BENEFICIAL MANAGEMENT PRACTICES

Environmental Manual

FOR LIVESTOCK PRODUCERS IN ALBERTA




Government of Alberta

Canada

Growing Forward

Agdex 400/28-2

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DISCLAIMER

This manual was prepared for Alberta producers to create a greater understanding of activities and strategies to reduce environmental risks and social concerns. It was written as a reference document based on the best available information from industry, government and interested stakeholders.

While the authors have made every effort to ensure this manual is accurate, current and complete, it should not be considered the final word on areas of law and practices covered. Individuals should seek the advice of appropriate professionals and experts as each situation may differ from those set out in the manual. Laws and guidelines are also subject to periodic updates and should be referred to regularly. Individuals should not extract portions of this publication, nor draw inferences, without considering all aspects of the livestock operation. The guidelines in this manual should not be adopted literally into policies or legislation in whole or in part by any level of government.

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ABOUT THIS BMP MANUAL SERIES

What is a Beneficial Management Practice or "BMP"?

- A BMP is defined as any management practice that reduces or eliminates an environmental risk.
- BMPs are site-specific practices that take into consideration legislation, practicality and operational needs for a specific operation.

What is the BMP Series?

This manual series covers all aspects of environmental risks for a farm operation.

The manuals include:

- BMP Environmental Manual for Alberta Farmsteads (Agdex 090-1)
- BMP Environmental Manual for Crop Producers (Agdex 100/25-1)
- BMP Environmental Manual for Cow/Calf Producers (Agdex 420/28-2)
- BMP Environmental Manual for Livestock Producers (Agdex 400/28-2)

To obtain any of the BMP Manuals, contact:

Alberta Agriculture and Rural Development
Publications Office
7000-113 Street
Edmonton, AB T6H 5T6
Phone: 1-800-292-5697

or visit www.agriculture.alberta.ca

FOR MORE INFORMATION

If you have comments or questions about this manual or would like more information about beneficial management practices (BMPs), you can e-mail duke@gov.ab.ca or call the Ag-Info Centre at 310-FARM (310-3276) between 8:00 am and 5:00 pm MT (Monday to Friday). If calling from out of province, call 1-403-742-7901.

BMP Series

Operational Practice	Appropriate BMP Manual
Cropping Practices	Cropping
Disposal Sites for Mortalities	Farmstead
Emergency Farm Plan	Farmstead
Energy Efficiency	Cropping, Farmstead
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Surface Water Management	Farmstead, Livestock
Water Management	Cow/Calf, Farmstead
Wildlife Habitat	Cropping

CONTENTS

Livestock agriculture is fundamentally important to Alberta's agricultural economy, generating at least 42% or $4.2 billion of annual farm cash receipts. (Oct 2009)

Chapter 1. INTRODUCTION

Agricultural intensity and land use have resulted in a greater need to improve manure handling and application practices. Issues driving this need are the:

- Increasing size of livestock operations and concentration of animals
- Increasing rural/urban interface
- Growing societal concern for the environment
- Increasing input costs, resulting in a growing need to maximize the economic nutrient value from manure

Livestock operations are growing in size while non-farming populations are moving into the rural areas. Odour from these operations tops the list of neighbour complaints. Therefore, it is becoming increasingly important that operators handle the greater volumes of manure in ways that minimize odour.

There is greater societal concern, shared by the agriculture sector, for protecting water resources. For livestock producers, this means greater attention to (and possibly investment in) manure storage capacity and facilities, equipment calibration for and timing of manure application, setback distances from water supplies and water bodies, and in-field practices to minimize soil erosion and runoff.

As synthetic fertilizer costs have increased, manure has become a more valuable resource. By understanding what nutrients are available in manure and what the crops and soils need, farmers can fine-tune what they apply on their fields, maximize the economic nutrient value from manure, and often reduce input and labour costs.

A MANURE MANAGEMENT SYSTEM MAY CONSIST OF THE FOLLOWING COMPONENTS:

- housing (barn, feedlot, wintering site, etc.)
- manure storage facility (lagoon, earthen manure storage, holding pond, etc.)
- manure application to land and crops
- manure treatment facility (composter, solid-liquid separator, digester, etc.)

As producers better understand the value and the importance of safe storage, handling and application of nutrients, they start using nutrient management planning. Producers adopting this "systems approach" benefit the agricultural industry, environment, rural communities and society.

1.1 LEGISLATION

Livestock producers need to know what legislation pertains to their operation for due diligence. There is environmental legislation from federal, provincial and municipal governments. Table 1.1 lists several of the provincial and federal acts, regulations and codes that relate to environmental aspects of livestock operations. Each government level has its own set of rules for environmental concerns. Compliance with the requirements of one level of government does not automatically ensure compliance with other levels.

Your operation must meet the legal requirements described in the acts, regulations and codes. For more information on regulatory requirements, contact the various government departments and agencies and/or lawyers. It is recommended that the actual legislation be consulted.

Know the rules
Good stewardship requires knowledge of and compliance with current regulatory requirements as established by federal, provincial, and local governments.

Copies of Alberta's acts and regulations are available online at www.qp.alberta.ca or in hard copy from the Queen's Printer. To order printed copies, call toll-free within Alberta, dial 310-0000 then 780-427-4952.

Federal laws are available at laws.justice.gc.ca.

Table 1.1 Selected Alberta and Federal Acts, Codes and Regulations with Relevance to Agriculture

Act, Code, Regulation	Who's Responsible	Website
Agricultural Operation Practices Act	Alberta Agriculture and Rural Development (administration)	www.agriculture.alberta.ca/aopa
	Natural Resources Conservation Board (enforcement)	www.nrcb.gov.ab.ca
Agricultural Pests Act	Alberta Agriculture and Rural Development	www.agriculture.alberta.ca
Animal Health Act	Alberta Agriculture and Rural Development	www.agriculture.alberta.ca
Canadian Environmental Protection Act	Environment Canada	www.ec.gc.ca
Code of Practice for Compost Facilities	Alberta Environment	www.environment.alberta.ca
Environmental Protection and Enhancement Act	Alberta Environment	www.environment.alberta.ca
Fisheries Act	Canada Department of Fisheries and Oceans	www.dfo-mpo.gc.ca
Historical Resources Act	Alberta Culture and Community Spirit	www.culture.alberta.ca
Navigable Waters Protection Act	Transport Canada	laws.justice.gc.ca
Pesticide Sales, Handling, Use and Application Regulation	Alberta Environment	www.environment.alberta.ca
Private Sewage Disposal System Regulations and Standards of Practice	Alberta Municipal Affairs	www.municipalaffairs.alberta.ca
Public Health Act	Alberta Health and Wellness	www.health.alberta.ca
Public Lands Act	Alberta Sustainable Resource Development	www.srd.alberta.ca
Soil Conservation Act	Alberta Agriculture and Rural Development (administration)	www.agriculture.alberta.ca
	Counties/Municipalities (enforcement)	
Species at Risk Act	Environment Canada	www.ec.gc.ca
Transportation of Dangerous Goods Act	Transport Canada	laws.justice.gc.ca
Various Safety Code Acts (Electrical Code, Fire Code, etc.)	Alberta Municipal Affairs	www.municipalaffairs.alberta.ca
Waste Control Regulation	Alberta Environment	www.environment.alberta.ca
Water Act	Alberta Environment	www.environment.alberta.ca
Wildlife Act	Alberta Sustainable Resource Development	www.srd.alberta.ca

***Agricultural Operation Practices Act* (AOPA)**
Alberta Agriculture and Rural Development (ARD) is the provincial ministry responsible for developing and updating AOPA to ensure that it meets the needs of the livestock industry and the public. ARD also has Confined Feeding Operation (CFO) Extension Specialists available to assist producers with technical information and solutions on manure management.

The Natural Resources Conservation Board (NRCB) is an agency of the Government of Alberta. It is responsible for regulatory functions under AOPA, processing applications and ensuring compliance with the Act and its regulations.

All operations handling manure fall under Alberta's *Agricultural Operation Practices Act.* For more information or assistance with manure management, contact: ARD CFO Extension Specialists or NRCB staff.

ARD CFO EXTENSION SPECIALISTS
Morinville: 780-939-1218
Red Deer: 403-755-1475
Lethbridge: 403-381-5885

NRCB STAFF
Lethbridge: 403-381-5166
Red Deer: 403-340-5241
Morinville: 780-939-1212
Fairview: 780-835-7111

1.2 WHAT'S IN THIS MANUAL?

If you are a livestock producer, you're already living with the reality of accountability regarding manure management. This manual will help you adapt and fine-tune your operation to get the most from your efforts.

Some Key Definitions:

Manure – feces, undigested feed, urine, bedding, wastewater and runoff. It can also contain pathogens and antibiotics.

Manure Management – managing manure through its entire cycle, from the animal to land application.

Nutrient Management – the responsible use of nutrients from livestock manure, other biological sources and/or commercial fertilizers to meet crop requirements while protecting water, soil and air resources. Nutrient management also includes managing the nutrients in the livestock feed as part of influencing the nutrients in livestock manure.

This manual's intention is to help you select and implement the right beneficial management practices for managing manure and other nutrient materials in your operation. You'll see some recurring themes.

1.3 THEMES

The concept of a systems approach

- Always considering the entire system from animal to field, through planning, implementation and evaluation.

The value of nutrient management planning

- Accounting for all nutrients and thereby reducing input costs.

The importance of managing all liquids

- Managing all liquids around facilities, storage areas, and handling equipment, and during nutrient application – regardless of whether you're managing solid manure, liquid manure, and/or other biological materials (such as milking parlour washwater or silage leachate).

The need for due diligence

- Matching nutrient storage and handling systems to your needs, sampling and testing for all nutrients, calibrating application equipment, applying at calculated rates, meeting setback distances, monitoring storage sites, monitoring application operations, developing contingency plans for spills, and keeping accurate records.

1.4 MANURE AS A RESOURCE

Manure has value both as a source of nutrients and as a soil conditioner – two good reasons for managing it as a resource.

To make the most of its potential, manure has to be stored, handled and applied in ways that retain its value, suit your operation, reduce the risk of environmental contamination and are affordable.

Table 1.2 Typical Nutrient Amounts and Values in Different Types of Manure

Manure Type	Nutrient Amount*						Approximate Total Nutrient Value*
	Nitrogen		Phosphate P_2O_5		Potash K_2O		
	kg/m³	lb/1000 gallons	kg/m³	lb/1000 gallons	kg/m³	lb/1000 gallons	
Dairy, Liquid	2.5	24.9	1.1	11.4	2.9	29.1	$27.98/1000 gal
Swine, Liquid	2.7	27.2	2.3	22.5	2	19.8	$28.72/1000 gal
	kg/tonne	lb/ton	kg/tonne	lb/ton	kg/tonne	lb/ton	
Dairy, Solid	2.9	5.8	1.8	3.5	5	10	$8.18/ton
Poultry, Solid	26.3	52.5	19.4	38.8	12	24	$47.80/ton
Beef, Solid	7.2	14.3	4.9	9.8	8	16	$16.84/ton
Swine, Solid	5.8	11.5	3.1	6.1	2.8	5.5	$9.78/ton

* Nutrient amounts and values in this chart are based on the following assumptions:

- manure is incorporated into the soil within 24 hours of application, estimated 25% ammonia-N loss
- all nutrients are required by this year's or subsequent crops for long-term value
- nitrogen is $0.47/lb; phosphate is $0.33/lb; potash is $0.43/lb
- 1 m^3 = 1000 litres
- imperial gallons reported
- numbers rounded to nearest decimal point
- approximate total value only considers value of nutrients; it does not attribute value to soil conditioning benefits of manure

THE MANURE AND COMPOST DIRECTORY is a website to facilitate the trade of manure and compost. It is available on the ARD website, www.agriculture.alberta.ca.

1.5 OTHER BIOLOGICAL MATERIALS

Manure is not the only biological nutrient material generated on farms or brought to farms for use as a nutrient source that needs to be managed.

Examples of on-farm source biological materials include: milking parlour washwater, silage leachate, and greenhouse wastewater.

Examples of off-farm source biological materials include: municipal sewage biosolids, paper biosolids, food processing byproducts, abattoir wastewater and drilling mud.

Like manure, these materials add nutrients and organic matter to the soil and therefore must be managed as a resource. Test the material so you know what is in it (including possible hazardous substances like heavy metals) and manage it appropriately. Using off-farm source biological materials requires approval from Alberta Environment.

1.6 MANURE ISSUES

Management of livestock manure and other biological materials is a challenging issue facing agriculture in Alberta. It's complex, with dimensions ranging from environmental concerns at a societal level, to nuisance concerns for neighbours, to health concerns for your family, farm workers and farm animals. It's all about managing risk while conducting your farm business.

Table 1.3 Concerns and Management Goals for Manure-Related Issues

Manure-Related Issue	Concerns	Management Goals
Economic	• is generally a net cost to livestock operations	• improve soil quality and fertility • reduce dependency on off-farm inputs
Environmental	• has potential risk of groundwater and surface water contamination • has potential risk of nutrient accumulation	• increase soil water-holding capacity • increase soil biological diversity • match nutrient removals with additions
Nuisance	• produces offensive odours • can be a source of flies	• minimize odour, flies • mitigate neighbour complaints
Human Health	• can contain pathogenic organisms	• minimize risks to human health

1.7 AGRICULTURE'S RESPONSE

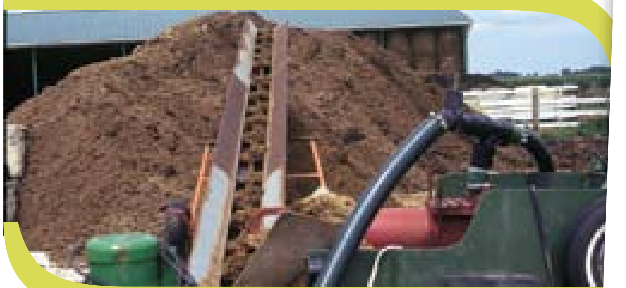
Over the past decade, manure-related issues have been addressed head-on by many, often diverse, groups involved in Alberta's agricultural community. Farm organizations, government agencies, municipalities, environmental non-governmental organizations and other partners are continuing to work actively and collaboratively.

Snapshots of manure management tools:

Sampling and testing manure for nutrient levels is a beneficial management practice. Like all BMPs, it integrates production targets with environmental goals.

Many farmers' questions about nutrient management have been answered through on-farm applied research and demonstration projects.

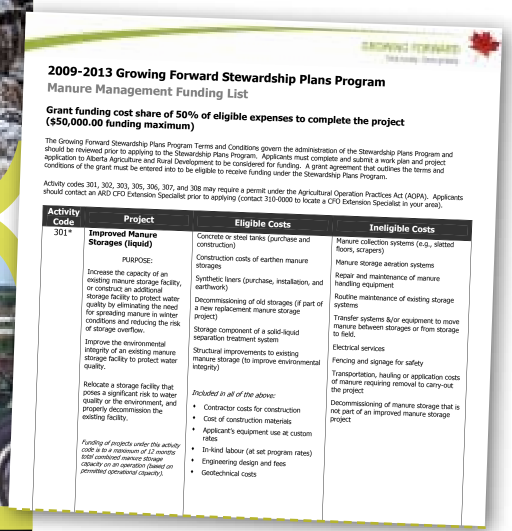
Research and advisory staff are working with producers to reduce manure-nutrient levels through improved livestock nutrition and feed.



Improvements in manure-treatment technology may reduce the volume of material to be managed and help to provide on-farm energy.

Advisory staff work with producers to help them manage manure from their operations in an economically and environmentally responsible manner.

Environmental Farm Plan – each participating producer develops a semi-detailed site assessment by rating components of the farm's environmental management system and completing an action plan.



2009-2013 Growing Forward Stewardship Plans Program

Manure Management Funding List

Grant funding cost share of 50% of eligible expenses to complete the project ($50,000.00 funding maximum)

The Growing Forward Stewardship Plans Program Terms and Conditions govern the administration of the Stewardship Plans Program and should be reviewed prior to applying to the Stewardship Plans Program. Applicants must complete and submit a work plan and project application to Alberta Agriculture and Rural Development to be considered for funding. A grant agreement that outlines the terms and conditions of the grant must be entered into to be eligible to receive funding under the Stewardship Plans Program.

Activity codes 301, 302, 303, 305, 306, 307, and 308 may require a permit under the Agricultural Operation Practices Act (AOPA). Applicants should contact an ARD CFO Extension Specialist prior to applying (contact 310-0000 to locate a CFO Extension Specialist in your area).

Activity Code	Project	Eligible Costs	Ineligible Costs
301*	**Improved Manure Storages (liquid)** PURPOSE: Increase the capacity of an existing manure storage facility, or construct an additional storage facility to protect water quality by eliminating the need for spreading manure in winter conditions and reducing the risk of storage overflow. Improve the environmental integrity of an existing manure storage facility to protect water quality. Relocate a storage facility that poses a significant risk to water quality or the environment, and properly decommission the existing facility. *Funding of projects under this activity code is to a maximum of 12 months total combined manure storage capacity on an operation (based on permitted operational capacity).*	Concrete or steel tanks (purchase and construction) Construction costs of earthen manure storages Synthetic liners (purchase, installation, and earthwork) Decommissioning of old storages (if part of a new replacement manure storage project) Storage component of a solid-liquid separation treatment system Structural improvements to existing manure storage (to improve environmental integrity) *Included in all of the above:* • Contractor costs for construction • Cost of construction materials • Applicant's equipment use at custom rates • In-kind labour (at set program rates) • Engineering design and fees • Geotechnical costs	Manure collection systems (e.g., slatted floors, scrapers) Manure storage aeration systems Repair and maintenance of manure handling equipment Routine maintenance of existing storage systems Transfer systems &/or equipment to move manure between storages or from storage to field. Electrical services Fencing and signage for safety Transportation, hauling or application costs of manure requiring removal to carry-out the project Decommissioning of manure storage that is not part of an improved manure storage project

The costs of some on-farm improvements to nutrient management practices and systems can be burdensome for individual farmers. In some cases, they can get assistance from municipal, provincial and federal programs.

Chapter 2. MANURE – THE BASICS

This chapter explores:

- physical and biological properties of solid and liquid manure
- chemical properties of manure odour and gases
- contamination risks from manure
- manure management as a system

Understanding the physical, biological and chemical properties of manure will help you manage manure safely and more effectively. Manure provides the same nutrients for crop production as commercial fertilizers. The challenge with manure is that the forms and ratio of the nutrients are not easy to change, nor easy to match to crop requirements. Over-application of manure can lead to problems such as contamination of water sources with nutrients and pathogens (disease-causing organisms), emission of odours and greenhouse gases, nutrient loading in the soil leading to crop lodging, and salt accumulation resulting in poor yields.

2.1 PHYSICAL PROPERTIES

Livestock manure has a variable composition. In other words, it has solid and liquid portions as well as organic and inorganic components. The composition of manure will vary with livestock type, age, size, nutrition, housing and bedding, as well as the nature and amount of materials (such as bedding and wastewater) added to it.

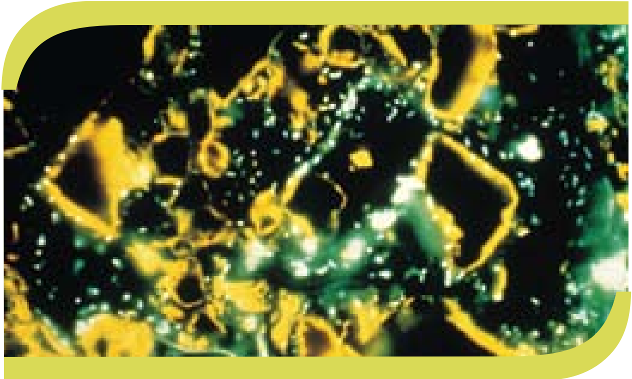
Table 2.1 Manure Components and Their Composition

Manure Component	Possible Composition
Feces	• undigested feed • other bodily wastes • pathogens • pharmaceuticals • organic forms of nutrients and organic acids • inorganic forms of nutrients and salts
Urine	• water • acids and salts • nutrients (e.g. nitrates)
Bedding	• straw, wood fibre • wasted solid feed
Water	• drinking water • leaking or spilled water • eavestroughs, precipitation, snowmelt
Washwater and Runoff	• facility washwater • milking parlour washwater • runoff from yards, stored feed and manure

ALL AGRICULTURAL OPERATORS IN ALBERTA must manage nutrients in accordance with the standards in the *Agricultural Operation Practices Act* (AOPA). For more details, talk to Alberta Agriculture and Rural Development's Confined Feeding Operation Extension Specialists or Natural Resources Conservation Board (NRCB) staff.

2.2 BIOLOGICAL PROPERTIES

Manure is made up of animal wastes, bedding, wastewaters and runoff. It is an ecosystem with all the necessities for biological habitat – namely space, cover, food and water. This can be a good thing, as biological organisms in healthy manure environments rapidly convert manure to soil organic matter and plant-available nutrients. But manure environments can also house pathogenic microbes and unwanted pests such as rodents.



Soil bacteria transform manure nutrients, making them useable by other soil life forms, such as protozoa, which in turn release inorganic nitrogen forms such as ammonium.

Table 2.2 Life Forms in Manure that Promote Decomposition

Soil Organism Group	Type of Organism	Function
Decomposers	Bacteria Fungi	• Transform manure into materials that can be used by other life forms (e.g. shredded straw into humus) • Retain (immobilize) nutrients in their tissue • Some are pathogens
Bacteria-Feeders	Protozoa Nematodes	• Release inorganic nutrients (e.g. ammonium, NH_4^+) • Destroy some pathogens
Fungus-Feeders	Nematodes Insects	• Release inorganic nutrients (e.g. NH_4^+) • Destroy some pathogens
Shredders	Earthworms Insects (e.g. springtails, dung beetles) Arthropods (e.g. centipedes, millipedes, pillbugs)	• Shred bedding and waste feed into finer-sized materials • Provide habitat and food for decomposers • Accelerate decomposition rate
Larger Predators	Large insects Rodents Birds	• Control populations of other organisms in manure • Aerate manure by burrowing

2.3 CHEMICAL PROPERTIES OF ODOURS AND GASES

The human nose is capable of detecting a broad range of odorous compounds – many at extremely low concentrations. Researchers have identified more than 165 odourless and odour-producing compounds that can originate from manure. It's this wide range and mix of compounds combined with our keen ability to detect odours that result in the variety of manure smells we experience.

Some of the more common compounds in manure gases are described in Table 2.3.

Table 2.3 Common Chemical Compounds in Manure Air Emissions

Compound	Description
Carbon Dioxide	• odourless • generated by microbial activity (anaerobic* and aerobic*)
Methane	• odourless • generated by anaerobic activity
Ammonia	• sharp, pungent, irritating odour, only mildly toxic • generated by anaerobic and aerobic activity • water-soluble and less dense than air • readily disperses in open environment, resulting in it being more of an odour concern within barns than during land application
Hydrogen Sulphide and Related Sulphur-Containing Compounds	• hydrogen sulphide gas has a powerful rotten-egg fragrance • produced during anaerobic decomposition of manure • water-soluble and heavier than air • humans can readily detect very low concentrations of H_2S, but not high concentrations • hydrogen sulphide can be very toxic if allowed to accumulate in enclosed spaces
Volatile Organic Acids	• wide variety of types and characteristics • mostly produced under anaerobic conditions • important contributors to manure odour
Phenolics	• highly odorous compounds • found in raw manure and increase under anaerobic conditions
Nitrous Oxide	• produced mainly by nitrification and denitrification of organic compounds that are present in manure • colourless and nonflammable gas • sweet and sometimes pleasant odour • known as laughing gas

* anaerobic means oxygen deficient; aerobic means oxygen rich

The amount and type of gases produced will depend on the type of manure and the way it's handled. Aerobic conditions will generate gases such as carbon dioxide and nitrous oxide. Anaerobic conditions (liquid manure storages, centre of solid manure piles) can generate such gases as hydrogen sulphide, ammonia and methane.

Some gases are often trapped within the bulk of manure until the storage is disturbed for spreading. That's why the smell is much worse at spreading time.

2.4 CONTAMINANTS FROM MANURE

Manure has the potential to cause contamination of water, air and soil. Like various other types of pollution, manure contamination can come from either point or non-point sources. Point sources are concentrated in one spot, for example, manure piles. Non-point sources are spread out over an area, for example, manure applied to fields.

A nutrient management plan is an excellent tool to minimize the environmental risks listed in Table 2.4.

Manure odour is strongest during land application. For the most part, odour-causing gases are trapped in stored manure.

Table 2.4 Contamination Risks from Manure

Resource	Key Potential Contaminants from Manure
Air	• Ammonia (NH_3) gases volatized from manure cause odours. • Nitrogen gases (N_2, N_2O) from denitrification; nitrous oxide (N_2O) is a greenhouse gas. • Methane (CH_4) from decomposing manure in barns and in storage is a greenhouse gas. • Sulphide gases are foul-smelling.
Surface Water and Aquatic Habitats	• Phosphates in solution or soil-attached in runoff can cause excessive algae blooms in surface water bodies. • Ammonia (NH_3) in manure runoff is toxic to fish and other aquatic organisms. • Nitrates in solution in manure runoff can cause excessive algae blooms in surface waters. • Bacteria and pathogens from stored and applied manure can reduce quality and safety of surface waters. • Organic matter from manure creates in-water habitat for bacteria and pathogens.
Groundwater	• Nitrates in solution can leach into groundwater, making it unsuitable as drinking water for humans, livestock watering or cleaning facilities. • Bacteria and pathogens can contaminate groundwater where water wells are improperly located, constructed, sealed, or maintained.
Soil	• Excessive soil nutrient levels can negatively impact crop growth and production. • Excessive soil nitrogen levels can lead to crop lodging. • Excessive soil phosphorus (P) levels increase the potential for total and dissolved P loss from the soil. • Salt accumulation, from repeated manure application, can result in poor crop yields and can even alter which crops will grow.

AMMONIA LOSSES CALCULATORS

The Ammonia Losses from Liquid Manure Applications Calculator and the Ammonia Losses from Livestock Buildings and Storage Calculator are simple tools for producers to use to perform a quick ammonia loss calculation for their operation. These calculators can determine how much nitrogen is not being utilized and also the cost associated with those losses. The estimation of those ammonia losses is beneficial in assessing ammonia conservation techniques and improving nutrient management recommendations. These calculators are available at www.agriculture.alberta.ca.

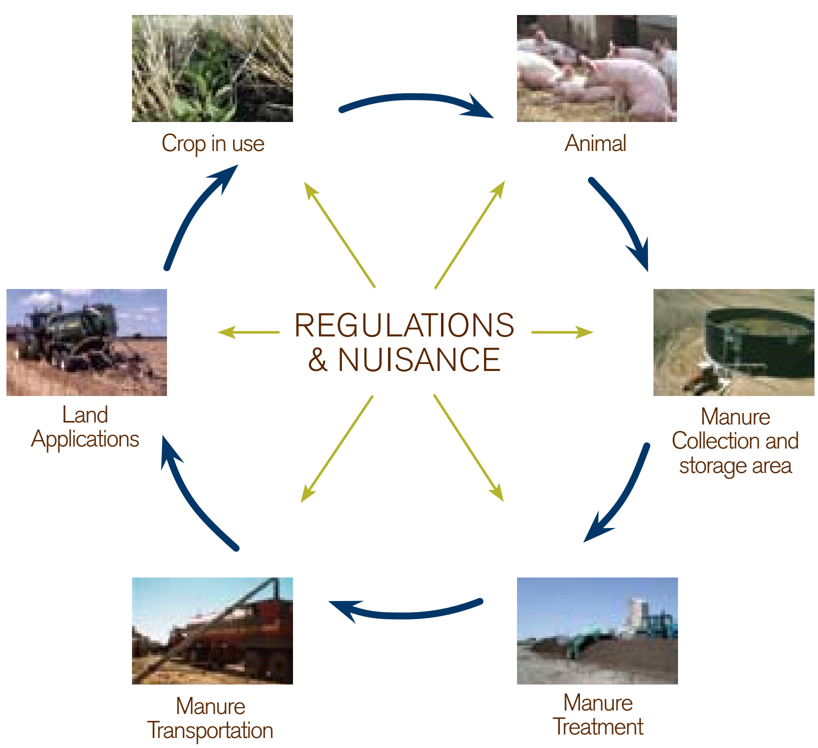
2.5 MANURE MANAGEMENT AS A SYSTEM

Manure management is a system. The scope of the system is strongly influenced by the type of livestock operation, the facilities, local site conditions and management practices. Some of these influences are given and not likely to change – such as the type of operation, soil type and proximity to environmentally sensitive areas. However, facilities and management practices can be changed and improved to meet both business and environmental goals.

The components of a "systems approach" to manure management are described below. Each component of the system is interactive – a planned change will impact other components of the system and thus the system itself.

Manure Management System Components

1. ***Livestock Management:*** production system, facilities, nutrition and feeding, bedding, and sanitation
2. ***Manure Storage and Handling:*** facility siting, site investigations, manure and other waste collection, transfer, storage and handling systems, and treatment alternatives
3. ***Surface Water Management of Facility:*** runon and runoff control, wastewater management
4. ***Nutrient Management Planning:*** accounting for all nutrient sources, testing levels in farm operation, assessing environmental risks and limitations, selecting nutrient sources, scheduling applications, calibrating application equipment and monitoring impact
5. ***Land Application:*** BMPs protecting soil, air and water and reducing nutrient loss, including cropping and tillage practices



Chapter 3. MANAGING MANURE STORAGE AND COLLECTION AREAS

This chapter discusses design and management of manure storage facilities and manure collection areas, which are areas like barns and pens from which manure is collected before storage.
The following aspects are addressed:

- environmental risks associated with site selection
- design considerations for manure storages
- loading and emptying
- maintenance and monitoring
- odour management options
- fly control
- decommissioning

Manure is collected and stored so it can be applied to the land at times that are compatible with weather conditions and cropping practices. Manure nutrients can be best utilized when spread near or during the growing season of the crop. Storage of manure allows producers to efficiently utilize their manure but poses challenges in developing and maintaining appropriate storage systems.

The main goals associated with collecting and storing manure include:

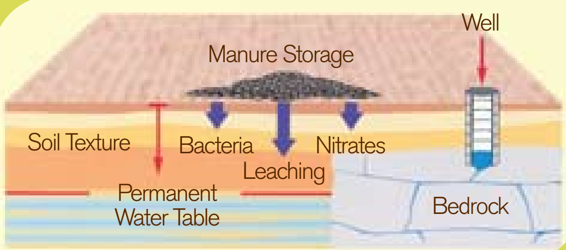
- protecting groundwater
- protecting surface water
- minimizing odours

NEW AND EXPANDING CONFINED FEEDING OPERATIONS need to meet permitting requirements, including manure storage requirements, as set out in the *Agricultural Operation Practices Act* (AOPA). As well if there is a change to an existing manure storage, the Natural Resources Conservation Board (NCRB) staff should be contacted to ensure that all necessary permits are in place.

3.1 SITE CONSIDERATIONS

To protect groundwater and surface water, the site or location of manure collection and storage areas must be managed by taking into account the natural characteristics of the area. Understanding the inherent risks of your site is the first step to managing it appropriately.

A livestock operation and manure storage located on a site with a deep groundwater resource, clay soils, and moderate slopes, and which is far away from sensitive areas poses a low environmental risk, so there are fewer restrictions for management and development of the site. Conversely, a similar facility on a site with coarse-textured soil over a shallow groundwater resource would be at a higher risk of groundwater contamination, so site development and management would require a larger investment of time and money.



Manure and manure nutrients can leach to groundwater on sites with coarse-textured soils, shallow depths to bedrock, and/or shallow groundwater resource.

3.1.1 Groundwater Contamination Risks

Groundwater quality is degraded when inadequately filtered water carries contaminants downward through the soil to the groundwater. If contaminants reach a groundwater aquifer, all water wells drawing water from that aquifer are at risk. Soil texture, geological formation and depth to groundwater significantly affect the degree of risk. General factors affecting the risk of contamination are outlined in Table 3.1.

Soil Texture

Soil texture is the relative coarseness or fineness of soil particles. It is the most important determining factor in the ease and speed with which water and contaminants can move through soil to groundwater.

Coarse-textured soils such as gravels and sands have large pore spaces between the soil particles. This allows water to quickly percolate downward to groundwater.

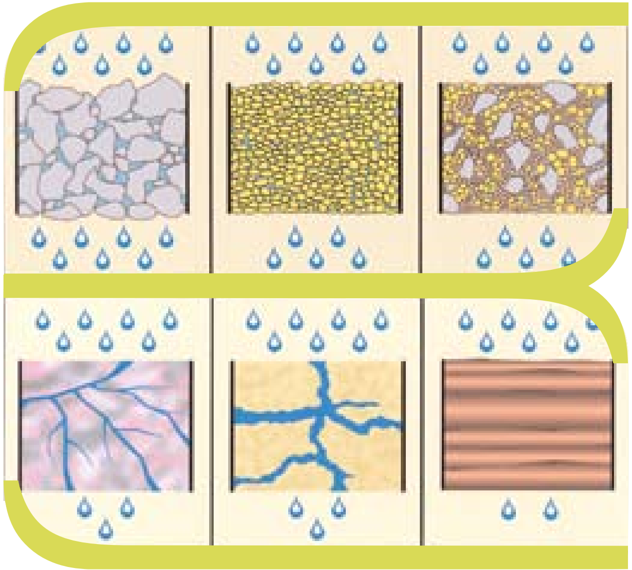
Fine-textured soils, such as clays and clay loams, bind compounds and provide better natural protection for groundwater. In these soils, the movement of water and contaminants through the soil is very slow. They act as a natural filter and allow for biological and chemical breakdown of contaminants before they reach groundwater.

Soil texture can be assessed using hand-texturing methods or with laboratory particle-size analyses to describe the relative fineness or coarseness of the soil particles. Soil maps are not as accurate as soil sampling but can provide an indication of the soil texture at the site.

Geological Formation

The geological formation under the surface varies greatly throughout the province. As a result the vulnerability of our groundwater resources to contamination is also variable.

Coarse-textured soils may require concrete, compacted clay or synthetic liner in order to prevent groundwater contamination.



Water moves slowly through uncracked clay soils and very quickly through gravelly and sandy soils.

A general understanding of the geological setting of your operation can be obtained through various published sources. These include soil data, water well reports, and geological maps.

Table 3.1 Factors Affecting the Vulnerability of Groundwater to Contamination

Factor	Explanation
Type of Soil above the Shallowest Water Table	Coarse-textured soils and soils with large cracks increase the risk of movement of water into the aquifer.
Depth to the Shallowest Water Table	Shallower water tables are more vulnerable.
Topography	Steep slopes increase water movement to low-lying areas, which have a greater chance of being directly connected to water tables.
Depth to Bedrock	Shallower bedrock can increase the risk of contamination. The upper surface of the bedrock is often highly fractured and conductive, and increases groundwater movement. It also acts as a conduit and moves water horizontally.

Depth to Groundwater

Filtering and treatment of contaminated water by natural processes primarily take place in soil above the water table in the unsaturated soil zone. In a naturally occurring, high water table, water and contaminants have little time to move through unsaturated soil before reaching shallow groundwater resources.

Water table depths can fluctuate significantly, depending on the season. Depending on the site, the depth to the water table can be assessed by:

- digging a hole in June or September and observing the depth to free water in the hole,
- using soil colour features and the soil drainage method to assess drainage class – usually done by soil specialists and engineers,
- referring to a local soil map to assess drainage class (e.g. the map will identify any areas of imperfect or poor drainage).

Site-Specific Assessment

A site-specific groundwater assessment will need to be conducted before the construction or expansion of a manure storage facility to determine the degree of groundwater sensitivity to contamination and the most appropriate measures to protect groundwater quality at the site.

These site-specific assessments and the design of any groundwater monitoring programs should be conducted by professionals with a specialized knowledge of geology and hydrogeology (the study of groundwater).

3.1.2 Surface Water Contamination Risks

Surface water can be found in various forms within a livestock operation. These include permanent water bodies such as creeks, dugouts, ponds, lakes, and sloughs as well as intermittent channels and ponds resulting from snowmelt and rainfall runoff. Surface water flow can provide a path to allow contaminants from the operation to flow into these water bodies.

To effectively reduce the potential risk, the goals to managing water pathways should include controlling the movement of water and providing an opportunity for manured water to be treated before flowing into a significant water pathway. The following factors that affect water pathways should be considered when developing action plans to reduce surface water contamination risks:

- Spring snowmelt presents a great risk of surface water contamination because the soil is still frozen and water infiltration is limited;
- Infiltration of water is slower in fine-textured soils (clay), increasing the amount of runoff from these soils which increases the risk of surface water contamination;
- Infiltration of water is faster in coarse-textured soils (sand), reducing the amount of runoff from these soils which decreases the risk of surface water contamination;

- Long and steep slopes increase the speed at which water will travel, reducing water infiltration rates and capture of contaminants;
- Packed soils and paved surfaces, as found in farmsteads, reduce infiltration and increase surface water runoff; and
- Permanent vegetation cover within the pathway will slow down water and can in turn capture both dissolved contaminants and soil particles with contaminants. Depending on the contaminant, this may be a form of treatment and reduce the risk to surface water.

For more information on managing surface water refer to Chapter 8.

3.1.3 Odour Risks

To varying degrees all livestock operations emit manure odours. In Alberta 26% of the nuisance complaints regarding agriculture concern odours (based on number of operations receiving complaints through the NRCB). Odour that is continuous and at excessive levels is atypical of normal farming practices.

Addressing odour issues is an important component of siting livestock facilities and manure storages. An odour problem that may arise at a site can potentially attract attention to other environmental problems – real or perceived. Proactive manure odour control measures will help ward off other neighbourly conflicts.

Table 3.2 Odour Reduction Options for Livestock Sites and Facilities

Technique	Considerations
Siting	• Where possible, choose the facility's location so that prevailing winds don't blow towards neighbours' homes. • Use existing or constructed windbreaks (trees or hilly areas) to direct wind and odours. • Consider the location of surrounding livestock operations and neighbouring residences.
Building Design and Maintenance	• Choose room designs, equipment and flooring that are easy to clean and require minimal amounts of water. • Design solid floors in livestock facilities so they slope towards gutters to ensure good drainage. • Keep facilities clean (e.g. regularly remove manure, wet feed, feed spillage and other products that could produce odour).
Corral/pen Design and Maintenance	• Design pens/corrals with slopes for good drainage; keep corral surfaces hard, smooth and free of loose manure; regularly fill in low-lying spots and potholes to reduce standing water. • Design settling channels and basins for easy machinery access for solids removal in all weather conditions. • Reduce feed spillage and clean up spills (e.g. adjust feeder design and/or reduce the level of feed in feeders).
Landscaping	• Keep storages out of main view. • Design with berms and side slopes to reduce visibility and manage air flow. • Plant trees to act as a visual barrier and provide considerable air movement and increase air dilution (but ensure earthen walls are unaffected by tree roots). Airflow is decreased within the existing trees on site and airflow and turbulence are increased around the site, which can increase dispersion. • Landscape the site to aid in keeping the site all-weather accessible and well drained.

3.2 MANURE STORAGE DESIGN CONSIDERATIONS

The design of your manure storage will be specific to your operation. The factors that you will have to consider include:

- amount of manure produced – depends on animal types and numbers
- type of manure – solid, liquid, semi-solid
- plans for land application – frequency and timing to meet your needs

3.2.1 Storage Capacity

Storage capacity should allow for operators to have timely application of manure. Applying manure on frozen or snow-covered ground increases the risk of runoff and the loss of valuable nutrients. Having adequate storage capacity allows operators to have flexibility in their application timing and reduces the cost of future expansion of manure storages.

Storage capacity takes into consideration the following factors:

- type of livestock
- number of livestock
- amount and type of bedding used
- volume of other wastewater such as milking centre washwaters, sanitation washwater and silage seepage, that are to be stored
- volume of other inputs such as roof water, runon water, rainfall and snowfall that can enter the storage system

Sources of information available to determine your storage capacity include:

- The AOPA Manure Characteristics and Land Base Code provides manure production volumes based on livestock species and type. The numbers are estimated volumes of manure production that also take into account bedding and wastewater.
- The dugout/lagoon calculator can be used to determine the actual size of your existing lagoon.
- Chapter 4.1 in the Nutrient Management Planning Guide explains how to calculate your manure inventory.
- Confined Feeding Operation (CFO) Extension Specialists can assist you.

All these can be found at www.agriculture.alberta.ca/aopa.

3.2.2 Manure Storage Systems

Operations will have solid, liquid or both types of manure storage. Solid manure storages are typically associated with beef production, some dairy, poultry and some hog operations. They can include feedlot pens, barns, and outside storage areas.

Liquid manure storages are typically associated with hog and some dairy operations. They can include

IT IS RECOMMENDED THAT MANURE STORAGE SIZE be large enough to allow operators to have flexibility in land application timing and frequency. New and expanding operations need to have at least nine months of storage as regulated in AOPA.

GEOTECHNICAL INVESTIGATION A geotechnical investigation is required to determine the geological characteristics below a proposed manure storage. The purpose of the investigation is to determine the naturally occurring soil and geologic conditions. The preliminary investigation will review existing information to decide if further physical investigation is warranted. The physical investigation would include the drilling of boreholes to study the subsurface. As well a hydraulic conductivity test would be conducted to determine the flow of water in the subsurface.

earthen manure storages, slurry storages, lined manure storages and concrete in-barn storages.

Several design options are available to protect groundwater and surface water. They include:

- natural clay liner
- compacted clay liner
- concrete liner
- synthetic liner
- steel for liquid manure storages
- temporary storage for solid manure

Natural Clay Liner

- This option depends on the geology of your site. Some parts of the province provide natural protection to groundwater as a result of naturally occurring clay layers between the manure storage and the groundwater resource.
- A geotechnical investigation will be required to ensure that the naturally occurring protective layer is adequate.
- Control of runon and runoff will have to be developed for the site. For more information read Chapter 8.
- Construction of a natural clay liner is simply landscaping the site for the use, either a feedlot floor or earthen manure storage.

Compacted Clay Liner

- Compacted clay liners are used when a naturally occurring protective layer below the storage does not exist but there is sufficient clay in the area that can be compacted to create a protective layer.
- A geotechnical investigation will be required to ensure that there is sufficient clay in the area and may initially demonstrate the lack of a naturally occurring protective layer.
- Control of runon and runoff will have to be developed for the site. For more information read chapter 8.
- Construction costs will include the proper development of a compacted clay liner.

Concrete or Steel Storage

- Geotechnical investigation is done to ensure that the soil conditions below the storage are stable enough to support a concrete or steel structure.
- Side walls can be incorporated into the design of a concrete pad to manage surface water flow onto the pad.
- Concrete storages will need proper seals between slabs to ensure no leaking, and be constructed with materials that can withstand the salt content of manure.

Temporary Solid Manure Storage

- Solid manure can be temporarily stored in areas that meet requirements for setbacks to common bodies of water; these requirements are set out in AOPA. Temporary storages can only be used once every three years for a maximum of seven months.

3.2.3 Loading and Emptying of Liquid Storages

Odours are released when liquid manure storages are loaded or emptied. During loading, the added manure can disturb the stored manure, causing gases trapped in the stored manure to be released. During emptying, liquid manure is agitated to obtain a consistent slurry of liquids and solids that will flow during loading or pump-out. The agitation and pumping release odorous gases.

To reduce odour when loading manure into a storage, discharge the new material beneath the surface of the existing stored manure. The discharge point should be in the bottom quarter of the storage. This technique is called bottom loading. It limits the disturbance of gases trapped in the manure. In addition, use a low discharge flow rate to prevent vigorous agitation of the manure.

New or improved manure storage facilities must be constructed so that the structure through which the primary cell is filled is located within the bottom quarter of the facility.

Be aware that several of the gases released by disturbed manure can be fatal. Several deaths have occurred in Alberta because of a lack of training and personal protection equipment while working with stored manure. For more information on the risk associated with manure gases, see Manure Application Safety in Chapter 7 on page 73.

CHOOSING A MILKHOUSE WASTEWATER HANDLING SYSTEM

Option	Considerations
Option 1: Add washwater to a liquid manure storage system.	• Pump to a properly designed liquid manure storage or feedyard runoff catchment. • Size storage to hold the additional wastewater.
Option 2: Store washwater in a separate storage system.	• Use properly designed concrete or earthen storage. • Size to store at least nine months of wastewater production. • Open storages release odours; reducing milk contents will reduce odours.
Option 3: Use a sediment tank and vegetative filter strip.	• If soil is too shallow, or has a high water table, choose another option. • Minimize manure and milk content in wastewater. • Reduce volumes by using water conservation techniques. • Use properly designed two-compartment "septic" tank with pump-out. • Use distribution header on discharge to spread effluent over larger area; alternate discharge location several times per year.
Option 4: Use lime flocculator treatment with treatment trench.	• Feed pre-rinse washwater to calves (reduce milk content). • Add 1.4 kg of lime to 1500 litres of wastewater, mix for 20 minutes and let settle for two hours (lime flocculates milk and soap solids, which then settle). • Pump clear water on top into disposal field system (treatment trench). • Flush bottom layer of wastewater (approx. 114 litres) into solid or semi-solid manure system.

3.3 MANAGEMENT PRACTICES FOR MANURE STORAGE

3.3.1 Maintenance and Monitoring

Visual Monitoring

There are several visual indicators of storage problems:

- Volume levels are not as expected.
- Wave damage to the liner.
- Erosion where manure enters into or is pumped from the storage.
- Cracking or slumping of the liner.
- Seepage, soft spots or slumping on the outside of the berm, or several feet out from the berm, that indicates leakage. Any leakage or slumping is a serious problem that requires immediate attention.
- Evidence of rodents. Rodent burrows can damage the liner and walls of the manure storage.
- Vegetation (tree and shrub roots). The roots of trees and shrubs growing in or near the storage can penetrate the liner and create leaks. Remove trees and other plants that start to grow in the manure storage. Trees, if planted, should be located with their mature root zone well beyond the storage.

Although most research regarding leakage from earthen manure storage structures has shown minimal problems, there may be some site-specific cases where more than visual monitoring is warranted.

Signage and Fencing

Hazardous areas such as storage structures, dugouts and water basins should be fenced/secured to prevent curious humans/unauthorized persons and animals from entering. A clearly visible sign should be erected at the entrance warning of the nature and danger of the facility.

Mowing

Keep weeds and grass mowed to promote a positive image, reduce flies and rodents, and reduce the potential for liner damage.

Sampling/Monitoring Wells

Sampling wells can be installed to regularly monitor water quality in the vicinity of the manure storage. Regular monitoring can be used to verify that the manure storage practices are protecting the environment, and can also act as an early warning that a change or repair is needed. A qualified engineer or hydrogeologist should design the monitoring well system and analyze the water quality data. After installation, the wells must be sampled to determine background conditions. Take samples at least twice per year for the first two years. After that, sampling once per year should be sufficient. Operations with a Natural Resources Conservation Board (NRCB) Permit will have conditions within their permit. Information is available from CFO Extension Specialists that provide direction to voluntary monitoring programs.

3.3.2 Odour

Table 3.3 lists BMPs to control odours from storages. Operators will have to make management decisions based on these practices and practices for odour control when applying manure. Technology and management practices can help alleviate odour-related issues; however the most effective and economical practice is to maintain good relations with your neighbours.

Table 3.3 BMPs to Control Odours from Manure Storages

Technique	Liquid Storage Considerations	Solid Storage Considerations
Natural Covers	• Reduce surface area exposure to ambient air. • Act as a filter on odour. • Depending on feed ration, manure storages can form a natural crust providing odour control.	• Does not apply.
Synthetic Covers	• Add cost but allow for capture of gases. • Reduce volume of liquid to be spread. • Challenges with agitation before spreading.	• Reduce water content of manure (by reducing rain water) and encourage aerobic conditions. • No runoff to handle.
Roofs	• Reduce surface area exposure to ambient air. • Can be a high capital cost. • Reduce water content of manure and encourage aerobic conditions. • Don't have to deal with precipitation.	
Biofilters	• Exhaust from barns or storages is blown through a porous bed of organic material (such as peat, straw, compost, etc.) that is kept moist. Naturally occurring microbes colonize the material and decompose odour compounds. • The systems require proper design and management to perform well and prevent ventilation problems. • Costly option and requires intensive management	
Chemical/Bio Additives	• Approach with caution – more failures than successes.	
Liquid/Solid Separation	• Done often in conjunction with other treatment. • Provides more options for further handling and management of manure.	• Collect liquid runoff from solid systems to encourage aerobic conditions.
Aeration	• Preferably done in conjunction with liquid/solid separation. • Has high energy demands.	• Has high energy demands. • Can have short-circuiting of air flow through pile.
Composting	• Need a very large carbon supply (e.g. straw) liquid to solid.	• Increased area and equipment required. • Need to manage leachate.
Anaerobic Digestion	• Costly to install and maintain, but revenue from energy generated may offset costs.	• Can mix solid manure with liquid manure for use in the digester.
Bottom Loading of Liquid Storages	• Discharge the new material beneath the surface of the manure. • The discharge point of the primary cell should be within the bottom quarter of the facility.	• Not applicable.

FOR MORE INFORMATION
regarding fly monitoring and control options, refer to A Guide for the Control of Flies in Alberta Confined Feeding Operations, available from www.agriculture.alberta.ca or by calling the ARD Publications Office at 1-800-292-5697.

3.3.3 Fly Control

Fly control is important due to the risk of disease transfer through flies, food safety concerns and the risk of nuisance complaints from neighbours. Because of the enclosed, controlled environment of barns, fly control can be a year-round process. Though complaints from neighbours mainly occur in the summer months, operators should be concerned about the fly population actively living in barns over the winter and the number of pupae overwintering from last summer's population. Both will contribute to the population that begins the next summer season. A larger initial population in the spring may result in greater fly problems earlier in the summer.

Producers can prevent fly outbreaks by implementing a fly management program that includes monitoring the population and a regular cleaning schedule of areas typical of fly breeding habitat. Fly populations involve four lifecycle stages (egg, larva, pupa, adult). Therefore, control methods should be conducted regularly, preferably weekly, to effectively disrupt the fly lifecycle and prevent fly outbreaks. If or when insecticides are used, animals should be removed from the area prior to application and all label instructions strictly followed. Remember, these chemicals will only affect the adult portion of the fly population and control of the population will only be short-term. Removal of fly breeding habitat is the key to effectively reducing fly populations.

Having a written fly management plan and communicating with your neighbours about the actions you are taking to reduce fly populations on your operation will help avoid potential nuisance complaints. Taking a proactive approach to fly control is your best defence.

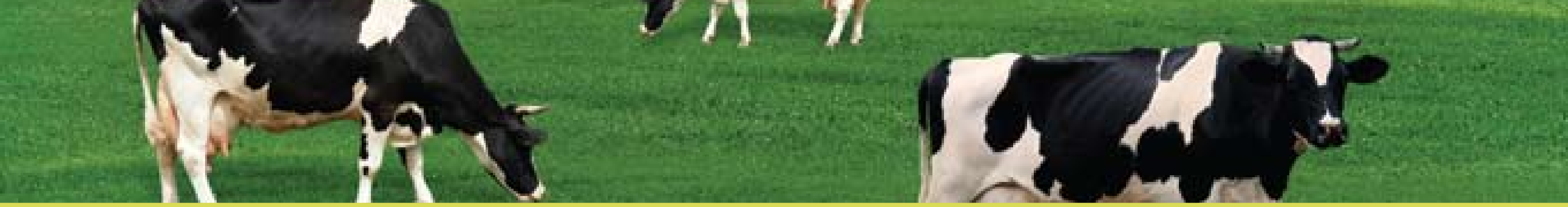
The following checklist is a tool for you to use in monitoring fly populations and in routine maintenance of key fly breeding habitats on your operation:

- Identify sites where flies are breeding on your operation.
- Use a weekly clean-up and maintenance checklist to ensure the effective control of fly populations on your operation.

Remember to keep records to confirm the actions you have taken to control fly populations on your operation.

3.4 TEMPORARY SHUTDOWN AND DECOMMISSIONING OF A MANURE STORAGE

CFO operators considering either a temporary operating suspension or a permanent shutdown of their CFO should contact ARD CFO Extension Specialists or NRCB staff to discuss options for their individual situation.



Chapter 4. MANURE TREATMENT

This chapter defines and explores the characteristics, advantages and disadvantages of three types of manure treatments:

- anaerobic digestion
- solid-liquid separation
- composting

Manure is usually applied to the land in its unaltered state, but in some situations manure may be 'treated' to alter its management. Manure treatment is often completed to change the moisture content of the material, making it easier to manage the manure or to reduce the environmental risks associated with manure management. Any treatment that changes the moisture content of manure will also affect the concentration and content of nutrients in the manure.

In situations where available cropland acreage is insufficient to recycle all of the manure produced by an operation, manure may be treated to change application dynamics and potentially make it practical to transport and apply the manure on land further from the operation. Treating manure may also make it a more favourable product for off-farm users to purchase or receive as a nutrient source.

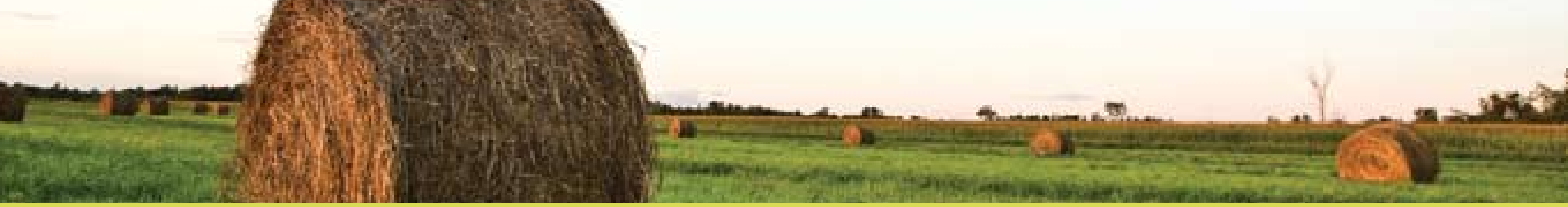
New treatment processes are continually being developed or adapted for manure. Manure managers who are interested in adopting new treatment technologies should be prepared to evaluate new technologies by participating in educational workshops, talking to people using and managing these technologies, and researching the technologies and their adaptability for local conditions. The adoption of manure treatment technologies can be very costly and time consuming in the short-term and the benefits may only be realized in the long-term. Potential benefits include: reduced manure volume, creation of value-added products, increased ease of manure management and reduced environmental risk.

Some of the most common methods of manure treatment in Alberta are anaerobic digestion, solid-liquid separation and composting.

Anaerobic Digestion

Solid-Liquid Separation

Composting



4.1 ANAEROBIC DIGESTION

The anaerobic digestion process is gaining attention in the agricultural industry because of its potential for renewable energy production and manure stabilization. These potential benefits are significant against the current backdrop of rising energy costs and growing environmental concerns.

Generally speaking there are two anaerobic digestion system configurations suitable for Canada:

Completely mixed: This type of system consists of a large tank in which new and old material is mixed. These systems are suitable for manure with lower dry matter content of 4% to 12%.

Plug flow: Typically this type of system consists of long channels in which the manure moves along as a plug. These systems are suitable for thicker liquid manure with 11% to 13% dry matter.

Anaerobic digestion is a naturally occurring process through which organic matter, such as crop residue, manure, spilt feed, food and meat processing waste, is broken down by micro-organisms in the absence of air. Most anaerobic digesters are operated in the temperature range of 15 to 45°C. The pH of the slurry in the digester is maintained between 6.5 and 7.5. The typical retention time of organic matter in the anaerobic digesters varies from two days to 60 days, depending on the type of digester and the concentration of organic matters processed.

The effluent coming out of the digester after the completion of the digestion process is known as digestate. Digestate may be processed to produce several value-added products and to reuse water as shown in Figure 4.1.

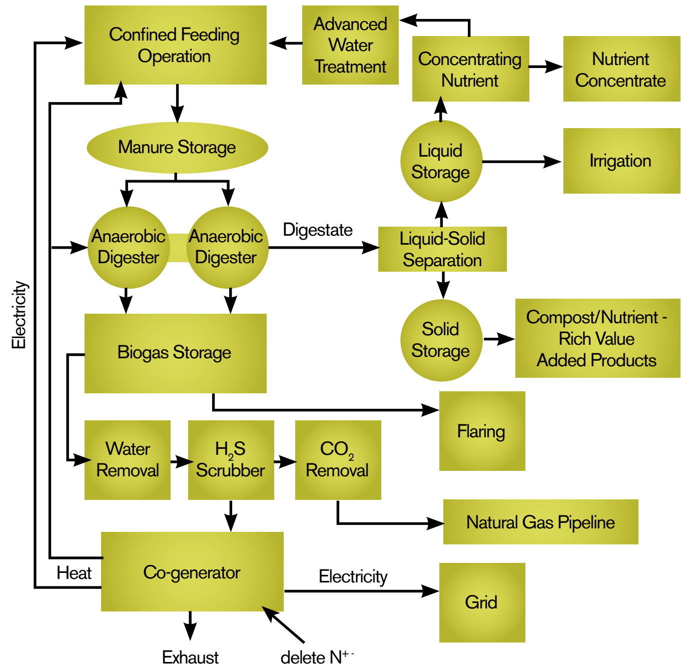
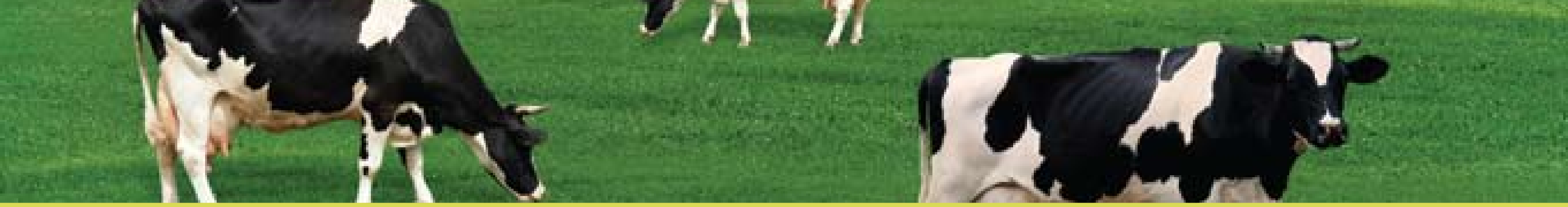


Figure 4.1 Schematic of the anaerobic digestion process

The first step in processing the digestate is separating the liquid and solid portions. Since the digestate has nutrient value, both the liquid and solid portions can be applied on land like manure. In addition, both streams may be further processed. For example, the liquid portion may be used for flushing purposes or purified further using advanced water treatment technologies to meet other water requirements on the farm. However, additional processing always requires additional investment.

In addition to the digestate, the anaerobic process converts some organic compounds to methane (CH_4) and carbon dioxide (CO_2) gases. The combination of these gases, ranging from 50 to 75% CH_4 and 25 to 45% CO_2, is known as biogas. Like natural gas, biogas can also be used as a fuel in power generators, engines, boilers and burners.

Biogas from anaerobic digesters also contains trace gases such as water vapour, hydrogen sulphide (H_2S),



nitrogen, hydrogen and oxygen. The water and H_2S gases require removal (see Figure 4.1) before biogas is used to produce energy. Biogas may also potentially be added to the natural gas lines if carbon dioxide is removed from the biogas.

BIOGAS IS A HIGHLY CORROSIVE AND FLAMMABLE GAS, and it contains traces of hydrogen sulphide (H_2S). Exposure to high concentrations of H_2S is harmful and may result in human fatality. Therefore, digester plant operators must be trained to handle H_2S and other biogas hazards.

Electricity can be produced from biogas using internal combustion engines and power turbines. While producing electricity, heat energy can also be recovered by using a sophisticated generator known as a co-generator. Co-generators usually contain an internal combustion engine or power turbine and heat exchanger to capture the heat generated while electricity is produced. Thus, co-generators have higher efficiency in energy production when compared to other electricity generators.

DIGESTER PLANT OPERATORS should follow standard safety procedures such as wearing safety gear, especially for hearing protection, as co-generators are generally noisy. The plant area should be fenced and have appropriate warning signs like "Danger, H_2S Area," "Stop" or "High Voltage."

Part of the heat energy produced during power generation is often used to heat the anaerobic digester. The rest is used to meet the various heating requirements of the farm.

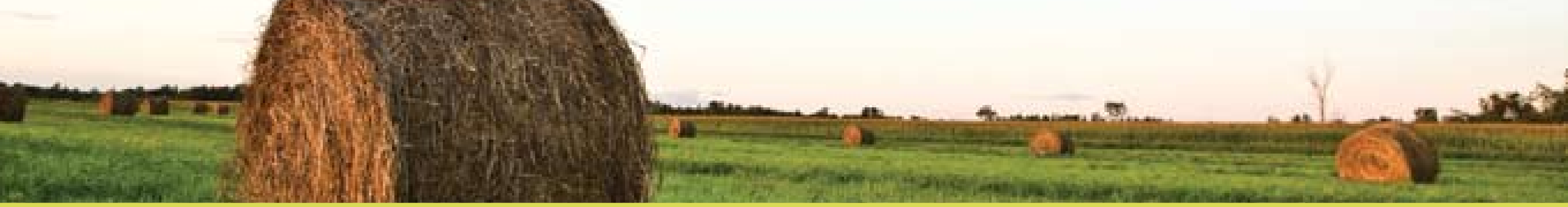
Electricity produced by the digester system can be used to meet the farm's electricity demand. The excess electricity may be sold to neighbouring communities or to the electricity supplier using the grid. Information regarding connecting excess electricity into the grid can be obtained from the electricity supplier.

Advantages of Anaerobic Digestion

- Odour reduction.
- Reduction of disease-causing micro-organisms (pathogens) – harmful pathogens like *E. coli* bacteria are considerably reduced when this process is used.
- Biogas production – biogas is known as renewable energy and reduces greenhouse gas emissions.
- Energy production.
- Nutrient retention for fertilizer use.
- Land application of solid and/or liquid digestate on cropland – this can help offset fertilizer costs.
- Soil conditioner production – the solid portion of the digestate may be sold as a nutrient-rich soil conditioner.
- Additional water for farm use – the liquid portion of digestate may be used for washing or flushing purposes or further purified for other farm water needs.
- Tipping fees for feedstock materials – tipping fees can be collected from producers or industries who want to sell manure or other biological materials as feedstocks for the digester.

Disadvantages of Anaerobic Digestion

- High capital costs may range from a few hundred thousand to a few million dollars. Some of the feasibility studies in North America



concluded that the payback period ranges from 5 to 16 years, when operated under optimum to worst conditions.

- Facility management expertise required.
- Labour and maintenance costs.
- Suitable only for very large operations.
- Utility connections may be difficult.
- Creation of two manure streams – Both solid and liquid materials must be managed.
- Process is sensitive to variation – high failure rates have been reported due to inadequate process control.

4.2 SOLID-LIQUID SEPARATION

Solid-liquid separation is a treatment technology that divides manure into solid and liquid fractions. This technology is used primarily with liquid or slurry manure systems.

Effective solid-liquid separation can remove a substantial amount of the organic solids from fresh liquid or slurry manure. The process creates a nutrient-rich solid fraction that has the economic potential to be hauled farther for land application now that the water fraction has been removed. In addition, the solid fraction has the potential to be composted and then land applied, sold or used as bedding in barns. The remaining liquid fraction contains fewer and smaller solids that are less likely to settle than in the original slurry. The liquid fraction still contains nutrients and can be applied to fields as a nutrient source or as irrigation water. Alternatively, the liquid fraction can be treated, recycled and reused within the operation as wash or flush water.

Separation efficiency depends on many factors, including the density, size and shape of particles, which depend on the source and quantity of bedding material, the amount of parlour water added, and seasonal changes in biological activity in storage ponds. The characteristics of the treatment technology, including treatment time, facility design and operation, also affect separation efficiency.

Several methods can be used to separate solids from liquids. The effectiveness of most separators improves as the solid content increases. The process is more effective with fresh rather than stored manure.

4.2.1 Separation Techniques

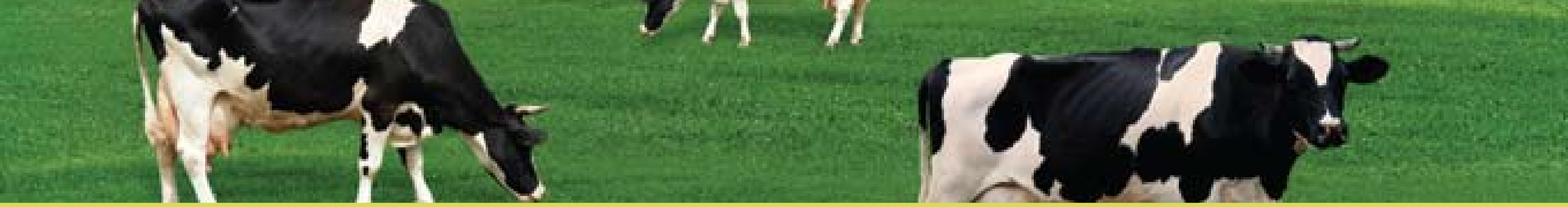
Sedimentation: This technique uses gravity to settle solids out of the slurry.

- Multi-cell earthen storages. This is the most basic and least effective method of solid-liquid separation.

Mechanical separation: This technique uses gravity plus mechanical means to separate the solids and liquids.

- *Centrifugal separators.* Several separators of this type have appeared on the market. They are generally high in price, low in capacity and not as effective as a press separator in producing a low-moisture solid fraction.
- *Screens.* Many variations of screen separators exist, including a simple, stationary sloped bar screen, a vibrating screen and screens with mechanical assistance. Most separators on the market at present are variants of the screen separator, usually with mechanical assistance in the form of scrapers, screws and/or hydraulic head to provide additional separating force. The screw press separates solids more efficiently than other technologies. These separators can be very cost prohibitive for some operations, yet practical for large operations.

Evaporation ponds: These may be effective in arid regions where much more water is removed by evaporation than is added by precipitation.



Dehydration: This method uses heat to remove moisture and is unpopular because of the high initial cost, maintenance and energy requirements.

Coagulation and flocculation: This relatively new technique for solid-liquid separation uses chemicals to aggregate suspended solids (coagulation) to form particles capable of settling out and to convert particles into large, rapidly settling flocs (flocculation).

4.2.2 Implications of Implementing Solid-Liquid Separation

Phosphorus (P) reduction in liquid fraction: About 96% of the P in manure is contained within the solid fraction. Therefore, P compounds are largely removed with the separated solids. Nitrogen (N) and P contents in the separated solids may be as high as 2% and 5%, respectively, depending on manure characteristics and the type of separation equipment. The addition of chemicals to the manure before separation can enhance P removal from the liquid fraction, significantly increasing the P content in the separated solids. The nutrient-rich, low-moisture solid fraction can be economically transported farther, allowing for the movement of nutrients farther from the yard, and reducing the risk of nutrient accumulation in nearby soils that have had frequent manure application in the past. Liquid from the separation process can be applied to nearby fields with a lower risk of nutrient accumulation because it contains less nitrogen, phosphorus and other constituents.

Water reuse and conservation: The separated liquid fraction can be treated using chemicals or ultraviolet light to kill pathogens. This allows the recycled water to be reused in the facility for livestock cooling, washwater or cleaning, reducing the need to use fresh water for these purposes. The recycled water could potentially be reused as a possible source of drinking water for livestock; however the cost of water treatment increases as the final water quality increases.

Ease of handling and transport: The removal of solids from the liquid fraction makes handling, pumping and application of the liquid easier. There is a lower potential to plug transfer pipes due to the reduction in solids, and less power is required to pump the same volume of material. The liquid fraction is easier to pump long distances in an irrigation system because it requires less pressure at the pump, minimizing the risk of ruptured seals and thus manure spills. As well, transportation of the solid fraction costs less due to the reduction in volume when liquids are removed.

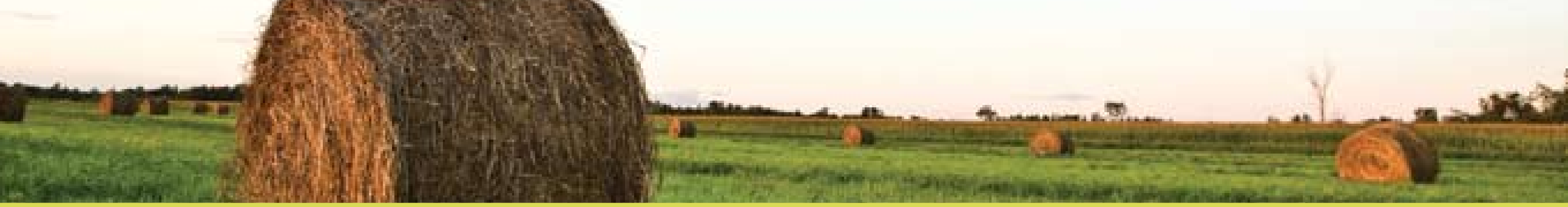
Odour reduction in liquid fraction: Odour generation largely depends on the amount of odour-producing organic substances remaining in the liquid. The separation process reduces the amount of organic compounds in the liquid fraction, reducing the organic loading and therefore the amount of odour released during storage, handling and application.

Lagoon volume reduction: Separating manure solids from the slurry before putting it into a lagoon reduces total slurry storage volume by 6 to 10% daily and volatile solids loading and lagoon treatment volume by 30 to 50%.

Two manure streams are created: Because this process creates two separate manure streams, two handling systems are needed: one for the liquid fraction and the other for the solid fraction.

Cost: Along with the capital, labour and maintenance costs of the separating device, some mechanical separation systems have high operating costs. The two handling systems must each be designed, operated and maintained, thereby increasing the cost of using a solid-liquid separator.

Increased management requirements: An operator must be knowledgeable to ensure the system is functioning properly. Regular maintenance is required to avoid breakdowns, depending on the type of separator. The increased concentration of P in the solid fraction must be managed properly to prevent P accumulation and environmental risks associated with P accumulation in fields.



4.3 COMPOSTING

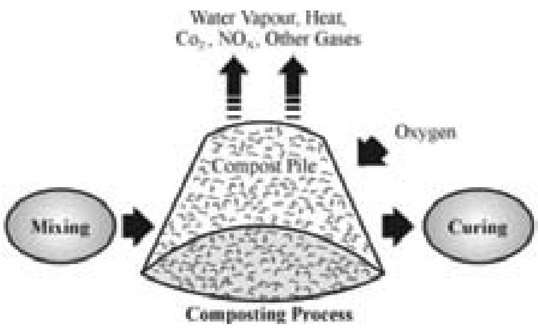


Figure 4.2 Basic Composting Process

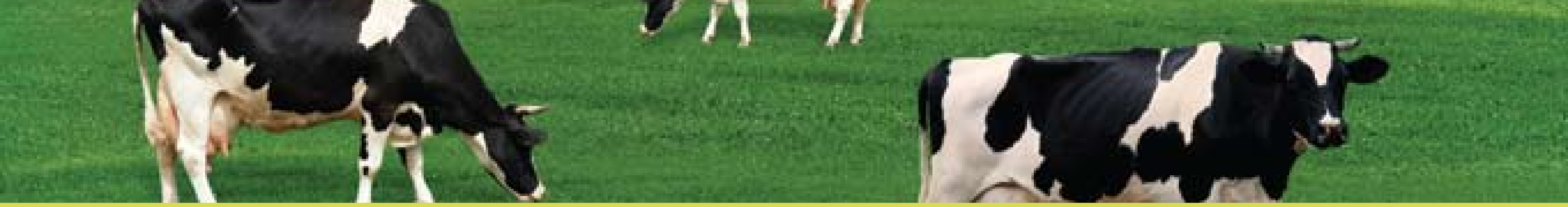
Manure composting is an aerobic, biological decomposition process that transforms solid manure and bedding material into stable, soil-like or humus-like material.

Requirements to achieve the best results from manure composting are:

- The moisture content of the material to be composted should be between 40 and 65%. If the moisture content is below 40%, the process is slow; if the moisture content is above 65%, the process may become anaerobic, which can create more odour. Since liquid manure is about 96% water, the solids must be separated from the liquid fraction in order for the solids to be composted. This requires solid-liquid separation. Housing systems using straw or shavings for bedding can produce solids suitable for composting.
- The material should have a carbon to nitrogen ratio (C:N) between 20:1 and 30:1. If the C:N ratio is too low, ammonia-N will volatilize (gas off) and be lost from the compost; if the ratio is too high, the process will take longer because nitrogen is in short supply compared to carbon.
- An oxygen content greater than 10% is ideal; the minimum oxygen content for composting is approximately 5%. Although oxygen naturally enters the material, its entry needs to be accelerated and oxygen needs to be available throughout the entire compost pile. This can be accomplished either by regular mechanical turning or by forcing air through the material using pipes and fans.
- A pH of 6.5 to 8.0 is required to promote the growth of the bacteria and fungi needed for manure decomposition. Most animal manures have a pH of approximately 6.8 to 7.4. The pH level of the compost may be adjusted by varying the mix of acidic and alkaline material.
- A temperature of 55°C to 60°C must be attained in the compost pile. Temperatures maintained at 55°C or greater for 15 days will eliminate most pathogens and weed seeds. Temperatures will be higher in the interior of the pile than the outer edges so the pile should be turned regularly to ensure that all of the material reaches and maintains those high temperatures.

THE MANURE COMPOSTING CALCULATOR

determines the amount of carbon source material and water needed to create a good compost mix. The Manure Composting Calculator is available at www.agriculture.alberta.ca



Advantages of Composting

- Reduces manure mass and volume, which can reduce hauling costs.
- Reduces odour during land application.
- Destroys pathogens.
- Kills weed seeds.
- Creates a soil conditioner.
- Converts nutrients into more stable forms.
- Creates a more consistent product that is easier to spread.
- Creates a product that has the potential to be sold.

Disadvantages of Composting

- Results in loss of ammonia-nitrogen.
- Requires time and labour.
- Poor management can lead to offensive odours and greenhouse gas emissions.
- Most practical for larger operations.
- May require the purchase and maintenance of composting equipment.
- Requires land for laying out windrows or piles for composting.
- If choosing to sell the final product, it requires marketing and potentially proper labeling.
- Requires a properly designed site for composting and potential leachate catchments.

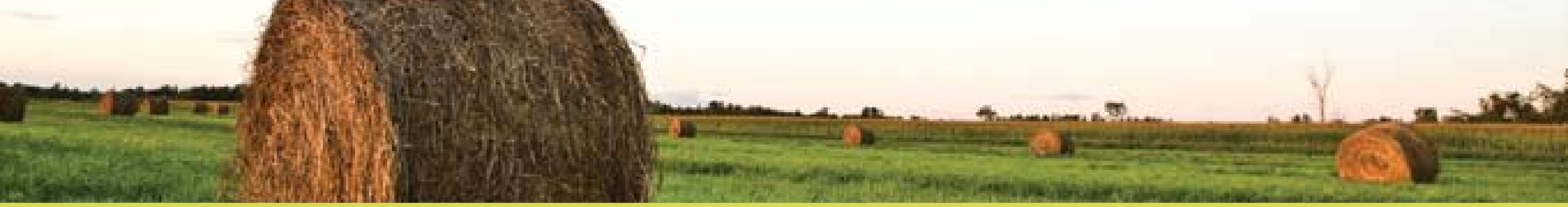
4.3.1 Composting Techniques

Various methods can be used for composting, including windrows, static piles with passive aeration, static piles with forced aeration, and reactor composting. All methods require careful management to ensure the elements of the composting process are supplied, maintained and optimized; otherwise the full benefits of composting will not occur.

Windrow composters can be used to accelerate the composting process.

Windrows: A windrow is a long, triangular pile with a width (4 to 5 m) about twice its height (1.5 to 2.5 m). The size must be large enough to maintain heat in the windrow and small enough to be managed with the equipment available. The manure piles or windrows are aerated by frequent mechanical turning, which maintains the composting process. A front-end loader or a specifically designed windrow turner can be used for turning.

FOR MORE INFORMATION see Manure Composting Manual, Agdex 400/27-1, available from Alberta Agriculture and Rural Development (ARD).



Advantages

- Mechanical turning moves material from the outer layer of the windrow into the centre. When properly managed, this facilitates the material being exposed to adequately high temperatures for at least 15 days, to kill pathogens and weed seeds.
- Material can be well mixed, promoting uniform breakdown, resulting in a consistent product.
- Generally produces compost faster than passive aeration composting.
- Easier to maintain the desired moisture content in the material as water can be added throughout the material as it is being turned.
- Relatively low capital cost.
- Mechanical turning helps to break up clumps of straw and manure, and adds oxygen to the pile.

Disadvantages

- Cost of windrow turning equipment (capital and operation).
- Relatively higher operational cost as compared to static piles.
- Time is required to turn and manage the windrow.
- Often requires more space than other forms of composting, such as static pile, because room is needed to move the windrows and/or move the equipment around the windrows.

Static pile with passive aeration: Composting piles or windrows are outfitted with aeration tubes throughout to aid in air movement through the material and sustain the composting process.

Advantages

- Less cost and maintenance than forced aeration static pile composting.
- Less capital investment in equipment than for other types of composting methods.

Disadvantages

- Difficult to maintain the proper temperature and moisture conditions in the pile or windrow.
- The proper composting temperature may not be maintained well enough, resulting in the survival of viable weed seeds, especially along the outer layer of the static pile.
- Potential for survival of pathogens if adequate temperatures are not maintained for at least 15 days; this is especially an issue for the material in the outer layer of the pile.
- Difficult to add water evenly throughout the pile to maintain the desired moisture content for composting process.
- Time to compost is longer.
- Final product is not as uniform as compost that is turned and mixed; no mechanical turning happens so clumps of straw and manure are not physically broken up.

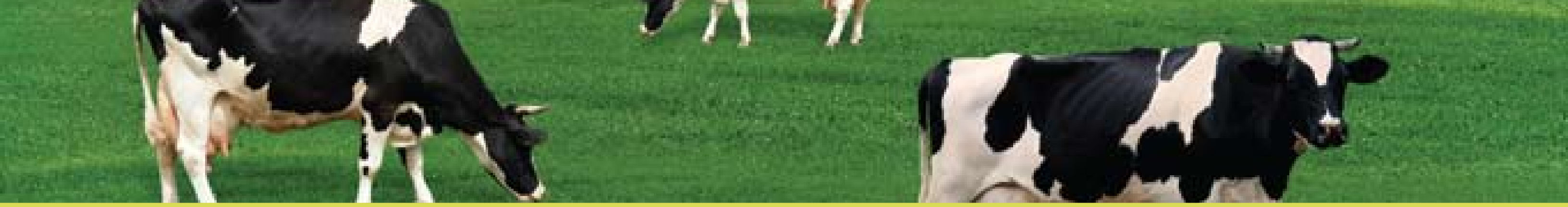
Static pile with forced aeration: Forced aeration uses fans or blowers to push air through ducts installed under the composting windrows. The rate of aeration is often dictated by the temperature of the composting media as measured by thermocouples installed within the media. The optimum aeration rate is influenced by a number of factors including the moisture content and porosity of the material.

Advantages

- Potentially lower start-up and maintenance costs than mechanical windrow turning.
- Easier to maintain proper aeration requirements than in passive aeration composting.

Disadvantages

- Potential for survival of pathogens and weed seeds if adequate temperatures are not maintained for at least 15 days, especially in the outer layer of the pile.



- Potential for very inconsistent compost quality.
- May reduce moisture content of the pile faster than passive aeration, resulting in the need to add moisture more often or in greater volumes to maintain ideal compost conditions.

Reactor composting (in-vessel composting): This technique involves composting in drums, silos or channels. Aeration is accomplished by continuous agitation using aerating machines, which operate in concrete bays, or by fans providing air flow from ducts built into concrete floors. Reactor processes are either horizontal or vertical flow. Some vertical reactors allow for mechanical agitation of solids and are usually fed with raw manure on either a continuous or intermittent basis. Horizontal reactors employ either a rotating drum system or a bin structure, which can include mechanical agitation.

Advantages

- Can be designed as a continuous process.
- Allows better control of the process and produces a consistent product with effective weed seed and pathogen kill.

Disadvantages

- Higher initial costs as the process is mechanized and capital intensive.
- Generally less flexible than other methods; reactors are generally built in one location (stationary) and they are sized to accommodate a certain volume of material, so they are unable to take in more material than their sizing allows.

4.3.2 Composting Regulations

The siting and operation of composting facilities that compost only livestock manure with no additives are regulated under Alberta's *Agricultural Operation Practices Act.* The siting and operation of composting facilities that compost livestock manure and also accept other agricultural and non-agricultural waste products are regulated under Alberta's *Environmental Protection and Enhancement Act.* The sale of compost is regulated under Canada's *Fertilizer Act and Regulations,* through the Canadian Food Inspection Agency.

Please see the appropriate acts to find the latest regulations affecting the siting and management of compost facilities and sale of composted material.

Chapter 5. MANURE TRANSPORTATION

This chapter describes the following issues related to transporting livestock manure:

- risks and considerations
- spillage and emergency planning
- costs

Manure transportation refers to the movement of manure from long-term storage or livestock facilities to either short-term storage locations or to field sites for application. The transfer may be completed using manure hauling equipment on roads or farm lanes or via pipeline systems across roads, ditches or fields. Safe and efficient manure transportation is an important component of good nutrient management.

5.1 TRANSPORTATION RISKS AND CONSIDERATIONS

Moving manure from storage to the field is an important part of a manure management system because of the costs incurred, the potential risks involved, and the possibility of nuisance for neighbours. The main risks associated with manure transportation include risks to human safety, the environment and the physical conditions of roads.

5.1.1 Reducing Manure Spillage Risks

Manure spills on the road can be in violation of Alberta's *Public Highways Development Act* (considered as litter) and Alberta's *Environmental Protection and Enhancement Act* (considered as pollution).

Spillage of liquid or solid manure during manure hauling may occur from seepage, overloading, blowing winds or equipment breaking. Appropriate management techniques and proper maintenance and operation of manure tanks or pipelines help to keep the roads and ditches free of manure spillage. Management techniques may include smaller loads, covered loads, or sealed end-gates on solid manure trucks.

BMPs for Nurse Tanks or Bladders

Nurse tanks or bladders are movable, temporary storage devices used in the field to store liquid materials prior to and during land application. The field application equipment either continually or intermittently fills from the nurse tanks or bladders, allowing the application equipment to continually apply manure without leaving the field. Tankers haul the liquid manure to the nurse tanks from the permanent storage facility.

Nurse tanks and bladders should be:

- leak-proof
- equipped with emergency shut-off values
- equipped with safety grills to prevent human entry
- located a safe distance from potentially sensitive areas such as surface water bodies or water supplies

THE MAIN RISKS ASSOCIATED WITH MANURE TRANSPORTATION include risks to human safety, the environment and the physical conditions of roads.

Tankers can be used to move manure to the field, allowing application equipment to continually apply manure.

BMPs for Permanent, Temporary or Portable Pipelines

Permanent pipelines are buried below-grade with risers/hydrants at specific locations. They are usually constructed with PVC or equivalent material. Temporary or portable pipelines are usually rigid aluminum pipe or large diameter hose material with threaded connectors. These pipelines can be dismantled and moved from field to field or farm to farm. Temporary lines may have to cross roads or highways to service fields; culverts may be used to facilitate this crossing. If pipeline systems are being used regularly, discuss with the Municipality or Province about the installation of small diameter culverts or a permanent, buried pipeline section specifically for use by the manure pipeline system.

WHEN WORKING WITH PIPELINE SYSTEMS that cross highways or roads, farm workers should wear high visibility clothing while performing all operations near the highway or road.

One of the most significant risks associated with pipeline systems is a break or leak in the line, resulting in the potential spill of a significant amount of manure. To minimize the risk associated with a spill from a temporary pipeline system that crosses a road ditch or culvert, make sure there are no connections near the culvert or ditch, and if possible use a single length of hose or pipe. Set secondary containment berms perpendicular to the road to contain spills or leaks. Flush the pipes with water, purge with air or cap the hose, and move the pipeline away from the culvert or ditch prior to disconnection.

Permanent or temporary pipelines should be:

- tested and inspected for leaks and breaks right after assembly and prior to each use;
- monitored for leaks during use and application;
- operated with two trained staff, connected with two-way communication at all times, or with one trained staff with automatic or remote-control shut-off technology to shut down the pump in case the pipeline breaks;
- constructed with pipe or hose that can support a flow velocity of 0.8 to 2.5 m/s
  - pipe or hose should be no less than 75 mm in diameter;
- fitted with connections that can withstand all likely conditions, such as head pressure from the pump; and
- flushed with water or air to clean out the hoses and pipes before moving to a different location.

Hard hoses and pipes carrying manure to fields should be monitored for leaks.

Try to minimize even minor losses of manure during transport. In the event of excessive spillage, clean-up measures, such as sweeping, scrapping, shoveling or vacuum pumping, may be required.

5.1.2 Emergency Spill or Accident Plans

Emergency plans are developed in case of a manure spill or accident and are implemented when manure or other contaminants are spilled or an accident occurs. It is important to remember that a plan is only useful if the information put into it is specific to your facility and if everyone involved with the handling and moving of manure is familiar with the plan. A well-designed and implemented response will minimize the risk to human and animal health, reduce economic losses and minimize the potential for environmental contamination.

To stop a manure pipeline spill, shut down pumps and valves.

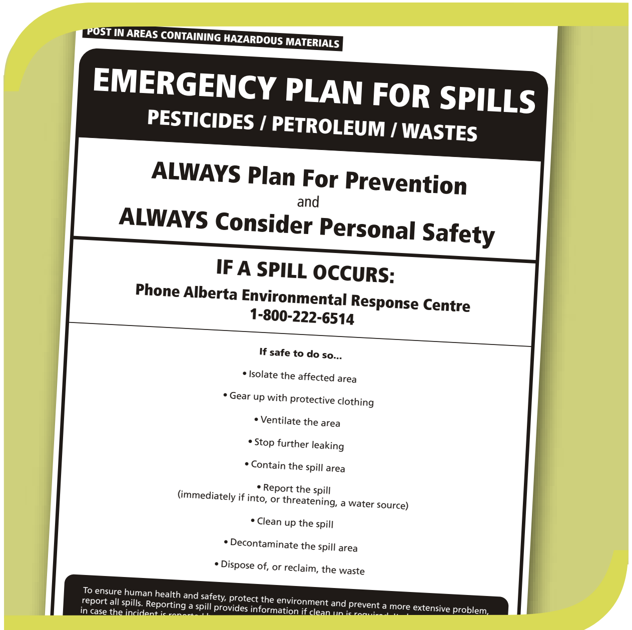
Dealing with Spills

The best solution to any emergency is prevention. Sound management practices will prevent many manure situations from becoming emergencies. In the event that a spill does occur, an emergency response plan will provide guidance to minimize the manure's impact on the environment and human health. Once the spill is contained, contact the NRCB and Alberta Environmental Response Centre to make them aware of the spill and possibly request assistance with site clean-up.

Water resource protection: Often common sense and simple approaches can be taken to interrupt the flow of manure toward and into surface waters. For example, tillage across and down slope of the manure path will slow the velocity of the flow. Berms or dams may need to be installed to restrict and direct the flow of manure and create a containment area. Berms can be constructed from soil with high clay content, used feed, straw, round bales or other absorbent organic matter. Once berms are installed, manure can easily be collected from the contained area and moved to an appropriate storage structure or field applied.

Contain spills. Prevent entry of manure into ditches and culverts.

Manure tanker or applicator accident: There is a good chance that a spill resulting from a manure tanker or applicator accident may include personal injuries (e.g. car accident). As in any manure emergency, *human injuries take precedence over all other responses.* Once the threat to human life or injury is under control, limiting the environmental impact becomes the main goal. Use warning devices, such as flares, flags or flashing lights, to protect on-coming motorists and individuals assisting with the clean-up. Once the site is safe, make every effort to immediately contain or block the flow from moving further downstream and implement removal and recovery procedures to abate or lessen the impact to water resources, as described above.


POST IN AREAS CONTAINING HAZARDOUS MATERIALS

EMERGENCY PLAN FOR SPILLS

PESTICIDES / PETROLEUM / WASTES

ALWAYS Plan For Prevention
and
ALWAYS Consider Personal Safety

IF A SPILL OCCURS:
Phone Alberta Environmental Response Centre
1-800-222-6514

If safe to do so...
• Isolate the affected area
• Gear up with protective clothing
• Ventilate the area
• Stop further leaking
• Contain the spill area
• Report the spill
(immediately if into, or threatening, a water source)
• Clean up the spill
• Decontaminate the spill area
• Dispose of, or reclaim, the waste

To ensure human health and safety, protect the environment and prevent a more extensive problem, report all spills. Reporting a spill provides information if clean up is required

In the event of a manure spill, call the Alberta Environmental Response Centre at 1-800-222-6514.

Equipment malfunctions: A leak from a manure truck or tanker can result in a relatively small volume of manure being spilt, but a leak from large volume systems such as draglines (umbilical cord systems) and irrigation systems can result in a very large volume of manure being spilt. However, even small volumes of manure spilt in close proximity to an environmentally sensitive area may have adverse impacts. Contain the spilt manure to stop it from moving into environmentally sensitive areas. Once the manure spill has been contained and cleaned up, the equipment needs to be fixed to prevent future malfunctions or leaks.

Developing a Plan

An emergency spill or accident plan that includes key contact numbers such as the NRCB, Alberta Environment and the Municipality, and standard operating procedures in the event of a spill or accident, is highly recommended. The plan may also identify areas of concern and available equipment. The plan should be kept in the cab of manure transport trucks for quick accessibility.

Standard Operating Procedures in the Event of a Manure Spill or Accident

You can adapt the following procedures to your own situation.

1. Make sure the area is safe to enter following an accident.
2. Tend to any human injuries.
3. Eliminate the source of the spill. If the spill is coming from a dragline or irrigation pipeline system turn off the pump and close valves to prevent siphoning.
4. Evaluate the site to determine if risks to the environment such as water bodies can be affected by the spill and assess the extent of the spill. Note any damages.
5. Contain the spill, possibly by using equipment to construct a holding area, berm or dike or by using sand bags or bales to construct a berm.
   - If the spill is in the field, till the soil ahead of the flow and perpendicular to the path of the flow to slow flow velocity and increase infiltration.
   - If flow is concentrated in a ditch or stream, create a set of earthen dams: first, downstream to minimize the movement of manure; second, upstream (if needed) to minimize additional clean water from becoming contaminated; and third, another dam further downstream to act as a back-up for the first dam.
   - Refer to your spill response resource list to quickly access equipment and/or labour necessary to address the spill.
6. Contact key agencies such as the Alberta Environmental Response Centre, NRCB, and the Municipality to notify them of the spill.
7. Clean up spilled material immediately to limit risk of injury and liability.
8. Document the spill in writing and take photos of the spill and clean-up efforts if possible.
9. Repair any components or equipment to prevent future spills.
10. Apply captured manure on cropland.

FOR MORE INFORMATION on manure transportation costs and calculating value from manure application systems, go online to www.agriculture.alberta.ca and search for the Manure Transportation Calculator.

5.2 TRANSPORTATION COSTS

The transportation of manure can result in significant costs depending on the travel distances and time required. The type and moisture content of the manure are also factors that affect transportation costs.

Solid manure generally has a low nutrient content and can contain a significant percentage of water. The greater the moisture content of the solid manure, the higher the costs associated with transportation and handling of the material. Composting of solid manure reduces its moisture content and decreases its volume by two-thirds. Reducing the volume and moisture of solid manure reduces transportation costs, so greater hauling distances become more economically feasible.

Liquid manure can contain a significantly higher concentration of nutrients than solid manure. The costs of transporting liquid manure are impacted by the water content of the material. The use of pipeline or dragline/umbilical manure application systems can significantly reduce the transportation costs associated with liquid manure management.

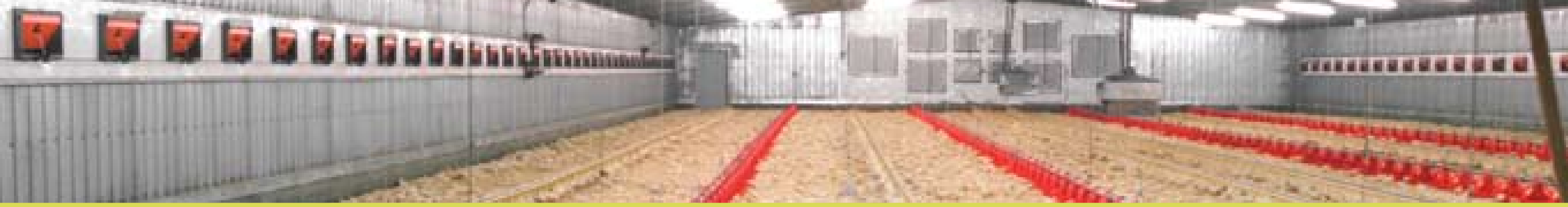
The use of pipeline or dragline manure application systems can significantly reduce the transportation costs associated with liquid manure management.

5.2.1 Maximizing the Value of Manure

The cost of transporting manure can be offset by maximizing the value captured from the manure through effective management and land application. The greater the value or benefit from the manure, the greater the offset.

The value of manure is a function of the manure's nutrient content, method and timing of manure application, field fertility levels and soil quality, and the crop to be grown. Value can be attributed to manure through the production of a crop, the reduction of input costs associated with crop production and the improvement in soil quality. The application of manure to fields that are already high in nutrients and do not require additional nutrients reduces the potential value or return from the manure.

To maximize the value of manure, apply it to fields in which the crop will be able to take advantage of the manure nutrients as much as possible, and to fields that have the lowest organic matter levels, poorest soil quality and/or have received no or minimal manure over the years.



Chapter 6. NUTRIENT MANAGEMENT PLANNING

This chapter explores:

- features of a nutrient management plan
- managing nutrients in manure
- nutrient use efficiency
- field assessment
- soil and manure sampling
    - interpreting manure test results
- manure inventory
- crop nutrient replacement

Your crops require adequate nutrients and conditions to produce your target yields. Some of these nutrients are supplied through the soil, but additional nutrients might need to be provided through the application of commercial fertilizer, manure, compost or crop residue. However, the application of excess nutrients poses a threat to the environment. Matching nutrient levels to crop demand protects the environment and maximizes the benefit of supplying valuable nutrients to your crops.

Manure and compost can provide many benefits to crops and the soil if handled properly. Manure is a source of plant nutrients. As well, its application to the land can improve soil tilth, structure and water-holding capacity, especially for poor quality soils, coarse-textured soils, soils low in organic matter or degraded soils. However, if manure application is not properly managed, excess nutrients may be applied to agricultural land, affecting soil and water quality. Manure is also a source of nitrogen gases, including ammonia and nitrous oxide (a greenhouse gas), which can be released during application, reducing air quality.

Nutrient management planning is not simply an accounting exercise. Although the paperwork of keeping records and calculating application rates is necessary, you also need to know where, how and when to apply nutrients for maximum benefit to crops and least impact on the environment. In other words, you need to ensure that what you planned is actually happening.

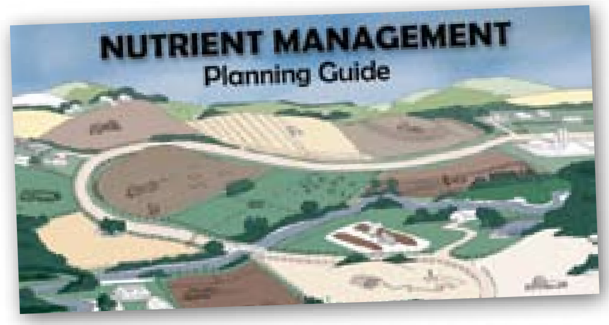
Nutrient management planning aims to optimize crop yield and quality, minimize fertilizer input costs, effectively use manure and compost, and protect soil, water and air quality. It focuses on applying the right amount of the nutrient-containing product in the right place at the right time. This involves setting realistic target yields, choosing the correctly balanced blend of nutrients, placing the nutrients as close to the growing plant as possible without damaging the plant, and applying the nutrients as close as possible to the time when the plants are actively growing.

Nutrient management planning uses a balanced fertility perspective, considering the amounts of all nutrients in the soil and the crop's requirements. Balanced fertility involves calculating and applying the appropriate amount of each nutrient, rather than basing recommendations on only one nutrient. A slight deficiency in one nutrient can affect the plant's ability to take up another nutrient. This results in unused nutrients that may be susceptible to leaching, runoff or gaseous losses.

ALL AGRICULTURAL OPERATORS in Alberta must manage nutrients in accordance with the standards in the *Agricultural Operation Practices Act* (AOPA).

Balanced fertility results in a well-fed crop, which produces a healthier, more extensive root system able to explore a greater area in search of nutrients and water. This results in more efficient extraction of nutrients and water, and because a higher yield is produced with the same amount of water, crop water use efficiency is improved.

Balanced fertility management also reduces erosion potential. The crop grows faster so the soil surface is covered more rapidly, protecting it from wind and water erosion. In addition, more biomass is produced so more crop residues can be left behind to protect against erosion.



For more information on nutrient management planning, get the Nutrient Management Planning Guide from the Publications Office of Alberta Agriculture and Rural Development (ARD) or download it from www.agriculture.alberta.ca.

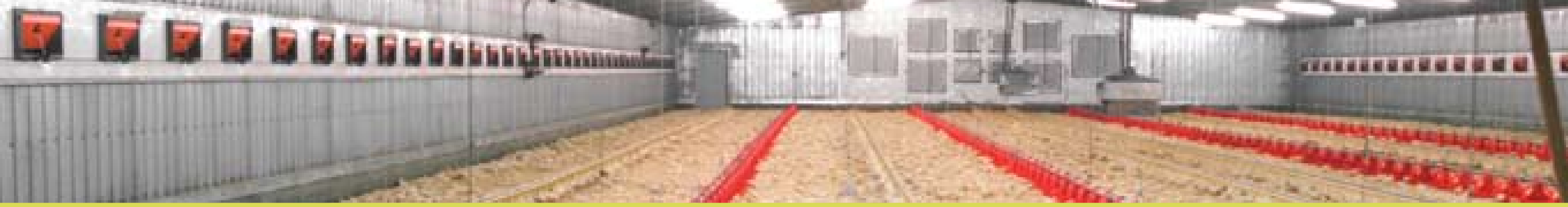
A TYPICAL NUTRIENT MANAGEMENT PLAN IN ALBERTA CONSISTS OF THE FOLLOWING COMPONENTS:

1. Field (or site) assessment – includes soil test information, area, soil texture, estimated length and grade of any slopes, problem soil conditions (e.g. solonetzic soils) and limiting physical features such as environmentally sensitive areas (e.g. water bodies).
2. Manure inventory – includes estimated nutrient content (from lab analysis or standard values), estimated manure volume(s) and desired information about the animal population or the operation (e.g. number of animals, phase of production, housing and feeding system, etc.).
3. Nutrient application plan – includes information about manure application and incorporation methods, equipment calibration, planned crop rotation, cropping system, crop fertility requirements, planned manure and commercial fertilizer application rates, nutrients applied from all nutrient sources, timing of application and incorporation.
4. Land management plan – includes information on production practices and other control systems to reduce post-application nutrient losses.
5. Record keeping system – includes a system of record keeping, and if required, a system that complies with the AOPA record keeping requirement for manure handling, application and transfer.

6.1 MANAGING NUTRIENTS IN MANURE

Manure should be managed as a resource to maximize its benefits and minimize its risks. To use manure as a resource, it is important to understand its composition.

The macronutrients in manure that contribute to plant growth are nitrogen, phosphorus, potassium, calcium, magnesium, sodium and sulphur. Manure also contains micronutrients such as boron, chlorine, copper, iron, molybdenum, zinc, selenium, chromium, iodine and cobalt. Manure provides the same nutrients for crop production as commercial fertilizers, though the



challenge with manure is the forms and ratio of the nutrients are not easy to change, nor easy to match to crop requirements.

Over-application of manure can lead to problems such as contamination of water sources with nutrients and pathogens, emission of odours and greenhouse gases, nutrient loading in the soil leading to crop lodging, and salt accumulation resulting in poor yields. The two most important nutrients to consider when managing manure to reduce risks to the environment are nitrogen (N) and phosphorus (P).

6.1.1 Manure Nutrient Availability

Testing soil and manure to determine their nutrient levels is the only way to be sure about how much manure to apply. Some nutrients in manure and other organic nutrient sources such as compost are in an inorganic form, which is readily available for crop uptake; other nutrients are slowly converted from an organic form to an inorganic form.

Nutrients such as nitrogen and phosphorus are present in manure in both inorganic and organic forms. Crops can not readily absorb and use nutrients in their organic from. Nutrients in their organic form must be transformed by soil micro-organisms into inorganic forms that crops can use. The process of conversion from organic compounds to inorganic compounds happens over time. So portions of the organic nutrients are converted each year into the inorganic forms that crops can use.

The inorganic forms of nutrients are immediately available to and usable by crops (Table 6.1). In manure the primary form of inorganic nitrogen is ammonium, whereas in compost the primary form of inorganic nitrogen is nitrate. Ammonium can quickly be converted into ammonia, which is a gaseous compound that readily volatilizes, or gasses off, so it is at risk of being lost from the productive system. Nitrate-N will not volatilize, but instead this form is soluble in water and is therefore at risk of being lost via surface runoff or leaching.

The higher the ammonium content of the manure, the higher crop-available nitrogen in the manure, and the greater the risk and therefore the cost of ammonium nitrogen losses during application. Manure types such as liquid dairy, liquid swine or poultry manure have a high concentration of ammonium in the manure. This means that a higher percentage of the nitrogen is available in the year of application and this manure has the highest risk of nitrogen loss.

Table 6.1 Form and Availability of Nitrogen and Phosphorus in Manure

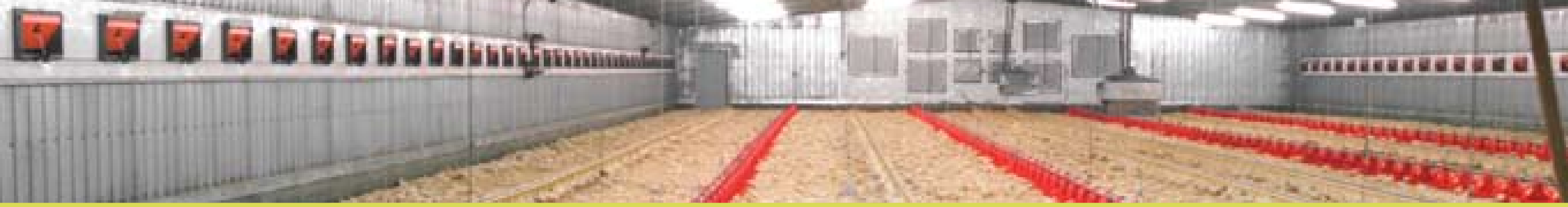
Nutrient	Form in Manure	Available 1st Year	Available 2nd Year	Available 3rd Year	Environmental Risks
Nitrogen (N)	Inorganic N •Ammonium (NH_4^+) •Nitrate (NO_3^-) Organic N	$NH_4^+ + NO_3^- +$ 25% of organic N content (for solid manure), 40% of organic N content (for liquid manure), 30% of organic N content (for poultry manure)	12% of initial organic N content (for solid manure), 20% of initial organic N (for liquid manure), 15% of organic N content (for poultry manure)	6% of initial organic N content (for solid manure), 10% of initial organic N (for liquid manure), 7% of organic N content (for poultry manure)	• Nitrate in groundwater • Volatilization[a] of ammonia • Denitrification[b] as nitrous oxide
Phosphorus (P)	Inorganic P ($H_2PO_4^-$ and HPO_4^{2-}) Organic P	70% of initial total P content	20% of initial total P content	6% of initial total P content	• P in surface runoff (particulate and dissolved) • P leaching into groundwater

a. Volatilization is the gaseous loss of a substance (e.g. ammonia) into the atmosphere.
b. Denitrification is the transformation, under high moisture or saturated soil conditions, of nitrate to gaseous forms, which can be lost to the atmosphere.
Note: The percentages listed in the table are only estimates. The availability of nutrients from organic sources, such as manure, depends on biological processes in the soil. These processes are affected by many factors, such as temperature, moisture and soil type.

The ratio of nitrogen to phosphorus in manure varies with livestock type, feed type and ration, and manure handling system. The ratio of these nutrients in manure does not match the crop's requirements. Cattle manure, for example, may contain 1 to 2 parts of nitrogen to 1 part of phosphorus (a ratio of 1:1 to 2:1). Crops require between 3 and 7 parts of nitrogen per 1 part of phosphorus (a ratio of 3:1 to 7:1). Due to this imbalance, manure application will provide either too little or excess nutrients for optimal crop growth.

A FEW FACTS ABOUT NITROGEN AND PHOSPHORUS:

- Plants can readily use inorganic nitrogen in the form of ammonium or nitrate.
- Organic nitrogen must be transformed to ammonium (via mineralization) or nitrate (via nitrification) form before plants can use it.
- Phosphorus (P) is generally found in three forms: particulate phosphorus (P attached to sediments), dissolved phosphorus (water-soluble P) and organic phosphorus.
- Plants can readily use dissolved phosphorus.



6.1.2 Managing Nutrient Losses and Risks

The plant nutrients in manure that are of greatest environmental concern are nitrogen and phosphorus. Losses of nutrients such as nitrogen and phosphorus from the soil through erosion, leaching or gaseous emissions can have serious environmental impacts as well as economic impacts through the direct loss of valuable nutrients and through the cost of replacing nutrients that have been lost.

Nitrogen and phosphorus behave in different ways once applied to the soil. Nitrogen in nitrate (NO_3^-) form moves easily with water. As a result, it can move across the soil surface with runoff or it can be leached below the root zone as water infiltrates and could eventually enter the groundwater. Nitrogen in ammonia (NH_3^-) form can gas off the soil surface to the atmosphere. Organic nitrogen is moved from the soil surface with soil erosion events.

Phosphorus, on the other hand, binds tightly to soil materials and does not move as readily with the soil water unless there are high phosphorus levels in the soil. As a result the most common pathway for phosphorus to enter water is through soil erosion. In situations with high soil phosphorus concentrations the amount of dissolved and unbound phosphorus increases in the soil solution, leading to increased phosphorus movement in water solution.

Many factors influence the potential movement of nitrogen and phosphorus to surface and groundwater including:

- soil type, texture and slope
- proximity of the nutrient to surface and groundwater
- soil fertility levels
- manure application and land management practices.

Factors that influence nutrient movement off a field need to be assessed on a site-by-site basis to determine their relative importance. So, for example, where soil phosphorus levels, as determined by soil tests, are high and erosion potential is high, the risk of phosphorus contamination of surface water from manure application is also high. In fact, the high risk may only apply to a portion of the field that is directly connected to the watercourse or water body. So management practices may be implemented in portions of the field to address the areas of higher risk.

For groundwater to be contaminated there must be both a source of nitrate in the soil and the opportunity for transport down the soil profile. Nitrate may be present in the soil from nutrients applied and not used during the crop year or from fertilizers or manure applied after crop harvest. Ammonium-nitrogen can volatilize to the air as ammonia gas if the manure is surface-applied, but when incorporated into warm, well aerated soil it's converted to nitrate quickly; the process is slower in cool, wet soils. Organic nitrogen must be mineralized to ammonium and then converted to nitrate, so this process generally proceeds slowly. The rate of all nutrient conversion processes depends on the temperature, so manure applied in the summer is much more likely to be converted to nitrate than manure applied in the late fall.

During the growing season usually crops are removing more water than is being added as precipitation, so normally there is no leaching or downward movement of nitrates. During the fall or after crop harvest, there are no growing plants to use any remaining nitrates and the amount of precipitation can be greater than evaporation, so water can move down through the soil profile, increasing the risk of nitrate leaching.

The rate of water movement down through the soil depends on the soil porosity. Gravel and sand soils are more porous than silt and clay soils. Shallow soils over bedrock provide less protection for groundwater, because contaminants aren't being filtered once they reach the fractures in bedrock.

To reduce nutrient losses by wind and water erosion:

- Leave some of last year's crop residue on the soil surface and reduce tillage. This increases water infiltration and reduces nutrient losses due to erosion.
- Include perennial forages in the rotation to increase infiltration, reduce the impact of wind and water on the soil, reduce nutrient losses, and take advantage of deep-rooted crops to harvest nutrients from deep in the soil profile.
- Establish grassed waterways in erosion-prone areas to slow water movement from the field and trap soil particles.
- Plant trees for windbreaks, reduce field widths or use strip cropping to reduce the distance wind travels in crossing unprotected fields.
- Build a runoff control basin or an embankment across a depression to slow water movement, trap sediments and reduce gully erosion. Slower water movement encourages organic matter, sediments and nutrients in the water to settle out or be trapped by surface residue.

Generally, surface-applied manure is susceptible to movement of nutrients in surface runoff.

To reduce nutrient losses from surface-applied manure by surface runoff:

- Apply manure as close as possible to the time of the crop's need, when crops are actively growing, in the spring for spring-seeded annual crops, and before seeding fall cereals.
- Inject or incorporate the manure as soon as possible.
- Do not apply manure if heavy rain is predicted within 24 hours after manure application.
- When a high amount of nitrogen is required by a crop, split the total amount required into two-thirds manure and one-third mineral fertilizer. Apply mineral fertilizer later in the season.
- Leave a buffer zone around lakes, streams and wells that meets or exceeds AOPA's setback requirements. Do not apply manure or commercial fertilizer to the buffer.
- Do not apply manure to frozen or snow-covered ground.

6.1.2.1 Nitrogen

Generally, the environmental risks associated with inorganic nitrogen are losses to water sources through leaching and surface water runoff or losses to air through denitrification and volatilization.

To reduce ammonium (NH_4^+) nitrogen losses into the air through volatilization:

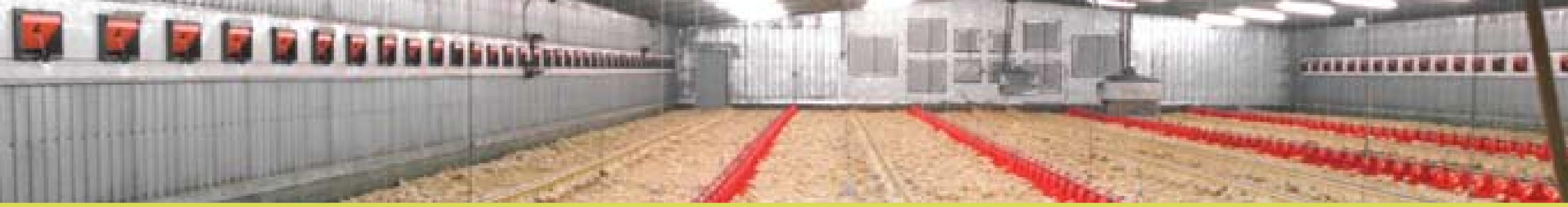
- Apply manure on humid and/or cold, non-windy days.
- Inject the manure or incorporate manure as soon as possible.

To reduce nitrate (NO_3^-) nitrogen losses to the air through denitrification:

- Avoid manure application in low, wet areas, where water can pool.
- Apply manure just before seeding, so nutrients can be used while plants are actively growing.

To reduce nitrogen losses to groundwater by leaching:

- Apply manure at agronomic rates; if nitrogen builds up in the soil profile it is at risk of being lost through leaching.
- Incorporate manure to increase the contact between the soil and the manure to tie up nutrients.
- Manage irrigation water application rates to minimize the risk of nitrogen leaching.



- Avoid spreading manure in low, wet areas or field areas prone to puddling.
- Apply manure just prior to seeding, so nutrients are used while plants are actively growing; unused nitrogen is at risk of being lost through leaching.
- Grow cover crops to capture available nitrogen and other nutrients and reduce water leaching.

6.1.2.2 Phosphorus

Generally, the environmental risks associated with phosphorus are losses to surface water sources through soil erosion or movement of dissolved phosphorus with surface runoff.

To reduce phosphorus losses:

- Inject or incorporate fertilizers and manure to avoid losses by runoff in areas that are adjacent to water bodies and/or have high runoff potential.
- Apply phosphorus based on the crop's P requirements and soil P levels. Contact a crop adviser or soil laboratory for recommended P levels for each crop.
- Test soil phosphorus annually to avoid over-applying fertilizers and manure. Over-application of manure will raise soil phosphorus levels above the recommended agronomic levels, increasing the risk of P loss from soils.
- Test soils in different landscape locations (e.g. hill tops, low spots) to determine if excess levels exist in low areas where runoff collects.
- Alter cropping, nutrient or soil management practices to reduce nutrient application, increase nutrient uptake and removal, or reduce the amount of runoff that is occurring.
- Take measures to prevent soil erosion by wind and water (see erosion control options listed above).
- Design a nutrient management plan based on phosphorus for areas that are particularly vulnerable to phosphorus runoff or leaching (e.g. flood plains, steeply sloped land, land with high water tables or shallow aquifers).

6.1.2.3 Potassium

Generally, potassium is not lost from the soil or production system. The risks associated with potassium are due to the accumulation of this nutrient in the soil and eventually in the growing crop. Excess potassium (K) in feed has been observed to reduce the absorption of magnesium (Mg) in the rumen, which is an important site of Mg absorption, resulting in overall impairment of Mg absorption. Low magnesium absorption from consumed forages is the most obvious cause of tetany. Unlike calcium, there is very little magnesium stored in the bones. Magnesium needs to be supplied in cattle rations on a daily basis.

To reduce the risk for tetany development due to potassium accumulation:

- Soil test prior to applying manure to determine K status of the field.
- Apply manure and fertilizer at agronomic rates to minimize the risk of K-related Mg deficiencies in your livestock feeds.
- Use nutrient management planning combined with improved manure application practices aimed at reducing nitrogen loss to help prevent K build-up in the soil.
- Test all feeds to assess the risk of tetany.
- Prevent tetany through ration supplementation.

6.1.2.4 Micronutrients and Trace Elements

Manures are rich in crop-required micronutrients such as boron, chloride, iron, molybdenum and zinc. They are also a source of micronutrients required for animal health, including selenium, zinc, copper, chromium, iodine and cobalt. Manure type and management have direct effects on plant and animal micronutrient levels. For example, zinc, copper, selenium and manganese levels from swine and poultry manure are often 10 to 100 times higher than from dairy manure.

For soil fertility, this means that annual manure applications aimed at meeting the crop's P and N needs may result in higher than expected soil levels of certain micronutrients. Some international studies have shown a soil build-up of elements such as copper, zinc and arsenic in fields with a history of heavy manure application. Be aware that the use of micronutrient levels in livestock feed in excess of the animals' nutritional requirements could have a negative impact on soil quality in the long term.

The best practices for managing soil levels of micronutrients are:

- Manage sources of micronutrients in livestock feeds and treatments.
- Test manure and soil for micronutrient levels.
- Adjust your nutrient management plan and application if necessary to build up micronutrient levels where needed and avoid excess in other areas.

6.1.2.5 Salts

Manure can contain significant amounts of salt (in the form of sodium) that may affect soil quality. High levels of sodium in the soil can disperse soil aggregates, degrade soil structure and reduce water infiltration rates. Saline soils can reduce crop yields and limit cropping options. Management of soil salinity is crucial for sustainable crop production.

Soil salinity is measured by passing electricity through the soil. The more salts in a soil sample, the greater its electrical conductivity (EC). EC is usually expressed in deciSiemens per metre (dS/m). A change of more than 1 dS/m may indicate a soil quality problem. If the EC is more than 2 dS/m, plant growth and yield may be affected. If the EC is more than 4 dS/m, manure application should not be considered. Refer to AOPA for regulated soil EC limits.

To control salt accumulation issues:

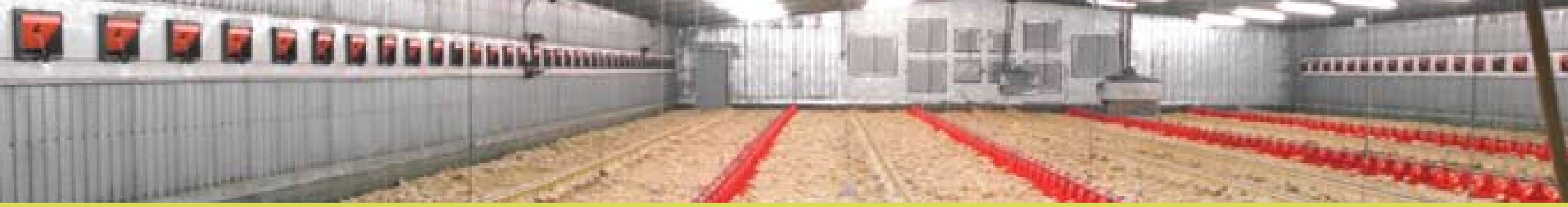
- Monitor salt levels in feed rations. (Contact a livestock nutritionist for recommended levels in feed.)
- Monitor the electrical conductivity level in soil through a soil test.
- Monitor the sodium adsorption ratio (SAR) level in soil, and do not apply manure when the SAR level is greater than 8. SAR is a measurement of sodium in relation to calcium plus magnesium. Soil SAR levels above 8 can decrease soil permeability and increase the potential for waterlogging.

6.2 NUTRIENT USE EFFICIENCY

Nutrient use efficiency refers to how well a crop uses available soil nutrients. As more nutrients are taken up and used by the crop, fewer nutrients remain in the soil to be lost or immobilized.

Techniques to improve nutrient use efficiency include:

- Providing the required amount of available forms of nutrients when the crop needs them.
- Placing nutrients where the crop roots can access them.
- Reducing the amount of nutrients



(such as nitrate) in the soil when the crop cannot use them.

- Accounting for and managing all sources of plant-available nutrients.
- Managing other cultural practices and conditions; a healthy crop will be able to utilize nutrients more efficiently than a poor crop.

6.3 FIELD ASSESSMENT

A key step in effective manure and nutrient management is to gather information on field characteristics. Five characteristics to identify during a field assessment are:

- soil physical properties, such as soil texture and structure
- slope grade and length, especially if adjacent to water bodies
- locations of water bodies, watercourses and wells
- problematic soil conditions, such as salinity, high or low soil pH, solonetzic or eroded soils
- past and current site management, such as manure and fertilizer application history, tillage and seeding practices, crop rotation, or presence of irrigation

During the field assessment, document any features that might affect crop productivity or the ability to apply nutrients or crop protection products, and any features that affect the environmental risk associated with producing a crop on that field. Identifying field features (e.g. springs, drainage areas) is particularly important if manure applicators are unfamiliar with the site. Awareness of these features provides the applicator with an understanding of the risks and liabilities associated with the field.

6.4 SOIL SAMPLING AND TESTING

An accurate soil test, with proper soil sampling and interpretation of soil test results, is an excellent nutrient management tool. Soil variability is a major concern when trying to obtain a representative soil sample. The strategy used to sample a field can address this challenge. Information collected during a site assessment can assist in choosing an appropriate strategy for a particular field.

Soil test results provide an inventory of plant-available nutrients and other soil chemical factors important for crop production. This information gives a basis for recommending applications of additional nutrients so you can tailor your nutrient applications to the crop's needs, avoid over-application of nutrients, reduce impacts on water, soil and air quality, save money and conserve energy.

Soil testing laboratories can develop fertilizer recommendations from a 0 to 15-cm depth sample, but these recommendations make assumptions about nutrient content in deeper layers. More reliable fertility recommendations and better nutrient management decisions can be made when nutrient levels are measured at these lower depths rather than estimated (e.g. for nitrogen and sulphur). Always use the same laboratory for soil analysis to ensure that analysis procedures are the same and results between years are comparable.

Soil tests should also be used to identify any excess nutrients or salts. If excess nutrients are found, manure application rates should be adjusted so that excess nutrients are utilized and commercial fertilizer is used to supplement other nutrient requirements.

FOR DETAILED INFORMATION on soil and manure sampling, see the Nutrient Management Planning Guide available from www.agriculture.alberta.ca or the ARD Agdex factsheets on Sampling Liquid, Solid and Poultry Manure. For more specific information regarding soil sampling and AOPA, see The AOPA Reference Guide or go to www.agriculture.alberta.ca/aopa.

GENERAL SOIL SAMPLING GUIDELINES

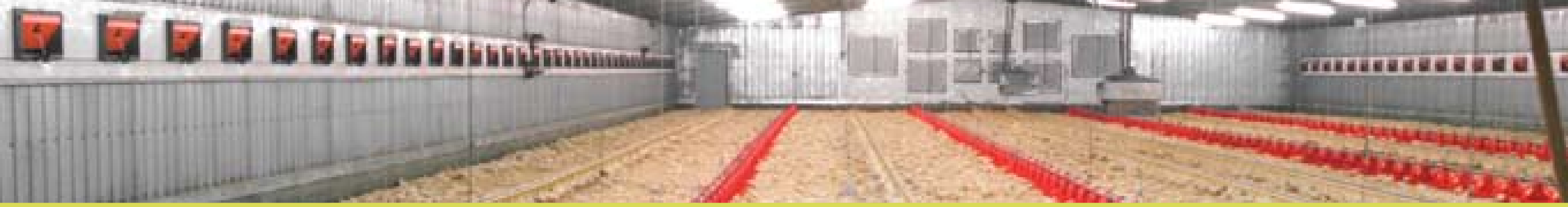
For any soil sampling strategy:

- Before sampling, consult the soil testing laboratory on lab-specific requirements for sample size, packaging and shipping, analytical options and costs. Some labs provide containers, labels and submission forms for soil samples.
- A soil sampling probe is best for taking samples. Augers can also be used but they can make it difficult to accurately separate depth intervals.
- Collect a representative sample, based on in-field variations in topography (slope), soil type, cropping management and cropping history.
- Take 15 to 20 cores for each representative bulk sample.
- Segment each core into lengths that represent depths of 0 to15 cm, 15 to 30 cm, and 30 to 60 cm.
- Separate the segmented cores by depth into clean, labelled plastic pails. Thoroughly mix the content of each pail, crushing any large lumps in the process. Avoid using metal pails to collect samples because they can alter the results of micronutrient tests.
- Take a single sub-sample (0.5 kg) for each sampling depth and submit for analysis.
- For hilly fields with knolls, slopes, or depressions, take samples from mid-slope positions to get a representative sample of the field average.
- Avoid sampling obvious areas of unusual variability such as: saline areas, eroded knolls, old manure piles, burn piles, haystacks, corrals, fence rows, old farmsteads, or any other unusual areas.
- For soils within 15 m of field borders or shelterbelts and within 50 m of built-up roads, either sample separately or avoid sampling.
- Always sample before manure or fertilizer applications.

6.5 PUT YOUR MANURE TO THE TEST

To determine an appropriate manure application rate to meet crop nutrient requirements, it is critical for you to know the manure's nutrient content. The nutrient content can be determined from book values or lab analysis. Although the best source of information is from sampling the manure from your operation, book values of nutrient content are better than not considering the nutrients in the manure at all when calculating manure application rates.

Manure nutrient composition varies widely between farms due to a host of factors such as: differences in animal species, bedding and feeding practices, and type of manure (solid or liquid). Book values may not reflect



the true nutrient composition of manure from individual farms. The only way to get reliable, farm-specific estimates of manure nutrient content is through manure sampling and analysis.

If manure is sampled annually for a 3-to-5 year period, a reliable estimate of average manure nutrient content for an operation can be established. Once historical averages have been developed, there is less need for annual sampling. However, if any component of the animal management, manure storage or handling system substantially changes, new historical averages will need to be developed.

Managers should sample manure and have it analyzed for nitrogen, phosphorus, potassium and total solids. Proper manure sampling is key to achieving a representative average of nutrient composition of the manure to be applied. For more information on sampling and analysis procedures, see the Nutrient Management Planning Guide.

To determine an appropriate manure application rate, know the manure's nutrient content.

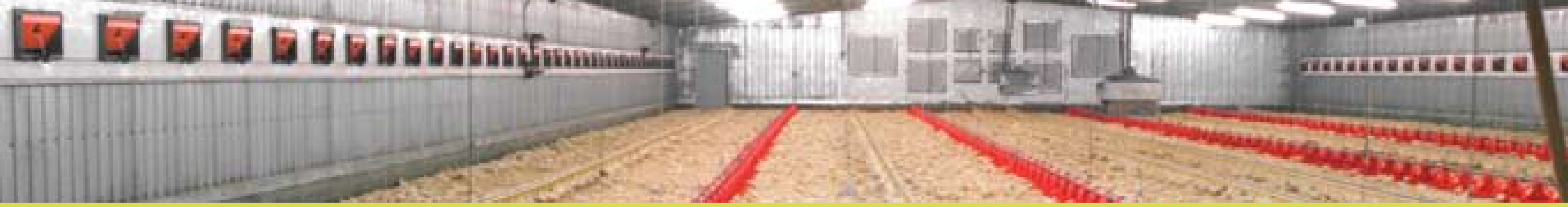
Table 6.2 Differences Between Sampling Manure Before or During Application

Parameter	Sampling Strategy	
	Sampling Before Application	Sampling During Application
Timeliness of Test Results	Manure test results can be used to calculate this year's application rates.	Cannot use analysis of samples collected during spreading to calculate this year's application rate.
Accuracy of Analysis	Manure tests may not be accurate or representative because manure is not thoroughly mixed.	Manure tests will be more reliable because sub-samples can be collected as the manure is being applied, getting a more representative sample.
Difficulty in Collection	Large equipment or agitation may be required to get a representative sample from manure storage.	Minimal time required to sample during application.
Safety	Sampling from storage facilities, especially lagoons or tanks, can be dangerous due to the risk of falling in or being overcome by gases.	Sampling from application equipment reduces the risk of falling in or being overcome by gases.

6.5.1 Recommended Practices for Sampling Manure

- Before sampling, consult the manure-testing laboratory on lab-specific requirements for sample size, packaging and shipping, turn-around times, analytical options, and costs. Some labs provide containers, labels and submission forms for samples.
- Recommended analyses for all manure samples:
  - moisture content or dry matter content
  - total nitrogen (total Kjeldahl nitrogen (TKN))
  - ammonium nitrogen (NH_4–N) (total nitrate nitrogen (NO_3–N) for compost samples)
  - total phosphorus (P)
  - total potassium (K)
- Proper sampling equipment:
  - 5-gallon plastic pail or large plastic garbage can
  - for liquid manure sampling: small collection can, pole and cup device or small bucket
  - for solid manure sampling: wheelbarrow, shovel, pitchfork, tarps and piece of plywood
  - clean, plastic bottle with a screw-on lid and several large plastic freezer bags
- Sample liquid manure during application:
  - Avoid sampling at the beginning and end of pumping, as these samples are less reflective of the manure's average characteristics than those taken midway through the pumping process.
  - Collect one sample for approximately every 1 million litres pumped.
- Sample solid manure during loading:
  - Avoid sampling from areas where moisture and bedding are considerably different from most of the pile.
- Sampling poultry litter from the production house:
  - The consistency, make-up and nutrient content of dry litter varies across the width of the production house, i.e. material from under the feeders and waterers will be different from the material along the walls. These differences must be considered when attempting to collect a representative manure sample from the litter pack in the production house.
  - There are two suggested methods for in-barn sampling of poultry litter, referred to as the 'point' method where the entire house is sampled in a zigzag pattern or the 'trench' sampling method where a trench is dug across the width of the production house.

TIP: Use only plastic buckets and bottles for manure samples. Do not use galvanized steel buckets because they can affect the results of the lab analysis for micronutrients. Do not use glass containers for sampling or shipping sub-samples due to the risk of breakage and personal injury.



IMPORTANCE OF AGITATING LIQUID MANURE

During storage, liquid manure tends to settle into different layers, each with a distinct nutrient profile. By agitating liquid manure, solids are disrupted and re-suspended, which facilitates storage emptying and improves the consistency (i.e. nutrient distribution) of the manure applied. Liquid manure can be agitated using various types of high volume pumps or propeller-type agitators. If the storage facility is large, it may be necessary to place agitators at several locations to get adequate mixing.

NOTE: Potentially lethal gases such as hydrogen sulphide (H_2S) are released when liquid manure is disturbed. Take special care to ensure adequate ventilation when there are people or animals present, and never enter a confined space where manure is present without a respirator.

Optional manure analysis could include: electrical conductivity (EC), pH, total carbon or carbon:nitrogen (C:N) ratio, chloride (Cl), sulphur (S), sodium (Na), calcium (Ca), magnesium (Mg) and micronutrients such as copper (Cu), manganese (Mn), zinc (Zn) and iron (Fe). It is usually not necessary to analyze manure for mineral constituents such as Ca, Mg, Zn and boron (B). Most manure contains significant quantities of these minerals and fields with a history of manure application are rarely deficient.

6.5.2 Interpreting Manure Test Results

Manure test results provide nutrient levels in the manure but will not provide recommended rates of manure application. Laboratories will report manure nutrient concentrations on an as-is basis in kg/tonne, lb/ton, kg/m^3, kg/1000 litres (L), lb/1000 gallons, percentages or parts per million (ppm). Manure nutrient results should be reported and used on a wet or "as is" basis because manure is spread wet.

For these measures to be useful in nutrient management planning, they must be converted into a format that the producer uses and the availability of each nutrient must be considered. The nutrients in manure exist in two forms, organic and inorganic. The inorganic forms are 100% available for crop use and in the case of nitrogen are at risk of being lost during application. The organic form must be converted by soil micro-organisms during the growing season to a form that crops can use, so only a portion of the organic form is available for crop use in a season. The manure application rate should be based on the estimated available nutrient content.

The higher the ammonium content of the manure, the higher crop-available nitrogen in the manure, and the greater the risk and cost of ammonium nitrogen losses during application. Manure types such as liquid dairy, liquid swine or poultry manure have high concentrations of ammonium. As a result these manure types have a higher percentage of the nitrogen available in the year of application and the highest risk of nitrogen loss.

Crop-available Nitrogen

The term 'crop-available N' refers to the amount of manure N that is available for crop use. This value will include the amount of the organic N that comes available during the growing season plus the amount of available inorganic N in the manure less the amount of inorganic N lost during application.

Most labs provide measures of total N and ammonium-N (NH_4–N) (and for compost nitrate-N (NO_3^-)). The difference of these two parameters provides an estimate of organic N in the manure:

Organic N = Total N–NH_4–N

Ammonium-N is at risk of being lost during manure application. The amount of loss depends on the application method and moisture and temperature conditions during application. Ammonium-N losses can be estimated using Table 6.3.

Although mineralization of organic N is controlled by soil moisture and temperature conditions, it is safe to assume for solid manure that 25%, for liquid manure that 40% and for poultry litter that 30% of the organic N will be mineralized into crop-available forms in the year following application:

Available organic N (year of application) = Organic N × 0.25 (solid) or 0.40 (liquid) or 0.30 (poultry litter)

Additional organic N will be mineralized in subsequent years and can be estimated when planning future manure applications using the following equations:

Available organic N (year 2) = Organic N × 0.12 (solid) {or 0.20 for liquid}{or 0.15 for poultry litter}
Available organic N (year 3) = Organic N × 0.06 (solid) {or 0.10 for liquid}{or 0.07 for poultry litter}

Crop-available Phosphorus
Most labs only report the amount of total P in a sample. To convert the amount of reported total P into the commercial fertilizer equivalent of P_2O_5, multiply total P by 2.29. Approximately 70% of total P in manure will be crop-available in the year it is applied. At least 90% of the total P will become available over time:

Estimated crop-available P (year 1) = Total P × 0.7
Estimated crop-available P (year 2) = Total P × 0.2
Estimated crop-available P (year 3) = Total P × 0.06

Crop-available Potassium
Most labs report the amount of total K in the manure sample. To convert the amount of reported total K into the commercial fertilizer equivalent of K_2O, multiply total K by 1.2.

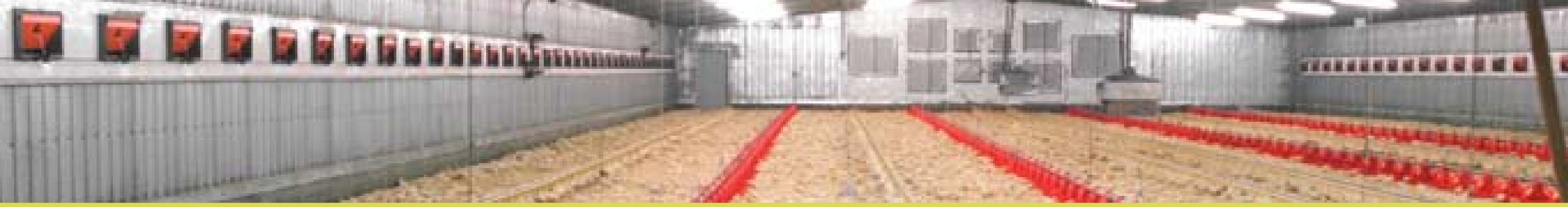
Unlike other nutrients, manure potassium (K) exists exclusively in the crop-available inorganic K^+ form. Approximately 90% of manure K is effectively crop-available:

Estimated crop-available K = Total K × 0.9

Table 6.3 Expected Ammonium Nitrogen Loss in Relation to Application Method, Timing and Weather Conditions

Application and Incorporation Strategy	Weather Conditions During Application				
	Average	Cool-moist	Cool-dry	Warm-moist	Warm-dry
Surface-applied, incorporated within 1 day[1]	25%	10%	15%	25%	50%
Surface-applied, incorporated within 2 days	30%	13%	19%	31%	57%
Surface-applied, incorporated within 3 days	35%	15%	22%	38%	65%
Surface-applied, incorporated within 4 days	40%	17%	26%	44%	72%
Surface-applied, incorporated within 5 days	45%	20%	30%	50%	80%
Not incorporated	66%	40%	50%	75%	100%
Injected	0%	0%	0%	0%	0%
Cover crop[2]	35%	25%	25%	40%	50%

1 These percentages would also apply to liquid manure broadcast (without incorporation) on bare soils.
2 These percentages would also apply to liquid manure broadcast (without incorporation) on land with residue, such as direct-seeded fields or forages.
Adapted from ARD 2004.



6.6 MANURE INVENTORY – DETERMINE MANURE PRODUCTION INFORMATION

The weight or volume of available manure should be determined prior to land application. Getting an accurate estimate of manure volume or weight is important:

- to estimate the required land base for manure utilization so nutrients are used efficiently and do not accumulate in the soil.
- to determine if you are subject to additional requirements under AOPA (e.g. if more than 500 tonnes of manure is handled).
- to estimate the time required to apply manure.

Weighing manure is the most accurate method for determining the quantity of manure applied. However, physically weighing manure may not be practical or safe, in which case the manure inventory must be estimated.

There are three options for estimating manure inventory:

1. Calculating the total volume of manure produced using book values for average manure production for each type of livestock.
   - Book values may not reflect the actual volume or weight of manure produced on a specific operation because of factors such as precipitation, feeding and bedding practices, and water conservation practices.
2. Using historical manure application records or capacity indicators in storage facilities.
   - Operations may have records documenting the volume of manure applied in the past (e.g. number of loads hauled). As long as the operation has not changed the number, management, or type of livestock, this estimate can be reliable enough for nutrient management planning. In addition, existing manure storage facilities may be equipped with capacity markers that provide easy estimates of the volume present.
3. Calculating an estimate of the pile weight or volume contained in a storage facility.
   - The weight or volume of manure in a storage facility can be estimated using direct measurements and calculations. This method can be used in the absence of historical manure application records, and is more operation-specific than using book values.

FOR MORE DETAILED INFORMATION ON MANURE INVENTORY, refer to the Nutrient Management Planning Guide available from www.agriculture.alberta.ca

Table 6.4 Average Volumes and Weights of Solid Manure Production Expected from Typical Livestock Housing Systems in Alberta

Species		Daily			Yearly		
		lb	kg	cu ft	tons	tonnes	cu ft
Beef	Feeders	8.4	3.8	0.21	1.53	1.39	75
	Finishers – Open Lot	13.1	5.9	0.32	2.38	2.16	117
	Finishers – Paved Lot	19.8	9.0	0.43	3.61	3.28	156
	Feeder Calves <550 lb	3.3	1.5	0.08	0.59	0.54	29
	Cow w/Calf	17.8	8.1	0.44	3.25	2.95	159
	Cows/Bulls	16.5	7.5	0.40	3.02	2.73	147
Dairy	Tie Stall	139.7	63.5	2.66	25.5	23.12	970
	Loose Housing	146.3	66.5	2.78	26.71	24.21	1016
	Replacements	42.9	19.5	0.82	7.83	7.10	298
	Calves	2.9	1.3	0.07	0.54	0.49	26
Swine	Farrow to Finish	86.4	39.3	1.74	15.76	14.29	637
	Farrow to Wean	26.6	12.1	0.54	4.85	4.40	196
	Farrowing	21.3	9.7	0.43	3.88	3.52	157
	Weaner	2.8	1.3	0.06	0.50	0.46	20
	Feeder	8.2	3.7	0.17	1.50	1.36	61
Poultry (per 100)	Layers – Belt Cage	9.9	4.5	0.41	1.81	1.64	149
	Layers – Deep Pit	13.0	5.9	0.31	2.37	2.15	112
	Broilers	6.0	2.7	0.30	1.09	0.99	108
	Broiler Breeders	15.8	7.2	0.59	2.89	2.62	217
	Layer Breeders	11.7	5.3	0.53	2.13	1.93	192
	Pullets	6.0	2.7	0.15	1.09	0.99	56
	Turkey Hens (Light)	13.6	6.2	0.85	2.49	2.26	309
	Turkey Toms (Heavy)	19.8	9.0	1.28	3.61	3.28	468
	Turkey Broilers	11.0	5.0	0.51	0.01	1.82	186
Horses	PMU	45.8	20.8	0.92	8.35	7.57	337
	Feedlot	15.2	6.9	0.46	2.77	2.51	169
	Donkeys	7.6	3.5	0.23	1.39	1.26	84
	Mules	11.4	5.2	0.35	2.08	1.89	127
Fur Farms	Mink (per 100)	30.8	14.0	0.71	5.62	5.10	260
	Fox (per 100)	77.0	35.0	1.24	14.05	12.74	454
	Rabbits (per 100)	100.1	45.5	2.49	18.27	16.56	908
Cervid	Elk	5.8	2.6	0.14	1.06	0.96	52
	Deer	2.9	1.3	0.07	0.52	0.47	25

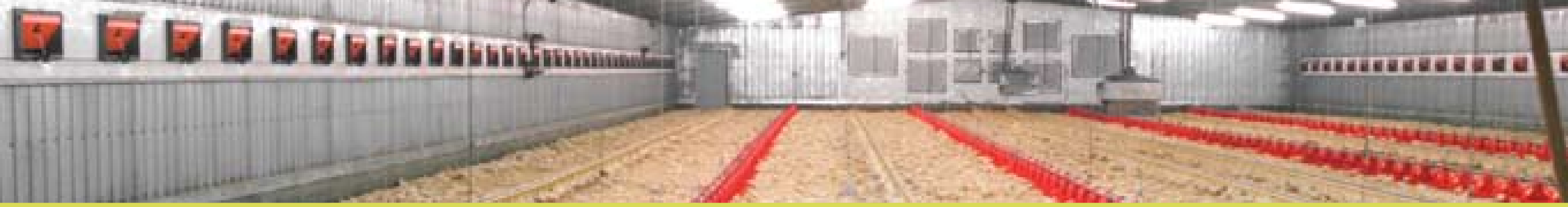


Table 6.4 Average Volumes and Weights of Solid Manure Production Expected from Typical Livestock Housing Systems in Alberta (continued from page 62)

Species		Daily			Yearly		
		lb	kg	cu ft	tons	tonnes	cu ft
Sheep	Bison	7.3	3.3	0.18	1.32	1.20	65
	Alpacas/Llamas	4.6	2.1	0.15	0.84	0.76	55
	Ewes w/Lambs	3.9	1.8	0.13	0.71	0.64	46
	Ewes/Rams	3.1	1.4	0.10	0.57	0.51	37
	Feeders	1.5	0.7	0.05	0.28	0.25	18
	Lambs	0.8	0.4	0.02	0.14	0.13	9
Goats	Meat/Milk (per Ewe)	5.9	2.7	0.19	1.08	0.98	70
	Feeders	0.6	0.3	0.02	0.10	0.09	6
	Nannies/Billies	3.1	1.4	0.10	0.56	0.51	36
Ratite	Emus	1.3	0.6	0.08	0.24	0.22	29
	Ostriches	2.4	1.1	0.15	0.44	0.40	53

Table 6.5 Average Volumes and Weights of Liquid Manure Production Expected from Typical Livestock Housing Systems in Alberta

Species		Daily			Yearly		
		gallons	litres	cu ft	gallons	cu M (tonnes)	cu ft
Dairy (* count lactating cows only)	Free Stall: Lactating Cows Only[1]	21.7	98.6	3.50	7934	36.0	1274
	Free Stall: Dry Cows	9.5	43.0	1.50	3454	15.7	554
	Free Stall: Lactating with Dry Cows Only*[2]	25.7	116.8	4.11	9381	42.6	1500
Swine (* count sows only)	Farrow to Finish *	14.4	65.7	2.31	5272	24.0	844
	Farrow to Wean *	4.4	20.2	0.71	1622	7.4	260
	Farrow Only *	3.5	15.9	0.56	1278	5.8	204
	Feeders / Boars	1.6	7.1	0.25	568	2.6	91
	Growers / Roasters	0.9	4.2	0.15	333	1.5	53
	Weaners	0.5	2.3	0.08	183	0.8	29
Poultry (per 100)	Chicken: Layers	6.0	27.1	0.95	2174	10.0	348

1 Includes milking parlour washwater of 30 L per lactating cow
2 Includes milking parlour washwater of 30 L per lactating cow (zero milking parlour washwater for dries)
Note: Dairy associated livestock is usually assumed to be solid manure production

6.7 CROP NUTRIENT REQUIREMENTS

The target yield for a given crop is an important factor in determining the amount of nutrients to be applied through manure and fertilizer. Nutrient requirements vary from one crop to another; therefore, under the same conditions, recommended application rates will be different depending on the crop. To estimate a target yield, average the yields of the previous four harvests for a given field and add 5 to 10% as an expected improvement factor.

Accurate manure application rates are based on manure and soil analyses, as well as past cropping history, past manure applications and current crop fertility requirements.

Chapter 7. MANURE APPLICATION

This chapter explores:

- manure application technologies
- calibration and maintenance of application equipment
- bio-security and equipment cleaning
- timing of manure application
- soil compaction related to manure application
- odour control during application
- manure application tips
- manure application safety
- calculating manure application rates
- record keeping

7.1 LAND APPLICATION

Deciding where, how and when to apply manure involves many considerations to ensure a practical, cost-effective system that minimizes environmental risks, meets regulatory requirements, and suits the specific needs of your operation.

7.1.1 Manure Application Technology

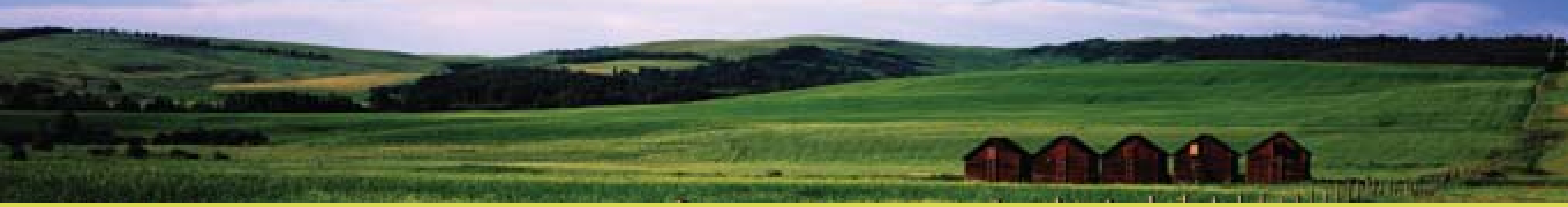
Choosing a method of manure application depends on the physical characteristics of manure (liquid or solid), type of operation, manure handling and storage, type of spreader and cost. The application system you choose will have implications for nutrient management and environmental risk, in particular nutrient placement and nutrient retention. All manure application technologies should meet the criteria of practicality, durability, desirable distribution pattern and minimal environmental impact.

Solid Manure

Most solid manure (20% or more solids) or compost is spread using broadcasting equipment, followed by tillage to incorporate the material into the soil. Delayed incorporation can result in increased odour, risk of nutrient loss in runoff and volatilization losses of ammonia-nitrogen, especially for non-composted manure.

Truck-mounted box spreaders improve travel times from storage to field compared to tractor pulled spreaders, which affects the length of time required to apply stockpiled manure. Soil compaction can be a problem, but is usually reduced by using dual or flotation tires, or by simply delaying application until field conditions are dry (for more information on compaction see page 70).

FOR MORE DETAILED INFORMATION regarding the regulated requirements for manure application and setbacks, contact Alberta Agriculture and Rural Development (ARD) Confined Feeding Operation (CFO) Extension Specialists or Natural Resources Conservation Board (NRCB) staff or go to www.agriculture.alberta.ca/aopa.



Liquid Manure
Liquid manure (less than 20% solids) can be surface-applied or directly injected into the soil. Liquid manure is typically stored under anaerobic conditions, which alters the decomposition processes, resulting in the production of more odour than solid manure. Delayed incorporation can result in increased odour, risk of nutrient loss in runoff and volatilization losses of manure ammonia-nitrogen.

Odour and related nuisance concerns have driven improvements in liquid manure application technology. Injection systems, drag-hose equipment, and other methods that limit the exposure of manure to the air have partially mitigated the odour problems. At the same time, these application methods reduce nitrogen loss, and therefore, preserve the fertilizer value of manure.

There are several things to consider when deciding on the type of application system that best suits your situation. The following describes some of the typical liquid manure application systems and considerations for each:

Injection systems: Manure injection uses ground openers, such as discs, cultivator shovels, or narrow knives, to open the soil creating a furrow. Typically, the openers are mounted on a tool bar, and a manifold directs the manure into the furrow created by the opener. Some machines then close the furrow using a packing wheel.

Injection is an effective method of manure application provided the manure is applied at proper rates and meets the following guidelines:

- Manure does not pool on the soil surface.
- Soil covers all the manure, and trenches are closed after application.

Proper injection provides excellent odour control, low runoff potential and low nutrient loss through volatilization. The majority of ammonia-N lost from manure application occurs in the first 24 hours after application. Injection is a one-pass application, which reduces the number of passes over the field compared to broadcast application plus incorporation.

The injection application requires more horsepower, fuel and time than the broadcast application, not including any additional incorporation passes. The amount of soil disturbance created by injection implements depends on the type of opener and the speed of application.

Injection Systems

Dragline systems: Dragline or direct-flow systems pump manure from the manure storage through an umbilical line directly to a manure application toolbar. The tractor drags the umbilical hose across the field as the attached toolbar either broadcasts or injects the manure. Equipment purchase costs are higher for this system than for spreader systems, primarily because of the cost of transfer pipe, but dragline systems typically reduce the time for manure application by at least 50% by eliminating the time spent loading and transporting manure to the field. The elimination of the application tank removes the majority of the weight of the application equipment, reducing soil compaction issues related to liquid manure application and reducing the fuel requirements for application.

The most significant risk to dragline systems is the potential for a spill to occur. If a break occurs in the umbilical line, a large amount of manure can be spilled from the system unless the pump is shut off. So in addition to operating the applicator in the field, dragline systems require staff to monitor or automatic shut-offs for the pump unit at the lagoon in case the umbilical line breaks.

Dragline Systems

Aerway and Broadcast systems: Manure is placed on top of the soil, crop and crop residue. Examples of broadcasting equipment include dribble bar, trail-hose, trail-hose with sleighshoe or Aerway™ attachments or splash plate.

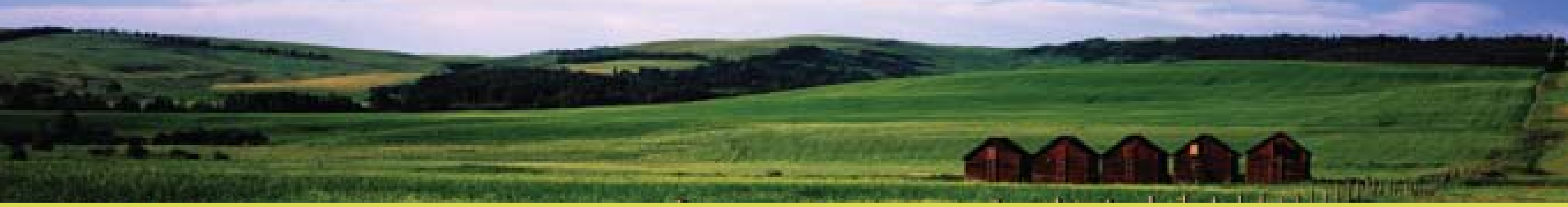
Broadcast application is often seen as the cheapest method of application since it is fast, but without any incorporation, it can result in significant amounts of odour and ammonia-N loss from liquid manure application. The greater the time-lag between application and incorporation, the greater the amount of ammonia-N loss.

The higher the arc of the broadcast application (i.e. irrigation or high-angle splash plate application), the greater the odour produced and ammonia-N lost. The loss of ammonia-N translates to a direct loss of value from the manure application, either in the form of reduced crop production potential or the requirement for purchasing nitrogen to replace the N that was lost. Technology such as trail-hose or low-angle manure application significantly reduces the contact between the air and the manure, thereby reducing the amount of odour and ammonia-N lost during application.

Broadcast Systems

Low-angle manure application reduces the arc of application, directing the liquid manure toward the soil surface. In a trail-hose application system, liquid manure is discharged through tubes, which run along the ground, directly onto the soil surface. This application method is also referred to as sub-canopy manure application. It increases the amount of manure applied directly to the soil and reduces the amount applied to stubble or cover crops, which reduces issues associated with refusal of grazing and more importantly reduces ammonia-N losses. A sleighshoe attachment works with the trail-hose system to move aside trash cover or forage crops so that manure is deposited directly on the soil, reducing the amount of odour and ammonia-N lost during application. The Aerway™ system creates slots in the soil surface, directly in front of the trail-hoses, assisting with manure infiltration.

An issue with trail-hose technology is the risk of hoses plugging during application. The frequency of plugging depends on the solid content of the material; lower solid



content means lower risk of plugging. For this reason, it is a good idea to include choppers and agitation in the distribution system. The manure can go through a chopper as it is pumped into the tank as well as when it is being pumped from the tank into the trail-hose system. In addition, the tank can have agitation inside to help keep solids in suspension.

Five important criteria can be used to compare performance of manure application equipment:

- manure placement
- nitrogen conservation
- odour nuisance
- soil compaction
- timeliness of manure application

The performance of selected application systems in relation to these characteristics is summarized in Table 7.1.

Table 7.1 Performance[1] of Selected Application Systems for Key Manure Application Considerations

Application system	Uniformity of Application	Ammonium – N Conservation	Odour Control	Soil Compaction	Timeliness of Application
Solid Spreading Systems					
Box Spreader, Tractor-pulled	F	VP	F	F	P
Box Spreader, Truck-mounted	F	VP	F	F	F
Liquid Spreading Systems					
Liquid Tank Spreader with Splash Plates	P	P	P	P	F
Liquid Tank Spreader with Drop Hoses	F	F	G	P	F
Liquid Tank Spreader with Knife Injectors	G	E	E	P	F
Liquid Tank Spreader with Shallow Incorporation	G	E	E	P	F
Drag-hose System with Shallow Incorporation	G	E	E	G	G

1 VP = Very Poor, P = Poor, F= Fair, G = Good, E = Excellent
From Koelsch, R. and Humenik, F. Not dated.

7.2 CALIBRATION AND MAINTENANCE OF MANURE APPLICATION EQUIPMENT

To be able to apply manure at desired rates, you need to know the performance capabilities of your application equipment. Equipment calibration should address the rate and uniformity of application. The two main reasons for calibrating manure spreaders are:

- to provide information on the actual rate applied, and therefore, the exact amount of nutrients applied.
- to allow for an accurate rate of application. In this case, speed and delivery rate need to be determined.

There are two calibration techniques:

1. The load-area method involves estimating the weight or volume of manure in a loaded spreader and then determining the area required to spread an entire load (or several loads).
2. The weight-area method involves weighing the manure spread over a known area to calculate the rate at which the manure was applied.

Select your calibration technique based on your application equipment and the type of manure. For injected liquid manure, use the load-area method since injected manure cannot be collected. For surface applications of liquid, solid, or compost manure, use the weight-area method.

Steps for the weight-area method are:

Step 1. Set a series of straight-walled pails or jars (for liquid manure) or several plastic sheets (for solid manure)
in the application path of the spreader.

Step 2. Apply manure over the sheets or pails.

Step 3. Collect the sheets and weigh them or measure the depth of the liquid in the pails and jars, and note the average.

Step 4. Use Table 7.2 to determine application rates.

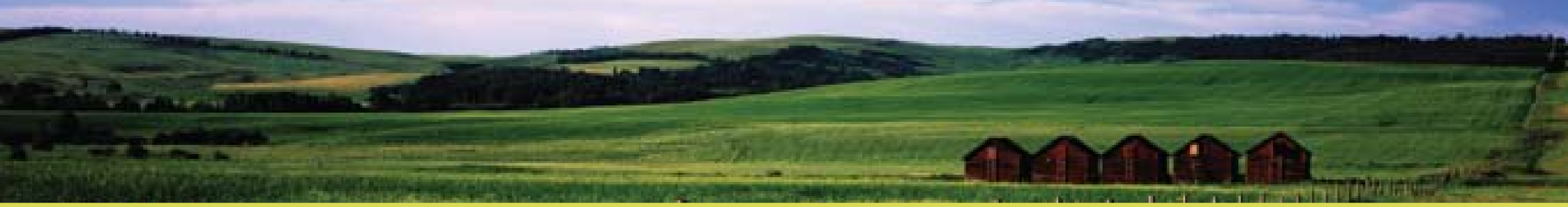
Table 7.2 Calibrating Manure Spreaders

Solid Manure Calibrations Using a 40-in X 48-in Sheet (opened feedbag)				**Liquid Manure** Calibrations Using a Straight-Walled Pail/Jar			
Manure Per Sheet		Application Rate		Depth of Manure in Pail		Application Rate	
lb	kg	tons/acre	t/ha	inches	cm	gallons/acre	L/ha
1	0.45	1.6	3.6	1/10	0.25	2,250	25,200
2	0.91	3.2	7.2	1/8	0.30	3,000	33,600
3	1.40	4.8	10.7	1/4	6.00	5,500	616,000
4	1.80	6.4	14.3	3/8	0.90	8,500	952,000
5	2.30	8.0	17.9	1/2	1.30	11,250	126,000
7	3.20	11.2	25.0	5/8	1.60	14,000	156,000
10	4.50	16.0	35.9	3/4	1.90	17,000	190,400
15	6.7	24.0	53.8	1	2.50	22,500	252,000

With the exception of tractors, most farm implements and equipment are used heavily, but for short periods of time. Manure application equipment is no different, and like all farm equipment, it should be ready to use and reliable when needed.

Preventive maintenance is essential to reduce the risk of down-time and serious malfunction - the kind that could cause personal injury or environmental damage. When preparing manure application equipment for storage, you want to ensure the equipment will be in good working condition next time you need it. Clean-up should be done as soon as possible (within hours) after application, since dried-up manure is difficult to clean and high salt content in the liquid manure can cause rapid rusting.

FOR MORE INFORMATION on manure application, get the Nutrient Management Planning Guide from ARD's Publications Office or download it from www.agriculture.alberta.ca.



Suggested maintenance for various pieces of manure equipment:

Pumps

- Run clean water through pump, then drain to protect from freezing.
- Cover metal with protective lubricant.
- If belt-driven, loosen the V-belt to reduce tension.

Electric motors

- Lubricate bearings.
- Cover motor to protect from dust and moisture.
- Lock control box.

Combustion engines

- Drain and replace oil when not in use.
- Remove spark plugs, place clean oil in spark plug holes, crank engine and replace plugs.
- Drain cooling system.
- Drain all fuel from engine and tank.
- Lubricate all moving parts.
- Remove battery.

Pipelines

- Flush with clean water. Empty washwater into manure or runoff storage, or collect and land apply the washwater.
- Be very careful when using an air system as compressed air can cause pipes to explode or be rapidly displaced. Proper equipment and operator training are necessary before an air system is utilized.
- Check for and repair leaks, and verify that repair worked.
- Keep valves open.
- Clean all pipe connections.
- Store portable units in a clean, dry place.

Hoses

- Flush with clean water to prevent crusting.
- Store on reels under roof.

Tankers

- Flush tanks and pumps with clean water.
- Drain tanks and hoses.
- Lubricate wheels and all moving parts.
- Never enter tanker without proper safety precautions.
- Prevent liquid manure from spilling onto roadways and take-off from storages or stop signs by using riser (chimney) to extend the loading opening.
- Ensure PTO guards always cover PTO shafts.

7.3 BIO-SECURITY AND EQUIPMENT CLEANING

Bio-security is a growing concern for producers, industry, government agencies and consumers. Maintenance and improvement of human, livestock and crop health are critical issues for producers and in most years determine bottom line financial performance. Manure applicators working on a variety of different operations need to be aware of the potential bio-security hazards their operation and practices may come in contact with.

BIO-SECURITY IS EVERYONE'S RESPONSIBILITY.

The most common bio-security concerns arise from the manure and interaction with the livestock. Manure can contain 10 billion bacteria per gram. More than

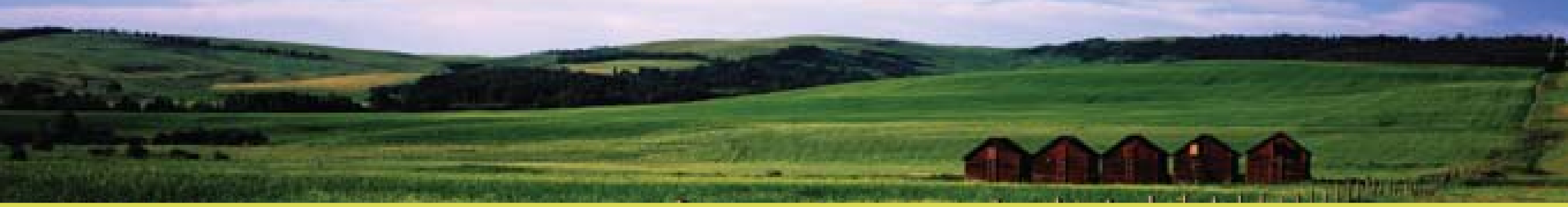
150 pathogens can cause zoonotic infections, which are infections that can move between animals and humans. Many types of bacteria, viruses and protozoans can be found in manure, such as: *Salmonella, E. coli, Brucella* spp. *Leptosipira* spp., *Listeria monocytogenes, Yersinia enterocolitics, Cryptosporidia, Giardia,* porcine reproductive and respiratory syndrome (PRRS), EMC virus, Johne's disease, bluetongue, transmissible gastroenteritis (TGE), foot and mouth disease (FMD), bovine rhinotracheitis (IBR) and influenza.

In addition to livestock and human bio-security concerns, the transfer of soil-borne pathogens via application equipment can also be a significant concern for crop health. Clubroot, caused by *Plasmodiophora brassicae,* is a serious disease of canola, mustard and other crops in the cabbage family. Resting spores are most likely to spread via contaminated soil carried from field to field by equipment. Tillage equipment represents the greatest risk of spreading the disease as soil is frequently carried on shovels and discs from field to field.

The transmission of pathogens from one operation to another can have significant economic and productive consequences. There is a real risk of disease transfer between livestock populations (barns) or between fields (e.g. clubroot) through the activities and actions of manure application. The risk of disease transfer is estimated to be low, but adopting bio-security protocols and practices can help to ensure custom manure applicators protect themselves as well as their clients from the spread of disease. Manure applicators could be targeted as the cause of an outbreak even if they were not responsible just because they were at the barn before a disease broke out.

Beneficial management practices for manure applicator bio-security include:

- Call the operation first; know what its bio-security requirements are and make sure you have the necessary supplies to follow them.
- Never go on farm without permission.
- Manure applicators should not enter a farm building for any reason.
- When moving between operations, move from the operation with the highest health standard to the lowest – during the day or week.
- Remember that small mistakes can lead to big issues.
- Pay special attention to any equipment that enters the buildings/barns.
- Change or clean boots between farms (i.e. boot exchange). Know how to clean and disinfect boots properly, using a boot brush to remove organic matter before washing in warm, soapy water. Dry boots before applying the proper disinfectant for the required amount of time. Or wear disposable boots supplied by the establishment.
- Bring a clean pair of coveralls to each facility visited or wear disposable coveralls supplied by the establishment. Wear layers instead of a winter coat, as it can be difficult to clean repeatedly.
- Wear gloves when handling manure or manure application equipment.
- Clean and disinfect all equipment and machinery between facilities – most importantly to kill pathogens but also to help maintain a professional / clean image.
- Clean your vehicle, and do not park it in manure or standing water. Clean and disinfect tires, mud flaps, wheel wells and floor mats before driving to another location.
- Tillage equipment represents the greatest risk of spreading a soil-borne disease as soil is frequently carried on shovels, discs and other openers. Almost all new soil-borne disease infestations begin near the field access, which indicates that contaminated equipment is the predominant spreading mechanism.



Be vigilant and diligent in removing potentially contaminated soil and crop debris from field equipment before leaving each field. Cleaning equipment involves knocking or scraping off soil lumps and sweeping off loose soil. After removal of soil lumps, wash equipment with a power washer, preferably with hot water or steam. Finish by misting equipment with weak disinfectant (1 to 2% active ingredient bleach solution). The use of a disinfectant without first removing soil is not recommended as soil inactivates most disinfectants.

- In situations where bio-security risk is uncertain, obtain advice from experts.
- Implement bio-security training for employees.

Table 7.3 Examples of Disinfection Agents

Agent	Details	Application Time
Vinegar	50/50 vinegar/water	30 min.
Sodium Carbonate	100 g/L water	30 min.
Citric Acid	2 g/L water	30 min.
Virkon (available at UFA & Co-op dealers)	2% solution	10 min.

7.4 TIMING OF MANURE APPLICATION

7.4.1 Seasonal Timing of Application

The goal of application is to get the manure to the desired crop when it needs the nutrients, in the right amount and with the least environmental impact. Notifying your neighbours of your intent to apply will ease their concerns.

Spring application is the most desirable for Alberta conditions because the time of high nutrient availability from manure matches the time of crop uptake. The greater the time-lag between manure application and when the crop can use the nutrients, the higher the risk of nutrient losses.

Unfortunately, timelines for application in the spring are usually tight due to inclement weather, risk of soil compaction and time required for other activities such as seeding. For this reason, it is important to carefully weigh the pros and cons of applying manure during the fall versus the spring. If fall application is chosen, it is important to ensure that those fields receiving manure are not prone to flooding or runoff, and that manure is applied before the ground is frozen.

Table 7.4 Manure Application Timing Considerations

Season	Beneficial Management Practices	Watch For:
Spring	• Apply to crops with the highest nitrogen requirement; high-yielding crops use N more efficiently. • Incorporate surface-applied manure within 24 hours. • Adopt good neighbour practices. • Side dress in row crops, i.e. dribbling. • Apply to land designated for annual crops before seeding. • Apply to row crops as side dressing after plants emerge. • Apply to well-drained soils.	• Soil compaction from tanker loads and traffic. • Runoff from excessive application rates or poor soil conservation practices. • Denitrification – loss of N gases to atmosphere on moist, poorly drained soils and cold, wet soils. • Rill erosion along strips and runoff. • Manure spills in irrigation or tractor-mounted systems. • Excessive odour and drifts. • Weather and soil conditions that promote ammonia-N loss. • Wet soils that are prone to compaction. • Excessive application, which can create a pollution hazard. • Planting too soon after heavy manure application, which can create ammonia toxicity and reduce germination and seed growth.
Summer	• Apply liquid manure to grassy pastures and hayfields – land is dry and less prone to compaction. • Apply liquid manure to forage and pastures to be reseeded/rotated. • Side dress liquid manure on row crops. • Apply liquid manure on cereal stubble. • Apply liquid manure to forage crops as soon as possible after harvest and before regrowth. • Apply to grasslands. • Apply to pasture early to avoid trampling regrowth. • Compost manure to reduce odour and break up clumps. • Do not apply to mature crops; they don't need nutrients.	• Risk of ammonia loss increases if not incorporated. • Rill erosion and runoff along injection strips. • "Smothering" of forages (mainly an issue with solid manures not spread uniformly and/or spread at high rates). • Loss of N if there is no rainfall within 72 hours of manure application. Rain helps nitrogen soak in.
Fall	• Apply solid or liquid manure prior to seeding winter cereals or cover crops. • Apply manure after corn and soybean harvest and incorporate the manure within 24 hours of application. • Apply to annual cropland that will be planted with winter cover crops.	• Risk of ammonia loss if not incorporated, no rain and temperature is $>10^{\circ}$C. • Risk of leaching if not absorbed by actively growing crop cover – avoid application on sandy soils. • Risk of denitrification on cold, wet and poorly drained soils. • Soil compaction from spreader loads and traffic can be a risk on moist or wet soils. • Apply only on well-drained soils. • Manure that soaks in too slowly on wet fields is at risk of running off with excessive water.

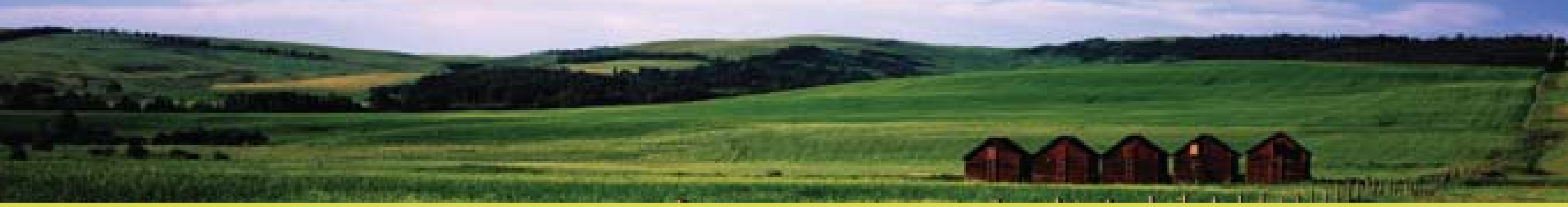


Table 7.4 Manure Application Timing Considerations (continued from page 69)

Season	Beneficial Management Practices	Watch For:
Winter	• Have enough storage capacity so that manure does not have to be spread on frozen or snow-covered ground. • In case of emergency winter application: - Contact the NRCB for permission to apply on frozen or snow-covered ground. - Apply on level field and non-sensitive areas. - Reduce application rates. - Increase setback distances from surface water. - Avoid spreading on land with history of floods or heavy runoff. - Apply to fields with heavy crop residue or seeded to perennial forages or winter cover crops where there is less possibility of runoff or flooding.	• Manure applied on frozen or snow-covered ground is at risk of being carried away by runoff and polluting surface water and impacting water quality. • Wet soils are prone to compaction.

Winter application is not a best management practice. Sometimes there are opportunities to apply and incorporate manure to unfrozen soils with no snow cover, but these conditions are rare. No crop is in place to absorb the surface-applied nutrients and there's too great a risk to surface water from snowmelt runoff.

There may be times when winter application is necessary; for example, if the storage has filled prematurely, it would to better to spread some manure in winter rather than face a spill when the storage overflows. A preferred approach is to have alternative storage pre-arranged in the event of a premature filling. If a winter application situation arises, contact your local NRCB office to discuss the situation prior to spreading.

7.4.2 Timing Application to Fit Weather Conditions

Beyond the seasonal timing of manure application, the weather conditions during the actual time of application also have implications for nutrient loss. The predominant form of crop-available nitrogen in manure is ammonium (NH_4–N), which is prone to loss through volatilization. Warm and dry conditions favour greater volatilization compared to moist, cool conditions (see Table 6.3).

The concentration of ammonium-N is significantly greater in liquid manure than in solid manure, so the concerns with ammonium-N losses are much greater and can be more costly from liquid manure application. Using a system that gets manure into the soil as soon as possible after application and applying the manure during cool, moist conditions minimize the opportunity for NH_4–N to volatilize.

7.5 SOIL COMPACTION

Hauling manure over fields can lead to soil compaction. Soil compaction takes place when soil particles are squeezed together, reducing the pore space between them, thereby reducing the space available for air and water in the soil.

Compaction can develop in any soil type. The changes in the physical condition of the soil can reduce its productive capacity and sometimes require costly and difficult measures to rectify. The decrease in pore space reduces air and water infiltration and increases the potential for surface runoff. Plant roots have difficulty penetrating the soil, restricting root growth, reducing nutrient and water uptake, and lowering yield potential. Compacted soil is also slower to warm in the spring and more difficult to till.

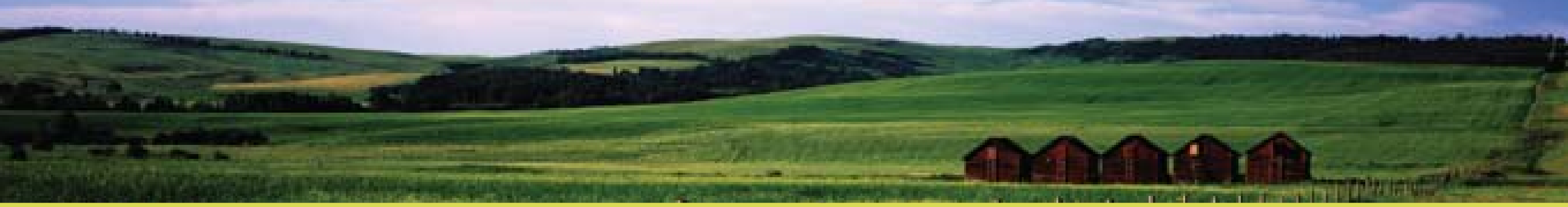
Factors affecting compaction are:

- Soils are generally most susceptible to compaction when they are wet, such as in the spring after snowmelt or following heavy rainfall.
- Medium- and fine-textured soils and soils low in organic matter compact easier.
- Frequent tillage increases the potential for compaction because soil structure is degraded.
- Frequent wheel traffic increases the risk of compaction.
- Heavy loads increase the risk of compaction. Although application equipment that can transport large amounts of manure may reduce the number of trips from the storage to the field, a larger total axle weight can cause greater compaction with a single pass. Large volume equipment can also cause compaction at greater depths making remedial tillage more difficult.
- Tire configurations where the equipment's weight is concentrated onto a small area increase the risk of compaction.

BMPs to reduce soil compaction during manure application include:

- Increase the volume of manure storage to provide for more application opportunities to facilitate applying manure when field conditions are favourable.
- Use dragline application systems for liquid manure to reduce traffic and equipment weight on fields.
- Restrict repeated vehicle traffic to specific areas of the field (e.g. use designated pathways).
- Apply manure when field conditions are favourable, and avoid conditions in which soils are more prone to compaction (e.g. following snowmelt or heavy precipitation).
- Minimize the axle weight of application equipment, reduce axle weight to less than 10 tons/axle, and use systems with more axles and tires.
- Maximize the footprint (the area over which the equipment's downward pressure is exerted by the tires) through the use of:
  - lower tire pressure
  - larger tires
  - radial tires
  - more tires (such as tandem axles)
  - equipment with front-wheel assist, four-wheel drive
  - track vehicles
- Modify cropping and tillage practices to provide more application windows; for example, apply manure prior to fall crops, after silage cuts or between forage cuts.
- Consider that crop rotation and reduced tillage may be more effective than deep tillage to lessen the impact of soil compaction.

Use equipment that minimizes compaction.



7.6 ODOUR CONTROL DURING APPLICATION

Odour control needs particular attention during land application. This is the time when your manure handling practices are most apparent to neighbours. This may also be the time when your reputation for environmental safety is questioned.

Table 7.5 Odour Control During Manure Application

Application BMP	Benefits	Drawbacks
Increase use of bedding.	• Reduces odours when wastes are handled as solids. • Keeps animals cleaner.	• Increases labour associated with solid systems and bedding. • Doesn't apply to liquid systems. • Increases volume of manure to be spread, increasing application costs.
Inform neighbours of your intentions.	• Shows your concern, improves relations. • Helps identify times when it may be inappropriate to spread for social reasons.	• Hard to satisfy everyone. • Requires planning ahead. • May require adjustments of plans.
Pre-till before manure application.	• Increases soil contact and infiltration. • Reduces odour.	• May risk excessive tillage and soil degradation.
Apply in cool weather.	• Reduces volatilization.	• May reduce opportunities to apply. • Don't apply to frozen soil.
Avoid application on calm, humid days, particularly if not incorporating.	• Avoids climatic conditions most conducive for odour. • Preserves nutrients.	• May restrict spreading in the summer months when soil conditions are ideal.
Apply when conditions are dry.	• Reduces anaerobic conditions.	• May reduce opportunities to apply.
Monitor wind direction when hauling manure to fields.	• Can take advantage of predominant wind directions to naturally direct odours away from sensitive areas.	• May reduce opportunities to apply. • Unpredictable – wind direction can change during application.
Avoid high-trajectory manure-spreading equipment.	• Reduces air/manure contact. • Increases control of spread.	• Other technologies may be more expensive and time-consuming.
Use dribble-bar applicators to keep manure close to the ground.	• Reduces air contact. • Applies to no-till systems. • Can potentially side dress in row crops.	• Applies to liquid systems only. • Offers less effective odour control than injection.
Inject manure in a concentrated band.	• Prevents contact of manure with air. • Allows manure to be spread post-emergence in row crops such as corn, increasing period available for manure application.	• Applies to liquid systems only. • Makes for slower application and requires more horsepower.
Incorporate as soon as possible after application.	• Reduces air/manure contact. • Preserves manure N.	• Can be more challenging for standing crops and in high crop-residue management system.

7.7 MANURE APPLICATION SAFETY

Safe operating procedures are the best way to prevent farm accidents related to manure handling. Safety procedures include:

- Use locked and signed entrances to keep people, pets and livestock out of any confined spaces or areas storing liquid manure.
- Keep storage area ventilation systems working and functional.
- Never fill a storage or tank completely.
- Evacuate livestock facilities when agitating and removing liquid manure from an in-barn storage and increase ventilation in barns to dilute H_2S concentrations and reduce impacts on animals.
- Use agitation tags and warning tape.
- Tarp over pump-up from in-barn pits to reduce air movement into and over in-barn pits and back up into the barn.
- Use sub-surface agitation, and do not direct agitation towards walls or pillars.
- Use H_2S detection systems to monitor the facility and area for H_2S levels.
- Watch for moving parts, such as PTO shafts and impellers.
- Handle transfer equipment with caution; there are high pressures in hoses and pipes. Before using an air system in pipelines, be very careful to ensure you have the proper equipment and adequate operator training.
- Put warning signs on all vehicles and equipment used on public roads.
- Keep brakes in good working order.
- Have emergency plans and post them where they are easily accessible to all staff and family members.
- Train all staff and family members in safety procedures.

7.8 MANURE APPLICATION TIPS

Manure should be applied with the goal of maximizing nutrient value while minimizing risk to the environment and risk of odours.

7.8.1 Tips for Applying Manure on Forages

Productive forage fields have high fertility needs, so nutrient levels need to stay high. Manure nutrients can work as well as commercial fertilizers and save you money. Consider your options for manure application, both for fields to which manure can be applied and for timing of application.

Injection disks with furrow closing packers.

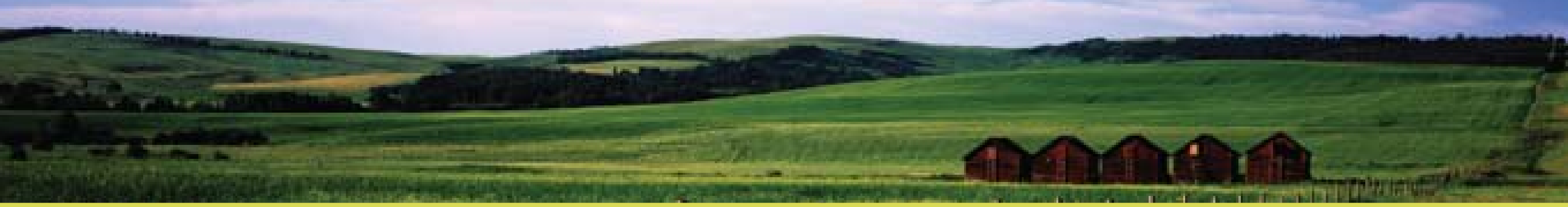


Table 7.6 Beneficial Management Practices for Applying Manure to Forages

BMP	Details
Analyze nutrient content of manure.	Use a manure analysis that indicates ammonium-nitrogen, phosphorus and potassium content of the manure to help determine most appropriate application rate. • The nutrient content of manure changes with livestock types and from farm to farm. • Applying too high a rate of ammonium-nitrogen could cause burn damage to forage regrowth. • When an analysis isn't available, a rate of 4000 gal/ac (with the exception of liquid poultry manure and highly concentrated liquid finisher hog manure) is safe for an alfalfa stand. • Since the ammonium-N content in solid manure is relatively low, nitrogen burn to new growth is not a concern (with the exception of high rates of solid poultry manure).
Use manure to establish forage stand.	Manure can be used at relatively high rates before seeding a new forage crop. However, there are a few precautions: • Manure should be applied and incorporated at least 5 days before planting. • High nitrogen and/or salt content in manure can lead to severe root injury in new seedlings, which will reduce plant stand. • New seedlings may also have higher weed pressure when manure is used prior to planting. Alternatively compost may be used to reduce the introduction of weeds.
Apply manure to grassy hay first.	Applying to the oldest and/or grassiest forage stands first will provide stands with needed nitrogen.
Apply right after harvest.	Applying before regrowth will prevent manure contact and potential nitrogen burn on new growth.
Apply to forages during the summer.	In sunny, hot weather, applying manure during late afternoon or early evening will help to minimize nitrogen loss and reduce potential nitrogen burn. Twelve to 18 hours without direct sunshine and with potential dew will reduce manure volatilization.
Watch for rain.	A gentle rainfall totalling about 10 to 12 mm will help incorporate nitrogen from manure. An erosive rain will increase risk of surface water contamination.
Avoid applying manure when soil is wet.	Wheel traffic from a heavy tanker will cause some crown damage and potentially some compaction – another reason to apply to older stands. Irrigating watery manure (<1% DM) will cause less damage to crowns. The benefit of washwaters for forage yields may be as much from the water as from the nutrients.
Modify application equipment.	Applying manure uniformly is difficult. Rates under 3000 gal/ac are hard to apply without applicator modification due to high tractor-speed requirement.
Watch for clumping of manure.	Where solid manure is being applied to forages, exercise extra caution: • In most cases, the manure is not applied uniformly enough. • When manure "clumps", it can cause a significant reduction in the crown stand.
Avoid application to hay or round bale silage.	Take precautions for manure applied to forage that will be used for wrapped, long-hay silage. • In some cases where manure was applied to regrowth, the bacteria from manure caused improper fermentation, which could lead to problems (spoiled areas) in silage.
Watch for manure-borne diseases.	Disease transmission from manure in forage has not been reported as an issue, but the question is raised periodically. • If you have a concern about a particular disease being carried in the manure, question your local veterinarian about how the disease is transmitted. • If the disease is carried in manure, then question how long the organisms survive in the soil under normal weather conditions.

Table 7.6 Beneficial Management Practices for Applying Manure to Forages (continued from page 74)

BMP	Details
Do not apply biosolids on legume forages.	Biosolids, specifically sewage sludge, have almost no potash. Forage crops have high nitrogen and potash needs. Since legume crops naturally produce nitrogen, legume forages have traditionally not been the best economic targets for the nitrogen from manure and biosolids. Livestock manure is a good source for replacing commercial potash; in contrast, biosolids are a poor choice for replacing potash needs of the crop.
Manage soil potassium (K) levels.	Precaution: high soil test levels of potash and high potash levels in manure can lead to high potassium (K) levels in forages, resulting in milk fever in dairy cows. • Alternatives to high K forages include off-farm sources of low K hay and/or dilution with low K forages such as corn silage, or anion/cation balancing.
Reduce fertilizer application.	When applying manure to forages, additional commercial fertilizer (particularly potash) application should be reduced to compensate for nutrients applied from manure.
Manage copper levels.	Precaution: manure containing high levels of copper (i.e. from farms using hog rations high in copper and/or cattle footbaths containing copper sulphate) should never be applied to sheep pasture. • Sheep have a low requirement for copper; their maximum tolerable level is close to their requirement. • A 5000-gal application rate of manure containing a copper level of 5 ppm applied regularly to pastures could kill sheep. • Manure applied to sheep pastures should be analyzed for copper in addition to the common nutrients.

7.8.2 Tips for Applying Manure After Cereal Harvest

- If you have winter cereals in your rotation, you have the opportunity to apply manure when risk of compaction is lowest and when there are fewer demands on your time.
- If you have bone-dry soils that may be cracked, pre-till before applying liquid manure. A light cultivation increases infiltration while reducing the risk of runoff through cracks to groundwater resources. Pre-tillage will also help to reduce odour and nitrogen losses, although not to the same degree as post-application incorporation.
- When manure is applied shortly after harvest, temperatures are usually warm and rainfall limited. Volatilization losses can be high if manure is not incorporated within a day or two.

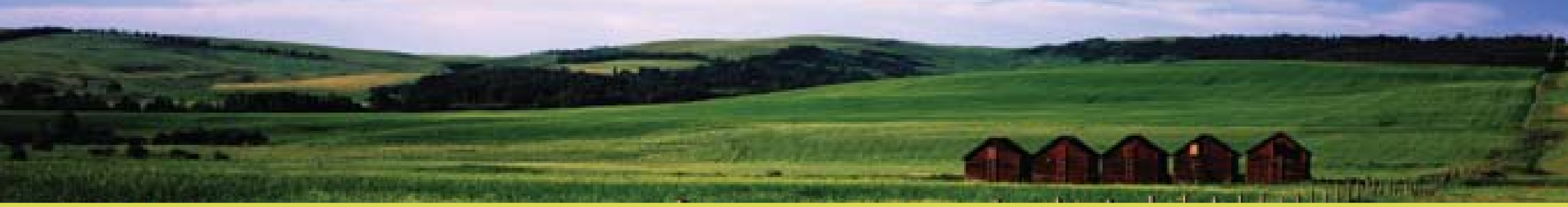
7.8.3 Tips for Improving Manure Application Uniformity

To maximize the benefits of manure application onto cropland, manure must be spread evenly and at an appropriate density. Variable application rates within a field can cause variations in crop yield.

Getting uniform manure application can be difficult. Calibrating applicators can help improve equipment consistency but you may need to change application practices to improve consistency.

Wind speed and direction often affect the degree of variation in liquid manure application. Variation is also influenced by changes in manure solid content.

The area behind a solid manure spreader that spreads from the back can receive up to two to three times more manure than areas to either side of the spreader. For side spreaders, the application density decreases with increasing distance from the spreader.



To improve uniformity of manure application:

- Heap solid manure evenly on the spreader.
- Determine the width of the spread pattern and determine the amount of overlap required.
- Incorporate perpendicularly to the direction of application.
- Determine differences in manure consistency between the beginning and end of the load and adjust speed accordingly.

7.9 SUMMARY OF BMPS FOR APPLICATION

- Remember that odours are more intense and ammonia loss increases with rises in temperature, humidity and wind.
- Have regard for neighbours' concerns when spreading near their homes.
- With liquid manure, use low-trajectory broadcast, surface-banding or injection application technology.
- Incorporate surface-applied manure as quickly as possible following application.
- Avoid applying manure to wet soils and during wet weather to reduce the risks of nutrient loss, runoff and soil compaction.
- Avoid spreading manure if rainfall occurs shortly before application or if heavy rain is predicted within 12 to 24 hours of spreading.
- Avoid surface application on steeply sloped land adjacent to watercourses, lakes, ponds and wetlands.
- Monitor for and be prepared to react to any spills.

7.10 CALCULATING MANURE APPLICATION RATES

Manure application is a system, one that is full of small uncertainties. To maximize the nutrient use efficiency from manure (which will also maximize profit and minimize environmental impact), a systems approach is needed that's sensitive to the unique attributes of manure. Calculating manure application rates and managing manure application timing and methods will reduce the opportunity for nutrient loss to the environment, thereby increasing the economic return from the nutrients applied in the manure.

Calculating manure application rates helps to: ensure that over-application of nutrients is minimized; decrease fertilizer input costs by having a greater understanding of what nutrients have already been supplied to the crop from the manure; and maximize the value realized from the manure nutrient applied.

Calculating manure application rates involves using the following information (some of which was discussed earlier):

- available land base
- soil nutrient content
- crop nutrient requirements
- nutrient content and volume of manure
- application method and conditions

Calculating manure application rates involves the following steps:

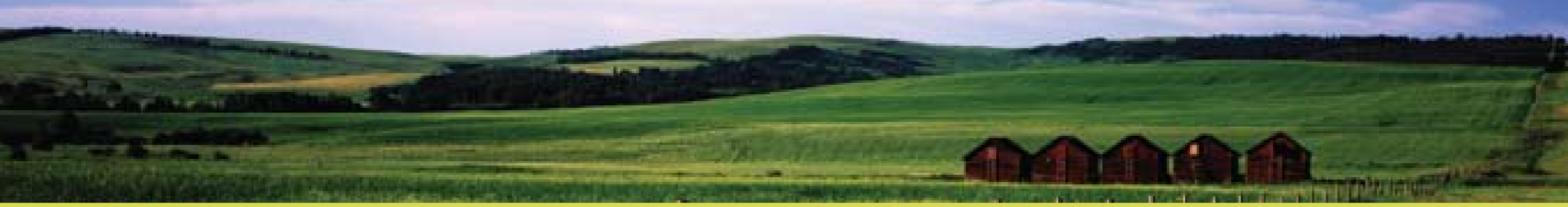
1. Determine the crop nutrient requirements for each field. The fields that will benefit the most from manure application will generally be the fields with the lowest soil test for N, P and K and growing crops with the highest N demand.
2. Determine average nutrient contents for the manure from past manure analyses or from book values and the volume of manure available for application.
3. Determine the basis for the application rate, i.e. nitrogen or phosphorus requirements. Calculate a target application rate that supplies 75% to 80% of the N requirement for the crop, or possibly 3 to 4 years of phosphorus requirements.
4. Calibrate the application equipment.
5. Collect samples from the manure storage as it's being emptied; if manure is applied to more than one field, collect samples for each field.
6. Record the actual amount of manure applied on each field.
7. Submit the manure samples for analysis.
8. From the analyzed manure nutrient content and the application rate, calculate the amount of available nutrients applied to each field.
9. Determine the amount of fertilizer required to make up the difference between total crop requirements and the nutrient amounts applied with the manure. Apply that fertilizer with the seed or after seeding.

Once manure application rates have been determined, an operation may find that it has a large surplus of manure in relation to the number of acres available for application. If this is the case, the operation may need to build cooperative relationships with surrounding landowners to secure additional land for manure application and/or it may need to consider alternative treatment measures, such as solid-liquid separation technologies or composting to increase the distance manure can be transported economically. The operation may also consider developing marketing options for the manure produced.

MEETING NITROGEN NEEDS

Nitrogen is mobile; unless it is quickly used by a crop, it could be lost to the air or groundwater. It is recommended that manure be applied to provide approximately 75% to 80% of the crop's nitrogen needs for the following reasons:

- Nitrogen release from organic material depends on the weather, and in cool, damp seasons the crop may not receive enough nitrogen from organic sources for optimum growth and yield.
- Manure application rates are not always uniform, so part of the field may receive insufficient manure to meet crop requirements. A blanket application of mineral N fertilizer helps to increase overall yield by ensuring all parts of the field have received some nitrogen.



7.11 RECORD KEEPING

Recording and keeping all documents related to nutrient management is important. Documents can provide information on how nutrient management is implemented on the farm, and where and when changes are needed. As well, keeping records will help to collect accurate on-farm data that can be used to generate site-specific information.

Suggestions for information that can be maintained include:

- type of animals and stage of production
- manure analyses by type of livestock or by storage unit
- volume or weight of manure produced
- legal land description of each field to which manure is applied
- area of each field to which manure is applied
- volume or weight of manure applied to each field
- date of application and incorporation for each field
- method of manure application and incorporation
- soil test results for each field to which manure is applied
- crop planted and yields by field and by year
- application rates of manure nutrients and fertilizer by field and year
- name of applicator
- weather conditions during manure application
- method of cropping

If manure is transferred off the farm, keep a record of:

- name and mailing address or legal land description of the person to whom control of manure is transferred each year
- date of the manure transfer
- volume or weight of manure transferred

FOR MORE SPECIFIC INFORMATION regarding the regulations for record keeping under AOPA, refer to the *Agricultural Operation Practices Act* or talk to ARD CFO Extension Specialists or NRCB staff, or visit www.alberta.agriculture.ca/aopa.

Chapter 8. SURFACE WATER MANAGEMENT

This chapter explores:

- runon and runoff – what they are, and the risks associated with them.
- various management options – runon reductions, runoff catchbasins, vegetated filter strips, and constructed wetlands

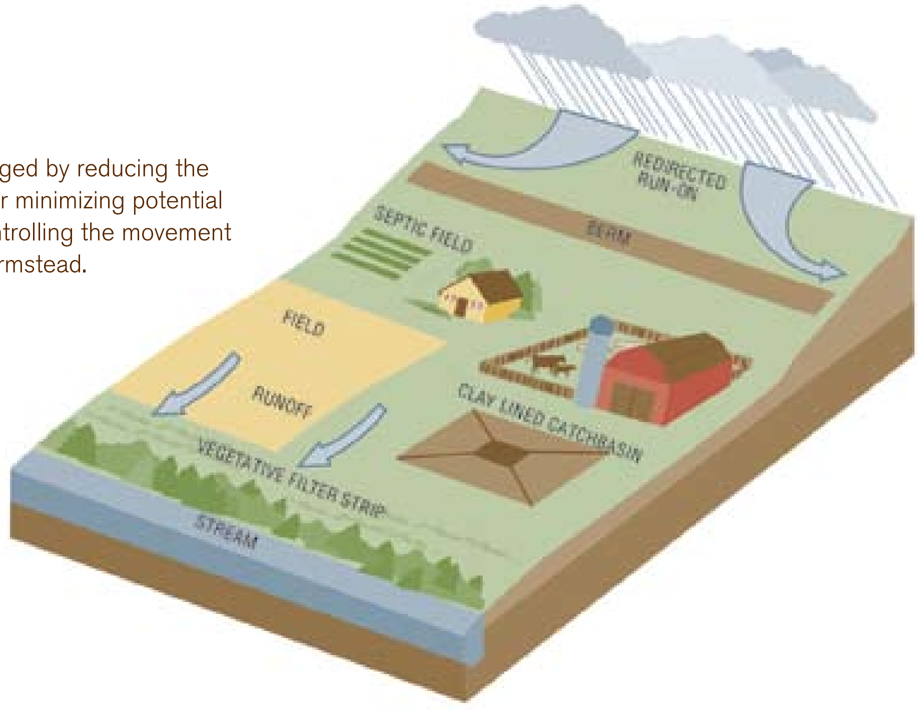
Livestock operations may have outside facilities such as yards, feedlot pens and outside manure storages that have the potential to contaminate surface water with manure. Other possible contaminants include fuel, pesticide, milk parlour washwater, silage leachate, cleaning products and disinfectants.

Controlling runon and runoff:

- Helps to protect water quality by preventing organic matter, phosphorus, nitrogen and pathogens in runoff from entering local surface waters or leaching to groundwater.
- Conserves valuable, nutrient-rich manure for use on crops.
- Aids compliance with provincial and federal regulations.
- Helps to ensure clean, dry lots, which enhance livestock health and are easier to maintain.

PERMITTED OPERATIONS may be required to have an approved runon/runoff control system. For more information, contact an Alberta Agriculture and Rural Development (ARD) Confined Feeding Operation (CFO) Extension Specialist or Natural Resources Conservation Board (NRCB) staff.

Water pathways can be managed by reducing the volume of water, eliminating or minimizing potential contaminant sources, and controlling the movement of surface water within the farmstead.



8.1 RUNON AND RUNOFF FLOW

One of the best ways to understand runon and runoff flow around your livestock operation is by mapping your operation, including its surface water flow patterns and other water sources, as listed below. This will help you understand where water is flowing from (runon water), how it is flowing through the operation, and where potential sources of contamination may be.

Sources of surface water flow can include:

- direct rain
- snow and snowmelt
- roof water
- overflowing waterers
- water from manure
- upslope runon waters

8.2 RUNOFF VOLUME

Solid manure storages, livestock yards and outdoor exercise areas should be equipped with a runoff management system that handles all the runoff generated by the facility. Runoff should not be allowed to negatively affect surface water.

The runoff volume will determine what options are available for managing your surface water. Volume depends on the precipitation received and the area being drained. Rainfall considerations include the intensity, frequency and duration of typical rainfall in the area as well as snowmelt. This information can be obtained from weather information service providers. The area drained can be determined from maps. For assistance in calculating runoff volume, contact your local ARD Confined Feeding Operation Extension Specialist.

8.3 RUNON MANAGEMENT

Runon should be minimized to reduce the volume of runoff. Methods to do this include:

- Maintain waterers and repair any leaks.
- Divert runon waters around the farmstead using natural topography or man-made structures

A clean water inlet pipe collects clean runon water upslope of a livestock yard and discharges it below the yard through a drain outlet.

BEFORE CONSIDERING A RUNOFF MANAGEMENT SYSTEM, divert all clean water away from the solid manure storage, livestock yard or permanent outdoor confinement area. This will reduce the volume of contaminated runoff that has to be managed.

such as ditches, dykes, berms or pipes to avoid water contact with manure, sewage or other potential contamination sources.

- Collect or divert runoff from roofs.
- If possible, locate the livestock yard, pens and manure storage on higher ground to prevent runon.
- Remove accumulated snow from the livestock yard or pens to minimize snowmelt runoff.

8.4 RUNOFF MANAGEMENT

Consider the following guidelines when assessing runoff management options:

- Locate potential contaminant sources such as manure storage areas away from water flow pathways and potential flood zones, or protect these areas with ditches, dykes or berms so contact with surface water flow is minimized or eliminated.
- Modify water pathways to reduce the risk of contaminant movement. For example, designing and planting a vegetative filter strip in a pathway can slow down water movement and allow suspended solids to settle. Another option is a constructed wetland. Constructed wetlands slow down water movement and contain it for a period of time, allowing biological activity to help reduce nutrient levels.
- Release the collected manured runoff in a controlled manner that allows for infiltration and treatment by vegetation and soils.

8.4.1 Runoff Control Options

Runoff control options include the following:

Catchbasins
Catchbasins can be used to collect contaminated runoff water and prevent the water from leaving the property. The catchbasin provides some treatment of the water, but releases from the catchbasin must be properly managed.

To minimize an accumulation of sediment in the catchbasin, a two-stage collection system works well, with the initial stage to settle out solids and the second stage to store the runoff.

If the facility requires permitting, the catchbasin will require engineering design and construction that meet provincial regulations and standards. Catchbasin siting should take into consideration the distance to neighbours and should be located above stream or river flood levels, at least 100 m or more from any water well or spring, and more than 30 m from any

Contact your ARD CFO Extension Specialist for assistance in designing catchbasins.

KEEP IN MIND that large-scale diversions are regulated by Alberta's *Water Act*. Farm runoff management systems must not significantly alter regular water flow, must not affect or alter a non-flowing water body and must not be located on a fish-bearing water body.

common body of water. The catchbasin should have a natural protective layer or a liner that provides adequate protection to the groundwater.

Catchbasins should be monitored to identify any possible risks and maintained to prevent soil and water contamination. Visual inspections will ensure that the liner is not damaged and that the walls are not eroding. Monitor liquid levels, and check for wave damage to the liner, erosion damage at entry and pumping points, cracking and slumping of the liner, seepage on the outside of the berm, and liner damage due to rodents and trees. Maintenance should be done to rectify any problems identified by monitoring the above. Having sampling wells to monitor groundwater conditions can also help minimize risks to groundwater.

Catchbasins should be emptied as they fill so they are ready for the next rainfall event or snowmelt. The catchbasin must be emptied in such a way that the contents do not create an environmental risk by leaving the land to which they are applied or by entering an open body of water. Options for managing the catchbasin effluent include: application to crops by releasing the effluent at a low flow rate when soil is thawed to ensure infiltration into soil and reduce the erosion risk; slow release into a vegetative filter strip; or release into a wetland.

Nutrient content of catchbasin effluent varies widely, although typically it contains low levels of nitrogen and little phosphorus, but high concentrations of sodium.

The catchbasin should be secured from access by animals or unauthorized persons.

Vegetative Filter Strips

A vegetative filter strip is a width or length of vegetation that acts as a filter to trap and use sediments and nutrients from runoff.

Vegetative filter strips may be sufficient to minimize runoff contamination from some livestock operations including feeding pens, manure stockpiles, wastewater pump-outs and manure spread on fields.

Factors influencing the effectiveness of a vegetative filter are:

- Season in which the filter is being used: it will not work well when soil is frozen.
- Drainage area upslope from the filter strip.
- Amount and form of precipitation (snow, rain, or both).
- Slope of the site and whether the natural topography lends itself to sheet or channel runoff.
- Vegetation cover in the filter strip area (stubble, grass or trees, etc.).
- Soil type (sandy, loam or clay).

Constructed Wetlands

Constructed or man-made wetlands can be used to collect and treat contaminated runoff or discharge from livestock operations. Constructed wetlands are man-made systems that are designed, built and operated to imitate natural wetlands.

To design and develop a wetland for effective wastewater treatment, it is necessary to understand the processes that occur in wetlands. Primary processes include:

- Breakdown and transformation of nutrients by micro-organisms and plants.
- Filtration and chemical precipitation through contact with plants and soil.
- Settling of suspended particles.
- Absorption and ion exchange on the surfaces of plants, sediment and litter.
- Predation and natural death of pathogens.
- Periodic harvesting of wetland plant material to prevent wetland nutrient overload.

Livestock producers must consider the advantages and limitations of such a system to determine whether a constructed wetland is suitable for their operation.

Advantages of a constructed wetland:

- Provides a high level of treatment. Test results show that phosphorus, nitrate-nitrites, ammonia, biological oxygen demand (BOD) and suspended solids can be reduced to acceptable levels.
- Can be relatively inexpensive to construct. A site with accommodating specifications keeps establishment costs low.
- Inexpensive to operate. A well-designed wetland transfers water through the system. Once established, properly designed and constructed wetlands are largely self-maintaining. Costs can be offset by harvesting forage from the area.
- Reduces, if not completely eliminates, odour. Unlike lagoons, research shows that odours from wetlands are minimal or non-existent.
- Handles variable wastewater loadings. Properly designed wetlands show tolerance for varying amounts of wastewater loading.
- Reduces the land area needed for wastewater application. Constructed wetlands reduce the concentration of contaminants, and therefore, the land area needed for wastewater application.
- Aesthetically pleasing. Constructed wetlands enhance the landscape with colour, texture and plant variety.
- Provides wildlife habitat. Wetlands attract wildlife and can improve the usefulness and attractiveness of an area.

Disadvantages of a constructed wetland:

- Requires a continuous water supply. Water must be added if the wastewater supply is insufficient for sustaining plant populations during dry periods.
- Can be relatively expensive to construct. Changing the lay of the land, adding soil amendments, liners and/or incorporating pumps add extra cost.
- Affected by seasonal weather conditions, which may reduce reliability. Seasonal weather conditions, such as cold and drought, reduce the effectiveness of the system.
- Can be destroyed by an overload of solids or ammonia. High ammonia levels caused by inadequate removal of solids destroys plant life in the wetland.
- Removes nutrients. Nutrients removed by the wetland system are unavailable for land application and crop production.

Chapter 9. BUILDING GOOD NEIGHBOUR RELATIONSHIPS

This chapter explores:

- BMPs for controlling odour, flies and dust
- tips for managing and resolving conflict
- dealing with complaints

Certain attributes of livestock farming, like odour and flies, come up again and again as being objectionable to neighbours. To some degree, factors like odour, flies, noise and dust are part of agricultural operations. Whether they are considered a nuisance or not is largely subjective; the person who smells the odour or hears the noise decides whether it is tolerable to him or her.

Nevertheless, you can reduce nuisances by using good farming practices based on common sense and courtesy. In the process, you can also help reduce conflicts with neighbours. Developing and maintaining good neighbour practices is really about managing relationships.

9.1 CRITICAL ISSUES FOR GOOD NEIGHBOUR RELATIONSHIPS

9.1.1 Odour

Farmers need to consider **FIDO** (frequency, intensity, duration, and offensiveness) of odours. Frequency of odour problems can be managed by reducing the number of times neighbours detect odours from your operation. Intensity is the strength of an odour; it is diminished by distance and dilution. Duration has to do with how long odours are present. Strong odours for a short period of time (hours) are usually considered less objectionable than a lighter odour for a long time (days). Offensiveness has to do with how objectionable something smells. For example fresh manure usually is judged less offensive than manure from a long-term anaerobic storage.

Tips to minimize odour issues include:

- To reduce odours from manure storage, see page 27.
- To reduce odours from manure application, see page 72.
- Notify your neighbours to let them know in advance of your manure spreading plans and be willing to adjust your plans to try to meet their needs.
- Don't spread on weekends or holidays.

9.1.2 Flies

Fly problems often result in neighbourhood disputes. It may be difficult to say for certain that flies originate from a certain farm, but they can upset neighbours.

Tips to control fly populations include:

- See page 28 for fly control practices.
- For more details, get the factsheet A Guide for the Control of Flies in Alberta Confined Feeding Operations available from Alberta Agriculture and Rural Development (ARD).

TECHNOLOGY AND MANAGEMENT PRACTICES can help alleviate nuisance issues. However the most effective and economical practice is to maintain positive relations with your neighbours.

9.1.3 Dust

Dust is another concern for neighbours, whether it is from barns, pens, fields or excessive farm traffic such as silaging, harvesting, or manure application.

Tips to control dust include:

- Apply dust palliatives to suppress dust (e.g. calcium chloride).
- Apply water from a truck or other portable spray system to farm roads.
- Set up wind barriers aligned perpendicular to the wind direction (e.g. continuous board fence, burlap fence, snow fencing, hay bales).
- Establish windbreaks placed perpendicular to the wind direction to trap larger sized dust particles.
- Stop or limit dust-producing activities during a high wind event.
- Reduce vehicle speed on dusty roads.
- Place hoods on fans so exhaust air is directed towards the ground.
- Wash fan blades, screening and hoods with water rather than using blowing air to clean them.
- Use up-to-date ventilation equipment to minimize exiting dust levels.
- In poultry facilities, use coverings on conveyor belts.
- Ensure pelleted feed is high quality; very small particles in feed can contribute to higher dust levels.
- Wet down feedlot pens.

Dust is a concern for neighbours.

9.2 MINIMIZING COMPLAINTS

First of all, how does your farm look to outsiders? A trashy and unkempt farmstead will raise suspicions. Neighbours may think “if your farm looks messy you must not be a good operator”. At the least, mow regularly and keep junk out of view. Keep buildings painted and in good repair. Use fences or vegetative screening to block items that may be considered unsightly.

Make sure the public sees your operation as a well-kept farmstead.

9.3 PREVENTING AND RESOLVING CONFLICT

Conflict often occurs between individuals because of a real or perceived difference in needs or values. Learning the skills necessary to prevent and resolve conflict is important in today's society. To avoid potential conflict you need to plan ahead, communicate with the community and document the actions taken on your operation to manage and reduce issues that may draw complaints. Ensure communication with your neighbours is open, honest and thorough to avoid misunderstandings and concerns.

Properly managed conflict can be productive because it can:

- encourage people to examine issues more carefully,
- deepen the understanding of concerns or issues for those involved,
- open the door to new ideas and alternative solutions,
- help foresee the consequences of proposed actions, and
- enable people to take risks and solve problems.

Tips for managing and resolving conflict include:

- Take the matter seriously; listen to and acknowledge concerns.
- Be open, tactful and sincere in identifying concerns and seeking understanding.
- Admit mistakes and apologize when they occur.
- Show understanding when others make mistakes and offer assistance to correct the issue.
- Shift the emphasis to mutually acceptable solutions and offer to look into the matter.
- Promptly respond to complainants with information needed to relieve concerns.
- Take responsibility and steps to mitigate damage or eliminate problems.
- Stay on top of on-going problems, while keeping neighbours informed of changes on the farm.
- Identify and involve people who support the operation and can help in dealing with conflict.
- Focus on keeping supporters onside and do not spend too much time dealing with opponents.

Hosting a well-planned farm tour gives neighbours a better understanding of your operation.

9.4 DEALING WITH COMPLAINTS OVER NUISANCE ISSUES

The *Agricultural Operation Practices Act* (AOPA) includes setbacks requiring an appropriate minimum distance of separation between farming operations and neighbouring residences to deal with odour nuisances. Complaints about livestock operations are reviewed by the Natural Resources Conservation Board (NRCB) to determine whether the operation is in compliance with AOPA. However, even though an agricultural operation is complying with the various regulations, the farm still can create nuisances for neighbours that need to be dealt with appropriately.

The Farmers' Advocate Office (FAO) may be requested to assist in dealing with complaints about odour, noise, dust, smoke or other nuisances resulting from agricultural operations. The FAO will work with a farm operator and his/her neighbours to find solutions to nuisance issues from farming activities that interfere with the neighbours' use and enjoyment of their property or dwelling. The FAO will provide the farm operator, the complainant and the municipality with possible solutions and systems to assist in resolving disagreements outside of the courts.

If a complaint is not resolved at this stage, a Practices Review Committee may also be established to assist in resolving the dispute. The committee is appointed by the Minister of Agriculture and Rural Development to ensure an open and transparent evaluation of the farm and to assess if the farm is following generally acceptable farming practices. A Generally Accepted Agricultural Practice (GAAP) certificate may be issued to a farm operation; the certificate acts as a due diligence defence if a neighbour files a complaint with the court.

Chapter 10. FOR MORE INFORMATION

The service providers, publications and web resources listed below can assist you in developing your manure management plan.

10.1 ALBERTA AGRICULTURE AND RURAL DEVELOPMENT

Confined Feeding Operation (CFO) Extension Specialists with Alberta Agriculture and Rural Development (ARD) are available to provide information on Alberta's *Agricultural Operation Practices Act* (AOPA) and the CFO permitting process for livestock producers, consultants, municipalities and other interested parties.

CFO Extension Specialista

North/Peace Region
Phone: 780-939-1218
Fax: 780-939-1269

Central Region
Phone: 403-755-1475
Fax: 403-340-4896

South Region
Phone: 403-381-5885
Fax: 403-382-4526

Website: www.agriculture.alberta.ca/aopa

10.2 NATURAL RESOURCES CONSERVATION BOARD

The Natural Resources Conservation Board (NRCB) is responsible for the permitting of CFOs and is also responsible for addressing complaints regarding the management of manure on agricultural operations in Alberta.

NRCB Offices
Lethbridge: 403-381-5166
Red Deer: 403-340-5241
Morinville: 780-939-1212
Fairview: 780-835-7111

NRCB 24-hour Response Line: 1-866-383-6722

Website: www.nrcb.gov.ab.ca

10.3 PUBLICATION SOURCES

Alberta Agriculture and Rural Development
Publications Office
7000-113 Street
Edmonton, AB T6H 5T6
Phone: 1-800-292-5697
Website: www.agriculture.alberta.ca and www.agriculture.alberta.ca/manure

Agricultural Operation Practices Act
Website: www.agriculture.alberta.ca/aopa

Natural Resources Conservation Board
Website: www.nrcb.gov.ab.ca

10.4 REFERENCES FOR ENVIRONMENTAL LIVESTOCK MANAGEMENT TOPICS

The following publications are available through the ARD Publications Office.

Website: www.agriculture.alberta.ca

10.4.1 General

Agdex 400/28-1	Managing Livestock Manure
Agdex 420/580-2	Cattle Wintering Sites: Managing for Good Stewardship
No Agdex	Alberta Feedlot Management Guide – 2nd Edition
Agdex 460/27-1	Manure and Pasture Management for Horse Owners

10.4.2 Nutrient Management Planning

ARD Website	Manure Management Planner 2008 (MMP)
ARD Website	Alberta Farm Fertilizer Information and Recommendation Manager (AFFIRM)
ARD Website /No Agdex	Nutrient Management Planning Guide

10.4.3 Manure-Related Issues

Odour

No Agdex	Dealing with Livestock Odour Concerns
No Agdex	How Does Alberta Legislation Address Odour
No Agdex	Measuring Odour
No Agdex	Odour Reduction Practices: Animal Diets and Land Application of Manure
No Agdex	Odour Reduction Practices - Considerations for Site, Buildings, Manure Storage and Treatment
No Agdex	Frequently Asked Questions on Livestock Odour

Water Quality

Agdex 576-1	Managing Nitrogen to Protect Water Quality
Agdex 576-2	Managing Phosphorus to Protect Water Quality
Agdex 576-3	Managing Feedlot Runoff to Protect Water Quality
Agdex 576-4	Managing Cow/Calf Operations to Protect Water Quality
Agdex 576-6	Manure Management to Protect Water Quality
Agdex 576-7	Hog Production and Water Quality: Minimizing the Risk
ARD Website	Siting to Prevent Water Pollution

Air Quality

Website	Ammonia Losses from Liquid Manure Applications Calculator
Website	Ammonia Losses from Livestock Buildings and Storage Calculator
Agdex 086-6	Ammonia Emissions and Safety
Agdex 729-4	Ammonia Emissions from CFOs: Control and Mitigation
Agdex 086-2	Hydrogen Sulphide Emission and Safety
Agdex 729-2	Methane (CH_4) Safety

Flies

No Agdex	A Guide for the Control of Flies in Alberta Confined Feeding Operations

10.4.4 Manure Production

No Agdex	Livestock Manure Contents and Values - Manure Characteristics and Land Base Code
No Agdex	Module 4 of the Nutrient Management Planning Guide

10.4.5 Manure Treatment

Manure Composting

No Agdex	Manure Composting Manual
ARD Website	Manure Composting Calculator
Agdex 400/27-2	Compost Temperature Measurement
Agdex 537-2	Compost Tea
Agdex 086-9	Fire - Compost and Organic Matter
ARD Website	Composting Regulations for Alberta
ARD Website	Windrow Composting Process
ARD Website	Composting Benefits and Disadvantages
ARD Website	Composted Versus Stockpiled Manure
ARD Website	Assessment of Compost Windrow Turners

Anaerobic Digestion

Agdex 768-1	Anaerobic Digesters
Agdex 768-2	Anaerobic Digesters: Frequently Asked Questions
Agdex 768-3	Biogas Energy Potential in Alberta
Agdex 768-4	Integrating Biogas, Confined Feedlot Operations and Ethanol Production

10.4.6 Land Application

ARD Website	The Alberta Soil Information Viewer
ARD Website	Area and Volume Calculators
ARD Website	Manure Transportation Calculator
ARD Website /No Agdex	Applying Manure on Perennial Forage Manual
Agdex 538 /120-1	Applying Manure on Perennial Forage: A Summary
Agdex 538-3	Ammonia Volatilization from Manure Application
Agdex 538-1	Manure Application and Nutrient Balance on Rangeland

10.4.7 Soil and Manure Sampling

Agdex 538-2	Sampling Liquid Manure for Analysis
Agdex 538-4	Sampling Solid Manure for Analysis
Agdex 538 /450-1	Sampling Poultry Manure for Analysis
Agdex 541-1	Alberta Fertilizer Guide
ARD Website	Soil Sampling and Testing
Agdex 540-1	Crop Nutrition and Fertilizer Requirements

10.4.8 Calculators and Software Tools

The following tools are available on the ARD website:

- Area and Volume Calculators
- Ammonia Losses from Liquid Manure Applications Calculator
- Ammonia Losses from Livestock Buildings and Storage Calculator
- Manure Composting Calculator
- Manure Transportation Calculator
- Manure Management Planner 2008 (MMP)
- Alberta Farm Fertilizer Information and Recommendation Manager (AFFIRM)

The following on-line calculators are currently under construction; contact a CFO Extension Specialist for more information.

- Affected Parties Radius Calculator
- Catch Basin Calculator
- Earth Manure Storage Calculator
- Minimum Distance of Separation Calculator
- Land Base Calculator
- Water Requirements Calculator

10.4.9 Manure Markets

ARD Website	Manure and Compost Directory

10.5 AOPA LEGISLATION

For all the information listed below, go to www.agriculture.alberta.ca/aopa.

10.5.1 Act and Regulations

- Agricultural Operation Practices Act
- Agricultural Operations, Part 2 Matters Regulation – AR 257/2001
- Standards and Administration Regulation – AR 267/2001
- Board Administrative Procedures Regulation – AR 268/2001

10.5.2 Codes

- Livestock Manure Contents and Values - Manure Characteristics and Land Base Code

10.5.3 Technical Guidelines

This is not a complete list.

- Concrete Manure Liner Guidelines
- Leak Detection and CFO's

10.5.4 Standard Factsheets on AOPA

Agdex 096-1	AOPA Reference Guide
Agdex 096-2	Permits and Regulations for Existing Operations
Agdex 096-3	Manure Management Record Keeping Regulations
Agdex 096-4	Wintering Sites and Livestock Corrals
Agdex 096-5	Manure Spreading Regulations
Agdex 096-6	Manure Management Regulations for Cow/Calf Producers
Agdex 096-8	Manure Characteristics and Land Base Code
No Agdex	Municipalities and the Agricultural Operation Practices Act (AOPA)
No Agdex	The Application of the Minimum Distance Separation (MDS) for Siting Confined Feeding Operations in Alberta

Appendix: Metric-Imperial Conversion Formulas

Conversions for Units Commonly Appearing on Manure Test Reports

Starting Unit	Multiply by	Desired Unit
Solid manure		
%	10	kg/t
%	20	lb/tn
kg/t	2	lb/tn
mg/kg	0.001	kg/t
g/kg	1	kg/t
t/ha	0.4461	tn/ac
Liquid manure		
%	10	kg/m^3
kg/m^3	1	kg/1000 L
%	100	lb/1000 gal
kg/1000 L	10	lb/1000 gal
mg/L	0.001	kg/1000 L
g/L	1	kg/1000 L
ppm	1	mg/kg and mg/L
L/ha	0.089	gal/ac

Abbreviations

t	metric tonne
tn	imperial short ton
mg	milligram
kg	kilogram
lb	imperial pound
ac	acre
ha	hectare
L	litre
gal	gallon (US)
ppm	parts per million
m^3	cubic metre

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Government of Alberta

Canada

Growing Forward

Agdex 400/28-2