# Confined Feeding Operations: Management Mechanisms

## Disclaimer:

This report is the last draft assembled by the Management Mechanisms subgroup, not a final version. The report represents the significant efforts of the subgroup and is presented for information only. Some of the information or interpretation contained in the report does not reflect the opinions or decisions of the Management Mechanisms subgroup or the Confined Feeding Operations project team.

Therefore, this report did not achieve consensus and does not have the sanction of the CFO project team.

**A report to the CASA CFO Project Team**
**from the Management Mechanisms Sub-group**

# DRAFT for discussion purposes only

November, 2007

## Acknowledgements

The Management Mechanisms Sub-group 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 sub-group 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 Sub-group 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 sub-group'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.

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# 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 sub-groups to address particular components of the team's terms of reference. The Management Mechanisms (MM) sub-group 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 sub-group 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 sub-group 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<br>• Improper management |
| Bottom loading | Manure Storage Facilities | $NH_3$, odour | • Retrofit costs<br>• 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<br>• Practice change<br>• 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 sub-group 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 sub-group 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 Sub-group 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 Sub-group 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 sub-groups to address particular components of the team's terms of reference. The Management Mechanisms (MM) sub-group 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 sub-group 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 Sub-group are noted in Appendix A and complete details of the sub-group'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 sub-group then prioritized the MM in the matrix. Industry, Non-government Organization (NGO) and Public Service members of the sub-group 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 sub-group 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 sub-group.

## 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 sub-group believes are worthy of further investigation; these are listed in order of how many of the six priority substances the mechanism addresses. The sub-group 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 sub-group, 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 sub-group 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<br>• Improper management |
| Bottom loading | Manure Storage Facilities | $NH_3$, odour | • Retrofit costs<br>• 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<br>• Practice change<br>• 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 within 12 hours. 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 sub-group 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 Sub-group 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 sub-group 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 Sub-group 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 sub-group 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 sub-group 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 Sub-group 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 Sub-group 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**:<br><br>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:**<br><br>a. High Efficiency Particulate Air (HEPA) filters.<br><br>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<br><br>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<br><br>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;<br><br>Selective removal of bioaerosols | | -same- | ASHRAE (2005) |
| d. Antifungal treated air filters<br><br>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:**<br><br>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% ($NH_3$)<br><br>Up to 100% ($H_2S$)<br><br>Up to 90% (Odour)<br><br>Up to 70% (VOC)<br><br>Up to 95% (Bacteria)<br><br>Up to 60% (Fungus)<br><br>Up to 90% (Endotoxins)<br><br>Up to 90% (Microbial VOC) | Complicated, biologically sensitive, management intensive, treatment system.<br><br>Operation may require services of contract specialist. Moisture availability is crucial for performance, among other requirements.<br><br>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.<br><br>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).<br><br>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).<br><br>Capital costs are reduced when incorporated into new barn design | | Mannebeck (1995); Hartung *et al.* (1997);<br>Hoop (1998);<br>Nicolai and Janni (1997, 1998a, 1998b, 1998c) |

| Management Mechanism | Substance | Potential Reduction | Practicality | Cost and Benefit | Gaps Analysis | References |
|---|---|---|---|---|---|---|
| **Biomass Filter:**<br>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:**<br>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.<br>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:**<br>Catalytic incineration performs the same destructive oxidation of odorous substances as thermal incineration but at a lower temperature, typically 350 to 400 ℃, hence fuel consumption is lower. The oxidation reaction takes place on the surface of the catalyst rather than in free air.<br>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:**<br>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% ($H_2S$)<br>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:**<br>Highly reactive radicals and plasma electrons generated by electrical discharge into the air.<br>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:**<br>Gases are oxidized by treatment of barn air with low doses of ozone. | Ammonia; Hydrogen Sulphide; Odour | Up to 58% ($NH_3$)<br>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.<br>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:**<br><br>Daily sprinkling of small volumes of vegetable oils in animal pens. | Ammonia, Hydrogen Sulphide; Odour; Particulate Matter. | Up to 90% ($NH_3$)<br>Up to 60% ($H_2S$)<br>Up to 70% (odour)<br>Up to 95% (PM) | Concerns about animal safety, e.g., slippery conditions in pens and alleys and, clean up.<br><br>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:**<br><br>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.<br><br>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.<br><br>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.<br>- Reduces conflicts<br>- Appreciate property value of both livestock facility and adjacent property<br>- Improves public<br><br>perception of livestock facility<br>- Reduce heating costs<br>- Protect livestock from wind and sun<br>- Potential reduction in feed costs in cold weather<br>- Reduce dust leaving property<br>- 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:**<br>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:**<br>Pathogens are inactivated through cell damage by exposure to UV radiation.<br>Tool - UV lights | Pathogens | High (surfaces)<br>Low (air stream) | | | -same- | |
| **Windbreak Walls:**<br>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.<br>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:**<br>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)<br>Has potential of reducing feed costs. | Inconsistent results reported by various researchers.<br>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:**<br>Include chopped barely, wheat, oats or brome straw. | Ammonia; Hydrogen Sulphide; Odour | Up to 95% ($NH_3$)<br>Up to 69% ($H_2S$)<br>Up to 90% (odour)<br>$H_2S$ 95% | Reapplication may be required to maintain effectiveness of cover.<br>Biocovers on outdoor manure storages<br>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);<br>Bicudo et al. (2004); Nicolai et al. (2005). |
| **Bottom Loading:**<br>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:**<br>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;<br>during storage period)<br>$H_2S$ 95% | Additional material handling is required during pump out. | Nutrient recovery.<br>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.<br>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.<br>$0.35-0.45 US per pig marketed. | Mannebeck (1985); DeBode (1991); Sommer et al. (1993); Karlsson (1996); ARDI (2001). |
| **Inflatable Plastic Covers:**<br>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:**<br>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.<br>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. | |
| **MANURE TREATMENT** | | | | | | |
| **Acid:**<br>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.<br>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:**<br>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:**<br>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:**<br>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.<br>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:**<br>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:**<br>Raise slurry pH by addition of calcium hydroxide. | Hydrogen Sulphide; Pathogens; Odour | | Highly technical process. Application may require services of contract specialist.<br>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:**<br>Solid-liquid separation of livestock manure involves the partial removal of organic and inorganic solids from liquid manure.<br><br>Solids are removed from manure slurry. | Ammonia; Odour | Up to 50% | | High capital and operational costs.<br>May not be cost effective for small operations.<br>-Recycling of water<br>-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:**<br>Air is pumped into manure slurry to enhance aerobic decomposition. | Odour; H2S;<br><br>Volatile fatty VOC (VFA - acids) | Up to 45%<br><br>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;<br>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:**<br>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:**<br>Cool top 10 cm of manure to 15$^{o}$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:**<br>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:**<br>Mitigate pathogen import to farms; Break cycle of pathogen amplification; Appropriate collection and treatment of animal waste; Control pathogen export from farm.<br>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) |

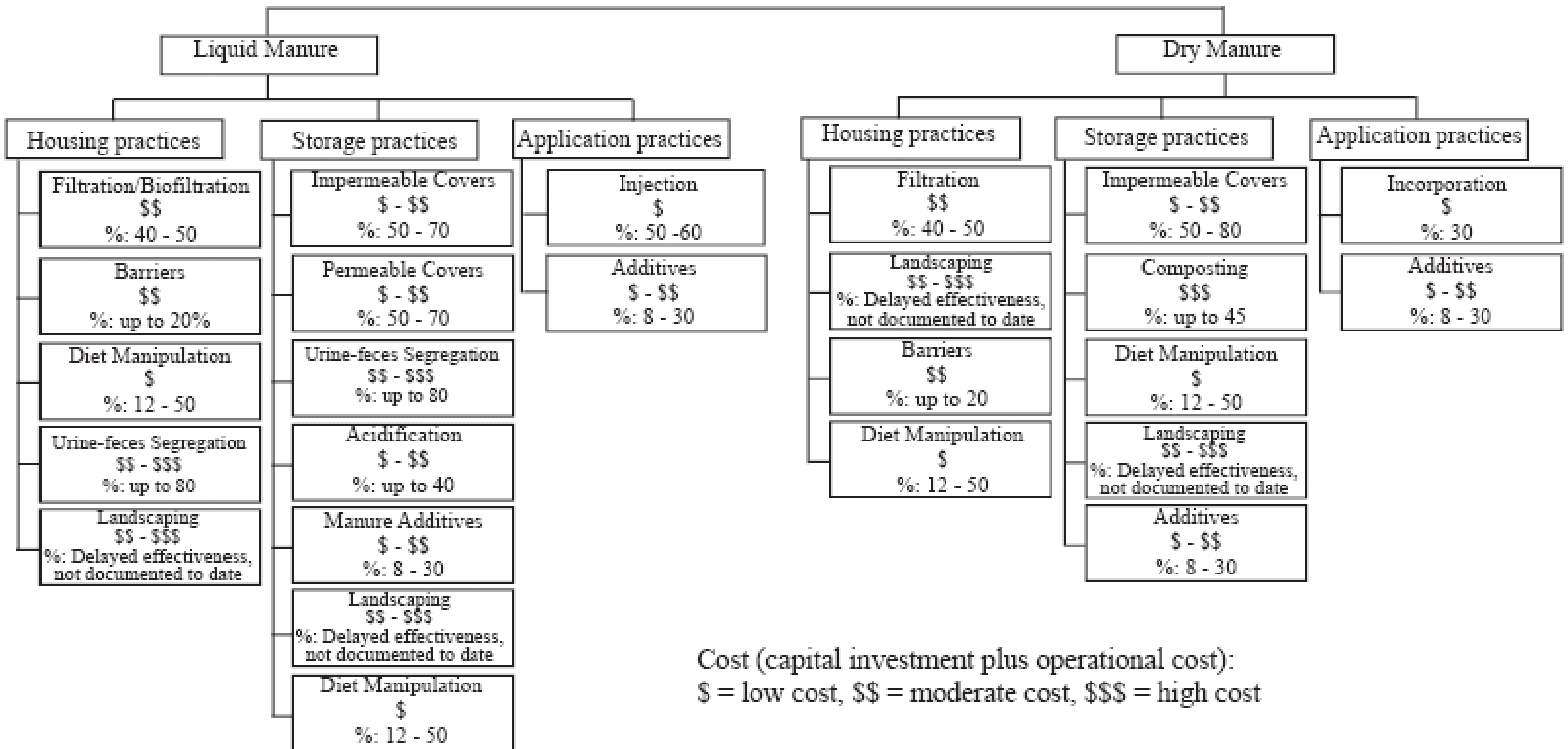
| Management Mechanism | Substance | Potential Reduction | Practicality | Cost and Benefit | Gaps Analysis | References |
|---|---|---|---|---|---|---|
| **<u>ROADWAY MANAGEMENT</u>** | | | | | | |
| **Dust Palliatives:**<br>Suppressants agglomerate fine particles; Adhere or bind surface particles; Increase 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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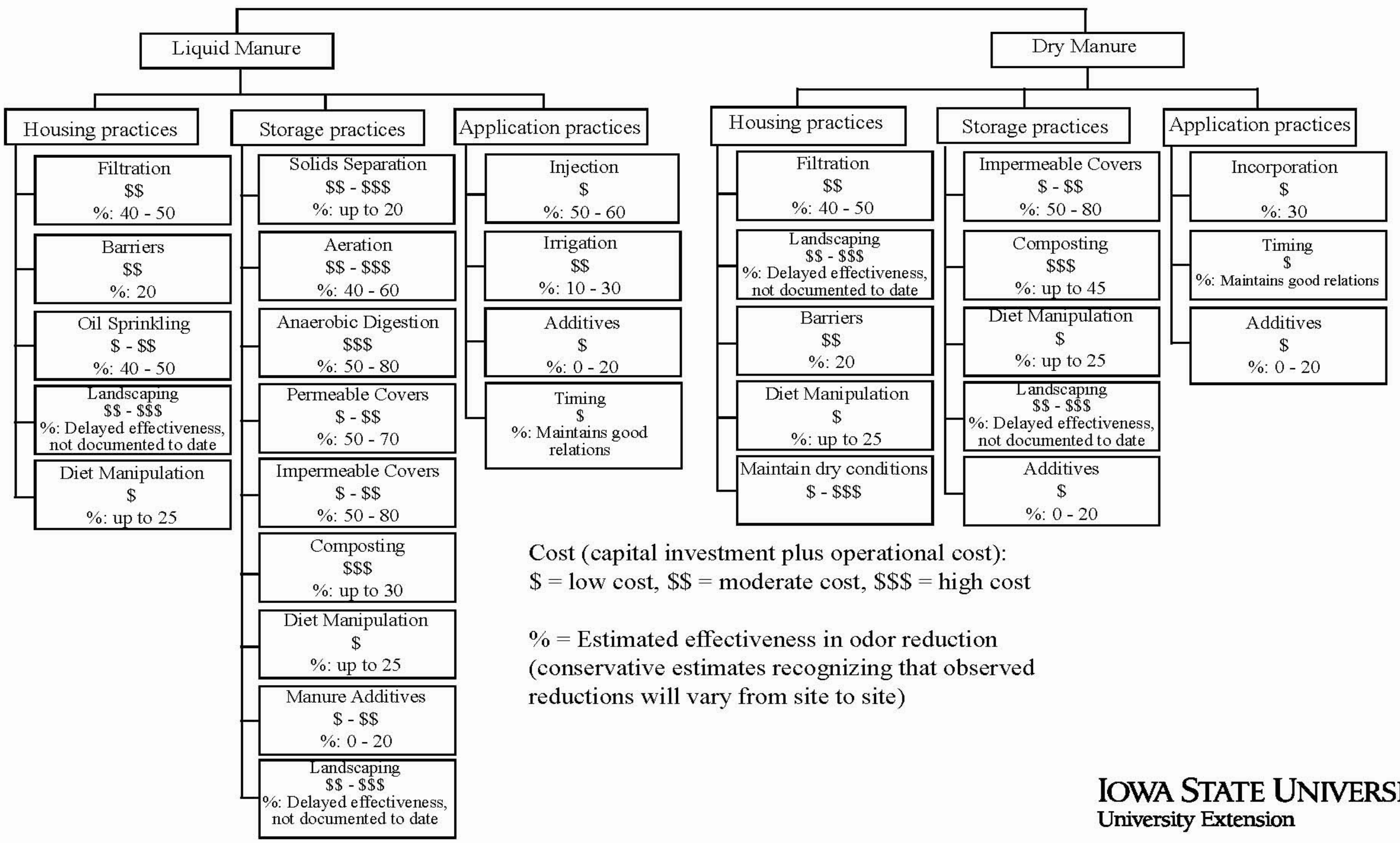
# Practices to Reduce Odor from Livestock Operations Flowchart

**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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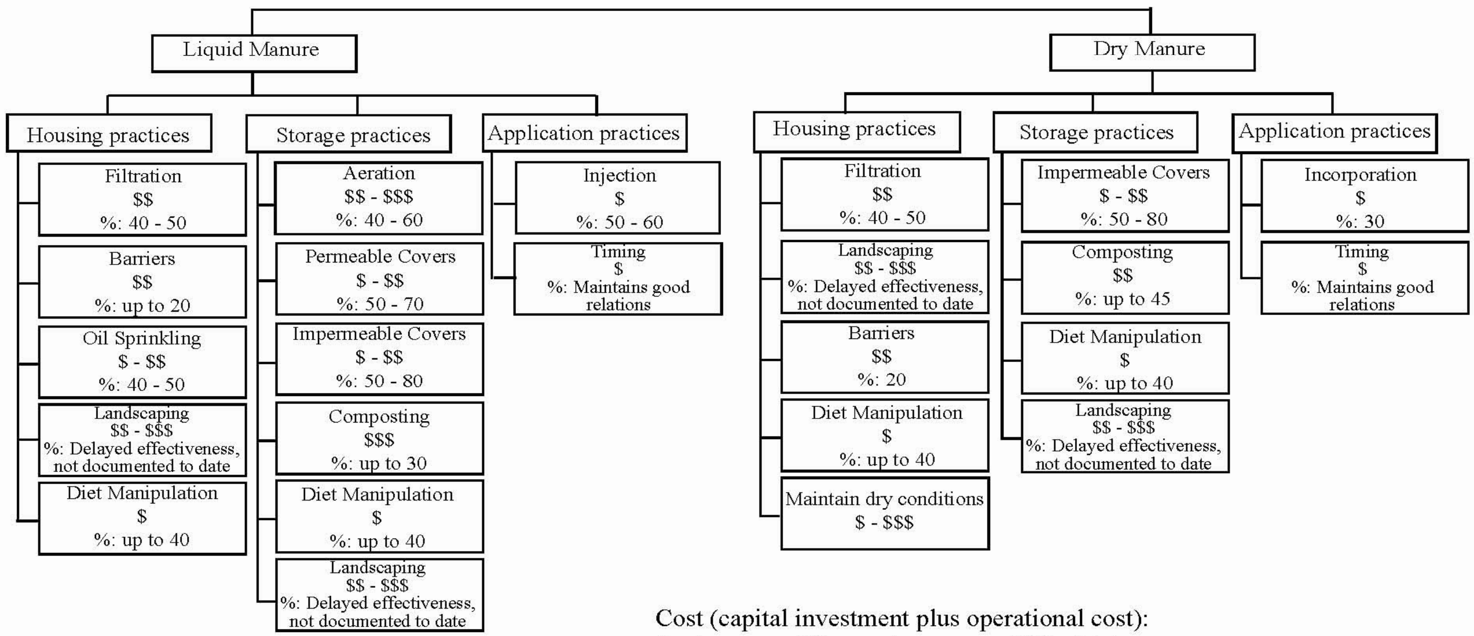
# Practices to Reduce Hydrogen Sulfide from Livestock Operations Flowchart

**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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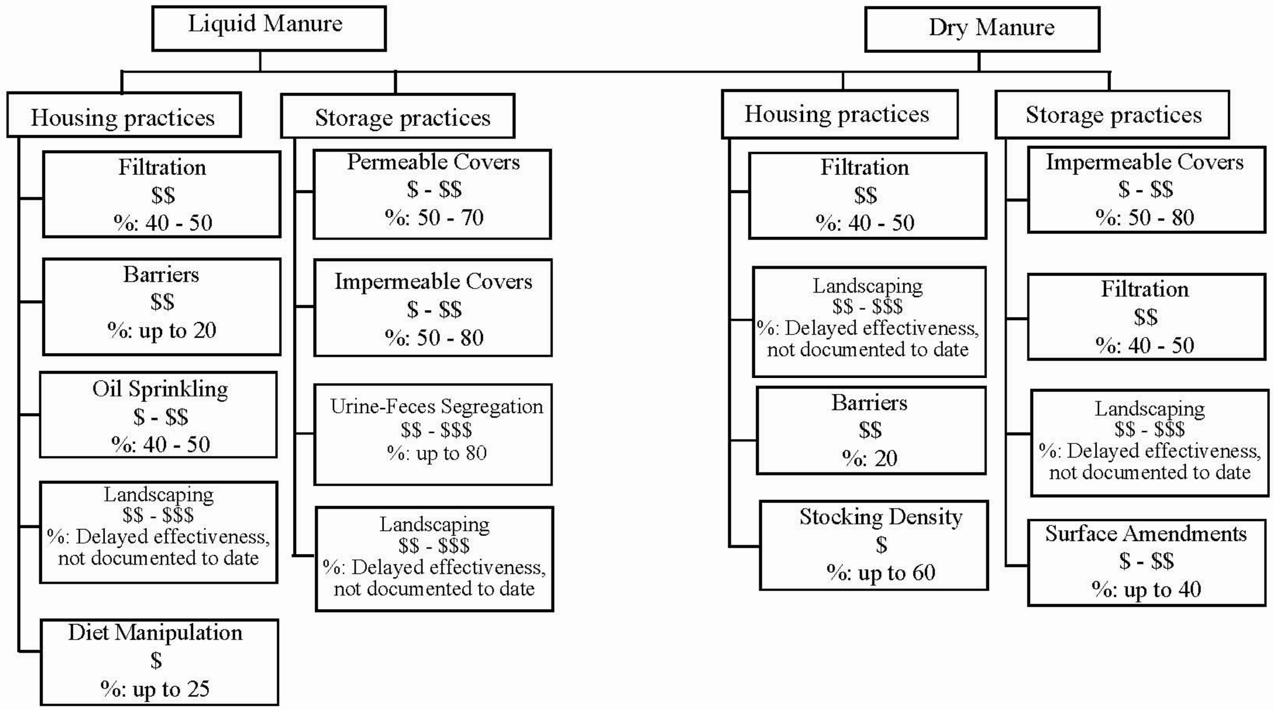
# Practices to Reduce Dust and Particulates from Livestock Operations Flowchart

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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## References

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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".<br>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%.<br>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%.<br>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<br>(10101) | 0.4<br>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.<br>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<br>(10101) | 0.4<br>Pathogens (0.1,0.1); PM (0.1,0.1) | 3.4 | (B, D) Same as Air Filtration: HEPA filter |
| | Frequent Manure Removal | 3<br>(10101) | 0.4<br>$NH_3$ (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<br>(10101) | 0.0<br>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.<br>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.<br>(F, G) Percentage reduction is unknown. |
| | Shelterbelts | 3<br>(Rating 01110) | 0.0<br>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.<br>(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<br>(10100) | 0.6<br>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.<br>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.<br>(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<br>(10100) | 0.4<br>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.<br>(E) Unknown for CFOs. |
| | Ultraviolet Radiation | 2<br>(10001) | 0.2<br>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.<br>(C) Unknown for CFOs.<br>(F, G) Assumes treatment will be applied to surfaces. |
| | Catalytic Incineration | 2<br>(10001) | 0.0<br>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.<br>(C) Unknown for CFOs. Custom-fabrication seems likely.<br>(F, G) Percentage reduction unknown. |
| | Cryogenic Condensation | 2<br>(10001) | 0.0<br>VOC (0,0) | 2.0 | (B to D, F, G) Same as Catalytic Incineration |
| | Manure Flush System | 2<br>(10100) | 0.0<br>$NH_3$ (0,0) | 2.0 | (B) Cost-benefit ratio is unknown.<br>(D) May only be applicable to new barn designs. In most situations, probably an impossible quest for existing barns.<br>(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<br>(10001) | 0.0<br>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<br>(10000) | 0.9<br>$NH_3$ (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.<br>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.<br>Complicated, biologically sensitive, management intensive, treatment system. May need to hire services of specialist to manage system.<br>(C) Requires custom fabrication.<br>(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<br>(10000) | 0.2<br>$NH_3$ (0.1,0.1); $H_2S$ (0,0); Odour (0,0) | 1.2 | (B, D) Similar to Biofiltration.<br>(C) Unknown for CFOs. Custom-fabrication seems likely.<br>(E) Concentration of substances in recirculated water may increase to toxic levels. Drainage will likely require secondary treatment. |
| | Non-Thermal Plasma | 1<br>(10000) | 0.2<br>$NH_3$ (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.<br>(C, E) Unknown for CFOs. |
| | Modified Floor Design: Deep Litter | 1<br>(10000) | 0.1<br>$NH_3$ (0.1,0) | 1.1 | (B, D) Costly to retrofit existing barns.<br>(C) May only be applicable to new barn designs. In most situations, probably an impossible quest for existing barns.<br>(E) May result in increased manure handling. |
| | Windbreak Walls | 1<br>(00001) | 0.0<br>Odour (0,0); PM (0,0) | 1.0 | (A) Unknown potential/effectiveness.<br>(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.<br>(C) Requires custom fabrication.<br>(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<br>(00001) | 0.0<br>Pathogens (0,0) | 1.0 | (A) Unknown potential/effectiveness.<br>(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.<br>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.<br>(C) Unknown for CFOs.<br>(F, G) Percentage reduction unknown. |
| | Air Filtration: Biomass filter | 1<br>(10000) | 0.0<br>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.<br>(C) Requires custom fabrication.<br>(E) When wet could provide suitable environment for pathogens to thrive and populate.<br>(F, G) Low reduction. Too porous to capture microorganisms and respirable particulate matter. |
| | Oil Sprinkling | 0<br>(00000) | 0.5<br>$NH_3$ (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<br>(00000) | 0.1<br>$NH_3$ (0.1,0); $H_2S$ (0,0) | 0.1 | (A to E) Application is still under investigation. |
| **<u>Animal Management</u>** | | | | | |
| | Diet Manipulation | 1<br>(00010) | 0.0<br>$NH_3$ (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.<br>(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<br>(11110) | 0.0<br>$NH_3$ (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.<br>(F, G) Percentage reduction variable. |
| | Liquid Manure Injection | 3<br>(10110) | 0.4<br>$NH_3$ (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.<br>(E) Release of $N_20$ (GHG). Potential for nutrient leaching exists. |
| | Solid Manure Injection | 0<br>(00000) | 0.4<br>$NH_3$ (0.1,0.1); Odour (0.1,0.1) | 0.4 | (A to E) Application is still under investigation. |
| **Manure Storage Facilities** | | | | | |
| | Biocovers | 4<br>(11110) | 0.5<br>$NH_3$ (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<br>(10111) | 0.0<br>$NH_3$ (0,0); Odour (0,0) | 4.0 | (B) Cost/benefit ratio unknown.<br>(F, G) Percentage reduction unknown. |
| | Inflatable Plastic Covers | 3<br>(10101) | 0.4<br>$NH_3$ (0,0); $H_2S$ (0.1,0.1); Odour (0.1,0.1); PM (0,0) | 3.4 | (B) High cost material.<br>(D) May experience difficulty removing cover for agitating and pumping manure. Maintenance of covers may also be a concern. |
| | Rigid Impermeable Covers | 3<br>(10101) | 0.4<br>$NH_3$ (0,0); $H_2S$ (0.1,0.1); Odour (0.1,0.1); PM (0,0) | 3.4 | (B) High cost material.<br>(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<br>(10101) | 0.2<br>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.<br>(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<br>(01110) | 0.0<br>$NH_3$ (0,0); Odour (0,0) | 3.0 | (A) Uncertain.<br>(E) Residual effects unknown. Variable.<br>(F, G) Percentage reduction is variable. |
| | Anaerobic Digestion | 2<br>(10100) | 0.2<br>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.<br>(E) Digestate has a high nutrient content that may easily be lost if applied on land directly. |
| | Feedlot Moisture Management | 2<br>(10100) | 0.2<br>Odour (0.1,0.1); PM (0,0) | 2.2 | (B) Cost is unknown.<br>(D) May be labour intensive to manage.<br>(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<br>(10100) | 0.2<br>Odour (0.1,0.1); PM (0,0) | 2.2 | (B, D, E) Same as Feedlot Moisture Management. |
| | Acid Additives | 2<br>(10100) | 0.0<br>$NH_3$ (0,0); Pathogens (0,0) | 2.0 | (B, D) Frequency of application and cost are unknown.<br>(E) May induce $H_2S$ emissions when pH of manure is lowered.<br>(F, G) Percentage reduction is unknown. |
| | Composting | 2<br>(10100) | 0.0<br>$NH_3$ (0,0); Pathogens (0,0) | 2.0 | (B, D) Cost is not well established. May be labour demanding.<br>(E) Nutrient losses, e.g. nitrogen loss in the form of $NH_3$ emissions.<br>(F, G) Variable. Odour emissions are not reduced but pathogens are destroyed. |
| | Lime Additives | 2<br>(10100) | 0.0<br>$H_2S$ (0,0); Odour (0,0) | 2.0 | (B, D) Frequency of application and cost are unknown.<br>(E) May induce $NH_3$ emissions when pH of manure is raised.<br>(F, G) Percentage reduction is unknown. |
| | Liquid-Solid Separation | 2<br>(10100) | 0.0<br>$NH_3$ (0,0); Odour (0,0) | 2.0 | (B) Costly technology to implement.<br>(D) May be labour intensive to manage.<br>(E) Variable. May result in increased material handling.<br>(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<br>(10100) | 0.0<br>$H_2S$ (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.<br>(D) May be labour intensive to operate and maintain.<br>(E) May induce release of $NH_3$.<br>(F, G) Percentage reduction is unknown. |
| | Temperature Control: Cooling | 2<br>(10001) | 0.0<br>$NH_3$ (0,0) | 2.0 | (B, D) Seems costly and difficult to retrofit existing barns. May also be costly to implement in new barns.<br>(C) Requires custom fabrication.<br>(F, G) Percentage reduction is unknown. |
| | Heat Drying | 0<br>(00000) | 0.0<br>Pathogens (0,0) | 0.0 | (A to E) Low feasibility.<br>(F, G) Percentage reduction is unknown. |
| | Pasteurization | 0<br>(00000) | 0.0<br>Pathogens (0,0) | 0.0 | (A to G) Same as Heat Drying. |
| **<u>Proper Planning</u>** | | | | | |
| | Increase Minimum Distance of Separation (MDS) | 2<br>(00101) | 0.0<br>$NH_3$ (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.<br>(B) Producers are interested in reduction of current MDS and not an increase for economic reasons including, transportation of consumables and livestock products.<br>(D) Not applicable to existing non-expanding facilities.<br>(F, G) Percentage reduction is unknown. |
| **<u>Quality Assurance Program</u>** | | | | | |
| | Biosecurity; Herd Health, BMP | 4<br>(11101) | 0.0<br>Pathogens (0,0) | 4.0 | (D) Resistance to change unless there are no alternatives.<br>(F, G) Percentage reduction is unknown. |
| **<u>Roadway Management</u>** | | | | | |
| | Dust Palliatives | 2<br>(10100) | 0.1<br>PM (0.1,0) | 2.1 | (B, D) Costly to implement. May be labour demanding.<br>(E) Leachate of salts is a concern. |

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

From the original list of management mechanisms, the NGO caucus evaluated each according to the criteria set by Alberta Agriculture. An mm was judged on a numerical scale: in order for it to be considered a valuable mechanism, it had to have a higher numerical evaluation. We disagree with this rating scale as there are several mms that fail to meet these numerical criteria but are effective in addressing a number of NGO stakeholder concerns. In the opinion of the NGO community, the binary assessment criteria used to determine the potential of the different management mechanisms, does not adequately consider the true potential of some of the mms being evaluated.

We also feel addressing the costs associated with implementing the various management mechanisms is a task beyond our own expertise. This is more of a financial matter between the individual producer and various government agencies. When evaluating costs and benefits of a particular management mechanism, what numerical value can you place on human health, community health or in general, quality of life? The management mechanisms do not fully address these concerns which rank as a priority for NGOs. Government, industry and NGOs have varied perspectives on the mms, as should be expected. However, in the end, our goal collectively is to improve air quality and reduce odours and emissions from Confined Feeding Operations. Hence, by reducing these odours and the emissions of the priority substances from these operations, many of our stakeholder concerns will be addressed.

We have compiled a list of the management mechanisms that we felt were most effective. They appear in random order except for #1 - Proper planning, which is by far the most important of all mms!

**NGO Management Mechanisms Assessment**

The NGO caucus used the same criteria as industry and the public service caucus to assess the various management mechanisms. These were described in Appendix D. One question we were also asked to answer was: how many of our stakeholder concerns would be addressed with the use of each of the different management mechanisms. The original list NGOs submitted contained three major areas of concern:

(a) emissions from the C.F.O. facility itself, which would include barns/feedlot, ventilation systems, manure storage facilities etc.

(b) emissions from the land application of manure

(c) impacts from high levels of dust generated from the facility itself as well as dust from the heavy truck traffic involved with the day to day operation of individual confined feeding operations.

Under these three broad categories, there were many specific concerns expressed by different members of the NGO community. They are included in the complete list in section 2, page 6 of the Management Mechanisms report. (They were also submitted to CASA via email on August 15th, 2006.)

1. Proper Land Use Planning - 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. Effective planning would also take into consideration long term development that may occur in areas located closer to communities, cities and more populated regions. This would address two, and possibly three, of the major stakeholder concerns. The question is: how much of an increase would be necessary to address the problems; it also does not address the emissions and other impacts when land application of manure is taking place. Scoring using the descriptors resulted in the following evaluation:

> (a) Proven - Individuals with no operations around them have no complaints; those with a couple of CFOs in proximity may have a few complaints at various times; those with several around them, have complaints when conditions warrant, which may vary in frequency depending on the season and the type of CFO operations in their area..
>
> (b) 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 would have to be implemented to deal with complaints.
>
> (c) Definitely available but not commercially.
>
> (d) Practicality - on the development level, it is practical when it is used as a planning tool by counties and municipalities.
>
> (e) No residual effects.
>
> (f) Reduction ??? - how can we assess whether the reduction is more than 50%? To evaluate this mechanism using the criteria established would depend on who is affected and to what extent. What numerical scale could adequately evaluate an individual's quality of life?

<u>**Numerical evaluation : (a) - 1 (b) - ? (c) - 1 (d) - 1 (e) - 1 (f) - 0 = 4.**</u>

2. Bio-covers and Floating Organic Covers – These are an effective way of minimizing odours from manure storage facilities. Covers limit solar heating and wind induced volatilization. Use of a floating permeable blanket can allow a 90% reduction in ammonia and hydrogen sulphide. Covers also provide an aerobic zone that aids in the aerobic degradation of odorous compounds from manure storage facilities. The use of

straw to cover such facilities is a practice that has been used by many hog producers to help reduce odours from the manure. Straw covered manure storage (EMS) facilities have proven to be effective in addressing odour problems in areas where there are neighbours living close to the hog operation.

For stakeholder concerns, two of the three major categories are being addressed with the use of bio-covers. 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 2 of our major concerns would be addressed and 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.

**Numerical evaluation - (a) - 1 (b) - 1 (c) - 1 (d) - 1 (e) - 1 (f) - .1 = 5.1.**

3. Bottom Loading –

This mechanism is addressed in AOPA.

By utilizing measures to add manure to lagoons and storage pits so as not to disrupt the surface crust on the storage facility, odours and emissions are significantly reduced.. This management mechanism addresses one of the major concerns of the NGO community and at least 7 of the public concerns. Under the criteria established:

(a) Proven technology - yes

(b) Cost Benefit - yes but more research is needed to establish the exact ratio of cost benefit. Neighbours recognize improvements using this technology because of the reduced amount of odours from the lagoons.

(c) Commercial availability - yes

(d) Practicality - yes

(e) Residual effects - none

(f) Reduction > 50% - not established - more research needed

**<u>Numerical Evaluation - (a) - 1 (b) - 1 (c) -1 (d) - 1 (e) - 1 (f) - 0 = 5</u>**

4. Manure Storage Tanks - Those with solid structural covers, e.g., steel tanks or concrete tanks with covers emit little odour except when they are emptied. In the case of tanks that are left open with no cover in place, it has been found that covering the storage tank can reduce odours by up to 90%.

For stakeholder concerns, this management mechanism will address two of the three major categories. As for general concerns, the eight are addressed. Under the criteria:

(a) Proven technology - yes

(b) 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.

(c) Such tanks are commercially available

(d) 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.

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

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

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

5. Frequent Manure Removal and Corral Cleaning –

The frequent removal of manure helps to reduce odours from the accumulation of manure within the facility or corrals. During dry conditions, removing loose manure from the pens helps to reduce PM. When evaluating this mechanism using the criteria, the following conclusions were reached:

(a) Proven technology - yes

(b) Cost Benefit - there are definitely benefits when facilities are kept clean. Most operators have the equipment available and if not, there are custom operators who clean corrals and other facilities.

(c) Commercial availability - yes

(d) Practicality - yes

(e) Residual effects - none other than frequent cleaning of corrals may remove excessive amounts of soil from the pen surface.

(f) Odour reductions > 50% - more research is needed to determine exactly the reduction levels when using this management practice.

**Numerical Evaluation - (a) - 1 (b) - 1 (c) - 1 (d) - 1 (e) - 1 (f) - 0 = 5**

6. Manure Spreading - Injection Methods -

Considerable odours are created when manure is spread on the land. With different methods of direct injection, odour problems can be reduced. . It can also significantly minimize the risk of water contamination; the one problem with this management mechanism is injection only works for liquid systems. Considerable literature is available to support the value of using direct injection as a manure management mechanism. In fact, it is considered to be one of the most effective Management Mechanisms available to address emission/odour issues pertaining to air quality. Although the additional benefits may be more difficult to assess, "as chemical fertilizer prices increase, the importance of capturing the nutrients in the soil will make direct injection a more cost effective method in manure management. Volatilization will almost be completely eliminated, thus retaining the nutrient value of the manure as well as reducing the degradation in air quality. The points below are supported by referenced documents, demonstrating how the potential additional costs of applying manure using injection can be offset:

• Nutrient retention value for crop growth
• No need for an additional incorporation pass with other equipment
• Minimizing emissions/odours
• Potential for pathogen transfer to livestock on grazing lands
• Significantly reduces potential for manure runoff into water sources in the event of storm or high water flows following manure application
• Injection with the draghose system significantly reduces the amount of time required to apply the manure onto soils (this is important for large volume operations)
• Easier to interest other farmers in the area to supply additional land for manure application acres
• Less resistance from neighbours to CFO development in their backyard

(Manitoba/Saskatchewan studies)"

A number of studies have been done which indicate the value of direct injection. These studies are cited below:

**"Estimating Manure Values" (University of Minnesota 1998)"** Inject or incorporate manure to avoid nutrient losses. Immediate incorporation or injection of manure results in about 25% more available nitrogen (compared to no incorporation) due to reduced loss of ammonia gas to the atmosphere. Injecting or incorporating manure will also reduce the risk of off-field manure transport."

**IOWA PM1754E**

"Soil injection controls odour emissions from manure during and after land application. Soil immediately covers the manure during soil injection, isolating it from the air above. Sixteen co-operators are demonstrating soil injection as part of the Odour Control Demonstration Project."

**"Land application PM1779E**"

"When injecting manure, application rates should be lower than broadcast rates since very little nitrogen is lost in the air."

"Manure injection systems are designed to place the manure under the soil and cover it. This method of applying manure has a number of benefits, including

- Reduced nitrogen volatilization losses;
- Reduced threat of runoff losses of nutrients and microbes;
- Reduced tillage trips due to the tillage benefits from the injectors; and
- Reduced odour during land application"

**"Meristem Ag Technology"**

"If producers are interested in controlling odour, retaining nutrients and treating manure as a resource, then injection is the way to go," says Sexton.

**"Manure maker or manure taker?"** (Top Crop Manager)

By Cedric Macleod GHG coordinator for the Canadian Pork Council

"Reducing manure odours and losses of nitrogen to ammonia during manure application cannot be dismissed in this discussion. Granted, reducing manure odour does little for your bottom line, but conserving nitrogen does, and when you lose ammonia at spreading you will also be producing manure odour. The best way to avoid both is to put manure in the ground by injecting it. A ton of research has been completed in this area, from the size and shape of shank type openers, to coulter injection systems, incorporation using airway pasture aeration equipment, to the distribution manifold needed to get it to the openers evenly and accurately. Moving to injection may present a few new challenges for your existing manure application system, but it will keep the neighbours happy and again help to add value to your manure."

**“Manure maker or manure taker part II” (Top Crop Manager)**

“Consider the manure nitrogen to phosphorus ratio (N:P) is 1:1 in an uncovered storage, but increases to 2:1 after installing a cover system as ammonia nitrogen losses are significantly lower. At a N:P ratio of 1:1, if the target is a 100lb/ac nitrogen application rate, you are also getting 100 pounds of phosphorus, but at a ratio of 2:1, applying 100 pounds of nitrogen only gives you 50 pounds of phosphorus per acre. In the first scenario, using manure with a N:P ratio of 1:1, it is not hard to see how soil phosphorus reserves can accumulate rather quickly without a cover system.

The key to managing these issues is to keep looking and moving forward when it comes to manure management, both in the barn and in the field. The message is that producers do not have to deal with a waste product in hog manure, but can find ways to add value to an already valuable nutrient product. This thinking is what it takes to make a farm a 'manure maker' as opposed to a 'manure taker'.”

**“Saskatchewan manure study”**

“Odours: Many different approaches have been previously used to apply hog manure to cropland, and many resulted in a large degree of odour release. Most of these used either irrigation guns or trucks with spreaders, which spread the manure on the surface. Surface application results in high levels of odour and nutrient losses if the manure is not quickly incorporated. It is now common practice that manure is injected below the soil surface and when this is done properly, there is very little odour released. The reason for injection is primarily to prevent loss of N but a very important secondary result is the reduction of odour. Another benefit of injection is that any concern of surface runoff due to heavy rain or spring snow melt is eliminated. High disturbance injection systems have been improved to allow higher application rates without plugging or odour release. In response to the increase in direct seeding and application to forages, low disturbance injections systems have also been developed. These systems have now been demonstrated to the public and have been adopted by industry to the extent that odour release from land application is now publicly understood to be able to be dramatically reduced. Some surface application is still being done, but it is decreasing rapidly.

- “The new Big Sky barns in the Canora-Kelvington area all incorporate manure injection as a means of manure application. Original community opposition due to odour has been reduced. Overall in Saskatchewan, hog manure is now almost always soil injected and this has reduced odour complaints.”

- “Swine manure injection has become standard in the industry as an application method and low disturbance injection is in use in grassland application. Where initially hog producers had difficulty finding land to place manure, demand now exceeds supply of manure.”

**“U of Manitoba crop response to injection tool type”**

“Although it is less costly, surface application method suffers from release of odour, surface runoff, and loss of ammonia via volatilization (Meisinger and Jokela 2000; Schmitt et al. 1995; Sutton et al. 1982). Apart from being a nuisance to the environment, loss of ammonia can also translate into reduction in crop yield. Injection of swine manure is a superior method to surface application in terms of reducing odour, runoff, and loss of ammonia, which eventually contributes to increasing crop yields (Mooleki et al. 2002; Assefa 2002; Rasmussen 2002; Charles 1999). Thus, injection is the recommended method of liquid manure application."

**"Study Shows Manure Injection Superior to Broadcast"**
Document sourced from Alberta Cattle Feeders Association website.

"Research conducted by the University of Saskatchewan in conjunction with the Prairie Agricultural Machinery Institute shows injecting liquid swine effluent is both agronomically and environmentally superior to broadcast application."

"University of Saskatchewan Soil Science Department Senior Research Scientist Dr. Jeff Schoenau says when manure is injected into the soil, using either high disturbance sweep type openers or low disturbance coulter, crop response and nutrient recovery are both much better which is an advantage both agronomically and environmentally."

**"Triple S Hog Manure Management Initiative…"**
"Injection of manure beneath the soil surface not only reduces odour, it also reduces nutrient losses due to volatilization. However, variable nutrient rates and difficulty in keeping manure below the soil surface have often been associated with land-injection application of manure. Cattle producers, who understand the nutrient benefits of hog manure, see manure injection as an inexpensive alternative to boost forage production. They also understand that improper application can cause poor palatability, pathogen contamination of grazing cattle and fouling or burning of grasses. Therefore nutrient control and proper below-soil-surface application is important."

"Although injection adds to the initial cost of land application, nutrient savings can offset the extra cost. In using swine pit manure; enough extra nitrogen can be retained to cover the cost difference between injection and broadcasting."

When considering the use of a management mechanism, one tends to look for information that would make apply to one's own jurisdiction - in our case, the province of Alberta. Below is an excerpt from such a document:

**"Manure Research Findings" AAFRD**
8.4.4 Injection

Injection is the most effective way to reduce odour emissions from the land application of manure (Yale Center for Environmental Law and Policy 2002). Manure has traditionally been injected into the soil using equipment with injection knives spaced 0.75 to 1.5 m (30 to 60 in.) apart. Manure is injected into the soil in a concentrated vertical band 150 to 200 mm (6 to 8 in.) below the soil surface. Newer equipment, such as sweep and disc injectors, can also spread manure horizontally under the soil surface, allowing for the faster breakdown of the manure (Yale Center for Environmental Law and Policy 2002)."

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.

Under the criteria established to evaluate the management mechanisms, NGOs feel injection ranks as:

(a) Proven technology - yes

(b) 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.

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

(d) Practical - yes

(e) 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.

(f) Reduction > 50% - uncertain - more research is needed to determine reduction levels.

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

7. Incorporation

"Rapid incorporation of applied manure into the soil helps to reduce odour problems. Manure should typically be incorporated within 12 hours of application to ensure minimal odours as well as maximum nitrogen retention (Yale Center for Environmental Law and Policy 2002). Equipment such as ploughs, rotary harrows or tines may be used for incorporation. In experiments undertaken in the Netherlands it was found that, on arable land, ploughing immediately after application reduced the odour emission rate during the first hour by 85% and by 52% over 48 h. Rotary harrowing reduced odour emissions during the first hour by 45% (Pain et al. 1991).When incorporation was delayed for more than 3 to 6 h after application there was no reduction in total emissions." This statement was taken directly from a document called "Manure Research Findings and Technologies: From Science to Social Issues" (pg. 205-206) written by Alberta Agriculture, Food and Rural Development. Rapid incorporation would address one of the NGOs major concerns as well as 8 of our general public concerns. Using the criteria to evaluate this management mechanism, we found:

(a) Proven technology - statistics provided in the document indicate it is a proven technology

(b) Cost Benefit - the information provided seems to indicate the benefits realized include a reduction in odours and emissions and an increase in nutrient retention.

(c) The equipment is commercially available.

(d) Practicality - to incorporate manure as soon as possible after application is ideal as the greatest nutrient retention is realized while odours and emissions are minimized.

(e) Residual effects - there may be problems with increased soil erosion once the crop residue is buried.

(f) Reduction greater than 50% - experiments seem to indicate that the faster the manure is incorporated, the greater the reduction in emission rates.

**Numerical evaluation - (a) - 1 (b) - 1 (c) - 1 (d) - 1 (e) - 0 (f) - .1 = 4.1**

8. Bio-filters - (open-bed and closed bed bio-filters). Open bed types are the most common for treating exhaust air from facilities. Bio-filtration 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) Cost- benefit - open bed systems are far less expensive to construct and operate. According to the Manitoba study, bio-filters must be low cost with minimal operation and maintenance costs. Page 53 of the study provides the details along with operational costs/hog. They worked even under Manitoba weather conditions, maintaining adequate temperature ranges.

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

(d) Bio-filters 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.

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

(f) Reductions greater than 50% - yes

**Numerical evaluation : (a) - 1 (b) - 1 (c) - 1 (d) - 1 (e) - 0 (f) - .1 = 4.1.**

9. 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) Cost-benefit - if neighbours are not complaining, other measures will not 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.

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

(d) Practical - yes

(e) 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). (Ex. Shielding of manure storage covers)

(f) Reduction level - we did not find any research on percentage of reduction

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

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

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

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

(e) Residual effects - more research is needed. 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.

(f) 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. Odour reduction in hog facilities ranged on average between 40-50 % and in some experimental operations 60-70%

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

11. 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 re-suspended 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. The 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) Cost-benefit - yes - methods above, if done properly will provide the expected benefit with reasonable expense.

(c) Commercial availability - yes

(d) Practicality - yes - all methods above are practical.

(e) Residual effects - if any of the systems are poorly designed or are not functioning properly, odours and emissions will be elevated.

(f) Reduction > 50% - no percentage levels were provided

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

12. Oil Sprinkling - 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) 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

(c) Commercial availability - yes

(d) Practicality - yes

(e) No residual effects.

(f) 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 , H2S. 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 other than oil sprinkling have not been adopted by industry due to input costs or effectiveness..."

**Numerical evaluation : (a) - 1 (b) - 1 (c) - 1 (d) - 1 (e) - 1 (f) - .1 = 5.1.**

13. Anaerobic Digesters - Closed systems are an efficient way of dealing with manure. Fewer odours are produced and it retains the fertilizer nutrients contained in the manure. Digesters address two of the three major stakeholder concerns and 8 of the general concerns for stakeholders. Under criteria evaluation:

(a) Proven technology - yes

(b) Cost-benefit - the benefits at this time are offset by the cost to establish the system and operate it.

(c) Commercial availability - available but too costly for producers

(d) Practicality is offset by the cost of the system for an individual producer

(e) Residual effects - the system works but more research is needed to apply the system to different climates.

(f) Reduction - the technology reduces odours and emissions but no percentages were found

**Numerical evaluation - (a) - 1 (b) - 0 (c) - 1 (d) - 1 (e) - 0 (f) - 0 = 3.**

14. Band Spreading – Band spreading is better than spraying into the air but less effective than direct injection. Ideally, the manure spread in this manner should be

incorporated as soon as possible to optimize nutrient retention. Manure is spread close to the ground surface with the use of a series of trailing pipes. This type of application method tends to minimize odours as the manure is released close to ground level. Of the stakeholders' main concerns, at least one is addressed with this method, of the public's general concerns, five are addressed. Using the criteria as established :

(a) Proven technology - yes

(b) Cost benefit - the use of this method of manure application seems to indicate the expense of retrofitting or purchasing equipment is offset by the benefit of nutrient retention as well as the reduction in odours and emissions.

(c) Commercial availability - yes, equipment can be purchased or retrofitted for t his manner of manure application. There are also custom operators who will band spread using this method of application.

(d) Practical - yes - manure is spread in a manner that reduces the nuisance effects of odour while retaining the nutrient value of the manure.

(e) Residual effects - more research is needed

(f) Reduction > 50% - odours and emissions are reduced using this method but to what extent is not yet known. More research is needed.

**Numerical Evaluation - (a) - 1 (b) - 1 (c) - 1 (d) - 1 (e) - 0 (f) - 0 = 4**

15. 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 optimum nutrient value retention in 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) 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.

(c) Commercial availability - yes

(d)Practicality - yes

(e) 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.

(f) Reduction > 50% - no -this practice usually increases odour and emissions

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

16. 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. It is necessary to assess the potential impact of diet manipulation and feeding practices on odour emissions. “Because nitrogen is a key component of ammonia and other odorous compounds, the higher the nitrogen content in the manure, the greater the potential for odour emissions . Research on feed conversion and odour control have found that nitrogen levels in the swine diet may affect the volatile fatty acid composition and $NH_3$ concentration. Synthetic amino acids substituted for traditional protein sources contribute to reducing the excretion of nitrogen by pigs. Proteolytic enzymes increase the ease at which protein is digested. Dietary supplements such as zeolite, bentonite, charcoal etc. can absorb odour but more research is needed to determine the effects of the these materials on swine growth and feed conversion efficiency. Plant extracts, enzymes and direct fed microbials may also help to decrease odour. Yucca extracts, as feed additives, may bind ammonia and other gases and thus decrease odour emissions from slurry during storage. Beneficial effects of these additives have been shown for both hogs and poultry.

The knowledge on odour emissions, diffusion, and abatement measures from Europe and the United States should be studied for applicability in other regions. Knowledge of odour concentrations enables experts to establish goals and basis of comparison to improve facilities and management practices. Several techniques, e.g., gas chromatography, distillation, liquid chromatography, and specific ion traps, have been used to characterize odours and to identify its constituents. The human nose is one of the best available odour detectors in the absence of standard methods. Dynamic olfactometers dilute the odours in the air to different concentrations for comparison with odour-free air, and the human nose is used as the measuring device.”

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) Cost benefit - there would definitely be a benefit to producers if they could reduce feed costs and still maintain the same rate of production

(c) Commercial availability - yes - different rations could be formulated with grains available here

(d) Practicality - it would be practical if a diet could be formulated that would be effective

(e) Residual effects - more research needed.

(f) Reduction rates - more research needed on different species at different stages of growth

**Numerical evaluation - (a) - 0 (b) - 1 (c) - 1 (d) - 1 (e) - 0 (f) - 0= 3.**

17. Composting - This involves the aerobic decomposition of manure into what is known as compost. This method of manure treatment converts manure into a soil conditioner which produces little odour and therefore creates less problems with flies. Composting reduces the bulk of the manure, and destroys weed seeds and pathogens but composting can increase emissions and odours, especially during the initial phases. To ensure proper composting, the piles must be managed properly to ensure they are adequately aerated. When considering the major NGO concerns, proper composting could address two, if not all three listed. Of the general concerns, seven could be addressed. The key to composting is it must be done properly, otherwise, odours and emissions will increase dramatically. Evaluating composting by the criteria:

(a) Proven technology - yes

(b) Cost benefit - if done properly, the cost benefit can be realized. There is a potential market for compost to offset costs. There are however additional costs to be realized when aerating the piles.

(c) Commercial availability - yes

(d) Practicality - yes

(e) residual effects - more research is needed to determine the extent of problems with emissions

(f) Reduction rates - more research is needed to determine how much emissions are actually reduced.

**Numerical evaluation = (a) - 1 (b) - 0 (c) - 1 (d) - 1 (e) - 0 (f) - 0 = 3.**

18. Sprinkling of Corrals – 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 then drift in whatever direction the 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. Sprinkling of the corrals would address one of the major stakeholder concerns and 9 of the more general concerns.

(a) Proven technology - shown to help with PM control but to the extent has not been scientifically proven.

(b) Cost benefit - the improvement in animal health and conditions for workers, as well as neighbours living in the area should offset the increased costs. Specific information is not available and more research would be required to determine the cost-benefit ratio.

(c) Commercial availability - yes

(d) Practicality - yes

(e) residual effects - none found in research other than there may be an increase in odour.

(f) Reduction rates - more research is needed to determine how much water would need to be sprinkled in the corrals to achieve the most benefit with PM control. Consideration has to be given to the fact that odour may increase with the application of water in the corrals.

**Numerical evaluation = (a) - 1 (b) - 0 (c) - 1 (d) - 1 (e) - 0 (f) - 0 = 3**

19. Watering of Gravel Roads – 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. This management mechanism would address one of the major stakeholder concerns and at least 6 of the general concerns Basically this management mechanism would help improve neighbour relations and the quality of life for those living along a road utilized for the types of agricultural activities described.

(a) Proven technology - shown to help reduce dust from the road traffic

(b) cost benefit - there is definitely a benefit for those living closer to the road.

Cost depends on the amount and frequency of watering required to control the dust..

(c) commercial availability - yes

(d) Practicality - yes

(e) residual effects - should be none if done properly

(f) Reduction rate >50% - more research is needed to determine the extent of PM control. The reduction rate is also affected by the amount of water applied to the road, the amount of traffic, weather conditions at the time.

**Numerical evaluation = (a) - 1 (b) - 0 (c) - 1 (d) - 1 (e) - 0 (f) - 0 = 3**

20. Electrical Cleaning of Airspace - 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, 9 concerns will be addressed with these types of mechanisms. As for the criteria:

(a) Proven technology - no

(b) 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

(c) Commercial availability - don't know

(d) Practicality on farm - not at this time

(e) Residual effects - unknown.

(f) Reduction >50% - no

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

21. Manure Additives - 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. It has been found that adding alkaline

material may reduce odours substantially by increasing the pH above 9.5, thus reducing hydrogen sulfide emissions. The drawback with this method is there may be an increase in ammonia emissions. As well, adding sphagnum peat moss or other acidifying materials to lagoons has been found to reduce odours. If additives were effective and reliable, they would address two of the three major concerns of stakeholders. Additives may also reduce odours and emissions when manure is spread on the fields which would address the third major stakeholder concern. As expected, the technology could address 9 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) Cost-benefit - none at this time. Estimated costs are varied and effectiveness of manure additives is questionable.

(c) Additives are available but with no concrete proof of effectiveness, their use is not justified.

(d) Practicality - it would be a practical management mechanism to use but at this time, it is not a practical mm.

(e) Residual effects - more research is needed.

(f) Reduction > 50% - no - more research is needed to arrive at results that are comparable in different studies.

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

22. Super Soils Systems – This is a manure processing technology that has been approved by the North Carolina 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. This management mechanism would address 2 of the 3 major concerns and 9 of the general concerns.

(a) Proven technology - research & pilot projects have shown the system is effective

(b) cost benefit - the system is expensive but there are benefits - further research is needed

(c) commercially available - available but not on a small scale

(d) Practicality - not at the present time - the system has been only used in large scale operations

(e) Residual effects - The information available indicates this management mechanism may prove to be extremely effective, however more research is needed.

(f) reductions >50% - more research is needed for more exact quantification

**Numerical evaluation - (a) - 1 (b) - 1 (c) - 1 (d) - 0 (e) - 0 (f) - 0 = 3**

Although the CFO team has been tasked with addressing air quality issues and the five priority substances along with odour, the implementation of some management mechanisms may have the potential to address other environmental concerns. As a result, the NGO community has submitted a revised matrix of management mechanisms with an additional column titled “Additional Benefits”. Comments in this column relate to the potential positive impacts which the MM could bring to the CFO operator and/or other stakeholders. Other outcomes are more difficult to quantify from a financial perspective; such as human health, animal health, social health, community relations, etc., but should also be included when considering the implementation of certain management mechanisms in existing, expanding, and/or future CFO developments in Alberta. Some of the mm’s considered will also have the potential to address issues which are not merely limited to air quality, one example being water quality. NGOs felt it was important to capture these additional benefits. When evaluating a particular management mechanism, if those benefits can be demonstrated clearly, industry may be more receptive in adopting and implementing that particular mm. Those that have the potential to offset costs by reducing operational, and/or land application costs may, as well, be more acceptable to CFO operators. In addition, with the high cost of chemical fertilizers, producers may be looking for alternative sources of fertilizer and nutrient recovery in manure may prove to be a significant source of revenue for CFO operations.

## NGO Management Mechanisms Preferences

| Management Mechanism | Category | Substances Addressed | Risks and Residual Effects | Additional Benefits |
|---|---|---|---|---|
| Planning | Permitting process (Animal housing Manure Application/treatment) | All | • ??? | • Reduce complaints<br>• Less resistance to expansion |
| Moisture management and dust control | Animal Housing | Odour, pathogens, PM | • Increased NH3 | • Less complaints<br>• Visibility on roads |
| Bio-covers | Manure Storage Facilities | $NH_3$, $H_2S$, odour | • ??? | • Bio-security<br>• Nutrient recovery<br>• Insect control |
| Bottom loading | Manure Storage Facilities | $NH_3$, odour | • Retrofit costs<br>• Effects on all emissions | • Nutrient savings |
| Shelterbelts/walls | Animal Housing | PM, odour | • Won't reduce emissions | • Heating costs<br>• Protect facility & livestock<br>• Protect lagoon covers<br>• Aesthetic value<br>• Atmospheric dilution |
| Band spreading | Manure Application | $NH_3$, odour | • Increased NOx and flies if not incorporated | • Nutrient retention if incorporated within 12 hrs |
| Manure injection<br><br>Rapid incorporation (within 12 hrs) | Manure Application | H2S, NH3, PM, Odour. | • Costs<br>• Specialized equipment | • Better nutrient utilization for crops<br>• Less complaints<br>• More adjacent land available for manure application<br>• Minimize risk of nutrient runoff<br>• Less resistance to expansion |
| Composting | Manure Treatment | $NH_3$, pathogens •4 Odours (when done properly) | • Increased $NH_3$ and NOx | • Nutrient utilization<br>• Income stream potentials<br>• Destroys pathogens<br>• Destroys weed seeds |
| Roadway management and dust palliatives | Roadway Management | PM | • Potential effects of palliatives used | • Safety & visibility |
| Solids separation | Manure treatment | | • Additional labor<br>• Specialized equipment | • Decrease land application costs<br>• Reuse of water for facility<br>• Additional revenue stream<br>• Nutrient recovery |
| Anaerobic digester | Manure treatment | All | • High capital costs<br>• Need for partnerships with other industries | • Electricity generation<br>• Reduce land application costs<br>• Additional revenue incoming waste processing<br>• Destroys pathogens<br>• Destroys weed seeds |
| Manure storage tanks vs lagoons | Manure storage | | • Durability | • Reduce emissions/odours |
| Frequent manure removal | Animal Housing | PM, odour, $H_2S$, $NH_3$ | • Increased energy and labour | • Animal health benefits |

**MM cost-benefit- examples (Anaerobic Digesters, Direct Injection)**

When considering the costs and benefits of the different management mechanisms, we stated previously this aspect was beyond the expertise of NGOs. Financial matters concerning the different confined feeding operations are the concern of individual producers. We do, however have an example of the costs and benefits of an anaerobic digester operating in Alberta. When evaluating the table below, the initial high capital cost is evident, however the long term potential of recovering those costs must not be overlooked. . The table below is from the Iron Creek Hutterite Colony's Anaerobic digester which has been in operation since 2003. Although there have been some technical/operational challenges, this project has demonstrated some positive outcomes for the operators.

Summary of Financial Considerations

| | |
|---|---|
| Capital Cost<br>Estimated Payback Period* 4.1 years | $2,000,000 |
| Average Electricity Sale Price | $.065/kWh |
| Operating and Maintenance Costs | $.02/kWh |
| Plant output 350kW, >3,000,000kWh/yr<br>Annual Revenues for Electricity | $95,645 /yr |
| Annual Savings in Electricity | $145,102 /yr |
| Annual Savings in Manure injection | $100,000 |
| Annual Savings in Heat | $202,954 /yr |
| Annual Savings in Water Hauling | $60,000 |

The Iron Creek example does point to some positive outcomes. We cannot, however, assume that every CFO in Alberta will be in a position to implement Anaerobic Digesters on their facility.

Other examples of operations benefiting from the use of digesters are included in table 9 below from a comprehensive US study: "Agricultural Biogas Casebook – 2004 Update"

**Table 9: Benefits of Operational Systems**
**Farm Name**
**Annual Benefits Savings or Revenues**

• Apex Pork odour reduction has stopped complaints

• Baldwin Dairy odour controlled, volume needing treatment reduced due to precipitation exclusion, easier handling of digested manure

• Double S Dairy $30,000 savings using digested solids for bedding

• Emerald Dairy odour controlled, volume needing treatment reduced due to precipitation exclusion, easier handling of digested manure

• Gordondale Farms $23,000 in biogas sales (based on kWh of electricity generated), $30,000 savings replacing commercial fertilizer with digested manure, $28,800 savings using digested solids instead of sand, reduced need for pest control in barns saving $5,000 per year, $2,000 in reduced propane use, herbicide savings (not yet calculated), less lime needed to balance pH in soil, significant odour control, extra heat allows use of warm flush flumes and daily scraping throughout the year

• Haubenschild Farms $66,000 in electricity sales and offsets, $50,000 savings replacing commercial fertilizer with digested manure, $30,000 savings in reduced herbicide use, $4,000 in reduced propane use, less stirring needed, better neighbor relations, improved operational flexibility

• Maple Leaf Farms odor reduction improved, continued operation despite encroaching residential development

• New Horizons $40,700 in electricity sales and offsets, process heat allows use of hydronics system, odour greatly reduced

• Stencil Farm electricity offsets, bedding cost savings, odor reduction, improved fertilizer quality of manure

• Tinedale Farms $75,000 saved using digested solids for bedding

**<u>"Manure Handling Strategies for Minimizing Environmental Impacts"</u>**

This literature presents a great deal more information on $NH_3$ losses after spreading of manure. It states "much of the $NH_3$ contained in liquid manure is lost to volatilisation during the air travel of fine droplets with "irrigation" (spreading of manure). "Failure to incorporate "broadcast" applied manure results in comparable loss of nitrogen; incorporation within 48 and, better yet, 24 hours following "broadcast" application will cut by a factor of four or so (Hilborn and Brown, 1995). Either one of these practices could translate in a nearly 15 $/ac loss in nitrogen (e.g. a loss of 45 lb/ac of NH3 from a target application rate of 80 lb/ac of available nitrogen for cereals), in addition to increasing the risk of odour nuisances to neighbours. Once again, a very close accordance between NH3 preservation for crop use and odour suppression is apparent."

**Conclusions**

Management Mechanisms have been researched extensively over the past 20 years and the NGO stakeholders believe that now is the time to move forward with the implementation of MM's to address air quality concerns. The implementation of various Management mechanisms must be considered on a case by case basis. CFO operators need to have access to important information regarding management mechanisms which would be feasible and effective in improving air quality for their particular operation. That being said there is a significant body of information available which has been the basis for recommendations from various organizations including Agriculture Canada. In a 1998 document "Research Strategy for Hog Manure Management In Canada"indicates that research at that time led to the recommendation of most of the management mechanisms which have been discovered and assessed by the MM subgroup. (keeping facilities clean, lagoon covers, rapid incorporation, manure injection, diet manipulation, shelterbelts, and anerobic digestion)

Although some stakeholders may feel that more research is necessary on specific management mechanisms, the NGO stakeholders believe that the information which has been gathered regarding various MM's during the subgroup's work indicates that several MM's could be implemented on CFO's in Alberta. Although costs associated with the implementation of some MM's the opportunities for offsetting those costs through nutrient recovery and other potential income sources must not be overlooked. At this point in time there may be some CFO operators who are using some of these MM's to address air quality concerns, but the MM subgroup was not tasked to assess the level of implementation on Alberta CFO's.

The Agricultural Operation Practises Act, recently revised in the fall of 2006, is the primary document used by industry and government agencies for establishing, expanding and regulating CFOs in the province of Alberta. It is the opinion of NGOs that this document fails to satisfactorily address air quality issues including odour and should be revised to address these concerns, in consultation with NGOs. The complaints mechanism, utilized to address calls regarding problems from a particular confined feeding operation, often does not satisfactorily address problems that arise from certain operations on a regular basis. Measures to encourage and enforce better management practices need to be in place for problematic operations. The only way to develop confidence in this complaint system is if the concerns of all are addressed promptly and effectively. Communication between all stakeholders is of utmost importance.

Perhaps these comments from NRCB decision report RAO4023 (pg 42-43) more accurately defines the limitations of existing legislation as they relate to air quality.

***"Applicants are not required to implement the best odour control approaches that technology practices can provide. Applicants are required to provide information about how their application will meet the required MDS. Applicants are not required to investigate possible odour control measures as part of an application to the NRCB. CFO operators may investigate possible odour control measures at any time, and if the measures are related to operation of the CFO, the CFO operator may implement odour control measures as they wish. Management measures to decrease the odours emanating from existing barns may or may not be implemented by the operator of the CFO".***

A recent Manitoba government document illustrates some of the challenges associated with Intensive Livestock Operations. ***"The idea that manure is a waste rather than a resource continues to linger in our psyche. We speculate that this attitude is not yet wholly purged from the industry, let alone from the general public."*** (http://www.gov.mb.ca/agriculture/news/stewardship/chapter6.pdf)

## Other Alberta Livestock Management Mechanisms Documents that have been available and in use prior to the Agricultural Operations Practices Act 2002;

There are several documents available that once served as the basis for permitting operations prior to 2002, when this process became the responsibility of the N.R.C.B. These documents contained valuable information which should still be utilized by planning agencies. Our concern is the fact that these reference documents have been in place for several years and yet odour and emissions related complaints persist.
Important excerpts from some of these documents are listed below:
From "Land Resource Planning Workshop Focus: Manure Management (1998)" in Section "11.6 Odour Control" (page 191) is the following:
"The trend towards large livestock production facilities has caused an increasing need for odour control technology. Odour conflicts are most frequent among new, large or recently-expanded operations located near populated areas.
Proper design and management of livestock-production facilities can alleviate a significant portion of the odours generated. Practices that can reduce odour include:

(1) frequent manure removal,
(2) removal of moisture,
(3) maintaining an aerobic state,
(4) appropriate facility siting,

(5) covered storage,
(6) good animal hygiene,
(7) use of proper land application procedures,
(8) maintaining a discrete storage area,
(9) exhaust air and dust control,
(10) general "housekeeping" (Minnesota Dept. of Ag. 1995b)."

Other references in this Section are from Nicolai 1995, Borg 1997, Manitoba Agriculture 1994, Gazdag 1997, and Farm Land News 1997.

From "Nutrient Management Planning From Livestock Production (2001)"
- Section "10.0 BMPs to Protect Air Quality" (pages 57 to 62):
"Strategies for odour control fall into two main categories”:
(1) preventing odours from forming and
(2) preventing odours from being released.

-Animal nutrition is a very important component of odour control, which is discussed in Section 12.3."

After 10.1 Sources of Odour, is 10.2 Reducing Odour (portion is quoted above) with sub-sections
(1) Preventing Volatilization and
(2) Aerated Storage,

followed by 10.3 Reducing Dust.
10.2 and 10.3 give approximately 34 consecutively different references, including County of Lacombe and Mountain View projects on straw covers, along with PAMI of Alberta having studies cited as well.

From "Beneficial Management Practices Environmental Manual for Hog Producers in Alberta (2002) in 7.0 Manure Collection, Storage, Transportation and Treatment (pages 66 to 78) in sub-section 5.1 "Odour control strategies" gives paragraphs on the following:

-Windbreaks
-Covers (Straw and Alternative materials)
-Additives
-Multi-cell storages

In addition there are other "Beneficial Management Practices...(books)" on Beef Feedlot, Cow-calf, Dairy, and Poultry", as well as a more recent on Crops.
From "Environmental Farm Plan (2003)"
in Section "12 Nuisance Control" are rating tables for practices from "1 Low Risk 2 3 4 High Risk".
These apply to sub-sections on:
(a) Timing,

(b) Distance to closest neighbour,
(c) Type of application,
(d) Liquid manure storage,
(e) Exterior environment,
(f) Interior environment,
(g) Dust Control,
(h) Barn and ventilation,
(i)Location of facility,
(j)Fly Contol,
(k) and Noise.

From "2000 Code of Practice for Responsible Livestock Development and Manure Management"

"Introduction... The purpose of the Code is to provide guidelines for the siting of new and expanding livestock operations with the intent of: ...

(a) -Minimizing the nuisance effects of intensive livestock operations.
(b) -Providing livestock operators with guidelines to minimize environmental and social impacts.
(c) -Providing livestock operators and municipal officials with a reference for conflict resolution..." (page 1)

"2.2.6 Proximity to Neighbours
Locate short-term manure storage to minimize nuisance to neighbours.
The MDS method indicated in Section 1 does not apply to short-term manure storage.
(page 7) "Section 6 Use of Animal Manure...

Odour nuisance, associated with the spreading of manure on land, can be minimized through proper timing, siting, method of incorporation, and frequency of application. For all new and expanding intensive livestock operations, a nutrient management plan is strongly recommended. The plan would include balancing long-term nutrient application rates with crop nutrient uptake while assessing the potential risk of nutrients entering water sources. (page 19)

6.4.6 Consideration of Neighbours
Apply manure to land when it is least likely to cause odour impacts to neighbouring residents. Use methods of incorporation appropriate to the odour sensitivity of the site. (page 22)

Section 8 Definitions...
Nuisance
An annoyance, such as odours, flies, and dust.

## References


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Commercial injection equipment http://www.hydro-eng.com/injection_units.htm

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http://www.gov.mb.ca/agriculture/news/triples/liquid.html

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http://www.albertapork.com/news.aspx?NavigationID=2497

Solid Manure Injection Proved Technically Feasible
http://www.farmscape.ca/f2ShowScript.aspx?i=22528&q=Solid+Manure+Injection+Proved+Technically+Feasible

Manure Handling Strategies for minimizing environmental impacts
http://www.gov.mb.ca/agriculture/livestock/pork/swine/bab10s08.html

Agriculture Canada Report (Research Strategy for Hog Manure Management In Canada)
http://dsp-psd.pwgsc.gc.ca/Collection/A42-77-1998E.pdf

Study Shows Manure Injection Superior To Broadcast November 22, 2001 Farmscape Episode 826 http://archives.foodsafety.ksu.edu/animalnet