FOREWORD

Beneficial Management Practices – Environmental Manual for Dairy Producers in Alberta

These farm practices guidelines were developed for Alberta dairy producers with the co-operation of industry, government and interested stakeholders to create greater awareness and understanding of beneficial environmental practices. Information presented in this publication is based on the best available research data and years of experience. The guidelines are intended to provide a range of management options for dairy operations of various sizes. This manual is a living document and will be updated regularly to incorporate additional proven technologies and information on environmental practices. Individuals not experienced in dairy production practices should not extract portions of this publication, nor draw inference, without considering all aspects of production. These guidelines should not be adopted literally into legislation, in whole or in part, by any level of government.

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Disclaimer

The primary purpose of the *Beneficial Management Practices – Environmental Manual for Dairy Producers in Alberta* is to assist producers with the implementation of management practices that promote environmental sustainability.

It is important to be aware that while the authors have taken every effort to ensure the accuracy and completeness of the *Manual,* the *Manual* should not be considered the final word on the areas of the law and practice that it covers. Producers should seek the advice of appropriate professionals and experts as the facts of each situation may differ from those set out in the *Manual.*

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Abbreviations and Conversions

Selected abbreviations and conversion factors:

Abbreviations:

- Phosphorus is elemental P.
- Phosphate is P_2O_5, which is a fertilizer unit.
- Potassium is elemental K.
- Potash is K_2O, which is a fertilizer unit.
- N is nitrogen.
- Organic-N is organic nitrogen.
- Total-N is total nitrogen.

Units:

- 1 kilogram (kg) = 2.205 lb. = 35.28 ounces = 1,000 grams
- 1,000 m = 3,281 feet = 39,370 inches = 0.6214 miles
- 1 m^3 = 1,000 litres = 264.2 gallons (U.S.) = 220 gallons (Imperial)
- 1 ha = 10,000 m^2 = 107,639 ft^2 = 2.471 acres
- 1 kg/ha = 1.12 lb./ac.
- 1% = 10 kg/tonne = 10,000 mg/kg = 10,000 parts per million (ppm)
- 1 ppm = 1 mg/kg (solid) or 1 mg/L (liquid)
- 1 lb. of P = 2.29 lb. of P_2O_5
- 1 lb. of K = 1.2 lb. of K_2O
- 1 ppm N, P or K (in 6 inches or 15 cm soil depth) = 2 lb. of N, P or K/ac.
  = 2 kg of N, P or K/ha

  i.e. If the lab report shows that P content in soil is 20 ppm,
  this is equivalent to: 20 x 2 = 40 lb. P/ac. or 40 kg P/ha.

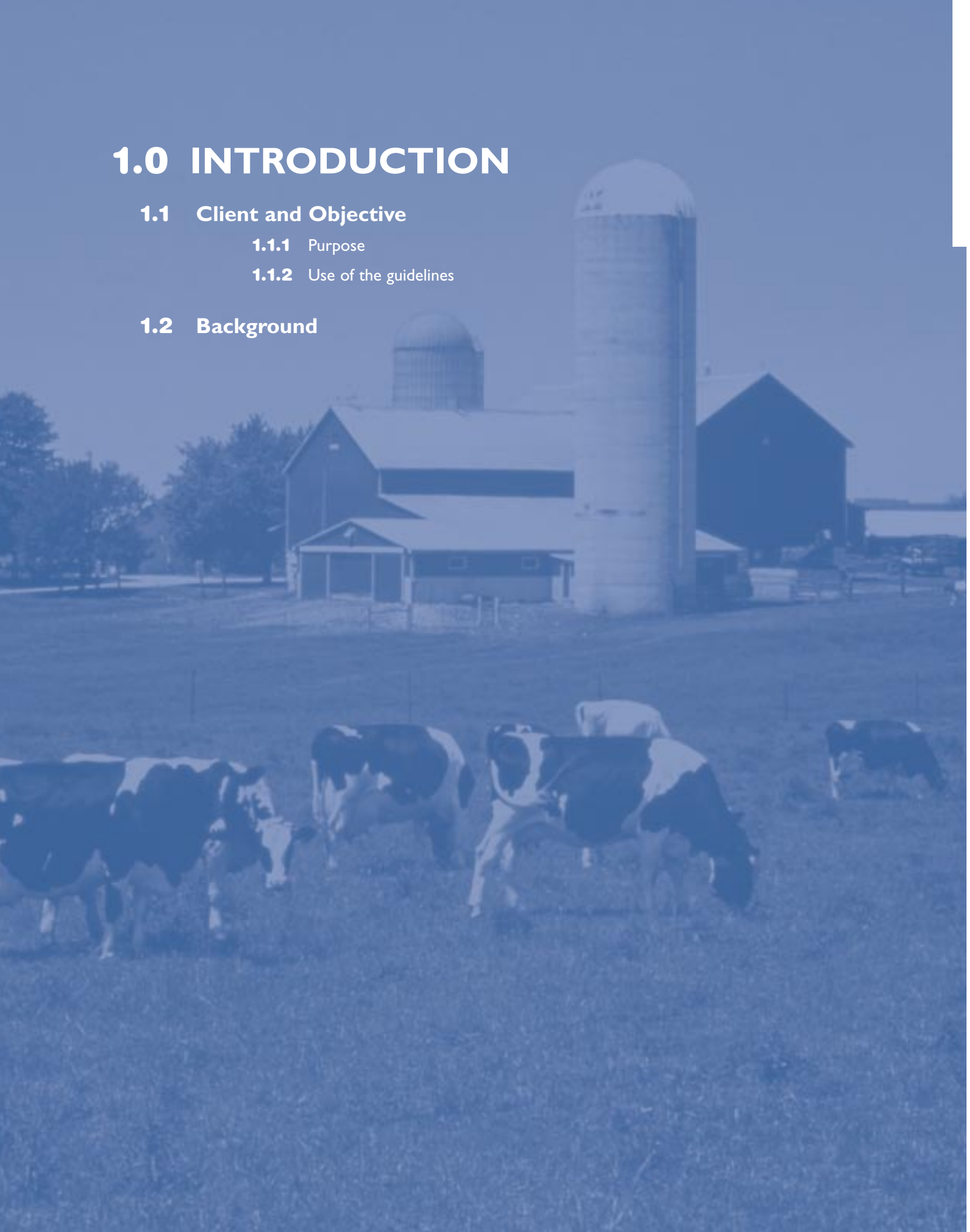
1.0 INTRODUCTION

1.1 Client and Objective

1.1.1 Purpose

1.1.2 Use of the guidelines

1.2 Background



1.0 INTRODUCTION

1.1 Client and Objective

The *Beneficial Management Practices: Environmental Manual for Dairy Producers in Alberta* was prepared to provide Alberta dairy producers with guidelines on environmentally responsible practices.

The objective is to use beneficial practices and nutrient management planning to reduce the impact of livestock production on soil, air and water. As well, the practices outlined in this manual will serve to reduce nuisance complaints related to livestock production. This publication will provide information on the following subject areas:

- The potential risks of livestock production on air, water and soil.
- Legal requirements of livestock operations.
- Social obligations of livestock operations.
- Site planning and management.
- Nutrient management.
- Alternative methods of manure treatment.
- Safe and responsible storage and disposal of agri-chemicals, petroleum products, medical waste and dead animals.

1.1.1 Purpose

The purpose of the *Beneficial Management Practices: Environmental Manual for Dairy Producers in Alberta* is to document, for producers and society, management options that are environmentally sound, comply with existing regulations and are economically feasible.

Due to the variability of local and regional conditions, not all of these practices pertain to any one specific dairy operation. Rather, one or a combination of these, coupled with other alternatives, may provide optimal results.

With the dairy industry's commitment to advancing management practices, as demonstrated in the evolution of dairy production over the past few decades, this manual will be updated as new standards and technologies are adopted.

These guidelines describe beneficial management practices designed to protect the environment and minimize nuisances such as odour, flies and dust.

1.1.2 Use of the guidelines

Dairy producers should use these guidelines to evaluate and improve their current management practices. When seeking a solution to a particular issue, all aspects of environmentally acceptable farm management should be taken into account. It is not recommended that individuals extract portions of this publication without considering the entire environmental context of the operation. Individuals should not assess an operation based solely on this publication.

1.2 Background

As stakeholders in the province's agriculture industry, Alberta's milk producers recognize and fully accept their responsibility to protect the environment. They understand and fully appreciate the need to manage their operations in a manner that will not be detrimental to air, water and soil quality. At the same time, Alberta's milk producers are dedicated professionals and considerate neighbours.

Recognizing that each dairy operation is part of a larger agricultural community, milk producers in Alberta, while striving for maximum efficiency in their farm operations, also strive for minimal effects on the quality of neighbouring environments. They recognize that the best environmental management practices will not only be beneficial to their own farm environments, but to the community as a whole.

Milk producers also recognize the need for improved environmental practices as part of an overall farm management plan. Many Alberta dairy farms are already enrolled in the Canadian Quality Milk Program, part of which requires best management practices for the environment. In conjunction with other agricultural sectors, dairy farmers in Alberta welcome their role as responsible environmental stewards.

1.0

2.0 ENVIRONMENTAL RISKS AND NUISANCE ASSOCIATED WITH LIVESTOCK PRODUCTION

2.0 ENVIRONMENTAL RISKS AND NUISANCE ASSOCIATED WITH LIVESTOCK PRODUCTION

2.1 Air Quality

The three primary sources of odour and air contaminants from dairy production are barns, manure storages and land application of manure. Dust and fumes from increased traffic associated with livestock production can also reduce air quality. The presence of contaminants does not equate to an environment or health risk unless minimum threshold values are exceeded. Air contaminants released from these sources may include: gases, particulate matter (dust), micro-organisms and endotoxins. Gases include ammonia, hydrogen sulphide, methane, sulphur and nitrogen compounds.

Gases and particulate matter are of the greatest concern to people working directly with livestock because they are exposed to the highest concentrations of contaminated air. In general, neighbours are at minimal risk from air contaminants because the contaminants are well diluted and dispersed in the air after travelling very short distances from their source.

2.2 Odour

The primary complaint about livestock operations is odour. Though odour is generally considered more of a nuisance than a health risk to neighbours, because of the degree of dilution and dispersion that occurs within short distances from the odour source, odour's impact on health is uncertain due to the high number of compounds that may be present at extremely low concentrations.

There is a difference between the psychological and physiological health effects related to odour exposure. Psychological effects such as irritation, can result from exposure to odour and often occur at levels well below those that can harm human health. Physiological effects can occur from exposure to specific compounds that make up odour, for example, asphyxiation from exposure to hydrogen sulphide (H_2S) in a confined space.

It is difficult to evaluate odour and its health effects for the following reasons:

- Psychological and physical health effects are not necessarily independent.
- Odour from livestock is made up of about 160 compounds. Humans have many and varied responses to these compounds.
- The proportion and characteristics of odour contributed by each of the primary sources (barns, storages and land application) are not well understood. Research is underway to characterize odours released from each of these sources.
- Odour intensity and offensiveness vary between individuals.
- Combining different odour compounds can have positive and negative effects on odour's intensity and offensiveness. These effects are not easily predicted.

Eliminating all odour from livestock operations is not feasible. However, there are management practices that can control odour within reasonable limits. Odour mitigation practices should strive to reduce the nuisance to neighbours, by minimizing the frequency, intensity, duration and offensiveness of odours.

2.3 Dust

Dust is composed of fine aerosol particles in suspension. These particles are various shapes and sizes and are both inorganic and organic. In animal housing, 70 to 90 percent of the dust is organic. Organic dust includes: dandruff, dried manure and urine, feed, mold, fungi, bacteria and endotoxins (produced by bacteria and viruses). Organic dust is biologically active and may react with the defence system of the respiratory tract. Inorganic dust is composed of numerous aerosols from building materials and the environment (concrete, insulation, soil).

Air quality in livestock facilities can affect the health of humans and animals if they are exposed to high concentrations of dust. Exposure to fine particles (less than 10 microns) of dust can cause eye and throat irritation and can potentially contribute to respiratory conditions such as asthma or chronic bronchitis. In barns with a high concentration of dust, workers should wear dust masks.

Dust and particulate matter exhausted from livestock facilities may not represent a direct health risk to neighbours because the survival rates of airborne micro-organisms are considered very low and the dilution factor of the air high. However, airborne particulate matter can contribute to odour.

2.4 Gases

Gases emitted from livestock operations may have an impact on global warming, acid rain and water quality. These gases can be generated in the barn, during manure storage and land application. Odour release from manure depends on the type of storage (liquid or solid), agitation frequency and manure spreading. Typical gases include ammonia, hydrogen sulphide, methane, sulphur, nitrogen compounds and several trace gases associated with odour. The properties and effects of these gases are shown in Figure 2.1.

Global warming refers to the increase in the earth's atmospheric temperature, which many scientists believe is a result of an increase in the concentration of "greenhouse gases." Water vapour, carbon dioxide (CO_2), methane (CH_4), halocarbons (used in refrigerants) and nitrous oxide (N_2O) are the main greenhouse gases in the atmosphere. Increases in all of these gases, except water vapour, are believed to be responsible for global warming.

The livestock industry in Alberta contributes approximately one percent of Canada's total greenhouse gas emissions. The bulk of agriculture emissions are nitrous oxide and methane. The majority of emissions from dairy production come from manure. Although the intensity and offensiveness of an odour may be high, it is not necessarily an indication of the presence of greenhouse gases. Research is required to establish the relationship between greenhouse gases and odours.

2.0

Figure 2.1 **Properties and Effects of Gases Emitted from Dairy Production**

Gas	Source	Properties	Health Effect		Environmental Effect
			Concentration	Symptom	
Ammonia (NH_3)	• manure decomposition, composting, commercial fertilizer and manure handling, storage application	• sharp, pungent odour (like glass cleaner) • lighter than air	**25 ppm** 2 – 6 ppm 20 – 30 ppm 40 – 200 ppm 3,000 ppm 5,000 ppm	• **Acceptable TLV*** • detectable but not considered a risk to public health • burning eyes • headaches, nausea, respiratory irritation • asphyxiating • could be fatal	• contributes to the formation of airborne particulates • may react with other compounds, potentially leading to acid rain and ozone depletion • soil and water acidification • contributes to odour
Hydrogen sulphide (H_2S)	• bacterial decomposition in manure without oxygen (anaerobic)	• heavier than air • accumulates near the floor in enclosed buildings • initially a rotten egg smell, but lethal concentrations paralyze sense of smell	**10 ppm** 2 ppm 20 ppm 50 ppm >500 ppm	• **Acceptable TLV** • detectable • paralyzes sense of smell • dizziness, nausea, headache, respiratory irritation • death from respiratory paralysis in seconds	• may react with other compounds, potentially leading to acid rain
Methane (CH_4)	• decomposition of manure without oxygen (anaerobic)	• no smell • lighter than air	50,000 ppm 500,000 ppm	• explosive when mixed with air • can cause headaches and eventually asphyxiation when oxygen is displaced	• a greenhouse gas that may contribute to global warming
Carbon dioxide (CO_2)	• anaerobic and aerobic decomposition of organic materials • plant and animal respiration • combustion of fossil fuels	• no smell • heavier than air	**5,000 ppm** 30,000 ppm 40,000 ppm 100,000 ppm 300,000 ppm	• **Acceptable TLV** • increased rate of breathing • drowsiness, headache • dizziness, unconsciousness • could be fatal in 30 minutes	• a greenhouse gas that may contribute to global warming • removed from the air by photosynthesis • stored in soil and oceans
Nitrogen oxides** (NO_x)	• NO_x naturally generated by bacterial processes, decomposition and fires • humans contribute primarily through burning fossil fuels	• NO and N_2O are colourless, NO_2 is reddish brown • NO_2 is the most common of NO_x and is one of the main components of smog		• NO_x not very soluble so symptoms may be delayed. Effects include respiratory irritation, coughing, fever and, in extreme situations, respiratory failure.	• potentially toxic to plants, leading to reduced growth • NO_x are the most potent greenhouse gases emitted by agriculture • may deplete ozone
Trace gases associated with odour	• anaerobic decomposition of manure	• often have distinct smells	• in low quantities, these compounds are not considered a serious threat to human health		• contributes to odour • may form airborne particulates

* Threshold Limit Values (TLV) are exposure limits that serve as guidelines to control health hazards in work environments. Alberta Occupational Health and Safety Association establishes these values.

** Nitrogen oxides (NO_x) include nitric oxide (NO), nitrogen dioxide (NO_2) and nitrous oxide (N_2O) (laughing gas).

2.5 Pesticides

Pesticides include insecticides, herbicides, fungicides and rodenticides. Pesticides can be a risk to non-target organisms, applicators and workers, if these products are not handled and applied properly. During pesticide application, spray droplets, mists or vapours may form. These airborne particles can drift and contaminate adjoining properties and water. Soil pollution can occur when pesticides are applied using improper application methods or rates, when disposal protocols are not followed and during spills. Storing large amounts of pesticides increases the potential for a significant pesticide spill to occur.

Pesticide mismanagement can eliminate beneficial insects, inhibit crop growth and reduce viable crop varieties. Depending on toxicity and dose of the pesticide, domestic animals and wildlife may be harmed by eating crops or soils that have had a pesticide application. Some pesticides may accumulate in plant and animal tissue and may make food unfit for human consumption. Pesticides, when misused, have great potential to pollute both surface and groundwater. Water pollution from pesticides can be the result of drift, runoff, leaching, erosion of contaminated soil, spills and direct introduction. The severity of pesticide contamination depends on the pesticide toxicity, dose applied and how the risk is managed.

2.6 Pharmaceuticals

A range of pharmaceutical products, including antibiotics, dewormers and reproductive hormones are used in the dairy industry. Most of these products are completely broken down in the animal's body and do not present a risk to the environment. However, concern has surfaced that some of these products could find their way from livestock manure into the environment and have a negative impact on the ecosystem. Two specific areas of concern are:

- Reproductive hormones that can act as endocrine disruptors. Endocrine disrupters are chemicals that affect the function of the body's endocrine system. They may cause health problems, reproductive failure and developmental abnormalities in both humans and wildlife. There are many sources of endocrine disruptors in the environment, including phytoestrogens (from plants), mycotoxins (from molds) and man-made chemicals that imitate certain hormones.
- Antimicrobials, such as sulfamethazine, that are excreted into the environment in an active form. This could potentially alter the population of bacteria in the environment or select for the development of drug-resistant bacteria.

There is little evidence to confirm that reproductive hormones and antimicrobials are significant issues at this time. The risk to the environment from pharmaceuticals is low. Drug residues are excreted at very low levels, and are then diluted with water and manure from other untreated animals. It is further diluted when the manure is spread on the land. Because the amount of drug present is extremely small, the concentrations in manure may not be high enough to have any effect on animals that come in contact with it. Thus far, there has been no evidence that residues from pharmaceuticals used in dairy production have created problems with the health of humans, wildlife or the environment. Research is ongoing to evaluate the potential environmental risk associated with certain antimicrobials and reproductive hormones.

2.0

2.7 Pathogens

Currently in Alberta, dairy cattle manure is not considered a major source of infectious disease for humans or livestock. There are three main reasons for this. First, many infectious diseases that occur in the rest of the world are not found here. Second, modern production practices and drinking water supply systems prevent many diseases from being transmitted. Third, the density of dairy cows in the province is relatively low.

Dairy manure contains a wide range of micro-organisms, including bacteria, viruses and parasites. Under certain conditions, some of these can cause disease in humans or livestock. Many of these organisms are also present in the feces of other livestock, pets, wildlife and in human sewage.

In recent years, many large outbreaks of waterborne disease have occurred in humans in North America. The increase in intensive livestock production has often been blamed. While it is not yet known how much of the problem can be attributed to agriculture, two things are certain – poorly handled manure can result in waterborne disease in humans, and other sources of contamination, such as human sewage, are also responsible. It is critical that manure be handled appropriately to minimize the risk of disease to both livestock and humans.

2.7.1 How disease is transmitted from manure

Disease-causing micro-organisms are referred to as pathogens. Manure pathogens are most often transmitted by the fecal-oral route (i.e. ingestion of manure or manure-contaminated feed or water). In livestock, this can occur through consumption of drinking water contaminated by manure, grazing on pasture recently spread with manure or when livestock have direct access to manure. Humans can ingest manure pathogens through consumption of contaminated drinking water, swimming in contaminated surface water or not washing hands after handling infected livestock or manure. Diseases that can be transmitted from animals to humans are referred to as zoonoses or zoonotic diseases. People most at risk of zoonotic disease are those working in barns or handling manure.

There are no diseases in Alberta that can be transmitted to humans or livestock through the air from dairy manure. The odour of dairy manure alone cannot cause infectious disease. Contamination of surface water is the main public health concern when handling manure. In order for manure pathogens to cause disease through water contamination, several steps need to occur. If any one of these steps is blocked, then transmission will not occur.

- First, the pathogen must be excreted by the cow. Not all pathogens are found in every barn, and most can be reduced by management or medication.
- Second, the pathogen must reach a water supply either by the animal defecating directly in the water, or by manure entering surface runoff or leaching to groundwater.
- Third, the pathogen must remain alive and capable of causing infection until the time it is ingested. Heat, cold and dryness can destroy many pathogens in a short period of time.
- Fourth, the pathogen must be ingested in high enough numbers to cause infection. Some organisms, such as *Salmonella*, must be ingested in very high numbers to cause disease, whereas only a few *Escherichia coli* O157:H7 bacteria may cause disease.

Often it is difficult to determine the source of a waterborne disease outbreak. Many of the same disease-causing micro-organisms are found in wildlife, birds, pets and human sewage. Therefore, if testing finds the suspect organism in one location, it cannot be automatically assumed this was the source. Testing many sources and using new diagnostic techniques to determine the strain of the organism are usually necessary to pinpoint the source of disease. Refer to Section 10.2 for a full description of pathogens that may be present in dairy manure in Alberta.

2.8 Soil Erosion, Compaction and Salts

Soil erosion refers to the loss of soil due to wind or water. Erosion potential depends on management practices and the specific topography, climate and soil type of a region. Water erosion can be the result of surface runoff from rainfall or irrigation. Wind erosion occurs when soil is not adequately covered. Wind and water erosion can cause environmental problems if soil nutrients or fine-grained material, such as silt and clay, enter water bodies.

To avoid soil erosion when applying and incorporating manure, a balance must be achieved among incorporation techniques, tillage and timing. Incorporating manure prevents nutrient losses and mixes organic matter in manure with soil. Mixing organic matter with soil increases the binding of soil particles and can reduce the potential for erosion. However, excessive tillage leads to compaction, decreases soil porosity and destroys soil structure and aggregate characteristics. This reduces the movement of water, air, nutrients and soil microbes through the soil. Timing manure application to avoid application on wet soil is critical to reduce soil compaction. Farm traffic, especially on headlands, can cause soil compaction, particularly when the soil is wet.

Excess salt levels, as shown by electrical conductivity measurements and sodium adsorption ratios, can increase in soils after successive manure applications. Manure can contain salts from the water used for livestock watering or from salts and minerals in feed. In many cases, salt levels are more likely to limit manure application on fields than nutrients such as nitrogen and phosphorus. Sodium, in particular, can cause problems with the soil, since it can cause structural changes in the soil and is toxic to plants at high levels.

2.9 Excess Nutrients

Spills, improper storage and over-application of fertilizers or manure may lead to excess nutrient concentrations in soil. Primary nutrients of concern are nitrogen, phosphorus and potassium. Excess nitrogen and phosphorus can cause soil and water quality problems. Excess potassium on forages can result in reduced feed quality. An overabundance of these nutrients can result in toxicity to plants and reduce crop yields. As well, nutrients that are not used by plants can leach out of the root zone and contaminate groundwater or run off to surface water.

2.9.1 Excess nutrients and water

Surface water. Elevated nutrients in watercourses can be caused by manure or fertilizer entering a watercourse directly, by runoff from fertilized fields or by nutrient-rich soil eroding from croplands. Nutrients, primarily phosphorus and nitrogen, accelerate eutrophication of water bodies. Eutrophication is the nutrient enrichment of surface waters. The most visible effects of eutrophication are massive blooms of algae and other aquatic plants. When algae and aquatic plants die, oxygen can be depleted, reducing fish survivability. Blue-green algae can be toxic to domestic animals and humans when ingested and can deplete oxygen levels in surface waters.

Nitrates in drinking water. Nitrate is formed through the nitrification process from the mineralization of organic nitrogen to ammonium and from ammonium to nitrate. Nitrate is a form of inorganic nitrogen that is soluble in water and is readily used by plants. Nitrate is very soluble in water and tends to quickly move down through the soil profile. Consequently, nitrate can concentrate in shallow groundwater.

Sources of nitrate in water include natural sources (e.g. peat bogs), commercial fertilizers (e.g. anhydrous ammonia), domestic sewage systems and manure. Studies in Alberta have shown that high levels of nitrate from livestock and land application of fertilizer or manure can be transported in surface runoff.

The established drinking water quality, Maximum Acceptable Concentration (MAC), for nitrate is 45 mg/L measured as nitrate (10 mg/L measured as nitrate-nitrogen). Nitrate levels below 45 mg/L do not appear to cause health problems. Above this level, however, there may be health concerns, particularly for pregnant women and for infants less than one year old, although this has rarely been reported.

Groundwater. Groundwater is the water that occurs in the pore spaces of soil and rocks. Aquifers are water-bearing layers that hold water in usable amounts. Typical aquifers are overlain by deposits of clay or shale. Unconfined aquifers occur when the groundwater is directly exposed to the atmosphere through openings in the soil. As a result, the risk of contamination to unconfined aquifers is great. Over-application of nutrients can result in nutrient leaching directly into the groundwater.

A confined aquifer is trapped below an upper confining layer of rock, clay or shale. The risk of contamination for confined aquifers is through direct movement of contaminants into the well from the wellhead or improperly maintained well casing. Manure seepage and chemical spills or seepage into the well should be prevented.

Seepage from improperly constructed or maintained manure storage structures and the associated risk of groundwater contamination is a serious concern in some areas, particularly where the subsoil underlying the storage consists of sand, gravel or fractured bedrock that allows movement of contaminants through the soil profile to shallow groundwater.

Over-application of manure on cropland or forage land can also present a risk of elevated nitrate levels in shallow groundwater. Studies in Alberta have shown that continuous over-application of manure can increase nitrate levels in shallow groundwater.

2.10 Other Water Concerns

Metals. Metals of concern include nickel, manganese, lead, chromium, zinc, copper, iron and mercury. Trace quantities of some metals are necessary for the growth of living things. However, even low metal concentrations can interfere with how the water is used. Elevated metal levels are toxic to most life forms. Metals are found in manure, waste oil and hydraulic fluids. Elevated metal concentrations can kill fish or accumulate in their tissues, making them unfit for human consumption.

Petroleum products. Gasoline, antifreeze, paints, solvents, hydraulic fluids and other oil-based substances can have direct and indirect harmful effects to groundwater and surface water. Direct adverse effects include the immediate toxic contamination of aquatic organisms that ingest petroleum products and interference with respiration in fish. Indirect negative effects include the destruction of fish food such as algae and other plankton, devastation of spawning areas, a reduction in the rate of photosynthesis by aquatic plants and poor stream aeration. Also, petroleum products can taint the flavour of fish, affecting its quality for human consumption.

2.11 Nuisance

Odour, noise, and traffic related to agriculture production are potential nuisances to the surrounding community if not managed property. Noise and traffic are inevitable, but beneficial management practices discussed throughout the following chapters may minimize the irritation to neighbours.

3.0 ENVIRONMENTAL OBLIGATIONS AND REGULATORY APPROVALS FOR LIVESTOCK PRODUCERS

3.1 Environmental Law Relating to Dairy Production – Environmental Protection Standards

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3.0 ENVIRONMENTAL OBLIGATIONS AND REGULATORY APPROVALS FOR LIVESTOCK PRODUCERS

The environmental obligations of existing dairy producers and the regulatory approval requirements for new and expanding operations are discussed in detail in the sections below.

Meeting environmental obligations requires an awareness of environmental law. The environmental obligations of a livestock producer are set out in statutes enacted by the provincial and federal legislatures, and through the common law, which is the body of law and rules established by the courts. The statutes that producers should be aware of include the *Agricultural Operation Practices Act* (AOPA), *Alberta Environmental Protection and Enhancement Act,* the *Public Health Act,* the *Livestock Diseases Act,* the *Water Act,* and the federal *Fisheries Act.* Livestock producers should also be informed of the common law rules of nuisance and how these rules are affected by AOPA.

The approval and siting process for the development and expansion of dairy operations can be time consuming and complicated. An increased awareness of this process can assist producers in planning for the development or expansion of their operations. Prior to January 1, 2002, the approval process for dairy operations was governed by the *Municipal Government Act,* municipal development plans, land-use bylaws and Alberta Agriculture, Food and Rural Development's *Code of Practice for Safe and Economic Handling of Animal Manures* (Code of Practice), the *Water Act,* and, potentially the *Public Highways Development Act.* Since January 1, 2002, primary responsibility for dairy operation approvals has been transferred from municipalities to the provincial Natural Resources Conservation Board (NRCB) under AOPA. (Additional information on the site selection and planning approval process is described in Section 5.0.)

3.1 Environmental Law Relating to Dairy Production – Environmental Protection Standards

A. ALBERTA LEGISLATION

3.1.1 Agricultural Operation Practices Act (AOPA)

AOPA establishes specific environmental protection standards for new and existing dairy operations.

3.1.1.1 Environmental Protection Standards

The Act and the Standards Regulations describe the specific standards that producers should understand.

The Act authorizes the NRCB to issue an enforcement order against a producer if the NRCB is of the opinion the producer is:

- Creating a risk to the environment.
- Causing an inappropriate disturbance.
- Contravening the Act or regulations.

3.1.1.2 Design and operating standards

The regulations describe the design and operating standards for livestock operations. Some of the standards apply to new and expanding operations, while others apply to all operations, including existing operations.

Manure management. The regulatory requirements for manure management apply to both existing and new operations. Producers are required to have sufficient land base to safely utilize manure. The regulations contain tables for determination of land base. It is an offence to exceed the nitrate-nitrogen limits of the regulations and the soil must be tested prior to application of manure if more than 300 tonnes are being applied annually.

Manure must be incorporated into the soil within 48 hours of application to the land. The regulations allow exemptions where the manure is being used on a forage or direct-seeded crop. It also allows for restricted manure application on frozen ground where the land is flat and additional setbacks are maintained.

General setbacks for manure spreading are as follows:

- No manure is to be applied within 30 metres of a water well.
- A minimum of 10 metres separation must be maintained from a body of water where manure is being applied by subsurface injection and 30 metres where manure is applied by incorporation.

Manure storage. The regulations contain requirements for the design and location of earthen storage and catch basins for the storage of liquid manure for new and expanding operations. The regulations state that if a producer uses earthen storage for liquid manure, the earthen storage must be able to hold nine months of storage and must be constructed of such compaction to achieve a hydraulic conductivity of not more than 1×10^{-6}cm/sec. In addition, the regulations require that the side slopes be constructed according to the stability of the soil. The regulations outline specific slope standards.

With respect to the suggested location of earthen storage and catch basins, the regulations require that producers:

- Avoid areas with a shallow water table.
- Maintain a minimum of 100 metres setback from a spring or water well and 30 metres from a body of water.
- Prevent surface water from entering the lagoon or catchment pond.
- Install a leakage detection system to monitor for potential contaminants.
- Implement fly control measures.
- Design for the bottom filling of the lagoon.
- Control access to the area and place warning signs.

Minimum Distance Separation (MDS). A MDS is required between new or expanding operations and their neighbours. The setback distances depend on the size of the new or expanding operation and the type of neighbour. The setback distances are measured from the portion of the operation closest to the neighbouring residence. For the purpose of measurement, the facility's manure storage is considered to be part of the operation.

The MDS does not apply to residences owned or controlled by the producer. It also does not apply where the neighbours themselves operate livestock operations and waive, in writing, the MDS.

Records. The regulations require producers to keep records of any documents that were used to obtain approvals. In addition, producers are required to keep the following records if they apply more than 300 tonnes of manure per year:

- Volume or weight of manure produced.
- Legal description of the land to which the manure was applied.
- Date and volume of manure applied to land.
- Application rates and incorporation methods used.
- Information on any person the producer gave manure to if more than 300 tonnes was given.

Producers are required to keep copies of these records for five years.

3.1.2 Environmental Protection and Enhancement Act

3.1.2.1 Prohibited releases

The *Environmental Protection and Enhancement Act* (EPEA) prohibits producers from releasing into the environment a substance in an amount, concentration or level, or at a rate of release, that causes or may cause a significant adverse effect on the environment. While "significant" is not defined in EPEA, "adverse effect" is broadly defined to mean the "impairment of, or damage to, the environment, human health or safety or property." This means that a producer cannot release or spread manure if the release or spreading of manure may cause a significant adverse effect to the environment. That is, if a producer spreads manure on land at a rate which will overload the nutrient value of the land, or if a producer releases manure on land where the manure will run into a watercourse, the producer will be in violation of EPEA.

EPEA also gives the government the power to issue an environmental protection order to an individual responsible for the release of an offensive odour, and to order that individual to, among other things, prevent, minimize or remedy the offensive odour or destroy the cause of the odour. However, these powers do not apply to offensive odours that result from an agricultural operation that is carried on in accordance with "generally accepted practices" for that operation. There is no definition of "generally accepted practices" for similar agricultural operations. Whether a producer is following "generally accepted practices" will be decided by the Environmental Appeal Board or a judge.

3.1.2.2 Duty to report

EPEA requires producers to report to Alberta Environment any releases that may cause an adverse effect on the environment. Failure to report a release can result in significant fines.

Typically, when a producer reports a release, Alberta Environment will require the producer to identify the steps that the producer is taking to prevent harm to the environment and to prevent the release from reoccurring.

3.1.2.3 Liability of directors and officers

If a corporation violates EPEA, any officer, director or agent of the corporation who was involved with the incident, even in a minor way, could face prosecution. This applies whether or not the corporation itself is prosecuted for the violation and regardless of whether the officer, director or agent works for a large corporation or simply a small incorporated family farm. This means that an officer, director or agent of a corporation is held personally responsible for violations of EPEA, if the officer, director or agent directed or participated in the violation in any way.

3.1.2.4 Strict liability offences

Offences under EPEA are "strict liability" offences. Unlike criminal offences, with strict liability offences, the courts are only concerned with whether the producer committed the offence, not whether the producer intended to commit the offence. If a producer caused impairment to the environment by releasing manure into a watercourse, the courts will not examine whether the producer meant to cause the impairment; the courts will only determine whether the producer caused the impairment.

If the producer did cause the impairment, the courts will convict the producer unless the producer can show that the action was in accordance with "due diligence" in running the operation and in carrying out the activity at issue. That is, if the producer can show that all reasonable steps were taken to prevent the contravention of EPEA, the producer will not be found guilty.

3.1.2.5 Fines

An individual is liable for a fine of not more than $50,000 for each offence under EPEA and a corporation is liable for a fine of not more than $500,000 for each offence. Each day that a release or impairment occurs is treated as a separate offence. For example, a release from a lagoon occurring over two days would be treated as two offences and expose the corporation to a maximum fine of $1,000,000.

3.1.3 Public Health Act

It is important for producers to be aware of the responsibilities regional health authorities have under the *Public Health Act* (PHA). The PHA gives health authorities significant powers to protect the public health. The PHA has priority over all provincial statutes, except the *Alberta Bill of Rights.*

The PHA allows a regional health authority, if it has reasonable and probable grounds to believe that a nuisance exists, to enter onto property, to inspect the property, take samples of any substance or equipment being used and perform tests at the property. The PHA defines "nuisance" as:

> "a condition that is or that might become injurious or dangerous to the public health, or that might hinder in any manner the prevention or suppression of disease."

In order for the regional health authority to enter the private place to perform these inspections and tests, the regional health authority requires either the consent of the owner, or a court order allowing these activities to occur. If the owner does not give consent to the regional health authority and the regional health authority applies to the courts to obtain an order, the PHA provides the judge with the authority to grant such an order without requiring the owner to have prior notice of the court application. Once the inspection, testing or taking of samples has occurred, if the regional health authority has reasonable and probable grounds to believe that a nuisance exists, the regional health authority can order the property to be vacated, declared unfit for habitation, closed or destroyed. In addition, the regional health authority has the authority to prohibit or regulate the selling of any livestock from the property.

As a result, should a regional health authority become aware of a public health hazard at a dairy operation, the regional health authority can take steps to protect the public health and have the health hazard eliminated. In addition, if an operator contravenes the regional health authority's orders, that operator is liable to a fine of not more than $100 for each day the contravention continues.

3.1.4 Livestock Diseases Act

The *Livestock Diseases Act,* through its regulations, requires that the owner of a dead animal dispose of the dead animal within 48 hours of death, by:

- Burying it with a covering of at least four feet of earth.
- Burning it.
- Transporting it to a rendering plant for disposal.
- Scavenging under very restricted circumstances.

If a producer fails to properly dispose of the dead animal, the producer is in violation of the *Livestock Diseases Act* and liable to a fine of not more than $10,000 or to imprisonment for a term of not more than one year or to both a fine and imprisonment. Producers should review *Destruction and Disposal of Dead Animals Regulations* for specific disposal standards.

B. FEDERAL LEGISLATION

3.1.5 Fisheries Act

3.1.5.1 Deleterious substance

Under the Canadian Constitution, the federal government has jurisdiction over the protection of fish habitat. To protect fish habitat, the federal government has enacted the *Fisheries Act.* The *Fisheries Act* prohibits anyone from depositing or permitting the deposit of anything into any type of water frequented by fish, which can have a "deleterious" or harmful effect on the fish. Further, the *Fisheries Act* prohibits anyone from depositing a "deleterious" or harmful substance in any place under any condition where the deleterious or harmful substance may enter any water frequented by fish. The *Fisheries Act* defines the phrase, "water frequented by fish" very broadly to include all internal waters of Canada. Therefore, this definition includes any creek, river, stream, lake or slough which is frequented by fish, including any creek which contains minnows in the spring, but dries later in the summer.

As a result, a producer commits an offence under the *Fisheries Act* when he spreads manure on land located near a stream frequented by fish and the manure migrates into the stream. The offence results even if the deposit of the manure does not actually cause harm to the fish. The mere fact that the manure migrated into water frequented by fish causes a violation of the *Fisheries Act* and may result in charges under this Act, unless the producer can prove that at all material times, the water is not, has not been, and is not likely to be frequented by fish.

In addition, a producer commits an offence under the *Fisheries Act* if he spreads manure on land which has a stream frequented by fish, even if the deposit of the manure does not in fact enter the water, but had a reasonable chance of entering the water. The mere fact that the manure had a reasonable chance to enter water frequented by fish violates the *Fisheries Act* and may result in charges under this Act. However, again, if the producer can prove that, at all material times, the water is not, has not been and is not likely to be frequented by fish, then the producer has not committed an offence under the Act.

3.1.5.2 Liabilities of directors and officers

If a corporation violates the *Fisheries Act,* any officer, director or agent of the corporation who was involved with the incident, even in a minor way, is liable on conviction to punishment under the *Fisheries Act,* whether or not the corporation itself has been charged. This is true regardless of whether the officer, director or agent works for a large corporation, or a small incorporated family farm. This means that, as with the *Alberta Environmental Protection and Enhancement Act,* an officer, director, agent or a corporate producer can by held personally responsible for violations of the *Fisheries Act,* if the officer or director directed or participated in the violation in any way.

3.1.5.3 Strict liability offences

As with the *Alberta Environmental Protection and Enhancement Act,* offences under the *Fisheries Act* regarding the deposit of deleterious substances or harmful substances into water frequented by fish are "strict liability" offences. That is, the courts are not concerned with whether the deposit of deleterious or harmful substances was intentional. The courts are only concerned as to whether a producer deposited a substance into any type of water frequented by fish where the substance could have a deleterious or harmful effect on the fish. In addition, the courts are only concerned with whether a producer deposited a deleterious substance in any place under any condition where the deleterious substance may enter any water frequented by fish. If a producer has performed either of these activities, the courts will convict the producer unless the producer can show that:

1) at all material times, the water is not, has not been and is not likely to be frequented by fish;
2) the producer acted with due diligence to prevent the commission of the activity at issue; or
3) the producer reasonably and honestly believed in the existence of the facts that, if true, the producer's conduct would be rendered innocent.

3.1.5.4 Fines

An individual or corporate producer is liable to a fine not exceeding $1,000,000 for the producer's first deleterious substance offence and to a fine not exceeding $1,000,000 or to imprisonment for a term not exceeding three years, or to both for any subsequent deleterious substance offence.

3.1.6 Due diligence and environmental management systems

3.1.6.1 Due diligence

In order to avoid a conviction under the *Alberta Environmental Protection and Enhancement Act* and the federal *Fisheries Act,* a producer must have acted with due diligence in running the operation and in carrying out the activity at issue.

Whether a producer acted with due diligence in any particular circumstance will be determined by the courts on a case-by-case basis. Generally, the courts have indicated that to act with due diligence, one "must take all reasonable steps to avoid harm. However, that does not mean [one] must take all conceivable steps."[1] In addition, the courts have established that, "reasonable care and due diligence do not mean superhuman efforts. They mean a high standard of awareness and decisive, prompt and continuing action."[2] In considering whether an accused acted with due diligence, the courts "...examine what was done, what controls were in place, what was the state of technology that existed through the evidence of lay and expert witnesses to determine if the accused acted reasonably in the circumstances."[3]

1. R. v. British Columbia Hydro and Power Authority [1997] B.C.J. No. 1744, paragraph 55.
2. R. v. Courtaulds Fibres Canada (1992) 9, C.E.L.R. (N.S.) 304 at 313 (Ont. Prov. Ct.).
3. R. v. Northwood Pulp and Paper (1992) 9, C.E.L.R. (N.S.) 289 at p. 293.

A court may examine the following points to determine whether environmental due diligence has been exercised:

(a) Did the livestock operation establish and monitor its pollution prevention system? For example, is there a reasonable nutrient management plan for the operation?
(b) Did the livestock operation ensure that it instructed employees to:
    (i) set up a pollution prevention system in order for the operation to comply with the industry practices and environmental laws, i.e. the Code of Practice and the permit conditions?
    (ii) report to the manager if the livestock operation was not complying with the system? For example, if soil-testing analysis indicated high nitrate levels, making it dangerous to apply more manure, was management told?
(c) Did the livestock operation review the environmental compliance reports provided by the operation's officers? Is there an annual review of the report and system?
(d) Did the livestock operation ensure that its officers and employees promptly addressed environmental concerns brought to its attention by government agencies or other concerned parties? Was the problem fixed?
(e) Was the livestock operation aware of the industry standards regarding environmental pollutants and risks?
(f) Did the livestock operation address problems immediately and in a timely fashion?[4]

In addition, a court may examine whether a corporation has an environmental management system, what the environmental management system contains, how detailed it is, and whether it is followed by the company, to determine whether the company acted with due diligence in carrying out the activity in question.

3.1.6.2 Environmental management systems

Environmental management systems are used by corporations to establish and implement policies and procedures for operating an environmentally sustainable business. An environmental management system will examine the corporation's operations to determine:

- How these operations impact the environment.
- What policies and procedures can be implemented to lessen or eliminate the operation's environmental impacts.
- What environmental standards and laws the corporation must follow.
- Whether the corporation is following these standards and laws.

The environmental management system will then put into place the policies and procedures to reduce the livestock operation's environmental impacts and to properly train the corporation's employees to meet and maintain the applicable environmental standards and laws. Finally, an environmental management system will provide for a periodic re-evaluation of these environmental policies and procedures.

Producers adopting an environmental farm plan are taking the preliminary steps toward development of an environmental management system.

4. R. v. Bata Industries Ltd. [1992] O.J. No. 236 at page 24-25 (Ont. Prov. Div) online: QL (O.J.), rev'd in part on other grounds 14 O.R. (3d) 354, rev'd in part on other grounds 127 D.L.R. (4th) 438.

3.1.7 Common law of nuisance and the Agricultural Operation Practices Act

The common law of nuisance is an individual's unreasonable interference with a neighbour's use and enjoyment of the neighbour's land. If a producer unreasonably interferes with the use and enjoyment of a neighbour's land by creating offensive odours, excessive noise or dust, or the presence of flies, the courts may force the producer to pay damages to the neighbour to compensate the neighbour for the nuisance and potentially could force the producer to shut down.

However, the Alberta government enacted AOPA to offer protection to producers from nuisance claims, as the government recognized that farms would typically produce some odours, noise and dust. AOPA states that a producer will not be liable in court for any nuisance resulting from the producer's operation, nor will the producer be prevented from carrying on its operation by a court injunction or order, if the producer has not contravened the local land-use bylaw and has followed "generally accepted practices for similar agricultural operations." The act defines a "nuisance" to include an activity which:

- Arises from unreasonable, unwarranted or unlawful use by a person of the person's own property, which causes obstruction or injury to the right of another person or to the public and produces such material annoyance, inconvenience and discomfort that damage will result.
- Creates smoke, odour, noise or vibration which interferes with the reasonable and comfortable use of a person's property.
- Is found to be a nuisance at common law.

The determination of "generally accepted practices for similar agricultural operations" is determined by a peer review board appointed by the Minister of Agriculture, Food and Rural Development.

3.1.8 Common law of negligence

In law, an individual is negligent if he fails to live up to a "duty of care" he owes to another individual. A "duty of care" is a duty held by one individual to avoid carrying out an activity that has a reasonable chance of causing harm or injury to another individual. Of course, it is impossible for any individual to avoid all activities that might harm another individual. Therefore, the law sets standards of conduct that must be met. The standard is one of reasonableness – the individual must behave in the way that a reasonable individual of ordinary intelligence and experience would behave in the same circumstance. How an ordinary individual would behave depends on factors such as the degree of harm that might occur and standard industry practices.

A dairy operator has a duty to operate in such a manner as to not cause harm to those individuals who could reasonably suffer harm if the operator does not act reasonably in running the operation. For example, an operator may be negligent if:

- The operator spreads manure on frozen land that has a heavy slope towards a creek.
- The creek becomes contaminated from manure spread during the spring runoff.
- The operator knew or ought to have known that neighbours receive their domestic water supply from the creek.
- The operator's neighbours become sick from the contamination.

In this situation, the "reasonable" operator would know or ought to have known that spreading manure on these lands with these conditions could result in the neighbours suffering harm. As a result, the livestock operator could be held liable for the harm or injury suffered by the neighbours.

3.2 Regulatory Approvals for Dairy Operations

3.2.1 Provincial approvals

Prior to January 2002, producers obtained approvals to build or expand a livestock operation from municipal governments through the issuance of a development permit.

The approval of livestock operations has been transferred to the Natural Resources Conservation Board (NRCB), under AOPA, development permits are no longer required.

Under AOPA, an "Approval" is required to build or expand dairy operations where milking cows, including replacements and dries, total 200 or more.

Producers building or expanding to a size below this number is required to obtain a "Registration." A Registration can be obtained from the NRCB through a review and approval process. In addition, producers seeking to build or modify a lagoon or manure storage on an existing operation are required to obtain an "Authorization" from the NRCB.

3.2.1.1 Natural Resources Conservation Board approval process

The NRCB approval process is illustrated in Figure 3.1.

The NRCB requires producers seeking an approval to provide the NRCB with the following:

1) Name, address and telephone number of the applicant.
2) A list of the persons who live close to the proposed site and who may be affected by the operation.
3) An evaluation of whether the application is consistent with the applicable municipal development plan.
4) Engineering plans for manure storage facilities, manure collection area and contamination management.
5) Hydro-geological assessments.
6) Numbers and species of livestock and stage of animal development of the livestock that will be at the confined feeding operation.
7) Legal description of the land on which the confined feeding operation is located.
8) A site plan, to scale, showing the location of all:
   i) Water bodies.
   ii) Water wells.
   iii) Property lines.
   iv) Residence locations of affected persons.
   v) Barns, corrals and pens.
   vi) Manure storage facilities and manure collection area.
   vii) Run-on and runoff controls.
9) An explanation of how the operation or expansion and its operation will meet the requirements of the regulations under the Act.
10) The legal description of the land where manure is to be spread for the first three years of the operation.
11) A nutrient management plan.

Once an application is deemed complete, notice of the application is advertised in the local newspaper or notices are sent to those in the area of the proposed site.

Anyone wishing to comment on the application has 20 days to file a written statement of concern. The NRCB reviews the concerns and, if there is merit to the concerns, forwards the statement to the producer. The producer then has an opportunity to respond to the statement of concern.

Once the NRCB is satisfied that the statement of concern has been addressed and the requirements of the Act and regulations have been met, the Board can issue an Approval for the project.

Those persons who filed a statement of concern and who were found to be directly affected by the project are given notice of the Approval and provided an opportunity to request that the Board review the Approval.

The NRCB will convene a review hearing at which the Approval with either be upheld or refused.

Figure 3.1 **NRCB Approval Process**

1. One Window Contact

Producer will learn what type of NRCB and other required provincial approvals and information are required.

2. Preparation of Application

Producer designs project, conducts studies and completes and submits a two-part application form that addresses all required provincial approvals and dispositions.

3. Application Deemed Complete

NRCB Approval Officer determines that application is complete and submits it to Alberta Environment and other agencies for confirmation that it contains all the required information. Applicant may be required to submit additional information.

4. Notice of Application

Affected parties are notified of the application. For registrations and authorizations, only the applicant and the municipal government are notified. For approvals, potentially affected parties are notified by letter or public notice and are asked to provide written statements of concern (SOC) that explain how they would be directly affected. If an approval is required under the *Water Act*, a joint notice or a separate notice may be required.

5. Technical Review

NRCB, Alberta Environment and other relevant agencies conduct technical reviews to determine whether the application meets the requirements of relevant legislation, regulations and standards. Copies of the application may also be submitted to regional health authorities and other agencies for their views on the application.

6. Review Statements of Concern

Approval Officer shares SOCs with Alberta Environment and other relevant agencies and determines which parties would be directly affected. The applicant is given the opportunity to address outstanding concerns.

7. Approval Officer's Decision

Approval Officer determines whether the application contravenes any of the regulations, standards or the municipal plan and then considers the SOCs and other information to determine whether the application can be approved. Application can be denied or approved with appropriate conditions.

8. Application for Board Review

Parties can seek Board review of any of Approval Officer's decision by submitting a letter within 10 working days of receiving that decision. If no concerns are received, the decision stands.

Water Act and Other Approvals Issued

Alberta Environment and other relevant agencies will only issue their approvals or dispositions after the NRCB has made its decision and there are no further opportunities for Board reviews of that decision.

9. Board Review and Decision

Board can choose whether to hold a review, and what issues and who will be heard if it decides to conduct a review. Parties will be asked to provide written submissions and evidence, and will be allowed to ask questions of others. The Board can decide to confirm or reverse the Approval Officer's decision and add or modify any terms and conditions.

Please note:

- Applications for REGISTRATIONS and AUTHORIZATIONS will be processed using Steps 1, 2, 3, 5 and 7 (marked in dark blue).
- Applications for APPROVALS will be processed using Steps 1 through 7.
- Steps 8 and 9 will apply only if a Board review is requested and obtained.

3.2.2 Water Act approvals

3.2.2.1 Process

A producer building a new livestock operation may require either a water approval or a water licence under the *Water Act.* The *Water Act* became law in January 1999.

A water approval is required for the undertaking of an activity. Under the *Water Act,* an "activity" includes the construction, operation or maintenance of a structure that may:

- Alter the flow or level of water.
- Change the location or direction of flow of water.
- Cause the siltation of water.
- Cause the erosion of any bed or shore of a body of water.
- Cause an effect on the aquatic environment.

If it is necessary for the producer to divert and use more than 6,250 cubic metres of surface water or groundwater per year (273,000 gallons/year), a water licence is required.

Applications for an approval or licence are submitted to Alberta Environment. In the application for either an approval or a licence, a producer should include the plans for the project, including scaled drawings, the legal land location, details regarding the affected water bodies, the location of any structures to be built or affected, the rate of diversion and the anticipated quantity of diversion. In addition, the producer should include reports related to the project, including a description of the project and hydrologic information.

Once a producer has submitted the approval or licence application to Alberta Environment, the department will require the producer to publish a notice of the application in one or more issues of the local newspaper in the area of the proposed approval or licence. The notice of the application will include, among other things, the location of the activity, the name of the applicant, a description of the activity or diversion, and an indication that, if any individual is directly affected by the application, a statement of concern can be submitted to Alberta Environment within a specific period of time.

3.2.2.2 Appeals to the Environmental Appeal Board

If the producer's application for a water approval or licence is granted, Alberta Environment will require the producer to publish a notice of the approval or licence in one or more issues of the local newspaper in the area of the proposed approval or licence. The notice must indicate that an individual who submitted a statement of concern to Alberta Environment regarding the application can file a notice of objection to the Environmental Appeal Board, within a reasonable period of time. In addition, if the producer's application for a water approval or licence is denied, the producer can file a notice of objection to the Environmental Appeal Board regarding the denial within a certain period of time.

If a notice of objection is filed with the Environmental Appeal Board, the Board will conduct a hearing. In ruling on an appeal, the Board may confirm, reverse or vary the decision of Alberta Environment. A decision of the Environmental Appeal Board can be appealed in very limited circumstances.

3.2.3 Transportation approvals

The *Highway Development Control Regulation* under the *Public Highways Development Act* prohibits the erection or placement of a development within 300 metres of a primary highway and 800 metres from the centre point of an intersection of a primary highway and another highway or public roadway. As a result, if a producer plans to construct an operation within these distances from a primary highway, the producer will be required to apply for and obtain a Roadside Development Approval from Alberta Infrastructure to construct a development near a primary highway. The Roadside Development Approval will set out the road access and setback conditions for the development.

If a producer is required to apply for a Roadside Development Permit, the producer should include the engineering drawings, the property description, the existing and proposed land-use and the closest distance of the proposed development to the highway property line.

Addendum

The information provided regarding environmental obligations and the approval process for dairy production in Alberta is for information only and should not be relied upon as legal advice. The producer should consult a lawyer since the facts of the producer's situation may change the producer's legal rights or the law may change.

Additional information on these issues can be obtained from Alberta Agriculture, Food and Rural Development's extension staff, the NRCB, consultants and lawyers. See Section 10.1 for contact information.

Copies of Acts and Regulations are available through the Alberta Queen's Printer (www.gov.ab.ca/qp) or contact qp@gov.ab.ca or (780) 427-4952 (toll free in Alberta by first dialing 310-0000).

4.0 PREVENTING, MANAGING AND RESOLVING CONFLICT

4.0 PREVENTING, MANAGING AND RESOLVING CONFLICT

4.1 What is Conflict?

Conflict is a struggle between two or more parties because of a real or perceived difference in needs or values. When people or groups of people are unable to reach a satisfactory understanding of their mutual issues, the result can be disagreement or conflict.

In today's world, conflict is inevitable and is present everywhere. Most people think conflict is negative and try to avoid it, but conflict can have a positive side. Conflict encourages people to examine issues more carefully. It deepens the understanding of problems. It opens the door to new ideas and alternative solutions. It helps people foresee the consequences of proposed actions, and enables them to take risks and solve problems. Properly managed, conflict can be productive and constructive.

4.1.1 Conflict in agriculture

In recent years, the number and intensity of conflicts facing farmers has risen sharply. Debates encompass a variety of environmental, political, economic and social issues. Public concern for human health and the environment has risen, as has inquiry into the agri-food industry and its practices.

A 1998 survey of Canadian farm organizations identified conflict over farm practices as one of the leading threats to the agriculture industry's future competitiveness. A study commissioned by the Canadian Farm Business Management Council (CFBMC) flagged issues management as one of the industry's top five priorities. In early 1999, focus groups were held across Canada to learn about farmer experiences related to farm and community conflicts. The focus groups also gathered ideas on dealing with conflict situations. The purpose of the study was to develop strategies and tools to manage conflict. Representatives from municipal, regional and provincial governments were also consulted.

4.1.2 Sources of conflict

The biggest concern neighbours have about livestock production is that it will disrupt their quality of life, mainly due to nuisance odour. Producers can lessen anxiety by exercising caution, consideration and common sense. While manure odour may not be an issue to those living on the farm, others may find it offensive. A commitment to sound manure management is a necessity. Once that commitment is made, it must be kept. Another concern is the potential for groundwater and surface water contamination. Nuisance concerns related to storage and handling of dead animals also creates conflict. Proper storage and disposal of carcasses is essential to minimize odour, flies and transmission of disease to other animals.

4.2 Preventing Conflict

The following tips and strategies to help producers prevent, manage and resolve conflict are based on the CFBMC focus group discussions involving producers and government representatives.

Producers identified the proactive approach as the wisest strategy to prevent conflict. The single most important thing producers can do to reduce the risk of conflict is to ensure that communication with neighbours is open, honest and thorough. This kind of communication is essential to lessen the impact of livestock operations on neighbours and to understand what upsets neighbours. Focus group participants also suggested that compliance with the laws governing farm management practices should be regarded as a minimum requirement. Employing progressive farm management practices and doing the very best job possible should help prevent conflicts.

4.2.1 Be a good neighbour

Farmers need to communicate with all of their neighbours to build "social capital" that could be drawn upon like a bank account when problems arise. Being a good neighbour, having a public relations program for the farm and contributing to the community are good ways to build social equity within the community.

Knowing and understanding neighbours is the first step in addressing concerns about a livestock operation. Producers should:

- Get to know the neighbours and let them get to know the operation.
- Be friendly.
- Keep neat, well-maintained farmyards that are less likely to draw complaints.
- Share the farm's bounty.
- Be helpful to neighbours in need.
- Get involved in the community. Join a local service group.
- Support local businesses. Hire local youths.
- Develop a public relations program for the farm. Support and make donations to local charities and community groups, such as sports teams and youth groups. Get the farm recognized for its contributions.
- Host farm tours, but do a dry run to prevent unintended negative consequences.
- Help neighbours learn more about the farm. Have an open house, picnic, barbecue or potluck. Explain why farmers do what they do.

4.2.2 Open house tours

Several types of an open house tour can be organized:

Public open house prior to building:

- Is a common approach for spreading information in a community.
- Can be used early in a new project development to gather ideas and test initial reactions of neighbours and the local community.
- Allow the public to learn more about the project.
- Provides neighbours with an opportunity to express their concerns.
- Ideally are held in a neutral location.

Tours held on-site prior to start up:

- Showcase the features of the operation to the livestock industry and the community.

Tours of existing operations:

- Explain beneficial management practices and help people learn about farming.

Tips for conducting a successful tour or open house:

- Find out who's coming and what they want to see. Ensure guests are "farm friendly" and genuinely interested, not out to gather evidence against the farm.
- Decide in advance and tell guests whether photos are allowed.
- Do a dry run. Walk all around the farm, ideally with a non-farm friend to get input on the way guests will see it. Remember, "normal" farming practices may disturb non-farmers.
- Ensure there are no hazards to public safety on the tour, that the farm is clean and tidy, and livestock are healthy. Pay special attention to waste disposal and herd health areas on the farm, as well as areas where drugs or agri-chemicals are used.
- Anticipate the kinds of questions guests are likely to ask, including challenging issues. Have clear, factual, well-reasoned answers ready for these questions. Be prepared to answer questions on the following topics: food safety, genetically modified foods, chemicals and residues, air, water, as well as soil contamination and animal welfare.
- Practice answering questions with family members or colleagues. Videotape the practice session. Appear confident, otherwise people may think questions are being avoided or the truth is being concealed.
- If the answer to a question is not known, say so, then offer to find an answer. Do not be baited or goaded into saying something that will be regretted later.
- Plan the tour and develop a presentation for each different visiting group. Emphasize the positive. Draw attention to the modern practices farmers are using to address society's concerns, as well as the agri-food industry's contribution to the economy and community fabric.
- Tailor each presentation to the audience. Whether visitors are school children, politicians, business people or other farmers, avoid using farming jargon.
- Talk about relevant topics. Do not be side-tracked.
- If appropriate, provide an activity that involves guest participation.
- Smile. Have fun. Guests should leave with good feelings about the tour.

4.2.3 Additional advice

- Have a good attitude. Be considerate and respectful to other people and their concerns.
- Know the rights of producers and of others.
- Be considerate. Let neighbours know in advance when manure spreading is planned. If neighbours have special events planned, try to work around them.
- When possible, avoid noisy, dusty or odorous activity on, or immediately before, weekends, especially long weekends.
- Before planning to expand, diversify or make changes to the operation, consider the impact on neighbours and the environment. Prepare a situation scan, detailing assumptions and understandings about who the neighbours are, what they care about, potential problems and plans for addressing any issues.
- Try to anticipate other peoples' reactions. Respond to their concerns.
- Do not let minor disputes blow out of control.
- Fight battles privately, away from public and media view.
- Develop a relationship with the media, municipal and provincial governments.
- Search out individuals and groups that can be allies. Identify, inform and involve people who support the operation and enlist their help in dealing with opponents.
- Concentrate on keeping supporters happy. Do not spend the majority of available resources dealing with opponents.

4.3 Managing Conflict

4.3.1 Damage control

Sometimes conflict is unavoidable no matter how much effort has been made to resolve an issue. When conflict does erupt, it should be managed in order to minimize the damage. Canadian farmers offered the following tips to prevent a conflict from escalating (study by the CFBMC):

- Take the matter seriously.
- Do not deny there is a problem and hope it will go away.
- Stay calm. Avoid getting angry or defensive. Refrain from blaming, accusing, chiding or belittling other people; it could escalate the conflict.
- Think before acting or speaking. "Sleep on it." Be diplomatic.
- Prevent small, specific conflicts from expanding into big, broad conflicts.
- Ask lots of questions. Find out what the other person is upset about. Do not debate the issues.
- Search out and identify the real issues. What people say may be quite different from what they are really concerned about. Concerns are often rooted in fear of change and the unknown, in a lack of understanding, or in a fear of losing control or the ability to influence decisions.
- Deal with emotions first. Then deal with the subject of the conflict.
- Listen to and validate concerns. Acknowledge understanding of the concerns and offer to look into the matter.
- Be prompt when getting back to complainants with the information that will ease their concerns.
- Stay on top of ongoing problems. Keep people informed of changes on the farm and progress being made.
- Do whatever is practical to fix problems and mitigate damage.
- Always tell the truth.
- Admit to mistakes. Take responsibility for employees' actions.
- Apologize. Make amends if possible.
- When others make mistakes, help them save face.
- Shift the emphasis to mutually acceptable solutions.

Consequences for failing to solve problems may include:

- Bad publicity.
- Lost credibility.
- Fines and penalties.
- Litigation: lawsuits and appeals.
- Referendums, petitions.
- Endless meetings, more studies.
- Project delays, escalated costs.
- Loss of goodwill.
- More regulations for the whole industry.
- Increased probability of future conflicts.
- Increased difficulty to resolve future conflicts.

4.4 Resolving Conflict

The most common reason for discussion breakdown and disagreement is poor communication. Communication is a fundamental element of resolving issues and therefore must be understood and practised well. Producers should listen and understand first, then explain their intentions. Listening also means understanding the meaning of the other person's message.

In today's society, conflict prevention management and resolution skills are essential. Learning the skills necessary to prevent, manage and resolve conflict may boost farmers' personal and collective competitiveness and prosperity. For assistance with conflict resolution, contact Alberta Agriculture, Food and Rural Development at 1-866-882-7677.

5.0 SITE SELECTION AND PLANNING

5.1 Site Selection

- **5.1.1** Site selection checklist
- **5.1.2** Assess local/community perception of dairy developments
- **5.1.3** Gather development application requirements
- **5.1.4** Evaluate ability to meet requirements
- **5.1.5** Evaluate resource base
- **5.1.6** Canadian water quality guidelines for livestock
- **5.1.7** Complete site-specific management plans
- **5.1.8** Share intent with stakeholders

5.2 Site Planning

5.3 Shutting Down Livestock Operations

5.0 SITE SELECTION AND PLANNING

5.1 Site Selection

The selection of a site for a barn is an important decision that has a strong influence on the economic and environmental sustainability of a dairy operation. A good site will provide many of the elements required for an operation to be successful in both the short and long term. Operators must balance the economic forces affecting their operation with consideration of issues such as environmental protection, animal welfare, food safety and other stakeholder concerns.

Selection of the appropriate site for a dairy barn will also provide the opportunity to meet long-term goals such as future expansion. Expansion opportunities are largely determined by the site selected.

Regardless of the size of operation, the site selection principles remain the same. However, finding an appropriate site for a large operation may require additional investigation in order to accommodate present and future needs. All operations require similar resources to operate effectively, while ensuring environmental sustainability and acceptable levels of impact on neighbours and neighbouring land uses. The size of the operation does not change these requirements, only the level of demand and the magnitude of potential impacts.

Expansion of an existing operation will require equal consideration of the business plan resource requirements and environmental sustainability issues.

This section outlines the basic process for site selection for dairy operations. When considering a new or expanded operation, operators should contact a Natural Resources Conservation Board (NRCB) Approval Officer for information and advice.

5.1.1 Site selection checklist

The process for development involves a list of logical steps. This will ensure that time and energy are spent efficiently and that development is successful.

When evaluating potential sites, it is also important to remember the interests of the other stakeholders, including such parties as neighbours (residents and landowners) and the local municipality.

Recommended steps between finalizing the business plan and actual construction:

- Assess local/community perception of livestock developments.
- Gather development application requirements from the NRCB.
- Evaluate ability of the site to meet development requirements, i.e., Minimum Distance Separation (MDS), land base, soil and groundwater investigation.
- Evaluate resource base, i.e. water supply, land and rural services.
- Complete management plans as related to the specific site.
- Share intent with stakeholders.
- Complete and submit required applications.
- Build upon approval, or return to development process.

When a suitable site has been located, based on the above checklist, apply to the NRCB for the approval. To speed up the decision-making process, work with the NRCB Approval Officer to ensure all necessary information is included. It is important to have all of the required information available to the Board. Delays in providing this information will slow the process and decision on an application.

For an application form, contact the NRCB offices or Web site (http://www.nrcb.gov.ab.ca/ILOpage.html).

5.1.2 Assess local/community perception of dairy developments

Assess the community and the surrounding neighbours' perceptions of the dairy industry and its potential development. Determine how any previous concerns on livestock developments in the area were handled. Identify community and local leaders who will have an impact on or be impacted by the development. This will allow producers to analyse any potential risks of future opposition and save a great deal of time and money. It is important to address all concerns, both real and perceived.

5.1.3 Gather development application requirements

At this stage, it is important to contact the NRCB Approval Officer to determine application requirements. The Approval Officer will describe the approvals required under the *Agricultural Operation Practices Act* (AOPA), *Water Act* and *Public Lands Act.*

The application form should contain all necessary approvals for the dairy operation, e.g. an application for a *Water Act* licence from Alberta Environment. Once the application is prepared and submitted to the NRCB, the Approval Officer screens the application to ensure the necessary information is included. The Approval Officer forwards the completed application to other agencies for their approvals. For example, Alberta Environment is responsible for the allocation of water resources under the *Water Act.* Any water diversion also requires a permit from Alberta Environment.

The application is reviewed to ensure that it has all of the required information. Once this information is provided, the application is deemed complete. Depending on the size of the operation (approval vs. registration), the NRCB may be required to notify affected parties of the proposed operation. Municipalities are always notified of an application.

Parties that might be affected by the operation, such as neighbours or municipalities, may submit statements of concern. These statements of concern will be reviewed. Attempts will be made to resolve issues raised by affected parties. Following this process, and once all the input from the municipalities, Alberta Environment *(Water Act),* etc., have been received, the Approval Officer will make a decision regarding the application. The Approval Officer has three options: approve the application, reject it or approve with conditions.

An approval for the development must be issued before construction begins.

Regional Health Authorities, Sustainable Resource Development (Public Lands) and Alberta Transportation may receive referrals on development applications. These provincial government agencies have the responsibility to investigate and take necessary action if a livestock operation has or exhibits the potential to have an impact on public health, the environment or transportation infrastructure.

5.1.4 Evaluate ability to meet requirements

Assess the site's capacity to meet the geographical, physical and regulatory requirements of a livestock development. A general assessment of the geographical requirements should have been done in the business plan phase. Assess the site based on its ability to provide convenient access to the infrastructure and resource base required to manage the proposed operation.

Ensuring suitable climatic conditions is generally not a pressing issue, as most locations in Alberta have a climate suitable for successful dairy production. However, there may be local factors that influence the siting of the development, such as wind, air drainage, other livestock operations, as well as environmental concerns.

Wind. Prevailing wind is an important factor to consider; however, the direction can vary between seasons. During summer, when odours are more intense and neighbours are outdoors more often, it is important to consider the direction of the prevailing winds. Also consider the effects of calm summer evenings. For example, under calm conditions, odours will not disperse as readily.

Air drainage. Under calm, summer conditions, the air near the ground can cool and drift down a slope. This is known as air drainage.

Other livestock. Consider other livestock operations when selecting a site for a new operation. Providing an adequate separation distance from other livestock operations is an important step in preventing the spread of livestock disease and cumulative nuisance effects. Consult a veterinarian to determine adequate separation distances from other livestock to prevent the transfer of disease.

Environmental concerns. AOPA is designed to help livestock producers minimize the environmental impact of livestock operations. The primary elements covered in the *Act, Regulations and Standards* are designed to address the potential for contamination of surface and groundwater, soil and air. These elements are:

- **Minimum Distance Separation (MDS).** The MDS is the setback or buffer established between an intensive livestock facility (source) and adjacent land users (receptors) to minimize odour nuisance. Minimum distance separations for various sizes of livestock operations are identified in the AOPA, *Standards and Administration Regulations.*
- **Manure storage.** Appropriate containment and storage of manure specific to the proposed site must be addressed. The *Act, Standards and Regulations* include criteria for safe storage of liquid and solid manure, as well as average volumes necessary for sizing the storage.
- **Nutrient management.** The *Act, Standards and Regulations* also include requirements to manage nutrients from manure to prevent negative environmental impacts. Nutrient management requirements, manure application limits, soil protection and records that must be kept by producers and users of manure are also outlined.

5.1.5 Evaluate resource base

Determine whether the site offers the required resource support necessary for the proposed operation. This includes availability of water, feed or land base necessary to produce feed and proximity to purchased input requirements and labour. Land base requirements for manure spreading should also be considered.

Land base. The land base required should be based on the agronomic use of the manure. It should accommodate projected crop production and be close enough for economical manure application (see Section 8 and AOPA).

Water resource management. Providing a safe, reliable supply of quality water for livestock is critical. Poor water supply can limit the size of an operation or affect animal health and performance. For example, sodium levels in water can affect herd health. A water or hydrology specialist (from Alberta Agriculture, Food and Rural Development [AAFRD]; Alberta Environment; the Prairie Farm Rehabilitation Administration [PFRA]; or a private consultant) can assist in determining the suitability of a water source for dairy production.

Water supplies and systems must be designed to meet peak demands. Water requirements can vary, depending on animal size, milk production, washing requirements, temperature, spray cooling systems, water quality, physiological state, activity level and the type of diet. Calculation of average daily and annual water requirements can be completed based on the number and size of animals, using Figure 5.1. Water requirements will be influenced by the ration fed to the cows and the minerals in their drinking water.

Some recommended maximum limits for water quality are listed below:

Total dissolved solids.....3,000 mg/L
Sulphate.....1,000 mg/L
Nitrate (as N)..... 100 mg/L

Groundwater availability. Information on groundwater availability in an area can be obtained from the Groundwater Information Service of Alberta Environment (1-780-427-2770). A water or hydrology specialist or local water well drilling contractor can also provide information on groundwater availability. In some cases, test drilling may be required to determine availability of water and its quality. Shallow water wells may be more susceptible to contamination and fluctuation in quantity than deeper wells. The *Water Act* may require a licence prior to drilling a well. Contact the NRCB or Alberta Environment for additional information on water licence requirements.

Dugouts and surface water. Construction of a large reservoir or dugout for a farm operation requires investigation of the sub-soil conditions at the site and consideration of the drainage area. Test drilling or test pits can provide valuable information regarding dugout design and construction equipment. Dugouts can be constructed in almost any texture of soil, but may require lining to prevent excessive seepage. Lining adds significantly to the cost, so a good clay-based site is preferable.

Figure 5.1 Recommended Flow Rates and Water Intake

	Average Daily Water Requirements
Holstein milking cow	136 litres per day* (30 gallons per day (gpd)**)
Holstein dry cow/replacement heifer	45 litres per day (10 gpd)
Calf, 600 pounds	23 litres per day (5 gpd)

* Includes 14 litres per day for wash water (** Includes 3 gpd for wash water)

Dugouts that are filled only by spring runoff should be designed to hold at least a two-year water supply, unless an alternative source can be used to fill the dugout in a drought year. Dugouts in the irrigation area of the province, or dugouts adjacent to rivers or lakes, must be at least large enough to supply water from the time the water is not available in the fall until water flows again in the spring. A one-year storage capacity is the recommended capacity for these dugouts. Planning and design information is available through PFRA or AAFRD.

Dugouts should not be located directly in a watercourse. If the dugout is located off to the side of the watercourse, then the water can be diverted into the dugout or past the dugout, depending on water quality. All waterways that supply the dugout should be grassed to prevent erosion and trap sediment and nutrients.

Steps to prevent contamination. Agricultural activities around a well or dugout may have negative impacts on water quality. To prevent well and dugout contamination, ensure the following:

Wells

- Ensure wells are properly constructed and sealed.
- Locate wells up-slope, away from sources of contamination.
- Properly plug any old, unused wells, as they can contaminate newer wells.
- Do not overapply manure; nitrate seepage can contaminate groundwater.
- Ensure manure storage structures, such as earthen manure storages, are properly built so that they will not seep into groundwater.
- Direct surface drainage from contaminated sources away from wells.
- Ensure that well casings, caps and venting are in good repair.

Dugouts

- Construct dugouts in proper drainage areas, away from potential sources of contamination.
- Apply manure and fertilizers to meet crop nutrient needs. Excess soil nutrient levels can lead to excess nutrient levels in the runoff water. This causes increased algae and weed growth in dugout water.
- Avoid spreading manure on snow or frozen ground.
- Maintain manure storages and sewage lagoons to prevent runoff or seepage.

Contact an experienced water or hydrology specialist (AAFRD, Alberta Environment, PFRA or a private consultant) to develop a plan to protect the operation's water resource.

Rural services. Any off-site inputs require reasonable access to related agri-business and staff. Good road access to the site is critical. Access to utilities such as power and gas is also a significant factor affecting site selection.

5.1.6 Canadian water quality guidelines for livestock

Item	Maximum Recommended Limit, ppm
Major ions	
Calcium	1,000
Nitrate + nitrite	100
Nitrite (alone)	10
Sulphate	1,000
Total dissolved solids	3,000
Heavy metals and trace ions	
Aluminum	5.0
Arsenic	0.51
Beryllium	0.12
Boron	5.0
Cadmium	0.02
Chromium	1.0
Cobalt	1.0
Copper (swine)	5.0
Fluoride	2.03
Iron	no guideline
Lead	0.1
Manganese	no guideline
Mercury	0.003
Molybdenum	0.5
Nickel	1.0
Selenium	0.05
Uranium	0.2
Vanadium	0.1
Zinc	5.0

5.1.7 Complete site-specific management plans

It is extremely important for dairy producers and stakeholders to develop clear, functional and appropriate management plans. This includes the overall operational plan as it relates to AOPA. A comprehensive nutrient management plan outlines in-barn management, transport to storage, storage period and land application. It should also include a plan for disposal of waste such as dead animals and pesticides.

It is also essential to be prepared with a clear, informed message regarding management intentions as they relate to minimizing nuisance, specifically odour and meeting the requirements for a livestock operation.

5.1.8 Share intent with stakeholders

A new project generally represents some form of change to a community. Typically, five to 10 percent of community members will support the project initially and five to 10 percent will oppose it. Opponents or supporters are unlikely to change their position. The remaining 80 percent, called the silent majority, are either undecided, indifferent or skeptical about the project. Failure to bring the silent majority on side can lead to opposition and seriously jeopardize the project. Various communication strategies can be used to win the support of this group. Open public participation is a communication strategy that has proven to be successful.

It is wise to begin by consulting with the community. This helps to build trust, understanding and support for the project. If the project proceeds too far before the public is informed, there may be problems with rumours and misinformation. Under AOPA, directly affected parties will be notified by the NRCB and will have an opportunity to review the application and raise concerns. Members of the public also have an opportunity to review an application for an approval, and may also submit statements of concern together with reasons why they should be considered to be directly affected parties

Public participation is not the only way to gain community support, but it is a powerful approach for paving the way. The following points outline key considerations and communication strategies for public participation in a successful project.

Knowing the community is critical to building support. One of the first steps is to identify the individuals and organizations in the community who will be affected by the project. How might they be affected? What information do these individuals want and need? Could the project be changed to better meet their needs? What is the history of the community? Which areas had problems initiating new projects in the past? Who are the people with power and influence? What is the perspective of community stakeholders? Gathering this type of information helps to develop a community social profile. This profile is vital for creating effective communication strategies.

Keep the community informed. To build community support for the project, ensure that the community is well informed and, ideally, part of the initial planning for the project. Any communication about the project must be open, honest and timely. Remember that there are a variety of approaches suitable for reaching different groups.

To reach young families, communicate through school newsletters or parent advisory meetings. The senior's activity centre is a good place to reach that interest group. Quick lunchhour gatherings in a central location might appeal to the working crowd. Some approaches may be more effective at different developmental stages of the project. Consider what information to share, who to communicate with and when. Do not always rely on print material or meetings to get the message across. Try to use a creative variety of public participation approaches to provide information and receive feedback.

Gather meaningful feedback from the public. Inviting the public to express its views and concerns about the project can help to enhance community support and ultimately the success of the project. As initiators of the project, be prepared to listen, respond and incorporate feedback given by community members.

If the community does not support the project, stand back and try to be objective. It may be that insufficient information has been provided. Perhaps the timing is off or the location is wrong. Take advice from the community and let its members know where their input has made a difference. If the intention is not to use feedback, do not ask for it. There is no integrity in the public participation process if the decisions are already made. A community that provides input, will likely attach some ownership in the project.

Plan communication strategies. The following strategies have proven to be effective in communicating with the public and building support for a community project:

- Informal consultation.
- Use of media.
- Open house (see Section 4).
- Fact sheet with tear-off response.
- Reference centres.
- Public forums.

5.2 Site Planning

Once a site has been located, a site plan is required. The location and orientation of structures can influence the potential for environmental impacts. Good site planning can also prevent neighbourhood disputes. When designing a site plan, consider the following:

- Adhere to required permit criteria, such as setback distances from roads and property lines or water diversion pathways.
- Locate buildings and storage facilities for fuel, fertilizer, manure, compost or pesticides at least 100 metres (328 feet) from wells and 30 metres (98.4 feet) from common bodies of water. If possible, choose a site of lower elevation than wells to prevent runoff or seepage of harmful substances into the water supply.
- Locate buildings and facilities on an adequately drained site, being careful to avoid low areas subject to flooding. Refer to AOPA, *Standards and Administration Regulations* for on-site planning requirements.
- Grade the area to divert contaminated runoff and prevent it from entering surface or groundwater.
- Grade or berm outside yards to allow collection of contaminated runoff before it reaches surrounding waterways, and to reduce the nuisance impact on neighbours.
- Ensure that emergency vehicles can access facilities in case of fire or other emergency.
- Position high-activity buildings and work areas away from neighbours to minimize sight and sound impact.
- Use screens such as shelterbelts to provide wind protection and reduce the operation's visual and odour impact on adjacent property owners.
- Divert roof runoff and any clean water away from the site.
- Adhere to the recommendations of the *Canadian Farm Building Code*.
- Invest in good storage and processing facilities for feed and feed ingredients. Adequate facilities and proper management can help avoid pollution and reduce losses due to spoilage, insect and rodent damage, and fire from spontaneous combustion.
- Before building new feed storage facilities, design a complete storage and handling system that incorporates both present and future requirements.
- Locate the feed processing and handling centre in an area that will allow large vehicle access and provide sufficient setback from neighbours. This will ensure neighbours are protected from noise, dust, traffic and the threat of fire.

5.3 Shutting Down Livestock Operations

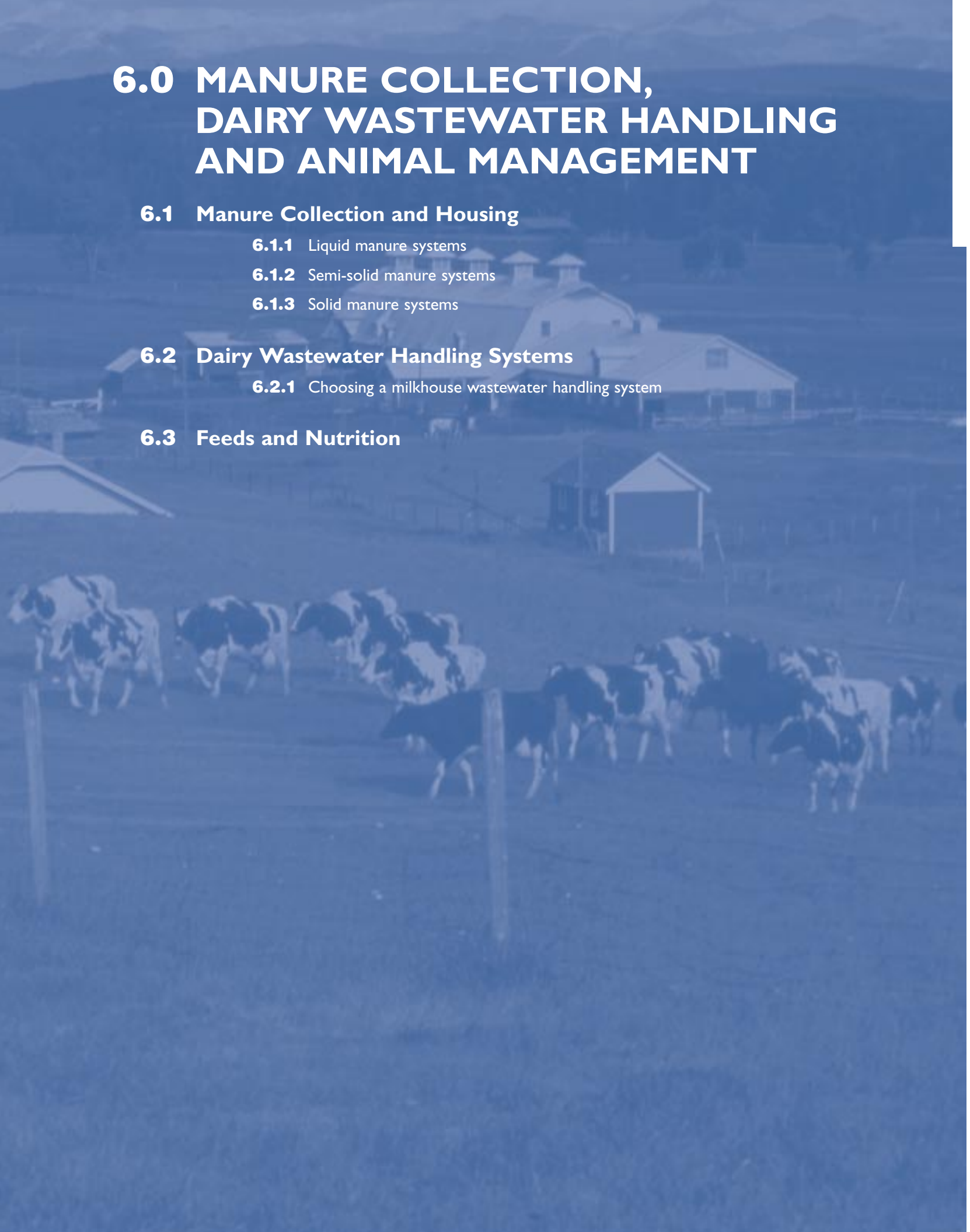
The development approval may define the period of time a facility can be empty before another approval is required for the operation. Steps should be taken to minimize any health or safety risk to humans and animals and to reduce any environmental impact.

Managing shutdowns.

- No matter how short the shutdown period, take steps to minimize risk to people and animals entering manure storage areas and buildings. Ensure signs are posted to advise of any potential dangers.
- Remove manure from buildings.
- During short-term shutdowns of one month or more, turn off water, unnecessary gas and electricity, control weeds and insects, and move manure from the barn to proper storage facilities.
- For longer-term shutdowns of six months or more, conditions of the permit and regulations may require a cleanup procedure within a certain period of time. Depending on permit requirements within the municipality, a new development permit may be necessary before restocking the barn.

For a permanent shutdown, check with the municipality for decommissioning (i.e. termination of permitting conditions) requirements. Some jurisdictions may also require a demolition permit for site cleanup.

6.0 MANURE COLLECTION, DAIRY WASTEWATER HANDLING AND ANIMAL MANAGEMENT



6.0 MANURE COLLECTION, DAIRY WASTEWATER HANDLING AND ANIMAL MANAGEMENT

6.1 Manure Collection and Housing

Intensive livestock housing systems are designed to maintain temperature, relative humidity, dust, gases and odour contaminants within acceptable limits. The housing system will determine the type of manure produced and the type of handling equipment. Livestock manure is classified as liquid, semi-solid, or solid, using the following criteria:

Liquid. Liquid dairy manure typically has a solids content of 12 to 13 percent as excreted. With the addition of washwater, typical liquid dairy manure from a free stall barn will have a solids content ranging from five to 10 percent.

Semi-solid. Manure handled as a semi-solid contains 10 to 20 percent solids, resulting from the addition of bedding materials, but not washwater.

Solid. This manure has a solids content greater than 20 percent. To produce solid manure, the liquid must be drained and the manure dried or have bedding added.

Regardless of the type of manure being handled, it is important to use properly designed equipment and to operate and maintain the equipment according to manufacturer's instructions. The equipment must be capable of functioning reliably in a corrosive environment. Equipment also requires proper maintenance for a long service life. Preventative maintenance and the use of reliable equipment are critical to avoid problems.

The manure collection system should minimize the release of moisture, dust, gases and odour in the barn, and provide good sanitation. Places where manure can collect should be eliminated to avoid nuisance odour and flies. In-barn manure storage should be minimized to avoid hydrogen sulphide gas release in the barn. Special provisions should be taken when stored manure is removed from a building.

When pumps are used in liquid systems, agitation is necessary to break up solid material. Problems can occur when clumps of solids enter the pump. Care should be taken to prevent solid materials, such as stones and construction materials, from entering the manure system.

In storage, dairy manure tends to separate into three layers. The heavy solids collect at the bottom, the liquids in the middle and the lighter solids, such as feed and bedding materials, will float to the surface. Manure removal from storage requires agitation to fully mix the three layers. Chopper pumps are appropriate since they do not easily become plugged with solids. These agitation pumps have capacities of about 200 L/s (2,600 gal./min.). While liquids are transferred by gravity or pumps, solid manure is transferred by conveyors, augers, piston pumps or front-end loaders.

6.1.1 Liquid manure systems

Manure is commonly handled as a liquid in various styles of dairy barns. The collection options are:

- **Solid floor alleys.** In the most common system, manure is scraped to a receiving pit by cable, chain, oscillating rod scraper or tractor blade. Washwater may or may not be added to the receiving pit. Manure is transferred to long-term storage using a large diameter (60-centimetre or 24-inch minimum) gravity flow pipe or pump.
- **Slatted floor alleys with shallow pits.** Manure is collected beneath the slats in shallow manure trenches. The manure is removed by high volume water flush, continuous flow, mechanical scraper or by agitation and pump removal. Washwater is usually added to the pits to reduce solids content and assist in manure handling.
- **Slatted floor alleys with deep pits.** The deep pit under the slatted floor serves as a combined collection and long-term storage facility. Another option is to combine the deep underfloor pit with additional separate long-term storage. This requires agitation and pump or gravity transfer.

These systems provide a wide variety of choices in balancing labour and reasonable building costs, adequate sanitation and suitable livestock environment.

6.1.2 Semi-solid manure systems

In free stall barns with solid floor alleys, the straw or shaving used for bedding produces a semi-solid manure. Manure is scraped to a transfer pump by cable, chain, oscillating rod scraper or by tractor blade. The manure storage is usually a sloping concrete pad with concrete or earthen sides and a pressure-treated wooden weir at the low end of the pad to drain seepage into a catch basin. Washwater is pumped into separate storage.

Semi-solid manure with minimum solids is transferred to storage using a large diameter (60-centimetre or 24-inch minimum) pipe or a reciprocating piston pump. High amounts of bedding/solids require mechanical scrapers to transfer manure to storage.

6.1.3 Solid manure systems

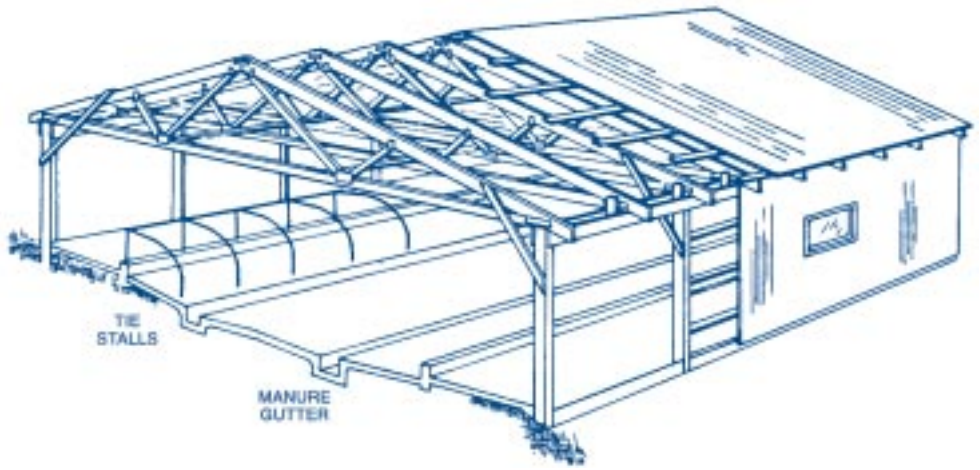
Alternatives to the free stall housing systems are stanchion and tie stall barns (Figure 6.1) that produce solid manure. Usually the cows are housed, fed and milked in the same stalls. Increased labour is often a disadvantage with tie stall barns. Mats and/or bedding maximize cow comfort. The stall should slope to a gutter that collects udder washings and urine. Manure consistency depends on whether and how much bedding is used. A grate cover over the gutter will keep cow tails, udders and feet out of the manure. Manure is removed from the barn using a narrow gutter and chain cleaner, and is stockpiled on a properly designed pad with runoff containment.

Tie, stanchion and freestall housing systems generate solid manure from bedded areas in maternity and isolation pens. Bedded, loose housing barns are also used to accommodate smaller milking herds, young stock or dry cows. The solid manure is typically cleaned out several times per year and stockpiled or is spread immediately.

Whenever bedded stalls are used within warm confinement barns, there is a potential for odour and flies. Ventilation of barns is difficult when there are a number of wet bedded areas. These problems can be avoided either by adding fresh bedding to keep the manure pack dry, or by frequently removing manure. Bedded stalls or loose housing systems will produce a solid type of manure.

Manure from all these systems must be managed in a manner that will not cause pollution.

Figure 6.1 **A Typical Tie Stall Barn**



6.2 Dairy Wastewater Handling Systems

Milking centre wastes contain many ingredients that may affect the environment. Milk centre wastes include manure deposited in the milking parlour, udder washings, equipment washwater containing milk, detergents, acids and chlorine. See Figure 6.2 for wastewater generation.

Milk

- A typical pipeline system holds about five to 10 litres of milk per day after milking. This adds between 2,000 and 4,000 litres of whole milk per year.
- When one litre of milk enters a stream and decomposes, it uses up all the oxygen in 10,000 litres of water. Milk requires five times more oxygen to decompose than manure.
- Bacteria growing in rotting milk may transmit diseases to animals drinking water downstream.

Phosphorus

- Producers use phosphate detergents and concentrated phosphoric acid to clean and sanitize milk lines and equipment.
- Phosphorus causes algae to grow in streams and lakes, using up oxygen and impacting the survivability of fish.

Nitrates

- Manure flushed onto the ground surface or into a treatment trench system may contaminate surface water and groundwater with nitrates. Properly sited operations may prevent contamination.

6.2.1 Choosing a milkhouse wastewater handling system

Option 1: Add washwater to liquid manure storage system.

- Pump to a properly designed liquid manure storage or feedyard runoff catchment.
- Size storage to hold the additional wastewater (see Figure 6.2).

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 (see Figure 6.2).
- Open storages release odours; reducing milk contents will reduce odours.

Option 3: Sediment tank and vegetative filter strip.

- If soil is too shallow, too heavy or has a high water table, choose another option.
- Minimize manure and milk content in wastewater.
- Reduce volumes by using 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.
- Check the level of sludge in the tank regularly and vacuum out as required.

Option 4: Lime flocculator treatment with treatment trench.

- Feed prerinse washwater to calves (reduce milk content).
- Add 1.4 kg of lime to 1,500 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 (approximately 114 litres) into solid or semi-solid manure system.

Figure 6.2 Wastewater Generation from Washing Operations

Washing Operation	Approximate Wastewater Generated (units vary)
Bulk tank	5 percent of bulk tank volume
Automatic	190–230 litres/wash
Manual	114–150 litres/wash
Milk pipeline	285–475 litres/wash
Milking system clean-in-place (CIP) parlour	45–75 litres/unit, four-cycle cleaning
Bucket milkers	114–150 litres/wash
Miscellaneous equipment	114 litres/day
Back flush	4 litres/cow/milking
Cow prep	
automatic	4–17 litres/cow/milking
manual	1–2 litres/cow/milking
wash pen	11–19 litres/cow/milking
Milkhouse floor	38–75 litres/day
Parlour floor (hose down)	190–380 litres/wash
Parlour floor and holding area	1,900–3,800 litres/wash

6.3 Feeds and nutrition

An overall strategy for reducing environmental impact of dairy operations is to feed and manage dairy cows to increase per-cow production of milk and milk components. This reduces the number of cows needed to produce milk and decreases the volume of manure produced. Increasing milk production requires high quality feed ingredients in properly balanced rations. Highly digestible diets are required to achieve superior levels of milk production. These high-quality diets improve the nutrient efficiency and reduce excretion of waste products in urine and manure.

To reduce the cost and environmental impact of feeding cows, it is important to supply nutrients at levels closely matched to animal nutrient requirements. Formulating diets based on cow requirements and keeping margins of safety at a minimum can significantly reduce nitrogen and mineral excretion. The best guide to the protein, amino acid and mineral requirements of dairy cattle is the *National Research Council Nutrient Requirements of Dairy Cattle (2001).*

Stage of production. The concentration of nutrients required in the diet is greatest in early lactation when milk production is highest, and declines as lactation progresses. Grouping cows by level of production or employing feeding systems such as computer controlled feeders, total mixed rations (TMR) and hand feeding allows for more precise diet formulation, thus minimizing excretion of nutrients in manure.

Feeding systems. Development and adoption of feeding systems that improve the ability to accurately weigh and blend feed ingredients should allow for more accurate ration formulation, reducing the need for large margins of safety in ration balancing. Blending ration ingredients into a TMR promotes stable rumen conditions, improves digestibility and promotes greater feed intake, resulting in increased milk production and more efficient nutrient utilization. Where concentrates are fed separately from forages, feeding forages before concentrates and dividing the daily concentrate allowance into three to four meals should be considered.

Feed analysis. Chemical analysis of feed ingredients is important for accurate ration formulation. This ensures that the nutrient needs of the cow are met and feeding of excessive levels of nutrients is minimized. Feed analysis of home-grown forages, purchased forages and bulk commodities, where practical, should be standard operating procedure. The tests requested should allow for overall evaluation of feed quality, quality of the protein fractions and phosphorus content. Request whether other nutrients might be needed to promote optimum production of milk and milk components. Feed testing labs routinely add new tests to their services. Consult a nutrition adviser on appropriate tests.

Ration formulation. Successful feeding programs must optimize synthesis of milk and milk components, maximize rumen fermentation, and promote optimal rumen microbial growth while minimizing nutrient excretion in manure and urine.

Nitrogen is a concern because it can contribute to contamination of surface water and groundwater. Twenty-five to 35 percent of the nitrogen consumed by dairy cows is secreted in milk. The remaining 65 to 75 percent is excreted in manure and urine. At higher levels of milk production, the amount of nitrogen excreted in manure and urine decreases.

Feeding nitrogen in excess of requirements, feeding too little or too much ruminally degradable protein or energy in the diet may increase nitrogen excretion in the manure or urine. Excess nitrogen is also excreted in milk as milk urea nitrogen (MUN). MUN can be used as a tool to measure whether the ration is properly balanced for total protein, rumen degradable and undegradable protein, and rumen available energy and it provides information on the amount of protein the animals are wasting. MUN testing is available from DHI service providers in Eastern Canada and some labs in the U.S. Subject to demand from producers and their advisers, this service could be provided by Western Canadian DHI Services.

In addition to nitrogen, energy from carbohydrates is required for rumen micro-organism growth. Synchronization of the degradation of carbohydrate and protein in the rumen should improve the incorporation of nitrogen into microbial protein. Increasing feed intake, providing more digestible organic matter to increase energy intake, and selecting carbohydrate and protein supplements with similar ruminal degradation rates will minimize nitrogen excretion.

Silage-based rations. The moisture content of silage changes from one area of the silo or bag to another. When blended into a TMR, it is important that moisture content of the silage be monitored and the ration adjusted to account for these changes. Silage that is drier than that used in formulation of the ration can result in underfeeding of concentrates, while higher moisture results in overfeeding of concentrates. Both situations can impair milk production and the efficiency of nutrient use. Microwave ovens or commercially available moisture testers can be used to check moisture content of silage. The schedule for testing will depend on the characteristics of the silage, method of storage and composition of the diet.

Synthetic amino acid supplementation. Feeding rations with lower levels of dietary protein, supplemented with rumen-protected amino acids, should minimize nitrogen excretion in manure and urine. Most ration balancing programs do not yet allow for balancing amino acids in cattle rations. More sophisticated computer models with this feature are available. However, these models require more information on feed composition and characteristics than is currently available and require additional testing under our production systems before they are appropriate for routine ration formulation. In their current format, these models may be useful for fine-tuning rations. Much research is currently being conducted in this area.

Forage quality. Feed high quality forages to reduce manure production. These forages offer greater digestibility and increased feed intake. Improvement in feed intake will allow reduction of protein concentration in the diet and contribute to increased milk production, resulting in greater efficiency of nutrient utilization.

Phosphorus supplementation. Phosphorus is the mineral with the greatest potential to contribute to environmental contamination. The majority of dietary phosphorus in balanced rations is excreted in manure with a minor amount in urine. Virtually all of the dietary phosphorus fed in excess of requirements is excreted in the manure.

Most dairy rations are formulated with large margins of safety included. The best guide to phosphorus requirements of dairy cattle is the *National Research Council Nutrient Requirements of Dairy Cattle (2001).* This most recent evaluation of phosphorus indicates that the availability of phosphorus is higher than previously thought. Dairy cattle absorb 64 percent of the phosphorus in forages and 70 percent of that in concentrates, compared to 50 percent in previous evaluations. Feed analysis for phosphorus in forages and purchased commodity feeds may allow nutritionists to reduce the margin of safety used in formulation. Incorporating this information into ration formulations could significantly decrease the amount of phosphorus fed and, consequently, the amount excreted in manure.

7.0 MANURE STORAGE, TRANSPORTATION AND TREATMENT

7.0 MANURE STORAGE, TRANSPORTATION AND TREATMENT

Manure is a valuable by-product from dairy farms. However, to avoid pollution, a well-planned manure storage system is required. This section deals with storage site selection, sizing and maintenance. Manure transportation and treatment are also included.

A storage facility is a permanent structure or location, designed and operated to contain manure, other wastes and contaminated runoff in an environmentally sound manner. Storage structures must provide flexibility to accommodate optimum timing for manure spreading, be sufficiently impervious to prevent leakage and provide an appropriate level of odour control. The design of the storage will depend on the number of animals involved, the storage time required, the type of manure to be stored and the site evaluation. Storage facilities must be designed to meet permit requirements and the requirements outlined in the *Agricultural Operation Practices Act* (AOPA). A professional engineer should certify the storage to ensure that it is structurally and environmentally sound.

7.1 Manure Storage Design Considerations

7.1.1 Manure characteristics

Depending on the housing situation, manure may be handled and stored as a liquid, solid or semi-solid. Manure is classified using the following criteria:

- Liquid – contains less than 10 percent solids. As excreted, manure typically has a solid content of 12 to 13 percent. Additional water comes from washing, spilled water and milkhouse waste.
- Semi-solid – contains 10 to 20 percent solids.
- Solid – solid content greater than 20 percent. To produce a solid, the liquid is drained and the manure is dried or has bedding added.

7.1.2 Anaerobic vs. aerobic storage

Manure storages are either anaerobic or aerobic depending on oxygen availability. Anaerobic action occurs in the absence of oxygen; aerobic action occurs in the presence of oxygen. Mechanical mixing or aeration creates aerobic conditions. Anaerobic storages are generally less costly than aerobic storage but are more odorous. Although aerobic storage is less odorous, more ammonia is released from the storage, which reduces the fertilizer value of the manure and can contribute to acid rain. Most storages in Alberta are anaerobic.

7.1.3 Site selection and construction of manure storage structures

According to AOPA, the manure storage must:

- Meet local property setback requirements.
- Be located at least 100 metres (328 feet) from a spring or water well and at least 30 metres (100 feet) from common bodies of water, such as streams, creeks and ditches.
- Be constructed according to the design criteria outlined in AOPA to prevent water, soil and air contamination.
- Be located at least one metre above the 1:25 year flood level.
- Have at least 0.5 metres vertical distance between the full level of the structure and the upper edge (freeboard).
- Be structurally sound, using professionally engineered designs.
- Be accessible by an all-weather road.
- Have berm and liner protection at locations in the storage affected by scouring (inlets, transfer pipes and agitation sites).
- Be adequately secured to prevent accidental entry of humans, animals and machinery.

7.1.4 Site evaluation

A thorough evaluation of the site is necessary to develop an economically feasible, structurally sound and environmentally safe storage design. A suitable design is based on assessment of the soils, geology and hydrogeology of the area. It is also necessary to consider social and economic factors. The initial site assessment must obtain sufficient information to evaluate the following basic site factors:

- Topographic characteristics including land slope and distance from water bodies.
- Surface and subsurface soil characteristics. Estimate of *in-situ* soil permeability and the suitability of the excavated materials to build a clay liner material and other related information.
- Site hydrogeology, including depth to water table, depth and quality of bedrock, existence of perched water tables, depth to the local aquifer and its quality and sensitivity.

Following a proper site assessment, strict design and construction requirements for the storage should be followed to achieve an impervious liner. If no concern arises from the initial site assessment, an earthen manure storage can be considered for the operation. If there is lack of information or a concern arises in the preliminary assessment, a more rigorous site investigation may be required. This will include a geotechnical field investigation of soil depth, texture and uniformity at the proposed site. Geotechnical parameters such as plasticity characteristics and actual permeability measurements, may be required. The construction specifications for manure storages are outlined in AOPA.

7.2 Types of Storage

7.2.1 Liquid storage

The most common type of liquid storage in Alberta is the earthen manure storage, lined with compacted clay or plastic material. If the storage poses a risk to groundwater, a concrete or steel storage tank may be required. When concrete or alternative storage facilities are used, a professional engineer should verify the design and construction of the facility and the manufacturer should be consulted about ongoing maintenance.

7.2.2 Semi-solid storage

Dairy manure will be semi-solid in facilities that use minimal amounts of bedding, for example, freestall barns. These structures should:

- Meet the criteria listed in Section 7.1.3 for manure storage structures.
- Have reinforced concrete walls, or equivalent, to adequately contain the manure.
- Have a concrete floor, which is sealed to the walls to provide a manure-tight storage and eliminate the entrance of ground or surface water.
- In areas with a high water table, be constructed entirely above ground to minimize seepage of groundwater into the structure (this will also facilitate cleaning out).
- If roofed, be well ventilated to prevent the accumulation of hazardous gases in the headspace area and to aid the drying of the stored manure.
- If fitted with a ramp, have guardrails and safety stops on the ramp to prevent a tractor from being buried in the manure.
- Have a suitable concrete slab area for tractor and manure spreader activity. This slab should be sloped away from the building so that water on the slab does not enter the storage area.

7.2.3 Solid storage

Solid storage can be classified as: short-term, long-term and in-barn storage. Short-term storage contains manure for no more than six months over a three-year period. Long-term storage is greater than six months.

- Prevent surface water runoff from the storage from entering an open body of water or leaving the property.
- Do not construct manure storages on the banks of rivers, drainage channels or depressions that may carry surface runoff to water sources.
- Use berms, catch basins and/or vegetative buffers to prevent runoff.
- Ensure the storage bottom is at least one metre above the water table.
- Storages for solid and semi-solid manure must be constructed at least one metre above the 1:25 year flood plain. If the 1:25 floodplain is unknown, locate the storage at least one metre above the highest known flood level.
- Construct in-barn storage used for alternative housing facilities as a long-term storage. Provide drainage and adequate bedding to prevent contaminated water from collecting in the barn. A slope of two to four percent in the barns provides the necessary drainage.
- Compost can be in either short or long-term storage, but must comply with the *Alberta Environment Code of Practice for Compost Facilities.*

7.3 Manure Storage Capacity

Manure storage facilities should provide enough storage space to allow the operator to spread manure when optimum crop uptake of the nutrients will occur, and when manure runoff from fields to surface water is unlikely. To allow manure to be spread when it is the most beneficial, a minimum storage period of nine months is required by AOPA. However, manure storage facilities are commonly built with a storage capacity of 12 to 14 months to minimize spreading costs.

1) Estimate storage capacity.
   - Estimate the volume of manure produced using Figure 7.1 as a guideline.
   - Evaluate an existing operation that is similar to the planned facility.
   - Contact one of the resource professionals listed in Section 10.

2) Account for management practices and facilities.
   - The volume of manure produced can vary due to spilled water and/or milkhouse wastewater.
   - If bedding is used in solid systems, the weight of manure may increase by 20 percent and the volume may double.

3) Account for the area's historical rainfall.
   - Where precipitation can enter the storage, the storage must have sufficient capacity when it is ready for clean out to handle a major rainstorm without overflowing. Storages should be designed to account for the highest rainfall that has occurred in the past 30-year period. AOPA provides useful weather data for predicting storage sizes.

4) Include reserve capacity in the storage to allow for the accumulation of solids.

5) Provide enough storage to allow flexibility in manure spreading; field conditions, labour availability, weather and local regulations affect manure application timelines. Short-term storage may mean increased management and labour, since time for setting up and putting away equipment is increased. More importantly, bad weather, labour shortages and equipment breakdowns can seriously disrupt the timing of this seasonal operation.

Figure 7.1 Manure Production Volumes*

Daily Solid Manure Production	lb.	kg	cu.ft.
Tie stall	139.7	63.5	2.66
Loose housing	146.3	66.5	2.78
Replacements	42.9	19.5	0.82
Calves	2.9	1.3	0.07
Daily Liquid Manure Production	**gal.**	**litres**	**cu.ft.**
Free stall (dries and milking)**	25.7	116.8	4.11 (includes washwater)

* Taken from *Agricultural Operation Practices Act.*
** Includes milking parlour waste of 30 L per milking cow.

7.4 Managing Manure to Control Odours

Odour is the result of decomposing organic matter. Frequent removal of the manure reduces the odour level in the barn. Aerobic manure decomposition – in the presence of oxygen – produces few odorous gases. Anaerobic manure decomposition – in the absence of oxygen – results in the release of many odours and sometimes dangerous gases, including ammonia, amines, hydrogen sulphide, mercaptans and methane. Anaerobic conditions occur when wet manure is stored in piles or when liquid manure is stored in pits for long periods.

Much of the odour in barns is from feces and urine on floor surfaces. Higher ventilation rates increase the rate of drying on surfaces, which reduces odour concentration. High ventilation rates, used during cold weather conditions, decrease the relative humidity in the barns and the consequent drier conditions produce fewer odours. However, higher ventilation rates must be balanced with the cows' need for adequate environmental conditions. More supplemental heat may be required because drafty conditions may have a negative effect on the cows.

Remove manure from the animal housing area to a separate storage location to reduce the release of odorous gases back into the barn. To further reduce odour, remove animal feces and urine continuously throughout the day.

To further minimize odours in the barn:

- Handle manure in as dry a state as possible.
- Remove waste feed and wet manure frequently.
- Remove and promptly dispose of dead animals and afterbirths.
- Check the direction of the prevailing wind before agitating or spreading manure to minimize the release and spread of odours and manure particles that would affect neighbouring residences or public places.

Windbreaks. Windbreaks are a sound odour control strategy. On a calm day, odorous air leaves the source in a stable plume. Windbreaks create turbulence that breaks up and dilutes the air. The distance required to create adequate air movement between the windbreak and the storage is being investigated.

Covers. Covers can be used to reduce odour and gas emissions from manure storages. Several different types of covers, such as straw, have been studied.

Alternative cover materials. These include foam, glass or clay particles, floating plastic sheets, plastic covers with a frame and geotextile covers held in place by negative air pressure. While these covers provide excellent odour control results, cost, anchoring and pump-out issues still need to be resolved.

Additives. Studies evaluated the effect of different types of feed and storage additives on the release of odour from barns and manure storages. The results of these studies are mixed.

7.4.1 Ventilation of the manure storage

Ventilating the headspace above the manure in the pit ensures that odorous air is exhausted outside the barn and into the atmosphere instead of building up to toxic levels in the barn. However, even if the odours are diluted compared to a non-ventilated headspace, the odours may still be strong and unpleasant, and may pose a problem beyond the farm. Research is currently underway in Alberta to develop a biofiltration technique to reduce the intensity and offensiveness of odours exhausted from barns.

7.5 Safety Precautions When Managing Livestock Manure

As manure decomposes, dangerous gases are released (see the above section on ventilation). When liquid manure is stored for a period of several weeks in an enclosed space, dangerous gases can accumulate in the headspace of the tank and in bubbles and dissolved gases within the manure itself. The greatest danger occurs when the manure is agitated. **During this operation, the gases held in the manure are released and concentrations can reach lethal levels within minutes.** Deaths have occurred as a result of farm workers entering manure storage structures.

"Manure Gas" (M-8710) from Canada Plan Service discusses the sources and types of gases of concern. This leaflet is available from Alberta Agriculture, Food and Rural Development (AAFRD). The most dangerous gas is hydrogen sulphide. Although it is readily detectable at low concentrations, at higher levels the gas paralyzes the sense of smell. Therefore, it is possible to unknowingly encounter a dangerous situation. As its concentration increases, hydrogen sulphide paralyzes the nerves that control the diaphragm, causing breathing to stop. **When concentrations are high, a single breath of the gas can be fatal.**

Good design and safe work procedures can prevent accidents. Workers should be properly trained to deal with manure gases, especially hydrogen sulphide. Long-term storage should not be in the same air space as the animals or workers. The agitation required to remove the manure from the barn can rapidly increase gas concentrations to lethal levels. A gas trap, to prevent gases from returning to the barn, must separate connections between the barn and long-term storage. Design the facility so that all servicing can be performed without entering the storage.

Provide maximum ventilation when agitating manure in an in-barn storage. All personnel should work in pairs. Evacuate all people from the air space above the storage and, if possible, animals as well. To create several feet of headspace for the gases, first begin pumping without agitation. Agitate below the surface and agitate no more than is necessary.

7.5.1 Developing an emergency plan for working with manure storages (a confined space work procedure)

Producers should be aware of the following definition of a confined space. It should:

- Be large enough and configured so that an employee can enter and perform assigned work.
- Have limited or restricted means for entry or exit (for example, tanks, vessels, silos, storage bins, hoppers, vaults and pits are spaces that may have limited means of entry).
- Not be designed for continuous employee occupancy.

Develop a detailed safe job procedure for entry into a confined space, such as a manure lagoon, pit or tank. Train personnel to carry out these duties.

A manure tank should never be entered without proper respiratory equipment. A breathing apparatus specifically built for this purpose, consisting of a full face mask and remote air tank and hose is required. SCUBA equipment is not adequate. Always work in pairs. If an accident does occur, apply appropriate first aid.

7.6 Maintenance of Earthen Manure Storages

Signage and fencing. Hazardous areas such as storage structures, dugouts and water basins should be fenced and have warnings posted to prevent curious humans and animals from accidents.

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

Odour. Decomposition of manure in storage structures can create odours that may be strong and offensive. When manure is undisturbed, gases are trapped beneath the surface within clusters of solid material. With time, the trapped gases increase in volume and rise to the surface in a bubble. At the surface, the bubble bursts and odorous gases are released into the atmosphere. This is a natural process that occurs slowly over time. It is important to note that strong and offensive odours are generated intermittently from manure storages. Weather conditions and practices related to loading and emptying can affect the odour release.

Weather conditions. Temperature influences the generation of odorous gases. During warm summer conditions, the temperature rises in stored manure, increasing microbial activity, resulting in faster decomposition of waste matter and an increase in the volume of odorous gases released. Under cold winter conditions, bacterial activity in storages will stop. Odour levels increase when bacterial activity stops or starts.

Wind and rain may influence the odours released from manure storages because they agitate the contents of the storage. A crust on the surface of outdoor manure storage helps contain odorous gases. However, if strong winds or heavy rain agitate the storage or disturb the crust that forms on the surface of some manure storages, the release of odorous gases may increase.

Loading and emptying. Manure is disturbed when storages are loaded or emptied. 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 releases odorous gases.

To reduce odour when adding new manure to a pre-existing volume in a manure storage, it is advisable to discharge the new material beneath the surface of the manure. The discharge point should be at least 1 metre from the surface of the manure and 0.5 metres above the bed of solids at the bottom. This limits the disturbance of gases trapped in the manure. In addition, use a low discharge flow rate to prevent vigorous agitation of the manure.

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 Section 2.4, Figure 2.1.

7.7 Monitoring Earthen Manure Storage Performance

7.7.1 Visuals

There are several visual indicators of storage problems. These include:

- Content levels that do not change.
- Wave damage to the liner.
- Erosion where manure enters 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, which indicates leakage. Any leakage or slumping is a serious problem that requires immediate attention.
- Evidence of rodents. Rodent burrows damage the liner and walls of the manure storage.
- Tree roots. To prevent roots from penetrating the liner and creating leaks, remove trees and 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 into leakage from earthen manure storage structures has shown minimal problems, there may be some site-specific cases where more than visual monitoring is warranted. These situations may include lagoons constructed in coarse soils, or where groundwater or water tables are within three metres of the bottom of the lagoon.

7.7.2 Sampling wells

Sampling wells can be installed to regularly monitor water quality. Changes in water quality in the vicinity of the manure storage could be impacted by the manure storage. Regular monitoring of water quality 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 be used to design the monitoring well system and analyse 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.

7.8 Runoff Control from Manure Storage

7.8.1 Vegetative filter strips

Vegetative filter strips are widths or lengths of vegetation that act as a filter to trap and utilize sediments and nutrients from runoff.

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

Factors influencing the effectiveness of vegetative filters are:

- Drainage area upslope from the operation.
- The amount and form of precipitation (snow, rain, or both).
- Slope of the operation site and whether the natural topography lends itself to sheet or channel runoff.
- Vegetation type (summerfallow, stubble, grass or trees).
- Soil type (sandy, loam or clay).

For example, frozen ground in the spring, combined with a packed non-vegetative thatch, will not "filter" contaminants as effectively as ground in the summer.

To date, there is minimal definitive research that verifies how to design a vegetative filter strip based on all of the above variables. However, the limited research that has been done suggests that the 30-metre wide separation from a watercourse, as specified in AOPA (60 metres for four to six percent slope; 90 metres for six to 12 percent slope), will be adequate for most runoff situations for feed pens, manure stockpiles and field spreading. For larger volumes of wastewater discharged on a more continual basis, the filter strips should probably be at least 90, 120 and 150 metres wide, respectively. Further research is required to determine more specific design details.

7.8.2 Wetlands

Wetlands are either naturally occurring sloughs or lowlands, or they are "constructed" wetlands that are designed and landscaped. In some instances, they might be used to collect and treat contaminated runoff or discharge from livestock operations. The nutrients and contaminants from the runoff are absorbed and utilized by the bullrushes, sedges and other marsh-type vegetation growing in the wetland area.

Wetlands must be properly evaluated and designed to ensure adequate retention and filtering. At a minimum, these lowlands or wetlands must be entirely contained on the producer's property, and soil conditions must be tested to ensure there is no leaching into groundwater. Research is currently underway to develop design criteria for Alberta conditions.

7.9 Manure Transportation

Moving manure from storage to the field is an important component of the manure management system. Manure hauling must be economically sound, safe and responsible. The nuisance risks associated with manure transportation include dust, spillage and physical impact on roads.

Traffic from manure hauling can be very intense for short periods of time. Traffic on gravel roads during dry, windy periods can result in significant dust generation. In "sensitive areas," such as near neighbours, dust suppression or detouring may be necessary. Dust suppression can include watering roads or applying calcium chloride. Contact a water hauling contractor for road-watering services.

Manure is considered a biodegradable product. However, direct spillage from manure trucks needs to be kept to a minimum. Manure haulers need to be aware of the risks when hauling on roads. Whether manure is wet or dry, spillage may come in the form of seepage, overloading or blowing. Whatever the case, appropriate management techniques and equipment are required to keep the roads and ditches free of manure spillage. This may mean smaller loads, covered loads or sealed end-gates on the manure truck. In the event of excessive spillage, clean-up measures, such as sweeping, will be required.

The intensity of traffic during manure hauling may have a significant impact on lower grade roads. Many livestock operators have entered into road-use agreements with their local municipalities, which clearly define responsibilities. These same road-use agreements may also include responsibilities related to dust generation and spillage.

Be aware that manure spills on the road can be in violation of the *Alberta Transportation Act* (litter) and the *Alberta Environmental Protection and Enhancement Act* (pollution). Also, producers should check with their local municipality about road bans prior to hauling manure.

Transporting manure is an important component of good nutrient management. Safe and efficient manure hauling is possible when these factors are considered.

7.10 Manure Treatment

Manure is a major source of nutrients for crop production and its application on cropland is generally recommended. However, there are cases where the availability of cropland is insufficient for recycling all of the manure produced from a livestock operation, and special situations where direct land application is not acceptable.

An alternative to direct land application of manure is to treat the manure prior to application or for off-farm use. If manure can be land-applied, treatment is an unnecessary expense. The most common methods of manure treatment in Alberta include solid/liquid separation and composting.

7.10.1 Solid/liquid separation

Advantages of separating liquids from solids:

- Reduces solids settling problems in large volume storages.
- Improves pumping and pipeline handling of liquid manure. Pumping liquids from one location to another does not require robust equipment.
- Creates a more consistent liquid portion for managing nutrients on land.
- Provides a solid product that is suitable for composting, thus creating value-added possibilities.
- Separates and concentrates the major phosphorus source in the solids. This increases options for better phosphorus management.
- Improves odour control.
- Volume reduction, which makes storage and handling more cost effective.

Disadvantages of separating liquids and solids:

- Creates two manure types that require separate storage and handling systems.
- Added cost, maintenance and labour.

The technology for effective and economic solid/liquid separation has been slow to develop.

The effectiveness of most separators improves as the manure solids content increases.

Current technologies include:

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

Centrifugal separators. Several separators of this type have appeared on the market. They are generally high in price, low in capacity and low in the ability to produce a low-moisture solids fraction.

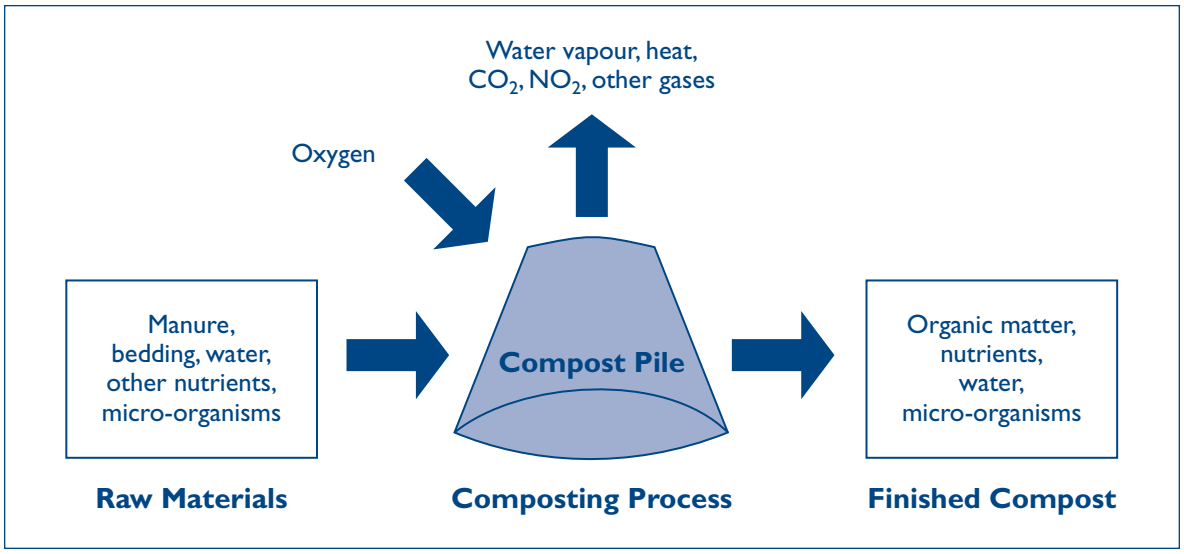
Screens. Many variations exist for screen separators, including the simple stationary sloped bar screen, vibrating screen and screens with mechanical assistance. Most separators on the market at the present time are variants of the screen separator, usually with mechanical assistance in the form of scrapers, screws and/or hydraulic head to provide additional separating force. Costs of these separators vary greatly, from cost-prohibitive to practical, on large operations.

The liquid fraction of manure can be irrigated onto fields. The liquids are diluted with irrigation water and applied using a centre pivot system with standard irrigation nozzles. To reduce impact on neighbours, aerating or diluting the liquids with irrigation water may reduce odour intensity and offensiveness.

For more information about liquid-solid separation, contact an AAFRD livestock operations engineer.

7.10.2 The composting process

Figure 7.2 **The Basic Composting Process**



The composting process has several basic requirements:

- Moisture content in the range of 40 to 65 percent. Since liquid manure is about 96 percent water, the solids must be separated from the liquid in order to be composted. This requires a solids/liquid separation process. Housing systems using straw or shavings for bedding produce solids suitable for composting.
- A carbon:nitrogen ratio of about 30:1.
- An oxygen supply. Oxygen enters either by regular mechanical turning of the compost or by forcing air through the material.
- A pH of 6.5 to 8.0.
- A temperature of 40 to 65 C in the compost pile. Temperatures maintained at 55 C or greater for 15 days will eliminate most pathogens and weed seeds.

7.10.2.1 Methods of composting

A wide range of technology is available for composting. Most compost processes for livestock manure require low investment and low labour inputs.

Windrows. The manure piles or windrows are aerated by frequent mechanical turning, which maintains the compost process. A front-end loader or a specifically designed windrow turner can be used for turning.

Advantages:

- Rapid product drying under warm temperatures.
- Produces a drier product.
- Handles large volumes of material.
- Produces a stable product.
- Relatively low capital cost.

Disadvantages:

- Requires large land areas.
- High operational costs.
- Releases odours.
- May require large volumes of bulking agent.
- Weather dependent.

Static pile/passive aeration. This is the low-end compost process available to most producers without capital investment. The manure windrow or pile undergoes a natural degradation process without the assistance of mechanical agitation.

Advantages:

- Low cost.
- Good pathogen destruction if 55 C is maintained for at least 15 days.
- Good odour control.
- Good product stabilization.

Disadvantages:

- Not space efficient.
- Disease-causing micro-organisms can survive this process if adequate temperatures are not maintained for at least 15 days.
- Compost produced by this method may be very inconsistent and may contain viable weed seeds.
- Affected by climate.
- Anaerobic conditions and/or overheating can cause unpleasant odours.

In-vessel aeration. This is a high-end process in terms of cost, requiring a specifically designed compost vessel usually of concrete, wood or steel. Aeration is enhanced by mechanically forcing air through the composting material. Under optimum conditions, this system allows better control of the process and produces a consistent product with high weed and micro-organism kill.

Advantages:

- Can be covered for weather protection and odour control.
- Space efficient.
- Can be designed as a continuous process.

Disadvantages:

- Highly mechanized and capital intensive.
- Requires careful management.
- Less flexible than other methods.
- Difficult to work around piping and ducting that is used to move air.
- Costly to operate and maintain the equipment.

In-barn composting. Some housing systems using bedding can be adapted to enable composting inside the barn.

7.10.2.2 Composting regulations

The siting and operation of composting facilities is regulated under the *Alberta Environmental Protection and Enhancement Act.*

The *Alberta Environment Code of Practice for Compost Facilities* outlines specific requirements for constructing compost facilities:

- A composting pad must be constructed with a minimum of 0.5 metres of clay-type material having a permeability of less than 5×10^{-8} m/sec. (or alternate material that provides equivalent protection).
- It must be constructed with a minimum slope of two percent so that the pad does not collect water or leachate.
- The provision of a run-on control system must be included to prevent the flow of surface water onto the storage, processing or curing areas.
- A runoff control and management system that provides protection of surface water quality is also required.
- A groundwater monitoring system may be required.

8.0 LAND APPLICATION OF MANURE

8.0 LAND APPLICATION OF MANURE

Manure or compost application to land can be a sustainable agricultural practice, provided proper nutrient management practices are followed. Manure is an organic fertilizer and a source of plant nutrients. Manure can also improve soil tilth, structure, aeration, and water-holding capacity. This is particularly true for coarse-textured soils, soils low in organic matter or degraded soils. Manure serves as a viable substitute for commercial inorganic fertilizer because of its on-farm availability, nutrient composition and ability to enhance the organic matter content of soil. However, if manure application is not properly managed, excess nutrients may be applied to agricultural land. In addition to nutrients, micro-organisms (including pathogens), weed seeds and salts are also present in manure.

Risks that may be associated with land application of manure and compost include:

- Excess phosphorus (P) and nitrogen (N) application on land from manure and mineral fertilizers may result in phosphorus runoff to surface water bodies and nitrate leaching to groundwater.
- Excess phosphorus in water bodies may cause excessive growth of aquatic plants. The decomposition of these plants can reduce oxygen to critical levels, which may adversely affect fish survival.
- Organic matter in a water source may cause physical and biological damage, including oxygen depletion.
- Excess nitrates may reduce ground or surface water quality and become toxic to aquatic life, humans and livestock.
- Disease-causing organisms may contaminate water, making it unsuitable for human and livestock consumption.
- High ammonia levels can poison fish and other aquatic organisms.
- Nitrogen gases, including ammonia and nitrous oxide (a greenhouse gas), may reduce air quality.
- High salinity in manure may decrease soil quality.

In this chapter, Nutrient Management Planning (NMP) will be addressed by outlining some possible Beneficial Management Practices (BMPs) related to land application of manure or compost. The overall objective of NMP is to effectively use manure, compost and/or mineral fertilizers as nutrient resources for optimum crop production in a manner that will reduce the impact of agriculture on the environment.

8.1 Nutrient Value of Manure

Manure should be managed as a resource, to maximize its benefits and minimize its risks. Nutrients can be effectively recycled when manure is used as a fertilizer, and this can reduce the need for commercial fertilizers.

To use manure as a resource, it is important to understand its composition. Manure is a mixture of water, organic matter, mineral matter, nutrients and other chemicals. The proportion of each component and the nutrient profile of the manure depends on animal age, manure storage and handling, bedding material and diet fed. The nutrients available in manure are nitrogen, phosphorus, potassium, calcium, magnesium, sodium, sulphur, and micronutrients such as boron, chlorine, copper, iron, molybdenum, zinc, selenium, chromium, iodine and cobalt.

8.1.1 Nitrogen and phosphorus in manure

Manure provides the same nutrients for crop production as commercial fertilizers, but the challenge with manure is that the forms and ratio of the nutrients are not easy to change. Nitrogen is present in manure as ammonium or as organic compounds. Generally, the environmental risks associated with nitrogen are losses to groundwater through leaching or losses to air through denitrification and volatilization. Phosphorus is present in manure as organic and inorganic forms and generally the risk to the environment is the movement of phosphorus in surface runoff from spring snowmelt and seasonal rainfall.

Facts about nitrogen and phosphorus:

- Only ammonium and nitrate (mineral or inorganic nitrogen) can be used by plants.
- Organic nitrogen must be transformed to ammonium (mineralized) and nitrate (nitrification) forms to be used by plants.
- Phosphorus (P) is generally found in three forms: particulate phosphorus (P attached to sediments), dissolved phosphorus (water soluble P) and organic phosphorus.
- Soil test nitrogen and phosphorus are measurements of the current plant available nitrogen and phosphorus. These measurements can be used to determine if additional nitrogen and phosphorus are required for optimum crop growth. Soil test phosphorus can also be used in the assessment of potential phosphorus runoff losses.

To reduce nitrate leaching:

- Apply manure based on the nitrogen rate from soil test recommendations.
- When a high amount of nitrogen is required, split the total amount required into two thirds manure and one third mineral fertilizer. Apply mineral fertilizer later in the season.
- Reduce the amount of time between application of manure and the highest demand for nitrogen uptake by the crop (e.g. apply in spring while plants are actively growing).
- Do not apply if heavy rain is predicted.
- Do not apply near streams or other water bodies. Producers must not apply manure within 10 metres of an open body of water if sub-surface injection is used, within 30 metres of an open body of water if manure is applied to the surface and incorporated within 48 hours, or within 30 metres of a water well (*Agricultural Operation Practices Act* [AOPA]).

To reduce ammonia losses into the air:

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

To reduce denitrification:

- Avoid manure application in low, wet areas.
- Apply manure prior to seeding, so nutrients can be used while plants are actively growing.

Figure 8.1 Nitrogen and Phosphorus in Manure

	Form in Manure	Available 1st year	Available 2nd year	Available 3rd year	Environmental risks
Nitrogen (N)	• Ammonium (NH_4^+) • Nitrate (NO_3^-) • Organic N	NH_4^+ + NO_3^- + 25% of initial organic N content	12% of initial organic N content	6% of initial organic N content	• Nitrate in groundwater • Volatilization* of ammonia • Denitrification* as nitrous oxide
Phosphorus (P)	• Inorganic P ($H_2PO_4^-$ & HPO_4^{2-}) • Organic P	50% 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

* Volatilization is the gaseous loss of a substance (e.g. ammonia) into the atmosphere. Denitrification is the transformation, under high moisture or saturated soil conditions, of nitrate to gaseous forms, which can be lost to the atmosphere. 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.

To reduce phosphorus in surface runoff:

- Inject or incorporate fertilizers and manure to avoid losses by runoff in areas and soils that are adjacent to water bodies and/or have high runoff potential.
- Test soil phosphorus at least once every three years to avoid over-applying fertilizers or manure. Over application of manure will raise soil phosphorus levels above the recommended agronomic levels (contact a crop adviser or soil laboratory for recommended P levels for each crop).
- Test soils in different landscape locations (e.g. knolls, low spots) to determine if excess levels exist in low areas where runoff collects.
- Apply manure according to soil test recommendations, crop yield goals and manure analyses. If manure is not analysed for nutrient content, book values can be used (AOPA). This will reduce excess nutrients in the soil and minimize buildup.
- Apply manure when it can be incorporated. Avoid spreading manure on snow or frozen soil.
- If manure is applied on forage or direct-seeded crops, or if the land is frozen or snow-covered, application must be in accordance with the nutrient limits, other manure application requirements (e.g. proximity to water), and must not adversely impact groundwater, surface water or create an odour nuisance. Surface application of manure on frozen or snow-covered land or on forage and direct-seeded crops without incorporation is only acceptable if the minimum setback distances are met (Figure 8.2). Surface water that comes in contact with surface-applied manure must not enter an open body of water or leave the owner's property.
- Base the nutrient management plan 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).
- Currently, there are no soil phosphorus limits in Alberta. However, research is underway to identify environmental limits.

To reduce nutrient losses by wind and water erosion:

- Leave some of last year's crop residue on the surface and reduce tillage. This increases water infiltration and reduces nutrient losses in wind-blown sediments and runoff.
- Build a runoff control basin or an embankment across a depression of concentrated water in a field. The embankment will act as a terrace, trapping sediments, slowing water movement and reducing gully erosion. By slowing water movement, the re-deposition of P in the field will increase.
- Construct a terrace by breaking longer slopes into shorter ones.
- Establish grassed waterways in erosion-prone areas to slow water movement from the field.

Figure 8.2 Minimum Setback Distances for Application of Manure on Forage or Direct-Seeded Crops or on Frozen or Snow-Covered Land (AOPA)

Mean Slope	Required Setback Distance from Open Body of Water
Less than 4%	30 m
4% but less than 6%	60 m
6% but less than 12%	90 m
12% or greater	No application allowed

8.1.2 Salt

Manure can contain significant amounts of salt that may affect soil quality.

Facts about salt:

- Management of soil salinity is crucial for sustainable crop production. Saline soils can reduce crop production and limit cropping options (contact a crop adviser for information on crop salinity tolerance).
- Salt can destroy soil quality. High levels of sodium disperse aggregates, degrade soil structure and reduce water infiltration through soil.

To control salt:

- Monitor salt levels in feed rations (contact a livestock nutritionist for recommended levels in feed).
- Monitor electrical conductivity (EC) level in soil. EC is a measurement of the flow of electricity through a material, such as water or a soil solution. The more salts in a soil sample the greater its 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, do not apply manure (AOPA).
- Monitor the sodium adsorption ratio (SAR) levels in soil. SAR is a measurement of sodium in relation to calcium plus magnesium. SAR levels in soil above eight can decrease soil permeability and increase the potential for water-logging.
- In soils with a high EC and high SAR, do not apply manure.

8.2 Manure and Soil Analyses

Manure analysis provides information on nutrient content. Based on nutrient analysis, the amount of nutrients available for crop growth can be estimated. To estimate crop-available nutrients in manure, the chemical make-up of the nutrients in manure, previous manure applications, volatilization, nitrogen fixation and mineralization (breakdown of organic matter into available plant nutrients) should be considered. When calculating manure application rates, include residual crop-available nutrients from manure applied in recent years.

Accurate manure analysis and application are important because problems can result from either inadequate or excessive nutrients in the soil. Manure analysis recommendations are based on the nutrient content in manure, crop to be grown, soil type, soil test, climate, soil moisture and other management practices, such as dryland versus irrigation.

8.2.1 Manure analysis

- Analyse manure for three to five consecutive years and compare results to the book values. If there is a large discrepancy, do not use the book values. Instead, develop new average values for the operation.
- Although the best source of information is from sampling the operation's manure, book values of nutrient content are available and are better than not considering the nutrients in the manure at all (e.g. AOPA).

8.2.2 Manure sampling

Manure testing helps generate a long-term database for planning and economic evaluation, as well as demonstrating due diligence. It is important that manure samples represent the entire volume of manure, not just the surface application. Achieving an appropriate manure application rate is closely related to how manure samples are collected.

For manure sampling:

- Collect composite samples that reflect the overall variability of the manure.
- When sampling liquid manure, agitate completely prior to sampling. If agitation is not done, sub-samples from different locations and depths of the storage facility should be taken.
- When sampling solid manure containing bedding and other materials, all compounds should be in the same proportion in the sample as they are in the pile.
- Collect about 20 samples from each manure source that needs analysis. Mix the samples together, remove a sub-sample (about 1 kilogram) and then place in a sealed container. Keep cool and send to the laboratory as soon as possible.
- Sampling before, but as close to land application as possible, helps build an accurate database. A good time to collect liquid manure samples is after lagoon agitation. Solid manure is best sampled directly from the manure truck loads (three to four samples per load).
- Use the manure analysis information to determine manure application rates.

8.2.3 Manure handling and shipping

A good understanding of how manure is handled helps to characterize the variability of manure composition in different manure piles, and assists in the collection of a representative sample.

For manure sample handling:

- Any handling that can cause the alteration of physical and chemical composition of manure samples should be avoided (i.e. leakage, nutrient losses to the air, loss of moisture, room/warm temperature).
- Use sealable freezer bags for solid manure. Seal the bag and prevent leakage by putting the bag inside another freezer bag (double bagging).
- For liquid manure, use plastic or glass containers.
- The samples should be sent immediately to the lab. Otherwise, the samples must be frozen until delivery.
- In all situations, the container should be only half-full and labelled with name, date and sample identification. The sooner the sample is sent to the lab, the more reliable the results.
- Contact the laboratory prior to sampling to obtain specific information on sample size, shipping instructions and costs.

Requesting manure laboratory results:

- Manure tests should at least include percentage dry matter, total nitrogen, ammonium nitrogen and total phosphorus. If there is a possibility of other soil deficiencies, other nutrients such as potassium, sulphur and micronutrients can be measured. Analysing EC and the SAR in manure are only necessary to determine if changes in feed rations affect manure quality.
- Manure test results should be in the same units as used for calibrating the manure application equipment (pounds or kilograms). Take special care when converting units.
- Manure nutrient results should be on a wet (or "as is") basis since manure is spread wet.

8.2.4 Soil analysis

Soil analysis is used as an index for nutrient availability in soil. Decisions about nutrient management cannot be made without knowing the nutrients available in the soil and their levels. The higher the nutrients in the soil test, the lower the application rate of fertilizer/manure. An accurate soil test (proper soil sampling and interpretation of soil test) can be an excellent nutrient management tool. However, misuse of a soil test leads to increased costs, yield losses and/or environmental contamination. Soil tests should also be used to indicate nutrient or salt excesses. If an excess is found, manure application rates should be based on the excess nutrient; then inorganic fertilizer can be used to supplement other nutrient levels.

For soil sampling:

- Collect a representative sample, based on in-field variations in topography (slope), soil type, cropping management and cropping history.
- Collect soil samples from depth intervals of 0 to 15 centimetres (0 to 6 inches), 15 to 30 centimetres (6 to 12 inches) and 30 to 60 centimetres (12 to 24 inches) at 20 to 30 sites per field or field management area. Place samples from each depth in a separate container. Sample to greater depths (below one metre) every three to five years to check for nitrate leaching in fields that receive regular manure application or fields with a history of heavy manure application.
- Mix samples taken from same depth intervals and remove about 0.5 kilogram (1 pound) from each depth. If the field is variable, keep the samples from different areas (variations) separate.
- 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. Tools may be borrowed or purchased from a fertilizer dealer or from some soil testing laboratories.
- Ideally, samples should be taken prior to seeding, but if time is a constraint fall sampling is the best alternative. Because changes in soil nutrients are slower below soil temperatures of 7 C, collect soil samples at or below this temperature, but prior to freeze-up.
- Analyse soil for at least plant-available nitrogen and phosphorus. Analyse for other nutrients (sulphur, potassium, micronutrients) if there is a possibility the soil may be deficient. It is also important to monitor soil salinity (EC) and possibly SAR on a regular basis.

Soil test interpretations:

- If nutrient recommendations are included in the laboratory report, there is no need for soil test interpretations.
- If recommendations are not included with soil test results, consult a crop adviser or private consultant to provide soil test interpretations and recommendations.
- Not all manure will have the right composition to meet crop requirements. Nutrients are not present in organic materials in the same proportions as crops require them.
- Adjust application rates to meet the requirement for nutrients that will result in the lowest application rate. Inorganic fertilizers can be used to supplement other nutrients to the recommended levels.
- Avoid yearly applications to the same land unless manure and soil tests indicate there is no risk of excess nutrient levels.

8.3 Crop Nutrient Requirements

Nutrient requirements vary from one crop to another. Therefore, for the same conditions, application rates will be different, depending on the crop. Targeted yield for a given crop is an important factor in determining the amount of nutrients to be added. Crop yield targets are used to determine nutrient requirements and the manure rate. To estimate targeted yield, average the yields of the previous four harvests for a given field and add five to 10 percent as an expected improvement factor.

The overall objective for considering manure and soil analyses, as well as cropping system components, is to determine an accurate manure application rate. An illustrated example is presented as a case study at the end of this section, to show how all the components are integrated.

To determine crop nutrient requirements:

- Apply the manure with the highest nutrient content to crops with the highest nutrient requirements (See Figure 8.3).
- Generally, legumes do not require additional N. Therefore, do not apply manure with high N content.
- Apply manure with the lowest nutrient content to fields closest to the manure storage site and the highest nutrient content to the farthest fields. This will reduce the cost of hauling, as a lower amount of manure is needed when nutrient concentration is higher.

Figure 8.3 Nutrient Uptake and Removal by Various Crops

Crop		Yield tonnes* or kg/ha	N	P_2O_5	K_2O
			kg/ha		
Spring Wheat	Removal	2,690	67	27	20
	Uptake	2,690	95	36	82
Winter Wheat	Removal	3,360	55	29	19
	Uptake	3,360	76	35	80
Barley	Removal	4,300	87	38	29
	Uptake	4,300	124	50	120
Oats	Removal	3,810	69	29	21
	Uptake	3,810	120	46	164
Rye	Removal	3,450	66	28	22
	Uptake	3,450	103	52	147
Corn	Removal	6,280	109	49	31
	Uptake	6,280	171	71	145
Canola	Removal	1,960	76	41	20
	Uptake	1,960	126	58	91
Flax	Removal	1,510	57	18	17
	Uptake	1,510	80	22	49
Sunflower	Removal	1,680	61	18	13
	Uptake	1,680	84	29	41
Potatoes	Removal	45*	143	41	242
	Uptake	45*	255	75	334
Peas	Removal	3,360	131	39	40
	Uptake	3,360	171	47	154
Lentils	Removal	1,290	68	21	37
	Uptake	1,290	103	28	86
Alfalfa		11*	103	28	86
Clover		9*	255	75	334
Grass		7*	242	63	226
Barley Silage		10*	115	34	146
Corn Silage		11*	174	59	138

* Conversion of yields to metric units assumed the following bushel weights (in pounds per bushel): wheat = 60; barley = 48; oats = 34; rye = 56; corn = 56; canola = 50; flax = 56; sunflower = 30, peas = 60; and lentils = 38.
P_2O_5 x 0.4364 = P
K_2O x 0.8301 = K
kg/ha x 0.8924 = lbs./ac.
tonne/ha x 0.4461 = ton/ac.

Source: *Fertilizer Institute of Canada (Modified)*

8.4 Method of Manure Application

Different methods of manure application have been developed to:

- Optimize nutrient availability.
- Minimize nutrient losses.
- Minimize odour.
- Spread manure uniformly.

Choosing a method of manure application depends on the physical characteristics of manure (liquid or solid), type of operation, handling and storage, type of spreader and cost.

8.4.1 Injection

The point of delivery is below the soil surface. Manure is placed in the soil using a shank mounted opener. Examples include cultivator shank-mounted openers, such as knives and sweeps, with a delivery hose located behind each opener.

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

- Pooling of manure on the soil surface does not occur.
- Soil should cover all the manure and trenches should not be left in the field.

Proper injection provides excellent odour control, low runoff potential and low nutrient loss through volatilization and leaching. The drawback to injection is high soil disturbance, especially at higher ground speeds. This may pose a problem in minimal till and forage situations.

8.4.2 Low disturbance injection

The point of delivery is at or below the soil surface. A small furrow is created in the soil using a cutting disk and manure is placed in the furrow using a delivery hose. Some machines then close the furrow using a packing wheel. Examples include disk systems, such as coulters.

Low disturbance injection is an acceptable method of manure application provided the manure is applied at proper rates and meets the following guidelines:

- All manure is placed in the furrows and remains there. Pooling of manure outside the furrows should not occur.
- Manure placed in the furrows should not be visible for very long after application.

Proper surface injection provides good odour control, low runoff potential and low-to-moderate nutrient loss from volatilization or leaching. The drawback of low disturbance injection is the cost of the equipment.

8.4.3 Broadcast with incorporation

The point of delivery is above the soil surface. Manure is placed on top of the soil, crop and litter and is later tilled into the soil. Examples of broadcasting include dribble bar, splash plate, and beater (solid manure). Examples of incorporation equipment include harrows, ploughs and cultivators.

Broadcast with incorporation is an acceptable method of manure application provided the manure is applied at proper rates and meets the following guidelines:

- After incorporation, pooling of manure on the soil surface does not occur.
- The sooner the incorporation, the lower the nitrogen loss to the air (incorporation within 48 hours).

Proper broadcasting with incorporation provides moderate-to-high nutrient loss and moderate runoff potential. The drawback of broadcast with incorporation is the soil disturbance that results. This method is, therefore, incompatible with minimal till and forage situations.

8.4.4 Broadcast

The point of delivery is above the soil surface. Manure is placed on top of the soil, crop and trash. Examples of broadcasting include dribble bar, splash plate and beater (solid manure).

Broadcast is only acceptable without incorporation on forage crops, direct-seeded crops and/or frozen or snow-covered ground. Broadcast method of manure should be applied at proper rates to minimize nutrient loss and runoff.

8.5 Time of Application

The best time to apply manure is before the early stages of crop growth. Spring application is the most desirable for Alberta conditions as high nutrient availability time matches crop uptake. However, there are usually fewer opportunities in the spring for application due to inclement weather, risk of soil compaction and time required for other activities. The longer the time between manure applications and when the crop can use the nutrients, the higher the risk of nutrient losses. Within a given season, nitrogen loss by ammonia to the air from surface applications is higher on dry, warm, windy days than on days that are humid and/or cold.

Figure 8.4 **Timing of Manure Application**

Season	Watch For	BMP
Winter	• Runoff that can pollute surface water. • Sensitive areas. • Sloping topography. • Manure that soaks in too slowly on wet soils. • Wet soils that are prone to compaction.	• Manure should be going into storage. • Avoid application on frozen or snow-covered ground. • Avoid spreading on land with a history of floods or heavy runoff. • In case of emergency, apply on grass or winter cover crops or on areas of high crop residue where there is less danger of runoff or floods. • Apply only on level, non-sensitive areas and only in emergencies (see Figure 8.2).
Spring	• Wet soils that are prone to compaction. • Denitrification that happens in cold, wet soils. • Excessive application that can create a contamination hazard. • Very dry soil with large cracks where liquid manure can flow into drainage systems. • Heavy surface residue that slows the drying process of seedbeds. • Planting too soon after heavy manure application can create ammonia toxicity and reduce germination and seedling growth.	• Apply to land before seeding annual crops. • Apply to row crops as a side dressing after plants emerge. • Work manure into soil within 48 hours after application. • Inject liquid manure. • Apply to well-drained soils. • Till very dry soil with large cracks before applying manure. • Allow for more time to dry following application of liquid manure.
Summer	• Loss of nitrogen if there is no rainfall within 72 hours. Rain helps manure soak in. • Mature crops that are not growing; they do not need nutrients. • Application on forages and direct seeded crops. See Figure 8.2 for slope and setback distances.	• Apply to grasslands, inject liquid manure. • Apply lightly on hay fields after cuttings. • Apply early enough to pasture to avoid trampling re-growth. • Compost manure to reduce odour and breakup clumps. • Consider injection of liquid manure.
Fall	• Denitrification in cold, wet soils. • Manure that soaks in slowly on wet fields; excess water will run off. • Wet soils that are prone to compaction. • Large dry cracks where liquid manure can flow into the drainage system.	• Apply liquid manure to grassland that has no history of runoff or floods. • Apply to annual crop lands before ground freezes, and incorporate within 48 hours. Base application rates on soil tests and crop rotation for next year. • Apply to well-drained soils. • Till very dry soil with large cracks before manure application.

Source: *Best Management Practices, Livestock and Poultry Waste Management: Agriculture and Agri-Food Canada and Ontario Ministry of Agriculture and Food, 1994.*

8.6 Calibration of Spreading Equipment

Spreading is an important operation in manure management. The possibilities for over or under application are significant. Therefore, it is crucial to correctly calibrate manure spreading equipment. It is ineffective to do proper soil and manure analyses and determine application rates based on targeted crop yield if spreading is not accurate.

Equipment calibration should address the rate and uniformity of application. In fact, one of the main concerns in manure application is how uniformly nutrients are distributed. Uneven nutrient distribution in the field creates areas where crop yield may be depressed by either excess or insufficient nutrients. The other concern is how to deliver the intended manure application rate.

The two main reasons for calibrating manure spreaders are:

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

Calibrate the spreader using manufacturer guidelines to ensure proper rate of application before each use. Check all parts of spreader to ensure proper working conditions. Refer to Section 10 for more information on equipment calibration.

8.7 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 generate accurate on-farm data that can be used to generate site-specific information.

Records that must be kept according to AOPA are:

- Volume or weight of manure production.
- If transferring or receiving manure from another operation, record name and address of person, date of the transfer and the weight transferred.
- If applying manure at 300 tonnes or more per year, also keep the following records:
  - Legal description of land to which manure is applied.
  - Area of the land to which manure is applied.
  - Weight of manure applied.
  - Application rates of manure nutrients and fertilizer by field and year.
  - Dates of application and incorporation, and methods used for each field.
  - Soil test results by field.

Other records that would be helpful to keep include:

- Farm manure production by type of animal and stage of production.
- Manure analyses by type or by storage unit.
- When and how manure is incorporated.
- Crop planted and yields by field and by year.
- Weather conditions.

Records should be kept for five years.

8.8 Other Beneficial Management Practices

8.8.1 Determine soil limitations

Not all soils are the same. In fact, the same manure application rate has different effects on different soils. When making decisions on manure application, consider these factors as they relate to soil type:

- Leaching potential.
- Runoff potential.
- Erodibility.

8.8.2 Determine proximity limitations

Manure and nutrients must be managed with more caution near open bodies of water, wells, rivers, creeks and drinking water to reduce the risk of contamination. Take into account connectivity to water bodies and runoff and erosion potential when applying manure.

8.8.3 Determine cropping system limitations

Extra precautions are needed when manure is used on reduced or no-till fields, pasture or crop cover. In these systems, incorporation of manure is only partial or not possible. Therefore, risk of runoff losses are relatively high depending on the landscape. To minimize nutrient losses from these systems, land with low runoff potential should be considered first.

8.9 Manure Management Planning Case Study

This example plan will illustrate, step-by-step, all the information reported in this chapter regarding nutrient management planning. As an example, a dairy farm will be used, with four fields for manure application (Fields 1 to 4). Two different lagoons of manure will be used.

In this example, phosphorus and potassium are reported as phosphate (P_2O_5) and potash (K_2O), respectively.

STEP 1: Determine on-farm manure production.

The implementation of manure nutrient management planning starts with an estimate of on-farm nutrient resources. Determination of manure production can be estimated by storage capacity, or by the herd size and the average daily, monthly or yearly production rate per animal (see AOPA, *Standards and Administration Regulation, Part 2, Schedule 3,* Table 6 for solid manure; Table 7 for liquid manure).

Equation 1
Estimated Manure Production = [Number of Animals] x [Amount produced per animal per year]

Example:

Animal numbers are:
- dairy = 200
- replacements = 80

In AOPA, *Standards and Administration Regulation, Part 2, Schedule 3, Table 7 Liquid Manure Production Volume,* gives the following amount of manure produced yearly:
- 9,380 gal./animal*.
- 1,440 gal./animal replacements.

* includes milking parlour wastewater of 7 gal./milking cow

Therefore:
Estimated Manure Production = (200 x 9,380 gal./year) + (80 x 1,440 gal./year)
= 1,991,200 gal./year

STEP 2: Analyse manure.

Example:

Assume two different lagoons of liquid manure. The lab results are as follows:

Lagoon 1
Total N = 46 lb./1,000 gal.
Ammonium N = 21 lb./1,000 gal.
Total P = 9.5 lb./1,000 gal. = 9.5 x 2.29* = 21.8 lb./1,000 gal. P_2O_5
Total K = 47.5 lb./1,000 gal. = 47.5 x 1.20* = 57.0 lb./1,000 gal. K_2O

Lagoon 2
Total N = 36 lb./1,000 gal.
Ammonium N = 16 lb./1,000 gal.
Total P = 7.5 lb./1,000 gal. = 7.5 x 2.29* = 17.2 lb./1,000 gal. P_2O_5
Total K = 37.5 lb./1,000 gal. = 37.5 x 1.20* = 45.0 lb./1,000 gal. K_2O
*See Abbreviations and Conversions page at the front of this Manual

N – nitrogen
P – phosphorus
P_2O_5 – phosphate
K – potassium
K_2O – potash

STEP 3: Calculate available nutrients in manure.

Calculate available nutrients and ammonia loss in manure for the current year's application using the following equations:

Equation 2
Available N=[organic-N x 0.25] +[Ammonium-N – [Ammonia-N x Loss Coefficient]]

Equation 3
Available P_2O_5 = Phosphate x 0.5

Equation 4
Available K_2O = Potash x 0.9

Figure 8.5 Predicted Losses (in percent) of Ammonium N Between Spreading and Incorporation of Manure Under Various Weather Conditions

Treatment	Average	Cool Wet	Cool Dry	Warm Wet	Warm Dry
			Spring/Summer		
Incorporated within 1 day (24 h)	25	10	15	25	50
Incorporated within 2 days (48 h)	30	13	19	31	57
Injected in season	5	5	5	5	5
Irrigation, incorporation within 3 days (72 h)	30	N/A	N/A	N/A	N/A
			Fall		
Early	66	40	50	75	100
Late	25	25	25	25	25
Cover crop if grown after manure application	35	25	25	40	N/A

Losses expressed as percentage of total ammonium N spread.

Adapted from AAFRD and LandWise Inc. 2001.

Example:

According to AOPA, *Standards and Regulation, Part 1, Nutrient Management,* manure must be incorporated within 48 hours. Therefore, assume an average ammonium loss rate of 30 percent (0.30). See Figure 8.5 for predicted losses of ammonium

Lagoon 1

Organic N = total N – ammonium N = 46 – 21 = 25 lb./1,000 gal.
Available N = (25 x 0.25) + [21 – (21 x 0.3)] = 21 lb./1,000 gal.
Available P_2O_5 = (21.8 x 0.5) = 10.9 lb./1,000 gal.
Available K_2O = (47.5 x 0.9) = 42.8 lb./1,000 gal.

Lagoon 2

Organic N = total N – ammonium N = 36 – 16 = 20 lb./1,000 gal.
Available N = (20 x 0.25) + [16 – (16 x 0.3)] = 16.2 lb./1,000 gal.
Available P_2O_5 = (17.2 x 0.5) = 8.6 lb./1,000 gal.
Available K_2O = (45 x 0.9) = 40.5 lb./1,000 gal.

STEP 4: Determine nutrient recommendations.

Determine nutrient recommendations based on soil tests, crops and expected yields.

When requested, nutrient recommendations are provided in the laboratory reports. If not, contact an AAFRD specialist or private consultant to help determine nutrient recommendations.

For a given field, a combination of AOPA, soil tests, crops and targeted yield data should be used to determine nutrient recommendations.

Example:

Figure 8.6 **Nutrient Recommendations for Each Field**

	Soil Tests			Nutrient Recommendations		
Field	N	P_2O_5	K_2O	N	P_2O_5	K_2O
	lb./ac.					
1	20	30	450	160	30	0
2	50	30	450	100	30	0
3	40	15	450	170	60	0
4	80	30	150	50	40	60

Note: When reviewing a soil test report, always note whether results for P are expressed as elemental phosphorus (P) or as phosphate (P_2O_5). To convert phosphorus to phosphate, simply divide the amount of phosphorus by 2.29.

STEP 5: Calculate residual available N.

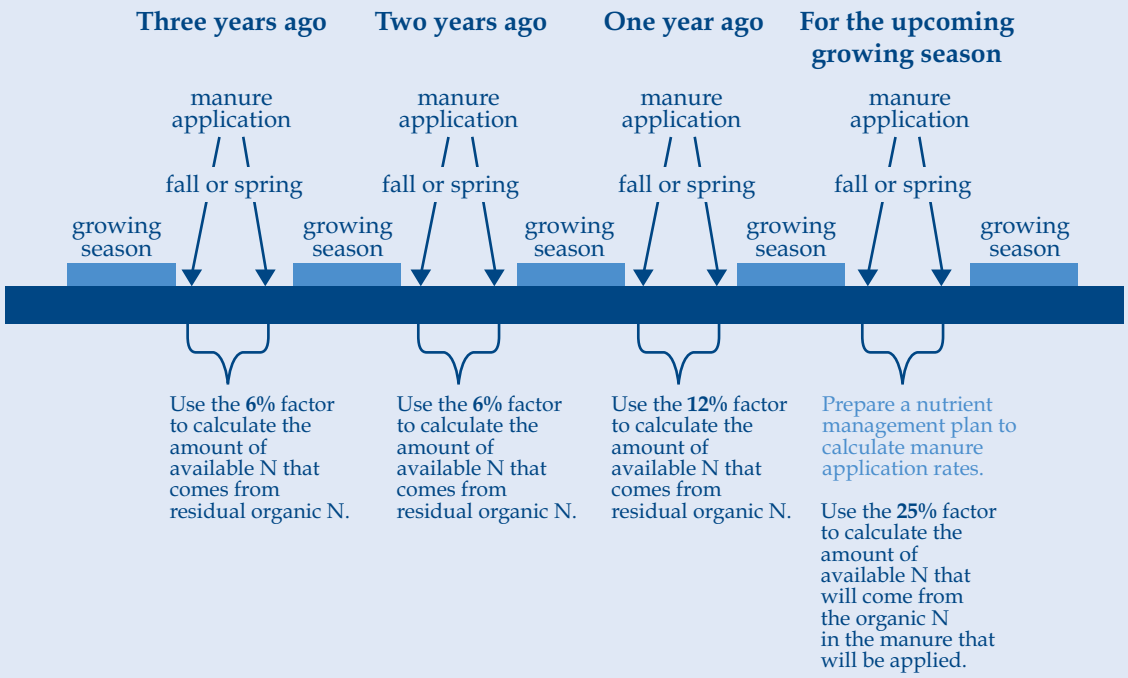
Calculate the residual available N from previous manure applications using the following equation:

Equation 5

Residual N = [0.12 x Manure applied one year ago x Organic-N content of the manure] +[0.06 x Manure applied two years ago x Organic-N content of the manure]

Determine the manure application of previous years using Figure 8.7.

Figure 8.7 **Residual Organic N in Manure**



From Barry Olson, AAFRD, personal communications, 2002.

Example:

Figure 8.8

Residual Nitrogen from Previous Manure Application

	Manure Applied		Organic-N Content of Manure		Residual-N
Field	1 year ago	2 years ago	1 year ago	2 years ago	
	---------- gal./ac. ----------		--------- lb./1,000 gal. ---------		lb./ac.
1	15,000	10,000	19	16	43.8
2	20,000	0	21	–	50.4
3	0	10,000	–	20	12.0
4	0	0	–	–	0
Column 1	*Column 2*	*Column 3*	*Column 4*	*Column 5*	*Column 6*

Residual-N from previous applications is calculated (Col = Column number):

Field 1
Residual N = (0.12 x Col 2 x Col 4) +(0.06 x Col 3 x Col 5) = 43.8 lb./ac.

Field 2
Residual N = (0.12 x Col 2 x Col 4) = 50.4 lb./ac.

Field 3
Residual N = (0.06 x Col 3 x Col 5) = 12.0 lb./ac.

STEP 6: Determine field and AOPA limitations.

It is important to determine the following field and AOPA limitations before applying manure:

- Slope.
- Proximity to water body and connecting streams.
- Nitrate-nitrogen limits in AOPA.
- Distance from manure storage (hauling distance).

Slope, proximity to water bodies and nitrate-nitrogen limits are discussed in AOPA under *Standards and Administration Regulation, Part 1, Nutrient Management.*

Example:

Figure 8.9

Field Characterization

Field	Hauling Distance (miles)	Field Limitations	AOPA Limitations
1	3	Slope 6%	With incorporation within 48 hours, 30 metres away from a common body of water or well.
2	4	Slope 4% and connected to a surface water body.	With incorporation within 48 hours, 30 metres away from a common body of water or well.
3	5	Forage	If less than 4% slope, must be 30 metres away from a common body of water or well.
4	0.3	None	With incorporation within 48 hours, 30 metres away from a common body of water or well. * Based on soil tests, if this soil was present in the Brown Soil Zone, the nitrate-nitrogen content would be over the allowable limit and no manure would be allowed to be applied to this field.

* Nitrate-nitrogen limits in AOPA.

STEP 7: Field prioritization.

This is where information is integrated to determine accurate rates, which optimize economic return and minimize nutrient loss to the environment.

Example of factors to consider:
- The slopes in Fields 1 and 2 are relatively steep compared to other field slopes; therefore, manure application should take phosphorus into consideration.
- The cost of hauling manure to Fields 2 and 3 might be relatively high; therefore, the manure lagoon or storage having the highest phosphorus nutrient content will be used.
- Field 3 is in pasture. Incorporation will not be an option; therefore, application will be based on phosphorus.

Calculation of application rate for each field:

Field 1:

Due to the steep slope, this field manure rate will be based on phosphorus.
Figure 8.6 shows the phosphate recommendation is 30 lb./ac.

- **If manure from Lagoon 1 is to be used:**

If manure is to be applied on P basis in this field:

Equation 6
Manure rate of application based on phosphorus = [Recommended Amount (Figure 8.6)] ÷ [Available phosphate in manure (Equation 3)]
Manure application rate based on phosphorus = 30 lb./ac. ÷ 10.9 lb./1,000 gal. = 2,752 gal./ac.

Equation 7
Crop available N = [Available N (Equation 2) x Rate of application] + Residual N (Equation 5)
Crop available N = (21 lb./1,000 gal. x 2,752 gal./ac.) + 43.8 lb./ac. = 101.6 lb. N/ac.

Equation 8
Fertilizer N to be added = Recommended amount (Figure 8.6) – [amount provided by manure, which is crop available (Equation 7)
Fertilizer N to be added = 160 lb./ac. – 101.6 lb./ac. = 58.4 lb. N/ac.

If manure is to be applied on N basis:

Equation 9
Manure application rate based on nitrogen = [Recommended amount (Figure 8.6) – Residual N (Equation 5)] ÷ Available N (Equation 2)
Manure application rate = (160 lb./ac. – 43.8 lb./ac.) ÷ 21 lb./1,000 gal. = 5,533 gal./ac.

Equation 10
Crop available P_2O_5 = [Available P_2O_5 (Equation 3)] x [Rate of application based on N (Equation 9)]
Phosphate applied would be = 10.9 lb./1,000 gal. x 5,533 gal./ac. = 60.3 lb. P_2O_5/ac.

This rate will result in an excess application of 30.3 lb./ac. (60.3 lb./ac. calculated to 30 lb./ac. recommended) of phosphate. The steep slope in this field means there would be a high risk of phosphorus runoff. Therefore, it is not recommended to base the manure application on N.

If supplemental phosphate were required it would be calculated as:

Equation 11
Fertilizer P to be added (if required) = Recommended amount (Figure 8.6) – [amount provided by manure, which is crop available (Equation 10)]

- **If manure from Lagoon 2 is to be used:**

  Manure application rate based on phosphorus (Equation 6) = 30 lb./ac. ÷ 8.6 lb./1,000 gal. = 3,488 gal./ac.
  Crop available N (Equation 7) = (16.2 lb./1,000 gal. x 3,488 gal./ac.) + 43.8 lb./ac. = 100.3 lb. N/ac.
  Fertilizer N to be added (Equation 8) = 160 lb./ac. – 100.3 lb./ac. = 59.7 lb. N/ac.

For Field 1, using manure from Lagoon 1 or 2 makes a difference on the rate of manure application, 2,752 gal./ac. versus 3,488 gal./ac. It is recommended to apply manure from Lagoon 1. This will decrease hauling costs. Save manure from Lagoon 2 for fields that are closer to the manure storage.

Field 2:

Due to the steep slope and the field's close connection to surface water, this field's manure rate will be based on phosphorus.

Figure 8.6 shows the phosphate recommendation is 30 lb./ac.

- **If manure from Lagoon 1 is to be used:**

  Manure application rate based on phosphorus (Equation 6) = 30 lb./ac. ÷ 10.9 lb./1,000 gal. = 2,752 gal./ac.
  Crop available N (Equation 7) = (21 lb./1,000 gal. x 2,752 gal./ac.) + 50.4 lb./ac. = 108.2 lb. N/ac.
  Fertilizer N to be added (Equation 8) = 100 lb./ac. – 108.2 lb./ac. = -8.2 lb. N/ac.
  Therefore, the addition of mineral fertilizer is not needed.

- **If manure from Lagoon 2 is to be used:**

  Manure application rate based on phosphorus (Equation 6) = 30 lb./ac. ÷ 8.6 lb./1,000 gal. = 3,488 gal./ac.
  Crop available N (Equation 7) = (16.2 lb./1,000 gal. x 3,488 gal./ac.) + 50.4 lb./ac. = 106.9 lb. N/ac.
  Fertilizer N to be added (Equation 8) = 100 lb./ac. – 106.9 lb./ac. = -6.9 lb. N/ac.
  Therefore, the addition of mineral fertilizer is not needed.

For Field 2, it is again recommended to apply manure from Lagoon 1, which allows lower application rate, therefore lower hauling costs.

Field 3:

This field is on pasture and manure will not be incorporated. Therefore, the manure rate will be based on phosphorus.

Figure 8.6 shows a phosphate recommendation of 60 lb./ac.

- **If manure from Lagoon 1 is to be used:**

  Manure application rate based on phosphorus (Equation 6) = 60 lb./ac. ÷ 10.9 lb./1,000 gal. = 5,505 gal./ac.
  Crop available N (Equation 7) = (21 lb./1,000 gal. x 5,505 gal./ac.) + 12 lb./ac. = 127.6 lb. N/ac.
  Fertilizer N to be added (Equation 8) = 170 lb./ac. – 127.6 lb./ac. = 42.4 lb. N/ac

- **If manure from Lagoon 2 is to be used:**

  Manure Application Rate based on Phosphorus (Equation 6) = 60 lb./ac. ÷ 8.6 lb./1,000 gal. = 6,977 gal./ac.
  Crop Available N (Equation 7) = (16.2 lb./1,000 gal. x 6,977 gal./ac.) + 12 lb./ac. = 125.0 lb. N/ac.
  Fertilizer N to be added (Equation 8) = 170 lb./ac. – 125.0 lb./ac. = 45 lb. N/ac.

For Field 3, using manure from Lagoon 1 or 2 makes a difference on the rate of manure application. It is recommended to apply manure from Lagoon 1. The application rate is lower, so hauling costs will be lower.

Field 4:

This field has no landscape proximity limitations; however based on soil tests, if this soil was present in the Brown Soil Zone, the nitrate-nitrogen content would be greater than the allowable limit and no manure would be allowed to be applied to this field. See AOPA, under *Standards and Administration Regulation, Part 1, Nutrient Management.*

Figure 8.6 shows a nitrogen recommendation of 50 lb./ac.

- **If manure from Lagoon 1 is to be used:**

  Manure application rate based on nitrogen (Equation 9) = [50 lb./ac. – 0 lb./ac.] ÷ 21 lb./1,000 gal. = 2,381 gal./ac.
  Crop Available P_2O_5 (Equation 10) = (10.9 lb./1,000 gal. x 2,381 gal./ac.) = 26 lb. P_2O_5/ac.
  Fertilizer P to be added (Equation 11) = 40 lb./ac. – 26 lb./ac. = 14 lb. P_2O_5/ac.

- **If manure from Lagoon 2 is to be used:**

  Manure application rate based on nitrogen (Equation 9) = [50 lb./ac. – 0 lb./ac.] ÷ 16.2 lb./1,000 gal. = 3,086 gal./ac.
  Crop Available P_2O_5 (Equation 10) = (8.6 lb./1,000 gal. x 3,086 gal./ac.) = 26.5 lb. P_2O_5/ac.
  Fertilizer P to be added (Equation 11) = 40 lb./ac. – 26.5 lb./ac. = 13.5 lb. P_2O_5/ac.

For Field 4, using manure from Lagoon 1 or 2 makes a difference on the rate of manure application. However, it is recommended to apply manure from Lagoon 2 as it has a relatively low hauling distance.

STEP 8: Manure and fertilizer needs per field.

Figure 8.10 **Nutrients Summary: Needs and Balance**

		Application Rate			Total Application		
		Manure	Fertilizer		Manure	Fertilizer	
			N	P_2O_5		N	P_2O_5
Field	Acres	gal./ac.	lb./ac.		gal.	lb./ac.	
1	75	2,752	58.4	0	206,400	4,380	0
2	150	2,752	0	0	412,800	0	0
3	30	5,505	42.4	0	165,150	1,272	0
4	100	3,086	0	13.5	308,600	0	1,350
			Total Required		1,092,950	5,652	1,350
			Balance*		**+898,250**	**-5,652**	**-1,350**

* Manure Balance:
Total manure in storage was 1,991,200 gallons. After application of 1,092,950 gallons, the manure remaining will be approximately 898,250 gallons.

Fertilizer needs are:
- 5,652 lb. of nitrogen.
- 1,350 lb. of phosphate.

9.0 DISPOSAL OF FARM WASTE

9.1 Disposal of Dead Animals

9.2 Disposal of Veterinary Waste

- **9.2.1** Sharps
- **9.2.2** Expired medicines

9.3 Disposal of Chemical Farm Waste

- **9.3.1** Pesticides
  - **9.3.1.1** Pesticide disposal
  - **9.3.1.2** Pesticide storage
  - **9.3.1.3** Pesticide container disposal
- **9.3.2** Handling and disposal of petroleum products (fuels and lubricants)
  - **9.3.2.1** Health and environmental risks
  - **9.3.2.2** Financial/liability risks

9.4 Leaks and Spills

- **9.4.1** Fuel leaks/spills
- **9.4.2** Lubricant leaks/spills

9.5 Options for Disposal of Contaminated Soils

9.0 DISPOSAL OF FARM WASTE

9.1 Disposal of Dead Animals

Refer to the *Destruction and Disposal of Dead Animals Regulations* under the *Livestock Diseases Act* in Section 3 for details on regulations pertaining to the disposal of dead animals. A copy of these regulations may be obtained from an Alberta Agriculture, Food and Rural Development (AAFRD) office, or by visiting the AAFRD Web site at www1.agric.gov.ab.ca. Two other useful references are: *Livestock Mortality Burial Techniques (Agdex 400/29-2)* and *Livestock Mortality Management (Disposal) (Agdex 400/29-1).*

Some death loss will occur on operations, no matter how well they are managed. It is important to dispose of dead animals quickly and effectively to reduce the risk of disease. It is also important in maintaining good neighbour relations. Carcasses can be a source of disease if scavenged by wildlife or pets. Some of these diseases can then be passed back to livestock or even humans.

The current *Destruction and Disposal of Dead Animals Regulations* requires all dead animals be disposed of within 48 hours by incinerating, burying, rendering, composting or natural disposal (scavenging). A dead animal may be stored for more than 48 hours after death if it is stored:

- For not more than one week in an enclosed structure with impervious walls and floors that have been constructed for the storage of dead animals.
- Outside during winter months when the ambient temperature is low enough to keep the dead animal completely frozen. Or,
- In a freezer unit.

There are restrictions on the use of composting, burial and natural disposal that must be followed in order to minimize the risk of disease spread and nuisance concerns. Composting, burial and natural disposal sites are required to be specific distances from waterways, well sources, major roads, residences and parks. For more information on these restrictions, refer to Section 3 or the *Destruction and Disposal of Dead Animals Regulations.* These sites must be on the producer's own property or property leased by the producer. Animals euthanized by drugs or those known to have died from infectious diseases or reportable diseases must not be disposed of by natural disposal.

Storage. Use special storage bins, or refrigerate or freeze carcasses until they can be taken to a rendering facility. This reduces odour, keeps them out of sight and prevents scavenging. Locate dead animal storage areas in areas that will minimize the spread of disease, for example, at the entrance to a farm site, to prevent collection vehicles from having to enter the property.

Clean up. Ensure storage areas are thoroughly cleaned after each pickup and that wastewater does not run into streams or other surface water.

Burial. Ensure dead animals are buried promptly to control odour, insects and scavenging. In the winter, during periods of intense cold, this may be difficult due to frozen ground. Be prepared to store the carcasses or have them rendered during these times. Locate the burial pit area away from livestock and screen it from view using trees, shrubs and fences. Do not locate burial pits where runoff could contaminate surface water or near wells or other water sources.

Dispose of other animal tissue waste such as afterbirths and tissues from surgery (e.g. castration) as carcasses, or send to a landfill in a sealed plastic container or bag. Blood or blood products from animals can be safely flushed down the drain.

9.2 Disposal of Veterinary Waste

9.2.1 Sharps

Sharps are veterinary and laboratory materials capable of causing cuts or punctures. Sharps include needles, syringes, scalpel blades, slides, cover slips, pipettes, broken glass and empty or expired pharmaceutical containers. There is a risk of needle stick injuries or cuts when these materials are not handled or disposed of properly. Certain drugs or vaccines may cause reactions or infections if they are present on broken glass or used needles that break the skin. Blood on used needles, collection tubes or other equipment may contain viruses or bacteria that can cause illness following a cut or needle stick injury. There are currently no regulations covering the disposal of sharps in agriculture.

To safely dispose of sharps:

Separate sharps from other waste. Injuries can occur while handling sharps on the farm or at the landfill, if staff are unaware of their presence, or if they are not in rigid containers. Plastic bags are unacceptable.

Use a labelled rigid sharps container for disposal. For needles and surgical blades, use a rigid plastic or metal puncture-proof container with a sealed lid. These can be obtained at many local veterinary clinics. Label clearly as sharps containers and not for recycling. A plastic jug with a narrow mouth, or a 20-litre (5-gallon) pail with a narrow opening in the lid also works well. Injuries can occur if workers try to retrieve an object from the container, so use narrow-mouthed containers or make a small hole in a well-sealed lid. Ensure children or animals cannot remove the lid. Do not attempt to recap needles before disposal – this is a common cause of needle stick injury. For pharmaceutical bottles and syringes, use a pail or other rigid container.

Remove waste from the farm. Take pails of bottles and syringes and containers of waste needles and surgical blades to the local veterinary clinic or hospital for disposal. Contact these facilities to ensure they accept these waste products. There are also private companies that pick up medical waste. Contact a local veterinary clinic or hospital for information. Labelled sealed containers can also be taken to Class 2 landfills, which accept medical waste and have perimeter fencing.

Do not burn sharps containers.

9.2.2 Expired medicines

Regularly check all drugs for the expiry date. Expiry dates appear on the label as EXP 08 2000, for example, or as 24APR01. All drugs past the expiry date should be discarded, as product safety and efficacy can no longer be guaranteed.

Medicines not past their expiry date sometimes need to be discarded as well. Products such as vaccines must be handled carefully (e.g. refrigerated) to maintain efficacy. If in doubt about how a product has been handled and whether it is still safe or effective (e.g. vaccine left at room temperature overnight), consult a veterinarian.

On some vaccines, the label states "Use entire contents when first opened." The remaining vaccine should be discarded after vaccination is completed – consult a veterinarian.

There are two classes of expired medicines – unused (unopened) and used (opened). Return unused expired drugs to the point-of-purchase, such as the veterinary clinic. Many manufacturers will accept them for disposal. Discard used or expired drugs the same way as sharps. Modified live virus vaccines should be rendered non-infectious before disposal to prevent the virus from potentially infecting workers or animals. This can be done by freezing, autoclaving, burning or adding bleach to the bottle. When disposing of either used or unused expired medicines, do not attempt to empty or wash bottles – discard them with their contents.

9.3 Disposal of Chemical Farm Waste

Chemical farm waste includes pesticides (herbicides, fungicides, insecticides, rodenticides), pesticide-treated seed, topical parasiticides (pour-on or powders for treating parasites), cleaners, disinfectants and petroleum products.

9.3.1 Pesticides

For complete details on safe pesticide use and disposal, consult the *Crop Protection Manual* (Agdex 606-1) available from AAFRD Publishing Branch, 7000-113 Street, Edmonton, Alberta T6H 5T6.

9.3.1.1 Pesticide disposal

Be careful when disposing of unwanted or expired pesticides. Pesticides are hazardous wastes and cannot be disposed of in sanitary landfills or by burning. Offer any leftover supplies to neighbours. Use a licensed hazardous waste disposal firm if pesticides have no further use. Names of companies that are licensed to handle hazardous waste can be obtained from Alberta Environmental Protection's Recycle Information Line at 1-800-463-6326.

9.3.1.2 Pesticide storage

Read the label for specific storage instructions. Store pesticides in a cool, dry place in their original containers. Keep pesticides from freezing and protect from excessive heat.

Do not store near feeds, food or fertilizers. Never store pesticides in well-houses or feed mixing and milling rooms. As well, pesticides should never be stored or mixed within 30 metres of an open body of water.

Pesticides should not be stored around the home and should be out-of-reach of animals and children. Store products that are highly toxic to mammals, such as certain rodenticides and parasiticides, under lock and key.

9.3.1.3 Pesticide container disposal

Carefully dispose of empty pesticide containers. Unrinsed, empty pesticide containers have the potential to contaminate ground and surface water, and can be toxic to fish and wildlife. Under the *Alberta Environmental Protection and Enhancement Act,* non-refillable plastic or metal pesticide containers (restricted, agricultural and industrial products) must be disposed of at a pesticide container collection site. A list of pesticide container disposal sites in Alberta and their hours is available from each municipality, in the *Crop Protection Manual,* or from Alberta Environmental Protection.

Containers must be clean (triple-rinsed or pressure-rinsed) and well-drained (dry) before disposal. In most cases, triple rinsing leaves plastic, metal or glass pesticide containers more than 99 percent free (less than 1 ppm) of residues. For details on rinsing, consult the *Crop Protection Manual.*

Paper bags and cardboard containers should be thoroughly emptied and disposed of in a sanitary landfill. Do not burn paper bags or cardboard containers. Outer packaging (e.g. cardboard box) can be burned or disposed of in a regular landfill. Some pesticide container sites have bins or separate areas for collecting outer packaging materials.

It is also important to dispose of containers from topical parasiticides, (e.g. pour-on compounds or powders for lice and mange) in a safe manner. These compounds can be

toxic to fish, wildlife, other livestock and humans. These products should be kept out of waterways and streams and not be allowed to contaminate foods or feeds. Some products are controlled under the *Pest Control Products Act* and it is an offence to use them other than as directed on the label. Containers should not be re-used and empty containers should be made unsuitable for reuse. For specific information on the disposal of unused and unwanted product and cleanup of spills, contact the regional office of Conservation and Protection, Environment Canada.

9.3.2 Handling and disposal of petroleum products (fuels and lubricants)

Fuels and lubricants can be toxic to humans, livestock, wildlife and fish. Proper storage and handling on the farm are necessary to limit risks to human and animal health, and the environment.

9.3.2.1 Health and environmental risks

Gasoline and diesel fuel. In humans, skin contact with gasoline and diesel fuel can cause irritation or chemical burns, while breathing vapours can cause headaches, dizziness and nausea. These products are possible causes of cancer. Spilled fuels will kill plant life and fish. Livestock will sometimes drink fuel, causing bloat and vomiting, depression, confusion, pneumonia and death, depending on the amount ingested. There is no effective treatment.

Waste lubricants. Waste lubricants include used motor oil, transmission fluid and power steering fluids. Like fuels, these products are petroleum distillates. They also may contain heavy metals such as lead, arsenic, cadmium or chromium, which can be toxic or leave residues in meat and milk. All lubricants should be washed from exposed skin as soon as possible. Livestock will consume these products and therefore should not have access to them.

Ethylene glycol (antifreeze). Antifreeze is extremely toxic to the kidneys of livestock, pets, wildlife and people. It is sweet tasting, so some animals, particularly cattle and pets, will drink large quantities if given the opportunity. Shortly after ingestion, animals appear to be intoxicated. They may vomit, become weak, convulse and die. If treated early, they may survive, but generally ethylene glycol poisoning is fatal.

9.3.2.2 Financial/liability risks

Lending and insurance agencies are concerned about the environmental risks associated with fuel storage or spillage, as well as the storage of lubricants and glycol, both new and used. They may require environmental assessments before approving loans or insurance policies. Spills of fuels or lubricants may come under the jurisdiction of the *Environmental Protection and Enhancement Act* (EPEA), and if deemed serious enough, will request appropriate cleanup measures.

Storing and Handling Fuel on the Farm, published jointly by United Farmers of Alberta and AAFRD, provides more complete details on storage tank options, and the risks associated with fire, leakage, spillage and evaporation. It can be obtained from AAFRD, Publications Branch, 7000 – 113 Street, Edmonton, Alberta, T6H 5T6.

9.4 Leaks and Spills

The best and lowest cost method of dealing with a potential environmental problem is prevention. However, leaks and spills are still likely to occur.

9.4.1 Fuel leaks/spills

To prevent environmental contamination:

- Always maintain separation distances from buildings, ignition sources and propane tanks.
- Store combustible materials away from fuel storage tanks.
- Keep vegetation mowed.
- Monitor fuel storage tanks to catch leaks early.

Underground tanks. In the event of a confirmed leak in an underground tank or line, contact Alberta Environmental Protection (1-800-222-6514). Personnel from Alberta Environment will outline cleanup procedures.

Above ground. In the event of an above-ground spill or leak:

- Stop the flow of fuel. Remove all sources of ignition. Be prepared to use a fire extinguisher. Remember, gas vapours flow downhill and are extremely explosive.
- Contain the spilled fuel by damming with earth or another suitable absorbent material. Protect water sources and septic systems.
- Work from the upwind side to avoid inhaling vapours and becoming engulfed in flames if a fire starts.
- Clean up and dispose of all fuel by shoveling the contaminated earth or absorbent material into metal or plastic containers. Be extremely cautious about sparks from rocks and metal. Dispose of contaminated cleanup materials in accordance with Alberta Environmental Protection guidelines.
- Ensure that all ignitable vapours are dispersed before resuming normal activities.
- It is a regulatory requirement that all spills and leaks of 200 litres or more of gasoline or diesel fuel be reported to Alberta Environmental Protection. Spills or leaks of lesser amounts must also be reported if they have, or may have, an adverse effect on the environment. An adverse effect is defined in the *Environmental Protection Enhancement Act* (EPEA) as impairment of or damage to the environment, human health or safety, or property. Any leak or spill of any amount into a watercourse, water body or groundwater must be reported.

9.4.2 Lubricant leaks/spills

Leaks or spills from lubricant drums or containers can be contained using the grated pan-pallet that the containers are stored on. Floor spills can be cleaned up with sawdust, rags or other absorbent materials. Numerous commercial companies have specific products for preventing or cleaning up lubricant spills on concrete. For spills on soil, excavate the soil and dispose of it in accordance with Environmental Protection guidelines.

Disposing of waste lubricants. Most bulk fuel agents will accept waste oil, oil filters and oil containers, as well as solvents, cleaning fluids and glycols. Engine oil, transmission fluid, hydraulic fluid and power steering fluid can be combined, but must not contain water, solids, solvents or glycols. Most bottle depots also have facilities to accept smaller volumes of waste oil, filters and containers. Several large waste-oil companies will pick up waste oils on the farm, if the farm has about 1,000 litres of product per visit. The farmer may even get paid one or two cents per litre if the waste oils are not contaminated. These companies can be found in the Yellow Pages under Oil-Waste.

Disposing of glycols. Do not drain glycols (e.g. antifreeze) onto the ground. Collect waste antifreeze in plastic containers and deliver to the depots mentioned above.

None of the above products should be accessible to livestock, children or wildlife. Containers should be well-labelled and have secure child-proof lids. Most cases of poisoning result when these products are accidentally left accessible to children or animals.

Motor oils or fuels should not be used directly on the skin of livestock. While these products were once recommended in the treatment of certain diseases, ingestion, even in small quantities, can produce illness or residue in the meat and milk products. In addition, these products should not be used to control dust in yard sites or on roads.

9.5 Options for Disposal of Contaminated Soils

Land spreading. Using naturally occurring soil micro-organisms, in conjunction with cultivation, organic matter (manure) and added nitrogen fertilizer, appears to be a reasonable method of breaking down hydrocarbons. Specific details, as to amounts of contaminated soils, per given area of cultivation for a given length of treatment time, are presently being studied. However, an adequate mix would appear to be 2.5 centimetres (1 inch) of contaminated soil spread on a field surface with approximately 45 kilograms (100 pounds) of manure and about 0.1 kilograms (1/4 pound) of nitrogen per 95 m^2 (100 $ft.^2$) and rototilled to a depth of 12 centimetres (5 inches). Work the area (aerate) every four weeks for at least one year to ensure adequate breakdown of fuels and possibly for two or more years for the breakdown of waste oils.

Landfill. Haul contaminated soil to an approved landfill site. Contact the landfill authority to ensure that the site accepts contaminated soil.

Burning. Approved mobile thermal extractors can be used; they have the proper after-burners to completely combust all of the hydrocarbons and heavy metals. Names of companies providing this service can be obtained from Alberta Environment. Open burning of contaminated soil or cleanup materials is not an approved method of disposal.

10.0 APPENDIX

10.1 Resources for Dairy Producers

10.0 APPENDIX

10.1 Resources for Dairy Producers

10.1.1 Confined feeding operations – new and expanding

- Natural Resources Conservation Board (NRCB)
  Toll-free response line: 1-866-383-6722
  www.nrcb.gov.ab.ca
  Lethbridge phone: (403) 381-5166
  Red Deer phone: (403) 340-5241
  Barrhead phone: (780) 674-8303
  Fairview phone: (780) 835-7111
  Edmonton phone: (780) 422-1977

10.1.2 Crop management

- Alberta Agriculture, Food and Rural Development
  Phone: 1-866-882-7677
  www1.agric.gov.ab.ca
- Canadian Organic Growers
  Box 6408
  Station J
  Ottawa ON K2A 3Y6
- Canola Council of Canada
  400 – 137 Lombard Avenue
  Winnipeg MB R3B 0T6
- Lethbridge Community College
  Agriculture and Farm Management Courses
  Phone: (403) 320-3323 (to register)
  (403) 329-7212 (for information)
- Agriculture and Agri-Food Canada
  Prairie Farm Rehabilitation Administration (PFRA)
  www.agr.gc.ca/pfra

10.1.3 Disposal of farm wastes

- Alberta's "Action-on-Waste" Recycle Information Line
  Phone: 1-800-463-6326
- Alberta Agriculture, Food and Rural Development
  Phone: 1-866-882-7677
  www1.agric.gov.ab.ca
- Alberta Environment Information Centre
  Main Floor, 9920 – 108 Street
  Edmonton AB T5K 2M4
  Phone: (780) 422-2079
  Fax: (780) 427-4407
- Alberta Special Waste Management Corporation
  Phone: 1-800-272-8873
- Alberta Used Oil Management Association (Recycling Centre for oil, filters, and containers)
  Phone: 1-888-922-2298
- Alberta Waste Materials Exchange (Edmonton)
  Phone: (780) 450-5408
- Environmental Services Association of Alberta
  Phone: 1-800-661-9278
- Environmental Strategies Branch (Action on Waste) – information on hazardous waste disposal sites
  Phone: (780) 422-2009 or (780) 427-6982

10.1.4 Energy efficiency

- Alberta Agriculture, Food and Rural Development
  Phone: 1-866-882-7677
  www1.agric.gov.ab.ca
- ATCO Gas
  Phone: 310-5678 (direct-dial)
- Energy Probe
  225 Brunswick Avenue
  Toronto ON M5S 2M6
  Phone: (416) 964-9223 ext. 246
- EPCOR
  Toll-free anywhere in Alberta: 310-4300
  In Edmonton, phone: 412-4000
  Toll-free fax: 310-4295
  E-mail: CustServ@epcor.ca
- Office of Energy Efficiency
  Natural Resources Canada
  18th Floor, 580 Booth Street
  Ottawa ON K1A 0E4
- Agriculture and Agri-Food Canada
  Prairie Farm Rehabilitation Administration (PFRA)
  www.agr.gc.ca/pfra

10.1.5 Fertilizer storage and handling

- Canadian Association of Agri-Retailers
  107 – 1090 Waverly Street
  Winnipeg MB R3T 0P4
  Phone: (204) 989-9300

10.1.6 Irrigation

- Agriculture and Agri-Food Canada
  Research Branch
  930 Carling Avenue
  Room 777
  Ottawa ON K1A 0C5
  Phone: (613) 759-7787
  Fax: (613) 759-7768
- Alberta Agriculture, Food and Rural Development
  Phone: 1-866-882-7677
  www1.agric.gov.ab.ca
- Alberta Environment
  Information Centre
  Main Floor, 9920 – 108 Street
  Edmonton AB T5K 2M4
  Phone: (780) 422-2079
  Fax: (780) 427-4407
- Alberta Irrigation Projects Association
  Suite 909, 400 – 4 Avenue South
  Lethbridge AB T1J 4E1
  Phone: (403) 328-3063
  Fax: (403) 327-1043
- EPCOR
  Toll-free anywhere in Alberta: 310-4300
  In Edmonton call: 412-4000
  Toll-free fax: 310-4295
  E-mail: CustServ@epcor.ca
- Irrigation District Offices

Aetna	(403) 653-4441
Bow River	(403) 654-2111
Eastern	(403) 362-1400
Leavitt	(403) 653-3376
Lethbridge	(403) 327-3302
Magrath	(403) 758-3400
Mountain View	(403) 653-2284
Raymond	(403) 752-3511
Ross Creek	(403) 529-9182
St. Mary River	(403) 328-4401
Taber	(403) 223-2148
United	(403) 626-3255
Western	(403) 934-3542

10.1.7 Livestock wintering sites

- Alberta Agriculture, Food and Rural Development
  Phone: 1-866-882-7677
  www1.agric.gov.ab.ca
- Feeder Association of Alberta Limited
  Box 4190
  Barrhead AB T7N 1A2
  Phone: (780) 674-5381
  Fax: (780) 674-6969

10.1.8 Livestock yards

- Agriculture and Agri-Food Canada
  Departmental Publications Service
  Corporate Management Branch
  300 – 885 Meadowlands Drive
  Ottawa ON K1A 0C5
  Phone: (613) 759-6610
  Fax: (613) 759-6726
- Alberta Agriculture, Food and Rural Development
  Phone: 1-866-882-7677
  www1.agric.gov.ab.ca
- Feeder Association of Alberta Limited
  Box 4190
  Barrhead AB T7N 1A2
  Phone: (780) 674-5381
  Fax: (780) 674-6969

10.1.9 Management of household wastewater

- Agriculture and Agri-Food Canada
  Research Branch
  777 – 930 Carling Avenue
  Ottawa ON K1A 0C5
  Phone: (613) 759-7787
  Fax: (613) 759-7768
- Alberta Agriculture, Food and Rural Development
  Phone: 1-866-882-7677
  www1.agric.gov.ab.ca
- Alberta Municipal Affairs
  Safety Services South
  7th Floor, 727 – 7 Avenue Southwest
  Calgary AB T2P 0Z5
  Phone: (403) 297-5759
  Fax: (403) 297-4147
- Safety Services North
  10155 – 102 Street
  Edmonton AB T5J 4L4
  Phone: (780) 427-8686
  Fax: (780) 427-9645

10.1.10 Manure use and management

- Agriculture and Agri-Food Canada
  Research Branch
  777 – 930 Carling Avenue
  Ottawa ON K1A 0C5
  Phone: (613) 759-7787
  Fax: (613) 759-7768
- Alberta Agriculture, Food and Rural Development
  Phone: 1-866-882-7677
  www1.agric.gov.ab.ca
- Lethbridge Community College
  Agriculture and Farm Management Courses
  Phone: (403) 320-3323 (to register)
  (403) 329-7212 (for information)
- Wild Rose Agricultural Producers
  14815 – 119 Avenue
  Edmonton AB T5L 4W2
  Phone: (780) 451-5912
  Fax: (780) 453-2669

10.1.11 Nuisance control

- Alberta Agriculture, Food and Rural Development
  Phone: 1-866-882-7677
  www1.agric.gov.ab.ca

10.1.12 Nutrient management for crop production

- Alberta Agriculture, Food and Rural Development
  Phone: 1-866-882-7677
  www1.agric.gov.ab.ca
- Alberta Environment, Information Centre
  Main Floor, 9920 – 108 Street
  Edmonton AB T5K 2M4
  Phone: (780) 422-2079
  Fax: (780) 427-4407

10.1.13 Pasture management

- Alberta Agriculture, Food and Rural Development
  Phone: 1-866-882-7677
  www1.agric.gov.ab.ca
- Alberta Forage Council
  Phone: (403) 782-0772
- Alberta Sustainable Resource Development
  Public Lands
  Stockmen's Range Management courses/Peace County courses
  Phone: (780) 624-6345
  Edmonton Area courses
  Phone: (780) 674-8231
  Lethbridge Area courses
  Phone: (403) 831-5486
- Ducks Unlimited
  Suite 200, 10720 – 178 Street
  Edmonton AB T5S 1S3
  Phone: (780) 489-2002
- Environment Canada
  Western and Northern Regions
  Twin Atria II
  2nd Floor, 4999 – 98 Avenue
  Edmonton AB T6B 2X3
- Lethbridge Community College
  Agriculture and Farm Management Courses
  Phone: (403) 320-3323 (to register)
  (403) 329-7212 (for information)

10.1.14 Pest management

- Agriculture and Agri-Food Canada
  Departmental Publications Service
  Corporate Management Branch
  300 – 885 Meadowlands Drive
  Ottawa ON K1A 0C5
  Phone: (613) 759-6610
  Fax: (613) 759-6726
- Alberta Agriculture, Food and Rural Development
  Phone: 1-866-882-7677
  www1.agric.gov.ab.ca
- Canola Council of Canada
  400 – 137 Lombard Avenue
  Winnipeg MB R3B 0T6
- Lethbridge Community College
  Agriculture and Farm Management Courses
  Phone: (403) 320-3323 (to register)
  (403) 329-7212 (for information)
- Olds College
  4500 – 50 Street
  Olds AB T4H 1R6
  Phone: 1-800-661-6537
  Fax: (403) 556-4711

10.1.15 Pesticide storage and handling

- Alberta Agriculture, Food and Rural Development
  Phone: 1-866-882-7677
  www1.agric.gov.ab.ca
- Alberta Environment
  Pesticide Specialists
  Grande Prairie (780) 538-5460
  Red Deer (403) 340-5310
  Calgary (403) 237-8262
  Lethbridge (403) 381-5511
- Croplife Canada
  21 Four Seasons Place
  Suite 627
  Etobicoke ON M9B 6J8
  Phone: (416) 622-9771
  Fax: (416) 622-6764
- Courses:
  Farmer Pesticide Certificate Course
  Olds College
  Phone: (403) 556-8321

  Pesticide Applicator Training Tutorial
  Olds College, Olds
  Phone: 1-800-661-6537 or (403) 556-4684
  Lakeland College, Vermilion
  Phone: (780) 853-8420
  Fairview College, Fairview
  Phone: 1-800-661-6490
  Lethbridge Community College, Lethbridge
  Phone: 1-866-853-8646

  Pesticide Applicator Home Study Course
  (commercial pesticide applicators)
  Lakeland College, Vermilion
  Phone: (780) 853-8646

10.1.16 Silage storage

- Alberta Agriculture, Food and Rural Development
  Phone: 1-866-882-7677
  www1.agric.gov.ab.ca
- Feeder Association of Alberta Limited
  Box 4190
  Barrhead AB T7N 1A2
  Phone: (780) 674-5381
  Fax: (780) 674-6969

10.1.17 Soil management

- Agriculture and Agri-Food Canada
  Departmental Publications Service
  Corporate Management Branch
  300 – 885 Meadowlands Drive
  Ottawa ON K1A 0C5
  Phone: (613) 759-6610
  Fax: (613) 759-6726

  or

  Agriculture and Agri-Food Canada
  Research Branch
  777 – 930 Carling Avenue
  Ottawa ON K1A 0C5
  Phone: (613) 759-7787
  Fax: (613) 759-7768
- Alberta Agriculture, Food and Rural Development
  Phone: 1-866-882-7677
  www1.agric.gov.ab.ca
- Ducks Unlimited
  Suite 200, 10720 – 178 Street
  Edmonton AB T5S 1S3
  Phone: (780) 489-2002
- Agriculture and Agri-Food Canada
  Prairie Farm Rehabilitation Administration (PFRA)
  www.agr.gc.ca/pfra

10.1.18 Storage of petroleum products

- Alberta Agriculture, Food and Rural Development
  Phone: 1-866-882-7677
  www1.agric.gov.ab.ca
- Alberta Environment
  Science and Standards Division
  Oxbridge Place
  4th Floor, 9820 – 106 Street
  Edmonton AB T5K 2J6
  Phone: (780) 427-5883
- Alberta Municipal Affairs
  Safety Services South
  7th Floor, 727 – 7 Avenue Southwest
  Calgary AB T2P 0Z5
  Phone: (403) 297-5759
  Fax: (403) 297-4147
- Safety Services North
  10155 – 102 Street
  Edmonton AB T5J 4L4
  Phone: (780) 427-8686
  Fax: (780) 427-9645
- Canadian Farm Business Management Council
  Phone: 1-888-232-3262
  Fax: 1-800-270-8301
- Learning Resources Distribution Centre
  12360 – 142 Street
  Edmonton AB T5L 4X9
  Phone: (780) 427-5775
- Petroleum Tank Management Association of Alberta
  Suite 980, 10303 Jasper Avenue
  Edmonton AB T5J 3N6
  Phone: 1-866-222-8265
- Underwriters Laboratories of Canada
  7 Crouse Road
  Scarborough ON M1R 3A9
  Phone: (416) 757-3611

10.1.19 Water bodies

- Agriculture and Agri-Food Canada
  Research Branch
  777 – 930 Carling Avenue
  Ottawa ON K1A 0C5
  Phone: (613) 759-7787
  Fax: (613) 759-7768
- Alberta Agriculture, Food and Rural Development
  Phone: 1-866-882-7677
  www1.agric.gov.ab.ca
- Alberta Environment, Information Centre
  Main Floor, 9920 – 108 Street
  Edmonton AB T5K 2M4
  Phone: (780) 422-2079
  Fax: (780) 427-4407
- Cows and Fish
  YPM Place
  2nd Floor, 530 – 8 Street South
  Lethbridge AB T1J 2J8
  Phone: (403) 381-5538
  Fax: (403) 381-5723
- Ducks Unlimited
  Suite 200, 10720 – 178 Street
  Edmonton AB T5S 1S3
  Phone: (780) 489-2002
- Environmental Law Centre
  204 – 10709 Jasper Avenue
  Edmonton AB T5J 3N3
  Phone: 1-800-661-4238
  Fax: (780) 424-5133
- North American Wetlands Conservation Council (Canada)
  200 – 1750 Courtwood Crescent
  Ottawa ON K2C 2B5
  Phone: (613) 228-2601
  Fax: (613) 228-0206

10.1.20 Water sources

- Agriculture and Agri-Food Canada
  Research Branch
  777 – 930 Carling Avenue
  Ottawa ON K1A 0C5
  Phone: (613) 759-7787
  Fax: (613) 759-7768
- Alberta Agriculture, Food and Rural Development
  Phone: 1-866-882-7677
  www1.agric.gov.ab.ca
  Additional references available from AAFRD:
  - *Water Analysis Interpretation* Agdex 400/716-2.
  - *Water Wells that Last for Generations*
  - *Dugouts for Farm Water Supplies* Agdex 716 (B30).
  - *Dugout Maintenance* Agdex 716 (B31).
  - *Seepage Control in Dugouts* Agdex 716 (B32).
  - *Float Suspended Intake for Dugouts* Agdex 716 (B34).
  - *Dugout Aeration with Compressed Air* Agdex 716 (B36).
  - *Hydrated Lime for Algae Control in Dugouts* Agdex 716 (B37).
- Alberta Environment, Information Centre
  Main Floor, 9920 – 108 Street
  Edmonton AB T5K 2M4
  Phone: (780) 422-2079
  Fax: (780) 427-4407
- Health Canada
  Canadian Government Publishing
  Communication Canada
  Ottawa ON K1A 0S9
  Phone: 1-800-635-7943

10.1.21 Woodlots, bush and shelterbelts

- Alberta Agriculture, Food and Rural Development
  Phone: 1-866-882-7677
  www1.agric.gov.ab.ca
- Alberta Environment, Information Centre
  Main Floor, 9920 – 108 Street
  Edmonton AB T5K 2M4
  Phone: (780) 422-2079
  Fax: (780) 427-4407
- Ducks Unlimited
  Suite 200, 10720 – 178 Street
  Edmonton AB T5S 1S3
  Phone: (780) 489-2002
- Environment Canada
  Western and Northern Region
  Twin Atria II
  2nd Floor, 4999 – 98 Ave
  Edmonton AB T6B 2X3
- Environmental Law Centre
  Phone: 1-800-661-4238
- Agriculture and Agri-Food Canada
  Prairie Farm Rehabilitation Administration
  www.agr.gc.ca/pfra
- Woodlot Association of Alberta Agriculture
  Box 3333
  Morinville AB T8R 1S2
  Phone: (780) 939-5858 or 1-800-871-5680
- Woodlot Information Hotline
  Phone: 1-800-619-5732

10.1.22 Additional resources available from AAFRD

- *Farm Water Supply Requirements* Agdex 716 (C01)
- *Water Requirements for Livestock* Agdex 400/716-3
- *Crop Protection (the Bluebook)* Agdex 606-1
- *Manure Management to Protect Water Quality* Agdex 576-6
- *Managing Feedlot Runoff to Protect Water Quality* Agdex 576-3
- *Alberta Fertilizer Guide* Agdex 541-1
- *Manure and Riparian Management in the 21st Century* (AAFRD video for loan)
- *Completing the Cycle: Nutrient Management* (AAFRD video for loan)
- *2000 Code of Practice for Responsible Livestock Development and Manure Management*
- *CPS Leaflets:*
  - *2000 Dairy Cattle Housing and Equipment*
  - *8713 Open Rectangular Manure Storage*
  - *8712 Concrete Covered Rectangular Manure Storage*
  - *8710 Manure Gas*
  - *8730 Open Circular Manure Storage Tanks*
  - *8731 Open Rectangular Manure Storage – Cantilever Walls*
  - *8732 Open Rectangular Manure Storage – Buttressed Walls*
  - *8733 Covered Circular Manure Storage Tanks*
  - *8734 Covered Rectangular Manure Storage Tanks*
  - *10704 Odour Control for Livestock Facilities*

10.1.23 Other resources

- *Destruction and Disposal of Dead Farm Animals Regulation* 229/2000
- *Environmental Protection and Enhancement Act*
  Available at government bookstores
- *Manure Management Series* (3 pamphlets)
  Wild Rose Agricultural Producers
  14815 – 119 Avenue
  Edmonton AB T5L 4W2
  Phone: (780) 451-5912
- Natural Resources Conservation Board
  Toll-free response line: 1-866-383-6722
  www.nrcb.gov.ab.ca
  Lethbridge phone: (403) 381-5166
  Red Deer phone: (403) 340-5241
  Barrhead phone: (780) 674-8303
  Fairview phone: (780) 835-7111
  Edmonton phone: (780) 422-1977
- *ManureNet*
  http://res.agr.ca/manurenet
- *The Health of Our Water*
  Agriculture and Agri-Food Canada
  777 – 930 Carling Avenue
  Ottawa ON K1A 0C5
  Phone: (613) 750-7787
- *Resource Efficient Agricultural Production (R.E.A.P.) Canada*
  www.reap.ca
  Click on publications. Milk wastewater articles under 'soils' heading.

10.1.24 General inquiries

ALBERTA MILK

- Edmonton office
  14904 – 121A Avenue
  Edmonton AB T5V 1A3
  Phone: (780) 453-5942
  Toll Free: 1-800-252-7530
  Fax: (780) 455-2196
- Wetaskiwin office
  5201 – 50 Avenue
  Wetaskiwin AB T5A 0S7
  Phone: (780) 361-1231
  Toll Free: 1-877-361-1231
  Fax: (780) 361-1236

10.2 Pathogens Related to Dairy Manure in Alberta

Escherichia coli (E. coli)

Many strains of *E. coli* are beneficial to human health and live in the gut of all healthy animals. However, some strains, such as *E. coli* O157:H7, can cause severe disease and even death. Infection with O157:H7 causes bloody diarrhea and can progress to a life-threatening complication known as hemolytic uremic syndrome (HUS). This infection is particularly dangerous for children and the elderly. Outbreaks have occurred from contaminated drinking water.

Salmonella species

There are a large number of species of *Salmonella*. Some strains infect only one animal species, while others are able to infect humans and a wide variety of domestic and wild animals, birds and reptiles.

Infected cows can carry the bacteria without any signs of illness. If the animals become stressed, outbreaks of diarrhea, often followed by death, can occur. Recently, new *Salmonella* strains have evolved that are resistant to many antibiotics (multi-drug-resistant *S. typhimurium* DT 104). These are of great concern as they are difficult to treat.

Research has shown that about one-quarter of dairy farms in North America may have *Salmonella*. On most farms that test positive for *Salmonella,* only a few animals will shed the bacterium. On a few farms, many positive samples from cattle and the environment can be obtained. The barn environment, including feed, dust, rodents or birds, can also harbour *Salmonella*.

The main concern with *Salmonella* in dairy is the risk to human health from direct contact with infected cows and consumption of non–pasteurized dairy products. *Salmonella* species are killed by pasteurization. One of the most common causes of human illness due to *Salmonella* is the consumption of bulk tank milk, with the young and elderly being affected more commonly and more severely. Current recommendations to reduce *Salmonella* in dairy barns include maintaining high biosecurity standards, including reducing rodent and bird access to feed.

Campylobacter

Campylobacter sp. occur in all livestock, but the major animal sources of *Campylobacter* infection in humans are poultry and cattle. Most infections are from food. The number of human infections involving antimicrobial-resistant *C. jejuni* in North America is increasing. There is concern that resistance is developing in livestock because of antibiotic use. *C. fetus* is the cause of infertility and abortion in cattle. Raw milk contaminated by infected cows is a major cause of foodborne human campylobacteriosis.

The importance of *Campylobacter sp.* in dairy cows is not clear. *C. jejuni* is rarely found in dairy cows. Water runoff from dairy operations is not considered a major source of *Campylobacter* infections in humans.

Leptospirosa sp.

Leptospirosa sp. differ from the previous three organisms in that it affects the kidneys rather than the digestive system. There are many species of *Leptospira* that affect livestock, wildlife and humans. Leptospirosis occurs worldwide, including some areas of Alberta.

Infected dairy cattle may have a fever, loss of appetite, decreased milk production or show no signs at all. Infections may cause abortions, stillbirths, weak calves and infertility. Kidney damage may be seen at slaughter in otherwise normal cows.

Leptospira bacteria live in the kidneys and are excreted in the urine of infected animals. Contamination of drinking water by urine of infected animals is one method of infection. Wildlife, especially skunks and rodents, are known to carry the disease and can infect livestock. Introduction of carrier cows into the herd is also a common method of infection.

Leptospira can survive in standing water or in liquid manure for several months. *Leptospira* does not survive in composted manure, dry soil or over winter. Damp climates, marshy regions and close contact with wildlife are typically associated with outbreaks of disease in livestock. Humans often contract the disease by swimming in contaminated water.

Prevention of leptospirosis depends on stopping transmission from infected wildlife, rodents or livestock. An effective rodent control program, including removal of vegetative cover for wildlife near the barn is essential. Wildlife should not have access to water sources, such as dugouts, or to manure from infected livestock. Outdoor livestock should not have access to standing water in areas where the disease is known to exist. Breeding stock entering the herd should be purchased from a clean herd and be quarantined.

Vaccination of dairy cattle reduces the symptoms of the disease, but does not completely prevent infection. In some areas of Alberta, breeding stock are routinely vaccinated against leptospirosis. Consult a veterinarian to determine if vaccination is warranted. Medication may reduce losses in an infected herd, but will not prevent infection. Good sanitation is essential to reduce spread in an infected herd.

Protozoan parasites

Protozoan parasites are single-celled parasites that survive quite well in waterways. They are considered today to be some of the most important causes of waterborne disease in humans. Water contaminated with these parasites is usually associated with animals defecating directly into the water or with human sewage.

Giardia

Giardiasis, or "beaver fever," is caused by a protozoan parasite called *Giardia duodenalis* (also called *Giardia lamblia*). It is found all over the world and is the most common disease-causing intestinal parasite of humans. The parasite causes moderate to severe diarrhea, with children and immunosuppressed individuals being the most vulnerable. Between two and seven percent of humans in Europe and North America are estimated to be infected. As many as 40 percent of people in developing countries may be infected. *Giardia* is transmitted through the fecal-oral route (usually between humans, e.g. in day-care centres), but waterborne transmission is also common.

Giardia occurs in livestock, pets and wildlife. It may cause disease in animals, such as diarrhea and reduced weight gain. It has been found in pristine wilderness waterways and is particularly common in the Canadian Arctic. Outbreaks of giardiasis in humans have been linked to drinking water contaminated with human sewage, agricultural runoff and wildlife feces. Giardiasis is the most frequently diagnosed waterborne disease in Alberta.

Giardia has been found in dairy cattle in Canada, the United States and Europe. It can be isolated in all ages of dairy cattle.

Some strains of *Giardia* are specific to certain animals and are not easily transmitted to other animals or humans. Other strains are easily transmitted between animals and humans. It is only these strains that are a risk to human health. Cattle have strains of *Giardia* that can infect humans.

Giardia produce cysts that can survive for months in water, resisting cold or freezing temperatures. These cysts are resistant to chlorination, which is commonly used to destroy pathogens in drinking water. For this reason, this parasite can be difficult to remove from drinking water. *Giardia* cysts can be removed from water through filtration or can be inactivated by boiling water or using powerful chemical agents (e.g. ozone).

Giardia cysts in liquid dairy cattle manure storage facilities deteriorate over time. Composting will also kill these cysts. It is considered unlikely that they could survive and be a serious risk for contamination of surface water when manure is spread on the land.

Cryptosporidium parvum

Cryptosporidium parvum, also known as "crypto," is a small protozoan parasite that causes diarrhea. Humans and a wide variety of animals. (e.g. cattle, pigs, horses, sheep, dogs, cats) and wildlife can be affected. Infections in animals and humans may not result in any disease at all, or in mild diarrhea that resolves itself in a few weeks. There is no effective treatment.

Cryptosporidium was not considered an important cause of disease in humans or animals until recently. Over the last two decades, there has been an increasing number of people with malfunctioning immune systems due to cancer therapy, organ transplantation or infections (e.g. HIV, human immunodeficiency virus). In these people, cryptosporidiosis is severe, difficult to treat and can cause death.

This parasite is also transmitted by the oral-fecal route and often through contaminated water. Poor hygiene leads to transmission between humans and from animals to humans. Fecal contamination of water by animals and humans may lead to waterborne outbreaks of cryptosporidiosis. Such an outbreak occurred in Milwaukee, Wisconsin, and led to the infection of over 5,000 humans. The source was traced to human sewage.

Cryptosporidium has been found in dairy cattle around the world, but is not considered a significant cause of newborn calf diarrhea (scours) in calves within a week of age. It is most commonly isolated in calves less than one month of age. Calves can be a source of this organism in the environment and efforts are needed to ensure that dairy calves do not have direct access to water courses which are used for human consumption. Groundwater sources, e.g. water wells, must be protected from surface contamination. Composting manure has been shown to kill these organisms over time.

Cryptosporidium produces environmentally resistant oocysts or eggs that are shed in manure.

They are resistant to chlorination and are so small that many water filtration systems cannot remove them. Therefore, contamination of drinking water with this parasite is of great concern.

Most human infections are acquired by person-to-person transmission (day-care centres, hospitals) and through consumption of drinking water contaminated by human sewage. There are several reports of veterinary students, farm workers and researchers developing infections after exposure to calves shedding large numbers of oocysts.

Other diseases of dairy cattle that may be of concern to the public

Listeria monocytogenes. *Listeria monocytogenes* is a zoonotic disease carried by cows. The bacteria can cause abortion, abnormal behaviour or generalized illness in affected cows. The milk of affected cows is a significant zoonotic risk because the bacteria may survive pasteurization. Although the bacteria can be isolated from the manure and abortions, the risk of these sources transmitting disease to people is low.

10.3 Spreading Equipment Calibration

Simple method

Weigh several spreader loads of manure and determine the area in the field that is covered after spreading. Determine the weight of the spreader and try to fill each load to a similar level. Once calibration rate is determined (volume or weight/area), rate adjustments can be made by adjusting the equipment and/or varying the ground speed.

There are a number of methods for calibrating manure spreaders, including:

Calibrating for surface manure application. Determine volume or weight of manure and size of area to be spread with one full load (area in acres).

- Weight can be determined by the difference in the spreader weight before and after spreading (be sure that the tank is completely empty).
- Volume can be calculated using tank sizes.

Therefore, the rate of application is:

Rate of application = (Volume or weight)/area Eq(1)

To calculate the spreading speed:

- C = capacity of the spreader (in tons, gallons) [use dimensions or user manual to calculate C].
- W = width of spread (feet).
- t = time it takes (in seconds) to empty one load (C).
- R = application rate (in tons or gallons/acre).
- D = distance (in feet) it takes to empty one load (C).
- 43,560 is number of feet per acre.
- 5,280 is number of feet per mile.
- 3,600 is number of seconds per hour.

Application rate is calculated as follows:

$$R = (43{,}560 \times C) \div (W \times D) \quad \text{Eq(2)}$$

Therefore,

$$D = (43{,}560 \times C) \div (W \times R) \quad \text{Eq(3)}$$

Speed is calculated as follows:

$$\text{Speed} = (D + 5{,}280) \div (t + 3{,}600) \quad \text{Eq(4)}$$

If equations (3) and (4) are merged then:

$$\text{Speed} = (t \times 43{,}560\ C) \div (3{,}600 \times 5{,}280 \times W \times R) \quad \text{Eq(5)}$$

Speed = 29,700 x [C ÷ (t x W x R)] (miles/hr.) Eq(6)

Where:
- t is in seconds
- C is in gallons or tons
- W is in feet
- R is in gallons or tons per acre

Example:

Consider these parameters:

- C = capacity of the spreader = 5,400 gal.
- W = width of spread = 12 ft.
- t = time it takes to empty one load (5,400 gal.) = 400 sec.
- R = application rate = 10,000 gallons/acre

Then,

Speed = 29,700 x [C ÷ (t x W x R)] (miles/hr.)
= 29,700 x [5,400 ÷ (400 x 12 x 10,000) = 3.34 miles/hr.

To calculate the rate of application from spreading speed, consider these parameters:

- C = capacity of the spreader (gal.)
- W = width of spread (ft.)
- t = time it takes to empty one load (sec.)
- Speed (mile/hr.)

Eq(6) can be rearranged to calculate the actual application rate as follows:

R = 29,700 x [C÷(t x W x Speed)] (ton or gal./acre)

Where:
t is in seconds
C is in gallons or tons
W is in feet
Speed is in mile/hr.

Eq(7)

Example:

- C = capacity of the spreader = 5,400 gal.
- W = width of spread = 12 ft.
- t = time it takes to empty one load (5,400 gal) = 400 sec.
- Speed = 4 miles/hr.

Then,

R = 29,700 x [C ÷ (t x W x Speed)]
= 29,700 x [5,400 ÷ (400 x 12 x 4)] = 8,353 gal./ac.

Tarp method

Another method is to lay out several tarps (3 m x 3 m in size) and drive over them with the spreader. Weigh each tarp with manure and subtract the weight of the tarps. Once the area of the tarps is known, the application rate can be calculated. Many tarp samples may be required to obtain an accurate value. To check on uniformity of application, lay five small tarps side by side in row, then drive over the tarps perpendicular to the row. Weigh the manure on each tarp. In addition to checking uniformity and application, the rate can also be calculated.