using plain language. The Guide provides some cross-references to the Technical Documentation to highlight additional information for the reader. Individual sections of this Guide and Technical Documentation are not intended to be read in isolation.

While the Guide and Technical Documentation provide dust management-related information relevant to most dust source types associated with key industry sectors in Alberta, the documents have some limitations. The Guide and supporting materials do not cover every possible activity, sector, dust source, and best practice where dust management considerations are relevant.

Furthermore, any one activity, sector or dust source may not be explicitly referenced in every section of the Guide and Technical Documentation.

Any examples related to specific activities, sectors, dust sources, and best practices, are for illustrative purposes only and may not be suitable or practicable for all operations or situations. Likewise, the Guide and Technical Documentation are Alberta focused; however, there are references in the Technical Documentation to dust-related requirements in other jurisdictions. These examples are not intended to guarantee applicability to Alberta.

These documents do not revise or replace any regulatory requirements and following the best practices within do not equate to or guarantee compliance. For more information, contact your compliance authority.

About the Clean Air Strategic Alliance

The Guide and Technical Documentation are the result of a "*Best Practices Guide for Dust Management in Alberta*" Project[1] undertaken by the Clean Air Strategic Alliance (CASA). CASA is a collaborative partnership composed of representatives selected by industry, government, Indigenous, and non-government organizations. Every partner is committed to a comprehensive air quality management system for Alberta. CASA was a registered not-for-profit Society under the Alberta Societies Act and its operations were supported by a grant provided by Alberta Environment and Protected Areas. For more information about CASA and the project, refer to the project team's final report.[1]

1 https://www.casahome.org/past-projects/best-practices-guide-dust-management-alberta-61/

Background

The project, in part, was initiated as the result of a previous CASA Non-Point Source Project (2015-2017),[2] which was tasked with helping to address non-point source air emissions.

Recommendation 10 from that project team was:

> *"…Alberta Environment and Parks and Alberta Transportation work with municipalities, construction companies, and other stakeholders to develop and disseminate a best practices guide to address dust from construction and roads that:*
>
> *i. identifies why this issue is important and what can be done to address it*
>
> *ii. provides templates for environmental policies and plans*
>
> *iii. prepares for potential requirements in the future."*

The scope of the project was expanded to include best practices for managing dust from other activities that are, or have the potential to be, major dust emission sources in Alberta.

Methodology

The Guide and Technical Documentation were developed based on information available to the project team and the consultant, including input provided by other stakeholders selected for engagement during the project.

The content of the Guide was informed by the Technical Documentation prepared by the consultant engaged to support the project (AECOM), under the guidance and direction of the project team. While most of the content of the Guide is based on the Technical Documentation, there are some areas where detail or context has been added.

The writing of the Technical Documentation was informed by a literature/jurisdictional review of dust management practices in Alberta and elsewhere, engagement (surveys, focus groups, workshop) involving stakeholders and communities which focused on identifying dust management issues and challenges and ensuring that the Guide was "user friendly," and the expertise and experience of the project team to guide and assist the consultant.

For more information, refer to the project team's final report and the Technical Documentation.

2 https://www.casahome.org/past-projects/non-point-source-project-team-37/

Terminology

Dust can be generated by many sources, some of which are associated with specific facility operations, and others which are only activity-related (e.g., driving on paved or unpaved public roads or undertaking construction or demolition). To simplify references to dust sources in the Guide, the terms "activity, operation/facility, and operator/responsible party" are used to cover all sources and types of dust generation.

Likewise, there are a range of terms in the Guide related to reducing dust emissions. In general, the Guide considers "dust mitigation" and "dust control" as an activity that reduces dust emissions directly (e.g., lower speed limit, watering), while "dust management" also includes indirect methods (e.g., people recording dust-related events and their magnitude and timing).

Add-on terms such as (dust management/mitigation/control) practices, actions, activities, measures, and methods are generally used interchangeably.

In addition, the Technical Documentation (Appendix 1) contains a glossary and list of abbreviations and acronyms for clarity of various terms used in the Guide and Technical Documentation. For example, definitions for "unpaved road" and "paved road" are broad and not limited to public roads or highways.

Purpose and Audience

The Guide and Technical Documentation are intended to assist municipalities and provincial regulators and be a resource for industry and other stakeholders in improving dust management in the province. Municipalities, industry, Indigenous communities, regulatory bodies, health and environmental non-government organizations, and other groups or individuals that are interested in, or impacted by, dust should find value in the materials.

Uses of the Guide and Technical Documentation may include preparing and updating dust management plans and supporting the preparation of *Environmental Protection and Enhancement Act* approval and registration applications.

The Guide and Technical Documentation identify a range of potential dust sources, considerations, and options for their management and measurement. They aim to help guide the development and implementation of dust management strategies and provide general information that is useful for anyone looking to understand and address dust issues in Alberta.

Contents

The Guide includes:

1. contextual information on dust and associated regulatory requirements in Alberta
2. a series of sections, organized to provide guidance and information that readers can use to develop a site-specific dust management plan
3. detailed technical and supporting dust management information in the Guide appendix

Dust Characteristics

For this Guide, dust is defined as:

> *"Small, dry, solid particles projected into the air by natural forces, such as wind, volcanic eruption, and by mechanical or man-made processes. Dust particles are usually in the size range from about 1 to 100 μm (micrometers) in diameter."* (IUPAC, 1990).

Dust can impact human and environmental health and create other issues including nuisance and maintenance problems. Management of dust is therefore an important and ongoing concern. See Section 2 of the Technical Documentation for more details on dust particle characteristics and potential impacts from dust.

There can be significant variations in the properties of dust particles depending on the nature of the dust source. Dust sources and their associated particles can range in size, chemical compositions, and aerodynamic properties all of which determine how dust particles are dispersed and deposited in the environment. Understanding each dust source's properties allows better understanding of the associated dust emissions' likely behaviour, which assists in identifying appropriate management options.

Size

Dust is one component of total ambient particulate matter (PM) and understanding the use of the term PM and the standard size classifications of PM is helpful in interpreting and understanding other literature.

The size of dust particles determines their mobility (smaller particles will travel farther) and potential impacts (e.g., particles less than 10 μm can generally be inhaled deep into the lungs).

The three main size classifications for PM are:

- $PM_{2.5}$ – particles 2.5 μm or less in diameter
- PM_{10} – particles 10 μm or less in diameter
- total suspended particulate (TSP) – a broader category that can include particles up to approximately 40-100 μm in diameter, depending on the measurement method

These size categories overlap: PM_{10} includes $PM_{2.5}$, and TSP includes both PM_{10} and $PM_{2.5}$. While TSP measurements may capture larger particles, particles larger than approximately 20–30 μm generally settle out of the air quickly and do not remain suspended for long periods

For dust management, PM_{10} and TSP are the most relevant dust measurement sizes, as the fraction of $PM_{2.5}$ in total dust is generally very small; however, all size fractions of dust are considered in this Guide.

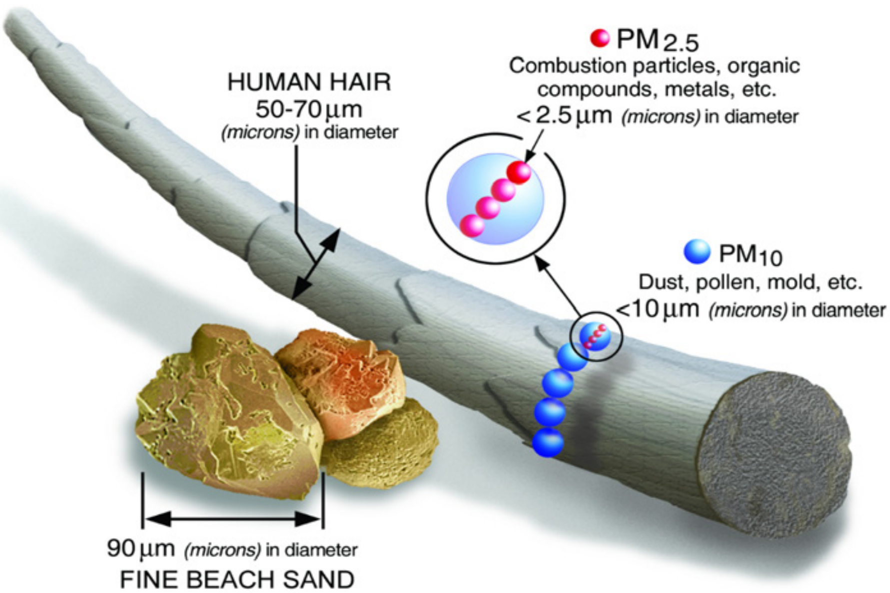


Figure 1: Dust Sizes

Source: https://www.epa.gov/pm-pollution/particulate-matter-pm-basics

Composition

Dust is primarily composed of geological materials such as mineral oxides and soil particles, but its exact composition is highly variable and can includes diverse constituents from anthropogenic (originating from human activity) sources like road dust, industrial processes, and construction activities.

For example, unpaved road dust consists primarily of soil derived minerals (quartz and clay), but other dust components could include asphalt and brake- and tire-wear.

Dispersion

The primary factor determining dispersion distance and deposition rate of dust is particle size; larger dust particles settle much more rapidly than smaller dust particles and therefore tend to settle closer to the source compared to smaller dust particles which remain suspended for longer periods and are therefore dispersed more widely.

The other main factors that can affect dust dispersion include:

- ground cover, e.g., trees, grassland, open fields
- meteorological conditions, e.g., wind speed and turbulence, rain and snow
- mechanical disturbance, e.g., material handling and traffic,
- the height above ground-level of dust source or the height at which dust is thrown, e.g., the "injection height" due to a moving vehicle wake
- moisture content and adhesion characteristics of the dust particles

Environmental and Health Impacts

Some examples of potential environmental impacts of dust include:

- reduction in plant growth in natural and agricultural systems (through reduced photosynthesis from dust on leaves)
- negative impacts on wildlife (e.g., respiratory health, habitat quality)
- increased incidence of plant pests and disease (dust acting as a medium for the growth of fungal disease)
- changes to nutrient cycles in terrestrial and marine ecosystems (dust can carry nutrients and trace metals)

Dust can have a wide range of impacts on human health. They can range from severe (e.g., asthma attacks, Chronic Obstructive Pulmonary Disease, risk of stroke, cancer) to minor (e.g., eye irritation, respiratory discomfort, allergic reactions).

Other Impacts

There are many other potential impacts of dust, such as:

- safety concerns (e.g., reduced visibility impacting driving conditions, slippery conditions caused by dust deposited on roads or the ground)
- increased operation and maintenance costs (e.g., cleaning, filter replacement).
- corrosion (through deposition of dust on exposed surfaces)
- pitting and scouring of surfaces (through wind carrying dust)
- impacts on electronic devices (e.g., overheating and malfunctions caused by dust infiltration in electronic devices or decreased power output of solar photovoltaic panels)
- reduced enjoyment of outdoor activities (e.g., respiratory irritation or reduced visibility of scenic vistas)

Persons experiencing respiratory or other health symptoms from dust exposure are encouraged to discuss this with their primary health care provider (i.e., family physician), who is in the best position to help assess, monitor, and address their health care needs. If they do not have a family doctor, they can visit Alberta Health Services' "Find a Doctor" or call Alberta Health Link (available 24-7 by dialing 811) at any time to speak to a registered nurse, or to be connected with a physician.

Dust Control Requirements in Alberta

There are a range of dust control requirements in Alberta, depending on the scale of the activity, potential dust impacts, type and location of the dust source, and many other factors. For general awareness, listed below are some dust-related requirements in Alberta. However, facilities should ensure that they are familiar with any dust management requirements applicable to their operations and ensure that their dust management plan and activities address these requirements.

- *Environmental Protection and Enhancement Act* (e.g., EPEA approvals and Code of Practice registrations)
- *Water Act* (e.g., water licences for dust suppression)
- *Agricultural Operation Practices Act* (e.g., nuisance, livestock and manure requirements under AOPA)
- best management practices (e.g., "Erosion and Sediment Control Manual")
- municipal bylaws

Further information on the requirements is included in the Technical Documentation (Section 3); any questions should be directed to the appropriate compliance authority.

Elements of Dust Management Planning

While dust management planning is a site- and facility-specific process that will differ for each operation or activity, the overall steps (as illustrated in Figure 2 below) may be relevant to most dust planning processes. Users of the Guide may need to adapt their approach based on the information, resources, and tools available to them.

It should be noted that the steps are interconnected; the steps may proceed in order as well as concurrently or involve iterative checking between two or more steps. For dust management, steps that could be iterative together are dust controls and monitoring; for example, dust monitoring results may indicate that dust controls should be improved.

These steps represent suggested best practices but are not an exhaustive list of requirements. Individual plan requirements may vary.

Figure 2: Elements of dust management planning.

The following sections describe each step in the "Dust Management Planning Cycle" and the associated technical information is in the Technical Documentation (Appendix 1).

Create a vision

The first step for a dust management process should be to define dust management goals, intent, and purpose, i.e., identifying the envisioned outcomes of the dust management plan.

There are many potential approaches to creating a vision for the dust management plan. For example, conversations with employees, compliance authorities, stakeholders, the community, or other relevant groups can be undertaken to determine dust-related issues, concerns, challenges, and opportunities. The outcomes of these discussions will help establish the desired dust management outcomes (e.g., reduced on-site dust impacts, fewer offsite dust complaints) and provide the basis, and continued motivation, for developing and implementing the dust management plan.

Other or complementary approaches to creating a dust management vision could involve reviewing existing dust management plans from similar operations (if available) or identifying current gaps or issues with current dust management activities that the vision would be intended to address.

The exact methods for creating a vision will depend on the nature of the dust source(s) and the nature of the parties responsible for these sources (a facility, a municipality, a contractor, an individual, etc.) and the nature and extent of dust impacts (onsite or offsite).

Identify and assess dust sources

Identifying each possible dust source and collecting information and data to quantify and characterize each source is the next step in developing a dust management plan. This step can occur in conjunction with the development of the vision for the plan. The purpose of this step is to gather enough information to determine the relative significance of each dust source, and to help inform the level of mitigative action needed.

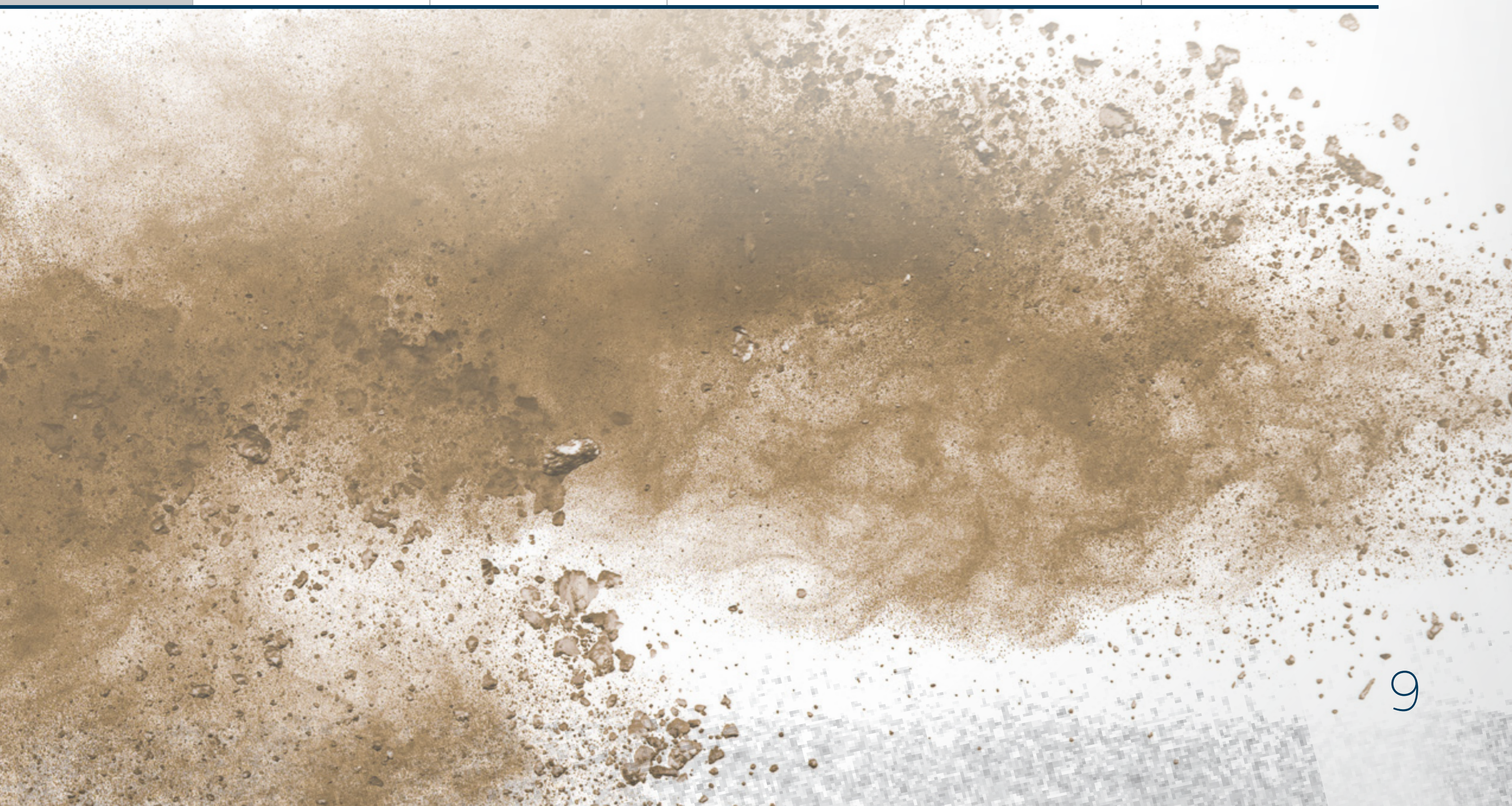
There are often many possible sources of dust that need to be considered. These can include material handling, land disturbance, unpaved or paved roads that have high traffic volumes, material stockpiles, exposed surfaces and construction/demolition activities. The Technical Documentation (see Section 5.2 and Glossary) describes major dust source types that are encountered in Alberta; while the documentation focuses on major dust sources, the dust management approach described in this Guide applies broadly, including dust sources that are not specifically mentioned.

The table on the following page can be customized and used to systematically identify and assess possible dust sources and activities:

Possible Dust Source/ Activity	Nature of Source	Experience with Dust from Source or Activity	Dust Generation Mechanism	Likely Frequency of Dust Generation
Roads	Unpaved roads	Dust observed with traffic and during dry and windy weather	Traffic	Periodic (weekdays 7:00AM to 5:00PM)
Land Disturbance	Sand and gravel extraction	Some dust at all times due to exposed surfaces but significantly higher during extraction activities and under dry and windy conditions	—	Periodic (weekdays 7:00AM to 5:00PM)
Material Handling	Transport and handling of feedstock “xx” to the site for onsite “yy” processing	Dust at all times but significantly increases under dry and windy conditions	—	Periodic (weekdays 7:00AM to 5:00PM)
Material Stockpiles	On site stockpiles of product	Dust at all times but significantly increases under dry and windy conditions	—	Ongoing

(See Technical Documentation Sections 4 and 5 for more details on dust sources identification and characterization)

	Number or size of sources	Intensity of Generation	Offensiveness / perception / visibility	Location/distance to nearest receptor	Other considerations
	Three roads, one on-site (2 km total), two offsite surrounding operation	Moderate to high during high traffic conditions or dry or windy weather, low otherwise	Generally low but high if impacting driver visibility	0-2 km (roadway leads to onsite building)	The effectiveness of watering during dusty periods
	—	—	—	—	—
	—	—	—	—	—
	—	—	—	—	—



Prioritize dust sources

This step in preparing a dust management plan focuses on determining which dust sources are the most significant based on the information and data collected in the previous step and assigning a priority level for management action (e.g., high, medium, low).

A commonly used process for determining priority is by assessing the potential for dust impacts through a FIDOL (frequency, intensity, duration, offensiveness, and location) analysis approach. FIDOL is a standard approach for prioritizing management actions based on the impacts that dust emission source(s) may have (see Section 4.2 of the Technical Documentation).

The following table can be customized and used to assist in the prioritization of dust management actions for each significant dust source. Hypothetical examples for its possible use are included.

Dust Source	FIDOL Assessment of Dust Source/Activity (based on Table in previous step)	Ease of Management	Current Management Status	Management Priority
Unpaved roads	Medium (there are some nearby residential properties and complaints have been received)	Medium	Ongoing – current management considered good but could be enhanced	Medium (based on complaints)
Material handling	Low (not an on-site issue and is distant from potential off-site locations where dust could be a nuisance or environmental impact issue)	Medium	Ongoing – current management considered good but could be enhanced	Low (based on minimal on and off-site impacts)

(See Technical Documentation Section 4 for more details on source prioritization.)

Select mitigation measures and monitoring

The first part of this step involves identifying the options available to improve management of the, at a minimum, high- and medium-priority dust sources identified and selecting the dust management option(s) that will be implemented.

Sections 4.1 and 4.3 of the Technical Documentation provide considerations for choosing a dust management approach and Section 5.3 of the Technical Documentation describes the benefit of using multiple mitigation approaches for improved effectiveness. Section 6 of the Technical Documentation describes possible dust management measures for major dust sources and includes details such as benefits, limitations, key considerations, and cost-effectiveness of implementation. The options for managing different source types can be collated in the following type of table and used to develop a site-specific dust management plan.

Source Type	Management Options	Comments
Unpaved roads	Changing road components/ structure	Very high up-front engineering and construction costs
	Chemical dust suppressants	Potential environmental runoff and vegetation damage, and corrosive to vehicles/infrastructure
	Paving (asphalt/chip-seal)	Highest up-front capital cost, and not practical for temporary roads such as haul roads

(See Section 6 of the Technical Documentation for more details on dust sources management options and their key considerations.)

The next part of this step involves identifying and selecting the appropriate monitoring methods for the dust source(s) that will be managed. Section 5.4 and Section 5.5 of the Technical Documentation list approaches to determine the effectiveness of dust mitigation and describe numerous dust monitoring options, respectively.

Monitoring is an important element of any dust management plan. It provides information about the efficacy of specific dust management actions implemented and it is necessary for deciding whether additional dust management actions may be required. Monitoring can also assist in dealing with dust related complaint issues by quantifying the level of dust pre- and post-action taken to address the issue.

Dust monitoring can range from systematic visual observations to sophisticated continuous particle monitors. Monitors can be fixed or portable, with monitoring locations (e.g., near the dust source, at the facility fenceline, at sensitive off-site locations) selected based on the dust source prioritization and the nature of its possible impacts. Monitors should be evaluated regularly to ensure that they are performing as expected.

The following table can be used to help determine the appropriate dust monitoring method(s) for each dust source being managed and how the monitoring data can be used to help achieve the goals of the dust management plan.

Dust Source or Management Issue	Monitoring Method	Monitoring Responsibility	Monitoring Response Trigger	Intervention	Effectiveness
Material Transfer	Visual	(Staff member name)	Visible dust plume more than 10 meters from transfer point	Implement Water Spray System	No visible dust 10 meters from transport point
Overall dust emissions	Dustfall collectors	(Work unit or staff)	—	—	—

(See Technical Documentation Section 5.5 for more details on dust monitoring.)

Develop a complaints management plan

Increased levels of dust can represent a significant nuisance that results in public complaints. When dust-related issues arise, an attempt could first be made between those generating and those impacted by dust to resolve issues directly, using informal means if possible. Formal complaints consume significantly more resources (time, effort) than resolving issues directly between the parties involved.

Developing a complaints management plan will help set goals and develop processes and tools to reduce or avoid complaints. This section lists some elements that a complaints management plan could include, and other considerations that may be helpful.

It should be noted that dust-related complaints can be the result of specific events (e.g., large dust releases over a few hours due to high winds, very dry conditions, a dust control malfunction), or the result of ongoing dusty conditions that result in a chronic dust issue. Complaints management should recognize and address both types of dust issues.

There are many potential approaches to developing a complaints management plan; the Technical Documentation (Section 5.6) includes examples of complaints management processes from Alberta and other jurisdictions. Below are some elements common amongst complaints management plans:

- a goal or vision for the plan (e.g., reducing or avoiding complaints, building trust)
- a means to receive complaints (call line, complaint forms, etc.)
- processes to handle complaints (e.g., decision tree, call log, recordkeeping, follow-up)
- staff training (e.g., how to handle complaints and how to investigate complaints received)
- communication to the public or affected parties about dust management activities and the complaints process

In addition to operator-led processes, complaints within Alberta may be directed to public authorities responsible for oversight of the operator's sector (e.g., Environment and Protected Areas, Alberta Energy Regulator, Alberta Transportation and Economic Corridors, the Natural Resources Conservation Board, and urban and rural municipalities).

Ideally, off-site parties have been notified by the responsible party that dust could be an issue and have been provided information on how to notify the responsible party of any high dust events they experience or any specific dust issues they have that could be related to the responsible party's dust source(s).

Prompt response to complaints and any required ongoing communication with complainants helps demonstrate a commitment to being a responsible community member. Additionally, by actively tracking, investigating, and resolving complaints, facilities can maintain positive community relations, and ensure the management plan remains effective and potentially adaptable to changing conditions and community concerns.

Affected parties can also be encouraged to share information and experiences outside a complaints process. This provides the opportunity for the responsible party to learn more about potentially unknown or less understood dust sources and their off-site impacts.

Implement the dust management plan

Once the option(s) for mitigation are determined, a mitigation measures implementation plan should be developed. The implementation methods and steps will depend on the dust mitigation options selected. Some general implementation considerations for different dust mitigation options are described in the Technical Documentation (Section 6).

Possible elements of dust management plan implementation include the following (see also Section 5 of the Technical Documentation):

- Formalizing a summary of the operation's dust sources and the dust management actions associated with each source. For some sources, this could include response triggers and subsequent actions.

- Assigning responsibilities for the implementation of dust management and the specific staff responsible for each component of the dust management plan.
- Operationalizing dust management as part of overall facility operational procedures, including complaints management.
- Outlining the criteria and measures that will be used to assess the effectiveness of the plan.
- Specifying when and how the dust management implementation plan will be reviewed and updated.

The implementation plan should consider staff training and record keeping (see Section 5.7 of the Technical Documentation) which can have benefits such as helping support regulatory reporting (if such reporting is required), the ability to demonstrate that action was taken (e.g., in response to inquiries), and ensuring ongoing consistency in implementation of the mitigation options.

Some examples of possible staff training topics are:

- dust and dust control related health and safety issues, and associated mitigation and personal protective equipment options/requirements
- visual dust assessments and conducting visual dust measurements
- regular staff workshops to review the status, and outcomes to date, of each dust management plan element, and discuss possible plan changes

Record keeping should cover all the activities that are considered an essential part of the overall dust management plan. For example, for unpaved road dust control, the following types of records could be maintained:

- location and kilometers of road subject to management
- watering frequency and watering rates (if water-based stabilizers are used, then the volumes of stabilizer used)
- if triggers were used to determine when and/or how much watering is done then information on when there was a trigger and who determined that the trigger criteria had been met
- the results of any dust monitoring that is linked to the road dust control activity
- any activities and/or events that affected the normal road dust management system
- information on any dust complaints received and action taken to address those complaints

Review and revise

Regular periodic internal audits of the dust management plan should be undertaken to drive continuous improvement, ensure the dust management plan evolves in step with operational shifts, considers emerging best practices, and aligns with community expectations.

An overall comprehensive dust management plan review and possible updating should be undertaken when there is a significant change in the location, type, or magnitude of dust emission sources or when monitoring data or complaints indicate there may be a need for improvement in the current plan. There may be no specific time interval for when a dust management plan should be updated unless a time frame is stipulated through a compliance authority. The overall goal should be to avoid major issues before they arise.

The review should consider whether the goals for the plan identified in the visioning step are still relevant and being met, and whether monitoring results are confirming that the dust mitigation measures are achieving the expected level of dust reduction, and whether the current mitigation actions are still reasonable and cost-effective.

One example of a continuous improvement approach is the “Plan, Do, Check, Act” model.[3] It involves planning a change, implementing it, evaluating the results, and making further change or tweaks, depending on the results.

3 https://www.lean.org/lexicon-terms/pdca/

Conclusion

This Guide outlines an approach and considerations for managing dust and should be read alongside the Technical Documentation (Appendix 1) for context and clarity. Although many elements of dust management are similar for all dust emission source types, each dust source situation is unique, and users of this Guide should consider local risks, conditions, challenges, and opportunities.

Dust management should be viewed as an ongoing and long-term process in which approaches and processes are regularly reviewed and evaluated to ensure dust-related impacts are addressed using appropriate tools, technologies, and practices.

Appendix 1
Technical Documentation

Best Practices Guide for Dust Management in Alberta – Technical Documentation

Clean Air Strategic Alliance

Project Number: 60724798

May 2026

Delivering a better world

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May 21, 2026

Project #
60724798

Subject: Best Practices Guide for Dust Management in Alberta – Technical Documentation – Final

Dear Mr. Carrigy:

AECOM is pleased to present our final version of the technical documentation to support the best practices guide.

It has been a pleasure working with you on this report and look forward to opportunities to cooperate again in future. Thank you very much.

Sincerely,
AECOM Canada ULC

Randy Rudolph
Associate Vice Present, Environment
Randy.rudolph@aecom.com

Encl.

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AECOM: 2024-12-21

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Distribution List

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Appendices

1. Introduction

This document forms the technical support for a "*Best Practices Guide for Dust Management in Alberta*" Project[1] undertaken by the Clean Air Strategic Alliance (CASA), the result of which is a best practice guide intended to assist municipalities and provincial regulators and to be a resource for industry and other stakeholders in improving dust management in the province.

The best practice guide identifies a range of potential dust sources and considerations and options for their measurement and management. It is recognized that the guide does not cover all possible dust generation related scenarios, operations, and circumstances, but an attempt was made to provide dust management related information relevant to most dust source types in Alberta. Its intent is to provide a general dust management framework that provides information which will be helpful for anyone attempting to understand and/or address dust issues.

This Technical Documentation volume contains:

- A summary of dust particle characteristics and health effects (**Section 2**)
- Regulatory requirements for dust control in Alberta (**Section 3**)
- Useful frames of reference for dust control (**Section 4**)
- Elements of dust management plans in Alberta (**Section 5**)
- Details of dust mitigation approaches (**Section 6**)

The Technical Documentation volume is referenced in the CASA document *Best Practices Guide for Dust Management in Alberta,* the overarching summary of this material.

CASA is a collaborative partnership composed of representatives selected by industry, government, Indigenous, and non-government organizations. Every partner is committed to a comprehensive air quality management system for Alberta. For more information about CASA and the project, refer to the team's final report.

1. https://www.casahome.org/current-initiatives/best-practices-guide-dust-management-alberta-61/

2. Dust Particles Characteristics and Health

2.1 Nature of Dust

The guide uses the dust definition (CASA, 2025) adapted from IUPAC *Glossary of atmospheric chemistry terms*:

> *Small, dry, solid particles projected into the air by natural forces, such as wind, volcanic eruption, and by mechanical or man-made processes. Dust particles are usually in the size range from about 1 to 100 µm (micrometers) in diameter (IUPAC, 1990).*

That definition corresponds to fugitive dust produced on roads, during agricultural operations, construction and industrial activities (for example bagging, conveying, crushing, demolition, drilling, grinding, milling, screening, shoveling, sweeping and applying pesticides in dust formulations).[2]

Unlike larger particles, those below 100 µm settle more slowly under the influence of gravity. In the air, smaller dust particles can sometimes travel far – hundreds of metres to tens of kilometres or more. While dust is suspended in the air, various chemicals or organic matter can attach to it. Thus, there might be difference in composition between dust at its origin and dust that settles farther away. Dust particles that are inorganic themselves can become long distance carriers for human or animal pathogens.

Although dust is ever-present, in regulatory frameworks, measurement protocols and scientific discussions, the broader concept term of **particulate matter** (PM) is often used instead. “Particulate matter refers to a complex mixture of solid particles and liquid droplets suspended in the atmosphere. Some particles, such as **dust**, dirt, soot, or smoke, are sufficiently large or dark to be visible to the naked eye. Others are so small they can only be detected using an electron microscope. (U.S. EPA, 2025)” The complete definition provided by the U.S. Environmental Protection Agency (EPA) is available in the guide Glossary.

The following PM related terms are the most often relevant in the context of dust (U.S. EPA, 2019), (NPRI, 2025).[3]

- $PM_{2.5}$ is particulate matter with a nominal mean aerodynamic diameter less than or equal to 2.5 µm. In practical terms, $PM_{2.5}$ consists of particulates mostly smaller than 2.5 µm in diameter. $PM_{2.5}$ includes not only dust in that size range, but all the other particulates like diesel soot, wildfire smoke, organic and inorganic aerosols, traffic exhaust, brake wear particles, and others. $PM_{2.5}$ is entirely included in the PM_{10}. However, the fraction varies by emission source. $PM_{2.5}$ is sometimes equated with respirable dust – although respirable dust is particulate matter smaller than 5 µm – which is dust consisting of very fine particles, small enough to penetrate deep into the human lungs (U.S. EPA, 1996). Many of the eminent problems caused by particulate matter pollution are associated only with $PM_{2.5}$, regardless of whether it is dust or not. Both Alberta Ambient Air Quality Objectives (AAAQOs) and Alberta Ambient Air Quality Guidelines (AAAQGs) reference $PM_{2.5}$.
- PM_{10} is particulate matter with a nominal mean aerodynamic diameter less than or equal to 10 µm. In practical terms, PM_{10} consists of particulates mostly smaller than 10 µm in diameter. PM_{10} includes not only dust in that size range, but all the other particulates like ash, microplastics, rubber particles from tire wear, various droplets, bacteria, fungi, pollen and other organic matter. PM_{10} is sometimes named inhalable dust, since particles of that size are able to bypass the human body natural defense mechanisms, such as nasal hairs and mucous membranes, which typically filter larger particles (U.S. EPA, 1996).

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2. *Such dust is quite different from the – out of scope – common household dust that primarily contains human dander, hair, skin flakes, food debris, natural and synthetic textile fibers, in addition to the just defined outdoor dust.*
3. *NPRI accounts for PM_{10} (NPRI substance identifier NA - M09), $PM_{2.5}$ (NA - M10) and TPM (NA - M08) only. NPRI does not refer to dust.*

- TSP denotes total suspended particulates.[4] It is the term used to approximate all the particulate matter smaller than about 30 µm in diameter. The AAAQOs contain limits for TSP.
- TPM is total particulate matter – all particulate matter with a diameter less than 100 µm. It is a term used in Canada to describe filterable particulate matter, excluding condensable particulate matter.

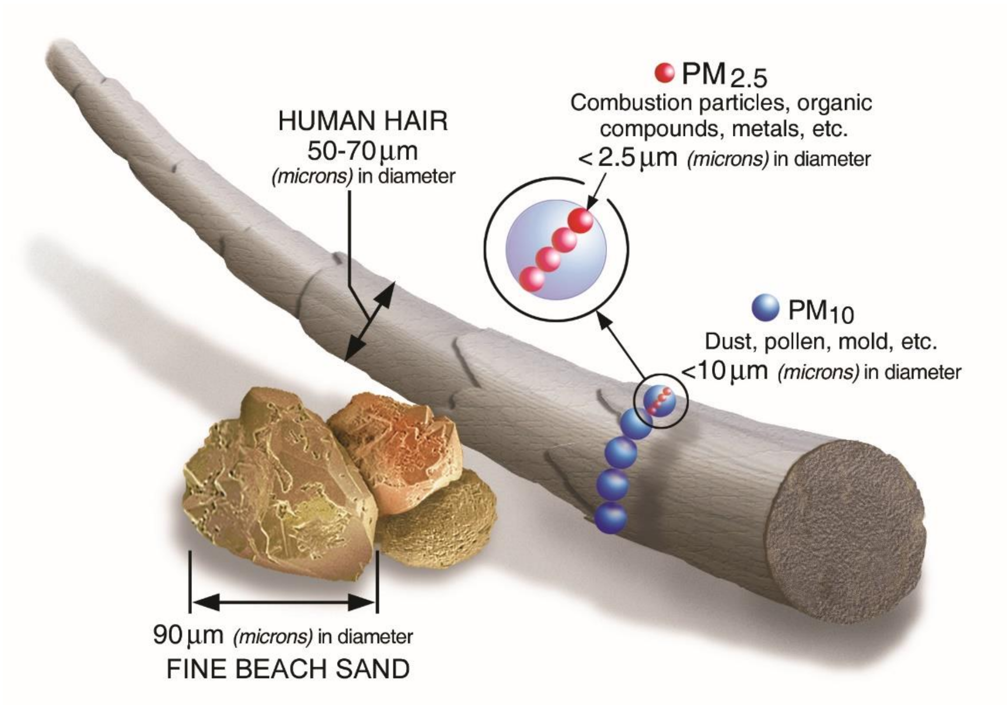

Figure 1: Relative Sizes of Particulate Matter (U.S. EPA, 2025)

In general, there is no fixed relationships between the amount of dust and measurements of PM_{10}, $PM_{2.5}$, TSP or TPM. However, for a specific location and unchanging dust sources, it might be possible to have relationships between dust and $PM_{10}/PM_{2.5}$ (Fan, Zhao, Yang, & Yang, 2021). Additionally, *Background Document for Revisions to Fine Fraction Ratios Used for AP-42 Fugitive Dust Emission Factors* contains a variety of experimentally determined $PM_{10}/PM_{2.5}$ ratios (U.S. EPA AP-42, 2025).

In Alberta, according to Canada's National Air Pollutant Emissions Inventory for 1990-2023 (ECCC, 2025), fugitive dust was primarily generated by:

- Unpaved roads. Dust is generated by vehicles traveling on unpaved roads, especially in rural and industrial areas.
- Construction operations. Activities such as stripping and grading, demolition, excavation and building construction contribute significantly to dust emissions. The issue is exacerbated by the predominance of fine-grained soils in many areas of the province, exposure of large open areas to wind, prolonged dry or windy conditions.

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4. *Since 1982 (U.S. EPA OSAP, 2025), as published in* Appendix B to Part 50, Title 40 – Reference Method for the Determination of Suspended Particulate Matter in the Atmosphere (High-Volume Method)*, the U.S. EPA has the following Federal Reference Method (FRM) for TSP measurement "An air sampler, properly located at the measurement site, draws a measured quantity of ambient air into a covered housing and through a filter during a 24-hr (nominal) sampling period. The sampler flow rate and the geometry of the shelter favor the collection of particles up to 25-50 µm (aerodynamic diameter), depending on wind speed and direction." (U.S. EPA CFR, 2025)*

- Wind erosion. Dust is generated by wind from open areas including fields used for crop production when they have insufficient vegetative cover.
- Paved roads. Vehicle movement on paved roads causes resuspension of loose material on the road surface and from unpaved shoulders.
- Material handling in
  - **Agriculture.** Tilling, harvesting and grain processing generate dust, particularly in dry conditions.
  - **Oil sands mining, extraction and upgrading.** Dust predominantly comes from petroleum coke piles and movement of heavy machinery or a mine fleet.
  - **Mining and Rock Quarrying.** Operations involving the extraction and processing of aggregates and minerals (coal, dolomite, shale) produce substantial dust.

There are many other smaller dust sources not listed but that may be important on a local level. For example, in agriculture dust is generated from CFOs, especially when the weather is hot during the day and when it cools down during the evening hours, animals become very active thus generating dust. During silage season and when manure is being hauled and spread on the fields, dust is a problem for people living near the activity.

2.2 Human Health and Well-Being

This subsection, and those that follow in **Section 2**, provide reasons why dust control and dust management plans are essential. It addresses the question "why bother with dust".

The following comprehensive books and reports provide current reviews of the known health issues related to particulate matter including dust:

- Integrated Science Assessment (ISA) for Particulate Matter (Final Report, Dec 2019) (U.S. EPA, 2019),
- WHO global air quality guidelines. Particulate matter ($PM_{2.5}$ and PM_{10}), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide (WHO, 2021),
- Supplement to the 2019 Integrated Science Assessment for Particulate Matter (Final Report, 2022) (U.S. EPA, 2022),
- Canadian health science assessment for fine particulate matter ($PM_{2.5}$) (Health Canada, 2022),
- Dust and Health Challenges and Solutions (Al-Dousari, A. & Hashmi, M. Z. (Eds.), 2023),
- Reconsideration of the National Ambient Air Quality Standards for Particulate Matter (U.S. EPA, 2024),
- Health Impacts of Air Pollution in Canada in 2018: 2024 Report (Health Canada, 2024).

These sources conclude that the primary negative health impacts from dust arise from particles in the PM_{10} or $PM_{2.5}$ size range. A brief listing of common or known dust induced health problems is presented below.

- Respiratory health issues: aggravated asthma, decreased lung function, difficulty breathing, silicosis[5].
- Cardiovascular health issues: increased risk of heart attacks, increased general cardiovascular risks due to dust induced chronic bronchitis.
- Cancer: increased risk of cancer caused by silicosis, increased risk of stomach cancer.

[5] *"Silicosis is an incurable lung disease that can lead to disability and death. Silicosis is the result of the body's response to the presence of silica particles in the lung." (CCOHS, 2024b)*

- Mortality: increased risk of death with acute silicosis and heart or lung diseases caused by dust.
- Other health issues: eye problems, skin allergies, kidney problems caused by silicosis.

Reducing dust levels reduces health risks.

The subsection below is based on information from the following resources:

- Mountains that See, and that Need to Be Seen: Aboriginal Perspectives on Degraded Visibility Associated with Air Pollution in the BC Lower Mainland and Fraser Valley (Carlson, 2009),
- Canadian Smog Science Assessment. Volume 1: Atmospheric Science and Environmental/Economic Impacts (Environment Canada and Health Canada, 2012),
- Integrated Science Assessment (ISA) for Particulate Matter (Final Report, Dec 2019) (U.S. EPA, 2019),
- Supplement to the 2019 Integrated Science Assessment for Particulate Matter (Final Report, 2022) (U.S. EPA, 2022),
- Quantitative Evaluation of Psychological Tolerance under the Haze: A Case Study of Typical Provinces and Cities in China with Severe Haze (Lu, Rui, Gemechu, & Li, 2022),
- Importance of Visual Air Quality (Clear Air BC, 2025).

In any outdoor setting, elevated levels of airborne dust can significantly reduce visibility, obscuring scenic views and prominent landmarks. This can be particularly detrimental to regions that rely on tourism, including certain areas of Alberta where visual quality is a key component of visitor experience.

Dust induced haze also diminishes the quality of daylight, producing a muted and dull atmosphere that can negatively affect human mood and reduce the perceived vibrancy of natural surroundings. In community contexts, degraded air quality from dust may necessitate the cancellation of outdoor sporting events, festivals, and other public gatherings to ensure the health and safety of participants.

2.3 Environment, Ecosystem and Aesthetics

The section below is based on information from the following resources:

- Canadian Smog Science Assessment. Volume 1: Atmospheric Science and Environmental/Economic Impacts (Environment Canada and Health Canada, 2012),
- Integrated Science Assessment (ISA) for Particulate Matter (Final Report, Dec 2019) (U.S. EPA, 2019),
- Supplement to the 2019 Integrated Science Assessment for Particulate Matter (Final Report, 2022) (U.S. EPA, 2022).

Historically, soiling of property was the first acknowledged effect of dust. That included the inability to naturally dry clothes or food outside.

Dust settling on buildings, windows, vehicles and outdoor equipment leads to their perceived (and sometimes actual) discoloration and an unkempt appearance. That necessitates more frequent cleaning, increasing costs for both individuals and businesses. If dust is not being removed, businesses might experience perception of neglect, while individual homeowners can face reduced property value.

Dust particles, especially those with abrasive properties, lead to accelerated wear and tear on equipment and exterior surfaces. Dust accumulation on surfaces may require more frequent cleaning. And that in turn can lead to accelerated deterioration of surfaces.

Dust infiltrating indoor causes problems described above, if an HVAC filtering system is not installed. HVAC filtering increases living, office or production cost.

Dust generated by vehicle traffic on untreated, unpaved roads can significantly impair visibility, posing a serious safety risk on both public highways and industrial roadways. Beyond transportation impacts, dust deposition influences broader environmental processes. When dust settles on snow, it reduces surface albedo, which accelerates the rate and alters the timing of snowmelt. This shift can have downstream implications for runoff patterns and seasonal water availability.

Dust emissions can alter soil chemistry, sometimes substantially, affecting ecosystems well beyond agricultural areas. These chemical changes may disrupt nutrient cycles, influence vegetation health, and modify habitat conditions. Water resources are similarly vulnerable; dust can degrade the visual quality of surface waters and, in some cases, affect their chemical composition, potentially influencing aquatic ecosystems and water treatment needs.

In addition, dust accumulation on solar panels diminishes their efficiency by obstructing incoming sunlight, leading to reduced electric energy production. This effect can be particularly pronounced in areas with persistent or high-volume dust emissions.

2.4 Dust Impacts on Agriculture

The section below is based on information from the following resources:

- Canadian Smog Science Assessment. Volume 2: Health Effects[6] (Health Canada, 2013),
- Integrated Science Assessment (ISA) for Particulate Matter (Final Report, Dec 2019) (U.S. EPA, 2019),
- Supplement to the 2019 Integrated Science Assessment for Particulate Matter (Final Report, 2022) (U.S. EPA, 2022),
- Review: the effects of dust on feedlot health and production of beef cattle (Urso, Turgeon, Ribeiro, Smith, & Johnson, 2021),
- Welfare of beef cattle (EFSA Panel on Animal Health and Welfare, 2025),
- *Impacts and Responses of Particulate Matter Pollution on Vegetation* in Airborne Particulate Matter. Source, Chemistry and Health (Saurabh Sonwani & Anuradha Shukla, 2022),
- *Impacts of Particulate Matter Pollution on Plants* in New Frontiers in Plant-Environment Interactions. Innovative Technologies and Developments (Tariq Aftab, 2023).

Elevated dust levels can adversely affect agricultural systems through several interrelated pathways. Increased airborne dust reduces the amount of solar radiation reaching plant surfaces, thereby constraining photosynthesis and contributing to diminished crop yields. The chemical composition of dust also plays a significant role, as certain constituents can alter soil chemistry and reduce nutrient availability, ultimately affecting soil fertility.

Fine particulate matter can impair plant physiological processes by lodging in open stomata and disrupting normal gas exchange. When dust accumulates on leaf surfaces, it can obstruct natural cooling mechanisms, which increases plant stress and reduces overall vigour. These compromised conditions create greater susceptibility to pests and diseases; dust deposits often provide a suitable substrate for fungal growth, heightening the incidence of plant pathogens. Additionally, dust on foliage can reduce the efficacy of pesticide applications by limiting spray penetration, and for market-ready fruits and vegetables, it can diminish visual quality and necessitate additional cleaning before sale.

Livestock can also experience negative effects from elevated dust exposure. Dust can cause eye irritation or conjunctivitis in farm animals, and accumulation on the skin may lead to irritations, sores, or secondary infections. Dust settling on forage can decrease palatability, which may subsequently reduce feed intake and dairy production. Furthermore, inorganic dust particles may act as carriers for certain animal pathogens, increasing the potential for disease transmission within herds. Exposure to dust can also cause respiratory illnesses[7] in animals. These illnesses can lead to animal death, even if treated.

6. *Subsections 14.3 and 15.3 are devoted to animals.*
7. *Acute interstitial pneumonia (AIP) in cattle is often observed to be correlated with dust (Ayroud, et al., 2000). However, dust is not found to be the direct cause (Urso, Turgeon, Ribeiro, Smith, & Johnson, 2021), (EFSA Panel on Animal Health and Welfare, 2025). Nevertheless, dust particles irritate the respiratory tract and are carriers of bacteria and fungi to the lungs.*

3. Dust Control Requirements in Alberta

Concentrations of particulate are regulated in Alberta by the *Alberta Ambient Air Quality Objectives* and *Alberta Ambient Air Quality Guidelines* which are periodically updated by Alberta Environment and Protected Areas (AEPA, 2024). Current requirements are to limit 24-hour and annual average ambient concentrations of $PM_{2.5}$ and concentrations within the TSP size range which includes all particles up to approximately 25 to 30 microns in diameter. The objectives and guidelines do not apply within the boundaries of the activity generating dust. AEPA (2024) also includes Alberta Ambient Air Quality Guidelines for dustfall in urban and industrial areas.

3.1 Dust Control Legislation in EPEA

The Environmental Protection and Enhancement Act RSA 2000 Chapter E-12 (EPEA, 2025), current as of December 11, 2025, does not contain references to either dust or visibility restrictions (opacity). The Substance Release Regulation (Alberta, 2006) provides requirements for visible emissions in Part 1 such as “No person shall release or permit the release into the ambient air of a visible emission so that it impairs visibility on a highway or on a developed property” and on opacity limits.

EPEA provides overarching, general provisions that apply to multiple types of emissions/releases (rather than specifying “dust” or other specific emission types), such as in EPEA 108 to 109 regarding prohibited releases and EPEA 110 regarding the duty to report releases (EPEA, 2025).

EPEA approvals for specific facilities may reference particulate or dust and may include specific mitigation measures or controls as well as record keeping requirements. When not specifically mentioned, dust may be included in general approval requirements such as those that require air emissions to not impair the quality of natural resources or cause adverse effects to well-being or health or harm property, vegetation or animals.

Alberta’s Ambient Air Quality Objectives (AAAQOs) and Guidelines (AAAQGs) are a component of Alberta’s Air Quality Management System. There is one AAAQO for $PM_{2.5}$, one AAAQG for $PM_{2.5}$, two AAAQOs for TSP, and two AAAQGs for dustfall, each for different averaging periods intended to manage specific adverse effects. These AAAQOs and AAAQGs cover a size range that includes all particles up to approximately 30 microns in diameters. Concentrations of particulate matter are considered in a variety of regulatory contexts that vary with the type of activity and emission source(s) releasing particulate matter as well as local considerations for air quality management (examples can be found in Alberta Ambient Air Quality Objectives and Guidelines (AEPA, 2024)).

AAAQOs can be used to assess the beyond project boundary impacts of air pollutants. Although AAAQOs are a regulatory tool, they by themselves do not regulate concentrations of particulate matter. Particulate matter concentrations are regulated by project-specific approvals, codes of practice, Substance Release Regulation, etc.

In Alberta, an Environmental Impact Assessment (EIA) evaluates environmental effects of proposed projects, including potential air quality issues like nuisance dust, which may require the development of project-specific dust mitigations. Dust management plans may be required to be developed as part of the EIA process or as a condition of project approval, especially for development in sensitive areas or if exceedances of thresholds are predicted through the EIA process.

3.2 Water Act Requirements

The Water Act regulates the diversion of water from both surface and groundwater sources. Companies or individuals who need water for activities such as dust control may be required to obtain authorization to divert water. In most cases, this authorization (approval or licence) is issued as a Temporary Diversion Licence (TDL), which allows short-term water use for a period of up to one year.

Effective January 13, 2026, an amendment to the Water (Ministerial) Regulation introduced a new exemption related to dust control. This exemption allows users to divert up to 100 cubic metres of water per source per day for bridge washing, sign washing, and dust control, without requiring a Water Act licence.

3.3 Dust Control in Codes of Practice and Authorizations

Additional references for dust control related to authorizations (approvals and Code of Practice registrations under EPEA) in Alberta are:

- The Standards for Landfills in Alberta (the Standards) require dust management as part of nuisance management (see section 4.5 of the Standards). https://open.alberta.ca/publications/9780778588269
- The Guide to Content for Industrial Approval Applications requires information on dust management (noted in multiple sections of the reference). https://open.alberta.ca/publications/9781460112557

A Code of Practice (COP) in Alberta may reference the need to manage particulate matter or dust, but not the means to do so. Fugitive dust was found to be defined in four COPs from 1996 onwards. These are subject to revision. For example, in the COP for Compost Facilities (Government of Alberta, 2022) *"fugitive dust"* means particulate matter that is generated by, emitted from, and escapes from a Class I or Class II compost facility. It is used as follows:

- "receptor site" means a site that may be exposed to odours or fugitive dust originating from a compost facility
- the moisture content of compost must be managed to prevent the generation of odours and fugitive dust
- the actions that will be taken to prevent the accumulation of each of combustible dust, combustible liquids, flammable liquids, or debris on or around buildings, fences, vegetation, vehicles, stationary equipment, and mobile equipment
- Nuisance management plan: […] actions that will be taken to prevent and control nuisances, including but not limited to litter, wildlife, noise, weeds, disease vectors, and dust.

In the COP for Asphalt Paving Plants, the COP for Concrete Producing Plants and the COP for Foundries (all dated September 30, 1996): "fugitive dust emissions" means dust emissions to the environment originating from a plant source other than a vent, flue, stack, or break or rupture in process equipment. The term fugitive dust is then used as follows:

- Fugitive dust emissions from the asphalt paving plant shall not cause an adverse effect.
- Fugitive dust emissions from the concrete producing plant shall not cause an adverse effect.
- The person responsible shall control fugitive dust emissions generated from the concrete producing plant operations. The person responsible shall control excessive dust generated from traffic in the vicinity of the silos and load out areas by wetting down the area, using dust suppressing agents, collecting and removing accumulated dust, or any combination of these.
- Fugitive dust emissions from the foundry shall not cause an adverse effect.

The COP for Landfills (September 1, 1996) does not define any dust, but refers to it:

- (...) the liquid waste is the liquid phase separated from sump waste of car wash bays or similar operations, and is used within the landfill area for irrigation or dust suppression
- The person responsible for a Class III landfill shall cover wastes as necessary to control nuisances such as litter, fires, disease vectors, odours and dust.

The COP for Pits (September 1, 2004) does not define any dust but refers to it as "information […] provided to the Director. […] A description of techniques that will be used to prevent wind and water erosion, and to limit the movement of dust from the pit". There is also an associate guide to the COP for Pits (2004) entitled *A guide to the code of practice for pits* (Alberta, 2004) which includes dust management expectations for larger aggregate pits.

The subsequent regulations and COPs, for a variety of purposes, refer to opacity limits as follows:

- Substance Release Regulation (Alberta, 2006):
  - "opacity" means the degree to which visible emissions obstruct the passage of light
  - Maximum opacity of visible emissions […] Where the opacity of visible emissions from a source is not governed by the terms and conditions of an approval or by a code of practice, the visible emissions released from the source shall not exceed an opacity of 40%.
- COP for Asphalt Paving Plants: the opacity from all air emission sources at the asphalt paving plant shall not exceed 40 percent, averaged over a period of 6 consecutive minutes.
- COP for Concrete Producing Plants: the opacity from all air emission sources at the concrete producing plant shall not exceed 40 percent, averaged over a period of 6 consecutive minutes.
- COP for Foundries: the opacity from all air emission sources at the foundry shall not exceed 20 percent, averaged over a period of 6 consecutive minutes, except for one 6-minute period per hour of not more than 40 percent opacity.

In its *Standard specifications for highway maintenance* Alberta Transportation has issued *Specification 53.31. Supply and Apply Dust Abatement* that in general terms describes procedures for work contracted by Alberta Transportation for dust control on gravel roads (Alberta Transportation, 2010). It is supplemented by *Alberta Transportation Products List, Dust Abatement* (Alberta Transportation, 2025). The list of approved materials is presented in the section on unpaved roads.

3.4 Other Alberta Regulatory Mechanisms

Stabilized Worksite Entrances is a best management practice described in the Alberta Transportation *Erosion and Sediment Control Manual* (Alberta Transportation, 2011). It describes in detail, design and requirements of a trackout (see Glossary) control device and of a cleaning system at site exit. Additionally, it states that: *Material accidentally deposited onto public roads should be cleaned as soon as possible.* In general, trackout refers to the movement of dust and dirt from an active site to outside roads or areas where it may be deposited and then re-suspended as dust.

The Agricultural Operation Practices Act (AOPA), (2025) includes nuisance requirements related to dust in Part 1 of AOPA. Part 2 identifies manure storage locations.

3.5 Dust Control in Municipalities

The following Alberta municipalities have local dust control bylaws:

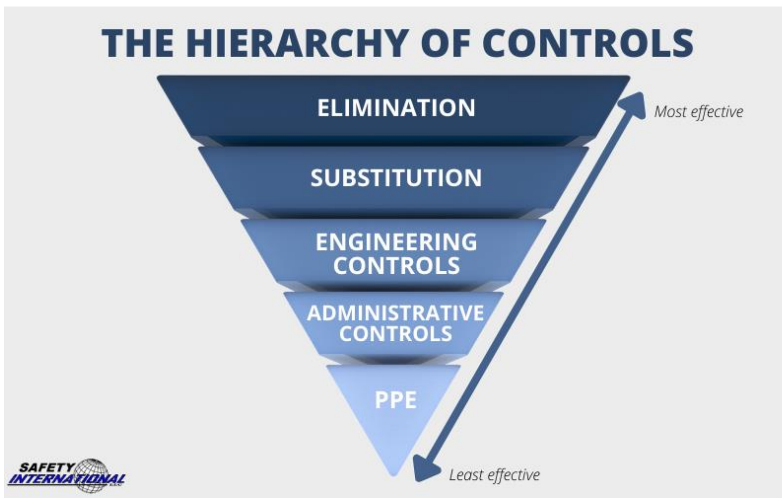
- Airdrie-Community Standards Bylaw, B-09/2012
- Calgary Bylaw 32M2023 - Community Standards
- Edmonton Bylaw 14600. Community Standards By-law
- Red Deer Community Standards Bylaw 3669/2021
- Spruce Grove C-1312-24 Community Standards Bylaw
- St. Albert Bylaw No. 12/2010
- Stony Plain Community Standards Bylaw 2591/PS/18

4. Complementary Views of Dust Management

4.1 Dust Management Hierarchy

A dust management hierarchy offers a structured, tiered framework for prioritizing controls, ensuring that the most effective measures are considered first and that reliance on less effective, behaviour-dependent approaches is minimized. Originating from occupational hygiene best practices, this hierarchy begins with eliminating dust generation, followed by substitution of less dusty processes or materials, then engineering controls, administrative controls, and, only as a last resort, personal protective equipment (PPE) (NIOSH, 2024), (CCOHS, 2024c), (OSHA, 2023). Applying this logic to dust management ensures that fugitive emissions are addressed at their source before resorting to masks or respirators (for on-site workers).

At each level of control, the feasibility of the control should be considered. Furthermore, any control must be consistent with policies, laws and regulations (safety, environmental, etc.).



Source: https://www.safety-international.com/posts/hierarchy-of-controls/

Figure 2: Hierarchy of Dust Controls

4.1.1 Elimination

Elimination, the top tier, completely removes the dust-generating process from the operation. Elimination should be considered first, since by removing the source entirely, no further control measures for that process are required, yielding the most permanent and risk-free solution.

For instance, paving a road or a parking lot removes the possibility for dust to originate from the unpaved area.

4.1.2 Substitution

When elimination is not feasible, substitution replaces a dusty material or process with an inherently lower-dust alternative. Substitution requires a careful assessment to confirm the replacement does not introduce equal or greater health or environmental risks.

For instance, a mine or quarry operation may replace an internal haul road with a conveyor which generates significantly less dust or could transport material as a slurry rather than in a dry state.

4.1.3 Engineering Controls

Engineering controls physically prevent dust from escaping into the work or off-site environment. Engineering controls could be very cost effective in managing dust, because process changes might not be required.

Typical measures may include water misting systems at conveyor drop points, fully enclosed transfer chutes, fully enclosed conveyor belts or fabric covers on stockpiles and haul trucks.

4.1.4 Administrative Controls

Administrative controls rank next, focusing on changing how, when, and where work is performed to limit dust exposure. Since administrative controls change the way work is done only by means of procedures, training and messaging (warnings), the outcome depends on worker compliance.

Examples include signs and markings as reminders, scheduling high-dust activities during low-wind periods or ceasing operations during periods of high wind, rotating personnel to reduce individual exposure durations, and instituting rigorous housekeeping protocols such as daily sweeping of paved areas and regular cleaning of wheel wash stations. Traffic speed reduction is an administrative control.

4.1.5 PPE

PPE is the final line of defence for mitigating the onsite impacts of dust, and involves equipping workers with respirators, protective eyewear, and over-garments designed to prevent inhalation or contact with fugitive dust. Because PPE effectiveness hinges on correct selection, fit-testing, training, and ongoing maintenance, it is inherently less reliable than higher-order controls and is therefore reserved for scenarios where elimination through engineering is not possible or during the implementation lag of permanent measures. PPE programs must be managed under formal respiratory protection standards to ensure real-world protection for the work force.

The use of PPE is not an option for off-site use except in emergency high dust events, similar to use of PPE in situations such as smoke produced by wildfires.

4.1.6 Summary

By systematically analyzing possibilities from elimination through to PPE, the dust management hierarchy may help to optimize resource allocation, safety, and compliance. The hierarchical approach is summarized in **Table 1**.

Table 1: Hierarchy of Dust Controls

Control Level	Benefits	Limitations	Considerations
Elimination	■ Completely removes the dust hazard	■ Often requires major process redesign and high capital investment	■ Feasibility of redesign ■ Production downtime ■ Return on investment ■ Timeline
Substitution	■ Reduces dust generation by using less dusty materials or methods	■ Alternative materials may introduce new hazards or performance issues	■ Feasibility of redesign ■ Material compatibility ■ Regulatory authorizations ■ Supply-chain reliability ■ Lifecycle costs
Engineering Controls	■ Highly effective at the source ■ Continuous, automated operation	■ High installation and maintenance costs ■ May need significant space	■ System design (cover, enclosure) ■ Energy consumption ■ Filter selection ■ Maintenance plans

Control Level	Benefits	Limitations	Considerations
Administrative Controls	■ Low upfront cost ■ Policies and procedures can be rolled out rapidly	■ Relies on consistent worker behaviour ■ Less reliable than engineering controls	■ Training programs ■ SOP development ■ Supervision ■ Monitoring ■ Record-keeping
Personal Protective Equipment (PPE)	■ Immediate protection for individual workers	■ Least effective dust mitigation ■ Depends on proper fit, use and upkeep ■ Not suitable for off-site neighbours	■ Fit testing ■ Inventory management ■ User comfort ■ Replacement schedules

4.2 FIDOL Lens

The application of the FIDOL framework - Frequency, Intensity, Duration, Offensiveness, and Location – enables:

- Systematic Analysis: Each FIDOL dimension provides a measurable parameter. For instance, Frequency, Duration and Intensity can all be tracked using continuous monitoring systems and Location can be determined through various continuous or time-integrated monitoring systems, or other means discussed in **Section 5.4**.
- Stakeholder and Indigenous Engagement: Offensiveness introduces a subjective but critical human dimension – how dust is perceived by workers, communities or individuals – enabling more responsive and socially attuned management.
- Spatial Targeting: Location allows for geospatial analysis, helping to pinpoint hotspots and prioritize interventions.

Table 2 shows how each component of FIDOL could contribute to dust management insights (Environment Canterbury, 2023).

Table 2: Insights and Possible Management Responses to Dust Considering FIDOL

FIDOL Element	Insight
Frequency	Frequent dust events can indicate chronic off-site exposure, even if individual events are minor.
Intensity	High-intensity dust plumes can travel off-site, especially under certain wind conditions.
Duration	Long-lasting dust events increase the likelihood of off-site impacts, especially for sensitive receptors like schools or hospitals.
Offensiveness	Dust may be perceived as offensive due to visibility, odour, or health concerns, even if technically within limits.
Location	Proximity to residential areas, ecological zones, or public infrastructure determines the severity of off-site risk.

4.3 Criteria for Choosing a Dust Management Approach

The following are some of the key criteria that could be considered when developing a dust management approach. References informing this section are (IFC, 2007), (World Bank Group, 1999), (Bolander & Yamada, 1999), (Washington State Department of Ecology (WSDE), 2016) and others.

1. Effectiveness

This criterion considers how well the methods control dust.

- **Dust Particle Size**: Some control methods are better for coarse dust (e.g., from gravel roads), while others are needed for fine particulate matter (e.g., PM_{10} or $PM_{2.5}$).
- **Duration of Control**: Watering may last only hours, while chemical stabilizers or paving could last weeks to years.
- **Consistency**: Does the management method perform reliably under varying conditions (e.g., wind, traffic, or equipment movement)?

2. Cost

Cost considerations may include both short-term and long-term financial impacts. There is a need to balance capital and operational costs. Lower capital costs may result in higher operational costs.

- **Capital Costs**: Equipment purchase (e.g., water trucks, sprayers). Spending more up front may reduce maintenance costs if less expensive options did not work well.
- **Operating Costs**: Labour, fuel, water, or chemical replenishment. Also costs for repair, rehabilitation.
- **Maintenance Costs**: Frequency of reapplication, wear on equipment, or road surface degradation.

3. Ease of Implementation

This includes how quickly and easily the method could be deployed and maintained.

- **Skill Requirements**: Does it require trained personnel or specialized contractors?
- **Infrastructure Needs**: Is there a need for storage tanks, mixing equipment, or road preparation?
- **Time to Apply**: Can it be applied during operations, or does it require downtime?

4. Environmental Impact

Environmental sustainability is important, especially for regulatory compliance, if applicable, and community relations.

- **Toxicity**: Are the chemicals used safe for soil, water and wildlife?
- **Runoff Potential**: Could the method impact or contaminate nearby water bodies?
- **Carbon Footprint**: Consider emissions from equipment or production of materials.
- **Water Footprint**: Consider sustainability of water use given regional water scarcity in the province.
- **Secondary Hazards**: Some suppressants may become slippery or corrosive.

5. Co-benefits

Dust control may be mandated to protect workers and neighbours.

- **Air Quality Improvement**: Reduces respiratory risks and visibility hazards.
- **Compliance with Standards**: Meet air quality and occupational health and safety regulations.

6. Site-Specific Conditions

Tailoring the method to the site ensures better performance and cost-efficiency. Other considerations include:

- **Climate**: In arid regions, water evaporates quickly; in wet climates, runoff is a concern.
- **Soil Type**: Sandy soils may need different binders than clay-heavy soils.
- **Traffic Volume**: High-traffic areas may require more durable solutions like paving or chemical stabilization.

7. Regulatory and Community Considerations

Stakeholder expectations and legal requirements may shape the choice. Considerations may include:

- **Receptors**: A FIDOL approach can help optimize the dust management approach.
- **Permitting**: Some dust management practices may require environmental permits
- **Community Perception**: Visible dust may lead to complaints or reputational damage.
- **Alignment with Sustainability Goals**: Organizations may prioritize eco-friendly methods to meet sustainability targets.

5. Elements of a Dust Management Plan

5.1 Contents

A robust Dust Management Plan (DMP) begins with a clear statement of purpose. There may be a benefit to integrating a DMP into a broader environmental management system. Embedding the DMP within ISO 14001 or a similar certified system could ensure controls are systematically reviewed alongside other management obligations. An example of the requirements of an Alberta plan for is included in **Section 5.7** and includes:

- Dust types and dust source inventory
- Mitigation measures and schedules
- Monitoring, record keeping, and reporting
- Review, audit, and continuous improvement.

Governance should assign clear ownership of the DMP. A designated plan owner secures resources, communicates commitments to regulatory agencies (if the facility is regulated) and integrates dust management into capital projects. Early consultation with permitting authorities and community stakeholders clarifies expectations and, where required, emission limits, monitoring requirements, and reporting intervals (Government of Western Australia, 2011).

For smaller operations, the guidance in **Section 5.7** is also valuable. At a minimum, consider:

- What is the purpose of the DMP? Being a good neighbour? Addressing a commitment to the municipality?
- What are the main dust sources, what kind of dust is generated, and which are priorities for mitigation? Generation of dust from a gravel pit with high silica content near a community would be a high priority for mitigation in dry weather, for example.
- Determine how you will decide if the plan is successful. For example, will it be fewer complaints from neighbours or less dust in the air? How will you measure success in either case?
- For priority sources, how will dust be mitigated? Consider the criteria in an earlier section (**Section 4.3**) including dust reduction effectiveness, cost, environmental impact, etc.

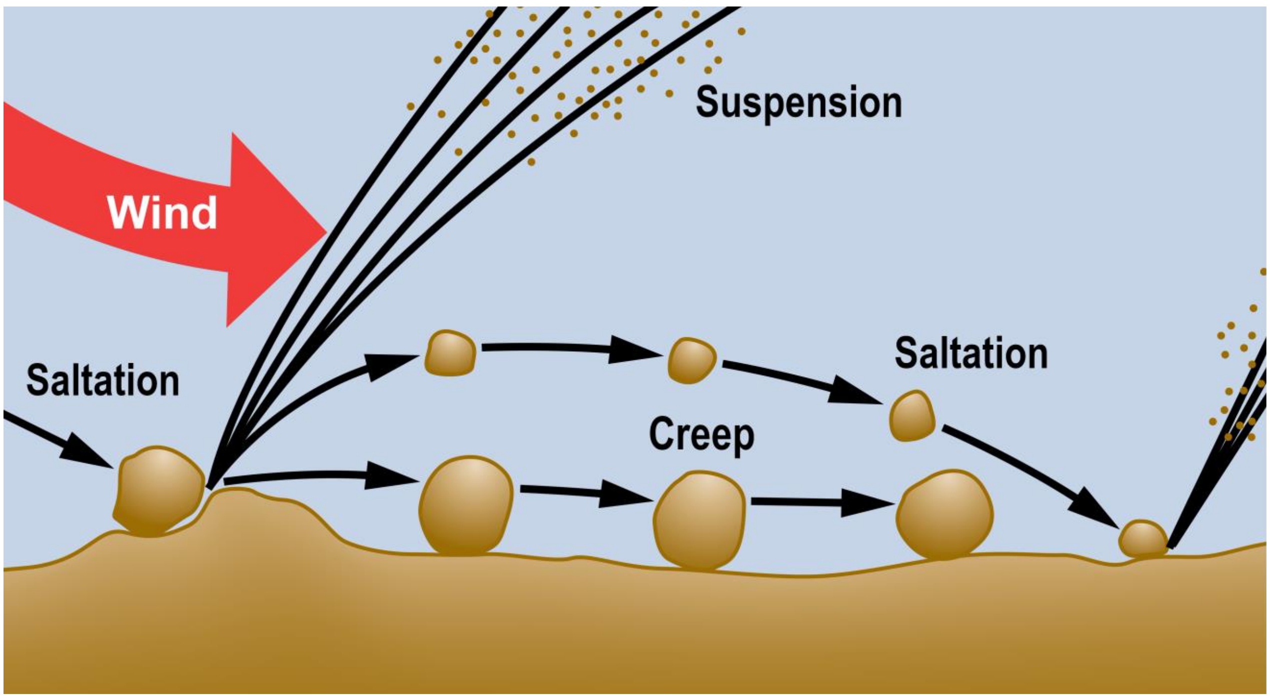
Smaller operations should consider how to document their plan simply and how they might improve the plan in future if needed.

5.2 Dust Sources

Canada's National Air Pollutant Emissions Inventory for 1990-2023 (ECCC, 2025) shows fugitive dust in Alberta was generated by:

- Unpaved roads: Dust is generated from vehicles travelling on unpaved roads, especially in rural and industrial areas.
- Construction operations: Activities such as stripping and grading, demolition, excavation and building construction contribute significantly to dust emissions. Alberta has a predominance of fine-grained soils in many areas of the province, and exposure of large open areas to wind, as well as a lack of effective measures to prevent detachment and transport (**Figure 3**). This issue is often exacerbated by use of heavy equipment during prolonged dry conditions or windy days.

- Wind erosion: Dust is generated by wind from open areas including fields used for crop production when they have insufficient vegetative cover (**Figure 3**).
- Paved roads: Vehicle movement on paved roads causes resuspension of loose material on the road surface. Some examples of surface loading: residual material from winter sanding applications; metal and tire particulates from vehicles.
- Material Handling
  - Agricultural tilling, harvesting and grain processing generate dust, particularly in dry conditions.
  - Oil sands mining, extraction and upgrading dust predominantly comes from petroleum coke piles and movement of heavy machinery / mine fleet (Dowdeswell, et al., 2010).
  - Mining and rock quarrying operations involving the extraction and processing of aggregates and minerals (coal, dolomite, shale, etc.) produce substantial dust.



Sourced: credit USDA-ARS Wind Erosion Research (USDA-ARS, 2019)

Figure 3: Mechanisms for Windblown Surface Dust Sources

In a DMP, potential dust sources could be inventoried by process and location. Each identified source could be characterized by its relative emission risk, proximity to receptors, and operational frequency. The FIDOL approach is an example of an assessment that incorporates these elements.

Dust emissions impact receptors and the DMP may consider how neighbours are affected. Assessments should be tailored to site conditions and objectives. Because sites differ, not all considerations may be applicable. In British Columbia, dust best management practices emphasize mapping adjacent land uses and identifying sensitive receptors such as residential areas, schools, and waterways (BC Ministry of Environment & Climate Change Strategy, 2020). U.S. EPA guidelines recommend overlaying air quality monitors and public health zones to identify whether impacts can be tracked in all zones. The Australian National Environment Protection Measure (National Environment Protection Council, 2013) advocates a one-kilometre buffer analysis around the site perimeter to catalogue potential impacts on flora, fauna, and communities.

5.3 Consider Multiple Mitigation Approaches

Mitigation options for dust control are described in detail in **Section 6**, describing the benefits and limitations of each. However, using *multiple* mitigation approaches can improve the effectiveness of dust management because it creates a synergistic, multi-layered "defense" that addresses different types of dust, emission sources, and environmental conditions. Here are some reasons why multiple approaches improve dust management e.g., (MOECC, 2017):

- **Overcoming Limitations of Single Methods:** Water suppression, while effective, requires constant reapplication and can reduce water supply or freeze on roads. Adding chemical additives (like binders or hygroscopic salts) reduces water usage while extending the duration of the control.
- **Addressing Different Stages of Generation:** A holistic approach targets the entire emission chain, including primary source reduction (e.g., covering materials), intermediate suppression (e.g., wetting), and secondary mitigation (e.g., windbreaks).
- **Adaptability to Changing Conditions:** Using various methods allows for flexibility based on changing weather or operational activity. For example, using chemical stabilizers to bind roads provides long-term, low-maintenance control, while mobile water trucks or fog cannons can be deployed instantly for high-dust tasks like crushing or along stretches of roadways adjacent to sensitive residents.
- **Handling Diverse Dust Types:** Different dust sources (e.g., traffic on unpaved roads, stockpiles, or material handling) require different solutions. Combining mechanical systems (like cyclones) with chemical dust suppressants (such as polymers) covers both indoor handling and outdoor storage needs.
- **Redundancy:** If one system fails (e.g., a water sprayer clogs), a secondary system (like a wind fence) acts as a safety net to limit release.

A combined strategy using the dust management hierarchy in **Section 4.1** and the individual mitigation techniques in **Section 6** can provide more consistent and durable results.

5.4 Measuring the Effectiveness of Dust Management

Approaches to determine the effectiveness of dust mitigation may include:

- Directly measuring air quality or dust deposition, including measurement of particulate concentrations in air or dustfall, and documenting visual inspections. Additional information is found in **Section 5.5**.
- Worker or community exposure assessments, including the use of personal exposure monitors such as some of the technology listed in **Section 5.5**. Other means would be community or worker surveys, or health surveillance, both of which are beyond the scope of this guide to discuss.
- Dispersion modelling to estimate the impact, of the mitigation methods applied, on air quality or deposition. Alberta Environment and Protected Areas (AEPA) provides guidance on the model and model approaches approved in the province (Alberta Environment and Parks, 2021).
- Operational metrics can be tracked to document what mitigation has occurred, such as the quantity and frequency of water application, vehicle speeds on site, and the maintenance conducted on mitigation equipment as documented in a log. These approaches don't directly measure mitigation success but document the mitigation effort.

Apart from the operational metrics approach, the results of methods described here may be benchmarked against Alberta Ambient Air Quality Objectives and Guidelines or compared to findings from environmental assessments.

5.5 Dust Monitoring

A monitoring program may ensure that mitigation efforts remain effective. Monitoring requirements should be customized to site-specific conditions and risks. As such, not all parameters or frequencies are appropriate for every site, and some monitoring may not be necessary. Continuous air quality monitors, such as light scattering PM_{10} samplers and beta-attenuation monitors, may provide real-time data for immediate action. Automated data management systems compile continuous dust readings into dashboards, triggering alerts when concentrations approach action levels. Dust deposition gauges (dustfall jars) allow periodic gravimetric analysis, while mobile meteorological stations track wind speed, direction and humidity. Some monitoring techniques, where a particulate matter sample is collected on a filter, allow for off-line speciation in a lab, whereas others do not (e.g., spectroscopic methods).

Quantitative monitoring such as passive particulate deposition or active suspended particulate (TSP, PM_{10} and/or $PM_{2.5}$) sampling on or off-site to evaluate the effectiveness of dust control practices and to quantify levels of fugitive dust and its composition leaving the site (BC Ministry of Environment & Climate Change Strategy, 2020) and/or the amount of dust being deposited over a given time period. Whichever methods (if any) are chosen to monitor the magnitude and extent of dust generated from the site, dustfall levels, and/or to characterize the quality of the dust to help understand potential effects, they need to be selected based on clearly defined monitoring objectives.

Monitoring approaches may include (UK Environment Agency, 2024):

- Gravimetric Analysis
- Optical Methods (Optical Particle Counters and Light Scattering Techniques)
- Extractive Sampling Techniques and Air Sampling Pumps
- Dustfall (Fallout) Monitoring
- Visual Dust Observations

Each method carries distinct advantages and limitations that make it suitable for specific applications – ranging from high-precision laboratory measurements to rapid real-time sensing deployed in urban networks.

Consideration should also be given to what metrics will be used to judge the effectiveness of the mitigation program. These may include comparison of monitoring data to baseline or background data, predicted values from environmental impact assessment studies, thresholds in established air quality criteria or site-specific criteria agreed on by regulators and stakeholders. Qualitative measures of effectiveness may also be considered, such as number of complaints or visual observations and may be most appropriate for some projects. Trendlines can be an effective way to show progress or consistency over time against a benchmark or goal in visual format.

5.5.1 Gravimetric Analysis

5.5.1.1 Filter Analysis

In this method, a known volume of ambient air is drawn through a pre-weighed filter. After the dust has been collected over a specified period, the filter is re-weighed in a controlled laboratory environment. The net increase in weight is then used to calculate the mass concentration (typically in $\mu g/m^3$).

Filter-based measurements can be made in any of the current particulate size ranges. Given the ubiquity of continuous measurements, filter analysis is most often used for determining the constituents of dust, such as metals or organics.

The benefits of the approach are:

- **High Accuracy and Standardization:** The method is well established and regarded as the calibration reference for newer techniques by the US EPA.
- **Regulatory Endorsement:** Agencies such as the United States Environmental Protection Agency (US EPA) and Environment and Climate Change Canada base many of their standards on gravimetric data. For example, emission measurements are based on particle mass collected on a filter (e.g., US EPA Method 5) as are ambient reference methods (e.g., US Code of Federal Regulations Part 50 Appendix L for particulate measurements)
- **Direct Mass Concentration:** It provides direct measurement of dust mass, essential for compliance with health-based exposure limits.

The limitations are:

- **Delayed Results:** Because it requires laboratory analysis after the sampling period, gravimetric results are not available in real time. This limits its use in provision of hourly Air Quality Health Index data, for example.
- **Event Resolution:** Limited ability to resolve short term events.
- **Labour Intensive and Costly:** Strict handling procedures, controlled environments, and expensive precision balances are necessary.
- **Limited Speciation:** While the method accurately quantifies mass concentration, further analysis is needed to provide information on particle size distribution or chemical composition.

5.5.1.2 Air Sampling Pumps

Air sampling pumps are widely used in industrial and occupational health settings to assess exposure levels and are also the method used to inject air into air sampling instruments. These devices draw air through collection media – such as filters or impaction cassettes – allowing subsequent laboratory analysis for both mass and, sometimes, chemical composition. For occupational health, they are designed in accordance with standards set out by agencies such as OSHA (USA) and similar Canadian organizations, ensuring reliability in exposure assessments. The uses of pumps are:

- **High Precision for Exposure Assessment:** Backed by regulated protocols (e.g., those established by NIOSH and OSHA),
- **Flexibility:** They can be designed for personal monitoring or deployed in fixed locations, accommodating a wide range of sampling durations.
- **Detailed Post-Analysis:** In the laboratory, samples can be analyzed not only for mass but also for chemical composition, adding depth to exposure assessments.

The limitations are:

- **Delayed Feedback:** Like gravimetric methods, analysis occurs post-sampling, making real-time assessments impossible.
- **Operational Variability:** Results may vary based on user technique or adherence to protocols, and maintenance/calibration is vital for accuracy.
- **Limited Temporal Resolution:** These systems do not capture rapid changes in ambient dust concentrations.

5.5.2 Continuous Particulate Concentration Methods

5.5.2.1 Beta Attenuation Monitors (BAMs)

BAM instruments rely on the attenuation of beta radiation as it passes through the particulate matter collected on a filter tape. This technique yields continuous mass measurements of ambient dust. The benefits of the BAM are:

- **Real-Time Data:** BAMs deliver continuous monitoring,
- **Robustness:** They are widely deployed in regulatory networks for particulate matter measurement – such as those used by the U.S. Environmental Protection Agency (U.S. EPA) and Environment Canada – because of their proven reliability in long-term monitoring.

The limitations of BAMs are:

- **Environmental Sensitivity:** Relative humidity and variable aerosol composition can affect attenuation characteristics and require frequent calibration.
- **Maintenance Requirements:** Due to the use of radioisotope sources and moving filter tapes, BAMs demand regular servicing and calibration to sustain accuracy.
- **Cost:** The method is relatively expensive and requires access to line power.

5.5.2.2 Tapered Element Oscillating Microbalance (TEOM)

The TEOM monitors measure the true mass of particles by continuously weighing a filter as particulates deposit on it. The filter is part of a tapered element whose oscillation frequency changes with mass load. The strengths of the approach are:

- **Direct Mass Determination:** TEOMs provide near-real-time gravimetric data
- **Long-Term Stability:** They were well-established in Alberta airsheds, offering consistent performance over extended periods

The limitations:

- **Sensitivity to Environmental Conditions:** TEOMs can be influenced by temperature and humidity variations. Losses of semi-volatile particles due to the heated sample stream may lead to underestimation of mass. In cold weather and at low concentrations TEOMs were found to understate concentrations compared to reference methods (Hsu, Wang, Chow, Watson, & Percy, 2016).
- **High Initial Cost:** The technology, while reliable, generally comes with higher capital and maintenance costs.

TEOMS are largely replaced in most monitoring networks, including Alberta airsheds, by more modern methods.

5.5.2.3 Optical Particle Counters (OPCs) and Light Scattering Techniques

Optical methods utilize light – often from lasers or LEDs – to detect particles as they traverse a sensing zone. When particles cross the light beam, they scatter light that is detected and quantified. This method is widely used for real-time monitoring in urban settings, industrial environments, and indoor air quality assessments (CARB, 2025). The benefits of the approach are:

- **Real-Time Data Acquisition:** Optical sensors provide immediate feedback of particulate concentrations
- **Detailed Size Distribution:** Many optical instruments not only count particles but also categorize them by size

- **Portability:** Compact optical devices can be integrated into fixed monitors, handheld units, or personal wearable technology.

The drawbacks of optical methods include:

- **Calibration Requirements:** Optical systems are sensitive to changes in ambient conditions such as humidity and temperature, and they require initial and regular calibration to maintain accuracy. While the units receive a general calibration at the factory, recalibration in local dust conditions is needed.
- **Indirect Measurement of Mass:** Optical sensors typically measure light scattering, which must then be correlated to mass concentrations using conversion algorithms that can be source specific.
- **Limited Chemical Speciation:** These methods cannot directly assess the chemical composition of particles.

5.5.2.4 Differences Between Low-Cost and Higher-Priced Optical Methods

Low-Cost Optical Sensors:

- **Design and Components:** Low-cost models often incorporate simpler light sources (e.g., basic LEDs), single-angle detectors, and off-the-shelf photodiodes. Their design prioritizes affordability for large-scale deployments, citizen science, or low-budget projects.
- **Performance Trade-offs:** While they can provide real-time data, low-cost sensors may have lower sensitivity and linearity, offering less precise particle size distribution and mass estimation. They are also more prone to drift over time and environmental interference such as high humidity or rapid temperature fluctuations.
- **Calibration Concerns:** Limited in-built calibration features mean that users often must perform periodic manual calibrations against reference methods, which can introduce inconsistencies over prolonged use.

Higher-Priced Optical Instruments:

- **Enhanced Sensor Technology:** These instruments typically use advanced laser sources with controlled power stability, multi-angle detectors, and sophisticated optics that account for variations in light scattering. This results in higher sensitivity and more reliable performance over a wide range of environmental conditions.
- **Robust Calibration and Data Processing:** High-end devices usually include automated calibration routines, error-correction algorithms, and improved signal processing that enhance accuracy and reduce the influence of ambient conditions.
- **Extended Data Functions:** In addition to providing finer size resolution and more accurate mass concentration estimates, these systems may integrate additional capabilities such as particle composition inference (using supplementary sensors) and connectivity with IoT networks for integrated air quality management.

Cost Considerations: The improved performance and durability come at a higher cost. By weighing these aspects, it is evident that low-cost optical sensors are ideal for distributed, large-scale, and less critical monitoring scenarios, whereas high-priced optical methods are better suited for applications where precision, reliability, and minimal maintenance are imperative (Giordano, et al., 2021). Low-cost optical sensors and associated correction methods have been evolving over time. Accordingly, their capabilities and the gaps between higher-priced optical methods will change over time.

5.5.3 Extractive Sampling Techniques and Dustfall Monitoring Methods

5.5.3.1 Extractive Sampling Techniques

Extractive sampling involves drawing a continuous stream of air from a specific environment – such as a factory duct or outdoor industrial site. The sample is then conditioned, transported, and analyzed separately. The strengths of the approach are:

- **Controlled Sample Environment:** Samples extracted from targeted sources can be analyzed with enhanced precision, as environmental variations are minimized during sampling.
- **Versatility in Analysis:** Extracted air can be subjected to multiple analytical methods, including both gravimetric and spectrometric techniques, allowing for simultaneous assessment of dust mass, size, and chemical composition.
- **Applicability in Harsh Conditions:** Specialized extractive systems are designed to handle the aggressive conditions ensuring consistent operation.

The limitations of the method are:

- **Complex Calibration and Maintenance:** The systems require extensive calibration to account for factors like flow rate, temperature, and humidity. Additionally, continual maintenance is often required to sustain performance.
- **Higher Operational Costs:** The complexity and robustness of extractive sampling systems can demand significant investment in both equipment and skilled personnel.
- **Potential Sampling Losses:** The process of transporting and conditioning the air sample can sometimes lead to particle losses, necessitating correction factors during analysis.

5.5.3.2 Dustfall (Fallout) Monitoring

Dustfall monitoring, often governed by standards such as ASTM D1739, utilizes passive collection devices such as open canisters or deposition plates to capture particles that settle out of the air over time. This method is widely used to assess cumulative dust deposition over periods ranging from days to months. This method is extensively used in Australia for assessing long-term deposition trends and environmental impacts (EPA Victoria, 2022) and the reasons include:

- **Cost-Effective:** Due to the simplicity of its collection devices, dustfall monitoring is very economical, particularly for long-term or widespread environmental studies.
- **Ease of Deployment:** The passive nature of the samplers means they can be easily distributed over large geographic areas, offering insight into spatial trends in dust deposition.
- **Long-Term Trend Analysis:** Continuous sampling over extended periods allows for robust statistical analysis of seasonal or annual dustfall trends.

Limitations of dustfall monitoring are:

- **Poor Temporal Resolution:** Because dustfall monitors collect data over extended periods, they are unable to capture short-term or event-driven changes in ambient air quality.
- **Weather and Environmental Influences:** Factors such as wind speed, rain, natural events (forest fires) and surface characteristics can significantly affect deposition rates, potentially skewing results.

- **Limited Health Relevance:** Dustfall data primarily indicate cumulative deposition and are not directly comparable to real-time airborne particulate matter (i.e., $PM_{2.5}$ or PM_{10}), which have immediate implications for respiratory health.
- **Sampling Efficiency Uncertainty:** The sampler design (e.g., the presence or absence of wind shields) can introduce variabilities that complicate data interpretation.

5.5.4 Visual Observations

Visual observation of dust or opacity is a practical and immediate method to support dust management. The potential benefits of using visual observations are:

- **Immediate Action Triggers**: Observations allow site managers to instantly pause high-emission activities or apply mitigation when a dust plume is spotted, rather than waiting for lab results.
- **Low Implementation Cost**: Apart from training staff, setting up a visual monitoring program is comparatively inexpensive with little or no instrumentation needed.
- **Source Identification**: Visual checks are the most effective way to pinpoint specific dust-emitting sources, such as a leaking conveyor belt or a dry unpaved haul road.
- **Community, Stakeholder & Regulatory Relations**: Active visual monitoring demonstrates vigilance to authorities and provides facts to quickly validate or defuse public complaints.
- **Standardized Methods**: Established protocols provide a basis for recording visible emissions for compliance. Some jurisdictions use opacity standards (e.g., Ringelmann scale or EPA Method 9 (opacity)) to regulate visible emissions. Trained observers can assess whether emissions exceed allowable limits which helps ensure compliance with environmental permits and avoid fines or shutdowns. For example, in Detroit onsite opacity < 5%, offsite = 0% unless a fugitive dust plan is filed (Detroit, 2024).

Limitations of using visual observations can include:

- **Misses Respirable Dust**: Visual inspections cannot detect fine particles, except when concentrations are sufficiently high.
- **Subjectivity and Human Error**: Estimates of dust opacity can be biased by lighting or adverse viewing conditions, potentially leading to inaccurate observations.
- **No 24-Hour Coverage**: Visual observations are difficult to sustain around the clock and may miss events that occur when observers are not present.
- **Delayed Detection**: Visual signs like haze or settling dust may appear too late, indicating that a control failure or excessive emission has already been in progress for some time.
- **Qualitative Data Only**: Unlike real-time sensors, visual observations do not provide the quantitative data required for detailed air quality analysis or forecasting.

Other features of visual observations can be (NEPSI, 2020):

- **Supplement to Instrumental Monitoring.** While instruments like PM_{10}/$PM_{2.5}$ monitors provide quantitative data, visual observation adds contextual understanding – such as identifying the source, direction, and dispersion of dust. Integration: Used alongside meteorological data and sensor readings for a comprehensive dust management strategy.

- **Flexibility.** Visual observations can be anywhere which adds flexibility to the overall monitoring strategy.
- **Training and Awareness.** Encouraging staff to observe and report dust conditions fosters a culture of environmental responsibility. Visual logs or mobile apps can be used to record observations and trigger mitigation actions.

5.5.5 Dust Monitoring Summary

An effective dust monitoring strategy may require a blend of multiple measurement techniques to provide a comprehensive assessment of airborne particulates. The choice of technique will depend on the specific requirements of the monitoring program, e.g., regulatory or process control, and involve balancing factors such as cost, response time, accuracy, and operational complexity. For instance, urban dust networks might deploy an array of low-cost optical sensors to capture spatial variability while relying on higher-end instruments for periodic calibration and compliance verification.

Separating the effects of natural events such as forest fires from program generated dust may take additional analysis. For example, in a sophisticated network, the ratio of measured $PM_{2.5}$ to PM_{10} levels, can be used as an indicator of dust events and dust influences. The possible use of $PM_{2.5}/PM_{10}$ as a dust metric and management tool could be considered when planning dust related monitoring programs.

Table 3 summarizes the key findings.

Table 3: Dust Monitoring Approaches

Monitoring Approach	Strengths	Limitations
Gravimetric Analysis	■ High accuracy, regulatory acceptance, and reliable mass concentration measurements. ■ Measures all size fractions	■ Time delays due to post-collection laboratory processing, and limited information on particle speciation.
Continuous Particle Concentration Methods	■ Regulatory approved, real time direct concentrations	■ High cost, some sensitivity to environmental conditions ■ Relatively higher detection limits than continuous optical methods ■ Usually limited to specific particle sizes (e.g., PM_{10})
Continuous Optical Methods	■ Real-time monitoring, immediate feedback on particle counts and size distributions and some have regulatory approval. ■ Near zero minimum detection limits ■ Can measure multiple size ranges with some approximations. Usually, the most accurate concentration estimates are for the regulated size ranges ($PM_{2.5}$ or PM_{10})	■ While low-cost optical sensors offer broad accessibility and ease of deployment, they may suffer from calibration drift and lower sensitivity. Concentrations are estimated based on an ideal particle composition unrelated to site-specific dust sources. ■ In contrast, higher-priced optical instruments come with advanced sensor components, more robust calibration routines, and enhanced environmental resilience, though at a significantly increased cost.
Extractive Sampling and Air Sampling Pumps	■ Targeted, controlled sampling that provides both mass and chemical composition data. ■ Measures all size fractions	■ Increased complexity, higher operational costs, and delayed result turnaround
Dustfall Monitoring	■ Economical and easy to deploy for long-term mapping of cumulative dust deposition ■ Samples all size fractions	■ Low temporal resolution and susceptibility to weather-driven variabilities, making it less effective for immediate health and/or nuisance assessments

Monitoring Approach	Strengths	Limitations
Visual Observations	■ Real time detection ■ Can be applied/used at any location ■ Can be based on accepted opacity standards ■ Low capital costs	■ Qualitive ■ Formal training needed for accepted standards ■ Requires diligence to frequently observe and document ■ Limited to the largest (visible) dust sizes or dense clouds of fine dust. Sizes not specified.

5.6 Complaints Management

While managing complaints may not be an explicit part of an organization's DMP, complaints management serves as an essential feedback loop, enabling prompt identification and potential mitigation of fugitive dust. Effectively handling complaints helps demonstrate a commitment to being a responsible community member. By actively tracking, investigating, and resolving complaints, organizations can maintain positive community relations, and ensure the management plan remains effective and potentially adaptable to changing conditions and community concerns.

In addition to operator-led processes, complaints may be directed to public authorities in Alberta, (i.e., Environment and Protected Areas, Alberta Energy Regulator, Alberta Transportation and Economic Corridors, and urban and rural municipalities) that may be contacted with complaints. Additionally, the Natural Resources Conservation Board (NRCB) is one of the public authorities for complaints (Natural Resources Conservation Board, n.d.).

The following sections provide two international examples where complaints are handled differently, as well as CASA's process that was developed by many Alberta stakeholders.

5.6.1 Example Complaint Management Process - New Zealand

The jurisdictional review found many discussions on dealing with dust complaints, but few that document detailed or unique approaches. (New Zealand, Ministry for the Environment, 2016) has a unique approach where it is noted that reactive (complaint-based) approaches have shortcomings, including:

- reluctance to complain, or ignorance of how to lodge a complaint
- excessive or frivolous complaints
- complaints stopping because of lack of action by those responsible for managing dust
- dust sources difficult to identify, and
- variable tolerance by individuals to dust deposition and airborne dust.

When characterizing nuisance dust, New Zealand takes a FIDOL approach as part of complaints management. Whether a dust event has an objectionable or offensive effect depends on the frequency, intensity, duration, offensiveness/character and location of the dust event. These factors drive the management of dust complaints. Different combinations of these factors can result in adverse effects. Location is particularly important as this relates to sensitivity of the receiving environment.

5.6.2 Example Complaint Management Process - CASA Odour

A comprehensive approach to complaint management exists for odour in Alberta (CASA, 2015) and could be readily adopted for dust complaints. Management begins with preparing for odour complaints, emphasizing the importance of public communication to inform the community about odour management and how to report odours. It highlights the need for a media strategy to address widespread or harmful odours, training employees on handling complaints, understanding relevant legislation or policy, and co-ordinating responsibilities with other organizations that may be involved in creating odour or in experiencing odour.

When handling an odour complaint call, the CASA odour management document stresses effective communication, listening to the caller, collecting details, and explaining the next steps. It also addresses managing repeat complainants by providing updates and advising callers to seek medical help if there are emergency or health concerns. Referrals to appropriate organizations are also part of the process.

The initial response to odour complaints involves developing a protocol for timely responses, typically within 24-48 hours, and ensuring follow-up calls and updates to the complainant. The investigation response includes keeping the complainant informed about the investigation status, ensuring investigator safety, using alternative data sources to aid the investigation, and maintaining proper records in compliance with legal requirements.

CASA (2015) provides a sample odour complaint form, which collects information such as caller details, odour description, frequency, duration, intensity, weather conditions, alleged source, previous reports, and additional comments. Additionally, the document includes an odour complaint decision tree and call log to help determine the next steps and appropriate referrals, and to record details of the complaint and actions taken.

5.6.3 Example Complaint Management Process - SPSO

An example complaint handling process from the Scottish Public Services Ombudsman (SPSO, 2020) is summarized here. The SPSO handles complaints about public services in Scotland, using a two-stage process. The first stage focuses on frontline resolution, aiming for quick resolution of straightforward complaints. The second stage involves investigation, which is triggered when complaints require a more in-depth review.

The key principles of the SPSO process are:

- **Fairness:** The process aims to be fair to both the complainant and the subject of the complaint.
- **Early Resolution:** The focus is on resolving complaints at the earliest opportunity, wherever possible.
- **Service Improvement:** Complaints are used to identify areas for improvement in service delivery.
- **Frontline Resolution (Stage 1):** This stage aims to quickly resolve simple complaints, often with an “on-the-spot” apology or explanation. SPSO staff are trained to address complaints at this level and strive for resolution within five working days, unless there are exceptional circumstances.
- **Investigation (Stage 2):** If a complaint is complex, serious, or hasn’t been resolved at the frontline, it moves to Stage 2. This stage involves a thorough investigation of the points raised, with a response usually provided within 20 working days.
- **SPSO Assessment and Guidance:** The SPSO will assess the complaint to determine if it can progress to the investigation stage. They may contact the complainant and the organization for further information, seek independent advice, and decide.
- **Investigation Process:** During the investigation, SPSO officers consider relevant evidence, may take independent specialist advice, and gather views from both the complainant and the organization.
- **Decision and Outcomes:** The SPSO weighs the evidence and decides, which may include upholding or not upholding the complaint, making recommendations, and taking action to fix the problem. They also communicate the decision to the complainant and the organization.
- **Monitoring and Improvement:** The SPSO uses information gathered from complaints to improve services and ensure continuous improvement.

5.7 Training and Record Keeping

Implementing a DMP can require comprehensive training programs that cover both theoretical knowledge and practical skills. New employees might undergo induction sessions detailing the health hazards of respirable dust, site-specific mitigation measures, and personal protective equipment requirements. Hands-on workshops teach operators to operate control systems, interpret real-time PM readings, and execute mitigations under varying weather scenarios.

Record keeping is typically required as part of a DMP. Records are useful if tailored to provide evidence that the mitigations and best practices described in the above sections are being used (BC Ministry of Environment & Climate Change Strategy, 2020).

5.8 An Example: AER Requirements for Oilsands Mine Dust Management Plans

The following illustrates one example of the expected contents of a dust management plan. It is specifically designed for oilsands mines and therefore is not applicable to all industries and dust generation activities. Nonetheless the contents are generally indicative of the kind of information in dust management plans.

The clauses below are illustrative. Numbering, wording, and content do not reflect a specific EPEA approval, and requirements may differ by facility and over time.

DUST MANAGEMENT:

1.1.1 The approval holder shall submit an updated Dust Management and Mitigation Plan, which can include a phased implementation, to the satisfaction of the Director on or before October 31, 2025, unless otherwise authorized in writing by the Director.

1.1.2 The plan referred to in subsection 1.1.1 is to include, at a minimum, the following components:

(a) Dust sources and dust types:

(i) For notable sources and activities that could contribute to fugitive dust emissions within the mine (including but not limited to roads, stockpiles and dumps, tailings locations, materials handling, and any other notable dust creating activities);

(A) Identify and describe the sources and activities; and

(B) Identify the contributing factors that result in the generation of fugitive dust emissions (including, but not limited to, predominant wind direction, location of piles, cleared areas, frequency of activity, process operating parameters, control efficiency, etc.);

(ii) Include a detailed site map which identifies the locations of notable dust sources and rank the sources by dust generating potential

(b) Dust management, mitigation, and response:

(i) Description of prioritization for response actions, both pro-active and reactive, for each notable dust emission source in (a);

(ii) Description of how the efficacy of the dust management, mitigation, and response will be assessed

(iii) Describe, and develop if not currently existing, a fenceline dustfall sampling program

(iv) Description of how the following monitoring, measurement, or observations will be conducted, and a description of dust control and response actions considering:

(A) Meteorological conditions

(B) On-site observations and/or monitoring

(C) Off-site dust observations or complaints; and

(D) Real time surveillance (personnel or technology based) for reactive response actions

(v) Description of water planned for dust suppression use, including the following:

(A) List of potential water sources and types; and

(B) Considerations related to dust suppression water use (including but not limited to locations and conditions).

(vi) Description of how the use of dust suppressants will be determined, and implemented

(vii) Description of how records will be kept associated with application of water and/or chemical suppressants, including actual location of water and/or chemical suppressant use, frequency, methodology for estimating water volumes, and tracking of volumes

(viii) Description of other management and mitigations to control dust (including, but not limited to progressive or temporary reclamation);

(ix) Describe, and develop if not currently existing, an internal dust response program that details how the control measures will be implemented with timelines, roles, and responsibilities; and

(x) Describe, and develop if not currently existing, a program for site-wide training for facility personnel and contractors for dust identification, reporting and management.

(c) Review and improvement:

(i) Description of how the plan will be reviewed and audited, including who will review and audit, how often reviews and audits will occur, and associated record keeping

(ii) Discussion of how evaluation of the plan and outcomes are approached, including who will evaluate, how often evaluation will occur, and associated record keeping

(iii) Description of how the plan and components of the plan will be revised, including what will trigger an update, or failing a trigger a regular update frequency, and who will complete the revisions. Revisions may consider updates of dust sources and dust types, the site map, dust mitigation and response plan, and stakeholder engagement approach.

(d) Description of reporting to be appended to the existing monthly industrial air monitoring report:

(i) Any fenceline particulate matter and dustfall exceedance to the Alberta Ambient Air Quality Guideline, as amended

(e) Description of reporting to be appended to the existing annual industrial air monitoring report:

(i) A summary of the approval holder's engagement with potentially dust impacted communities in dust management and mitigation

(ii) A summary or chemical dust suppressant use and location

(iii) A summary of water suppressant use and location

(iv) Dust monitoring results, trends, and any exceedances

(v) On-site/Off-site dust observations and complaints; and

> *(vi) A summary of activities undertaken related to the implementation of dust management and mitigation activities (b) through (c); (f) any other dust management specified in writing by the Director, unless otherwise authorized in writing by the Director.*

1.1.3 If the plan referred to in subsection 1.1.1 is found deficient by the Director, the approval holder shall correct all deficiencies identified in writing by the Director by the date specified in writing by the Director.

1.1.4 The approval holder shall implement the plan referred to in subsection 1.1.1, as authorized in writing by the Director.

1.1.5 Any changes to the plan referred to in subsection 1.1.1 shall be authorized in writing by the Director before implementation.

1.1.6 The approval holder shall revise and resubmit the Dust Management and Mitigation Plan should written direction be provided by the Director.

6. Site-Specific Dust Management Approaches

It is important to note that the following dust management approaches may have other considerations that may make them impractical. Each approach should be tailored to each site's conditions and objectives. Because sites differ, some activities or approaches may not be possible.

6.1 Unpaved Roads

6.1.1 Unpaved Roads Summary

As noted in **Section 5.2**, unpaved roads are the largest source of dust in the province, and the impacts can be significant locally (**Figure 4**). This section summarizes the overall findings on reducing emissions from unpaved roads (see **Table 4** below). Information was largely taken from the following references: *Dust Control for Unpaved Roads* (FCM, 2005), (Ninja De-Icer, 2024), (Konst, 2018) and (Li, et al., 2022) in addition to sources in specific sections. The relative costs may not accurately reflect those in Alberta and thus should be considered and used with caution. Due diligence is needed for site specific application.

Figure 4: Dust Generated by a Vehicle on an Unpaved Road

Table 4: Summary of Benefits and Limitations of Unpaved Road Mitigation Options

Mitigation Option	Benefits	Limitations	Key Considerations	Cost-Effectiveness	Relative Cost
Changing Road Components / Structure (Section 6.1.4)	■ Improves drainage and ride stability long-term ■ Reduces rutting, washboarding and subsidence ■ Keeps fines in the pavement to suppress dust at the source	■ Very high up-front engineering and construction costs ■ Requires specialized design & equipment ■ Major traffic disruption during rebuild	■ Traffic volumes & axle loads ■ Subgrade bearing capacity ■ Drainage design & geotechnical data	■ Moderately high cost per ton of dust avoided, but life-cycle savings from fewer grading cycles and aggregate replacements	$$-$$$
Chemical Dust Suppressants (Section 6.1.5)	■ Rapid application and quick dust reduction potential ■ Wide product choice for diverse soils & climates ■ Hygroscopic types offer multi-month effectiveness	■ Potential environmental runoff & vegetation damage ■ Corrosive to vehicles/infrastructure ■ Reapplication needed every 3–12 months or potentially sooner, depending on product and road surface material	■ Soil type, gradation & moisture ■ Product durability & pH ■ Environmental approvals	■ Mid-range cost per mile/year; 40–60% fewer aggregate losses vs untreated roads yields strong ROI	$$
Paving (Asphalt / Chip-Seal) (Section 6.1.6)	■ Virtually eliminates dust generation ■ Very durable surface, low routine upkeep ■ Stable ride quality and skid resistance	■ Highest up-front capital cost ■ Inflexible on low-volume roads ■ Major rehab required at end of design life ■ Not practical for temporary roads such as haul roads	■ Projected traffic growth ■ Funding streams & life-cycle analysis ■ Pavement design standards	■ Very effective (80% dust removal) but cost-prohibitive for < 200 ADT; 10 to 20-year payback only on busy routes	$$$
Traffic Controls (Speed Limits, Signage) (Section 6.1.7)	■ Lowest implementation cost ■ Immediate reduction in dust from slower vehicles ■ Can be combined with enforcement or public education programs	■ Dependent on driver compliance & enforcement resources ■ Limited effect if speed rules ignored ■ Does not address fine loss or structural rutting	■ Local driver behaviour ■ Enforcement capacity ■ Placement of signs & repeaters	■ Low cost per ton of dust reduction but low total reduction (20–30%); best used in conjunction with other methods	$
Watering (Truck / Sprinklers) (Section 6.1.8)	■ Very simple & inexpensive technology ■ Immediate dust drop ■ Easy to adjust volume & frequency	■ Short-lived effect (hours to days) ■ High water consumption & O&M cost ■ Can soften road, cause rutting & erosion ■ Water Act authorization may be required for water source ■ Authorization from the municipality may be required if using potable water sources.	■ Proximity to water source ■ Target frequency vs. evaporation rate ■ Road traffic schedule ■ Price, availability of water	■ Low initial cost per application but high annual O&M; frequent wetting raises total cost by 50–80% vs suppressants	$
Windblown Dust Controls (Windbreaks, Barriers) (Section 6.1.9)	■ Natural, no-maintenance once established ■ Traps airborne particles before dispersal ■ Provides ecological & aesthetic co-benefits	■ Takes 2–5 years to mature ■ Requires large setbacks ■ Seasonal efficacy & irrigation need in arid zones	■ Prevailing wind patterns ■ Local plant species ■ Initial irrigation & maintenance plans	■ Moderate cost; 50–70% reduction in ambient dust over multi-year life; high benefit on windy plains routes	$$
Unpaved Shoulders (Gravel / Aggregate) (Section 6.1.10)	■ Controls edge erosion & whip-off ■ Constrains stray fines into roadside ■ Reduces washboarding at margin	■ Does not reduce centreline dust ■ Needs additional aggregate and periodic regrading ■ Not a standalone dust solution	■ Shoulder width & cross-slope ■ Aggregate gradation & compaction ■ Drainage beyond edge	■ Moderate cost per mile; 20–40% reduced aggregate loss and grading frequency; cost-effective on moderate-volume roads	$$

6.1.2 Systematic Approach to Implementation of Controls

An example decision chart shown in Appendix D illustrates one process of arriving at a DMP. It was adapted from USDA *Dust Palliative Selection and Application Guide* (Bolander & Yamada, 1999) and represents a systematic approach that could be applied directly to dust on unpaved roads in Alberta and, with appropriate modification, to other dust sources as well. It shows a 'one size fits all approach' is not an expected outcome.

6.1.3 Factors Affecting Dust Emissions from Unpaved Roads

The information presented here may be applicable to all unpaved roads, private and public, including commercial, industrial, utility, etc., (Nicholson, Branson, Giess, & Cannell, 1989), (Nicholson & Branson, Factors affecting resuspension by road traffic, 1990). Following are some of the key factors affecting emissions of road dust using information from *AP-42: Compilation of Air Emissions Factors from Stationary Sources* (further, just AP-42) (U.S. EPA AP-42, 2025):

- When a vehicle travels on an unpaved road, the force of the wheels on the road surface causes pulverization of surface material. The resulting particulates are lifted and dropped from the rolling wheels and the road surface is exposed to strong air currents in turbulent shear with the surface beneath the vehicle. The turbulent wake behind the vehicle continues to act on the road surface after the vehicle has passed. The quantity of dust emissions from a given segment of unpaved road scales linearly with the volume of traffic.
- Dust emissions from unpaved roads have been found to vary directly with the fraction of silt (particles smaller than 75 microns in diameter) in the road surface materials. Best practice may include to measure the silt content of the road surface. The recommended protocols for sampling and analysis of road dust can be found respectively in AP-42: Appendix C.1 Procedures for Sampling Surface/Bulk Dust Loading and AP-42: Appendix C.2 Procedures for Laboratory Analysis of Surface/Bulk Dust Loading. Field tests show that road silt content is normally lower than in the surrounding parent soil, because the fines are continually lifted by the vehicle traffic and blown off the road, leaving a higher percentage of coarse particles.
- At industrial and other sites, where haul trucks and other heavy equipment are common, dust emissions are highly correlated with vehicle weight. On the other hand, there is less variability in the weights of cars and pickup trucks that commonly travel publicly accessible unpaved roads.
- On roads with less variability in vehicle weight, the moisture content of the road surface material may be more important in determining differences in emission levels between southern and northern Alberta.

Precipitation and snow cover affect emissions, and both are highly variable in Alberta. When assessing the potential for road dust, the ECCC document "Road Dust Emissions from Unpaved Surfaces: Guide to Reporting" assumes not only that no dust emissions occur on days with precipitation exceeding 0.2 mm, but also on days when the road surface is covered with snow or is frozen without high traffic volume (ECCC, 2024). This guidance may not reflect actual conditions and therefore should be used with caution.

6.1.4 Changing Road Components/Structure

According to (Barnes & Connor, 2014) good gravel roads begin with three basic principles: the right materials, the right profile and good drainage. Fulfilling all three conditions is necessary for the road to carry traffic, resist tire abrasion, resist damage due to rain and snow, resist wash boarding and minimize dust generation. For dust reduction, surface cover is important, and the guidance is to cover frequently traveled unpaved roads with low silt content material such as asphalt, concrete, recycled road base, slag[8] or gravel to a minimum depth of 10 cm (4 inches). Periodic grading helps refresh the material on the surface.

Surface improvement, by measures such as adding gravel to a dirt road, can be effective when applicable. The environmental impact occurs mostly during the construction phase.

6.1.5 Chemical Dust Suppressants

Chemical dust suppressants are commonly used to reduce dust on well-travelled, unpaved roads. The rule of thumb is to apply a chemical stabilizer in sufficient quantity and frequency to maintain a stabilized surface. Government of Nunavut (Nunavut, 2014) classifies chemical dust suppression products into seven broad categories:

- Chloride (e.g., $CaCl_2$ – calcium chloride and $MgCl_2$ – magnesium chloride) salts and brines. These chemicals are either mixed in place with the top few centimeters of surface material or they are topically sprayed. Water-attracting chemical dust suppressants are recognized for providing the best combination of application ease, durability, cost and dust control for semi-arid, semi-humid and humid climates. They can have significant impacts on the reduction of dust (e.g., 30 to 80%). However, they require frequent re-application to maintain long-term dust suppression performance.
- Their benefits must be balanced against environmental impacts of chlorides. Chlorides are corrosive to metals: steel, including some stainless steels, copper and aluminum (Bolander & Yamada, 1999). They degrade nearby vegetation, surface water, groundwater and are toxic to aquatic species. However, the aquatic toxicity of magnesium chloride is due to the magnesium cation Mg^{2+} (CCME, 2011).
- Organic non-bituminous chemicals (which include lignosulfonates, sulphite pulp mill liquors, tall oil pitch, pine tar, vegetable oils and molasses) adhere to the soil particles or physically bind the soil particles together to increase particle mass and cohesion. They tend to require frequent application.
- Environmental impacts of chemical dust suppressants include being sticky, odorous and visually unappealing. Excluding vegetable-based, they are slow to biodegrade, may contribute to deoxygenation of surface water (i.e., from spills) and may cause the road to become slippery when wet.
  - Milligan Bio-Tech Road Dust Suppressant (Alberta, 2023) is listed as a Proven Product under Alberta Transportation’s Products List, Dust Abatement. This is a canola-based product which can be used on clay and gravel roads. It is water repellant, drying the road faster than calcium chloride preventing greasy slippery roads. It is manufactured in Saskatchewan.
  - DUST/BLOKR Sugar Blend is listed as a Proven Product under Alberta Transportation’s Products List, Dust Abatement. It is a biodegradable, non-toxic (Cypher Environmental, 2021) proprietary mixture of water, lignin, cellulose, glucose, sucrose, fructose, maltose and magnesium oxide. DUST/BLOKR is manufactured in Manitoba.
  - Petroleum-based binders and waste oils are insoluble and create a sealed surface on the road. They can be very effective, since they form a hard crust and are waterproof which both help to protect and stabilize the road surface. However, there may be significant sealed surface leakages containing hazardous components that may contaminate surface and groundwater. For example, in 2012, Alberta Government published *Used Oil as Dust Suppressant* (Alberta Environment and Sustainable Resource Development, 2012) under Acceptable Industry Practices (AIP).

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8. Slag is normally neither used nor available in Alberta. However, the reference to it was retained illustrating the range of materials.

- Electro-chemical stabilizers attract positively charged fine dust particles and bind ionically to them. They also expel adsorbed water from the soil and increase compaction. These stabilizers are considered environmentally acceptable, but vegetation (on shoulders) does not easily establish on compacted sites where sulphonated petroleum products have been used.
- Polymers, most effective in lightly trafficked surfaces, are composed of long-chained molecular structures. These dust suppressants can stick to more particles and bridge greater gaps between particles. Polymers developed in recent years are environmentally friendly and can be applied in a broad spectrum of conditions.
- Enzyme slurries promote compaction, which reduces dust generation. They have been effective under highly specific trafficked surface and aggregate conditions.
- Cementitious binders work by chemically and permanently binding soil particles together.

The Federation of Canadian Municipalities published a guide *Dust Control for Unpaved Roads* (FCM, 2005) that includes a table comparing some of the above categories. The table minus seawater and water entries is reproduced in Appendix C. Environment Canada republished the part of the guide that contains the table *Comparison of Calcium Chloride and Magnesium Chloride Application and Performance* in their *Best Practices For The Use And Storage Of Chloride-Based Dust Suppressant* (Environment Canada, 2007). That table is presented in Appendix B.

(Alberta Environment and Sustainable Resource Development, 2012) and (Environment Canada, 2007) together can be used as definitive references on the deployments of calcium chloride and magnesium chloride as unpaved roads dust suppressants. The U.S. Federal Highway Administration created a table *Chart for Refining Additive Selection* that ranks various chemical additives (FHWA, 2013). It is reproduced in **Table 5**.

Table 5: Chemical Additives for Dust Suppression

Chart for Refining Additive Selection

Additive Category	Traffic			Surface Material								Climate During Traffic		
	Vehicles per Day			Plasticity Index/ Shrinkage Product			Fines (% passing No.200 Sieve [75 µm])							
Dust Palliative	<100	100-250	>250[1]	<5 / <50	5-15 / 50-365	>15 / >365	<5	5-10	10-20	20-30	>30	Wet	Damp to Dry	Dry[2]
Water absorbing														
Calcium Chloride	A	A	B	C	A[3]	C[3]	C	B	A	B[3]	C[3]	C[3,4]	A	C
Mag Chloride	A	A	B	C	A	B[3]	C	B	A	B[3]	C[3]	C[3,4]	A	B
Organic petroleum/Mineral oils														
Asphalt emulsion	B	B[5]	B[5]	A	B	C	B[6]	B	B[5]	C	C	B	A	A
Petroleum resin	A	B[5]	B[5]	A	B	C	B[5]	B	A	C	C	B	A	A
Mineral oil	A	B	B	B	A	C	C	B	A	B	C	B	A	A
Organic non-petroleum														
Lignin	A	A	B[5]	C	A	B[3,5]	C	B	A	B[3,5]	B[3,5]	C[4]	A	A
Tall oil	A	B	C[5]	A	B	C	C	B	A[5]	B[5]	C	B	A	A
Vegetable oil	A	C	C	B	A	C	C	B	A	C	C	C	A	B
Bio-Fluids	A	A	B[5]	C	B	A	C	C	A	A	C[3]	C[3,4]	A	C
Synthetic polymer emulsion														
Synthetic polymer[5]	A	B[5]	C[5]	A	A	C	C	A	A[5]	C	C	A	A	A
Synthetic fluids														
Synthetic Fluid[7]	A	A	B[5]	B	A	B	C	A	A	A	B	B	A	A
Electrochemical/Enzyme														
Electro-Chemical[5,8]	A	A	B	C	B	A	C	C	A	A	A	B	A	A
Enzyme[5,8]	A	A	B	C	B	A	C	C	A	A	A	B	A	A
Other (mechanical)														
Clay Additives[5]	A	B	C	A	B[3]	C	A	B	B	C	C	C[3]	A	A

Performance relative to unpaved road with no chemical treatment: A = Good B = Fair C = Poor

[1] Higher application rates/more frequent rejuvenation required for high truck traffic
[2] >20 days with less than 40% relative humidity
[3] May become slippery in wet weather if shrinkage product >250
[4] May leach out in heavy rain
[5] Mix-in treatment usually required
[6] SS-1 or CSS-1 with only clean, open-graded aggregate
[7] EPA Definition
[8] Requires reactive (usually expansive) clay minerals to react with

Chemical suppressants must be matched to the situation. In case of a mismatch, they could be ineffective. For example, magnesium chloride – $MgCl_2$ – requires the relative humidity (RH) to be at least 32% – regardless of temperature – and might not be a good fit in dry areas of Alberta. There are many products that can damage the environment and there is no clear consensus on the long-term environmental impact of some stabilizers currently used – their use on industrial roads could come at moderate to low costs. However, there are circumstances when a frequent reapplication might be required to maintain an acceptable level of control (typically once or twice a year in Alberta although more frequent application may be needed). Chemical suppressants are generally more cost-effective than water but not necessarily for temporary roads common at mines, landfills and construction sites.

6.1.5.1 Environmental Impact of Common Polymers

There are three common types of synthetic polymers used for dust control.

- Polyacrylamide (PAM). PAMs are considered environmentally safe (Government of Canada, 2009). This type of polymer is widely used in food production to control dust and reduce runoff (Cahn, 2014).
- Acrylic Copolymers. They are generally considered to be biodegradable with minimal toxicity risk to flora and fauna (Steevens, et al., 2007).
- Polyvinyl Alcohol (PVA). Although considered non-toxic, PVA is known to introduce microplastics to the environment (Rolsky & Kelkar, 2021).

There are also many non-synthetic polymers used for dust control like lignosulfonates, guar gum, xanthan gum, starch-based biopolymers, cellulose derivatives and molasses. Although such non-synthetic polymers are considered biodegradable and safe, individual commercial products might contain additives that require a separate evaluation of toxicity and environmental impact.

6.1.6 Paving

Considerations for conversion of an unpaved road into a standard paved road are very complex. They are well beyond the scope of this document. A handbook published by FHWA entitled *Gravel Roads: Construction & Maintenance Guide* (FHWA, 2015) includes an appendix *When to Pave a Gravel Road* that analyses in detail what, when and how. Paving by itself is just one of many expenses. Given a typical unpaved road, such a project requires spending money on new drainage, new shoulders, correcting road geometry and usually replacing the gravel with the base that would adequately support pavement. It should also be factored in that the vehicles would travel faster and possibly be heavier.

However, in situations when the average daily traffic (ADT) volume is low and consists of light vehicles, thin pavement over an existing gravel road could be considered. The appendix quoted above – *When to Pave a Gravel Road* (FHWA, 2015) – provides steps to follow when performing a cost-benefit analysis. Some of the factors to evaluate are:

- A lightly paved road will not carry heavy vehicles. If tractor-trailers with a load are to be accommodated, a proper road needs to be constructed. A single heavy vehicle can damage a lightly paved road to such an extent that (costly) reconstruction would be required.
- There will be a need to repair winter breaks. Pothole repairs are costlier and more complex than on gravel roads.
- The ADT used to justify paving generally range from a low of 50 vehicles per day to 400 or 500. Some jurisdictions in the U.S. use the threshold of 150 ADT to start cost benefit considerations.
- Paving a road tempts drivers to drive faster. As speed increases, the road must be straighter, wider – engineered to be safe. Bridges may need to be widened.

- Gravel might need to be replaced since a base for pavement requires a different type of gravel.
- Adequate drainage must be provided.
- Even a lightly paved road will decrease driving cost for users.

The environmental impact of paving occurs largely during the construction phase. Paved road surfaces in use will still emit fugitive dust from several processes:

- Resuspension of Loose Material: Traffic on paved roads can agitate and lift loose material (dust, debris) present on the road surface, leading to PM emissions.
- Surface Loading: The amount of loose material on the road surface (surface loading) is a key factor in determining PM emissions. This surface loading is constantly replenished by various sources, including wind and water erosion, construction activities, and snow/ice control measures.
- Unpaved Shoulders: Unpaved shoulders adjacent to paved roads can also be a significant source of PM emissions, particularly in areas with high traffic volume.

Emissions from paved roads can be reduced with sweeping and washing. According to *A review on the effectiveness of street sweeping, washing and dust suppressants as urban PM control methods*, (Amato, Querol, Johansson, Nagl, & Alastuey, 2010) using both techniques results in about a 30% reduction in emissions. With newer technology efficiencies higher than 50% can be achieved.

Paving is highly effective; however, its high initial cost is often prohibitive. Furthermore, paving is not feasible for industrial roads with heavy vehicle traffic or possibility of spillage of oil-based material in transport, or temporary roads (i.e., mining haul roads).

6.1.7 Traffic Controls

Traffic controls place restrictions on vehicles limiting their speed, weight, spacing or number on the road. According to WRAP *Fugitive Dust Handbook* (WRAP – Western Regional Air Partnership, 2006), these measures seek to limit:

- the volume of traffic present on the road. Emissions are linear with the traffic volume.
- the type of traffic present on the road. For example, limit vehicle weight, either curb weight or GVWR on the road
- the mean vehicle speed.

For example, some industrial plants have restricted employees from driving on plant property and have instead instituted bussing programs. This eliminates emissions due to employees traveling to/from their worksites. Although the heavier average vehicle weight of the buses increases the base emission factor, the decrease in vehicle-miles-traveled results in a lower overall emission rate.

The Central Okanagan recommends implementing a speed limit of at most 32 km/h for surfaced roads and 8 km/h for unmade surfaces to slow vehicles and therefore reduce fugitive dust emissions: (Regional Air Quality Program, 2022):

- speed control: 50 km/h - dust control efficiency 25%
- speed control: 32 km/h - efficiency 65%
- speed control: 16 km/h - efficiency 80%

Although the actual relationships involve many variables, it could be expected that – in a first approximation – reducing the vehicle speed would proportionally reduce opacity[9] (Thenoux, Bellolio, & Halles, 2007) (U.S. EPA, 2000). For example, if at speeds of 30 km/h measured opacity is 40%, then at speeds of 15 km/h measured opacity could be around 20%.

Finally, rural Alaska considers traffic control to be part of a behavioural change. It recommends reducing speed, reducing the frequency of rapid acceleration and deceleration and reducing ATV use where walking is an option (Alaska DEC, 2018).

In real traffic patterns, traffic controls provide moderate emission reductions since the best speed is the lowest possible speed (and difficult to enforce). Environmental impact and cost are complicated to determine.

6.1.8 Watering

Watering is one of the more common and widespread means to mitigate road dust. For example, it was recommended by the Federation of Canadian Municipalities in its *National Guide to Sustainable Municipal Infrastructure. Roads and Sidewalks* (FCM, 2005).

It is considered best practice that watering as a control is defined in terms of frequency. The South Coast Air Quality Management District *Rule 403. Fugitive Dust* (SCAQMD, 2005) recommends watering all roads used for any vehicular traffic at least once per every two hours of active operations (3 times per normal 8 hour work day), and watering all roads used for any vehicular traffic once daily together with restricting vehicle speeds at the same time.

Watering is one of the control methods in Alaska (Alaska DEC, 2025), Arizona Maricopa County (MCAQD Rule 310, 2010), (MCAQD Rule 310.01, 2010), California Imperial County Air Pollution Control District (ICAPCD, 2012), province of New Brunswick (NBDT, 2010), (Moncton, 2022), the Territory of Nunavut (Nunavut, 2014).

Some jurisdictions do not recommend watering. Nevada Clark County and the province of British Columbia do not use watering on unpaved roads, just chemical dust suppressants. *Unpaved Road Dust Management, A Successful Practitioner's Handbook*[10] published by U.S. Department of Transportation – Federal Highway Administration does not consider watering on unpaved roads, just chemical dust controls (FHWA, 2013). The technical reference manual *Environmentally Sensitive Maintenance for Dirt and Gravel Roads* (PSU, 2007) notes that watering should not use potable water treated with chlorine.

Watering can be very effective, but its efficiency drops to zero after it evaporates. It is not effective on sandy or muddy soils; under such circumstances the road must be improved first. Watering is also only temporarily effective in a dry climate when it is hot and windy. Under such conditions, trying to use more water might lead to overwatering and road structural damage, while not giving the desired dust control since more water would create runoff with silt. Watering is also not recommended in freezing conditions.

6.1.9 Windblown Dust from Unpaved Roads

Unpaved roads are subject to fugitive dust emission by wind alone, regardless of vehicles travelling and these emissions could be quite substantial.

Mitigation options may include wind breaks to reduce the wind speed affecting the road. Shrubs, preferably native shrubs – so they can withstand climatic challenges and not disrupt the local ecosystem and may be more sustainable than artificial wind barriers (usually fences). The fencing might be the preferred option when the wind

9. Beyond road dust that is not the case, since there is no simple relationship between concentration of particles smaller than $PM_{2.5}$ and atmospheric opacity.

10. The handbook is a result of field tests in Arkansas, Colorado, Idaho and Montana that have climate and geography like Alberta.

protection is needed immediately or while waiting for the vegetation to be established, and the only option when a barrier made of vegetation is not feasible. Depending on circumstances, wind breaks also might protect roads from dust blowing onto them.

Mitigation options for windblown dust are examined in more detail in **Section 6.3**.

6.1.10 Unpaved Shoulders

Even if vehicles do not travel on road shoulders, fugitive dust is produced by turbulent air movement caused by vehicles traveling on the paved portion of the road. A study *Particulate Emission Rates for Unpaved Shoulders along a Paved Road* (Moosmüller, et al., 1998) carried out in the San Joaquin Valley (Southern California) gave an estimate for the emissions from unpaved shoulders within the San Joaquin Valley, and found them to be on the same order-of-magnitude as from windblown dust. The conclusions also indicated that dust emissions on paved roads from unpaved shoulders vary greatly and mostly come from large size vehicles or vehicles with poor aerodynamics traveling at high speeds (greater than 80 km//h).

Previously discussed controls of dust on unpaved roads also apply to unpaved shoulders.

- Spraying with dust suppressants (either water or chemicals, that is the same products as presented earlier).
- Properly maintaining shoulders, so they do not trap water in pools. Pools accumulate silt and when dried the silt becomes airborne as dust.

6.1.11 Unpaved Road Dust Mitigation Cost and Effectiveness

6.1.11.1 Cost

Available control options vary in terms of cost, effectiveness environmental impact and applicability. Ultimately, when developing control plans, both the type and amount of traffic and how long the road will be in service need to be considered (U.S. EPA AP-42, 2025).

One of the more important aspects of mitigation is cost. At a high level, factors affecting cost are:

- **Surface Type:** The type of surface (gravel, asphalt, concrete) significantly impacts the overall cost.
- **Surface Area:** The longer the road, the higher the total cost.
- **Material Costs:** Fluctuations in the price of asphalt and other materials can affect the final price.
- **Labour Costs:** The cost of labour for construction and paving can vary.
- **Site Conditions:** Factors like soil type, drainage and existing infrastructure can affect the cost.
- **Contractor Fees:** Different contractors have different pricing structures.

In 2012, the Alberta government published Used Oil as Dust Suppressant (Alberta Environment and Sustainable Resource Development, 2012) under Acceptable Industry Practices (AIP). The table showing costs of various dust mitigation practices is reproduced below (**Table 6**).

Table 6: AIP Best Practice Dust Suppressants

Dust Suppressant	Advantages	Disadvantages	Quantity (L/km)	2012 cost / km/year
Water and Wetting Agents	no environmental impact	■ short term ■ frequent application ■ erosion	6 000	$17 000 to $40 000
Calcium Chloride	effective in areas with relative humidity greater than 30%	■ water supplies ■ soil salinization and reclamation ■ plant life ■ aquatic species	15 000	$2 500 to $7 000
Lignosulfonates	effective	■ moderately toxic to plant life and rainbow trout	20 000	$2 500 to $7 000
Oil-based (asphalt emulsions, used oils, crude oil, etc.)	effective	■ may have adverse impact on vegetation, soil, or water supplies	15 000	up to $7 000

6.1.11.2 Summary of Effectiveness

The most common approaches to mitigation of dust from unpaved roads are summarized in **Table 7**. Estimates of typical efficacy were compiled from various documents of U.S. Environmental Protection Agency.

Table 7: Common U.S. EPA Dust Controls

Mitigation	Typical Effectiveness	Environmental Impact	Cost	Ease of Use
Watering	25-88%	low to medium	very low to very high	Usually easy to implement with minimum training.
Chemical Application	80-95%	low to high	low to high	More difficult to implement requiring moderate training on safe use, storage, clean-up of chemicals.
Traffic Controls	up to 100%, for example if traffic is detoured around a specific location	very low to low	very low to low	Speed controls required complex planning but when implemented are very easy to use.
Paving	up to 95%	medium	high to very high	Requires complex planning, trained crews and a range of equipment. When paved, roads are easy to use.
Road Structure Improvement	up to 80%	low (medium if construction required)	medium to high	Requires complex planning, trained crews and a range of equipment. When paved, roads are easy to use.

6.2 Construction & Demolition

6.2.1 Overview

Information in this section was largely compiled from the approaches enacted in those areas of the southwestern United States that not only share arid and semi-arid climates (like southern Alberta) but also have decades of widely acknowledged experience in fighting fugitive dust. The primary sources were:

- South Coast Air Quality Management District Rule 403. Fugitive Dust (SCAQMD, 2005)
- Maricopa County Air Quality Department, Compliance and Enforcement Division (MCAQD) Dust Abatement Handbook (MCAQD, 2024)
- Maricopa County Air Quality Department, Compliance and Enforcement Division Rule 316 Handbook. Non-metallic Mineral Processing and Related Operations (MCAQD, 2024)

- Ontario Ministry of the Environment and Climate Change Technical Bulletin – Management Approaches for Industrial Fugitive Dust Sources (MOECC, 2017)
- Environment Canada. Transboundary Issues Branch Best Practices for the Reduction of Air Emissions from Construction and Demolition Activities (Cheminfo, 2005).

Table 8 was created based on data from (WRAP – Western Regional Air Partnership, 2006) and from the South Coast Air Quality Management District (SCAQMD) Rule 403. (SCAQMD, 2005). A comprehensive approach to construction, demolition and any earth-moving activities during windy conditions can be found in the SCAQMD Rule 403.1 (SCAQMD, 2004). Such information could be useful in windy, semi-arid areas like Lethbridge or Calgary. Additional guidelines describing control measures needed to manage fugitive dust generated by large roadway projects can be found in the SCAQMD Rule 403.2 (SCAQMD, 2022).

According to (MOECC, 2017), fugitive dust sources include vehicle traffic on paved or unpaved surfaces, blow-off from a load during haulage, loading and unloading of materials, material handling, screening and sorting, dry sweeping, and wind erosion of open storage piles, berms and open surfaces. Other common activities during construction and demolition that may contribute to fugitive dust emissions include blasting, drilling, crushing, jack hammering and grinding.

Table 8 summarizes the benefits and limitations of each of the mitigation measures reviewed for dust generated by construction and demolition activities. Cost guidance is also included but may not accurately reflect the Alberta situation – caution is advised.

6.2.2 Watering

At construction sites, a common dust control measure is to apply water to those surfaces that might emit dust when dry. On construction sites, water would be typically applied not only using water trucks equipped with spray bars, but also by sprinkler systems with a variety of nozzles and water cannons of various types. Such watering systems should be designed to cover the desired areas.

The mechanism of action is the same as described in the section on unpaved roads: watering increases the moisture making particles heavier and more likely to stick together, thus less likely to become airborne. Also, the dust already airborne will agglomerate and fall out from the air because of its increased mass.

6.2.3 Chemical Stabilizers

Chemical stabilizers bind dust particles together and prevent them from becoming airborne. Commercial products are often classified in different ways, one of the often-used groupings follows (more detail was provided in **Section 6.1.5**):

- water absorbing products
- organic petroleum (e.g., asphalt emulsions, cut/liquid asphalt, dust oils, petroleum resins)
- organic non-petroleum (e.g., lignosulfonates, tall oil emulsions, vegetable oils)
- polymer products (e.g., polyvinyl acetates, vinyl acrylics)
- synthetic products (e.g., iso-alkane compounds)

6.2.4 Dust and Wind Fences

Deployment of dust and wind fences is covered together with natural barriers in **Section 6.3**.

Table 8: Summary of Benefits and Limitations of Construction and Demolition Mitigation Options

Mitigation Option	Benefits	Limitations	Key Considerations	Cost-Effectiveness	Relative Cost
Watering	▪ immediate dust suppression ▪ simple and fast to deploy	▪ requires frequent reapplication ▪ runoff and erosion risk ▪ high water use	▪ water availability ▪ frequency of application ▪ soil/surface type	▪ low upfront cost ▪ high O&M ▪ best for short-term control	$
Chemical Stabilizers	▪ longer-lasting control ▪ effective under varied conditions	▪ environmental concerns ▪ reapplication needed ▪ may be slippery	▪ soil/surface compatibility ▪ product selection ▪ traffic volume ▪ regulatory approval	▪ good ROI for longer-term projects	$$
Dust & Wind Fences	▪ reduces wind speed, traps airborne dust ▪ low maintenance	▪ requires space ▪ visual impact ▪ less effective in turbulent winds ▪ structural concerns in strong winds	▪ wind speed and direction ▪ fence height and porosity ▪ material durability ▪ site layout	▪ effective in windy zones	$$
Perimeter Sprinklers	▪ continuous suppression at site boundary ▪ automated	▪ infrastructure complexity and cost ▪ water use ▪ limited reach	▪ nozzle type ▪ droplet size ▪ wind conditions ▪ site layout ▪ water availability	▪ good for boundary control	$$-$$$
Cleaning Systems at Site Exit	▪ prevents trackout ▪ improves compliance ▪ reduces need for off-site suppression	▪ installation and maintenance costs ▪ water use ▪ sediment management	▪ vehicle types ▪ sediment collector design ▪ water recycling ▪ frequency of use	▪ high initial cost ▪ effective for regulatory compliance	$$$
Onsite Speed Control	▪ easy to enforce ▪ low cost	▪ depends on driver compliance ▪ enforcement ▪ limited effect on fine dust	▪ signage ▪ driver compliance ▪ enforcement ▪ site layout	▪ low (signage) to moderate (speed bumps, etc.)	$-$$
Surface Roughening	▪ reduces wind erosion on inactive surfaces ▪ simple to implement	▪ temporary ▪ not suitable for active areas ▪ not suitable for all soils or slopes	▪ wind orientation ▪ soil type ▪ equipment availability ▪ timing (before wind events) ▪ slope stability	▪ low cost	$
Vegetative Windbreaks	▪ long-term dust and erosion control ▪ ecological benefits (habitat creation) ▪ low maintenance	▪ slow to establish ▪ seasonal effectiveness ▪ space requirements	▪ native species ▪ irrigation ▪ maintenance ▪ spacing	▪ moderate (initial planting + upkeep) ▪ low maintenance costs (good long-term value)	$$
Material Handling Practices	▪ simple behavioural change ▪ improves safety	▪ requires training ▪ operational changes	▪ drop height ▪ moisture content ▪ equipment type	▪ high effectiveness ▪ low cost if integrated early	$
Wet Suppression	▪ effective for cutting, grinding, and demolition	▪ requires misting systems ▪ water supply ▪ not feasible in freezing conditions ▪ runoff concerns ▪ adds moisture to material	▪ timing and frequency; equipment compatibility; droplet size ▪ nozzle placement ▪ dust type ▪ drainage	▪ highly effective for fine dust	$$
Temporary Paving	▪ significant reduction ▪ improves site access	▪ high initial cost ▪ not suitable for short-term sites	▪ traffic volume ▪ site duration ▪ drainage ▪ timing of paving ▪ maintenance ▪ removal after use	▪ effective for high-traffic areas	$$$
Equipment Redesign	▪ long term benefit ▪ improves efficiency (e.g., enclosed conveyor)	▪ capital investment ▪ may require retrofits	▪ retrofit feasibility ▪ equipment lifecycle ▪ dust source ▪ manufacturer support	▪ high upfront cost ▪ long-term savings	$$$
Operations on Frozen Ground	▪ natural dust suppression ▪ no water needed	▪ seasonal - ▪ limited to winter months	▪ scheduling ▪ safety ▪ surface/soil type	▪ very cost-effective if feasible	$
Haul Distance Reduction	▪ less vehicle movement ▪ reduces dust and other emissions	▪ may require site redesign ▪ logistical constraints	▪ planning site layout ▪ material staging ▪ route optimization	▪ higher upfront cost if redesign required ▪ lowered operational cost due to fuel and wear and tear reductions	$$-$$$

6.2.5 Perimeter Sprinklers

Sprinklers are typically located around the perimeter of the site. The supply pipework can be buried underground, clipped to the fencing or just laid on the surface. Nozzles are usually directed to spray toward the interior of the property, so that water is not sprayed beyond the property line. The premise is that dust particles will attach to the water droplets and fall out of the air and will not travel outside the site perimeter.

Depending on the size of dust particles, nozzles should be distributing either large droplets for suppressing coarser dust particles – like those generated by aggregates and raw materials – or produce fine mist that helps control finer dust particles. Some systems produce both large and fine droplets.

6.2.6 Cleaning Systems at Site Exit

A tire wash system that can wash the entire circumference of each wheel of the vehicle may be considered. Additionally, a vehicle wash (a cosmetic wash) may be considered if there is substantial dust on the vehicle body. Water spray from the nozzle should have pressure of at least 40 psi (MCAQD, 2024).

Alberta Transportation's *Erosion and Sediment Control Manual* (Alberta Transportation, 2011) specifies that at the exits of a construction site, water supply should be included to wash off excess soil from vehicles prior to exiting the construction~~s~~ site. Additionally, sediment from vehicle washing should be collected and that sediment should be retained on construction site.

6.2.7 On-site Speed Control

Speed control is one example of an administrative approach to dust control. That could include all roadways within a site, not only haul roads since, because as explained in **Section 6.4**, vehicles create dust from unpaved shoulders. Speed controls are site specific and need to reflect local needs.

In some jurisdictions, the recommended on-site speed limit of vehicles is 25 km/h (15 mph) (MCAQD, 2024). Lowering the limit below 25 km/h (15 mph) might be required if substantial dust is generated at that speed. If speed signage does not result in desired speeds, installing speed control devices might enforce the posted limit.

6.2.8 Additional Construction- Related Mitigation

Other mitigation approaches that maybe applied to construction sites are: (details of which are covered elsewhere in this document):

- Creating a rough surface on bare flat areas may help reduce dust emissions by minimizing wind shear at the soil surface
- Wind speed reduction above the surface using windbreaks, vegetative barriers, shelterbelts, and wind fences
- Minimizing drop height of materials to the lowest height possible by drivers (operators) unloading truck beds, loader buckets or excavator buckets. Unloading slowly, including during screening operations.
- Wet suppression by applying water to:
  - demolished materials or by pre-wetting materials to be demolished
  - the active face when working the pile or to the entire pile during periods of inactivity
- Paving of temporary on-site roads
- Early paving of permanent roads

- Equipment redesign to minimize dust emissions
- Transporting over frozen ground
- Planning to reduce on-site haul distances

6.3 Wind Erosion

6.3.1 Overview

Given an open area, natural wind action on bare or sparsely vegetated land lifts soil and transports the resulting dust. That is especially noticeable during dry, windy conditions common in the Prairies. Wind erosion can occur on any disturbed open land under sufficiently strong winds.

Winds that lifted sand or dust can give rise to sand and dust storms (SDS). Although the majority of SDS occur in Africa and Asia, they happen both in the U.S. and Canada (including Alberta – **Figure 5**) (UNEP, WMO, UNCCD, 2016).

Source: CU185875 by Unknown. Courtesy of Glenbow Library and Archives Collection, Libraries and Cultural Resources Digital Collections, University of Calgary. https://digitalcollections.ucalgary.ca/asset-management/2R3BF1O9QX87

Figure 5: Dust Storm, Pearce Airport, Lethbridge Area, Alberta, 1942

Large parts of Alberta have a cold, semi-arid climate thus extensive and readily available expertise from geographies without long cold winters is not directly useable. The Government of Alberta published *An introduction to wind erosion control* (Alberta, 2017) that considers local conditions. In addition to methods specific to agriculture, the recommended measure to control dust from wind erosion is use of shelterbelts and as emergency measures increasing the surface roughness or covering the soil with straw or manure.

Alberta Transportation published *Erosion and Sediment Control Manual* (Alberta Transportation, 2011) which contains a large set of Best Management Practices. Some of them may be applicable for wind erosion control on large flat surface areas, borrow pits, and stockpiles.

The Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) together with Agriculture and Agri-Food Canada (AAFC) published a series of *Best Management Practices* related to wind erosion and these documents can be referenced for specifics related to the industry:

- Controlling soil erosion on the farm (BMP26E) (OMAFRA, 2012)
- Erosion control structures (AF165) (OMAFRA, 2017a)
- Wind strips (AF187) (OMAFRA, 2017b)
- Wind erosion (AF193) (OMAFRA, 2018)
- Field windbreaks (AF167) (OMAFRA, 2019)

AOPA (2025) identifies manure management practices in Alberta, some of which could include manure application as a potential dust suppressant.

While specific methods can be applied to specific source conditions, in practice a range of mitigation may be needed. For example, the City of Fort Collins in its Dust Prevention and Control Manual (Fort Collins, 2016) prescribes that on areas where vegetation is being established or will remain exposed and inactive for 30 days there needs to be some form of soil retention. Listed methods are compost, mulch and erosion control mats (properly anchored soil mats).

Table 9 summarizes the mitigation options best suited to wind erosion control and discussed in more detail in subsequent sections.

6.3.2 Dust Suppressants

Some (chemical) dust suppressants are highly effective (details were presented in **Section 6.1.5**).

Even if watering is selected – as it can often be implemented easily and quickly – chemical dust suppressants should be considered because water might not be available. Either through widespread drought conditions or due to problems with water infrastructure. For example, in 2024 there were two periods, each lasting weeks, when the City of Calgary implemented its Stage 4 outdoor water restrictions that – according to *Calgary Water Utility By-law 40M2006* – does not allow water use for construction purposes including grading, compaction and dust control. And again, Stage 4 outdoor water restrictions in Calgary were in place for more than two weeks at the beginning of 2026.

6.3.3 Shelterbelts and Fencing

6.3.3.1 Vegetative Shelterbelts

Vegetative shelterbelts may effectively reduce windblown dust. They are created by planting rows of trees, shrubs, and sometimes grasses (or even tall crops) perpendicular to prevailing winds. Man-made alternatives are fences and artificial windbreaks. Both types of barriers reduce wind speed and the area affected by erosion (Alberta, 2014).

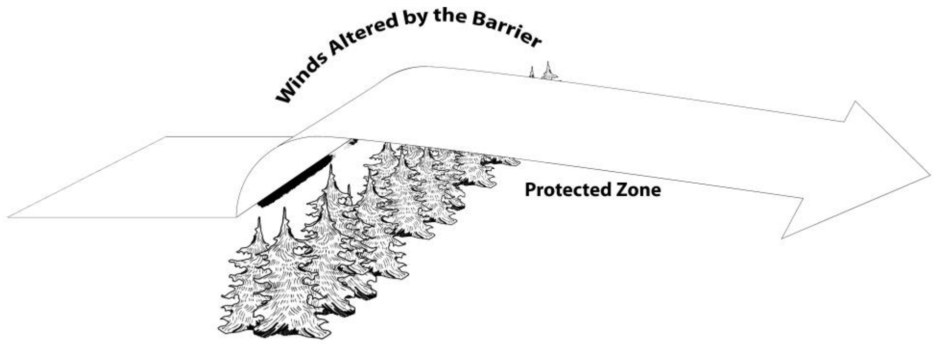
Non-vegetative and vegetative windbreaks should have 30-50% porosity to be most effective. Allowing some airflow reduces turbulence.

In general, vegetative barriers offer biodiversity, ecological, microclimate and soil health benefits over non-vegetative ones. The vegetative barriers could also be significantly cheaper to install. On the other hand, the non-vegetative barriers may often be deployed much faster, since they do not take years to mature. They may also be installed in environments hostile to vegetation and made in much larger range of sizes.

Table 9: Summary of Benefits and Limitations of Wind Erosion Mitigation Options

Method	Benefits	Limitations	Key Considerations	Cost-Effectiveness	Relative Cost
Dust Suppressants	■ rapid deployment ■ effective in dry conditions; long-lasting with polymers or chlorides ■ longer lasting than water alone	■ environmental concerns (runoff, toxicity); reapplication needed	■ selection of appropriate chemical ■ environmental impact ■ application frequency ■ regulatory authorizations	■ more cost-effective than frequent watering	$$-$$$
Shelterbelts and Fencing	■ protects moderate areas ■ long term solution ecological benefits	■ vegetative barriers take time to establish ■ non-vegetative barriers can be costly and require maintenance ■ limited effects more than 10 barrier heights downwind	■ barrier height, spacing, and porosity ■ placement relative to wind direction ■ maintenance needs. ■ area to be covered	■ high ROI for vegetative (long-term) ■ moderate to high for engineered fences (immediate effect)	$$-$$$
Graveling	■ immediate reduction ■ durable and low maintenance	■ requires significant material ■ desired gravel may not be locally available ■ grading needed ■ not suitable for all terrain	■ gravel size (0.25–3 in), silt content <6%, depth ≥2 in ■ application rate ■ gravel availability ■ site suitability	■ moderate cost ■ effective for long-term control with minimal upkeep	$$
Paving	■ eliminates most dust emissions ■ low maintenance	■ very high cost ■ not feasible for large or low-traffic open areas.	■ surface type ■ traffic load ■ drainage design ■ duration	■ low-cost effectiveness for dust control alone ■ justified if combined with other infrastructure needs	$$$
Restricting Vehicular Access	■ eliminates soil disturbance and dust generation ■ reduced safety concerns	■ requires enforcement ■ may not be feasible in all areas	■ use of signage and physical barriers ■ public communication	■ high-cost effectiveness ■ low-cost method with significant dust reduction potential	$
On-site Speed Control	■ easy to implement with signage	■ enforcement may require physical speed control devices	■ use of signage and physical barriers ■ monitoring and enforcement	■ low (signage) to moderate (speed bumps, etc.)	$
Soil Treatment (Surface Roughening)	■ increases surface roughness and reduces wind shear ■ stabilizes soil	■ not suitable for all soil types or slopes ■ may require reapplication (temporary effects) ■ inactive areas only	■ orientation of grooves to wind ■ compatibility with site use and soil condition	■ moderate; effective when combined with other methods	$
Vegetative Cover	■ long term ■ improves soil health ■ creates habitat	■ takes time to establish ■ seasonal effectiveness varies	■ use of native species ■ site preparation ■ maintenance (irrigation)	■ high-cost effectiveness ■ long-term solution with ecological benefits	$
Mulching	■ reduces soil loss and dust generation ■ improves soil moisture retention	■ may require anchoring ■ requires reapplication ■ effectiveness varies with material	■ material type and application rate ■ site slope and exposure	■ moderate cost ■ highly effective for short-term and permanent stabilization	$$
Watering	■ immediate effect ■ easy to implement	■ short-lived effect ■ water availability issues ■ not viable in drought	■ frequency and volume of application ■ water availability	■ low to moderate; might be effective short-term ■ requires frequent application (high cost if frequent)	$$-$$
Liquid Manure Application (Agricultural Land)	■ uses a waste product	■ May cause additional odour ■ Limited to agricultural land	■ Regulatory alignment (Agricultural Operation Practices Act, Standards and Administration Regulation)	■ high-cost effectiveness	$$-$$

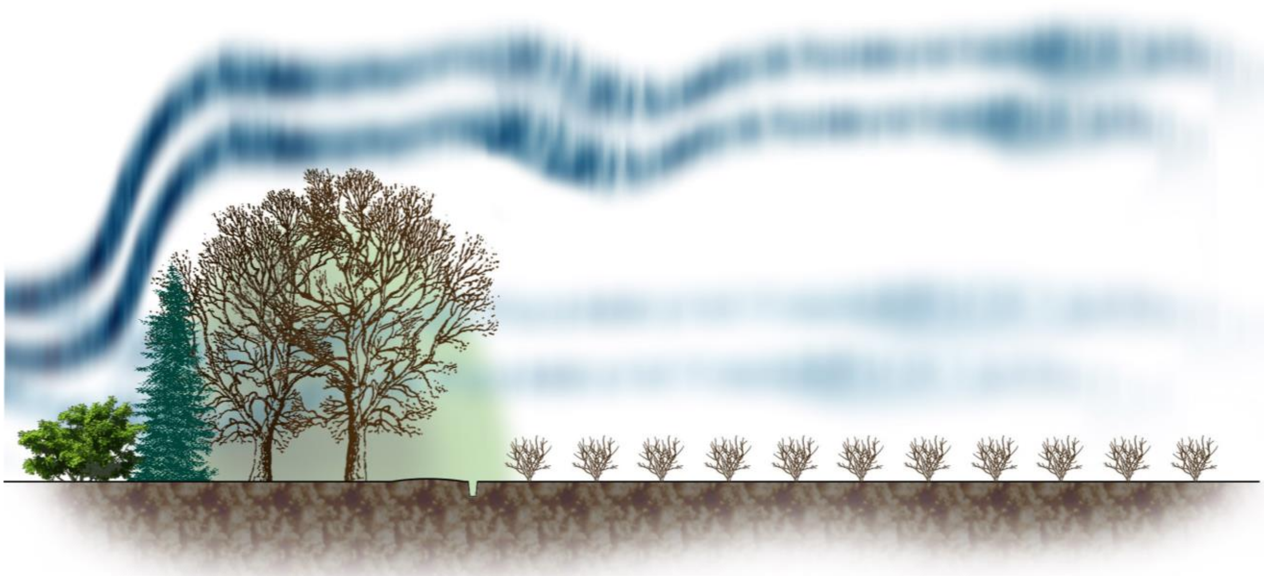
Regardless of its type, windbreaks may offer effective protection at downwind distances to 10 times their height (**Figure 6**). Barriers have no measurable influence on airflow starting at distances of 30 times their height. There is also some protection on the upwind side, up to a distance equal to a barrier height. On the upwind side, the protection effect ceases to be observed at approximately 4 times the barrier height.



Source: Picture from Principles of Wind Erosion and its Control (Presley & Tatarko, 2009)

Figure 6: A Windbreak and the Protected Distance behind it

Vegetative shelterbelts work the best when containing a mixture of trees and shrubs (**Figure 7**). If cost allows, a hybrid structure consisting of vegetative and non-vegetative barriers might offer the optimal results regardless of the weather conditions.



Source: Picture by Gmihail, from WikiMedia Commons, CC-BY-SA-3.0-RS licence.

Figure 7: Preferred Composition of a Shelterbelt Containing a Mixture of Trees and Shrubs

Due to significant differences in their time to deployment and the cost of deployment, vegetative barriers tend to be preferred for wind erosion control across large areas of agricultural land. Non-vegetative barriers are more often adopted in construction, industrial and infrastructure protection. All types of barriers require continuous maintenance which might include a need to remove accumulated dust. If prevailing winds are the same in wintertime, both vegetative and non-vegetative barriers may also function as snow fences.

6.3.3.2 Fencing

Wind and dust fences are engineered barriers designed to mitigate the dispersion of airborne dust by modifying wind flow. Their operation centres on two complementary mechanisms: reducing wind velocity and capturing particles.

6.3.3.2.1 Wind Fences

Wind fences are typically constructed from porous or semi-porous materials. Their design allows a portion of the wind to pass through while simultaneously slowing down the oncoming air. By reducing wind velocity, these fences lower the kinetic energy available to lift and transport dust particles and enhance the rate of dust deposition. For instance, specialized systems can be engineered to reduce wind speeds by up to 75-85% over open areas (BC Ministry of Agriculture, 2015). **Figure 8** is an example of a wind fence.

Source: Picture by Dust Solutions Inc., from Dust control handbook for industrial minerals mining and processing. Second edition. (NIOSH, 2019)

Figure 8: An Industrial Wind Fence

6.3.3.2.2 Dust Fences

Dust fences use dense mesh or similar barrier materials to physically intercept windborne dust. They are often installed near sources of dust, such as construction sites or vehicular thoroughfares, to capture particulates before they disperse into the broader environment. Unlike wind fences, which modify airflow across a larger area, typical dust fences act as a localized filter, capturing dust and requiring periodic cleaning or material replacement to maintain their efficiency.

In heavy-industry settings – such as mining operations or mineral processing facilities – wind fences may be deployed along large stockpiles. High-performance wind fences with engineered porosity may be preferred because they provide extensive coverage and require less frequent maintenance (**Table 10**).

Table 10: Effectiveness and Cost Comparison of Wind and Dust Fences[1,2,3]

Feature	Wind Fences	Dust Fences
Effectiveness	Reduces wind speed by up to 85%	Captures airborne dust
Best Use	Large industrial sites, stockpiles	Urban areas, construction zones
Cost	Higher initial investment due to materials and installation	Lower cost but requires maintenance
Maintenance	Minimal upkeep required	Regular cleaning and replacement needed

Notes: 1. WeatherSolve. Dust Suppressants and Control Solutions for Industry and Environmental Protection. Retrieved from https://www.weathersolve.com/en-au/case-studies/dust-suppressants-and-control-solutions-for-industry-and-environmental-protection/
2. Wet Earth. Wind Fences, Wet Earth Dust Control Products & Systems. Retrieved from https://www.wetearth.com.au/wind-fence-dust-control.
3. Airtight. WIND FENCE DUSTTAMER® SYSTEMS. Retrieved from https://airtight.com.au/product/wind-fence-dusttamer-systems/

Industrial plants, particularly those handling powders or granular materials, may combine both wind and dust fences to manage fugitive dust emissions. Urban settings present different challenges. Dust fences along construction sites and busy roads may work to protect nearby residential areas from fugitive dust. These structures are usually less robust than industrial systems but are designed with aesthetics and ease of maintenance in mind. They may offer targeted dust capture, ensuring that the localized accumulation of dust is minimized, though they often require more frequent cleaning and replacement.

In cities in Europe and Canada, wind fences have been incorporated into urban planning (Blocken & Carmeliet, 2004), (Hörteborn, Zboinska, Chernoray, & Ander, 2023) to create sheltered, low-dust environments in parks and transit zones.

6.3.4 Graveling

According to the WRAP Fugitive Dust Handbook (WRAP – Western Regional Air Partnership, 2006) and supporting technical guides, graveling (adding surface aggregate) is a common mitigative measure for controlling dust by reducing the availability of "silt" or fine particles that become airborne. The benefits of using gravel for dust control include:

- Source Reduction: Covering high-silt surfaces with large aggregates or lower-silt materials like gravel effectively reduces the amount of fine material available to be tracked out or entrained by wind and traffic.
- Structural Stabilization: Quality gravel helps lock coarser materials in place, maintaining the road's shape (crown) and improving drainage, which indirectly prevents the formation of dust-producing hazards like potholes and rutting.
- Economic Preservation: Retaining aggregate on the road surface prevents the loss of "fines" – the binding material – which can otherwise be lost at a rate of up to one ton of aggregate per mile for every vehicle that passes daily.
- Emission Reduction: When applied as part of a surface treatment or combined with chemical suppressants, graveling can contribute to reducing particulate emissions by 30% to 80%.

The limitations of gravel for controlling dust may include:

- Moderate Efficiency: On its own, the use of gravel is considered less effective than more permanent solutions like paving

- Requirement for Maintenance: Gravel is not a one-time fix; it requires repeated additions and regular maintenance (grading and shaping) to remain effective
- Dependency on Binder: Applying gravel without a proper binder often leads to poor performance, as the material can be easily scattered by vehicles or washed away by rain
- Traffic and Speed Impact: The effectiveness of a gravel surface is significantly compromised by high vehicle speeds and heavy weights, which continue to pulverize road materials into new dust
- Cost-Effectiveness Decay: The cost-effectiveness of adding gravel as a mitigative control drops significantly as the total surface area to be treated increases.

Several US jurisdictions provide guidance on the use of gravel in dust control. The City of Fort Collins notes: "install gravel or similar materials with sufficient depth to reduce dust" (Fort Collins, 2016). The Arizona Department of Environmental Quality in *Fugitive Dust Emissions from Nonresidential Construction* (ADEQ R18-2-D1302, 2025) mandates: "Apply and maintain clean gravel to a depth of two inches", where "Clean gravel means a mineral or rock aggregate ranging in size from 0.25 to 3 inches on its longest dimension that is either natural or the product of a mineral processing operation and contains no more than 6% silt by weight."

Dust Control Handbook for Industrial Minerals Mining and Processing[11] from NIOSH (NIOSH, 2012) contains the following procedure "Another method for reducing wind erosion is the use of gravel blankets. The use of fine (0.02- to 0.25-inch), medium (0.1- to 0.5-inch), and coarse gravel (0.25- to 1.5-inch) applied at 20, 50, and 100 tons per acre, respectively, results in insignificant amounts of wind erosion (<25 pounds per acre). The smaller the diameter of the gravel, the smaller the amount of gravel required to prevent wind erosion. However, this only applies to a diameter down to 2 mm. Once the gravel diameter is less than 2 mm, wind erosion will increase, as particles <2 mm in the gravel will make the surface more erodible".

6.3.5 Paving

Only some considerations in **Section 6.1.6** are applicable here, given the potentially larger areas considered to be influenced by wind erosion.

There are many "off road" areas that may benefit from paving. Some examples are railway yards, parking lots, warehouses, bus terminals, truck stops, construction sites, access roads, and material handling areas.

However, due to the high cost of paving, dust control is not likely to be the primary decision factor. For example, city parking lots and bus terminals could be paved for reduced maintenance, aesthetics, or convenience.

6.3.6 Restricting Vehicular Access

Open areas with exposed soil, not designated for travel (not roads), maybe marked as no traffic areas, or traffic should be discouraged. Preferably actively discouraged by means of barriers or other means that would make the area unpassable.

6.3.7 Soil Treatment

Creating a rough surface is a technique that can be used on coarse-textured soils. It should be used only as an additional control. Replacing a bare flat area, a rough surface may help reduce dust emissions by minimizing wind shear at the soil surface. Grooves, depressions, ridges or furrows should be created perpendicular to the predominant wind direction using discing, ripping, tilling or other methods like simple tracking with machinery

11. The second edition of the handbook (NIOSH, 2019) does not include quoted information. It refers to the first edition.

equipped with tracks. It is the same technique as creating grooves, depressions, ridges or furrows perpendicular to water flow on slopes.

In areas without traffic or with only very light traffic, chemical or organic stabilizers may be used to create a soil crust thus eliminating erosion, as described in the section about construction.

6.3.8 Vegetative Cover

In the areas of a construction site not subject to vehicle traffic or ground disturbance, vegetative cover[12] may help with binding soil together and reduces wind velocity at the ground surface. Potential for dust to become airborne can be reduced.

Planted seedlings and sown seeds should be the same varieties as the local vegetation, so called native plant and seeds. That way there is a higher possibility that they may adapt to the local climate and have a chance to endure.

Sometimes, a quick establishment is required only for a short term (such plants or seeds are termed agronomic). Early succession species that can quickly establish to provide stability, erosion cover, and reduce the potential for weeds and invasive species are an important consideration when selecting a seed mix for vegetative cover. The following table, from Alberta Transportation *Erosion and Sediment Control Manual* (Alberta Transportation, 2011) illustrates the difference between native and early succession cover. **Table 11** covers Zone 4, which includes Hanna District and those parts of Lethbridge District and Calgary District east of Highway 22. At the time of writing, Alberta Transportation and Economic Corridors is in the process of updating the seed mixes; **Table 11** content may change.

Some vegetative covers provide protection also during the winter. However, the results depend on chosen varieties, plant maturity, soil and local climate conditions.

Table 11: Zone 4 Native and Agronomic Seeds

Seed Mix Zone	Native Seed Mix - Zone 4		% by Dry Weight
	Common Name	Latin Name	
4 Mixedgrass and Dry Mixedgrass	Slender Wheat Grass	*Agropyron trachycaulum*	30%
	Canada Wildrye	*Elymus canadensis*	15%
	Mountain Brome	*Bromus carinatus*	15%
	Northern Wheat Grass	*Agropyron dasystachyum*	10%
	Western Wheat Grass	*Agropyron smithii*	5%
	Indian Rice Grass	Orzyopsis hymenoides	5%
	Alkali Grass	Puccinellia distans	10%
	Needle and Thread Grass	Stipa comata	10%

Agronomic Seed Mix - Zone 4		
Common Name	Latin Name	% by Dry Weight
Pubescent Wheat Grass	*Agropyron trichophorum*	32%
Dahurian Wildrye	*Elymus dahuricus*	30%
Sheep Fescue	*Festuca ovina*	30%
Cereal Rye	*Secale cereale*	8%

12. Any plant introduction must be done in accordance with the Weed Control Act of Alberta.

6.3.9 Mulching

This section compares soil loss reduction for bare soil to vegetation, to mulching and to other methods. It is included only as an illustration of relative effectiveness, since actual results depend on terrain, soil and climate (rainfall, etc.). All approaches may produce substantial reductions in soil loss and therefore dust generation.

Table 12 was adapted from *Cover Management Factors for Construction Sites*[13] in *Understanding Erosion with the Revised Universal Soil Loss Equation* by Northwest California Resource Conservation and Development District (NCRCD, 2016).

Table 12: Reduction in Soil Loss by Vegetative Cover

		Reduction of Soil Loss
Vegetative Cover	None (fallow ground)	0%
	Native vegetation (undisturbed)	99%
	Temporary ryegrass, 90% (perennial)	95%
	Temporary ryegrass, 90% (annuals)	90%
	Permanent seedings (90%)	99%
	Sod (laid immediately)	99%
Mulch	Hay (0.5 tons/acre)	75%
	Hay (1.0 tons/acre)	87%
	Hay (1.5 tons/acre)	93%
	Hay (2.0 tons/acre)	98%
	Wood chips (6 tons/acre)	94%
	Wood cellulose (1.75 tons per acre)	90%
Other	Competent gravel layer	95%

6.3.10 Watering

Depending on water availability, use regular application of water (possibly with surfactants) to keep soil moist such that fine particles agglomerate and are too dense to become airborne fugitive dust. This control method also captures fugitive dust generated by site activities.

As mentioned earlier, light frequent watering is better than less frequent, heavy watering. Care must be taken to avoid overwatering as it may cause erosion. For example, clay might float to the surface. A danger of surface damage due to water over-penetration is especially present in large flat areas that might not have adequate drainage.

6.4 Paved Roads

6.4.1 Overview

Dust loadings on a paved road surface may build up by being tracked out from unpaved areas such as construction sites, unpaved roads, parking lots and shoulders; by spills from trucks carrying dirt and other particulate materials; by transport of dirt collected on vehicle undercarriages; by wear of vehicle components such as tires, brakes, clutches and exhaust system components; by wear of the pavement surface; by deposition of suspended particles from many emissions sources; and by water and wind erosion from adjacent areas. (Watson & Chow, 2008).

13. *The values of cover management factor (**C factor** column) were omitted. They are equal to 1 – reduction of soil loss and are only needed when using the Revised Universal Soil Loss Equation. Also, fabric on slopes was not included, since the results were not numerical, just described as "variable".*

Mitigation options for paved roads are summarized in **Table 13** with further details in following sections.

Table 13: Summary of Benefits and Limitations of Paved Road Mitigation Options

Method	Benefits	Limitations	Key Considerations	Cost-Effectiveness	Relative Cost
Paving Shoulders	■ reduces dust generation from vehicle movement near road edges ■ reduces windblown dust generation	■ may be costly to implement ■ not always feasible depending on terrain and budget	■ traffic safety ■ dust generation from unpaved shoulders even when vehicles stay on paved road	■ moderate to high	$$-$$$
Speed Control	■ reduces resuspension of road dust and wear-based particulate emissions. ■ immediate dust reduction	■ requires enforcement ■ may not be effective without compliance	■ Target speeds below 80 km/h ■ especially important for roads with unpaved shoulders	■ low (signage) to moderate (enforcement systems)	$-$$
Road Sweeping / Vacuuming	■ removes debris as well as dust	■ effectiveness depends on technology used ■ may generate dust if not properly equipped	■ use PM_{10}-efficient sweepers; water or vacuum systems required; avoid dry sweeping	■ moderate to high (equipment and operation)	$$-$$$
Trackout-control Devices	■ Prevents mud and dust from being carried onto paved roads from construction sites. ■ Reduced need for sweeping or watering	■ requires space and maintenance ■ may not be feasible at all access points	■ use gravel pads, grizzlies, or paved exits ■ follow Alberta Transportation guidelines	■ moderate	$$
Watering	■ very simple & inexpensive technology ■ immediate dust drop; ■ easy to adjust volume & frequency	■ water runoff must be controlled to avoid environmental impact ■ short-lived effect ■ authorization may be required for water use ■ authorization may be required if using potable water sources	■ prevent water from entering storm drains or waterways ■ proximity to water source ■ cost of water	■ low to moderate	$-$$

6.4.2 Unpaved Shoulders

Shoulders of a paved road may be designed to be paved due to traffic safety considerations. If they are not, **Section 6.1.10** on unpaved shoulders noted that even when vehicles stay on the paved road, considerable dust could be generated. Thus, depending on traffic and budget, paving shoulders may be reconsidered.

Controlling dust on the unpaved shoulders of paved roads provides significant safety, maintenance, and environmental benefits by binding fine particles ("fines") that would otherwise blow away or migrate, causing road edge deterioration. While effective, it requires ongoing investment and proper product selection to avoid environmental contamination or vehicle damage.

The benefits of dust control include (FCM, 2005), (Nunavut, 2014):

- Improved Safety and Visibility: Dust clouds from shoulders often reduce visibility for drivers, particularly when vehicles pull over or drift. Controlling this dust significantly increases driving visibility.
- Reduced Maintenance Costs: The fine particles on a shoulder act as a binding agent. Retaining them prevents the loss of aggregate and reduces the frequency of expensive repairs like grading, pothole filling, and re-graveling.
- Preventing Edge Drop-off: Uncontrolled dust leads to the erosion of the shoulder, creating a dangerous drop-off between the paved road and the gravel shoulder. Dust suppression keeps the shoulder stable and level with the pavement.
- Extended Road Life: By stabilizing the gravel and preventing fines from leaving the shoulder, the overall integrity of the road structure is maintained, reducing long-term rehabilitation costs.
- Environmental and Health Protection: Reduces the amount of airborne dust that causes respiratory issues in nearby communities and prevents damage to surrounding vegetation and water bodies from sedimentation.

The limitations of attempting dust control on unpaved shoulders include (FCM, 2005), (Nunavut, 2014):

- Recurring Costs and Labour: Dust control is rarely a one-time fix; it is a maintenance activity that requires reapplication (often annually or seasonally) to remain effective.
- Product Selection and Environmental Concerns: Some products, such as chloride salts (calcium/magnesium chloride), can be corrosive to vehicles and, if misapplied, can run off into water bodies or affect soil vegetation.
- Weather Dependency: Extreme heat can cause rapid moisture loss, reducing the effectiveness of hygroscopic products (like salts). Conversely, heavy rainfall immediately after application can wash the product away.
- Application Constraints: For maximum effectiveness, traffic must be restricted for one to two hours after application. It should not be applied to areas prone to flooding, which can cause chemical contamination.
- Maintenance Challenges: Some binders (e.g., petroleum resins) form a hard, sealed crust that is difficult to reshape with conventional grading equipment once it fails or forms potholes.

6.4.3 Speed Control

The U.S. Environmental Protection Agency (EPA) notes that one of the most critical factors influencing the resuspension of road dust is the mean speed of vehicles traveling on the pavement. Controlling dust through speed reduction – primarily for vehicles on unpaved roads and machinery operation – is a highly effective, low-cost preventive method. It focuses on reducing the initial generation of dust rather than capturing it afterward.

Among the benefits of this approach are:

- High Effectiveness: Reducing vehicle speed is one of the most effective ways to reduce dust emissions. Lowering vehicle speeds from 60 km/h to 30 km/h can reduce dust emissions by as much as 65% (Nunavut, 2014).
- Low Cost and Simple Implementation: This method requires only speed limit signs, enforcement, and driver awareness.

Some limitations of the use of speed control for dust management are (Nunavut, 2014):

- Operational Inefficiency: Slowing down vehicles and machines directly impacts production speeds, increasing travel time on work sites and potentially reducing overall operational efficiency.
- Enforcement Challenges: Ensuring compliance with lower speed limits can be challenging, requiring constant monitoring or traffic management to be effective.
- Does Not Eliminate Dust: Speed reduction is a mitigation strategy that reduces dust generation, but it does not eliminate it. In very dry conditions, even slow vehicles can still create significant dust.
- Not a Complete Solution: It is often not sufficient on its own and usually needs to be combined with other methods, such as watering or chemical suppressants, to achieve significant dust reduction in high-traffic or very dry areas.

With respect to the science behind the effectiveness of speed reduction, empirical evidence indicates that at lower speeds, the balance between dust deposition and removal shifts so that the resuspension rate is notably diminished (*AP-42: Chapter 13. Section 13.2.1 Paved Roads* (U.S. EPA AP-42, 2025)). Furthermore, on-board particle sensors used in roadway studies have recorded lower PM_{10} emission factors when speeds were reduced. This supports the idea that speed control may be an effective mitigation strategy – not only by reducing the direct aerodynamic lifting of road dust but also by lessening friction-based wear (from, for example, tire and brake interactions) that could otherwise contribute to particulate generation (Fitz & Bufalino, 2002).

This information is supported by a California study *Particulate Emission Rates for Unpaved Shoulders along a Paved Road* (Moosmüller, et al., 1998) which concluded that dust emissions on paved roads from unpaved shoulders mostly come from large size vehicles or vehicles with poor aerodynamics traveling at high speeds (greater than 80 km/h). Thus, in cases of paved roads with unpaved shoulders, dust control may support limiting speed on such roads to 80 km/h. Lower speeds may also reduce emissions from the paved surface.

6.4.4 Road Sweeping / Vacuuming

Street sweeping is an effective method for removing dust and debris from paved roads and preventing them from becoming airborne. According to *A review on the effectiveness of street sweeping, washing and dust suppressants as urban PM control methods*, (Amato, Querol, Johansson, Nagl, & Alastuey, 2010) about a 30% reduction in emissions can be achieved, and even more than 50%, when using the newest technology.

Other benefits are, by removing pollutants, such as oil, heavy metals from brake and tire wear, and general trash, sweeping prevents them from being washed into storm drains and local waterways during rain events, protecting ecosystems and water supplies. Sweepers remove hazardous materials like broken glass, nails, and loose gravel, which reduces the risk of tire punctures, skidding, and accidents for pedestrians, cyclists, and motorists. In addition, removing abrasive grit and sediment extends the lifespan of road surfaces and drainage systems, preventing issues like clogged drains, potholes, and erosion, which in turn lowers long-term maintenance and repair costs for municipalities and private operators.

Limitations are that older mechanical broom sweepers are less effective at capturing fine particles than newer regenerative air and vacuum-assisted models. The direct positive impact on ambient air quality (reduction of PM levels) can be short-lived, sometimes lasting only a few hours, as traffic quickly resuspends remaining particles or brings new ones to the surface. Sweeping efficiency is highly dependent on various factors, including the frequency and timing of cleaning, traffic volume, road surface quality (cracks and uneven sections can trap dust), and weather conditions.

A set of minimum requirements for a PM_{10}-efficient street sweeper was developed by South Coast Air Quality Management District in the early 2000s.

- Rule 1186. PM_{10} Emissions from Paved and Unpaved Roads, and Livestock Operations (SCAQMD, 2008)
- Rule 1186.1. Less-Polluting Sweepers (SCAQMD, 2009)

In 2003, the City of Toronto started a *Clean Roads to Clean Air Program* and subsequently has developed its own standard of road tests that evaluates effectiveness of both removing dust from streets and reducing the amount of airborne dust generated by the sweeping process itself. The tests are publicly available (Toronto, 2016):

- PM_{10} and $PM_{2.5}$ Street Sweeper Efficiency Test Protocol
- Operational On-Street Test Protocol

The City of Fort Collins (Fort Collins, 2016) prohibits mechanical sweeping for the removal of dust or other debris without the use of water, vacuum system with filtration or other equivalent dust control method. There is a provision to exclude from the above requirement sweeping that occurs between lifts[14] of asphalt paving operations or due to preparation for pavement markings.

6.4.5 Trackout-control Devices at Egress Points

Trackout (track-out, track out and carry-out or carryout) means materials or contaminants being carried out of the site onto the road (MCAQD Rule 310, 2010). Typical trackout-control devices may include:

- A Gravel Pad is a stabilized construction entrance, designed to remove the mud and dirt from the tires of vehicles leaving a construction or industrial site. Using gravel pads reduces fugitive dust caused by trackout onto paved roads and surfaces. The use of such pads may also reduce the need to remove trackout from paved surfaces, as well as help prevent stormwater pollution.
- A Grizzly is a device using rails, pipes or grates to dislodge mud, dirt and debris from the tires and undercarriage of vehicles prior to leaving the work site.
- Paving of at least 20 metres (100 feet), at a width of at least 6 metres (20 feet) may also be a trackout-control device.

Alberta Transportation *Erosion and Sediment Control Manual*[15] (Alberta Transportation, 2011) specifies that a gravel pad should be located at stabilized worksite entrances of construction sites, and as such is a temporary measure. The requirements for a gravel pad are:

- minimum of 15 m in length
- width should be sufficient to accommodate the widest anticipated vehicle (minimum of 3.6 m in width)
- thickness should be a minimum of 30 cm and should comprise 5 to 10 cm diameter coarse aggregate placed on top of woven geotextile filter fabric
- there should be sediment control measures to collect washed off sediment from gravel pad.

Other recommendations are (Alberta Transportation, 2011):

- If impractical to construct at all access points, limit vehicle access traffic to entrances with the control
- Entrances located with steep grades should be avoided
- Granular material should be added or regraded when required.

14. Lift is a layer of pavement placed by the asphalt paver.
15. Many best practices that prevent erosion and runoff have an added – but not stated – benefit of dust control.

6.4.6 Watering

Water used for dust control can be prevented from entering any storm drainage or waterway. Means of doing so include the use of water sprays or mist to create a surface crust, thereby reducing run-off. Other measures to contain the runoff include (MOECC, 2017):

- Storm Drain Protection: Use storm drain inserts, filter socks, or catch basin covers to catch sediment, debris, and oil before runoff enters the drain.
- Silt Fences & Barriers: Install fiber rolls, silt fences, or sandbags around catch basins to prevent contaminated runoff from entering the system.
- Berms: Install berms or dikes to direct water away from drains and towards infiltration areas.
- On-Site Retention: Create temporary berms, ditches, or basins to allow water to settle on-site rather than entering storm systems.

Other aspects related to water use have been discussed in previous sections.

6.5 Material Handling

Except where additional references were added, the following sections provide a high-level overview of the mitigation of dust from material handling. Materials that might produce dust include the following: mined materials, salt, aggregates, essentially any fraction of soil (starting with clay), oversize rock, fertilizers, pesticides etc. The same rules apply to compost, grain, manure and waste; however, they are outside the scope of this guide. Presented mitigation measures are based on the following references:

- National Institute for Occupational Safety and Health (NIOSH) *Best Practices for Dust Control in Coal Mining* (NIOSH, 2021)
- NIOSH *Dust Control Handbook for Industrial Minerals Mining and Processing. Second edition* (NIOSH, 2019)
- South Coast Air Quality Management District *Rule 403. Fugitive Dust* (SCAQMD, 2005)
- Maricopa County Air Quality Department, Compliance and Enforcement Division *Rule 316 Handbook. Nonmetallic Mineral Processing and Related* Operations (MCAQD, 2024)

The first two of the above manuals contain in-depth coverage of the topic. The last two contain regulations from entities respectively in Southern California and Arizona that are widely patterned in other places with arid or semi-arid climates.

Material handling can apply to agricultural materials including manure (The Agricultural Operation Practices Act (AOPA), 2025).

- Confined feeding operations (feedlots, etc.) need a permit to exist but every person in Alberta that manages manure must follow the manure components of AOPA.
- A feedlot pen or barn has a permitted liner to protect water quality from the manure and when manure is removed it needs to be either stored in another location that has a permitted liner, moved to a short-term storage location, or land applied.

Mitigation options for material handling activities are summarized in **Table 14** with further details in following sections.

Table 14: Summary of Benefits and Limitations of Material Handling Mitigation Options

Method	Benefits	Limitations	Key Considerations	Cost-Effectiveness	Relative Cost
Stopping Activities in Strong Winds	■ mitigation obvious to public ■ supports worker and public safety	■ requires commitment to decision making based on wind ■ operations disruption and schedule impact	■ define local thresholds for high winds ■ integrate into operational planning	■ very cost-effective – simple operational change with minimal direct cost	$
Changing Hauling Operations	■ May improve road safety and material containment ■ long lasting with chemical application to roads	■ requires infrastructure and vehicle modifications ■ frequent reapplication to haul roads ■ chemicals may have environmental impacts	■ upfront planning costs but potential long-term savings e.g., through optimized routeing ■ traffic volume, climate, and soil type ■ use covered trucks, maintain freeboard, design roads for load type	■ low (tarping) to moderate (gravel application) to high (chemical application to haul road)	$-$$$
Loading and Unloading Improvements	■ generally low capital cost ■ minimal water use (misting, dry fog system)	■ equipment upgrades and operator training ■ higher initial cost ■ best in enclosed areas	■ material stability ■ drop height ■ water availability ■ moisture sensitivity ■ enclosure feasibility	■ high: low-cost interventions with significant dust reduction	$
Grading and Landscaping	■ May support site stabilization ■ quick application ■ polymers may offer longer-term control	■ water use and timing critical ■ may delay construction ■ may require repeated application	■ Soil composition ■ weather conditions ■ environmental regulations	■ water: low; polymers: moderate to high	$-$$$
Frequent Manure Removal	■ May improve air quality ■ May reduce odour ■ provides a compost source	■ requires regular maintenance and monitoring ■ labour intensive ■ requires equipment ■ watering may increase odour	■ livestock density ■ moisture control ■ pathogen management ■ runoff prevention	■ moderate – simple practices with measurable benefits	$
Storage Pile Management	■ Controls dust from stockpiles using geometry, covers, and treatments.	■ may require space, materials ■ sealants may degrade with time ■ runoff control	■ available space for pile geometry, windbreaks ■ storage pile materials ■ weather conditions ■ environmental issues	■ moderate – effective when integrated but may involve capital costs	$-$$
Wet Suppression and Prevention	■ simple and effective ■ adaptable to many processes	■ water supply and droplet control critical ■ runoff management – avoid over wetting ■ may affect material ■	■ droplet size and nozzle placement ■ water availability ■ material sensitivity ■ reapplication frequency	■ moderate – effective but requires ongoing water use and maintenance	$$
Drilling and Blasting Improvements	■ May reduces dust at source ■ May improves safety	■ water use may affect safety ■ equipment cost and wear ■ may affect blast efficiency	■ blast design ■ material type ■ regulatory compliance	■ moderate – effective but operationally complex	$$-$$$

6.5.1 Work Practices and Equipment

Many of the best practices and many regulations require stopping or curtailing operations in high wind conditions. High wind definitions could be very local. For example, *Rule 403.1. Supplemental fugitive dust control requirements for Coachella Valley sources* (SCAQMD, 2004) defines high wind conditions as sustained winds of 25 mph (40 km/h) or greater, or wind gusts of 35 mph (56 km/h) or more. In reviewing the guidelines, there appear to be no relationship to wind direction since the prevailing objective is to minimize fugitive dust.

6.5.1.1 Hauling

Consideration should be given to processes already described previously about procedures on unpaved and paved roads (**Sections 6.1** and **6.4**). Additionally:

- Consider road design that minimizes possible spills. For efficiency, there could be separate roads for light traffic and empty trucks, while loaded trucks travel at lower speeds on roads with gentler slopes and designed to withstand heavier loads.
- Consider covering open-bodied trucks when the truck is carrying materials that could become airborne. That applies both to loaded and empty trucks. Attention must be paid that there is no spillage through holes or seams of the cover. It is suggested that the load must leave at least 7.5 cm (3 inches) of freeboard.

Additional considerations for hauling or transport activities include

- Use tarps or other suitable enclosures on haul trucks
- Check belly dump truck seals regularly and remove any trapped rocks to prevent spillage
- Follow any trackout prevention/mitigation requirements
- Use covers at conveyors' transfer point(s).

For uncovered haul trucks:

- If the bed of an emptied truck was washed upon unloading, it may not need to be covered.
- It is suggested that within a facility, a tarp may not be required if the bulk material is sprayed with water or the trucks travel at such low speeds that there is minimal dust coming from the load.

6.5.1.2 Loading and Unloading

Control measures for these activities may include:

- Stabilize material while loading to minimize fugitive dust emissions
- Maintain appropriate freeboard on haul vehicles
- Stabilize material while transporting to limit fugitive dust emissions
- Stabilize material while unloading to minimize fugitive dust emissions
- Secure loads to prevent shifting or spilling. Vehicles carrying aggregate materials (like sand, gravel, or rocks) may consider covering with tarps or similar devices depending on the freeboard
- Minimize the drop height into transport vehicles or onto conveyors
- Provide water while loading and unloading to minimize visible dust plumes (e.g., deploy misting where dust is generated)
- Plan activities with consideration of high winds and nearby receptors.

6.5.1.3 Grading and Landscaping

Examples of control measures include:

- Pre-apply water to depth of proposed cuts
- Reapply water as necessary to maintain soils in a damp condition and
- Stabilize soils once earth moving activities are complete.

Additional guidance to consider:

- Grade each project phase separately, timed to coincide with construction phase
- Upwind fencing may prevent material movement on site
- Apply water or a stabilizing agent in sufficient quantities to prevent the generation of visible dust plumes.

6.5.2 Feedlot Activity

Feedlot pen dust is the result of pen manure being broken down into fine powder that becomes disturbed and elevated into the air above the feedlot. The most effective method to minimize dust emissions is to remove excess manure from the pen, plus monitor and remove any loose, un-compacted materials that accumulate over the summer. Secondary management practices to further minimize dust emissions include applying water to the pen surface and increasing the pen stocking density (Ministry of Agriculture and Forestry, 2020). Additional Alberta specific, information can be found in the report *A Review of Beneficial Management Practices for Managing Undesirable Air Emissions from Confined Feeding Operations* (Alberta, 2011) and a note *Feedlot pen floor design, management and production implications* (Behlke, 2024).

6.5.3 Storage Piles

Storage pile considerations presented below may apply to overburden stockpiles, construction material stockpiles and other material stockpiles. International best practices draw from scientific research and case studies from North America, Europe, and other regions. These practices address fugitive dust by combining engineering controls, chemical treatments, operational adjustments, and sometimes biological methods, usually based on US EPA guidance. Below is an overview of key control types along with a detailed discussion and a summary table highlighting their potential benefits and limitations.

Adjusting operational practices – such as optimizing pile geometry, segregating material types, scheduling material handling during lower wind conditions, or scheduling materials to site immediately before use, or reducing pile heights – may significantly limit dust generation. These methods may integrate seamlessly into routine operations and are cost-effective, although their impact on dust reduction may be less immediately noticeable than active suppression measures (MOECC, 2017), (Cheminfo, 2005).

The geometry of stockpiles – such as shape, height, and orientation – may have a significant impact on dust emissions, especially in open storage or bulk material handling environments. Conical piles tend to have higher dust emissions due to steeper slopes and more exposed surface area to wind. Trapezoidal or elongated piles may reduce wind acceleration over the surface, thereby lowering dust lift-off. Flatter slopes may reduce the wind shear stress on the surface, which is a major driver of dust emissions (Ma, et al., 2022). In addition, taller piles may create stronger wind eddies and turbulence, increasing the potential for dust to be lifted and dispersed. Larger volumes may mean more surface area exposed to wind, especially if the pile is not compacted or covered. Piles aligned perpendicular to prevailing winds may experience higher wind erosion and dust emissions, so aligning piles parallel to wind direction may reduce the wind's impact on the surface and lower emissions (Ma, et al., 2022). Weathered or crusted surfaces (from moisture or chemical treatment) may significantly reduce dust emissions by binding fine particles. Freshly disturbed piles (e.g., after loading/unloading) may be more prone to dust generation (*AP-42: Section 13.2.4 Aggregate Handling and Storage Piles* (U.S. EPA AP-42, 2025)). Finally, complex pile geometries may create turbulent wake zones, which may either trap dust or enhance dispersion depending on the wind speed and direction. Computational Fluid Dynamics models show that wind speed and turbulence intensity around piles are critical in determining dust lift-off and transport (Ma, et al., 2022).

Water spraying is one of the most used methods worldwide. By frequently applying water to the material surface, dust particles are agglomerated and less likely to become airborne. However, the approach is sensitive to wind and high temperatures, and it demands a continual water supply, which can be challenging in arid regions or during water restrictions (U.S. EPA, 2022). Watering may also result in material leaching into the soil.

Chemicals such as lignosulfonates, magnesium chloride, and various polymers may provide longer-lasting dust suppression compared to water alone. These agents help bind fine particles, reducing dust liberation even under adverse climatic conditions. International practices employ these methods for their durability. Chemical suppressants might have environmental side effects, require careful handling, and sometimes add to operational costs (see discussion in **Section 6.1.5**).

Physical barriers may include wind fences and windbreaks, enclosures, or simply covering the pile with tarpaulins or netting (Cheminfo, 2005). These solutions work by reducing wind speed at the dust source, thereby mitigating the dispersion of particulate matter. While effective in maintaining consistent dust control, such systems are often expensive to install and maintain and may be less adaptable to changing operational needs and varying pile geometries (MOECC, 2017).

In some cases, promoting vegetation around or on the storage piles may provide a natural, long-term dust control mechanism. Once established, plant cover may stabilize the soil, reducing the potential for dust release. However, this approach requires a longer-term perspective and may be heavily dependent on local climate and soil conditions; it might not offer a rapid solution for dust issues in Alberta. Approaches listed in **Section 6.3** – including hydroseeding, seeding with either topsoiling or hydromulching, live staking or sodding – may expedite establishment.

Other techniques to potentially reduce emissions from in-use stockpiles include minimizing material drop heights, curtailing activities in high winds, and progressive reclamation. Mitigation measures for storage piles are summarized in **Table 15**.

Table 15: Summary of Dust Control Types for Storage Piles

Control Type	Benefits	Limitations
Pile Geometry	■ Easy to implement and cost effective ■ Improve material handling ■ Minimal ongoing maintenance	■ Requires planning ■ May require more land area than available ■ Less effective where wind speed and direction are variable
Water Spraying/ Moisture Control	■ Immediate dust suppression ■ Inexpensive and simple to implement	■ High water consumption ■ Effectiveness decreases in windy or high-temperature conditions ■ Requires frequent application as water evaporates
Chemical Dust Suppressants/ Stabilizers	■ Longer-lasting control compared to water ■ Effective under varying environmental conditions ■ Minimizes operational downtime	■ Potential environmental concerns ■ Higher operational costs ■ Requires proper handling and application monitoring
Physical Barriers (Windbreaks, Enclosures, Covers)	■ Consistent reduction in wind speed and dust dispersal ■ Minimal daily maintenance once installed	■ High initial installation and maintenance costs ■ Not always suitable for dynamic operational environments ■ May require bespoke design solutions

Control Type	Benefits	Limitations
Site Layout and Operational Practices	■ Cost-effective when integrated into routine operations ■ Reduces overall dust generation through strategic planning ■ Minimal extra equipment needed	■ May necessitate significant operational changes ■ Delivers more incremental improvements ■ Dependent on continuous management and monitoring
Vegetative Stabilization	■ Environmentally friendly and sustainable ■ Provides long-term stabilization ■ Can enhance site aesthetics	■ Slow to achieve effective coverage ■ Dependent on local climate and soil conditions ■ Requires ongoing maintenance and may not be viable for immediate dust control needs

The most effective strategy may be often one that integrates several approaches (**Section 5.3** includes a broader discussion of the benefits of multiple approaches). By combining multiple techniques (e.g., adjusting pile geometry, overlaying physical barriers or covers, and using chemical suppressants), this approach may minimize the sources of dust at multiple levels. Integrated approaches can be more complex, requiring more detailed planning, new equipment, and often significant changes to existing operations. The integration of technology or multiple devices can mean higher upfront capital costs.

6.5.4 Wet Suppression and Prevention (Water or Foam)

The following two methods may be used to control dust using wet sprays at mining and mineral processing operations. Depending on the application, one of the methods or a combination of both could be used.

- Airborne dust prevention may be achieved by direct spraying of the material to prevent dust from becoming airborne. The goal is to increase the moisture content, typically while material is being conveyed, to prevent airborne dust generation during a transfer to another conveyor, stockpile or transport vessel or vehicle.
- Airborne dust suppression may involve knocking down dust already airborne by spraying the dust cloud with like-sized droplets at the point of dust generation. This causes the particles to collide, agglomerate, and fall out from the air because of their increased mass. Dust suppression is designed to only wet the airborne dust.

Most wet spray systems use water sprays. However, the general concepts are applicable to systems that use other sprayed liquids, such as surfactant solutions to reduce the surface tension of the liquid droplets, solutions containing anti-freezing agents for applications in cold environments and more viscous liquid solutions that dry to create a film over dust-laden surfaces to prevent dust from becoming airborne.

A comprehensive guide to conveyors and efficient bulk materials handling, *Foundations: The Practical Resource for Cleaner, Safer, More Productive Dust & Material Control. Fourth Edition*, published by Martin Engineering Company (Swinderman, Marti, Goldbeck, Marshall, & Strebel, 2009), offers the following guidelines for dust suppression presented in **Table 16**.

Table 16: Wet Suppression Applications

System Type	Application						
	Transfer Point	Crushers & Mills	Storage Piles	Rail Car Dump Station	Conveyor Trippers	Ship Loading	Ship Unloading
Water spray	×			×			
Water fog	×						
Water + air fog	×			×		×	
Water + surfactant spray	×		×	×	×	×	×
Foam	×	×	×		×	×	

System Type	Application						
	Transfer Point	Crushers & Mills	Storage Piles	Rail Car Dump Station	Conveyor Trippers	Ship Loading	Ship Unloading
Hybrid system dust suppression + passive dust collection	×	×					
Hybrid system dust suppression + active dust collection	×	×		×			×

Notes: Water + surfactant spray and foam a may be best when a residual effect is needed (multiple application points, crushers, long distances between application points, stackers, etc.).
Water spray, water fog and water + air fog may be short-term solutions (until water evaporates) and may be best when a longer-term residual effect is not required.
Some kinds of materials (for example cement) and/or processes may not permit the addition of any chemical.

6.5.4.1 Water Application

When water is used to control dust, it may have a limited-time residual effect due to evaporation and may need to be reapplied at various points throughout the process to remain effective. Overapplication in the amount/volume of moisture may be a problem in all operations and may impact the equipment as well as the total process and transportability.

In most cases, a properly designed suppression spray system using finely atomized water sprays will not exceed 0.1% moisture application. However, in systems that address prevention over larger areas with plain water, larger droplet sprays may add up to 5% moisture to the process (Swinderman, Marti, Goldbeck, Marshall, & Strebel, 2009).

6.5.4.2 Nozzle Location

Due to the unique characteristics of each application, there are no simple rules for specifically locating spray nozzles in dust control applications. However, the following guidelines may contribute to spray system efficiency:

- For wet dust prevention systems, nozzles should be located upstream of the transfer point where dust emissions, in most cases, are being created, with care taken to locate nozzles for the best mixing of material and water.
- Additional nozzles should be located at the transfer points to wet as much of the surface area of the material as possible.
- For airborne dust prevention, the nozzles should be located at an optimum target distance from the material – far enough to provide the coverage required but close enough so that air currents do not carry the droplets away from their intended target.
- Droplet size also needs to be considered when setting the correct target distance.
- Transfer points should be enclosed as much as possible to prevent the dust and water droplets or fog from escaping the transfer points before the agglomeration process is complete.
- For airborne dust suppression, nozzles should be located to provide maximum time for the water droplets to interact with the airborne dust.

6.5.4.3 Controlling Droplet Size

When wetting material to achieve dust prevention, the goal is to wet to the point where dust does not become airborne. In these applications, droplet sizes above 100 µm (preferably 200 to 500 µm) should be used.

In contrast, for airborne dust suppression, where the goal is to knock down existing dust in the air, the water droplets should be in similar size ranges to the dust particles. The intent is to have the droplets collide and attach themselves (agglomerate) to the dust particles, causing them to fall from the air. To achieve this goal, droplets in the range of 2 to 20 μm have been shown to be most effective. If the droplet diameter is much greater than the diameter of the dust particle, the dust particle simply follows the air streamlines around the droplet. If the water droplet is of a size comparable to that of the dust particle, contact occurs as the dust particle follows the streamlines and collides with the droplet. For optimal agglomeration, the particle and water droplet sizes should be roughly equivalent. The probability of impaction also increases as the size of the water spray droplets decreases, because as the size of the droplets decreases, the number of droplets increases.

6.5.4.4 Methods of Atomization

Atomization is the process of generating droplets by forcing liquid through a nozzle, which is accomplished by one of the following methods.

Hydraulic or **airless atomization** controls droplet size by forcing the liquid through a known orifice diameter at a specific pressure. Generally, the higher the liquid pressure, the smaller the droplet size. This method utilizes high liquid pressures and produces relatively small- to medium-sized droplets in uniformly distributed fan, full cone, or hollow cone spray patterns. Hydraulic fine spray nozzles are preferred in most areas because operating costs are lower since compressed air is not required.

Air atomizing controls droplet size by forcing the liquid through an orifice at lower pressures than the hydraulic atomizing method and using compressed air to break the liquid into small droplets. This method produces very small droplets and uniform distribution in a variety of spray patterns. However, it is more complex and expensive because it requires compressed air. In most cases, air atomizing nozzles are effective in locations where dust particles are extremely small and the nozzles can be near the dust source, although some applications require large-capacity air atomizing nozzles to throw their sprays long distances to reach the dust.

Dry fogging controls droplet size by utilizing a nozzle design that passes water through high-frequency sound waves produced by a highly accelerated mixture of water and compressed air. The speed of the compressed air and water mixture hitting a small cup in front of the nozzle reflects the energy back into itself and creates a sonic shock wave that produces very small droplets in a cloud dispersion. Like air atomizing nozzles, dry fog systems require compressed air. The very small droplets produced make dry fog nozzles particularly effective at knocking down respirable airborne dust.

6.5.4.5 Chemical Additives to Control Droplets

Surfactants are sometimes used in wet spray applications because they lower the surface tension of the water solution, which has the following effects:

- a reduced droplet diameter
- an increase in the number of droplets for a given volume of water and
- a decrease in the contact angle, defined as the angle at which a liquid meets a solid surface.

The use of surfactants increases the rate at which the droplets can wet or coat dust particles; thus, less moisture is used to produce the same effects as a typical water application. Small amounts of surfactants can be injected into the spray water, typically in a dilution range of 1:700 to 1:1500, to improve the wetting and subsequent control of dust particles (Swinderman, Marti, Goldbeck, Marshall, & Strebel, 2009). Despite the effectiveness of chemical additives, it must be noted that they are not often used in the metal/nonmetal mining industry based upon several limitations, as described below.

- Surfactants are significantly more expensive than a typical water application
- They can alter the properties of the mineral or material being processed

- They can damage some equipment, such as conveyor belts and seals
- Surfactant systems require more upkeep and maintenance than typical water systems
- Surfactants have limited usefulness in the metal/nonmetal mining industry as opposed to in the coal industry, since ore or stone are much easier to wet than coal due to its hydrophobic nature (NIOSH, 2021).

6.5.5 Drilling and Blasting (non-abrasive blasting)

The drilling process is used for blasting operations that are conducted to fragment rock. Dust controls for drilling and blasting processes are covered together. While blasting seemingly generates large amounts of dust, the operation occurs infrequently enough that it is not considered to be a significant contributor. In general, drilling is a may be a larger dust source.

Table 17 is a short summary of the popular control measures that may be deployed whenever they are possible/practical.

Table 17: Popular Control Measures for Drilling and Blasting

Control Measure	Description
Placement	Drilling and subsequent blasting to be completed below grade reducing the susceptibility of emitting fugitive dust.
Enclosures	Enclosing (for example using berms) drill and blast sites to reduce dust dispersion.
Drilling Improvement	Temperature permitting, change to wet drilling.
Vegetation and Dust Fences	Plant vegetation (trees) around blast sites to reduce dust dispersal or use dust fences for temporary activities.
Operational Shut-down	Stop dust generating activities in high wind conditions (usually at wind speeds greater than 25 km/h or 15 mph).

6.5.5.1 Explosives Detonation

The following methods of dust suppression may be used for the control of dust during blasting.

- Wetting down the entire blasting area prior to initiating the blast. This procedure minimizes dust being entrained into the air from the blasting activity by allowing it to adhere to the wet surfaces. Its effectiveness depends upon the time interval between watering and blast initiation – with the possibility of exposure to the surface atmospheric conditions causing the moisture to quickly evaporate and rendering the watering ineffective. However, safety considerations may preclude wetting the blast area during the “tying in” phase of the blast, where all the individual hole charges are connected prior to blasting.
- Using water cartridges (water ampoules) together with explosives. The water cartridge is a properly sized plastic bag that is prefilled with water or can be filled in the hole. The cartridges can be placed in front of, alongside, or behind the explosive without causing any adverse effects to fragmentation.
- Using an air-water fogger (water blast) spray prior to, during, and after initiating the blast. This setup uses both compressed air and water forced through a nozzle to create a fogged-in blast area. The nozzle is located at an approximate distance of 30 m from the face, is turned on prior to blast initiation, and remains operational for 20 to 30 minutes after the blast.
- Using blasting mat, that is a covering usually made of scrap tires, logs, old conveyor belts, ropes or wire cables, placed over a blast site to prevent flyrock and reduce dust. Flyrock is a rock that is unpredictably propelled into the air by the force of the explosion from a blasting site (Roy, 2005).

6.5.5.2 Drill Rigs

Dust-suppression and crushed-rock-cutting collection systems are available on many drill-rig models to help control fugitive dust. Rubber skirts and water-misting controls may contain rock fines and dust around the blasthole collar.

Cyclone mechanical dust collectors remove drill cutting from the hole collar and place them alongside the drill rig. Cyclone systems reduce the dust in the air and minimize the chance for drill cuttings to fall back into the hole from the collar region, thereby keeping the hole open for maximum explosives loading.

6.5.5.3 Wet Drilling

Injecting water into the compressed air may be successful in reducing dust liberated by drilling at surface mines. After being injected through the drill pipe column to the bit, air and water droplets flush the cuttings and dust from the hole through the annular space between the drill pipe and surrounding rock. As the water and dust travel up the drill hole, particles are wetted by the water droplets, thus increasing drop-out when the airstream exits the hole. Dust reductions up to 96% were observed. However, there are several operational issues that must be addressed when using wet drilling, including the need to monitor and control water flow rate, the need to periodically fill the on-board water tank and protect against freezing in cold weather, and the need to protect tri-cone rotary drill bits from the injected water.

The amount of water added to the bailing air is critical from dust control and operational perspectives. Sufficient water should be added to effectively control generated dust, but too much water can lead to problems with flushing the cutting from the hole, drill pipe binding, increased bit wear and hole degradation.

The useful life of tri-cone bits can be shortened by 50% when wet drilling due to rapid degradation of drill bit bearings by hydrogen embrittlement and accelerated bit wear as a result of operating in the abrasive rock-water slurry environment at the drilling interface. To prevent this problem, the water injected into the bailing air must not reach the tri-cone bit.

6.5.6 Material Processing

6.5.6.1 Crushing

Dust control at crushers may be achieved through application of water, by enclosure of the dust source with or without exhaust ventilation, or a combination of wet and dry methods. Generally, the upper portion of the crusher (feed side) should be enclosed as completely as possible.

Wet dust control methods for crushing operations, involve wetting the process material before crushing, after crushing, or both. This is essentially treating the crushing operation as two transfer points, the feed side and discharge side. Crushing creates smaller-sized material with an associated increase in surface area, which will be dry. Thus, material wetted prior to crushing for dust control will likely have to be wetted again to address the additional dry surface area.

6.5.6.2 Milling (Grinding)

Milling, often called grinding, is a process by which granular minerals are reduced in size by compression, abrasion, and impaction. Materials discharged from mills can range in size from less than 40 to 300 μm for tumbling mills and from 40 to less than 15 μm for stirring mills.

Although mineral processing milling can be done wet, the industrial minerals industry primarily utilizes dry milling.

The most important consideration for dust control within a grinding/classification/product storage circuit is dust containment, and the second is dust collection. All material-conveying equipment related to a milling or grinding circuit should consider being enclosed. In addition, all transfer points should consider being fully enclosed.

During operation, grinding circuit equipment should be tightly closed and maintained under a slight negative pressure by a dust collection system. This means that any air leakage will flow into and not out from the equipment, keeping the dust contained.

6.5.6.3 Screening

Screening operations can produce high levels of dust because smaller-sized material is handled. Airborne dust is generated from the vibrating screen decks that accomplish the size separation. Additionally, material must fall some distance as part of the separation process, and some dust will be suspended by this process.

Dust control for screening systems is like that for crushers, although wet systems are generally not used due to blanking of the screen openings by the wet material. Also, screens are not normally subject to large surges of material flow as are crushers. This is because screens operate most efficiently within a designed flow range.

Screens should be totally enclosed, and water suppression systems (when compatible with the process) or dust collection and exhaust systems should be incorporated. Necessary openings in the screen enclosure must be minimized, and inspection and maintenance openings must be provided with tight-fitting closures.

These control procedures are summarized in the table below.

Table 18: Dust Controls for Material Processing

Procedure	Description
Placement	Equipment to be located below grade where possible reducing the exposure to wind erosion
Minimizing Drop Height	Material is to be dropped from the shortest possible distance
Housekeeping	Minimize dust accumulation on equipment and in material processing areas, reducing the probability of re-entrainment and generation of fugitive dust emissions
Operational Shut-down	Conduct material processing with consideration of wind conditions

6.5.7 Abrasive Blasting (Sand Blasting)

Outdoor blasting poses unique challenges because ambient winds and environmental factors may cause dust to disperse unpredictably. To combat these issues, jurisdictions have adopted several engineering and administrative controls designed to capture dust at the source, minimize fugitive emissions, and protect both worker health and the surrounding community (*AP-42: Chapter 13. Section 13.2.6 Abrasive Blasting* (U.S. EPA AP-42, 2025)).

In Europe, (strict regulatory) guidelines and occupational health standards often drive the use of wet blasting and temporary blast enclosures. These systems have been proven to effectively confine dust even in variable outdoor conditions. In the USA, industry practices have increasingly focused on point-of-generation capture – using vacuum blasting systems and integrated extraction units – to reduce airborne particulate levels. Meanwhile, in Canada, environmental agencies have developed emission estimation tools and guidance that underscore the importance of proper dust control in abrasive blasting operations, especially when estimating fugitive dust releases under different wind conditions (ECCC, 2023).

Table 19 outlines common dust control methods used during outside sand blasting. The table lists each method's general effectiveness, strengths, and limitations based on both practical field experiences and regional guidelines from Europe, Canada, and the USA.

Table 19: Dust Controls During Abrasive Blasting

Dust Control Method	Effectiveness	Strengths	Limitations
Blast Enclosures (Mobile/Temporary)	▪ **High** when properly sealed and combined with dust extraction systems	▪ Confines blasting dust within a dedicated area ▪ Can be integrated with ventilation or extraction units ▪ Minimizes environmental spread	▪ Requires precise design and sealing to prevent leaks ▪ Setup can be cumbersome and may disrupt workflow
Vacuum Blasting Systems	▪ **High** - Immediate capture at the source	▪ Captures dust directly as it is generated ▪ Reduces operator exposure significantly	▪ High initial investment and integration complexity ▪ Often less portable and demands regular maintenance
Wet Blasting / Water Suppression	▪ **Very High** – Near complete suppression when optimized	▪ Binds dust particles effectively, preventing aerosolization ▪ Widely adopted in European outdoor operations	▪ Requires consistent water supply and proper water management to control runoff ▪ May impact surface finish quality
Cyclone Dust Collectors	▪ **Moderate** – Approximately 80% effective, best for coarser particles	▪ Simple design with few moving parts ▪ Low operational cost ▪ Useful as a preliminary dust separation step	▪ Less effective with fine particles ▪ Typically optimized for enclosed environments; outdoors may need supplemental controls
Supplementary Controls (Curtains, Drapes, Water Curtains)	▪ **Moderate** – Serve as add-on barriers rather than standalone solutions	▪ Inexpensive and easy to deploy ▪ Can help direct and limit the spread of dust ▪ Flexible for temporary setups	▪ Not sufficient alone for comprehensive dust control ▪ Effectiveness can be compromised by strong winds and improper installation

Integrating multiple control measures is common. For example, coupling a blast enclosure with an active vacuum or wet suppression system can provide a layered defense against fugitive emissions. In outdoor settings, these combined approaches must account for local weather patterns and site-specific factors such as ambient wind speeds (Government of Canada, 2023a).

For further information on European legislation driving emission controls, below is an overview of EU guidelines related to dust control during sand blasting – especially as they pertain to controlling respirable crystalline silica and other hazardous dusts. In the EU, dust control is not governed by a single regulation but by several overlapping directives (names shown in bold) and standards that together shape safe practices in abrasive blasting operations.

Directive 89/391/EEC (Framework Directive) requires employers to carry out comprehensive risk assessments and implement preventive measures to safeguard worker health. This directive obliges companies to minimize exposure to airborne contaminants, including dust generated during sand blasting.

Directive 2004/37/EC specifically addresses exposure to carcinogens and mutagens. Since crystalline silica has been identified as a carcinogenic hazard, this directive mandates that employers take strict measures – including engineering controls such as dust extraction and wet blasting – to reduce airborne dust concentrations.

Although primarily aimed at chemical hazards, **Directive 98/24/EC** (Chemical Agents Directive) also plays a role if the dust contains hazardous substances. In parallel, **Directive 2008/50/EC** on ambient air quality sets air quality standards that influence how outdoor blasting operations are managed so that their particulate emissions do not compromise community air quality.

Beyond the core directives, EU countries often adopt additional technical standards (EN standards) and best practice guidelines. For example, documents such as the NEPSI guidelines for sand blasting in factories provide detailed operational advice that aligns with these directives.

7. Glossary

The following definitions are used throughout the guide. They were adapted from the South Coast Air Quality Management District Rule 403 (SCAQMD, 2005), Rule 403-1 (SCAQMD, 2004), Rule 403-2 (SCAQMD, 2022) and WRAP Fugitive Dust Handbook (WRAP – Western Regional Air Partnership, 2006). Some of the terms presented here are used extensively while at the same time remaining not defined in Alberta and Canada. Thus, wherever possible, the original wording was preserved, since the definitions come from the fugitive dust framework. Whenever required, the measurements were additionally converted and provided in metric units.

- **Active operations** means any source capable of generating fugitive dust, including, but not limited to, earth-moving activities, construction/demolition activities, disturbed surface areas or agricultural operations.
- **Aggregate crushing and grinding** means any activity that mechanically reduces the size of loose or stockpiled materials to produce sand, gravel, crushed stone, quarried rock or other aggregate material (such as recycled concrete or asphalt).
- **Aggregate material** means mineral particles, such as sand or stone, typically derived from a mechanical process.
- **Anemometers** are devices used to measure wind speed and direction.
- **Asphalt emulsion** is a stable colloidal mixture of asphalt binder and water that contains a small addition of an emulsifying agent.
- **Best available control measures (BACM)** are techniques that achieve the maximum degree of emissions reduction from a source, as determined on a case-by-case basis considering technological and economic feasibility.
- **Bulk material** is sand, gravel, soil, aggregate material (such as recycled concrete/asphalt) less than 5 cm (2 inches) in length or diameter and other organic or inorganic particulate matter.
- **Chemical stabilizers** are any non-toxic chemical dust suppressant which must not be used if prohibited for use by any applicable law, rule or regulation. The chemical stabilizers shall meet any specifications, criteria or tests required by any federal, provincial or local authority. Unless otherwise indicated, the use of a non-toxic chemical stabilizer shall be of sufficient concentration and application frequency to maintain a stabilized surface.
- **Chemical wetting agent** is a compound added to water in order to enhance the penetration of water into dusty material and prevent dust emissions.
- **Clay** is cohesive soil with individual particles not visible to the unaided human eye (less than 0.002 mm in diameter). Clay can be molded into a ball that will not crumble.
- **Construction/demolition activities** means any on-site mechanical activities conducted in preparation of or related to, the building, alteration, rehabilitation, demolition or improvement of property, including, but not limited to the following activities: grading, excavation, loading and unloading, crushing, cutting, grinding, milling, planing, shaping or ground breaking.
- **Construction vehicle** means graders, bulldozers, excavators, cranes, loaders, backhoes, tractors, haul trucks and other similar vehicles used at a large roadway project.
- **Control measure** means a procedure or course of action taken to reduce air pollution. Preventive measures reduce source extent or incorporate process modifications or adjust work practices to reduce the amount of pollutants. Mitigative measures involve the periodic removal of pollutant causing materials, such as the cleanup of spillage on travel surfaces and cleanup of material spillage at conveyor transfer points.

- **Controlled emissions** means estimated emissions (total or by source category) after application of control measures, i.e., remaining emissions.
- **Crust** is the hard outer surface of soil (or other dust producing material) that inhibits the wind erosion of underlying fine particles.
- **Cut and fill** means the activities of earthmoving equipment where soil or rock is removed from an area (cut) and deposited elsewhere on shallow ground (fill).
- **Deposition** is accumulation of airborne particles on ground-level surfaces through gravitational settling and other physical phenomena.
- **Disturbance** means destabilization of a land surface from its undisturbed natural condition thereby increasing the potential for fugitive dust emissions.
- **Disturbed surface area** is a portion of the earth's surface which has been physically moved, uncovered, destabilized or otherwise modified from its undisturbed natural soil condition, thereby increasing the potential for emission of fugitive dust. This definition excludes those areas which have:
  - been restored to a natural state, such that the vegetative ground cover and soil characteristics are like adjacent or nearby natural conditions
  - been paved or otherwise covered by a permanent structure; or
  - sustained a vegetative ground cover of at least 70 percent of the native cover for a particular area for at least 30 days.
- **Dunes** are ridges or mounds of loose, wind-blown material, usually sand.
- **Dust** means fine, dry particles of matter able to be suspended in the air 1 to 100 μm in size.
- **Dust control supervisor** means a person who has the authority to quickly use sufficient dust control measures to ensure all rules are followed.
- **Dust suppressants** are water, hygroscopic materials, solution of water and chemical surfactant, foam or non-toxic chemical/ organic stabilizers not prohibited for use by any applicable law, rule or regulation, as a treatment material to reduce fugitive dust emissions.
- **Earth-moving activities** means the use of any equipment for any activity where soil is being moved or uncovered and shall include, but not be limited to the following: grading, earth cutting and filling operations, loading or unloading of dirt or bulk materials, adding to or removing from open storage piles of bulk materials, landfill operations, weed abatement through disking, soil mulching and agricultural tilling.
- **Emission factor** is a value that relates the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant. These factors are usually expressed as the weight of pollutant divided by a unit weight, volume, distance or duration of the activity emitting the pollutant.
- **Emission parameters** are values that affect pollutant emissions, such as moisture level and silt content of the emitting material.
- **Emission reduction** is amount (mass or percent) of emissions eliminated by control application.
- **Erosion potential** is a value representing the potential for suspension of surface dust by wind erosion. Depending on the presence of a surface crust or surface disturbance, particle size distribution and moisture content, a site is characterized as having
  - unlimited erosion potential,
  - limited erosion potential or
  - no erosion potential.
- **Fines** are smaller particles within the gravel mix, typically anything smaller than 10 mm (3/8 inch). These fines play a critical role in stabilizing the gravel by filling the spaces between larger rocks, which

helps compact the surface and create a smoother, more stable road. Insufficient fines result in loose gravel that is difficult to drive on. Fines interlock larger gravel pieces, improving stability and reducing their displacement under traffic. They are an essential component of gravel road construction and maintenance, ensuring durability and usability. At the same time, having too many results in dust in dry conditions and mud in wet weather

- **Fugitive dust source** is an emitter of airborne particles where the particulate emissions cannot reasonably be passed through a stack, chimney, vent or other functionally equivalent opening. Fugitive dust sources include roadways, construction (earthmoving and demolition), material handling operations, soil tillage and wind erosion.
- **Fugitive dust** means any solid particulate matter that becomes airborne, not from an exhaust stack, chimney or vent, but directly or indirectly because of someone's activities.
- **Fugitive dust control plan** means a plan to control fugitive dust.
- **Gravel** is unconsolidated, granular mineral material produced by the natural disintegration of rock caused by weathering ranging from 5 mm to 76 mm in diameter. Classification systems and technical definitions of gravel vary widely. Values 5-76 mm correspond to sizes from 1/5 inch to 3 inches in the U.S. practice – and are compatible with the U.S. Army Corps of Engineers definition used by WRAP (WRAP – Western Regional Air Partnership, 2006).
- **High wind conditions** depend on the surface material, state, or nature of the surface disturbance. Instantaneous wind speeds that exceed 40 kilometres per hour (25 mph) can cause TSP size particles to be emitted from a surface. Lower wind speeds can cause emissions of smaller particles. "High" wind speeds are therefore site and context specific.
- **Inactive disturbed surface** area means any disturbed surface area upon which active operations have not occurred or are not expected to occur for a period of 20 consecutive days.
- **Large operations** means any active operations on property which contains 0.2 square kilometres (50 acres) or more of disturbed surface area; or any earth-moving operation with a daily earth-moving or throughput volume of 3,850 m^3 (3,850 cubic meters or 5,000 cubic yards) or more three times during the most recent 365-day period.
- **Material pile** means any accumulation of bulk materials, construction/demolition debris, excavated material or typical roadway material which is greater than eight feet in height.
- **Material pile cover** means plastic sheeting at least 10 mil (0.254 mm or 0.01 in) thick that overlaps a minimum of 60 cm (24 inches) and is anchored and secured so that no portion of the material pile is exposed to the atmosphere.
- **Mitigative control** is a control measure that periodically removes exposed dust-producing material.
- **Mulch** is any material used to cover a soil surface to conserve soil moisture and prevent erosion.
- **Non-erodible material** means objects larger than 1 centimeter in diameter that are not susceptible to movement even on windy days (e.g., gravel, hard-packed soil clods).
- **Open storage pile** is any accumulation of bulk material, which is not fully enclosed, covered or chemically stabilized and which attains a height of 0.9 metre (3 feet) or more and a total surface area of 14 m^2 (150 square feet) or more.
- **Opacity** is a measure of how much light is blocked by the visible dust.
- **Particulate matter (PM)** is the generic term for a broad class of chemically and physically diverse substances that exist as discrete particles (liquid droplets or solids) over a wide range of sizes. Particles originate from a variety of anthropogenic stationary and mobile sources, as well as from natural sources. Particles may be emitted directly or formed in the atmosphere by transformations of

gaseous emissions such as sulfur oxides (SO_X), oxides of nitrogen (NO_X), ammonia (NH_3) and volatile organic compounds (VOCs). Examples of secondary particle formation include:

– the conversion of SO_2 to sulfuric acid (H_2SO_4) vapour that nucleates new particles or condenses on existing particles and further reacts with NH_3 to form various inorganic salts (e.g., ammonium sulphate, $[NH_4]_2SO_4$, or ammonium bisulphate, NH_4HSO_4);

– the conversion of nitrogen dioxide (NO_2) to nitric acid (HNO_3) vapour that condenses onto existing particles and reacts further with ammonia to form ammonium nitrate (NH_4NO_3); and

– reactions involving gaseous VOCs yielding organic compounds with low vapour pressures that nucleate or condense on existing particles to form secondary organic particulate matter.

The chemical and physical properties of PM vary greatly with time, region, meteorology, and source category, thus complicating the assessment of health and welfare effects (U.S. EPA, 2019).

- **Paved road** means a public or non-public improved street, highway, alley, public way or easement that is covered by typical roadway materials but excluding access roadways that connect a facility with a public paved roadway and are not open to through traffic. Typically, public paved roads are those open to public access. Non-public paved roads are any paved roads not defined as public.
- **$PM_{1.0}$, PM1.0 or PM1** means particulate matter with an aerodynamic diameter smaller than or equal to 1 µm (1 micron, 1 micrometre).
- **PM_{10}** or **PM10** means particulate matter with an aerodynamic diameter smaller than or equal to 10 µm (10 microns, 10 micrometres).
- **$PM_{2.5}$ or PM2.5** means particulate matter with an aerodynamic diameter smaller than or equal to 2.5 µm (2.5 microns, 2.5 micrometres).
- **Preventive control** is a control measure that inhibits or minimizes the accumulation of exposed dust-producing material.
- **Prewatering** means application of water during construction and earthmoving operations to excavation areas and borrow pits before earth is excavated. The areas to be excavated are moistened to the full depth from the surface to the bottom of the excavation to achieve an optimum moisture content for fugitive dust control.
- **Revegetation** is vegetative cover that has been established on previously disturbed ground, such as a construction site.
- **Rock** means soil particles greater than 63-76 mm in diameter (3 inches; technical definitions vary).
- **Sand** means soil particles ranging from 0.05 to 2.0 mm in diameter; individual particles are visible to the unaided human eye.
- **Sensitive receptor** refers to places where people live or spend a lot of time, such as homes, apartments, schools, daycare centres, hospitals, retirement homes, nursing homes, hospices, prisons and dormitories.
- **Sheltering elements** are blockages to wind that inhibit wind erosion of soil. Examples include wind fences and trees.
- **Sieving** is a process of passing a material through a series of woven square meshes of decreasing size to separate particles into different particle size classes. For agricultural soil classification, wet sieving disperses the material in a liquid before passing the suspension through one or more sieves. Dry sieving is used to characterize material dustiness levels.
- **Silt content** is percentage of particles less than 74 µm in physical diameter (i.e., fraction passing a standard 200-mesh sieve).

- **Silt** is noncohesive soil whose individual particles are not visible to the unaided human eye (0.002 to 0.05 mm). Silt will crumble when rolled into a ball.
- **Soil** is a surface material consisting of disintegrated rock and organic material.
- **Stabilized surface** means any previously disturbed surface area or open storage pile which, through the application of dust suppressants, shows visual or other evidence of surface crusting and is resistant to wind-driven fugitive dust and is demonstrated to be stabilized.
- **Surface disturbance** – see "Disturbance."
- **Surface loading** is mass of loose material per paved road surface area. Total surface loading is measured by vacuuming a known area of paved road surface to obtain all material regardless of particle size. Silt surface loading is obtained by sieving the total surface loading and refers only to particles with physical diameters less than 74 μm.
- **Surface stabilization/treatment/improvement** means the paving, graveling, chemical stabilization or watering of a dust-emitting surface to prevent dust emissions due to mechanical disturbance and wind erosion.
- **Tillage** is a practice of producing a soil surface to maintain surface residue, prepare a seed bed, conserve soil moisture and reduce wind erosion.
- **TPM** is total particulate matter – all particulate matter with a diameter less than 100 μm. It is a term used in Canada to describe filterable particulate matter, excluding condensable particulate matter.
- **Trackout or track-out** means any bulk material (for example dirt, mud, debris) that adheres to and agglomerates on the exterior surface of motor vehicles, haul trucks and equipment (including tires) that have been released onto a paved road and can be removed by a vacuum sweeper or a broom sweeper under normal operating conditions. Also traces of dirt or other bulk material that spill onto a paved road from an improperly loaded haul truck.
- **TSP** denotes total suspended particulates. It is the term used to approximate all the particulate matter smaller than about 30 μm in diameter. Since 1982 (U.S. EPA OSAP, 2025), as published in Appendix B to Part 50, Title 40 – Reference Method for the Determination of Suspended Particulate Matter in the Atmosphere (High-Volume Method), the U.S. EPA has the following Federal Reference Method (FRM) for TSP measurement "An air sampler, properly located at the measurement site, draws a measured quantity of ambient air into a covered housing and through a filter during a 24-hr (nominal) sampling period. The sampler flow rate and the geometry of the shelter favor the collection of particles up to 25-50 μm (aerodynamic diameter), depending on wind speed and direction." (U.S. EPA CFR, 2025)
- **Typical roadway materials** means concrete, asphaltic concrete, recycled asphalt, asphalt or any other material that performs similarly.
- **Uncontrolled emissions** are total emissions before application of any control measures.
- **Unpaved roads** means any unsealed or unpaved roads, equipment paths or travel ways that are not covered by typical roadway materials. Non-public unpaved roads are any unpaved roads not defined as public.
- **Vegetative cover/residue** is organic matter, either growing or dead, that protects the soil surface from the erosive force of wind.
- **Visible dust** – For regulatory purposes, means airborne particles that obscure an observer's view to a degree equal to or greater than a specified opacity limit.
- **Wet stabilization / watering** – see "Surface stabilization."

- **Visible roadway dust** means any sand, soil, dirt or other solid particulate matter which is visible upon paved road surfaces, and which can be removed by a vacuum sweeper or a broom sweeper under normal operating conditions.
- **Wind erosion** is removal of dry soil particles from the ground surface by wind, causing airborne particulate matter downwind of the emitting soil area.
- **Wind-driven fugitive dust** means visible emissions from any disturbed surface area which is generated by wind action alone.
- **Wind barrier / wind sheltering** – see "Sheltering elements."
- **Wind gust** is the maximum instantaneous wind speed as measured by an anemometer.
- **Wind shear** means force of wind parallel to a surface that can remove loose particles, as opposed to wind directly impacting the surface.
- **Worst-case emissions** – see "Uncontrolled emissions."

8. References

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9. Abbreviations and Acronyms

AAFC – Agriculture and Agri-Food Canada

BAAQMD – Bay Area Air Quality Management District (Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, western portion of Solano, southern portion of Sonoma counties)

BACM – best available control measures

CDC – Centres for Disease Control and Prevention, the national public health agency of the United States

CC – Clark County, the most populous county in Nevada, includes Las Vegas

ECCC – Environment and Climate Change Canada

EPA – Environmental Protection Agency, an independent agency of the United States government tasked with environmental protection matters

ICAPCD – Imperial County Air Pollution Control District (includes Salton Sea)

NIOSH – National Institute for Occupational Safety and Health, NIOSH is part of CDC

O&M – operations and maintenance

OMAFRA – Ontario Ministry of Agriculture, Food and Rural Affairs

OSHA – Occupational Safety and Health Administration

PM_{10} – particulate matter with an aerodynamic diameter smaller than or equal to 10 microns (10 micrometres)

PM10 – PM_{10}

$PM_{2.5}$ – particulate matter with an aerodynamic diameter smaller than or equal to 2.5 microns (2.5 micrometres)

PM2.5 – $PM_{2.5}$

wROI – return on investment

San Joaquin Valley APCD – SJVAPCD

SCAQMD – South Coast Air Quality Management District (Los Angeles County except for Antelope Valley AQMD, Orange County, western portion of San Bernardino and western portion of Riverside counties)

SJVAPCD – San Joaquin Valley Unified Air Pollution Control District (all of Fresno, Kings, Madera, Merced, San Joaquin, Stanislaus, Tulare, and Valley air basin portions of Kern counties)

South Coast AQMD – SCAQMD

TPM – total particulate matter

TSP – total suspended particulates

VDE – visible dust emissions

VKT – vehicle kilometres travelled (Canadian term corresponding to the US VMT)

VMT – vehicle miles traveled

WRAP – Western Regional Air Partnership (of states, tribes, federal land managers, local air agencies and the US EPA) is a membership organization supporting western regional air quality analysis and planning needs of its members

Appendix A

Focus Group Feedback

Appendix A. Focus Group Feedback

A.1 Survey Results

A.1.1 Summary of Results

A.1.1.1 Impact of Dust Issues on Daily Activities and Operations

Health Impacts. Dust exposure can lead to respiratory problems, asthma, allergies, and headaches for workers and community members. Prolonged exposure increases risks of chronic respiratory diseases.

Visibility and Safety. Dust reduces visibility, especially on unpaved roads, increasing the likelihood of accidents and operational hazards.

Operational Disruptions. Equipment performance may degrade due to dust accumulation, leading to scheduling delays and increased maintenance costs.

Environmental and Community Concerns. Dust affects local flora, water sources, and air quality, often resulting in community complaints and environmental degradation.

Monitoring and Planning: Daily dust monitoring and adaptive management plans are essential to mitigate impacts, especially during adverse weather conditions.

A.1.1.2 Dust Control Mitigations

Watering. Regular road watering and sprinkling are the most common dust suppression techniques, though their effectiveness depends on frequency and local climate.

Chemical Suppressants. Products like calcium chloride and MG30 are widely used for longer-lasting dust control but are corrosive or impact environment (soil and water salinization).

Engineering Measures. Paving, tackifiers and improved road design help reduce dust generation at the source.

Operational Adjustments. Implementing speed limits and standard operating procedures (SOPs) can minimize dust disturbance.

Agricultural and Air Quality Practices. Zero tillage practices, windbreaks and cover crops mitigate dust generation in rural and agricultural settings.

A.1.1.3 Top Challenges in Dust Management

Cost. The most significant barrier is the expense associated with dust control materials, equipment and labour.

Weather and Climate. Wind, rain and drought are some of the uncontrollable factors that can exacerbate dust problems and disrupt mitigation efforts.

Environmental Concerns. The use of chemical suppressants can lead to toxic runoff and create negative ecological impacts, requiring careful selection and application.

Regulatory Issues. Inconsistent enforcement or lack of clear guidelines hinder effective dust management.

Operational Constraints. Limited resources, equipment and trained staff can restrict the implementation of dust control programs.

A.1.1.4 Best Practices for Dust Management

Operational and Regulatory Measures. Develop and enforce SOPs, conduct regular monitoring to ensure policy compliance.

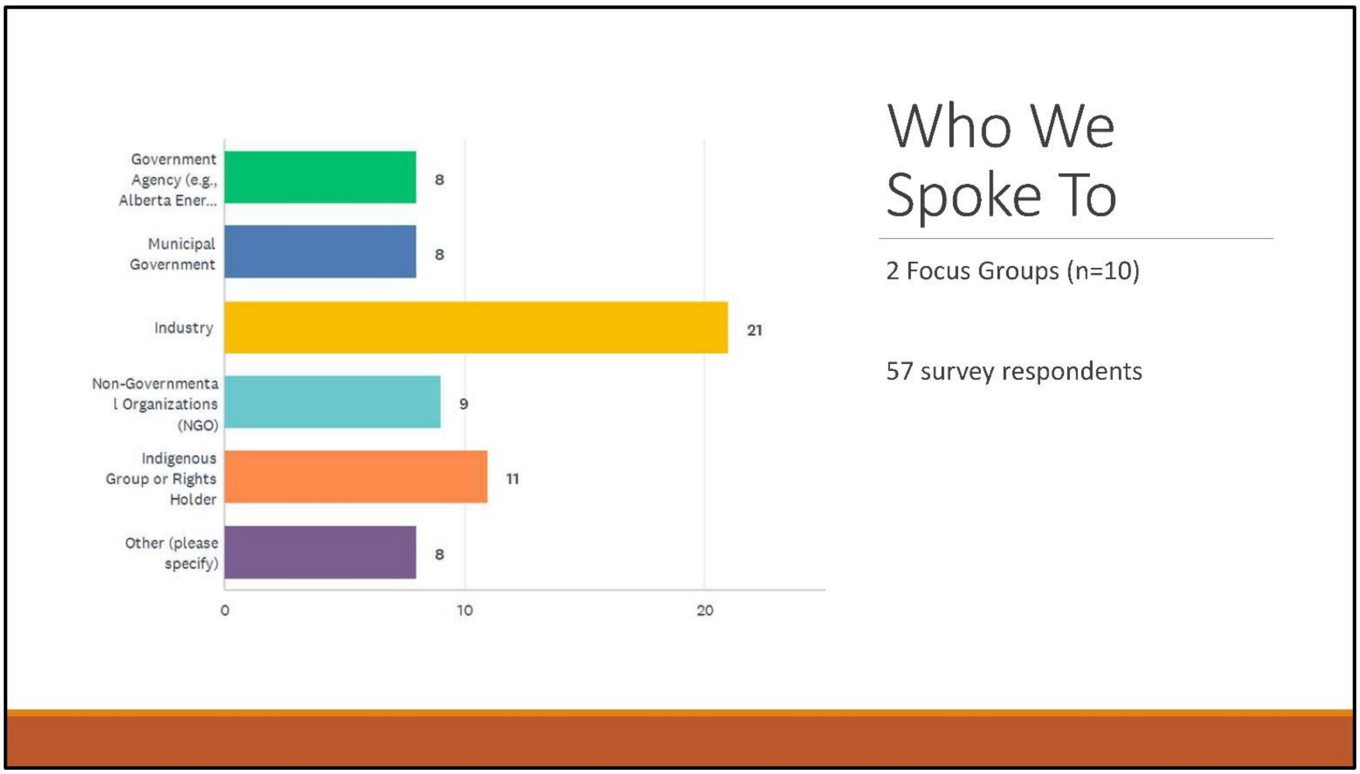
Infrastructure Improvements. Invest in paving, improved road design and other permanent solutions that minimize dust generation.

Water and Chemical Applications. Use water and chemical suppressants judiciously, balancing effectiveness with environmental safety.

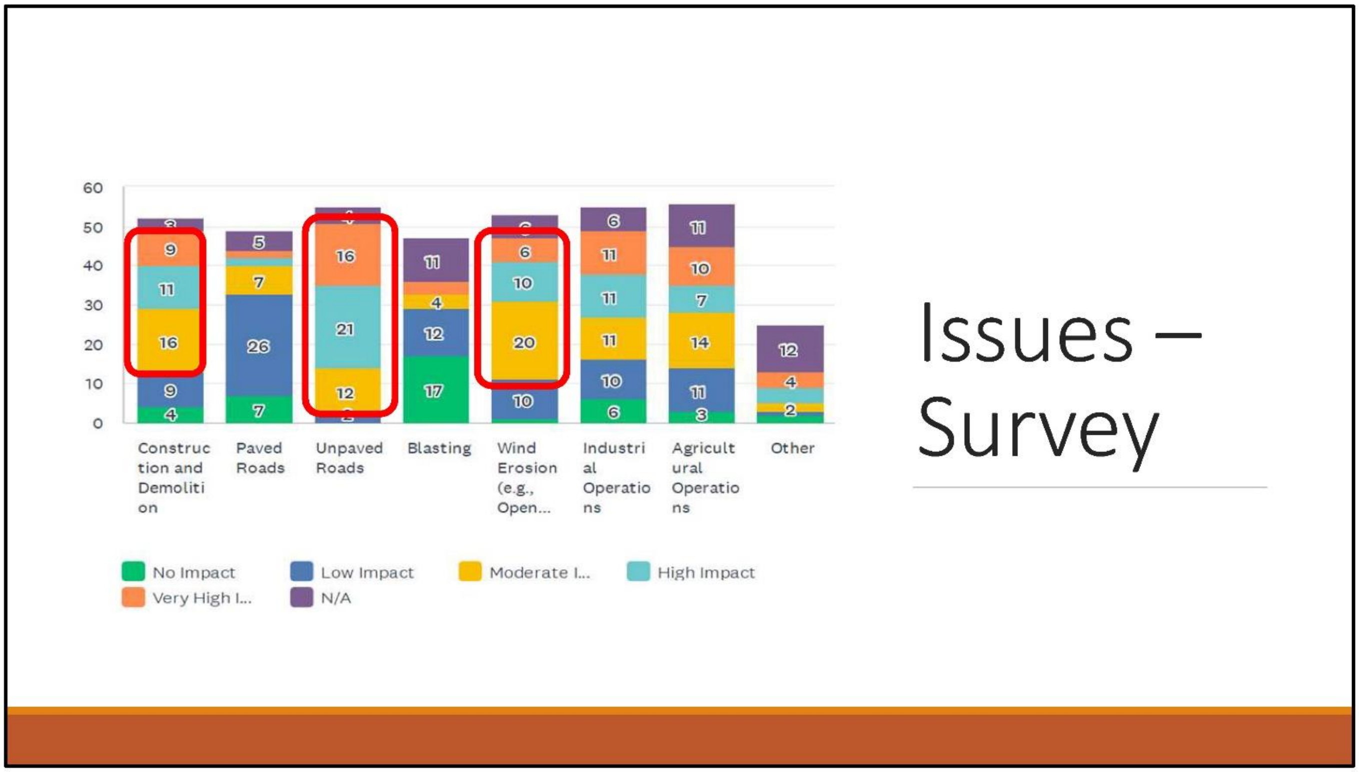
Environmental and Agricultural Practices. Adopt zero tillage practices, windbreaks and cover crops to reduce dust in agricultural areas.

Innovation and Education. Promote newer proven technologies and increase public awareness through training and outreach programs.

A.1.2 Detailed Survey Results



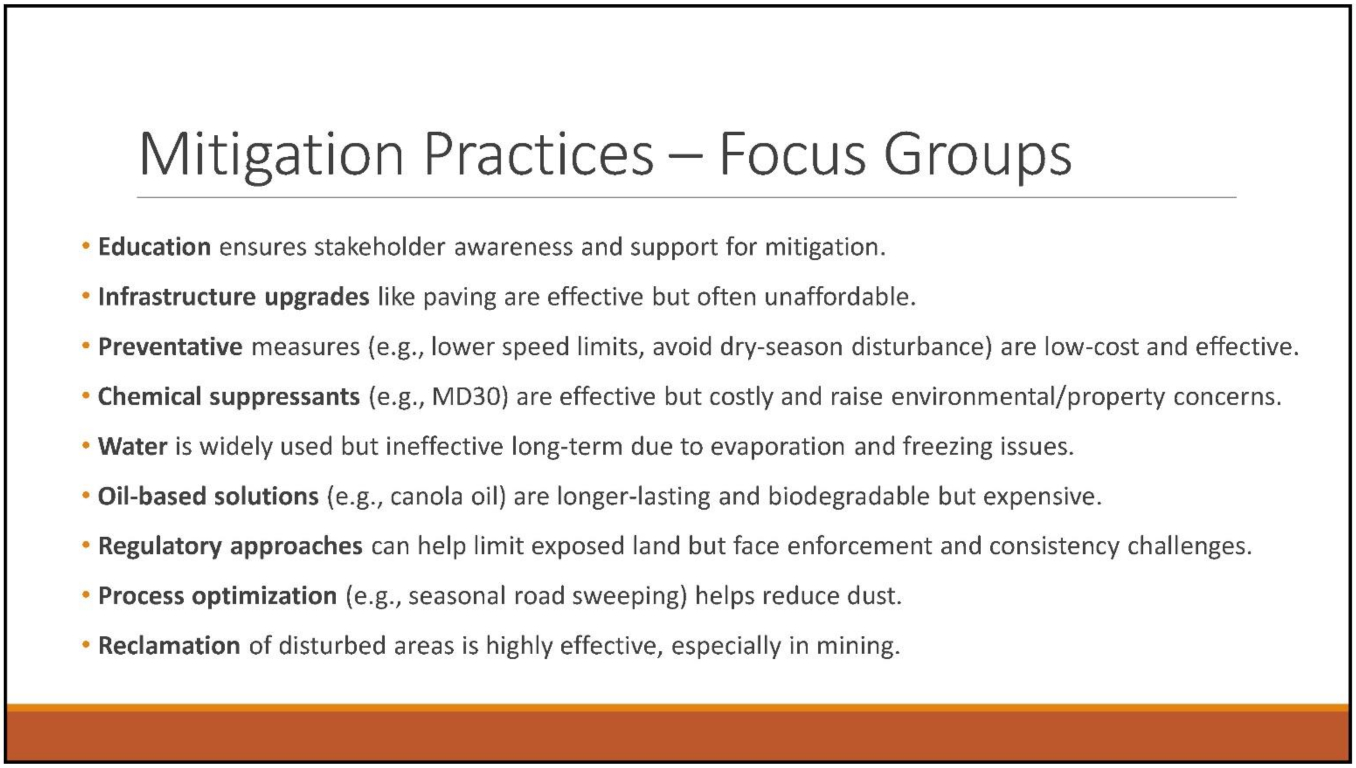
Feedback was collected during via two focus groups and a survey. Community focus group (n=5 participants, June 5, 2025), and the industry focus group (June 5, 2025, n=5). The survey was conducted virtually from April 10 – May 2, 2025.



Respondents indicated that dust issues impacted a number of daily activities with environmental / community concerns, and health impacts being the highest voted number of issues. Dust-related impacts include health risks, reduced visibility and safety, operational delays, environmental concerns, and the need for ongoing monitoring and planning.

There are many common dust sources or dust-generating activities within the area that were discussed between the two sessions. Common sources of dust included:

- Dust from travel along gravel and unpaved roads
- Stockpiles
- Construction and maintenance of facilities and roads.
- Agricultural processes
- Wind erosion
- Industrial processes
- Reclamation



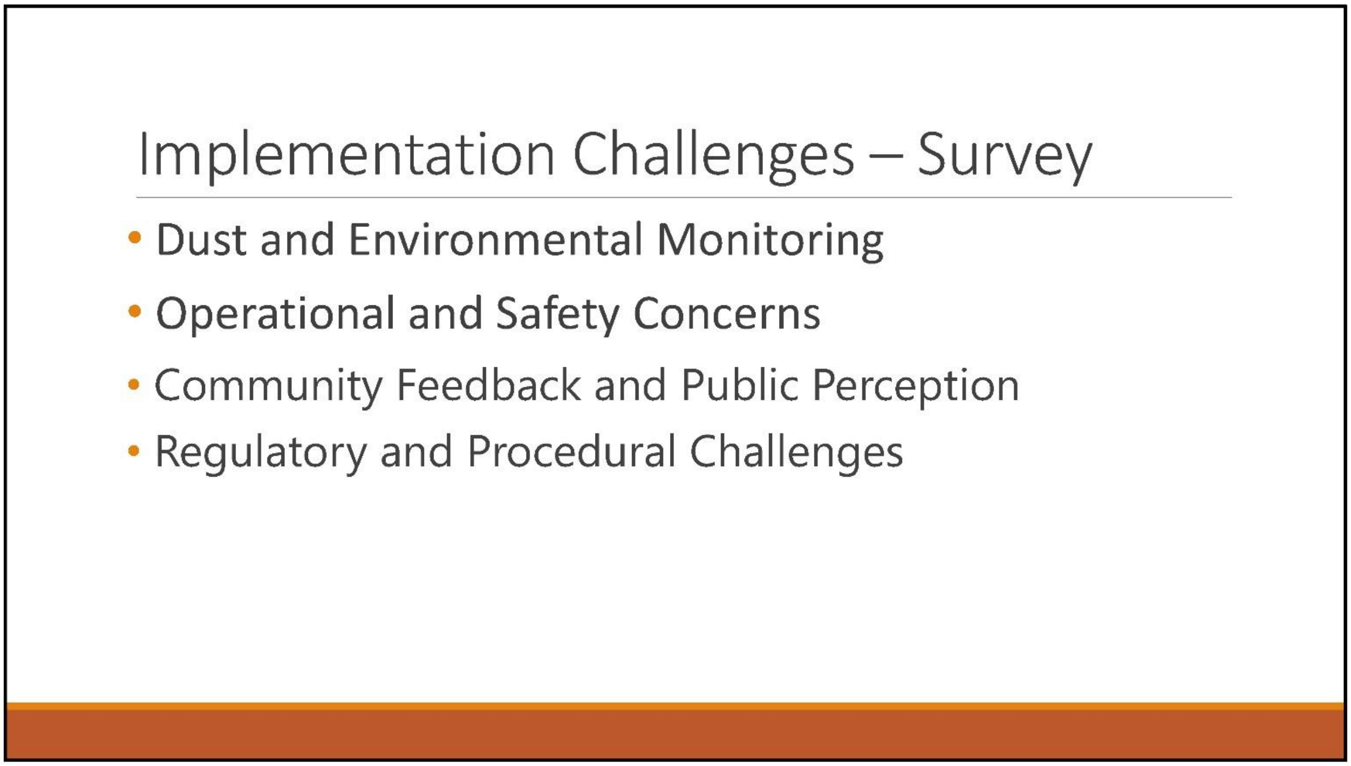
Effective dust control measures listed were similar across the industry and government focus groups

- **Chemical suppressants**, such as MD30 (calcium chloride), are generally effective, especially when combined with strategies like reducing road speeds and adjusting hauling schedules based on weather. However, they are costly over large areas and raise environmental and property concerns, such as rust and chemical buildup in closed-loop systems. The effectiveness of these suppressants also depends on proper application techniques, such as disturbing and re-hardening the road surface.
- **Water**, while commonly used, is largely ineffective for long-term dust suppression. It evaporates quickly in hot weather and is impractical during colder months due to freezing and limited access.
- **Oil-based solutions**, like lightly applied canola oil, offer longer-lasting results and are biodegradable, making them a more environmentally friendly option. However, they are expensive due to fluctuating market prices.
- **Regulatory approaches** can help by limiting the amount of exposed land and preserving existing vegetation, which naturally controls dust. Yet, inconsistent messaging and enforcement, along with the influence of well-funded industries, make regulatory efforts difficult to implement from the ground up

<u>Contractor Environmental Responsibilities Package (CERP), Environmental Construction Operations (ECO) Plans</u>

- **Process optimization**, such as timing road sweeping with seasonal changes like snowmelt, can also help reduce dust.
- **Reclamation** of disturbed areas, particularly in mining, is one of the most effective strategies, as it directly addresses the source of dust.
- **Education** plays a vital role in dust management by ensuring that all stakeholders – council members, staff, residents, and developers – understand the issue and support mitigation efforts.

- While **infrastructure upgrades** like paving gravel roads are highly effective, they are often impractical due to budget constraints.
- Finally, **preventative measures** such as lowering speed limits on haul roads and avoiding land disturbance during dry conditions can significantly reduce dust generation with relatively low cost and effort.
- **SURVEY: Personal and Community Measures** - Individuals often use air purifiers and masks to reduce dust exposure. Community feedback highlights the importance of consistent and effective dust control efforts to protect health and quality of life.



Respondents indicated that the more prevalent challenge to dust management was cost. This answer was also reflected in the focus groups. Weather concerns were also noted with comments that the wind, drought and rain were uncontrollable and disruptive. Environmental concerns was the third highest voted challenge with respondents indicated they were concerned about chemical suppressants and run-off.

Dust and Environmental Monitoring

- Environmental monitoring programs have evolved based on long-term data to address local dust concerns.
- Mitigation strategies are generally manageable but can increase operational costs.

Health and Quality of Life Impacts

- Dust exposure is linked to asthma, allergies, headaches, fatigue, and reduced lung function.
- It also affects livestock, plant growth, and general cleanliness.
- In some cases, people avoid outdoor activities, impacting cultural practices and treaty rights.

Operational and Safety Concerns

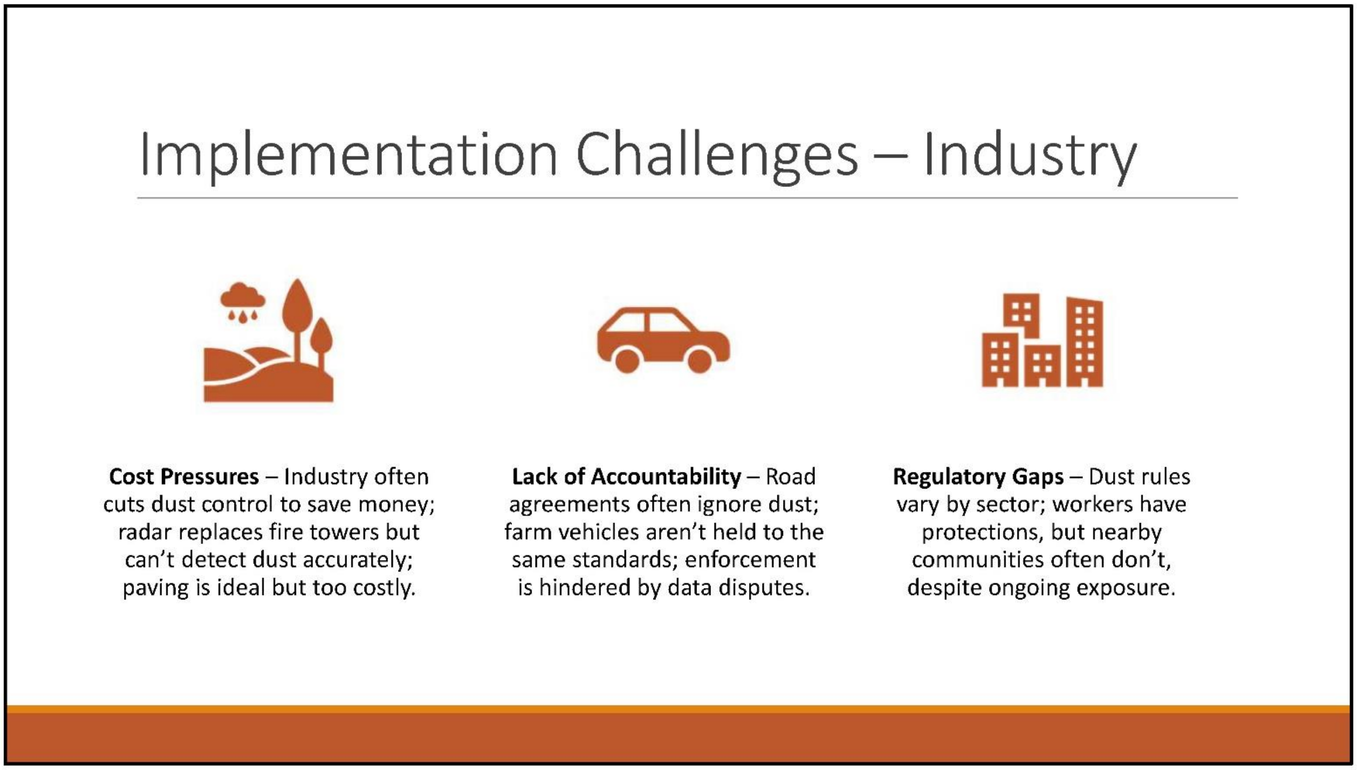
- Dust can impair equipment performance and increase maintenance needs.
- It slows down operations and reduces visibility on unpaved roads, creating safety hazards.
- Activities often need to be rescheduled based on dust and wind conditions.

Community Feedback and Public Perception

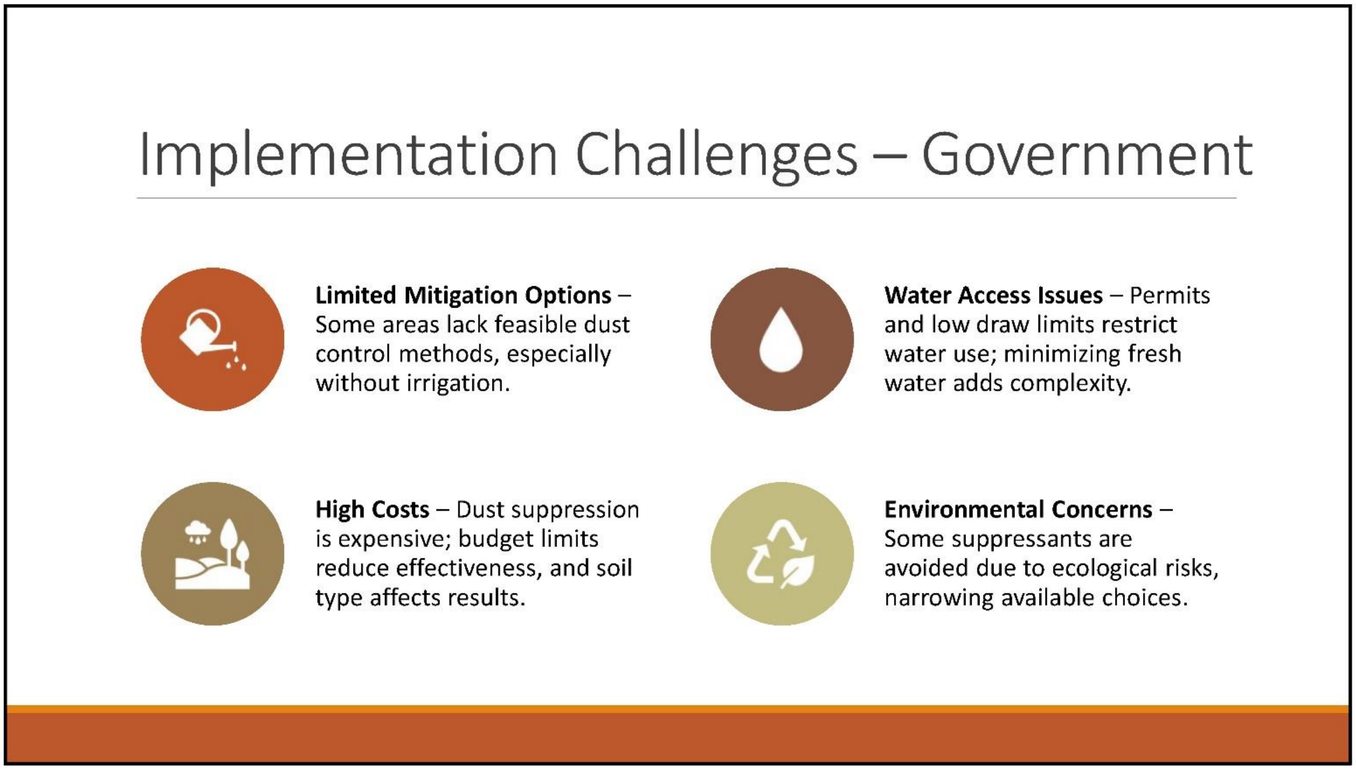
- Residents, especially in rural and agricultural areas, frequently report dust problems.
- There is a perception that construction sites lack effective dust control.
- Concerns about contamination and frustration over limited responses are common.

Regulatory and Procedural Challenges

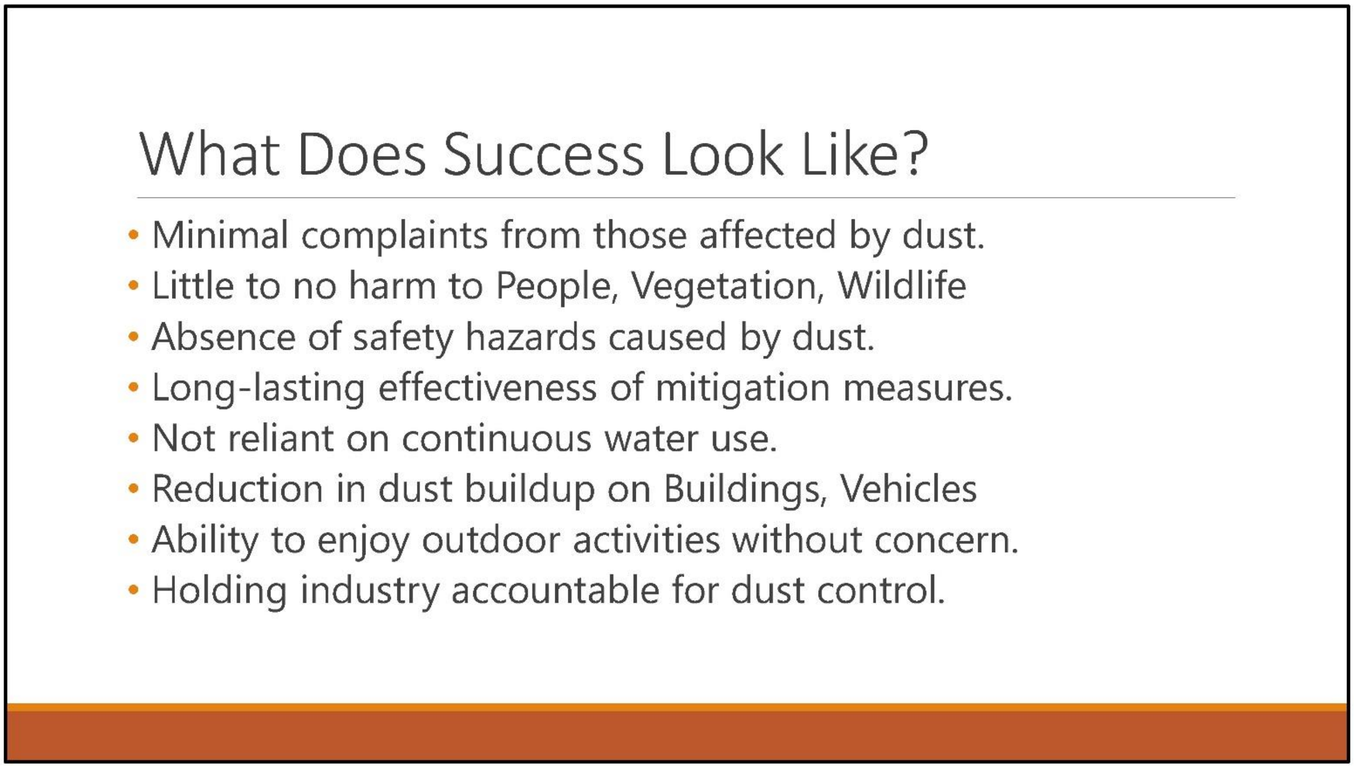
- Large projects typically follow approved dust control thresholds, but smaller ones often lack oversight.
- There is confusion about how to report dust issues and who is responsible.
- In agricultural contexts, dust is sometimes dismissed as a nuisance, limiting regulatory action.



- **Lack of Effective Mitigation Methods** – In some cases, effective dust control simply is not possible. For example, farmers without access to irrigation have limited options beyond hoping for rain. Additionally, efforts to reduce dust – like redesigning roads – can be costly and may lead to greater environmental disturbance.
- **Access to Water** – Accessing water for dust control often requires permits, and the allowable draw rates can be low. Many operations aim to minimize fresh water use, adding another layer of complexity to dust suppression efforts.
- **Cost Constraints –** Watering roads and running suppression equipment is expensive, especially over large areas. Contractors may reduce watering to stay within budget, and suppressants often have only short-term effects. Soil type also plays a role – silt dries quickly and creates dust, while clay retains moisture but still requires costly treatment.
- **Environmental Impacts** – Some dust suppression products are avoided due to potential environmental risks, limiting the range of usable options.



- **Cost Pressures –** Industry often prioritizes investor interests over community and environmental well-being, minimizing spending on dust control unless required. Cost-saving measures, like replacing staffed fire towers with radar, have introduced system flaws – radar can't distinguish between smoke and dust. While paving roads is the most effective solution, it's financially unfeasible for many areas, and even promised paving projects have gone unfulfilled.
- **Accountability Gaps –** Although some road maintenance agreements exist with industry, they often exclude dust management. Agricultural vehicles, which also generate dust, aren't subject to the same permitting or cost-sharing requirements, raising fairness concerns. Monitoring-based enforcement is also challenged by disputes over data accuracy and source attribution.
- **Regulatory Uncertainty –** Dust regulations and communication lack consistency across sectors. While on-site workers have exposure standards and protective measures, such protections don't extend to nearby communities, who may face continuous exposure without clear guidelines or support.



Participants indicated that successful dust mitigation would be characterized by minimal complaints from those affected, little to no harm to people, vegetation, or wildlife, and the absence of safety hazards caused by dust. Effective measures would be long-lasting, not reliant on continuous water use, and would reduce dust buildup on buildings and vehicles, allowing for outdoor activities without concern. Additionally, success would involve holding industry accountable, ensuring cost-effective and publicly acceptable solutions, and achieving compliance with regulatory standards.

Measuring + Monitoring

The government focus group provided in-depth knowledge of the measuring and monitoring methods associated with dust issues. However, both groups commented on:

- Complaints
- Air Quality Monitoring
- Visual Inspections

A.2 Focus Groups Summary

The CASA Dust Best Practices Guide Project held two focus groups in May 2025 – one with community representatives and another with industry stakeholders – to gather insights on dust sources, challenges, and effective mitigation strategies across Alberta. The community group included municipal and Indigenous representatives, while the industry group featured participants from sectors such as energy, forestry, and transportation. Both groups emphasized the widespread impact of dust from unpaved roads, industrial activity, and reclamation sites.

Key themes from both sessions included the need for clearer regulations, cost-effective and environmentally safe mitigation methods, and better monitoring and accountability. Community participants highlighted challenges like inconsistent enforcement, limited funding, and public health concerns, while industry participants focused on operational constraints, such as access to water, suppressant effectiveness, and safety issues related to visibility. Both groups agreed that successful dust mitigation should reduce complaints, minimize health and safety risks, and be tailored to local conditions and receptors.

Participants' input informed the final guide to support improved dust management across Alberta.

A.2.1.1 Most Prevalent Dust Sources and Dust-Generating Activities

Government Focus Group. Participants reported that the most significant sources of dust vary by region and land use. In urban areas like Edmonton, wind erosion and soil storage are primary contributors. In rural and industrial regions, unpaved roads (comprising up to 90–95% of the network in some municipalities), variety of process plants, quarries and open pit mines, tailings dykes and traffic from agriculture are dominant sources. In oil sands operations, coke dust and dust from poor reclamation of mine sites.

Industry Focus Group. Unpaved roads, gravel roads, construction activities (including blasting), maintenance operations, sawdust piles, and stockpiles are the most prevalent dust sources. Agricultural activities such as cultivation and field work, as well as operations around confined feeding facilities, also contribute significantly. In industrial settings, constant disturbance from heavy vehicles, frequent road grading, and wind erosion around ponds, coke piles, and sulfur piles are major contributors.

A.2.1.2 Greatest Issues and Challenges Related to Dust and Dust Management

G. High cost is a recurring concern. Challenges include the equitable allocation of dust control funding and the lack of clear regulatory standards. Hygroscopic suppressants (e.g., chloride-based ones) might contribute to slippery roads, be a factor in corrosion – of both steel and concrete – and accelerate rutting when leaching into roadbeds. Legacy developments and inconsistent enforcement complicate dust management. Unclear financial responsibilities, regulatory gaps and unclear guidelines hinder enforcement and consistent application of dust management practices.

I. The difficulty of applying dust suppressants due to frequent road grading, the large footprint of industrial operations, heavy traffic creating visibility issues and the loss of dust suppression effectiveness after maintenance are the main issues. Accessing water for dust control is a significant challenge, due to permitting constrains and low draw rates from streams. In agriculture, controlling dust around livestock facilities is particularly difficult due to the vast surface area and restrictions on suppressants.

A.2.1.3 Effectiveness of Current Dust Management and Mitigation Measures

G. Chemical suppressants (often various chlorides) are widely used and generally effective. However, they are expensive and raise environmental or damage to property concerns (respectively runoff and corrosion). Alternative approaches, such as using low-grade oil or canola oil for road capping, have been effective and are more environmentally friendly.

Paving roads is often considered cost-prohibitive and not feasible for many municipalities. Limiting the area of land that is stripped and graded during development, maintaining vegetative cover, and progressive reclamation of mine sites are also effective strategies. In large cities, prioritizing road sweeping in the spring helps reduce dust before rainfall.

I. The most effective dust control measures are dust suppressants and lowering road speeds. At least lowering the speeds for heavy vehicles or near sensitive areas or residences. Timing activities to avoid hauling during dry conditions. In general, trying to not disturb the soil in dry conditions. The effectiveness of suppressants varies. Water is only temporarily effective, particularly in hot weather, because it evaporates rapidly. Canola oil is one of the longer-lasting option, capable of hardening the road surface and reducing dust for most of the season. The effectiveness depends significantly on the method of application. For example, roughening the road surface before suppressant application and then compacting that surface afterward improves results. Some suppressants, particularly those containing chlorides, pose significant environmental challenges. The example given was contamination of the industrial closed-loop systems.

A.2.1.4 Challenges in Implementing Dust Management Practices

G. Implementation is hampered by financial constraints, inconsistent regulatory frameworks, and difficulties in enforcing standards. Industrial stakeholders often prioritize return on investment, sometimes at the expense of residents, wildlife, and livestock. Municipalities face challenges in cost-sharing with agricultural operators, who are less regulated than industry users. The maintenance of paved roads is often unaffordable, and there is a lack of clarity about which party is responsible for dust mitigation. Resource limitations, both in terms of funding and personnel, further complicate consistent implementation.

I. Implementation barriers include limited options for farmers without irrigation, the need to time activities around rainfall and frequent movement of goods and livestock generating dust. Obtaining permits for water use is often slow. Cost is a major factor for both contractors and municipalities. Environmental impact of some suppressants leads to avoidance of certain products. Vast areas and prioritization of high-impact zones further complicate management. Dust generation depends on soil type, with silt-based soils drying faster and quickly generating more dust.

A.2.1.5 Methods Used to Measure or Monitor Dust Issues

G. Most municipalities rely on a complaint-driven system, responding to dust nuisance reports from residents. Some regions have air monitoring stations that track particulate matter (PM2.5 and PM10), while others use passive dust collection systems to quantify dust deposition over time. In industrial areas, monitoring is sometimes conducted off-site, which can limit the accuracy of data. There is a recognized need for more consistent, on-site monitoring and for establishing clear baselines to measure progress. The use of public reporting systems (e.g., 311) and regular inspections of erosion and sediment control are common practices.

I. Most participants rely on visual assessment and public complaints to monitor dust. Active haul areas receive more attention and water trucks are deployed when dust becomes visible. In mining areas, dust canisters are used to collect and measure particulate matter, and particle research is conducted to understand dust characteristics. Monitoring is limited during freezing conditions, as water-based suppression is not feasible. There is extensive $PM_{2.5}$ monitoring across the province (fires are identified as a primary $PM_{2.5}$ source).

A.2.1.6 Impact of Dust Issues on Daily Activities and Operations

G. Dust significantly affects both quality of life and operational efficiency. Residents report dust infiltration into homes and public buildings, leading to health concerns and aesthetic issues. Dust accumulation on vehicles and property is a frequent complaint, and agricultural productivity can be affected when dust interferes with plant health and pesticide application. In industrial and mining regions, dust exposure is a chronic issue, with workers and residents facing ongoing health risks. The lack of effective dust management can erode public trust and lead to increased complaints.

I. Dust impacts visibility for road users and creates safety concerns, especially near residences and towns. It affects equipment, such as fans and filters, and can accumulate on leaves in forested areas, with rainfall providing natural mitigation. In agricultural settings, dust is a persistent challenge and only rain provides significant relief.

A.2.1.7 Effectiveness of Specific Dust Control Measures

G. Chemical dust suppressants are effective but costly and can have environmental drawbacks. Light oiling and the use of biodegradable oils (such as canola oil) are cited as effective, lower-impact alternatives. Limiting land disturbance during development, maintaining vegetative cover, and progressive reclamation are also effective. Watering roads is less effective due to rapid evaporation and high operational costs. In urban areas, timely road sweeping is important for dust control. Education and stakeholder and Indigenous engagement are critical for achieving buy-in and consistency in dust management practices.

I. Effective measures include applying dust suppressants and timing activities (e.g., reducing landscape disturbance) to avoid dry conditions. Water is effective but only temporarily, especially in hot weather. The method of suppressant application is critical; roughing up the road surface before application and then hardening it improves effectiveness. Canola oil has been trialed and found to last most of the season, though it is expensive. Lowering road speeds for heavy haulers especially during dry periods is also effective.

A.2.1.8 Successful Dust Control Mitigations (Measuring Success)

G. Success is measured by a visible reduction in dust, fewer complaints from residents and compliance with regulatory standards. Cost-effectiveness and public acceptance are also important indicators. In mining and industrial regions, holding industry accountable and achieving a balance between operational needs and community health are seen as critical. Establishing clear baselines and consistent monitoring are necessary for tracking progress.

I. Success is measured by limited complaints, minimal harm to receptors (humans, plants, water bodies) and improved safety. Ideally, a long-lasting suppressant would be used that does not require continuous water usage. Availability of a comprehensive guide and clear operating procedures would also be indicators of success.

A.3 Minutes of Dust Management Project Team Workshop, June 24, 2025

QEII Building, Edmonton & Microsoft Teams 10:00 a.m. – 2:00 p.m.

In Attendance

- Ann Baran, Southern Alberta Group for the Environment
- Anna Zawadzka, City of Calgary*
- Charles Grimm, Suncor
- Cory Schmidt, Imperial Oil
- Courtney Brown, Canadian Association of Petroleum Producers/Canadian Natural Resources Ltd.
- Danlin Su, Prairie Acid Rain Coalition
- David Spink, Prairie Acid Rain Coalition (Co-Chair)
- Dianne McIsaac, Wood Buffalo Environmental Association
- Dirk Zeijlemaker, Graymont
- Elizabeth Adelakun, Heidelberg Materials
- Jacob Bossence, Alberta Beekeepers Commission
- Jeroen Pieterse, City of Calgary*
- Kristina Morris, Lakeland Industry & Community Association*
- Kristi Anderson, Mewassin Community Council
- Laura Cline, SIL Industrial Minerals
- Laurie Cheperdak, Alberta Primary and Preventative Health Services*
- Melody Garner-Skiba, Intensive Livestock Working Group*
- Monica Klaas, Alberta Seed Processors Association*
- Sunny Cho, Alberta Environment and Protected Areas
- Wade Frick, City of Calgary*

AECOM Staff

- Erin Huck, Senior Urban Planner
- Randy Rudolph, Associate Vice President, Environment

CASA Staff

- Alec Carrigy, Project Manager
- Andre Asselin, Executive Director
- Anuja Hoddinott, Senior Advisor
- Katie Duffett, Senior Project Manager

***Attended remotely via Microsoft Teams**

Alec convened the workshop at 10:02 a.m.

1. Welcome and Objectives Overview

Alec opened the meeting with a land acknowledgement followed by a round table of introductions.

The draft dust best practices guide was distributed to participants prior to the workshop. The workshop objectives were to validate the draft dust management best practices in the guide and identify ways to enhance its usability.

Alec reviewed the agenda. There were no changes.

Alec provided an overview of the Dust Best Practices project, including the project goal and objectives, and the approach taken by the project team in developing the draft guide. Results from surveys and focus groups on the guide's table of contents had been incorporated prior to the workshop. The workshop is the last stage of engagement, however there will be opportunities for further review and comment on the updated draft guide. The guide is expected to be complete and publicly released in mid-2026.

2. What We Heard

Erin reviewed the focus group and survey results, which are summarized below.

Surveys

- There were 57 responses from a variety of sectors.
- Construction and demolition, unpaved roads, and wind erosion were noted as high impact dust sources by many respondents.
- Implementation challenges reported included dust and environmental monitoring, operational and safety concerns, community feedback and public perception, and regulatory and procedural challenges.
- There were comments on how complaints are logged and managed, and the challenges involved.

Focus Groups

- Two focus group sessions were held. One was for community representatives and the other for industry.
- Mitigation practices discussed included education, infrastructure upgrades, preventative measures, chemical suppressants, water, oil-based solutions, regulatory approaches, process optimization, and reclamation.
- Quality of life impacts were a concern, such as human health and dust accumulation on vehicles.
- The industry group noted cost pressures, lack of accountability, and regulatory gaps as implementation challenges.

Both the survey and focus groups had comments on how complaints are logged and managed, and the challenges involved.

It was noted that one of the regulatory gaps is that in some industries workers have protections related to dust exposure, but not all.

Erin asked the workshop participants what successful dust management looks like, and received the following responses:

- Stakeholders are satisfied that the people creating the dust are doing everything they can while recognizing that dust can't be eliminated and there will inevitably be some impacts.
- Minimal complaints are received from those impacted by dust.
- There is little to no harm to people and the environment, and people can enjoy outdoor activities.
- Dust is not creating safety hazards.
- Mitigation is not reliant on continuous water use.
- We are holding each other accountable for dust control.
- Practical applications are being used on a consistent basis.

3. Presentation of Draft Guide

Randy provided an overview of the draft best practices guide.

The guide attempts to take a neutral stance and is focused on activities that generate dust rather than specific industries. It is also organized using a hierarchy of actions. For example, the first step is to prevent dust from being generated in the first place, and if it can't be prevented, then the next step is mitigation. It is based on the FIDOL (frequency, intensity, duration, offensiveness/character, and location) approach, which is typically used for odour assessments but is very applicable to dust as well.

The information in the guide was generated through a literature review. Most of the information available was on mitigation approaches used in the United States, but there are some examples taken from other areas.

4. Confirmation of Best Practices by Dust Source

The workshop participants separated into breakout groups and were asked to discuss whether any dust sources or mitigation measures are missing from the draft best practices guide. They were given 40 minutes for discussion and then reported on the results in plenary. The results are summarized below.

Dust Sources or Mitigations

- There are no environmental impacts listed for polymers.
- There are long-term costs and benefits for some mitigations that aren't considered. For example, establishing vegetation alongside a roadway may have a high up-front cost but that could be amortized over 20 years.
- There are industry-specific processes that generate dust which aren't included in the guide. There could be a section called "processes" that includes some of these.
- Using vegetation as a windbreak isn't covered as a potential mitigation.
- The guide mentions the National Pollutant Release Inventory (NPRI) being a basis for identifying dust sources, but not all dust generating activities have reporting requirements. There are also other inventories, like the Annual Emissions Inventory Reporting Program (AEIR).
- Mitigation measures have impacts and there should be alternatives suggested if those impacts are undesirable. For example, paving a parking lot or road can cause water infiltration issues, and alternatives without those issues should be proposed in that section.
- The impacts of surfactants on aquatic ecosystems are missing.
- Information on how to prevent water used as a dust suppressant from entering waterways is missing (the guide says to prevent this but doesn't say how).
- Cost limitations are applicable to more than just unpaved roads.
- Who helps pay for mitigations? There are some cost-sharing options for things like gravel roads (e.g., permitting requirements).
- Clarification is needed on who is subject to dust management.

- The Ringelmann method could be added as an example of how to visually assess dust.
- Silica dust and specific treatments for it could be added.
- The Calgary water feeder break could be used as a case study – how would this impact watering activities on roads? Other examples that could be case studies:
  - Dust study for Mud Lake; lake had dried up and dust blowing from the lake was impacting a nearby community.
  - Drought is impacting communities and dry conditions means more dust.

Framing or Context

- There should be a flowchart or decision tree to help users find out what content is relevant for them.
- There isn't any information on provincial guidance for things like impacts of different mitigations. Some of this information is available through Alberta Energy Regulator, as there are permits required for some chemical mitigations.
  - Outlining the regulatory authority would be helpful (e.g., if an organization wanted help or information, who should they contact?).
- The document should include some information on CASA and the project team's goal.
- Visual representations of dust would be helpful – such as fraction size and travel distance, to give people a reference point.
  - Before and after photos could be included (e.g., gravel roads before and after mitigations are applied).
  - Some sections are very text heavy, and visuals would help.
- How other provinces in Canada control dust and how that compares to Alberta could be included, where information is available.

Source/Mitigation Measure Section Structure

- It would be helpful for the mitigation measures to have a summary table at the start that gives some high-level information on strengths, weaknesses, and considerations so people can tell easily whether something is applicable to them.
- There should be information on considerations for different contexts (e.g., mitigation goal, receptors, resources needed).
- Stockpiles could be broken out into a whole section or under another one, in more detail.
- Unpaved and paved roads should be combined into one section.
- Some topics seem to show up out of nowhere, and they could use better introductions.
- Design stage should be included where applicable.
- Could have symbols next to practices that apply to specific sectors, to have easy reference for which practices apply to them (but then all sectors would need to be included as symbols, not only major ones).

5. Guide Usability

The workshop participants separated into breakout groups to discuss ways the guide could be made more usable and useful for the target audience. The results are summarized below.

Guide Approach

- "How to be a good neighbour" is the underlying driver of the guide and that should be articulated somewhere at the beginning.
  - Alternatively, this could be addressed in the section on complaints management.
- This is a best practices guide and not an implementation guide – make sure to maintain the intent.

- Prevention of dust should be emphasized over dust mitigation (e.g., planning around seasonality).
  - E.g., planning around dust seasonality.
- There should be a section at the beginning of the guide that gives some information on how to approach the topic (e.g., identify your dust sources, identify your receptors, make a list of considerations, select and implement appropriate mitigation measures, evaluate their success).
- This is more of a reference book than a guide; it's missing components such as criteria for helping users select appropriate mitigations.
- Guide should be scalable for big and small operations.
- The intended audience should be clear, but even if it's directed at industry and other groups who are mitigating their own dust sources, it will also be a resource for other users. Municipalities have their own uses and for communities, it can be used to help them understand the topic and ask educated questions.

Overall Guide Structure

- The guide doesn't single out individual sectors, but there can be sector-specific information included as references, perhaps as an appendix (e.g., the Confined Feeding Operations report from CASA).
- Should there be a section for emerging technology?

Internal Consistency & Streamlining

- The terms used in the guide should have definitions (e.g., what does local scale mean?).
- Some mitigations or sources had more information than others – this should be made consistent.
  - Extra information could be put into an appendix to improve document flow.
  - Very technical information should be moved to the appendix.
- The document should contain hyperlinks to other relevant parts of the document, so users don't have to manually scroll pages if there's relevant information elsewhere in the document.
- Reference material should be in the appendix or as a footnote with a link where possible instead of being in the body of the report.
- The guide is supposed to be focused on non-point sources, but there is a section for point sources. Some discussion is needed to determine if it should be included. If so, it needs context and clarification.
  - Consider another title?
- Early in the document there is reference that is PM_{10} and greater, but the health impacts listed in a later section are cardiovascular and respiratory, which are the health impacts of $PM_{2.5}$. Clarification needed in both sections about dust including the $PM_{2.5}$-PM_{10} fraction and about the health impacts of different fractions.
- Some of the mitigations in the guide are not used often in Alberta; these should be moved to the appendix.
- References being in text can interrupt the flow (e.g., brackets with full references). Footnotes would be preferred.

Practical Resources and Tools

- Templates, tools, or checklists might be useful for people who are looking at the guide but don't have established processes or procedures around dust management.
  - Another example is providing a template or suggestions for the complaints process. Who is the contact person, what information should someone who is making a complaint include.
- Dust management plan templates would help smaller organizations.

Other

- The guide itself should be easy to find (e.g., easily found on the CASA website).
- The guide should be distributed to appropriate industry associations, like Alberta Sand and Gravel Association and Farmers Advocacy groups, for greater reach.

- There are resource needs associated with dust mitigation that aren't well covered. For example, you may need to train staff on how to make a visual opacity assessment for monitoring purposes.
- There is disparity in industry roles to implement the best practices vs. accept them as information.
- Some sectors are highlighted more than others in the guide – this could be perceived as finger pointing.
- Dust impacts soil acidity, and that's not well-documented.
- The guide will need updating in the future to ensure it stays relevant.

6. Next Steps and Closing

A lot of feedback on the guide was received during the workshop, and Alec noted that not all changes may be within the project scope or possible with the resources available for the remainder of the work. The feedback will be reviewed by AECOM and the project team following the workshop, and they will create a plan for incorporating the changes.

Attendees were encouraged to send any additional feedback to Alec within the next week to ensure it can be considered. After the draft is updated with the workshop feedback there will be an opportunity to review the changes and submit further comments.

A summary of the workshop will be sent to participants within the next couple of weeks.

The workshop was adjourned at 2:05 p.m.

Appendix B

Comparison of Calcium Chloride and Magnesium Chloride for Dust Suppression

Appendix B. Comparison of Calcium Chloride and Magnesium Chloride for Dust Suppression

Source	Application	Functional Mechanism	Performance Advantages	Performance Restrictions
Calcium Chloride				
Three forms: ■ Type I flake, at 77% to 80% purity. ■ Type II flake, at 94% to 97% purity. ■ Clear liquid at 35% to 38%.	■ Usually, one to two treatments per year. ■ Follow-up: apply 1/2 to 1/3 initial dosage. **Flakes:** ■ Initial application, flake: at 0.5 to 1.1 kg/m^2. **Liquid:** ■ Typical application 0.9 kg/m^2. ■ Typical application liquid: 35% to 38% solution at 0.9 to 1.6 l/m^2.	■ Attracts and retains moisture at a relative humidity of 29% at 25°C and 20% humidity at 38°C. ■ Assists compaction. ■ Treated road can be regraded and recompacted with less concern for losing moisture and density.	■ Retains moisture and attracts moisture from the air. ■ Lowers freezing point of water minimizing frost heave and reducing freeze-thaw cycles. ■ Increases compacted density of road material. ■ Effectiveness retained after reblading.	■ Slightly corrosive to steel (also some stainless steel), highly to aluminum and its alloys. ■ Rainwater tends to leach out highly soluble chlorides. ■ If high fines content in treated material, the surface may become slippery when wet.
Magnesium Chloride				
■ Produced from natural salt brine. ■ By-product of potash production.	■ Usually, one to two treatments per year. ■ Initial application: 28-35% solution. ■ Typical application: 1.4 to 2.3 l/m^2. ■ Follow-up: apply 1/2 initial dosage.	■ Attracts and retains moisture at a relative humidity equal to or greater than 32% independent of temperature. ■ More effective than calcium chloride solutions for increasing surface tension, resulting in a very hard road surface when dry. Treated road can be regraded and recompacted with less concern for losing moisture and density.	■ Reduces evaporation rate of moisture in the road. ■ Lowers freezing point of water minimizing frost heave and reducing freeze-thaw cycles. ■ Increases compacted density of road material more so than calcium chloride.	■ Corrosive to steel, though inhibitors can be added. ■ Solubility results in leaching during heavy precipitation.

Appendix C

Comparison of Chemical Dust Suppressants

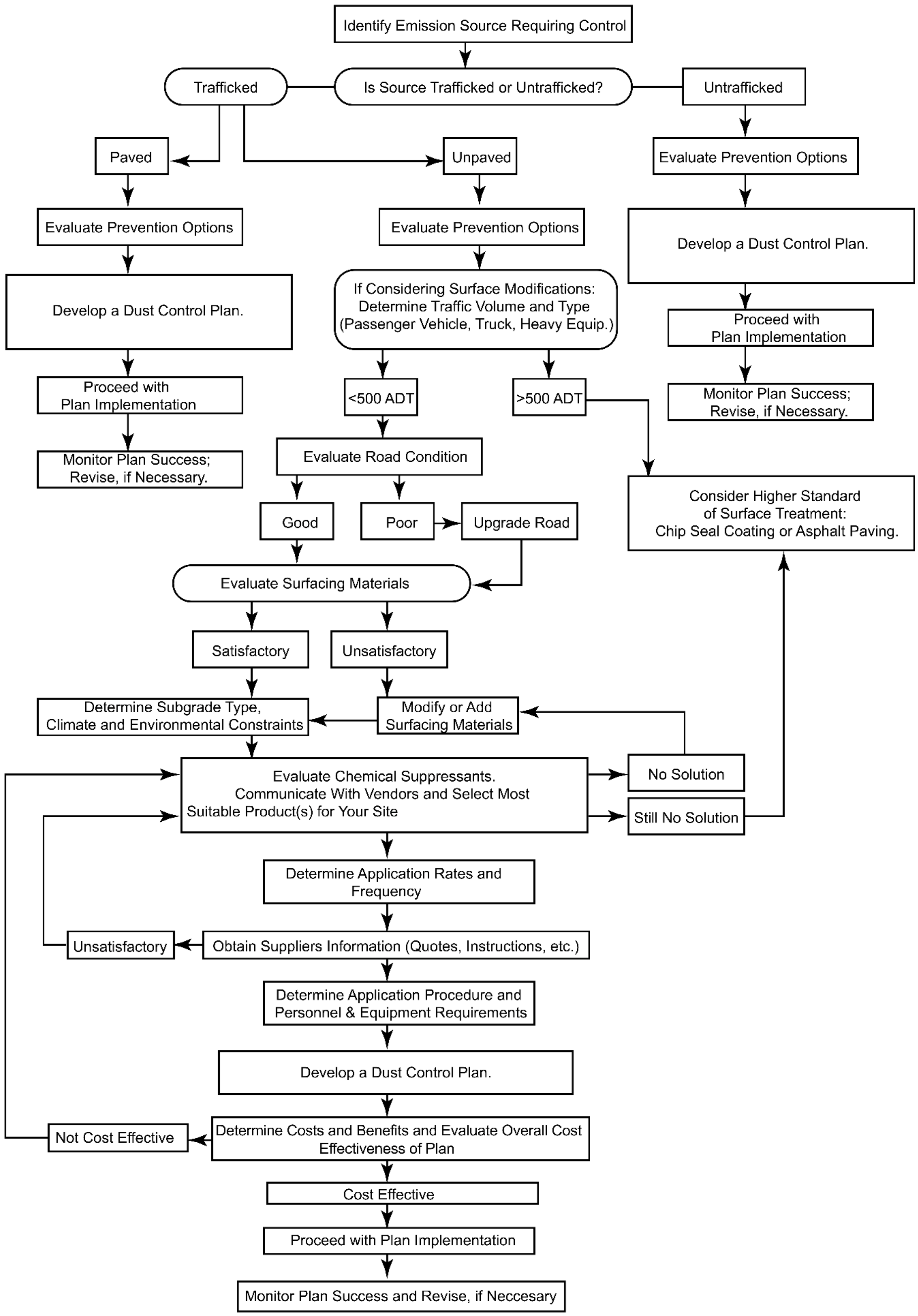
Appendix C. Comparison of Chemical Dust Suppressants

Types	Source	Functional Mechanism	Application	Performance Advantages	Performance Limitations	Environmental Considerations
Lignin Derivatives	■ Paper-making industry by-product containing lignin and carbohydrates in solution. Specific composition depends on chemicals and processes used to extract cellulose.	■ Act as adhesives, binding road surface particles together.	■ one or two treatments a year, typically. ■ 10–25% solution 2.3–4.5 L/M2	■ Greatly increases dry strength of road surface materials. ■ Imparts some plasticity to road surfaces; lowers freezing point of road surface and base. ■ Effectiveness retained after reblading.	■ Can be leached out of the road during heavy precipitation ■ (CaCO3 added ingredient, can neutralize acidity). ■ Proper aggregate mix (4%–8% fines) is important to performance. ■ Becomes slippery when wet, brittle when dry.	■ Lignin products have a high BOD (biological oxygen demand) in aquatic systems. ■ Spills or runoff into surface or groundwaters may create low dissolved oxygen conditions that are detrimental to aquatic life.
Synthetic Polymer Emulsions	■ Synthetic formulations composed of polyvinyl acetates, vinyl acrylic copolymers, copolymer methacrylates polybutadiene.	■ Bind road surface materials together by adhesion.	■ Usually, one treatment Lasts two years. ■ 40%–50% solution 1.4–4.5 l/m2	■ Applicable to a range of emission sources ■ Functions well in sandy road surface materials. ■ Some types allow seeded vegetation to grow through the polymer matrix.	■ Require proper weather conditions and time to cure; may be subject to UV (sunlight) degradation. ■ Application equipment requires timely cleaning ■ No residual effectiveness after reblading.	■ None.
Bitumens, Tars and Resins Residual Fuel Oil Technical White Oils Fuel Oils #4, #5, #6	■ Petroleum, coal and plastics industry by-products.	■ Asphalt and resinous products are adhesive. ■ Petroleum oil products coat road surface particles, increasing their mass.	■ Refer to manufacturer's guidelines.	■ Water insoluble when dry; provide a degree of surface waterproofing. ■ Good residual effectiveness.	■ Surface crusting, fracturing and potholes may develop. ■ Long-term application may cause road to become too hard for reblading. ■ Will not prevent frost heave.	■ Application of used oils is prohibited. ■ Some petroleum-based products may contain PAHs.

Appendix D

Decision Flowchart

Appendix D. Decision Flowchart



Appendix E

New Brunswick DoT Checklist

Appendix E. New Brunswick DoT Checklist

The following checklist was adapted from the checklist Protection Measure / Environmental Consideration for dust control included in the New Brunswick Department of Transportation *Environmental Management Manual*. (NBDT, 2010):

- Try to limit activities that generate fugitive dust during high winds.
- A permit must be obtained for the withdrawal of water from a watercourse and must be available on the work site
- Are field staff familiar with the requirements?
- Water trucks shall not be driven into a watercourse/wetland.
- Water trucks shall not be driven down to the edge of the watercourse/wetland unless the area is firm enough so that this action does not cause rutting.
- If the existing ground becomes disturbed, are there the appropriate erosion control measure materials available for immediate installation?
- Rock and gravel may be moved by hand to obtain a pool for a suction pipe, but a pool cannot be created by using any powered equipment.
- Ensure that the amount of water withdrawn from the water source is not excessive.
- Ensure that the intake hose is properly screened.
- If a petroleum leak occurs, do you have a spill kit available?
- Ensure that the water truck is not leaking petroleum product and is not re-fuelling or getting services within 30 m of a watercourse/wetland.
- The water trucks shall have a method of controlling the application rate, so that no excess water flow into a watercourse/wetland.
- Ensure that water (runoff) does not directly enter any watercourse/wetland.

Appendix F

Example Mitigation Costs – Unpaved Roads

Appendix F. Example Mitigation Costs – Unpaved Roads

Available control options vary in terms of cost, efficiency, environmental impact and applicability. Ultimately, when developing control plans, both the type and amount of traffic and how long the road will be in service need to be considered. (U.S. EPA AP-42, 2025).

One of the more important aspects of mitigation is cost. At a high level, factors affecting cost are:

- **Surface Type:** The type of surface (gravel, asphalt, concrete) significantly impacts the overall cost.
- **Surface area:** The longer the road, the higher the total cost.
- **Material Costs:** Fluctuations in the price of asphalt and other materials can affect the final price.
- **Labour Costs:** The cost of labour for construction and paving can vary.
- **Site Conditions:** Factors like soil type, drainage and existing infrastructure can affect the cost.
- **Contractor Fees:** Different contractors have different pricing structures.

Product used in Alberta and adjacent jurisdictions include:

- Durasoil is being used on haul roads by Brion Energy, including roads with heavy vehicles and is used on roads in Alaska
- Roadtek is listed as a **Proven Product** under Alberta Transportation's Products List, Dust Abatement. Roadtek is manufactured in Alberta by Guardian Chemicals
- EcoAnchor is listed as a **Proven Product** under Alberta Transportation's Products List, Dust Abatement. EcoAnchor is manufactured in Alberta by Landloc
- Soiltac is being used by *Airdrie* BMX Club and Okotoks BMX Club on their track. It is used on roads in Muskeg River Mine and Jackpine Mine (Canadian Natural Resources Limited). It is also used on roads in Alaska.

Paving a two-lane road in Alberta (as an example), probably the most expensive dust mitigation option, can cost from $100,000 to $1,000,000 per mile, depending on the type of surface (gravel, oil/dust control or hot-mix asphalt). Cypress County shows the following costs (https://www.cypress.ab.ca/p/roads#:~:text=Road%20Construction)

- **Gravel Road:** A high-grade gravel road can cost around $62,000/km ($100,000 per mile).
- **Oil or Dust Control Surface:** Adding an oil or dust control surface to a gravel road can increase the cost by $100,000 per mile.
- **Hot-Mix Pavement:** Hot-mix pavement (asphalt) can cost about $1,000,000 per mile.

The City of Calgary posted that **Backlane Paving** costs range from $6950 to $7600 per back lane, per property owner (for a property 15.24 m wide), with an amortized cost of $660 to $720 per year. https://www.calgary.ca/roads/back-lane-paving.html

In Alberta, the cost of dust suppression by road watering varies by municipality, with some charging by the linear metre (e.g., $6.50/metre up to 200 metres, then $13.00/metre). Others charge a flat rate per 100 metres (e.g., $200 plus GST). https://www.sturgeoncounty.ca/roads-transportation/dust-suppression/.

Examples of costs for application of chemical dust suppressants on Alberta roads.

- **Sturgeon County:** The cost to apply dust suppression is shared between the County and resident. Fees vary based on the type of suppressant used and the length of application.
  - CaCl2 with a rust inhibitor – a fee of $405 for the first 100 m and $118/10 m for additional length up to 100 m.
  - Mineral oil – a fee of $1097 for the first 100 m and $187.20/10 m for additional length up to 100 m. Mineral oil is placed over a thin layer of recycled, crushed asphalt millings instead of being placed directly on bare gravel.
  - Oil – a fee of $4,165 for the first 100 m and $494/10 m for additional length up to 100 m.

  https://www.sturgeoncounty.ca/roads-transportation/dust-suppression/

- **Municipal District of Taber:** The municipality charges $1.42 per linear foot, with a minimum length of roadway treatment of 122 metres (400 feet) for MG30 (a blend containing calcium chloride and magnesium hydroxide)
  https://www.mdtaber.ab.ca/p/dust-suppression#:~:text=cost.
- **Leduc County:** Residents desiring dust control product on the county road adjacent to their residence pay for
  - $CaCl_2$ – a fee of $640.45 plus GST for the first 122 metres (400 feet). Cost beyond 122 metres is an additional $10.50/metre. Two applications. Lasts one season (until Fall).
  - DL10 (petroleum-based) – a fee of $4359.55 plus GST for the first 122 metres. Cost beyond 122 metres is an additional $40.98/metre. One application. Lasts one year from application.

  https://www.leduc-county.com/en/living-here/dust-control.aspx
  https://calendar.leduc-county.com/Meetings/_Download/20f668bf-361f-4b08-b371-ab68007e369e
  https://calendar.leduc-county.com/Default/Detail/2020-05-15-0000-2020-dust-suppression-program

An Alberta publication *Used Oil as Dust Suppressant* (Alberta Environment and Sustainable Resource Development, 2012) under Acceptable Industry Practices (AIP) presents costs for various dust mitigation practices. While more than a decade old, the table reproduced below provides a useful rank comparison specific to Alberta experience.

Dust Suppressant	Advantages	Disadvantages	Quantity (L/km)	2012 cost / km·year
Water and Wetting Agents	no environmental impact	■ short term ■ frequent application ■ erosion	6 000	$17 000 to $40 000
Calcium Chloride	effective in areas with relative humidity greater than 30%	■ impact to water supplies ■ soil salinization and reclamation ■ harmful to plant life ■ harmful to aquatic species	15 000	$2 500 to $7 000
Lignosulfonates	effective	■ moderately toxic to plant life and rainbow trout	20 000	$2 500 to $7 000
Oil-based (asphalt emulsions, used oils, crude oil, etc.)	effective	■ may have adverse impact on vegetation, soil, or water supplies	15 000	up to $7 000

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