Confined Feeding Operations: Management Mechanisms

A report to the CASA CFO Project Team
from the Management Mechanisms Subgroup

DRAFT for discussion purposes only

October 17, 2007

Acknowledgements

The Management Mechanisms Subgroup of the Confined Feeding Operations Project Team gratefully acknowledges the contribution of stakeholders to this work. A number of subgroup and team members supported the subgroup's work by hosting meetings and contributing valuable staff resources behind the scenes. All members of the subgroup were very committed to completing their task and the volunteer time and energy is very much appreciated. The work of Atta Atia and Ike Edeogu with Alberta Agriculture and Food to prepare the first draft of the report is particularly acknowledged.

Purpose of this Report

This report from the Management Mechanisms Subgroup of the Confined Feeding Operations Project Team recommends how the CFO team can move forward on management mechanisms. The report focuses on the points noted in task 7 of the subgroup's terms of reference; specifically, it:

- Assesses the effectiveness of various management mechanisms using the criteria described in the terms of reference,
- Summarizes stakeholder concerns and includes proposals for addressing them, and
- Recommends management options for mitigating air emissions from CFOs.

Contents

Executive Summary **1**

1 Introduction **5**

2 Stakeholder Concerns **6**

3 Conclusions and Recommendations **7**

3.1 Draft Priority Management Mechanisms **7**

3.2 Further Review of Management Mechanisms **12**

3.3 Information for Producers **13**

Appendix A: CFO Management Mechanisms Subgroup Members **14**

Appendix B: CFO Management Mechanisms Subgroup Terms of Reference **15**

Appendix C: Management Mechanisms Matrix **16**

Appendix D: Management Mechanisms Preferred by Public Service and Industry Caucuses **43**

Appendix E: Management Mechanisms Preferred by Non-Government Organization (NGO) Caucus **53**

List of Tables

Table 1. Summary of Priority Management Mechanisms 8

Table 2. First Order Assessment Criteria used to Rank CFO Management Mechanisms Matrix 43

Table 3. Second Order Assessment Criteria used to Rank CFO Management Mechanisms Matrix 43

Table 4. Management Mechanism Matrix Ranked in Order of Preference by Public Service and Industry Caucuses 46

Executive Summary

As part of its mandate, the Clean Air Strategic Alliance (CASA) Confined Feeding Operation (CFO) project team aims to develop a strategic plan to improve the management of air emissions from existing and future CFOs in Alberta. To help it with this task, the project team established four subgroups to address particular components of the team's terms of reference. The Management Mechanisms (MM) subgroup was asked to:

- Determine stakeholder concerns with respect to emissions from CFOs,
- Identify technologies and management practices that have the potential to mitigate, reduce, minimize or eliminate emissions from CFOs in Alberta, and
- Generate and forward a list of recommended MM for further consideration by the project team.

Representatives from the three sectors (industry, non-government organizations, and public service representing different federal, provincial and municipal governments, and quasi-judicial agencies) worked together on these three key tasks. To summarize, some of the potential goals and concerns raised were:

- Reduced emissions
- Reduced cost
- Competitiveness in a global market place
- Certainty about any future regulatory/management regime
- Safety of products
- Health of consumers
- Keeping business in Alberta
- Open-mindedness
- Moving Alberta forward on environmental issues
- Co-benefits/synergies
- Improved stakeholder relationships

The subgroup then created a matrix of management mechanisms (technologies and management practices) with the potential to reduce, eliminate or minimize emissions of six substances: ammonia, hydrogen sulphide, odour, particulate matter (PM), pathogens and volatile organic compounds (VOC), either directly from CFOs or from associated activities. The matrix template included the following categories:

- Type of MM
- Substances MM has been reported to reduce or is believed to reduce
- Potential reduction as a percentage or otherwise
- Practicality of using the MM
- Cost and benefit of the MM
- Gaps in knowledge or information regarding the MM
- References

Some management mechanisms will have benefits for all stakeholders and these may not be readily quantifiable.

The management mechanisms were arranged within eight categories representing various aspects of a CFO where a management mechanism might be applied. The following categories were used:

- Animal Housing
- Animal Management
- Manure Application
- Manure Storage Facilities
- Manure Treatment
- Land Use Planning
- Quality Assurance Program
- Roadway Management

All subgroup members then had an opportunity to rate the management mechanisms using the following descriptors:

- Proven technology
- Cost-benefit assessment
- Commercial availability
- On-farm practicality
- Negative residual effects
- Emission reduction greater than 50%
- Emission reduction greater than 75%

Assessment and evaluation details are provided in Appendix D of this report. The industry and public service caucuses agreed on their ratings and came up with one list, while NGOs developed their list separately (see Appendix E).

The last step in the process was to review the two lists and arrive at one short list. The subgroup reached consensus on a short list of eight potential management mechanisms that it deems worthy of further detailed investigation:

- Frequent manure removal
- Moisture management
- Biocovers
- Bottom loading
- Shelterbelts
- Band spreading with rapid incorporation and/or manure injection
- Composting
- Dust palliatives used for roadway management

The table below summarizes the benefits and possible risks of each mechanism.

Summary of Priority Management Mechanisms

Management Mechanism	Category	Substances Addressed	Risks and Residual Effects
Frequent manure removal	Animal Housing	PM, odour, H_2S, NH_3	• Increased energy and labour
Moisture management	Manure Treatment	Odour, pathogens, PM	• Alternate between risk of increasing odour and increasing dust
Biocovers	Manure Storage Facilities	NH_3, H_2S, odour	• Sustainability • Improper management
Bottom loading	Manure Storage Facilities	NH_3, odour	• Retrofit costs • Effects on all emissions
Shelterbelts	Animal Housing	PM, odour	• Won't reduce emissions
Band spreading with rapid incorporation and/or Manure injection [to be discussed by the team]	Manure Application	NH_3, odour	• Cost • Practice change • Increased NOx and flies
Composting	Manure Treatment	NH_3, pathogens	• Increased NH_3 and NOx
see category Dust palliatives	Roadway Management	PM	• Potential effects of palliatives used

The subgroup agreed that more information and an assessment of mechanisms is needed, as we do not know all the risks and benefits. The first stage of the study recommended below should help to highlight these.

Thus the subgroup is recommending to the CFO project team that further investigation be undertaken to determine the ability of each management mechanism to reduce emissions of all six substances, and to scientifically quantify the reductions and document any negative residual effects of the mechanisms.

Recommendation 1: Further Investigation of Priority Management Mechanisms

The Management Mechanisms Subgroup recommends that:

A multi-stakeholder group should be formed to oversee a two-stage study.

Phase 1: Paper Study: The purpose of the paper study would be to narrow the short list of eight to two or three of the most promising MMs. A consultant, agreed to by consensus, should review and assess data on the eight MMs to determine their potential effectiveness, substances they mitigate, their cost, risks and environmental and economic benefits. In addition to reviewing data, the consultant would be asked to talk directly to the researchers of previous studies to find out what they did and assess the credibility of the work. This work may take one year or more and should be funded in a multi-stakeholder fashion to ensure participation and ensure the outcome is to the satisfaction of stakeholders.

Phase 2: Scientific experiment: Phase 2 would be an in-depth look at the two or three most promising MMs, at an estimated cost of at least $500,000 per MM. To the extent possible, work will be coordinated with other agencies, and will look at ways to improvise and use existing approaches that don't require operators to make large capital investments. The intent is to identify solutions that can be implemented, and to focus on addressing air emissions specifically, without causing adverse negative effects.

Recommendation 2: Factors to Consider in Further Reviews of Management Mechanisms

The Management Mechanisms Subgroup recommends that the following variables be considered in further reviews of possible management mechanisms:

- **Different types of operations** (hog, dairy, etc) will have differing objectives and emissions, potentially requiring the use and application of different mechanisms.
- **Variability within operations of the same type** further complicates the picture (e.g., even though two operations are both feeding chickens, they may be of different sizes and have different circumstances).
- **Environmental performance** varies across the industry.
- **Different regulations and rules** apply depending on the time of the permit, and some operations are grandfathered. Therefore, some MMs are already dealt with by regulations, while others are not. Furthermore, not all operations are bound by regulations.
- **Different ages and sizes of operations**: Some operations may not be around for that much longer, while some have a long-term time horizon. Size is also an important factor and influences the potential emissions from an operation as well as the possible management options. Overall, management has more effect on emissions than age or size of the operation.

1 Introduction

As part of its mandate, the Clean Air Strategic Alliance (CASA) Confined Feeding Operation (CFO) project team aims to develop a strategic plan to improve the management of air emissions from existing and future CFOs in Alberta. To help it develop a strategic plan, the CFO project team established four subgroups to address particular components of the team's terms of reference. The Management Mechanisms (MM) subgroup was charged with identifying technologies and management practices that have the potential to mitigate, reduce, minimize or eliminate emissions from CFOs in Alberta. Furthermore, the subgroup was asked to generate and forward a list of recommended MM for further consideration by the project team at the end of its assignment. The members of the Management Mechanisms Subgroup are noted in Appendix A and complete details of the subgroup's mandate appear in the Terms of Reference in Appendix B.

One of the first tasks was to identify all the stakeholder concerns related to CFOs so that these could be considered when developing management mechanisms. These concerns are noted in section 2. The next task was to create a matrix of MM; i.e., a tabulated list of MM that have the potential to reduce any or all of the following substances: ammonia (NH_3); hydrogen sulphide (H_2S); odour; particulate matter (PM); pathogens (including bioaerosols); and volatile organic compounds (VOCs). The matrix provided specific information on each MM according to the following criteria: affected substances; potential reduction; practicality; cost and benefit and; information or knowledge gaps. Furthermore, the MM were categorized according to the source of emissions or concern. For instance, MM to mitigate emissions from animal housing facilities were grouped together. The complete MM matrix, along with additional flow chart information on four substances and a full list of references, is presented in Appendix C.

The subgroup then prioritized the MM in the matrix. Industry, Non-government Organization (NGO) and Public Service members of the subgroup worked in their caucuses to review the matrix and prioritize the MM in their order of preference, documenting any procedures or criteria they used to rate the various MM. The Public Sector and Industry caucuses developed their priorities in concert, and this list appears in Appendix D. The NGO caucus preferences are shown in Appendix E.

The subgroup then met to review and discuss the two lists and collaboratively developed a short list of eight MM that it agreed to recommend to the CFO project team. The short-listed MM for consideration by the CFO project team are presented and described in Section 3, along with some important conclusions reached by the subgroup.

2 Stakeholder Concerns

The stakeholder concerns listed below are a compilation of concerns presented by each caucus to the MM subgroup. They are not presented in any order of priority, nor are the sources of the concerns identified.

- Emissions from the CFO facility itself. These include emissions from barns and feedlots, ventilation systems and manure storage facilities.
- Emissions following the application of manure on land.
- Impact of high dust levels generated daily by truck traffic on unpaved municipal roads.
- Property value (resale of land).
- Is it worth making improvements to that property? (example, a new house).
- Health concerns (breathing, vomiting, bloody noses, headaches, mood changes, diarrhea).
- Livestock health.
- Employee health.
- Long-term health effects of exposure to CFO emissions.
- Social issues (personal, family, community levels) and negative implications on quality of life e.g. loss of sleep due to poor ventilation in attempt to restrict odours entering residence.
- Public perception and mistrust of “farmers” - financial implications.
- Enjoyment of property (playing, working outdoors, improvement to property may not be worthwhile).
- Threat of more CFO expansion under existing legislation & regulations.
- Public air quality concerns are being brushed off as “nuisance” when levels of emissions are unbearable.
- Dust from CFOs, particularly under hot, dry, and calm conditions.
- Do the emissions from CFOs and the dust affect the quality of food from local gardens or market gardens in the vicinity of CFOs? Emissions are comprised of many compounds - are they absorbed by plants through the soil or rainfall? Is the quality of our food supply being affected by such emissions?
- Agricultural emissions form a significant portion of nitrogen (and other) emissions in Alberta and have implications on the rest of Canada.
- Failure to reduce emissions and/or manage emissions to minimize environmental impacts locally and in particular, on a larger scale.
- Lack of effective monitoring to determine biological and chemical processes and consequent environmental impacts.
- The need to achieve environmental and economic sustainability in livestock production.
- Inadequate mechanism to deal with odour complaints.
- Impact of emissions on the well being of the public.
- Inability to reach agreements promptly, i.e., by bringing industry, government and NGOs together cooperatively to tackle issues.

- Air quality may become a barrier to growth and/or competitiveness of the livestock industry.
- Inability to develop and implement air quality standards relative to biological, non-point sources.
- Use of air quality issues as an indirect means to resolve land use or other conflicts?
- Lack of cost effective options/alternatives to manage air quality emissions from confined feeding operations.
- Unequal and unfair treatment across industries in the province and within the agriculture sector.
- Failure of existing or proposed air quality standards to recognize, accommodate and account for the uniqueness of different industries in the province.
- The CFO industry is concerned that it will face emission standards that are not appropriate for the level of risk associated with CFO emissions and will make CFOs uncompetitive and uneconomical.
- CFOs often face strong pressure to adopt management mechanisms that are used in other areas of the world where the political, economic, social and climatic conditions are very different from those in Alberta.
- Opponents of CFOs, regulators, and political decision makers often insist on the use of management mechanisms that are not feasible or are prohibitively expensive as a method of restricting or eliminating CFO development.

3 Conclusions and Recommendations

3.1 Draft Priority Management Mechanisms

All three sectors were actively involved in the prioritization process and agreed on eight management mechanisms that the subgroup believes are worthy of further investigation; these are listed in order of how many of the six priority substances the mechanism addresses. The subgroup is of the view that more work is needed to determine the ability of each mechanism to reduce emissions of all six priority substances, scientifically quantify the reductions and document any residual effects of the mechanisms.

- Frequent manure removal
- Moisture management
- Biocovers
- Bottom loading
- Shelterbelts
- Band spreading with rapid incorporation (within 12 hours) and/or manure injection [to be discussed by the team]
- Composting
- Dust palliatives for roadway management

All eight MMs target reduction of physical emissions and nuisances, as opposed to being designed to address health or other effects. Seven of these MMs address the source of emissions, shelterbelts being the exception, which was seen as positive by the subgroup, because in terms of efficiency, costs and benefits, it is better to deal with emissions at source.

To assist the team in determining priority areas for further work, the subgroup prepared a table that summarizes some of the key considerations. Each of the eight mechanisms is described in more detail below.

Table 1. Summary of Priority Management Mechanisms

Management Mechanism	Category	Substances Addressed	Risks and Residual Effects
Frequent manure removal	Animal Housing	PM, odour, H_2S, NH_3	• Increased energy and labour
Moisture management	Manure Treatment	Odour, pathogens, PM	• Alternate between risk of increasing odour and increasing dust
Biocovers	Manure Storage Facilities	NH_3, H_2S, odour	• Sustainability • Improper management
Bottom loading	Manure Storage Facilities	NH_3, odour	• Retrofit costs • Effects on all emissions
Shelterbelts	Animal Housing	PM, odour	• Won't reduce emissions
Band spreading with rapid incorporation and/or Manure injection [to be discussed by the team]	Manure Application	NH_3, odour	• Cost • Practice change • Increased NOx and flies
Composting	Manure Treatment	NH_3, pathogens	• Increased NH_3 and NOx
see category Dust palliatives	Roadway Management	PM	• Potential effects of palliatives used

Frequent Manure Removal

This management mechanism may be applied to indoor (barn) or outdoor (feedlot pens) animal housing facilities. It requires an increased number of manure removal activities from a facility by scrapping, flushing or some other practice. Note that it only addresses the removal of manure from the facility but does not address how the manure is handled once removed from the facility.

Compared to the other management mechanisms under the animal housing category, frequent manure removal is considered to be relatively cheaper than some of the other mechanisms. Furthermore, it targets manure, which is the primary source of emissions. If technology is not used (e.g., scrappers), it may require increased use of labour.

Further investigation of this management practice is recommended to determine factors such as costs associated with increased energy or labour use. Furthermore, additional assessment of the optimum removal frequency for manure from various livestock types and the effect on air emissions is recommended.

Moisture Management

The aim of this prospective management mechanism is to control moisture content of manure in feedlot pens or manure litter. Means through which this may be achieved include installing proper drainage systems (e.g., minimum pen slope requirements as noted in the Agricultural Operations Practices Act and Regulations), minimizing opportunities for spills to occur, and others. However, issues related to practicality and the cost of implementing such a mechanism do not seem to be well defined.

Further investigation of this management practice is recommended to identify additional methods that may be used to control the moisture content of manure by CFOs. Furthermore, the effects of controlling manure moisture content on all emissions from CFO manure storage facilities need to be quantified and potential residual negative effects documented.

Biocovers

The use of biocovers to mitigate emissions from manure storage facilities involves the application of bio-degradable organic matter on the surface of such facilities. Organic matter includes material such as wheat straw, barley straw and oat straw. Since these materials are often readily available to CFO producers, it helps to keep the cost of this management mechanism low compared to some of the other mechanisms within the manure storage facilities category.

Further investigation of this management practice is recommended to quantify the effects of biocovers on all emissions from CFO manure storage facilities. Furthermore, potential negative effects of utilizing this management mechanism need to be well documented.

Bottom Loading

This management mechanism refers to filling manure storage facilities below the manure surface. By loading the facilities below the surface, splashing or agitation of manure is avoided and the release of highly concentrated emissions into the air is minimized. The Agricultural Operations Practices Act and Regulations (AOPA) requires CFOs to install bottom loaded manure storage facilities.

Further investigation of this management practice is recommended to quantify the effects of bottom loading on all emissions from CFO manure storage facilities. Furthermore, the requirements and cost of retrofitting non-AOPA-regulated CFOs with “bottom loading” systems are unknown.

Shelterbelts

Unlike other management mechanisms on the short list, shelterbelts do not deal with the source of the emissions, but rather the aftermath. However, unlike other management mechanisms that also target emissions from the source, this mechanism has a number of potential benefits.

Firstly, as emissions leave the animal housing facility, the trees in a shelterbelt force the air into the upper atmosphere where additional mixing and dilution, is expected to occur. In some cases, such as low wind speed days, emissions from the housing facilities may be trapped in the foliage of the trees preventing further dispersion downwind.

Secondly, the presence of trees around a housing facility can reduce the "wind chill" effect on the facility. This implies that energy requirements to counter heat losses will also be reduced, and may result in energy savings.

Finally, a shelterbelt may improve the aesthetics of a farm site, thereby placing housing facilities out-of-sight. This may have the psychological benefit of limiting complaints to occurrences that are genuine.

Further investigation of this management practice is recommended to quantify the effects of shelterbelts on all emissions from CFOs. Furthermore, potential negative effects of this management mechanism need to be well documented.

Dust Palliatives for roadway management

This management mechanism focuses on mitigating the emission of particulate matter from road surfaces as a result of truck traffic to and from CFOs. A number of dust palliatives, including water, are used to keep dust levels low. It seems that there are pros and cons of using any of these palliatives.

Further investigation of dust palliatives is recommended to quantify the effects of this management mechanism on dust emissions from roadways in the vicinity of CFOs. In addition, the potential negative effects of the different palliatives need to be well documented.

Band Spreading with rapid incorporation and/or Manure Injection

Band spreading refers to the application of manure just above the ground surface through a series of trailing pipes. Manure is released right at the ground surface where the mean wind speed is zero or approaches zero. This helps to keep the emissions localized to the application site and is best followed by immediate incorporation. Unlike manure injection, band spreading is considered to be a cheaper practice to mitigate the release and transportation of emissions from manure applied on land. It is probably also a technique to which CFO operators can easily adapt.

The AOPA contains specific requirements for the application of manure. Section 24 addresses Manure Application Limits, noting:

> *24(1) A person must apply manure, composting materials or compost only to arable land and, subject to subsections (5) to (7), if applied to cultivated land, the manure, compostable materials or compost must be incorporated within 48 hours of application.*
>
> *(2) An applicant for an approval or registration or an amendment of an approval or registration must satisfy an approval officer or the Board that for the first year following the granting of the application, the applicant*
>
> > *(a) has access to sufficient land, to meet the land base requirements determined in accordance with the Code,*
> >
> > *(b) has a nutrient management plan that indicates that the applicant has access to sufficient land for application of the manure to be produced, or*

(c) has a manure handling plan that reduces or eliminates the need to comply with the land base requirements determined in accordance with the Code.

(5) A person may apply manure, composting materials and compost without incorporation

(a) on forage or directly seeded crops, and

(b) subject to subsections (6) and (7), on frozen or snow-covered land, if the manure, composting materials or compost is applied at least 150 m from any residence or other building or structure occupied by people.

(7) If the Board considers that weather conditions prevent the normal application of manure, composting materials or compost, the Board may permit, by a notice, the owners or operators of confined feeding operations or manure storage facilities described in subsection (6) to apply manure, composting materials and compost on frozen or snow-covered land in a geographical area, within a set time and subject to any other conditions imposed by the Board in the notice.

Further investigation of this management practice is recommended to quantify the effects of band spreading on all emissions from land-applied manure by CFOs. Furthermore, potential negative effects of utilizing this technique need to be well documented.

Composting

Composting is an aerobic process that facilitates rapid microbial decomposition of organic matter (e.g., manure) into a stable end product. Compost is purported to have several benefits including stabilization of organic matter in the manure, destruction of pathogens and weed seeds, improved nutrient quality and is a good soil conditioner. The key to the success of this management mechanism is to ensure that the conditions required for the aerobic decomposition to occur are adequately met. These conditions include the correct proportions in a mixture of a nitrogen source (e.g., manure) and a carbon source (e.g., wheat straw), moisture content, porosity, oxygen availability, temperature and acidity. Often it is the effort (cost, time, labour) associated with meeting these requirements that is the drawback to the adoption of composting as a manure treatment practice.

Further investigation of this management practice is recommended to quantify the effects of composting on all emissions from CFO manure storage facilities. Furthermore, potential negative effects of utilizing this management mechanism need to be well documented.

The subgroup observed throughout its own research and discussions that there continue to be very large gaps in information and, in reality, the suite of available MMs is limited. Information gaps are deep and wide in terms of effectiveness, costs, possible synergistic effects, co-benefits, and actual starting points for emissions. Much more information is needed in order to select and apply the most appropriate management mechanism(s), because there will always be tradeoffs and it is impossible to reduce emissions to zero. It might also be necessary to use more than one technology to solve a problem; e.g., ammonia emissions come from different sources and each source may need a different technique. Also, different mechanisms may be needed for each substance. Each category might require different mechanisms, and even within each category a range of approaches may be needed.

Recommendation 1: Further Investigation of Priority Management Mechanisms

The Management Mechanisms Subgroup recommends that:

A multi-stakeholder group should be formed to oversee a two-stage study.

Phase 1: Paper Study: The purpose of the paper study would be to narrow the short list of eight to two or three of the most promising MMs. A consultant, agreed to by consensus, should review and assess data on the eight MMs to determine their potential effectiveness, substances they mitigate, cost, and their risks. In addition to reviewing data, the consultant would be asked to talk directly to the researchers of previous studies to find out what they did and assess the credibility of the work. This work may take one or more years and should be funded in a multi-stakeholder fashion to increase credibility of the results.

Phase 2: Scientific experiment. Phase 2 would be an in-depth look at the two or three most promising MMs, at an estimated cost of at least $500,000 per MM. To the extent possible, work will be coordinated with other agencies, and will look at ways to improvise and use existing approaches that don't require operators to make large capital investments. The intent is to identify solutions that can be implemented, and to focus on addressing air emissions specifically without causing adverse negative effects.

3.2 Further Review of Management Mechanisms

During its discussions, the subgroup noted a number of important points and factors that influence the potential management mechanisms that could be considered by confined feeding operators. These factors should be taken into account in any further reviews of potential management mechanisms.

Recommendation 2: Factors to Consider in Further Reviews of Management Mechanisms

The Management Mechanisms Subgroup recommends that the following variables be considered in further reviews of possible management mechanisms:

- **Different types of operations** (hog, dairy, etc) will have differing objectives and emissions, potentially requiring the use and application of different mechanisms.
- **Variability within operations of the same type** further complicates the picture (e.g., even though two operations are both feeding chickens, they may be of different sizes and have different circumstances).
- **Environmental performance** varies across the industry.
- **Different regulations and rules** apply depending on the time of the permit, and some operations are grandfathered. Therefore, some MMs are already dealt with by regulations, while others are not. Furthermore, not all operations are bound by regulations.

- **Different ages and sizes of operations**: Some operations may not be around for that much longer, while some have a long-term time horizon. Size is also an important factor and influences the potential emissions from an operation as well as the possible management options. Overall, management has more effect on emissions than age or size of the operation.

3.3 Information for Producers

The subgroup felt it was essential to narrow the list of potential management mechanisms because of the many challenges in trying to assess a very long list. However, it is clear that CFOs vary a great deal and that some mechanisms not on the short list could work very well in certain circumstances. No one approach is likely to solve all the problems. Some MMs will be more appropriate in some situations than others. It’s up to individual operators to consider the full range of options and how these options might be applied to their operations. Thus, the subgroup feels strongly that the full list of management mechanisms should be retained so that producers can review and consider the ones most suitable for their operations.

Appendix A: CFO Management Mechanisms Subgroup Members

Name	Organization
Atta Atia	Alberta Agriculture and Food
Ann Baran	Southern Alberta Group for the Environment (SAGE)
Kerra Chomlak	Clean Air Strategic Alliance (CASA)
Ike Edeogu	Alberta Agriculture and Food
Jim McKinley	Natural Resources Conservation Board (NRCB)
Rients Palsma	Alberta Milk
Denis Sauvageau	Friends of an Unpolluted Lifestyle (FOUL)
Carrie Selin	Alberta Milk
Barb Shackel-Hardman	Alberta Agriculture and Food
Rich Smith	Alberta Beef Producers
Ross Warner	Society for Environmentally Responsible Livestock Operations (SERLO)

Former Subgroup Members:
Matthew Dance, CASA
Kevin McLeod, CASA

Appendix B: CFO Management Mechanisms Subgroup Terms of Reference

November 29, 2006

Goal

To identify stakeholder concerns and to provide advice and direction to the Confined Feeding Operations Project Team on Management Mechanisms.

Definitions

Management mechanisms include technologies as well as approaches and practices for the management of air emissions from CFOs. For example, technologies can include bio-digesters while approaches and practices can include a range of manure management techniques and feed practices.

Key Task Areas

1. Identify and define stakeholder concerns with a focus on air quality issues in Alberta.
2. Identify management mechanisms.
3. Assess the effectiveness of management mechanisms in addressing air quality concerns from CFO's in Alberta and other jurisdictions. This assessment will include, but not be limited to, a review and discussion of:
    a. Practicality / Usability
    b. Costs and benefits (including short and long term, positive and negative, & not limited to air)
    c. Shared responsibility and funding (pertaining to implementation)
    d. A gaps analysis
    e. % Emissions change
4. Develop a work plan and budget
5. Provide regular progress updates to the CFO Team
6. Provide a summary report outlining the work and activities of the subgroup. This report should include:
    a. Assessment of effectiveness of various management mechanisms, including costs and benefit analysis as per KTA 3
    b. Summary of stakeholder concerns and proposals for addressing them
    c. Recommendations on how the CFO team should move forward and discuss

Timelines

June 2007	CFO report to the CASA Board
May 2007	CFO report complete
Feb 2007	Management mechanisms subgroup report to the CFO team
Nov 2006	Hire a contractor, if appropriate
Oct 2006	CFO Approval of an RFP and money, if appropriate
	Summary of stakeholder concerns – provided to team in advance of October 16/17 meeting

Appendix C: Management Mechanisms Matrix

Management Mechanism	Substance	Potential Reduction	Practicality	Cost and Benefit	Gaps Analysis	References
ANIMAL HOUSING						
Acid Scrubber: In an acid scrubber, the pH of the recirculation water is kept below 4 by the addition of acid, usually sulphuric acid. The ammonia dissolves in the liquid phase and is captured by the acid forming an ammonium salt solution which is discharged on a regular basis and replaced with fresh water. Sulphuric acid and/or peracetic acid.	Pathogens, Ammonia	High		Peracetic acid is exorbitant for continuous exhaust air treatment.	Limited or no info on potential reduction, practicality and costs and benefits for CFOs in Alberta.	Sommer and Hutchings (1995); Melse and Ogink (2005).
Activated Carbon Adsorption: Activated carbon is generally considered for organic gases and vapours, some inorganic gases and some metallic vapours. The mechanism which attracts and attaches the molecules to the surface of the pores known as Van der Waals forces.	VOC, Odour				-same-	Sublette et al. (1982); Dorling (1978)
Air Filtration: a. High Efficiency Particulate Air (HEPA) filters. A throwaway, extended-medium, dry-type filter in a rigid frame, having a minimum particle-collection efficiency of 99.97% (that is, a maximum particle penetration of 0.03%) for 0.3µm particles of thermally generated DOP or specified alternative aerosol	Pathogens	Maximum removal of airborne microorganisms	High pressure drop		-same-	ASHRAE (2005); IEST (2006); Nelson, et al. (1988)

Management Mechanism	Substance	Potential Reduction	Practicality	Cost and Benefit	Gaps Analysis	References
b. Ultra Low Penetration Air (ULPA) filters A throwaway, extended-medium, dry-type filter in a rigid frame, having a minimum particle-collection efficiency of 99.999% (that is, a maximum particle penetration of 0.001%) for particles in the size range of 0.01 to 0.02µm, when tested in accordance with the methods of IES-RP-CC007	-same-	-same-	-same-		-same-	ASHRAE (2005)
c. High efficiency, dry media, extended surface filters These filters have lower pressure differentials than HEPA filters operating at the same face velocity and, when properly selected, will remove the contaminants of concern.	-same-	Less removal of bioaerosols compared to HEPA and ULPA filters	Lower pressure drop; Selective removal of bioaerosols		-same-	ASHRAE (2005)
d. Antifungal treated air filters An air filter fitted with anti fungal agents.	-same-	Variable	Effectiveness limited by loading of filter with dust particles		-same-	

Management Mechanism	Substance	Potential Reduction	Practicality	Cost and Benefit	Gaps Analysis	References
Biofiltration: A type of air pollution control technology that uses microorganisms to treat odourous air.Typically comprises of a bed of organic or inorganic material (medium). As air passes through the biofilter the microbes on the bed material are expected to convert odorous gases into non-odorous compounds.	Ammonia; Hydrogen Sulphide; Odour; Pathogens; VOC	Up to 93% (NH_3) Up to 100% (H_2S) Up to 90% (Odour) Up to 70% (VOC) Up to 95% (Bacteria) Up to 60% (Fungus) Up to 90% (Endotoxins) Up to 90% (Microbial VOC)	Complicated, biologically sensitive, management intensive, treatment system. Operation may require services of contract specialist. Moisture availability is crucial for performance, among other requirements. Presence of several substances (including gases, PM, etc.) in air emissions from livestock buildings or covered manure storage facilities may affect performance, depending on the concentrations of these substances. Costly to implement when treating building air emissions from livestock operations. Extensive treatment systems are required to treat the large volumes of air exhausted from such buildings, especially during the Summer months.	Biofiltration costs for a 700-head farrow-to-wean swine facility are estimated at $0.25 per piglet, amortized over a 3-year life of the biofilter. (Power 2004). Although biofilters have been successfully used in other industries, there are few reported cases where a biofilter has been shown to be economically viable when applied to CFOs (Zahn et al., 2001). Capital costs are reduced when incorporated into new barn design		Mannebeck (1995); Hartung *et al.* (1997); Hoop (1998); Nicolai and Janni (1997, 1998a, 1998b, 1998c)

Management Mechanism	Substance	Potential Reduction	Practicality	Cost and Benefit	Gaps Analysis	References
Biomass Filter: Filtration material is mounted vertically like a series of windbreak walls. Exhaust air is forced through the filtration material as it leaves the building.	Odour; Particulate Matter	Up to 90% (dust)	Extensive treatment systems are required to treat the large volumes of air exhausted from such buildings, especially during the summer months. Efficiency drops at high summer ventilation rates.			Hoff et al. (1997)
Bioscrubber: The concept of bioscrubbing is similar to biofiltration. Both rely on microbial degradation of NH_3. The difference between bioscrubbing and biofiltration is that the bioscrubber is housed in a closed tower containing water. When ammonia passes through the tower, it will be captured and absorbed by water, then oxidized by the microorganisms. Similar to closed system biofilter. Water is sprayed into airflow stream. May or may not be used in conjunction with biofilter.	Ammonia; Hydrogen Sulphide; Odour	Up to 89% (NH_3)	Extensive treatment systems are required to treat the large volumes of air exhausted from such buildings, especially during the Summer months.	$5.70 per marketed pig per bioscrubber unit	Limited info on expected H_2S and odour reduction for CFOs in Alberta.	Schirz (1986); Bottcher et al. (1999); Feddes et al. (2001); Snell and Schwartz (2003)
Catalytic Incineration: Catalytic incineration performs the same destructive oxidation of odorous substances as thermal incineration but at a lower temperature, typically 350 to 400 °C, hence fuel consumption is lower. The oxidation reaction takes place on the surface of the catalyst rather than in free air. Fixed bed (monolith; packed bed) or; Fluid bed incinerators.	VOC, Odour	Very high odour removal efficiencies >95%	Poor feasibility due to low VOC concentrations in livestock building air emissions.		Limited or no info on potential reduction, practicality and costs and benefits for CFOs in Alberta.	USEPA (1992); USEPA (1995); USEPA (1996); Hermia and Vigneron (1993).

Management Mechanism	Substance	Potential Reduction	Practicality	Cost and Benefit	Gaps Analysis	References
Cryogenic condensation: Cryogenic condensation uses the cooling value of liquid nitrogen in a condenser to recover VOCs emitted during manufacturing processes. The system condenses VOC emissions by	-same-	Typical control efficiency range for VOCs is from 95 to >99% The control efficiency varies with condensation and			-same-	Zeiss and Ibbetson (1997); Davis and Zeiss (1997, 2002).
Cryogenic condensation Cont'd: vaporizing liquid nitrogen to provide the cooling source to indirectly cool the process stream to low temperatures.	-same-	temperature, which can be automatically controlled by adjusting the amount of nitrogen flow delivered to the process condensers.			-same-	
Floor Modification: The type and amount of floor area exposed to manure in animal housing facilities can have a significant effect on emissions.	Ammonia	Up to 57% (deep litter); Up to 46% (grooved + perforated + scraper); Up to 27% (metal slatted floor)	New barn designs			Braam et al. (1997a); Hoeksma et al. (1993); Aarnick et al. (1997); Ni et al. (1996); Swierstra et al. (1995); Braam et al. (1997b); Swierstra et al. (2001).
Flush System: Flush manure in alleys.	Ammonia	Up to 50%	Large volume of water is required.	Moderate	Limited or no info on potential reduction, practicality and costs and benefits for CFOs in Alberta.	Garcia *et al.* (2003)

Management Mechanism	Substance	Potential Reduction	Practicality	Cost and Benefit	Gaps Analysis	References
Frequent Manure Removal: Frequent scraping and manure removal. Daily bedding replacement	Ammonia; Hydrogen Sulphide; H_2S Odour; Particulate Matter (Feedlot)	Up to 91% (NH3 - poultry) Up to 79% (H_2S) Up to 50% (odour)	Frequent manure removal from barn (e.g., daily - poultry) may be an option for some operations. Biweekly pit emptying had a 79% reduction in H2S emissions compared to every six weeks		Limited or no info on potential reduction, practicality and costs and benefits for CFOs in Alberta.	Heber et al. (2001); Lorimor et al. (2002); Ivanova-Peneva, and Aarnink (2004); Lim et al. (2004).
Non-Thermal Plasma: Highly reactive radicals and plasma electrons generated by electrical discharge into the air. Odorous and toxic gases are converted to non-odorous and non-toxic compounds when passed through plasma.	Ammonia; Hydrogen Sulphide; Odour	Up to 100% (H_2S)	Extensive treatment systems are required to treat the large volumes of air exhausted from CFO buildings, especially during the Summer months.	High cost	Limited info available.	Zhang (1996); Ruan *et al.* (1997); Ruan *et al.* (1999); Wang (2001); Goodrich and Wang (2002).
Ozone Treatment: Gases are oxidized by treatment of barn air with low doses of ozone.	Ammonia; Hydrogen Sulphide; Odour	Up to 58% (NH_3) Up to 33% (H_2S)	Half-life of ozone is very short (10 to 30 minutes). It cannot be stored and must therefore be generated on-site. No significant reduction in air pollutants when ozone is applied to meet occupational health and safety (OHSA) limits.	Estimated at $6 to $11 per unit of pig production capacity.		Elenbaas-Thomas et al. (2005); Priem (1977); Singer (1990); Tate (1990); Wu et al. (1999); Keener et al. (1999); Bottcher et al. (2000); Hill et al. (2002).

Management Mechanism	Substance	Potential Reduction	Practicality	Cost and Benefit	Gaps Analysis	References
Oil Sprinkling: Daily sprinkling of small volumes of vegetable oils in animal pens.	Ammonia, Hydrogen Sulphide; Odour; Particulate Matter.	Up to 90% (NH_3) Up to 60% (H_2S) Up to 70% (odour) Up to 95% (PM)	Concerns about animal safety, e.g., slippery conditions in pens and alleys and, clean up. Inconsistent info on effectiveness for reducing gaseous emissions, especially odour.	Estimated manure treatment with oil can incur an annual cost of US$ 4.68 per pig place.	Limited info on impact on human and animal health.	Takai et al. (1993); Zhang et al. (1996); Zhang et al. (1997); Jacobson et al. (1998); Feddes et al. (1999); Nonnenmann et al. (2004); Paszek et al. (2001); Pahl et al. (2000).
Shelterbelts: Rows of trees and other vegetation are planted around a building.	Odour; Particulate Matter	Tree leaves physically trap dust particles that may be laden with nitrogen. Root systems will absorb up to 80% of the nutrients that might escape the proximity of the poultry operation. Lowering wind speeds over storage lagoons can reduce convective transfer of odorous compounds from the surface allowing for slower release of the odour plume. The trees also facilitate dilution in the upper atmosphere.	May take several years to establish effective shelterbelt.. When developing a plan to mitigate odor concerns from a livestock facility of any type, shelterbelts should receive substantial consideration. Shelterbelts are not only effective at odor control, but project the farm's concern for the environment in general.	Estimates of a shelterbelt planted around a 3,000-head hog facility using "higher" cost trees ($25 per shrub or tree), calculated out to $0.68 per pig for one year, amortized over 20 years at 5 percent interest, is just $0.09 per pig. These costs include maintenance costs. - Reduces conflicts - Appreciate property value of both livestock facility and adjacent property - Improves public perception of livestock facility - Reduce heating costs - Protect livestock from wind and sun - Potential reduction in feed costs in cold weather - Reduce dust leaving property - Capture snow for filling dugouts for livestock.	Limited or no info on potential reduction, practicality and, costs and benefits for CFOs in Alberta.	Bottcher et al. (1998); Bottcher et al. (1999); Bottcher et al. (2000); Bottcher et al. (2001); Ford and Riskowski (2003); UMES (2001); Magette et al. (2002); ISUE (2004a, 2004b); Tabler (2004); Bollinger and May (2005); Kulshreshtha and Kort (2005)

Management Mechanism	Substance	Potential Reduction	Practicality	Cost and Benefit	Gaps Analysis	References
Thermal Incineration: Thermal incineration is the process of oxidation of combustible gases and odorants in a waste stream by heating the odorous air with fresh air or oxygen to a high temperature in a furnace. Direct flame; Recuperative or; Regenerative incinerators.	VOC		Poor feasibility due to low VOC concentrations in livestock building air emissions.		-same-	USEPA (1995)
Ultraviolet (UV) Radiation: Pathogens are inactivated through cell damage by exposure to UV radiation. Tool - UV lights	Pathogens	High (surfaces) Low (air stream)			-same-	
Windbreak Walls: Wall made of tarp or other porous material is placed 3 to 6 m from exhaust fans.	Hydrogen Sulphide, Odour, PM	Windbreak walls have been constructed with 10-foot pipe frames and tarpaulins, and placed at the end of swine-finishing buildings, immediately downwind of the exhaust fans. Downwind dust and odour concentrations were reduced on demonstration facilities, in areas with windbreak walls, due to plume deflection.	May not be suited for animal buildings equipped with multiple fans at non-uniform locations around the building. Limited success when wind directions and atmospheric conditions change.		-same-	Bottcher et al. (1998); Bottcher et al. (2000); Bottcher et al. (2001); Ford and Riskowski (2003); UMES (2001); Magette et al. (2003); ISUE (2004a, 2004b)
ANIMAL MANAGEMENT						
Diet Manipulation: Modify animal diets to increase retention or use of specific nutrients by the animal and reduce emission of undesirable gases.	Ammonia, Hydrogen Sulphide; Odour	Up to 40% (H_2S – pigs); Up to 19% (NH_3 – pigs); Up to 50% (odour – cattle)	Must be used with care since production can be significantly affected with extreme dietary modification.	\$0.50 per head (dairy) Has potential of reducing feed costs.	Inconsistent results reported by various researchers. Limited info on effects on animal health & productivity.	Payeur et al. (2002); Clark et al. (2005a, 2005b).

Management Mechanism	Substance	Potential Reduction	Practicality	Cost and Benefit	Gaps Analysis	References
MANURE APPLICATION						
Manure Injection: Inject liquid or solid manure below the soil surface.	Ammonia; Odour	Up to 80% (NH_3) Up to 90% (odour) Odour concentrations at 4 and 24 hours were below detectable levels for all treatments.	Liquid manure injection offers a number of advantages over Broadcasting: The increasingly popular "umbilical" drag hose system is often less expensive and is a rapid application method for producers whose land is near their manure source.	Up to $1.39/year/ sow + $0.68/finisher pig. $0.50 per marketed pig; Fewer odours; Ability to place nutrients directly into the seedbed reduce loss of fertilizer value. Estimated costs to inject manure are $0.003 per gallon above the cost to haul and broadcast liquid manure. A portion of the added cost can be recaptured in the form of decreased nitrogen losses for injected manure versus broadcast application.	Limited info on solid manure injection.	Phillips et al. (1988); Fleming et al. (1998); AAFRD (2005); ISUE (1998a).
Band Spreading: Discharge manure at ground level through series of trailing pipes.	Ammonia; Odour	Up to 50% (NH_3; odour)			Limited or no info on potential reduction and practicality for CFOs in Alberta.	MAFF (1998)

Management Mechanism	Substance	Potential Reduction	Practicality	Cost and Benefit	Gaps Analysis	References
MANURE STORAGE FACILITIES						
Biocovers: Include chopped barely, wheat, oats or brome straw.	Ammonia; Hydrogen Sulphide; Odour	Up to 95% (NH_3) Up to 69% (H_2S) Up to 90% (odour) H_2S 95%	Reapplication may be required to maintain effectiveness of cover. Biocovers on outdoor manure storages have recently gained popularity in the US and parts of Canada because they work very well, are easily managed and are affordable	Up to $1.61 per square meter.$0.25 -0.40US per marketed hog; $0.10 per square foot; Minimal	Economic analysis. Costs offset by nutrient recovery	Jacobson (1998); Bundy et al. (1997a); Clanton et al. (2001); Xue et al. (1999); ISUE (1998b); Bicudo et al. (2004); Nicolai et al. (2005).
Bottom Loading: Discharge new material beneath the surface of stored liquid manure.	Ammonia; Odour				Limited or no info on potential reduction, practicality and costs and benefits for CFOs in Alberta.	Muck and Richards, (1983); Wilkerson et. al. (1997); Feddes and Edeogu (2001).

Management Mechanism	Substance	Potential Reduction	Practicality	Cost and Benefit	Gaps Analysis	References
Rigid Impermeable Covers: A wooden roof or concrete lid is placed overtop a manure storage tank. Gases may be vented.	Ammonia; Hydrogen Sulphide; Odour; Particulate Matter	Up to 95% (odour; during storage period) H_2S 95%	Additional material handling is required during pump out.	Nutrient recovery. Comparing the changes in TKN and ammonia nitrogen in the open EMS and the covered EMS systems, the results indicate that the covered EMS can reduce nitrogen loss by approximately 82% and maintain approximately 93% of the nitrogen levels in the influent during the storage period. High cost. Usually more expensive than other types of covers but can last up to 15 years depending on the material. Reduction of pest control costs (insects - flies).	Limited info on practicality; cost and benefit. $0.35-0.45 US per pig marketed.	Mannebeck (1985); DeBode (1991); Sommer et al. (1993); Karlsson (1996); ARDI (2001).
Inflatable Plastic Covers: These Impermeable covers are used in place of rigid covers. They may be used with positive or negative air pressure systems.	-same-	-same-		-same-	-same-	Clanton et al. (1999); Funk et al. (2004).
Long Term Storage: More than one storage facility. Each facility has at least 30 or 90-day storage capacity.	Pathogens	High	AOPA requires manure storage		Limited or no info on potential reduction,	DEFRA (2001)

Management Mechanism	Substance	Potential Reduction	Practicality	Cost and Benefit	Gaps Analysis	References
(Long-Term Storage, cont.)			capacity of up to at least 9 consecutive months. However, most of the manure storages are continuously loaded over the 9-month period. Continuously loaded systems are not as effective as batch-type systems where fresh material is separated from aging material during the storage period.		practicality and costs and benefits for CFOs in Alberta.	
<u>MANURE TREATMENT</u>						
Acid: Lower slurry pH by addition of nitric or sulphuric acid.	Ammonia; Pathogens		Highly technical process. Application may require services of contract specialist. Low pH could cause erosion of concrete and steel structural components. Expect H_2S emissions to increase.		Limited or no info on potential reduction, practicality and costs and benefits for CFOs in Alberta.	McCrory and Hobbs (2001); Kroodsma et al. (1994); Huijsmans et al. (1994); DEFRA (2001).
Anaerobic Digestion: Biological process where organic carbon is converted to methane by anaerobic bacteria under controlled conditions of temperature and pH.	Odour; Pathogens	Up to 85% (odour)	High cost of installation. Large scale digesters appear more feasible than smaller systems.		-same-	Welsh et al. (1977); Roos and Moser (1997); Moser (2001); DEFRA (2001)

Management Mechanism	Substance	Potential Reduction	Practicality	Cost and Benefit	Gaps Analysis	References
Chemical Additives: Additives may counteract or bind chemical compounds.	Ammonia; Odour	Variable	Some products are effective at reducing ammonia but do not have a similar effect on odour.	Low cost		Moore et al. (2006); Nicolai et al. (1997).
Composting: Aeration is crucial for the success of this treatment system. Aeration helps piles reach temperature levels that can effectively destroy pathogens. This may be achieved by turning the piles or by using a fan to force air through the pile.	Odour; Pathogens		Managing a compost pile to operate effectively can be labour intensive and costly. Composting can also lead to increased emission of ammonia. Operation may require services of contract specialist.	More than $1.50/head (feedlot); Using tractors and loaders range from 20 cents to 40 cents per head of swine marketed.		DEFRA (2001); ISUE (1998c).
Heat Drying: This process applies direct or indirect heat to reduce the moisture in biosolids. It eliminates pathogens, reduces volume, and results in a product that can be used as a fertilizer or soil amendment.	Pathogens				Limited or no info on potential reduction, practicality and costs and benefits for CFOs in Alberta.	USDA (2005)
Lime: Raise slurry pH by addition of calcium hydroxide.	Hydrogen Sulphide; Pathogens; Odour		Highly technical process. Application may require services of contract specialist. Expect NH_3 emissions to increase.		-same-	Fenlon and Mills (1980); DEFRA (2001).

Management Mechanism	Substance	Potential Reduction	Practicality	Cost and Benefit	Gaps Analysis	References
Liquid Solid Separation: Solid-liquid separation of livestock manure involves the partial removal of organic and inorganic solids from liquid manure. Solids are removed from manure slurry.	Ammonia; Odour	Up to 50%		High capital and operational costs. May not be cost effective for small operations. -Recycling of water -Reduced land application costs $25 per sow, or $7 to $10 per finishing pig space. $135 per dairy cow.	Improved separation efficiency.	Sneath et al. (1988); Zhang and Westerman (1997); Converse and Karthikeyan (2002); ISUE (1998d).
Mechanical Aeration: Air is pumped into manure slurry to enhance aerobic decomposition.	Odour; H2S; Volatile fatty VOC (VFA - acids)	Up to 45% The wind driven aerator effectively maintained the odour potential of the test storage below that of the control storage in spite of receiving test manure weekly. The aerator in this project is a cost effective means of controlling odours from the liquid manure storage.	Can increase ammonia emissions	$6 per marketed pig; Costs savings at manure application time (no agitation required)		Heber and Ni (1999); Westerman and Bicudo (1999); Westerman and Zhang (1997); Zhang and Zhu (2003); Hilborn and DeBruyn (2006).
Pasteurization: Pasteurization is the use of heat to reduce the number of bacteria in a liquid	Pathogens	Highly effective and consistent reduction in combination with anaerobic digestion	High cost of installation with anaerobic digester. Large scale digesters appear more feasible than smaller systems.		Limited or no info on potential reduction, practicality and costs and benefits for CFOs in Alberta.	DEFRA (2001); Mohaibes and Heinonen-Tanski (2004); De Benedictis et al. (2007).
Temperature Control: Cool top 10 cm of manure to 15°C; Lower temperature by recirculating water through ground loop geothermal system.	Ammonia	Up to 50%		Initial: $45 per pig space; Annual: $7 per pig space.	-same-	Gustafsson et al. (2005); Den Brok and Verdoes (1997); Andersson (1995); Panetta et al. (2005).

Management Mechanism	Substance	Potential Reduction	Practicality	Cost and Benefit	Gaps Analysis	References
Feedlot Moisture Management: Ensure adequate drainage; Keep moisture between 25 and 35%; provide slope between 2 and 4%.	Odour; Pathogens; PM	Up to 80%	Researchers have found that when the moisture content of the open lot surface is between 25 and 40 percent, both dust and odor potentials are at manageable levels.		Limited or no info on potential reduction, practicality and, costs and benefits for CFOs in Alberta.	Paine et al. (1976); Weaver et al. (2005); Miller and Berry (2005); Sweeten (1998); ISUE (2004a); Auvermann (2001); Auvermann and Rogers (2000)
Poultry Moisture Management:	-same-	High			-same-	
Super Soils Systems						
<u>PROPER PLANNING</u>						
Minimum Distance Separation:	VOC; Ammonia; Hydrogen Sulphide; Odour; PM; Pathogens;	-unknown-			Limited or no info on potential reduction, practicality, costs and benefits for AB CFOs.	AOPA (2005)
<u>QUALITY ASSURANCE PROGRAMS</u>						
Pathogen Control: Mitigate pathogen import to farms; Break cycle of pathogen amplification; Appropriate collection and treatment of animal waste; Control pathogen export from farm. Tools – Biosecurity protocols; Farm-specific herd health plans; Best Management Practices (BMPs) and Extension services.	Pathogens				Limited or no info on potential reduction, practicality and, costs and benefits for CFOs in Alberta.	OSUE (2006); Anderson (2005)

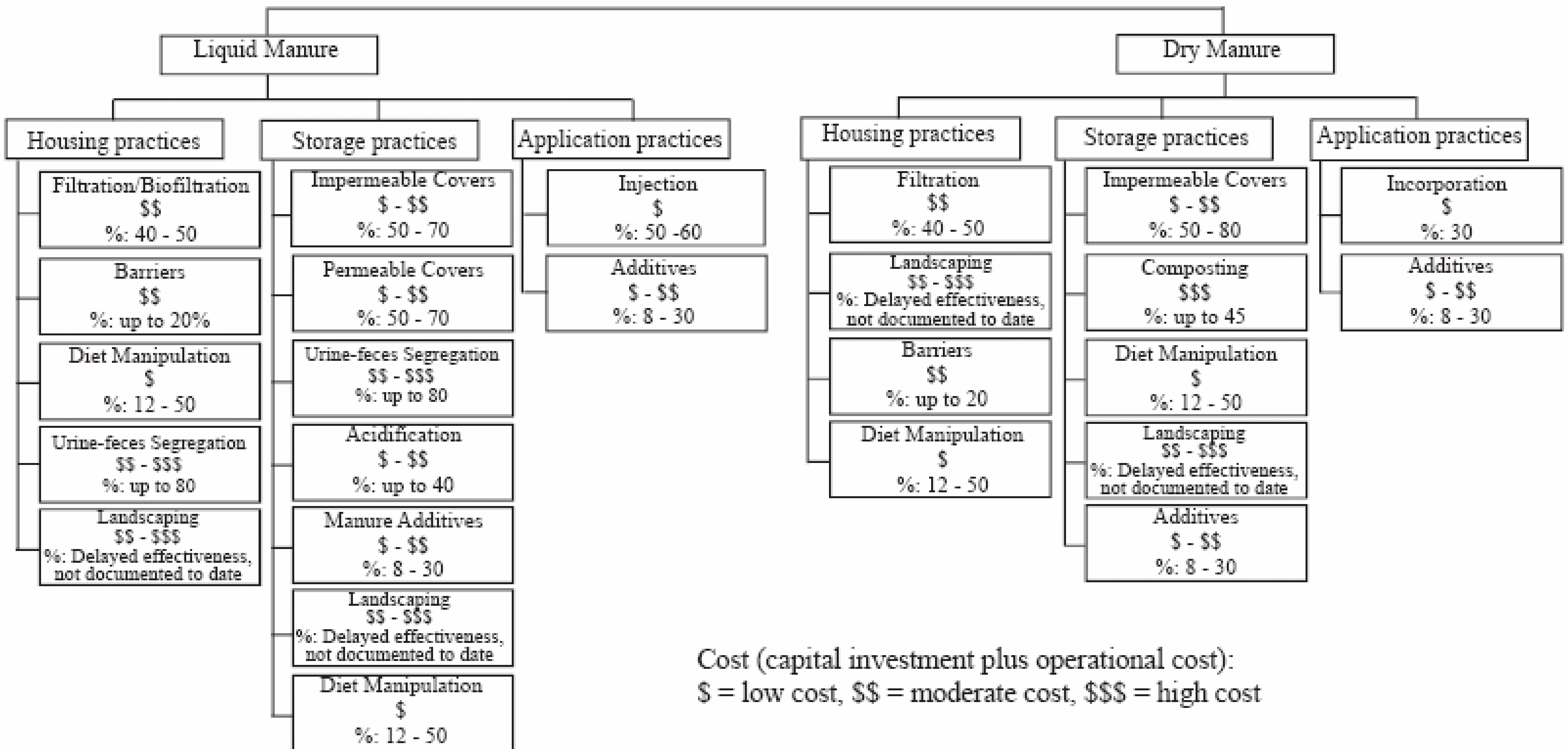
Management Mechanism	Substance	Potential Reduction	Practicality	Cost and Benefit	Gaps Analysis	References
ROADWAY MANAGEMENT						
Dust Palliatives: Suppressants agglomerate fine particles; Adhere or bind surface particles; Increase density of road surface material	Particulate Matter		Treatment is not permanent and palliative needs to be reapplied periodically.		Limited or no info on potential reduction, practicality and, costs and benefits for CFOs in Alberta.	Foley et al. (1996); Bolander (1997, 1999).

Notes:

- A personal observation of shelterbelts located adjacent to neighbouring property is that they have an opposite effect (ON WHAT?). The trees actually concentrate the odour plume and prevent it from drifting away once atmospheric conditions deposit in the trees.
- Carcass disposal measures (composting, incineration, burial, rendering).
- Pit additives (various studies).
- Cattle feedlot information missing (facility design, screening, location, pen management etc…).
- Tank manure storage facilities have less surface area to emit odours compared to earthen manure storage facilities.
- Quick incorporation after spreading. Investigate effect of time length between application and incorporation on emissions.
- Manure Application timing and duration
- Waste solutions Canada
- Barn pit design
- Investigate effectiveness of manure application using a truck-mounted tank versus drag hose application. More recent cost figures need to be included in the analysis, including cost regarding nutrient values, manure application comparisons and water savings.
- Biogas perspectives - http://www.omafra.gov.on.ca/english/engineer/facts/bg_rpt_omafrafinal.htm#4
- GAPS analysis could include need for a survey on use of various management mechanisms by Alberta producers.

Practices to Reduce Ammonia Emissions from Livestock Operations Flowchart

Practices to control ammonia emissions associated with livestock can be applied to animal housing areas, manure storage areas, and land where manure is applied. This fact sheet is designed to provide producers with information on relative costs and effectiveness of odor control practices. This fact sheet accompanies, *Practices to Reduce Ammonia Emissions from Livestock Operations*, (PM 1971a).



Cost (capital investment plus operational cost):
$ = low cost, $$ = moderate cost, $$$ = high cost

% = Estimated effectiveness in odor reduction (conservative estimates recognizing that observed reductions will vary from site to site)

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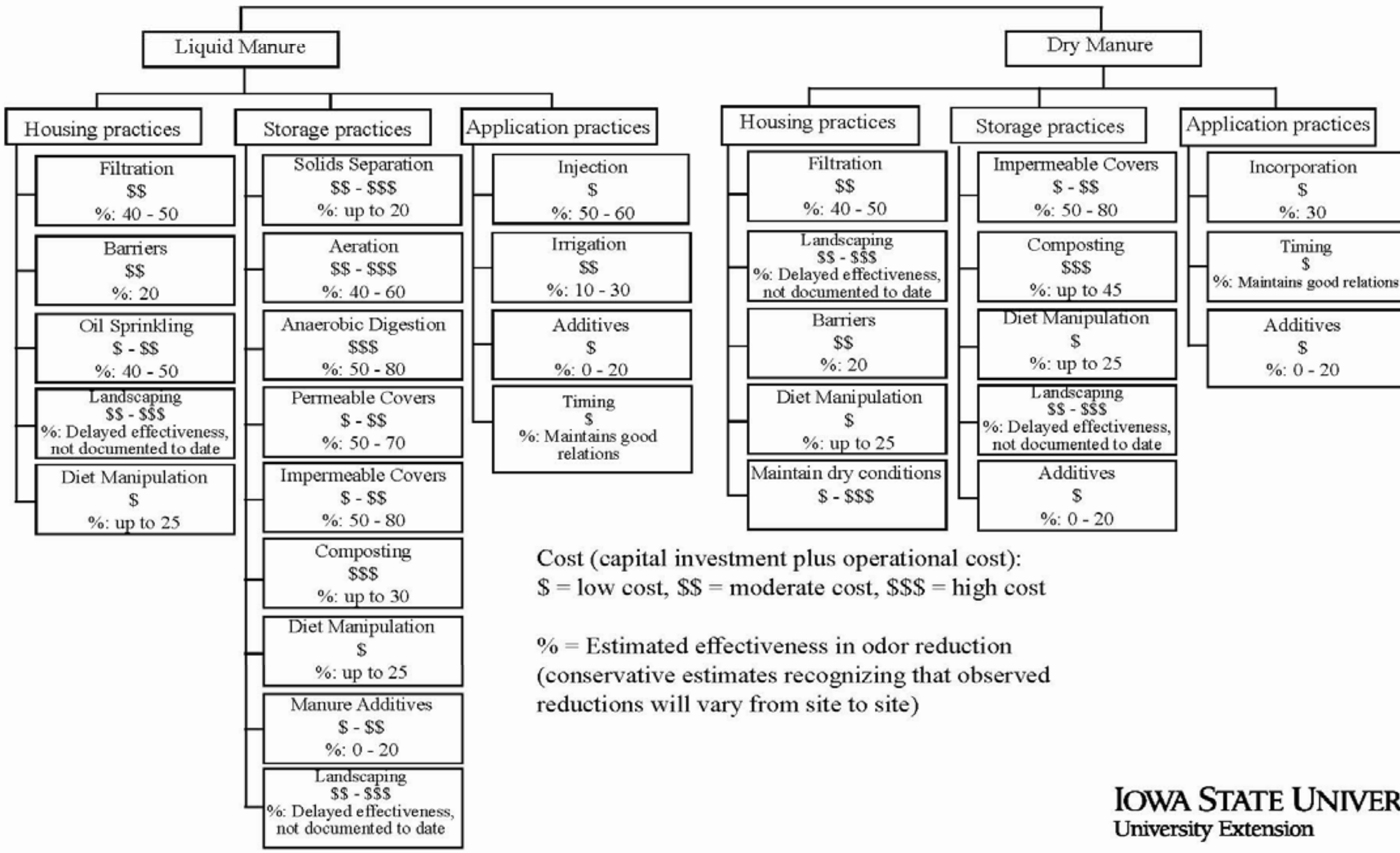
Practices to Reduce Odor from Livestock Operations Flowchart

Practices to control odor emissions associated with livestock can be applied to animal housing areas, manure storage areas, and land where manure is applied. This fact sheet is designed to provide producers with information on relative costs and effectiveness of odor control practices. This fact sheet accompanies, *Practices to Reduce Odor from Livestock Operations*, (PM 1970a).



Cost (capital investment plus operational cost):
$ = low cost, $$ = moderate cost, $$$ = high cost

% = Estimated effectiveness in odor reduction (conservative estimates recognizing that observed reductions will vary from site to site)

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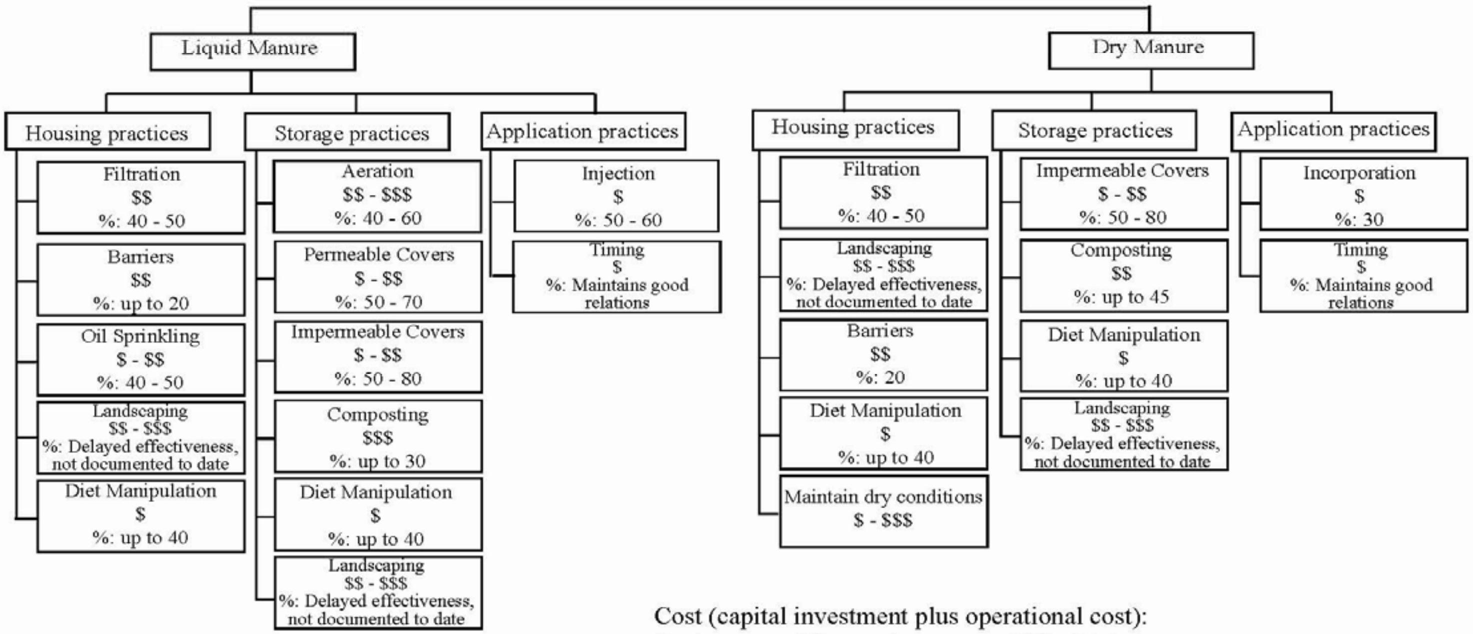
Practices to Reduce Hydrogen Sulfide from Livestock Operations Flowchart

Practices to reduce hydrogen sulfide emissions associated with livestock can be applied to animal housing, manure storage areas, and land where manure is applied. This fact sheet is designed to provide producers with information on relative costs and effectiveness of hydrogen sulfide control practices. This fact sheet accompanies, *Practices to Reduce Hydrogen Sulfide from Livestock Operations*, (PM 1972a).



Cost (capital investment plus operational cost):
$ = low cost, $$ = moderate cost, $$$ = high cost

% = Estimated effectiveness in odor reduction (conservative estimates recognizing that observed reductions will vary from site to site)

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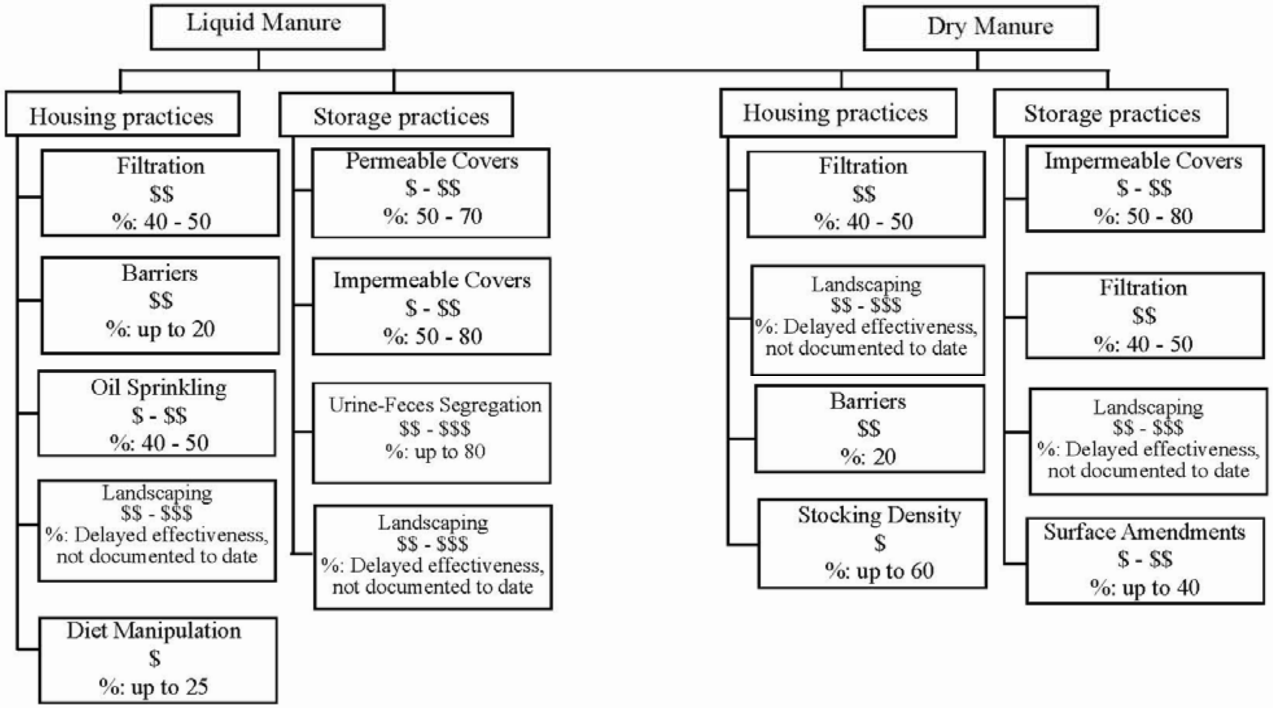
Practices to Reduce Dust and Particulates from Livestock Operations Flowchart

Practices to control dust and particulate emissions associated with livestock can be applied to animal housing amd manure storage areas. This fact sheet is designed to provide producers with information on relative costs and effectiveness of dust and particulate control practices. This fact sheet accompanies, *Practices to Reduce Dust and Particulates from Livestock Operations*, (PM 1973a).



Cost (capital investment plus operational cost):
$ = low cost, $$ = moderate cost, $$$ = high cost

% = Estimated effectiveness in odor reduction (conservative estimates recognizing that observed reductions will vary from site to site)

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Appendix D: Management Mechanisms Preferred by Public Service and Industry Caucuses

1. Criteria

Alberta Agriculture and Food (AF) developed a set of criteria (Tables 1 and 2) to rate the various management mechanisms (MM) outlined in the MM matrix. Public service caucus stakeholder concerns addressed by each MM were not taken into consideration, since the concerns were rather general and not related specifically to the MM.

Table 2. First Order Assessment Criteria used to Rank CFO Management Mechanisms Matrix

Code	Descriptor	Score	
		Yes	*No
A	Proven Technology	1	0
B	Cost-Benefit	1	0
C	Commercial Availability	1	0
D	On-Farm Practicality	1	0
E	Negative Residual Effects	0	1

* Includes qualifiers such as “unknown” or “variable”.

Table 3. Second Order Assessment Criteria used to Rank CFO Management Mechanisms Matrix

Code	Descriptor	Score	
		Yes	*No
F	Reduction > 50%	0.1	0
G	Reduction > 75%	0.1	0

* Includes qualifiers such as “unknown” or “variable”.

2. Glossary of Terms

Definitions for the descriptors presented in Tables 1 and 2 are outlined below:

A.	Proven Technology	MM has been evaluated and verified by third party groups and shown to be capable of effectively reducing at least one of the six substances. Alternatively, the MM may also be commonly used commercially as a generally acceptable mechanism, both within the livestock industry and in other industrial applications.
B.	Cost/Benefit Assessment	Assesses how much it would cost to implement (installation, operation and maintenance) a given MM relative to the benefits that might be achieved. Benefits may include the potential to generate additional revenue through the implementation of a MM or the reduced use of a resource for production-related activities.
C.	Commercial Availability	Specifies if a MM is readily available commercially and may be purchased from a supplier. It includes services such as custom fabrication or implementation of a MM based on a readily available design.
D.	On-Farm Practicality	Assesses if it is practical to apply a MM on the farm. Although a MM may cost effectively reduce at least one of the six substances in a non-CFO industry it may not be cost effective to apply it to a CFO. Furthermore, it may be impractical for the farm to independently operate the MM due to high labour, management and/or time requirement or, technical complexity of the MM.
E.	Negative Residual Effects	Addresses if a MM has a scientifically defined residual effect with a negative, undesirable impact on the environment, CFO, cost, etc. If there is a negative effect, this descriptor is scored a “0”. Alternatively, if there is no negative effect, or it is positive then it is scored a “1”. Assumption(s): If the residual effect is unknown or variable then it is assumed that there is no residual effect and this descriptor is scored a “1”. Furthermore, if a MM has both a negative and positive residual effect then, the negative effect is assumed to take precedence over the positive effect and this descriptor is scored a “0”.
F.	Reduction > 50%	MM is reported to scientifically reduce the emission of at least one substance from the CFO animal housing facilities, manure storages facilities, land application sites, etc., by over 50%. Assumption(s): If a MM is reported to result in a low potential reduction of any substance, according to the MM matrix, then that MM will be considered to reduce that substance by 50% or less.
G.	Reduction > 75%	MM is reported to scientifically reduce the emission of at least one substance from the CFO animal housing facilities, manure storages facilities, land application sites, etc., by over 75%. Assumption: If a MM is reported to result in a moderate or high potential reduction of any substance, according to the MM matrix, then that MM will be considered to reduce that substance by (i) greater than 50% but less than 75% and, (ii) greater than 75%, respectively.

3. Rating CFO Management Mechanisms

Table 3 outlines management mechanisms that may be used to mitigate emissions of air-borne substances from CFOs in Alberta, in descending order of preference. The MMs have been organized relative to those aspects of the CFO production system where they may be implemented. For instance, an air filtration system may be used in the exhaust vent of a mechanically ventilated livestock building as opposed to a manure storage facility. This approach was chosen because in many cases, more than one management mechanism may be required to mitigate emissions from CFOs. The aspects of the production system where MMs may be implemented include, animal housing (indoors or outdoors), animal management, manure application, manure storage facilities, manure treatment, quality assurance programs and roadway management.

3.1 First Order Assessment

MMs listed within each aspect of the CFO production system were assessed according to the descriptors presented in Table 1 above. Where applicable, an attempt has been made to provide an explanation or reasons why a management mechanism descriptor has been scored a zero. Such comments are also included in the table. Based on their total score the MMs were then ranked in descending order of preference. For instance, “planting a shelterbelt” scored a sum total of “4” points and ranked higher than “installing an acid scrubber” which scored a sum total of “3” points.

3.2 Second Order Assessment

In the second order assessment, the MMs ranked according to 3.1 above, were further assessed based on the number of substances that each MM is capable of reducing and according to the criteria outlined in Table 2. For instance, assuming a MM can potentially reduce PM and VOC by 40% and 60%, respectively, then according to the descriptors in Table 2, that MM would only be scored as follows, PM (0,0) and VOC (0.1, 0) for a sum total of “0.1” points. In other words, according to Table 2, the MM does not decrease PM by up to 50% or 75% and so codes F and G would be rated as, F = 0 and G = 0, for PM while, codes F and G would be rated as, F = 0.1 and G = 0, for VOC because it decreases VOC by over 50% but not up to 75%.

Table 4. Management Mechanism Matrix Ranked in Order of Preference by Public Service and Industry Caucuses

Target	Management Mechanism	*Score			Comments
		1st Order (Code A to E)	2nd Order (Code F & G)	Total	
Animal Housing					
	Air Filtration: HEPA filter	3 (10101)	0.4 Pathogens (0.1,0.1); PM (0.1,0.1)	3.4	(B, D) Too costly for implementation in livestock buildings. Large air volume flows through barn in summer to keep it cool. Large pressure drops anticipated due to filters. Pressure drop will increase when PM clogs filters. Will likely require replacement of existing fans with higher capacity fans or booster fans to handle increased pressure drop across flow system. Also expect need for frequent filter cleaning.
	Air Filtration: ULPA filter	3 (10101)	0.4 Pathogens (0.1,0.1); PM (0.1,0.1)	3.4	(B, D) Same as Air Filtration: HEPA filter
	Frequent Manure Removal	3 (10101)	0.4 NH_3 (0.1,0.1); H_2S (0.1,0.1); Odour (0,0); PM (0,0)	3.4	(B, D) MM may apply to beef, dairy, pig and poultry operations. Frequency of manure removal is not explicitly defined. Is manure removal daily, hourly, etc? In either case, what are the labour and energy requirements? Is it practical and how much will it cost?
	Activated Carbon Adsorption	3 (10101)	0.0 VOC (0,0)	3.0	(B, D) Too costly for implementation in livestock buildings. Large air volume flows through barn in summer to keep it cool. Large pressure drops anticipated due to restricted airflow through bed of activated carbon material. Will likely require replacement of existing fans with higher capacity fans or booster fans to handle increased pressure drop across flow system. Alternatively, may require large footprints of activated carbon beds to keep pressure drop to a minimum. Effectiveness of the latter is unknown. (F, G) Percentage reduction is unknown.
	Shelterbelts	3 (Rating 01110)	0.0 Odour (0,0); PM (0,0)	3.0	(A, E) Not certain of the effectiveness of this MM. Do the trees also trap and concentrate emitted substances such as odour, only to release these substances at higher dosages later on? Furthermore, after a rainfall event, substances may be washed out of the air and run off into surface water sources, thereby creating a new environmental concern. (F, G) Percentage reduction unknown.

* 1st Order: See Table 1   2nd Order: See Table 2   Total: Sum of 1st Order score and 2nd Order score

Target	Management Mechanism	Score			Comments
		1st Order (Code A to E)	2nd Order (Code F & G)	Total	
Animal Housing Cont'd.	Acid Scrubber	2 (10100)	0.6 Pathogens (0.1,0.1); PM (0.1,0.1); NH_3 (0.1,0.1)	2.6	(B, D) Too costly for implementation in livestock buildings. Large air volume flows through barn in summer to keep it cool. Large pressure drops anticipated due to restricted airflow through scrubber vessel and water spray pressure. In addition, moisture has to be recaptured, purified and reused. Will likely require replacement of existing fans with higher capacity fans or booster fans to handle increased pressure drop on flow system. Will vessels be stationed inside or outside the barn? If outside, vessels will need to be winterized. (E) May induce H_2S emissions if condensed moisture is mixed with stored manure, i.e., by reducing the pH of the manure.
	Electrostatic Precipitation	2 (10100)	0.4 Pathogens (0.1,0.1); PM (0.1,0.1)	2.4	(B, D) Too costly for implementation in livestock buildings. Large air volume flows through barn in summer to keep it cool. (E) Unknown for CFOs.
	Ultraviolet Radiation	2 (10001)	0.2 Pathogens (0.1,0.1)	2.2	(B, D) Expensive technology. Not effective for treating air directly. May be more effective for treating surfaces. Difficult to implement inside barn with multiple surfaces. (C) Unknown for CFOs. (F, G) Assumes treatment will be applied to surfaces.
	Catalytic Incineration	2 (10001)	0.0 VOC (0,0)	2.0	(B, D) Expensive technology. Low VOC concentrations emitted from animal barns imply that VOCs in the exhaust air will have to be pre-concentrated prior to incineration. The latter will require additional cost. (C) Unknown for CFOs. Custom-fabrication seems likely. (F, G) Percentage reduction unknown.
	Cryogenic Condensation	2 (10001)	0.0 VOC (0,0)	2.0	(B to D, F, G) Same as Catalytic Incineration
	Manure Flush System	2 (10100)	0.0 NH_3 (0,0)	2.0	(B) Cost-benefit ratio is unknown. (D) May only be applicable to new barn designs. In most situations, probably an impossible quest for existing barns. (E) Where applied, may facilitate the spread of disease if open channel design is used, i.e., if the channels run from one pen or room through to the next.
	Thermal Incineration	2 (10001)	0.0 VOC (0,0)	2.0	(B to D, F, G) Same as Catalytic Incineration

Target	Management Mechanism	Score			Comments
		1st Order (Code A to E)	2nd Order (Code F & G)	Total	
Animal Housing Cont'd.	Biofiltration	1 (10000)	0.9 NH_3 (0.1,0.1); H_2S (0.1,0.1); Odour (0.1,0.1); Pathogens (0.1,0.1); VOC (0.1,0)	1.9	(B, D) Too costly for implementation in livestock buildings. Large air volume flows through barn in summer to keep it cool. Large pressure drops anticipated due to restricted airflow through bed material and clogging pore spaces with dust or biomass. Will likely require replacement of existing fans with higher capacity fans or installation of booster fans to handle increased pressure drop on flow system. Alternatively, may require large bed footprint in order to keep pressure drop to a minimum. Complicated, biologically sensitive, management intensive, treatment system. May need to hire services of specialist to manage system. (C) Requires custom fabrication. (E) Leachate produced may be toxic (high levels of nitrites). If biofilter is improperly managed, may trigger emissions of odour and H_2S.
	Bioscrubber (no acid)	1 (10000)	0.2 NH_3 (0.1,0.1); H_2S (0,0); Odour (0,0)	1.2	(B, D) Similar to Biofiltration. (C) Unknown for CFOs. Custom-fabrication seems likely. (E) Concentration of substances in recirculated water may increase to toxic levels. Drainage will likely require secondary treatment.
	Non-Thermal Plasma	1 (10000)	0.2 NH_3 (0,0); H_2S (0.1,0.1); Odour (0,0)	1.2	(B, D) Too costly for implementation in livestock buildings. Large air volume flows through barn in summer to keep it cool. Large pressure drops anticipated due to restricted airflow through bed material and clogging pore spaces with dust or biomass. (C, E) Unknown for CFOs.
	Modified Floor Design: Deep Litter	1 (10000)	0.1 NH_3 (0.1,0)	1.1	(B, D) Costly to retrofit existing barns. (C) May only be applicable to new barn designs. In most situations, probably an impossible quest for existing barns. (E) May result in increased manure handling.
	Windbreak Walls	1 (00001)	0.0 Odour (0,0); PM (0,0)	1.0	(A) Unknown potential/effectiveness. (B, D) May be costly to implement considering barn sizes, large air volume and need for adequate reinforcement to resist strong winds. Not applicable to barns with ceiling-mounted ventilation systems. (C) Requires custom fabrication. (F, G) Percentage reduction unknown.

Target	Management Mechanism	Score			Comments
		1st Order (Code A to E)	2nd Order (Code F & G)	Total	
Animal Housing Cont'd.	Air Filtration: Antifungal filter	1 (00001)	0.0 Pathogens (0,0)	1.0	(A) Unknown potential/effectiveness. (B, D) Too costly for implementation in livestock buildings. Large air volume flows through barn in summer to keep it cool. Large pressure drops anticipated due to filters and even more when filters are clogged with PM. Will likely require replacement of existing fans with higher capacity fans or booster fans to handle increased pressure drop across flow system. Also expect need for frequent filter cleaning. (C) Unknown for CFOs. (F, G) Percentage reduction unknown.
	Air Filtration: Biomass filter	1 (10000)	0.0 Pathogens (0,0); PM (0,0)	1.0	(B, D) Large pressure drops anticipated due to restricted airflow through bed. Will likely require replacement of existing fans with higher capacity fans or booster fans to handle increased pressure drop across flow system. (C) Requires custom fabrication. (E) When wet could provide suitable environment for pathogens to thrive and populate. (F, G) Low reduction. Too porous to capture microorganisms and respirable particulate matter.
	Oil Sprinkling	0 (00000)	0.5 NH_3 (0.1,0.1); H_2S (0.1,0); Odour (0,0); PM (0.1,0.1)	0.5	(A to E) Mostly effective at the research level. Uncertainty at the commercial level. Lack of information on automated application systems or on effects of this practice on human and animal health and wellbeing. Clean up is also an issue. Odour reduction is variable.
	Ozone Treatment	0 (00000)	0.1 NH_3 (0.1,0); H_2S (0,0)	0.1	(A to E) Application is still under investigation.
<u>Animal Management</u>					
	Diet Manipulation	1 (00010)	0.0 NH_3 (0,0); H_2S (0,0); Odour (0,0)	1.0	(A to C, E) Application is still under investigation. Effectiveness of various diets is variable. Not clear if new standards have been established. (F, G) Percentage reduction variable.

Target	Management Mechanism	Score			Comments
		1st Order (Code A to E)	2nd Order (Code F & G)	Total	
Manure Application					
	Band Spreading (liquid)	4 (11110)	0.0 NH_3 (0,0); Odour (0,0)	4.0	(E) Potential for leaching and runoff of nutrients is high. In situations where manure is not incorporated immediately, the residual odour effect is unknown. (F, G) Percentage reduction variable.
	Liquid Manure Injection	3 (10110)	0.4 NH_3 (0.1,0.1); Odour (0.1,0.1)	3.4	(B) Costly technology. Benefits are not clearly defined. Some uncertainty, e.g. soil disturbance. (E) Release of N_20 (GHG). Potential for nutrient leaching exists.
	Solid Manure Injection	0 (00000)	0.4 NH_3 (0.1,0.1); Odour (0.1,0.1)	0.4	(A to E) Application is still under investigation.
Manure Storage Facilities					
	Biocovers	4 (11110)	0.5 NH_3 (0.1,0.1); H_2S (0.1,0); Odour (0.1,0.1)	4.5	(E) Organic material can cause problems during agitation of manure. Material may need to be ground before passing through pump. Organic material is also susceptible to wetting and sinking. Reapplication may be required periodically.
	Bottom Loading	4 (10111)	0.0 NH_3 (0,0); Odour (0,0)	4.0	(B) Cost/benefit ratio unknown. (F, G) Percentage reduction unknown.
	Inflatable Plastic Covers	3 (10101)	0.4 NH_3 (0,0); H_2S (0.1,0.1); Odour (0.1,0.1); PM (0,0)	3.4	(B) High cost material. (D) May experience difficulty removing cover for agitating and pumping manure. Maintenance of covers may also be a concern.
	Rigid Impermeable Covers	3 (10101)	0.4 NH_3 (0,0); H_2S (0.1,0.1); Odour (0.1,0.1); PM (0,0)	3.4	(B) High cost material. (D) Typically associated with manure storage in a concrete or steel tank. Manure handing (pumping in and out) may not be as simple. Facility maintenance may also be a concern.
	Long Term Storage: Batch Fill	3 (10101)	0.2 Pathogens (0.1,0.1)	3.2	(B) Costly because of the need for more than one storage facility. The idea is to fill storage facilities in batches and not continuously over the year. Once filled, leaving each storage facility dormant for 30 to 90 days should help destroy pathogens. (D) More practical during the design and planning of new CFOs.

Target	Management Mechanism	Score			Comments
		1st Order (Code A to E)	2nd Order (Code F & G)	Total	
<u>Manure Treatment</u>					
	Chemical Additives	3 (01110)	0.0 NH_3 (0,0); Odour (0,0)	3.0	(A) Uncertain. (E) Residual effects unknown. Variable. (F, G) Percentage reduction is variable.
	Anaerobic Digestion	2 (10100)	0.2 Odour (0.1,0.1); Pathogens (0,0)	2.2	(B, D) Costly to retrofit existing barns or implement in new barns. Also more complicated. May need to hire services of specialist to manage system. (E) Digestate has a high nutrient content that may easily be lost if applied on land directly.
	Feedlot Moisture Management	2 (10100)	0.2 Odour (0.1,0.1); PM (0,0)	2.2	(B) Cost is unknown. (D) May be labour intensive to manage. (E) Difficult to maintain balance between moisture content that will inhibit odour emissions and moisture content that will limit dust emissions.
	Poultry Moisture Management	2 (10100)	0.2 Odour (0.1,0.1); PM (0,0)	2.2	(B, D, E) Same as Feedlot Moisture Management.
	Acid Additives	2 (10100)	0.0 NH_3 (0,0); Pathogens (0,0)	2.0	(B, D) Frequency of application and cost are unknown. (E) May induce H_2S emissions when pH of manure is lowered. (F, G) Percentage reduction is unknown.
	Composting	2 (10100)	0.0 NH_3 (0,0); Pathogens (0,0)	2.0	(B, D) Cost is not well established. May be labour demanding. (E) Nutrient losses, e.g. nitrogen loss in the form of NH_3 emissions. (F, G) Variable. Odour emissions are not reduced but pathogens are destroyed.
	Lime Additives	2 (10100)	0.0 H_2S (0,0); Odour (0,0)	2.0	(B, D) Frequency of application and cost are unknown. (E) May induce NH_3 emissions when pH of manure is raised. (F, G) Percentage reduction is unknown.
	Liquid-Solid Separation	2 (10100)	0.0 NH_3 (0,0); Odour (0,0)	2.0	(B) Costly technology to implement. (D) May be labour intensive to manage. (E) Variable. May result in increased material handling. (F, G) Percentage reduction is unknown.

Target	Management Mechanism	Score			Comments
		1st Order (Code A to E)	2nd Order (Code F & G)	Total	
Manure Trmnt. Cont'd.	Mechanical Aeration	2 (10100)	0.0 H_2S (0,0); Odour (0,0); VOC (0,0)	2.0	(B) Costly technology to implement. Requires large volume of air and powerful pumps to deliver the air. (D) May be labour intensive to operate and maintain. (E) May induce release of NH_3. (F, G) Percentage reduction is unknown.
	Temperature Control: Cooling	2 (10001)	0.0 NH_3 (0,0)	2.0	(B, D) Seems costly and difficult to retrofit existing barns. May also be costly to implement in new barns. (C) Requires custom fabrication. (F, G) Percentage reduction is unknown.
	Heat Drying	0 (00000)	0.0 Pathogens (0,0)	0.0	(A to E) Low feasibility. (F, G) Percentage reduction is unknown.
	Pasteurization	0 (00000)	0.0 Pathogens (0,0)	0.0	(A to G) Same as Heat Drying.
Proper Planning					
	Increase Minimum Distance of Separation (MDS)	2 (00101)	0.0 NH_3 (0,0); H_2S (0,0); Odour (0,0); Pathogens (0,0); PM (0,0); VOC (0,0)	2.0	(A) Unknown. Effectiveness needs to be quantified. (B) Producers are interested in reduction of current MDS and not an increase for economic reasons including, transportation of consumables and livestock products. (D) Not applicable to existing non-expanding facilities. (F, G) Percentage reduction is unknown.
Quality Assurance Program					
	Biosecurity; Herd Health, BMP	4 (11101)	0.0 Pathogens (0,0)	4.0	(D) Resistance to change unless there are no alternatives. (F, G) Percentage reduction is unknown.
Roadway Management					
	Dust Palliatives	2 (10100)	0.1 PM (0.1,0)	2.1	(B, D) Costly to implement. May be labour demanding. (E) Leachate of salts is a concern.

Appendix E: Management Mechanisms Preferred by Non-Government Organization (NGO) Caucus

Each mechanism from the NGOs' original list was evaluated according to the criteria set by Alberta Agriculture. A MM was judged on a number scale: in order to be considered as a valuable mechanism, it had to have a higher numerical evaluation. Concerns were noted about the rating scale. Some MMs do not meet the criteria and still may address a number of NGO stakeholder concerns. Also, cost of implementation of a particular mechanism is really a criterion beyond our expertise. This is one aspect that really applies to the producers, and what level of support they may get from governments. As NGOs, our goal is to see improvement in air quality from CFOs. By what methods or at what cost is beyond our own scope. We have paid our own price in different ways because of industry. How do you place a numerical value on health, or quality of life? Possibly each sector should have compiled its own evaluation scale. Government, industry and NGOs have varied perspectives on the mechanisms, as should be expected, but in the end, our goal collectively is to improve air emissions from CFOs.

1. <u>Proper Land Use Planning</u> - This may include increasing minimum distance separation from a CFO to the nearest residences and would help reduce problems with dust, odour, emissions, noise, traffic, etc. It would also take into consideration long term development for certain areas located closer to communities, cities and more populated regions. This would address two, and possibly three, of the major stakeholder concerns if the operation had compost piles. The question is how much of an increase would be necessary to address the problems; it also doesn't address the emissions and other impacts when land application is taking place. Scoring using the descriptors:

(a) Proven - Anyone with no operations around them has no complaints, those with a couple may have a few at various times, those with several around them, have complaints when conditions warrant. Proof enough?

(b) Reduction ??? - how can we assess whether the reduction is more than 50%? To set this type of criterion depends on who is affected. How do you evaluate quality of life?

(c) Cost-benefit - for any future operations, there is a cost-benefit as the reduction in complaints from neighbours will offset any extra management tools that will not have to be utilized in order to deal with complaints .(

d) Definitely available but not commercially.

(e) Practicality - on the development level, it is practical when it is used as a planning tool by counties and municipalities.

(f) No residual effects.

<u>Numerical evaluation : (a) - 1 (b) - ? (c) - 1 (d) - ? (e) - 1 (f) - 1 = 4.</u>

2. <u>Biocovers and Floating Organic Covers</u> – These are an effective way of minimizing odour from manure storage facilities. Covers limit solar heating and wind induced volatization. Covers also provide an aerobic zone that aids in the aerobic degradation of odorous compounds from manure storage facilities. For stakeholder concerns, two of the three major categories are being addressed with the use of biocovers. Odour at manure spreading is not addressed. With an estimated 50% odour reduction when using natural crusts and an estimated 99% odour reduction (Heber et al., 1999) with impermeable floating plastic covers, at least 9, if not more, of our stakeholder concerns will be addressed. Such a marked reduction in odour will certainly prove to be a benefit for all. Under the criteria:

(a) Proven technology - yes

(b) Cost-benefit - yes - odours and emissions will be reduced. Solid covers are ideal and can almost eliminate odours from lagoons, however they are expensive whereas other types of covers are cheaper and more accessible. Impermeable plastic covers are estimated to reduce odours by 99%

(c) Commercial availability - yes

(d) Practicality - yes

(e) Residual effects – no; even organic covers are relatively inexpensive.

(f) Reduction > 50% - yes. In areas with strong winds, consideration has to be made as to the type of cover employed.

<u>Numerical evaluation - (a) - 1 (b) - 1 (c) - 1 (d) - 1 (e) - 1 (f) - .1 = 5.1.</u>

3. <u>Bottom Loading</u> – Evaluated at 5.1, but this mechanism is covered in the AOPA, so need not be addressed by the subgroup.

4. <u>Manure Storage Tanks</u> - Those with solid structural covers, e.g., steel tanks or concrete tanks with covers emit little odour except when they are emptied. For stakeholder concerns, they will address two of the three major categories. As for general concerns, the usual nine or so are addressed. Under the criteria:

(a) Proven technology - yes

(b) Odour and emissions are reduced more than 50% until the tanks are emptied.

(c) Cost-benefit -the benefit comes by having the manure contained in a tank that is emptied when needed. Odour and emissions are noted at this time but while the manure is contained in the tanks, emissions and odours are reduced.

(d) Such tanks are commercially available

(e) Practicality - depends on the individual operators. The purpose of a tank is practical. The initial investment may be expensive but the investment is long term.

(f) Residual effects - should be none unless the tank starts to leak.

<u>Numerical evaluation - (a) - 1 (b) - .1 (c) - 1 (d) - 1 (e) - 1 (f) - 1 = 5.1</u>

5. <u>Frequent Manure Removal and Corral Cleaning</u> – Evaluation = 5

6. <u>Manure Spreading - Injection Methods</u> - Considerable odours are created when manure is spread on the land. With different methods of direct injection, odour problems can be reduced. For our stakeholders, injection is preferable to surface spreading and would be a practice that would address one of the major stakeholder concerns - manure spreading. Of the general concerns, at least 7 would be addressed. It can significantly minimize the risk of water contamination, but only works for liquid systems. Under the criteria:

(a) Proven technology - yes

(b) Reduction > 50% - unknown if such specifics even exist.

(c) Cost-benefit - equipment is expensive but with reduced emissions and loss of nutrients into the atmosphere, a benefit for producers exists. Also with injection, there is no need to have to till the land to incorporate the manure.

(d) Equipment is commercially available and there are also several contractors who will provide the service.

(e) Practical - yes

(f) Residual effects - if injected properly, this mm will work to reduce odours and emissions of ammonia, hydrogen sulphide. Pathogens and harmful bacteria will also be directly injected into the ground.

Numerical evaluation - (a) - 1 (b) - 0 (c) - 1 (d) - 1 (e) - 1 (f) - 1 = 5.

7. Biofilters - open-bed and closed bed. Open bed types are the most common for treating exhaust air from facilities. Biofiltration addresses many of the issues from CFOs: ammonia, VOCs, hydrogen sulphide, pathogens. When looking at stakeholder concerns, it will address two of the three major concerns but, manure spreading, once again, is not addressed. Of the general concerns, 9 are addressed. Under the criteria:

(a) Proven technology - yes

(b) Reductions greater than 50% - yes

(c) Cost- benefit - open bed systems are far less expensive to construct and operate. According to the Manitoba study, biofilters must be low cost with minimal operation and maintenance costs. Page 53 of the study provides the details along with operational costs/hog. Biofilters used with livestock operations do receive benefits in the form of heat generation. They therefore do not need supplementary heat. They worked even under Manitoba weather conditions, maintaining adequate temperature ranges.

(d) They are commercially available however the system is complex and needs more research to make the system more affordable and easier to operate.

(e) Biofilters are an excellent management mechanism. The cost to construct, operate and maintain an open bed system (page 58 - Manitoba study) is estimated at \$0.50 - \$0.80 per finished market hog.

(f) Residual effects - the moist biofilter material provides a good environment for pests. As well, when it is time to dispose of the biofilter medium, nutrients within the medium may need to be analyzed to quantify the nutrients sequestered.

Numerical evaluation : (a) - 1 (b) - 1 (c) - 1 (d) - 1 (e) - (f) - 0 + reduction >50% - .1 = 4.1.

8. Shelterbelts and Artificial Walls Around Operations – These help to reduce PM, odours, noise and other aspects. Of stakeholder concerns, it addresses two major ones; odours from land application of manure will not be addressed. Of the general concerns, 8 will be addressed. Criteria:

(a) Proven - If it seems to help, does that mean it’s proven? This is based according to whose standards?

(b) Reduction level - didn’t find any research on percentage of reduction

(c) Cost-benefit - if neighbours aren’t complaining, other measures won’t have to be employed to address complaints. Trees also increase the value of property, provide privacy and protection from winds. Artificial walls can also be erected.

(d) Commercial availability - Trees, wind screens and artificial walls are available on a commercial level.

(e) Practical - yes

(f) Residual effects - none if placed in locations that will not interfere with operation of barn fans. Trees also need minimal maintenance and windscreens help in reducing wind effects in areas like Southern Alberta. Windbreaks enhance dispersion of odour but do not reduce emission rates. According to the Texas A & M paper: " Windbreaks placed down wind of exhaust fans and manure storage areas may provide an economical management practice for livestock operations when used in conjunction with other air cleaning practices and have been considered a best available technique for swine producers" (page 16).

Numerical evaluation : (a) - ? (b) - ? (c) - 1 (d) - 1 (e) - 1 (f) - 1 = 4

9. Bio-scrubbers - These are an effective way to remove odorous compounds from exhaust air, however there is limited research for livestock operations. Bio-scrubbers are successful in reducing PM10 as well as ammonia and odour emissions. Technology has focused on cheaper bio-filter systems requiring less maintenance. If this mechanism could be refined to work, it could be proven to be effective, however more research is required. For the sake of addressing stakeholder concerns, this mechanism would address the same number of NGO stakeholder concerns as the previous ones. Under the criteria:

(a) Proven technology - both bio-scrubbers and chemical scrubbers are effective but researchers quote different levels of effectiveness so more research is needed.

(b) Reduction greater than 50% - some researchers quote 22% effectiveness while others quote 70-80% effectiveness in swine facilities. More research needed to establish which is correct. Odor reduction in hog facilities ranged on average between 40-50 % and in some experimental operations 60-70%

(c) Cost-benefit - not yet established. However any reduction in emissions and odor provide benefit in the respect that many stakeholder concerns are addressed.

(d) Bio-scrubbers are commercially available but at great expense.

(e) Practicality - could be practical - they are being used in Europe more than bio-filters. Bio-scrubbers are efficient for removing odor but are primarily used for the removal of ammonia in The Netherlands.

(f) Residual effects - more research needed. However both types of scrubbers are being installed in new housing systems in the Netherlands - approximately 30% of the fattening pigs are housed in these types of facilities with minimum extra yearly costs for investment.

Numerical evaluation: (a) - 1 (b) - 1 (c) - 0 (d) - 1 (e) - 1 (f) - 0 = 4.

10. Barn Manure Handling Systems and Designs - Odour and cleanliness go hand in hand. (i) Slatted floors help separate manure from the animals. Proper slat spacing is essential for this mm to be effective. An increase in slatted floor area, especially with increased animal numbers may reduce PM as the hooves of the animals will force accumulated manure into the pits or flush gutters rather than leaving it on top to be resuspended into the air. Under floor storage pits hold the manure until it is transferred to a lagoon or tanks. (ii) Solid floors allow for manure accumulation which would increase odours and emissions - ammonia, hydrogen sulphide, PM. They would require frequent cleaning to reduce the emissions and odours. With solid floors, a slope towards gutters will aid in waste drainage. Bedding would also help in reducing odours. (iii) Flush systems are used to collect manure from under floor and open pit gutters. The manure is discharged into some sort of manure storage facility, e.g., lagoon, tank or basin. (iv)

Mechanical scrapers are reasonably successful and adaptable to barns. Problem is that residual manure increases ammonia and odour levels. (v) Solid manure system - bedding material is used to absorb the urine and feces. Cleaning is done after each production cycle is complete or four or five times annually. This mm creates aerobic composting which generates little odour. A deep-bedded system allows aerobic bacteria, fungi and other organisms to survive. In all these different manure handling systems, if done properly, two of the three major stakeholder concerns will be addressed. With the general concerns, at least eight will be addressed, but only if these systems are functioning properly. Using the criteria:

(a) Proven technology - yes
(b) Reduction > 50% - no percentage levels were provided
(c) Cost-benefit - yes - methods above, if done properly will provide the expected benefit with reasonable expense.
(d) Commercial availability - yes
(e) Practicality - yes - all methods above are practical.
(f) Residual effects - if any of the systems are poorly designed or are not functioning properly, odours and emissions will be increased.
<u>Numerical evaluation - (a) - 1 (b) - 0 (c) - 1 (d) - 1 (e) - 1 (f) - 0 = 4.</u>

11. <u>Oil Sprinkling</u> - Literature states it is “a flexible remedial method that can improve air quality by both suppressing dust and potentially reducing odorous gas volatilization” (Pahl et al., 2002). If the practice is effective, 2 of 3 major concerns will be addressed. The one not addressed is field spreading of manure. Of our general concerns, 9 are addressed. Using the criteria:

(a) Proven technology - seems to be
(b) Reduction greater than 50% - according to the reference article above from Texas A&M University, rates using different oils were listed - some with 50% and greater reduction rates for PM, ammonia , H_2S. The report “Odour Production, Evaluation and Control” submitted to the Manitoba Livestock Manure Management Initiative, page 60-61 lists different reduction levels and assessments of oil sprinkling. In the concluding remarks, they state: “suppressing dust emissions at the source by some form of oil sprinkling is the most cost-effective.” ... technologies <u>other than</u> oil sprinkling have not been adopted by industry due to input costs or effectiveness...”
(c) Cost-benefit - yes - low cost and minimal power consumption are also listed with certain types of sprayers designed for use. As well, vegetable oils are recommended over mineral oil because of cost, availability and biological safety
(d) Commercial availability - yes
(e) Practicality - yes
(f) No residual effects.
<u>Numerical evaluation : (a) - 1 (b) - .1 (c) - 1 (d) - 1 (e) - 1 (f) - 1 = 5.1.</u>

12. <u>Anaerobic Digestors</u> - Closed systems are an efficient way of dealing with manure. Less odour is produced and it retains the fertilizer nutrients contained in the manure. Digestors address two of the three major stakeholder concerns and 8 of the general concerns for stakeholders. Under criteria evaluation:

(a) Proven technology - yes
(b) Reduction - Does reduce odours and emissions but no percentage was found

(c) Cost-benefit - the benefits at this time are offset by the cost to establish the system and operate it.
(d) Commercial availability - available but too costly for producers
(e) Practicality is offset by the cost of the system for an individual producer
(f) Residual effects - the system works but more research is needed to apply the system to different climates.
Numerical evaluation - (a) - 1 (b) - 0 (c) - 1 (d) - 1 (e) - 0 (f) - 0 = 3.

13. Band Spreading – Band spreading is better than spraying into the air but less effective than injection or immediate incorporation after application. **Evaluation = 3**.

14. Surface Spreading of Manure - Solid or liquid manure can be spread directly onto the soil surface. This practice produces considerable odours and emissions resulting in complaints from affected neighbours. The practice must be used in conjunction with tillage, and the manure should be incorporated into the soil within 12 hours. This also ensures nutrient value to the soil. Unfortunately such is not the case in many instances, and problems with odours and emissions exist with this management mechanism. This practice is responsible for at least one of the major stakeholder concerns. Of the general concerns, at least 9 are affected by this practice. Using the criteria:
(a) Proven technology - no - it is a method used to remove manure from corrals and barns
(b) Reduction > 50% - no -this practice usually increases odour and emissions
(c) Cost-benefit - benefit is to the landowner and producer. The manure provides nutrients and bulk to the land while the practice cleans a producer's barn, corrals etc. For the residents, there is no benefit - the practice creates odour and dust problems.
(d) Practicality - yes
(f) Residual effects - manure provides nutrients to the land but without incorporation will increase emissions and odours as well as the possibility of runoff that could contaminate water sources.
Numerical evaluation - (a) - 0 (b) - 0 (c) - 1 (d) - 1 (e) - 1 = 3.

15. Diet manipulation - By reducing protein intake, ammonia and hydrogen sulphide emissions can be reduced which in turn will reduce odours. Strategies to improve feed digestion will also help reduce the amount of nitrogen excreted in hog manure. In regards to stakeholder concerns, any reduction in odours and emissions produced will address two and possibly all three of the major concerns. As expected, 9 or more of the general concerns will also be addressed. Under the criteria:
(a) Proven technology - no
(b) Reduction rates - more research needed on different species at different stages of growth
(c) Cost benefit - there would definitely be a benefit to producers if they could reduce feed costs and still maintain the same rate of production
(d) Commercial availability - yes - different rations could be formulated with grains available here
(e) Practicality - it would be practical if a diet could be determined that would be effective
(f) Residual effects - more research needed.

<u>Numerical evaluation -</u> <u>(a) - 0 (b) - 0 (c) - 1 (d) - 1 (e) - 1 = 3.</u>

16. <u>Composting</u> – Numerical evaluation = 3.

17. <u>Sprinkling of Corrals</u> – This would reduce PM when conditions warrant; e.g., in the evening, cattle can become quite active and churn up loose, dry dirt and manure particles. Clouds of dust drift in the direction winds take them. Conditions are worse when there is little or no wind, often making driving conditions extremely hazardous. During these conditions, individuals often complain about difficulty breathing, coughing and burning eyes.

Numerical evaluation = ???

18. <u>Watering of Gravel Roads</u> – This would reduce dust from heavy truck traffic during silaging and manure hauling seasons. Other agricultural activities also create dust (e.g., combining), but these are short term and minimal compared to CFOs.

Numerical evaluation = ???

19. <u>Electrical Cleaning of Airspace</u> - this includes ionization, electrostatic precipitation and ozonation. These are used to reduce PM. Since odour particles attach to small dust particles, effective measures to reduce PM will also help to reduce odour. For our stakeholders, if odour and dust are addressed, all three of the major concerns will also be addressed. For the general concerns, the same 9 or 10 concerns will be addressed with these types of mechanisms. As for the criteria:

(a) Proven technology - no
(b) Reduction >50% - no
(c) Cost benefit - any reduction in PM and odour will provide a benefit to stakeholders, however the initial and maintenance costs along with static electricity costs will offset any benefits
(d) Commercial availability - don’t know
(e) Practicality on farm - not at this time
(f) Residual effects - unknown.

<u>Numerical evaluation - (a) - 1 (b) - 0 (c) - 1 (d) - 0 (e) - 0 (f) - 0 = 2</u>

20. <u>Manure Additives</u> - There are a number of studies with conflicting results. The effect of additives is subject to other influences, e.g., building, ventilation methods, manure handling, feed and management practices. Additives could reduce ammonia, bacteria, ph levels and various pathogens. If additives were effective and reliable, they would address two of the three major concerns of stakeholders. Additives may also reduce odors and emissions when manure is spread on the fields which would address the third major stakeholder concern. As expected, the technology could address 9 or more of the general concerns of stakeholders. As for the criteria:

(a) Proven technology - no - however some additives are effective in the lab environment. Practical field studies are necessary for further evaluation.
(b) Reduction > 50% - no - more research is needed to arrive at results that are comparable in different studies.
(c) Cost-benefit - none at this time. Estimated costs are varied and effectiveness of manure additives is questionable.

(d) Additives are available but with no concrete proof of effectiveness, their use is not justified.
(e) Practicality - it would be a practical management mechanism to use but at this time, it is not a practical mm.
(f) Residual effects - more research is needed.
Numerical evaluation - (a) - 0 (b) - 0 (c) - 0 (d) -1 (e) - 0 (f) - = 1.

21. Super Soils Systems – A manure processing technology that has been approved by the North Caroline government to address the issues surrounding large scale livestock operations, in this case hogs. It appears that the state will allow more hog industry development provided that the new development uses this or other technological advances that virtually eliminate many of the environmental concerns surrounding manure. The Super Soils System turns hog waste into material for soil amendments and fertilizers, while removing almost all suspended solids, phosphorus and ammonia from the wastewater. It also significantly reduces greenhouse gas emissions.
Numerical evaluation = ???

Over the last nine years or so, a number of Alberta farm publications have recommended various management mechanisms to address air quality concerns. Five of these were brought to the attention of the subgroup. The CFO Project Team will also be apprised of this information, which could be used in developing the strategic plan:

- Land Resource Planning Workshop Focus: Manure Management
- Nutrient Management Planning from Livestock Production (section 10.1 and 10.2)
- Beneficial Management Practices Environmental Manual for Hog Producers in Alberta (section 7, 5.1)
- Environmental Farm Plan (Section 12)
- 2000 Code of Practice for Responsible Livestock Development and Manure Management.