2.0 ENVIRONMENTAL CONSIDERATIONS

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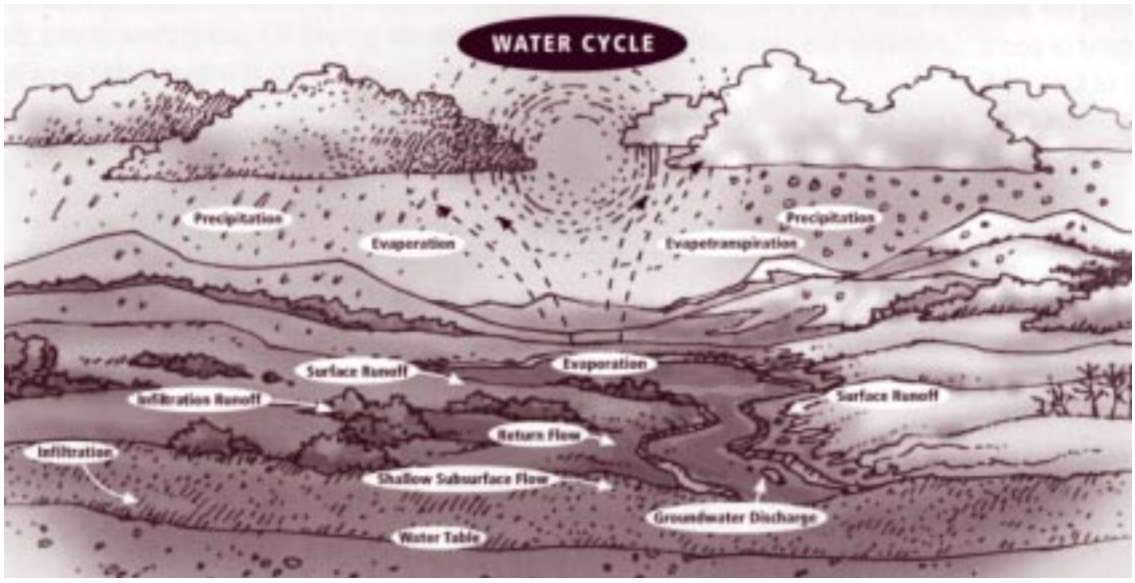
This section provides background information on the environmental risks associated with cow/calf production and encourages cow/calf producers to consider the environmental consequences of their management decisions. This section will discuss the impacts on air, soil, water and biodiversity, as well as nuisance issues associated with cow/calf production. Beneficial management practices (BMPs) designed to mitigate the impact of cow/calf operations on the environment are found in following sections. Legislation regarding environmental issues is discussed in Section 13 of this manual.

2.1 Water Quality

Agricultural activities, when improperly managed, can have a significant impact on the quality of water resources. Cropping and livestock practices can produce contaminants including sediment, nutrients (nitrogen and phosphorus) from inorganic fertilizers and organic livestock wastes, pest control chemicals such as herbicides and insecticides, micro-organisms from livestock wastes, salts and trace elements. Contaminants can enter surface and groundwater, either attached to sediment or dissolved in water, throughout the water cycle. Impacts on water quality can restrict water suitability for uses such as potable water, stock water, irrigation, sport fishing and other recreation.

Figure 2.1 **Water Cycle**



2.1.1 Water erosion

Water running over the surface of the soil, called runoff, can pick up, carry and deposit soil particles, which can lead to water erosion. Water erosion removes topsoil, limiting the productivity of the land. If the eroded particles are carried and deposited in a water body, water quality and aquatic habitat are impacted.

Factors affecting the risk of water erosion:
Soil covered by plants or plant residue is less susceptible to water erosion than bare soil. Crop residue and growing plants absorb the impact of raindrops and slow the flow of runoff, therefore reducing the risk of erosion. Roots hold soil in place and add to the organic matter content of the soil, which further enhances its stability.

- The greater the amount and intensity of snowmelt or rainfall, the greater the risk of water erosion.
- Long steep, uninterrupted slopes are especially prone to erosion because water accelerates as it travels downslope.
- Fine to medium-textured soils, especially clay and silt low in organic matter, are the most prone to erosion.
- Clay soils can be prone to crusting, which limits water infiltration (the movement of water into the ground). Less infiltration means more runoff and a greater risk of water erosion.
- Soils with a shallow, impermeable layer (hardpan) are more prone to erosion because this layer limits water infiltration.
- Excessive tillage leaves soil prone to water erosion by compacting the soil, thus decreasing its ability to absorb water. Tillage also removes the protective vegetative cover and reduces organic matter.
- Soils high in organic matter can absorb more water than those low in inorganic matter.

2.1.2 Excess nutrients

Elevated nutrient levels in watercourses can be caused by manure or fertilizer entering a watercourse directly, or by runoff from fertilized fields and livestock sites. Nutrients, primarily phosphorus and nitrogen, accelerate eutrophication of water bodies.

Spills, improper storage and over-application of fertilizers or manure may lead to excess nutrient concentrations in soil and runoff.

The main 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. Over-application of manure on cropland or forage land can also elevate nitrate levels in shallow groundwater.

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 is depleted, reducing fish survival. As well, the decay of blue-green algae is toxic to domestic animals that drink the water.

2.1.3 Groundwater

Groundwater is the water that collects in the pore spaces of soil and rocks. **Aquifers are water-bearing layers that hold groundwater in usable amounts.** Typical aquifers are overlaid by very tight deposits such as clay or shale. Unconfined aquifers or water table aquifers are close to the ground surface and are directly exposed to the atmosphere through spaces 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. Contamination of confined aquifers occurs when contaminants move directly into the well from the wellhead or through an improperly maintained well casing.

Seepage from improperly constructed or maintained manure and silage storage structures and the associated risk of groundwater contamination are serious concerns 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.

The water table is the point at which the soil pore spaces are 100 percent saturated with water. This may or may not be water that can be collected for use.

2.2 Soil Quality

Maintaining soil quality is the key to maintaining healthy and productive landscapes. Soil quality is important to support and sustain crop, range and woodland production as well as water supplies.

Soil quality can be degraded by inappropriate tillage and cropping practices, excessive livestock grazing or improper application of animal manure, fertilizers or pesticides.

2.2.1 Soil erosion

Soil erosion refers to the loss of soil due to wind or water. Erosion potential depends on the specific topography, climate and soil type of a region and on the management practices used at the site. Erosion removes topsoil, the most productive soil layer, reducing the levels of organic matter and nutrients, which results in lower productivity. Wind and water erosion can cause environmental problems if eroded soil particles become airborne or enter water bodies. As well, eroded soil can carry pesticides and nutrients that further decrease water and air quality. Water erosion can be the result of surface runoff from rainfall, irrigation or snowmelt. Wind erosion occurs when soil is not adequately covered, allowing strong winds to pick up and carry soil particles.

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

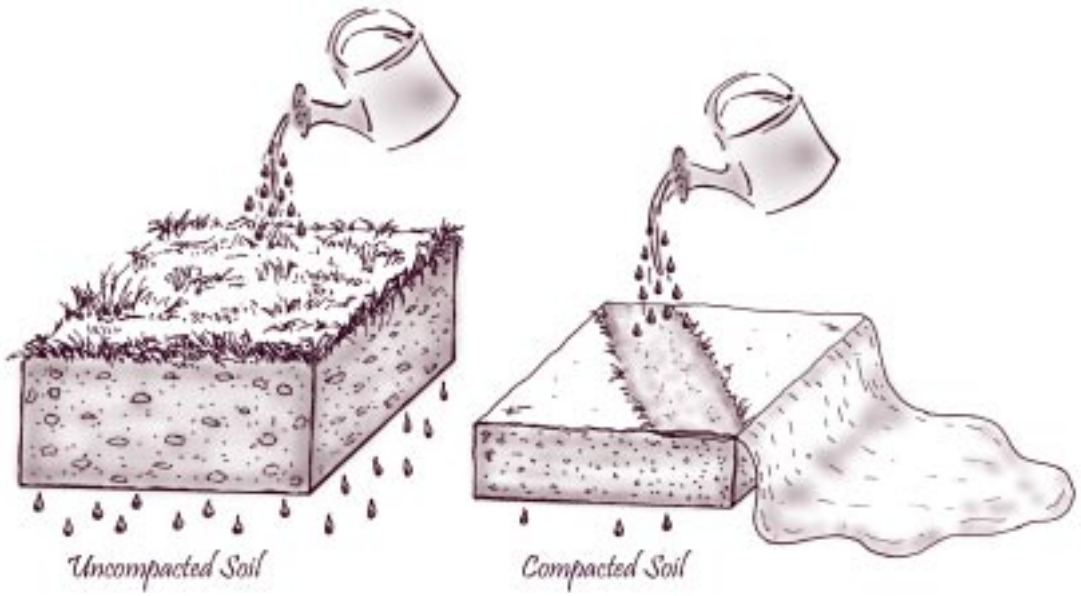
2.2.2 Soil compaction

The compaction of soil by cattle can limit the productivity of the land. One hoof of a mature cow can exert approximately 20 to 30 pounds of pressure per square inch. This reduces soil porosity and the productive capacity of the forage, pasture or crop. Typically this occurs when cattle are permitted to overgraze a pasture or range as a result of inappropriate grazing strategies.

Symptoms of soil compaction are:

- Uneven plant growth.
- Nutrient deficiencies.
- Plant water stress.
- Shallow root systems.

Figure 2.2 Relation of Soil Compaction to Water Retention



2.2.3 Soil organic matter

Soil organic matter is composed primarily of plant residue in various stages of decomposition. Organic matter accumulates in soil when plant residues are added or returned to the soil more quickly than soil micro-organisms are able to decompose them. Organic matter occurs naturally in all Alberta soils, though the amount varies considerably according to location.

Organic matter improves the physical and chemical properties of soil by:

- Holding individual soil particles together in soil aggregates, therefore reducing the risk of soil erosion.
- Improving soil structure, workability, aeration, water infiltration and water-holding capacity.
- Reducing the risk of soil surface crusting, which can reduce or prevent seedling emergence.
- Storing and supplying nutrients that are essential to plants and soil micro-organisms.

Loss of soil organic matter results in reduced fertility, poor water-holding capacity, greater risk of erosion and lower crop yields.

Factors affecting organic matter content:

- Organic matter tends to accumulate more quickly in cooler, wetter areas, and decomposes more quickly in warmer, drier areas.
- Optimal fertilizer usage, including manure, increases organic matter levels by increasing production and therefore the amount of residue (the plant material remaining after grazing or haying, including leaves, stems and roots).
- Practices that leave soil prone to erosion increase the loss of organic matter.

2.3 Air Quality

2.3.1 Greenhouse gases

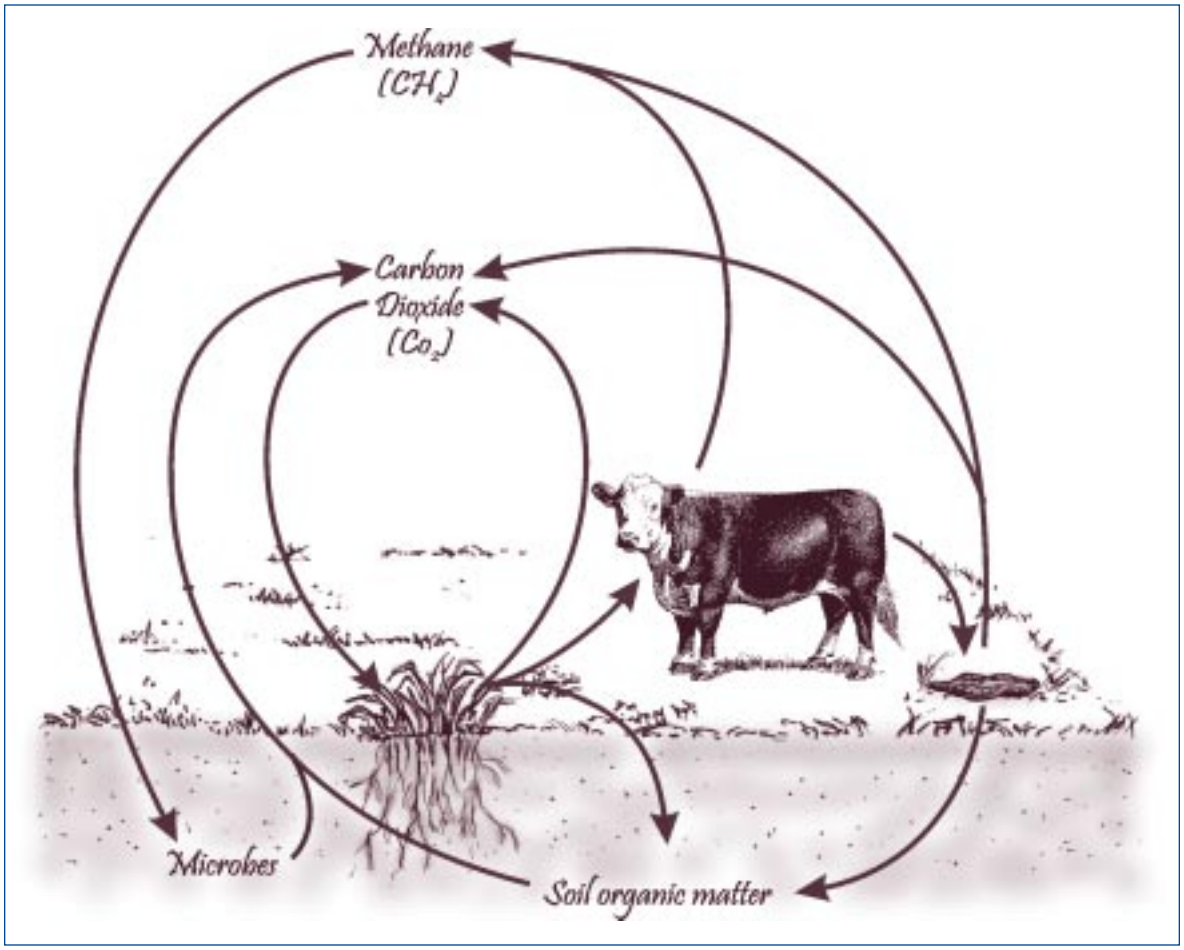
Some gases emitted by livestock operations may have an impact on global warming. Global warming refers to the increase in the earth's surface temperature, which many scientists believe is a result of an increase in the concentration of specific greenhouse gases. Water vapour, carbon dioxide, methane, ozone, halocarbons (used in refrigerants) and nitrous oxide are the main greenhouse gases in the atmosphere. Global warming could result in more extreme weather events such as tornadoes, droughts and winter storms, leading to increased forest fires and damage to water resources. For agricultural producers, seeding dates, crop variety choices, pest and disease management, and water resources may be affected by increases in climatic variability.

The main greenhouse gases emitted from cattle are methane and nitrous oxide. Research indicates that more than 80 percent of the nitrogen animals digest is excreted in their manure and urine. All animals produce methane during digestion, but cattle and other ruminants produce more methane because of the slow fermentation of feed in the rumen.

Greenhouse gas emissions from livestock are also directly related to feed and nutrient losses. Even small changes in management practices can increase feed efficiency:

- Feed higher quality feed and rations.
- Feed lipids, such as canola oil, that add energy and inhibit methane production.
- Add bacterial supplements to feed to help convert methane in the rumen to carbon dioxide and to improve overall digestion.

Figure 2.3 CO_2 and CH_4 Flow in a Livestock Based Agro-Ecosystem



Manure emits more methane when it decomposes under low oxygen (anaerobic) conditions (e.g. poorly aerated manure piles). Manure management at all stages (e.g. stockpiling, composting, storage and spreading) influences the amount of methane released. Specific management practices can ensure the nutrients in manure make their way into soil where plants can use them. These practices include:

- Distributing winter feed sites over a large area to encourage cattle to spread out, which more evenly distributes manure.
- Frequently moving the bedding pile to encourage cattle to use all pasture areas.
- Feeding livestock on level ground to prevent manure runoff from entering nearby water bodies.
- Limiting livestock grazing in riparian areas.
- Encouraging the growth of beneficial insects to ensure manure is recycled into the soil.
- Using proper methods when composting to avoid anaerobic conditions.

These practices will also minimize the amount of methane and nitrous oxide emitted.

Good range management is the key to reducing greenhouse gas emissions when cattle are on pasture. It increases forage productivity and root mass development, which maintain more carbon in the soil. Good range management involves intensive grazing, which ensures the maintenance or improvement of pasture quality. Swath grazing can also extend the grazing season and reduce emissions.

2.3.2 Odour

The primary complaint about livestock operations is odour. The impact of odour on human health and well-being causes concern, especially when odours are disagreeable and persistent. However, odour is generally considered a nuisance to neighbours rather than a health risk because of the degree of dilution and dispersion that occurs in the air within short distances from the odour source.

2.3.3 Dust

Dust, in addition to being a social concern, creates environmental problems. It can cause respiratory problems for people and animals and it can reduce visibility on roadways. Dust may carry particles from vehicle emissions and manure volatilization. It will also carry odour.

Factors affecting dust levels:

- Areas susceptible to wind erosion are at a greater risk of contributing dust to the atmosphere.
- Higher vehicle speeds, increased traffic and lower moisture conditions on gravel roads can increase dust levels.

2.4 Biodiversity

The loss of biological diversity can decrease future land use opportunities and threaten sustainability. Biodiversity is an important part of various ecological processes. The creation of flora and fauna monocultures, through the loss of wetlands, riparian areas and wildlife habitat and improper pest management can impact the environmental sustainability of agriculture.

A loss of biodiversity affects agriculture in many ways. For example:

- A loss of wetland and riparian habitat has a direct negative effect on the water cycle, water quantity and quality.
- Decreasing the diversity or variety of wild species means less genetic material available for natural evolution.
- A decrease in soil organisms inhibits decomposition, the cycling of nutrients and energy, and the formation of soil.
- Insect species that are critical as crop pollinators and biological pest control agents can be lost.

Figure 2.4 **Biodiversity**

2.4.1 Wildlife

Agriculture relies on biological diversity and natural resources to sustain key functions of agro-ecosystems that support food production and security. Conserving and restoring wildlife habitat contributes to biodiversity, and aids the environmental functions on which agriculture depends. These functions include:

- Protection of water quality.
- Regional water cycling.
- Nutrient cycling.
- Maintenance of soil fertility.
- Pollination.
- Pest control.
- Climate regulation.

Agricultural ecosystems (or agro-ecosystems) refer to ecosystems used in agriculture. Each species in an agro-ecosystem is part of a web of relationships connected by flows of energy and materials. Farmers and ranchers manage this flow on their land. Healthy, diverse habitats provide recreational, economic and quality of life benefits as well as other environmental benefits for farmers and rural communities.

Producers must be attentive to factors that affect wildlife habitat on pasture and hayland. Practices that protect soil, water and air quality are also beneficial to habitat. These practices include:

- Rotational grazing.
- Leaving carryover.
- Maintaining healthy riparian areas along streams and lakes.

The following practices that may harm wildlife should be avoided:

- Draining or backfilling wetlands, whether they are permanent or temporary.
- Pesticide applications, which can harm non-target plants and animals if not managed properly.
- Land uses that fragment natural landscapes and reduce habitat quality by limiting the movement of wildlife from one area to another.

2.4.2 Riparian areas

Riparian areas are the lands adjacent to water bodies where the landscape, vegetation and soils are strongly influenced by the presence of water. Healthy wetlands and riparian areas are important to reduce flooding, prevent erosion, protect water quality and provide habitat. They are an essential part of water cycles and local ecosystems.

Degradation of riparian areas can have a negative impact on the environment:

- Water quality and quantity will be reduced.
- Salinity control provided by wetlands will decrease.
- The recharging of groundwater and surrounding soil moisture levels will decrease.
- Biodiversity will diminish, as will many opportunities for recreation such as hunting and fishing.

Figure 2.5 Healthy Riparian Area

2.5 Pesticides

Pesticides include insecticides, herbicides, fungicides and rodenticides. If not handled and applied properly, pesticides can be a risk to non-target organisms, applicators and workers. During pesticide application, spray droplets, mists or vapours 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 pesticides increases the potential for a significant pesticide spill to occur.

Pesticide mismanagement can harm beneficial insects, inhibit plant growth and reduce the viability of forage varieties. Consumption of contaminated plants or soil may harm domestic animals and wildlife. Pesticides that accumulate in plant and animal tissue can make food unfit for human consumption. Pesticides 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 application. The severity of pesticide contamination depends on the toxicity and management of the pesticide in question.

2.6 Pharmaceuticals

A range of pharmaceutical products, including antibiotics and reproductive hormones, are used in the cattle industry. While most of these products are completely broken down in the animal's body, some pharmaceutical residues can be excreted at very low levels. Because the residue amount present in manure is extremely small, there may not be any effect on animals that come in contact with the residue. Thus far, there has been no evidence that residues from pharmaceuticals used in cattle production have created problems with the health of humans, wildlife or the environment.

2.7 Pathogens

Disease-causing micro-organisms are referred to as pathogens. Diseases that can be transmitted from animals to humans, causing disease in both, are referred to as zoonoses or zoonotic diseases.

How disease is transmitted from manure. Manure pathogens are most often transmitted through the fecal-oral route (i.e. ingestion of manure or manure-contaminated feed or water). In livestock, this can occur by drinking water contaminated by manure, grazing on pasture recently spread with manure or directly ingesting manure. Humans can ingest manure pathogens by drinking contaminated water, swimming in contaminated surface water and by not washing hands after handling infected livestock or manure. People most at risk of contracting zoonotic disease are those working with animals or handling manure. Zoonotic diseases that are transmittable from cattle to humans include brucellosis, tuberculosis and salmonellosis.

In order for manure pathogens to cause disease through water contamination, several steps need to occur. If any one of these steps is blocked, transmission will not occur.

- First, the pathogen has to be excreted by the animal. Not all pathogens are found in every animal and some pathogens can be reduced through management or medication.
- Second, the pathogen has to reach a water supply by the animal defecating in the water, from surface runoff or from contaminated groundwater flow.
- Third, the pathogen must remain alive and capable of causing infection by 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. For example, *Salmonella* must be ingested in very high numbers to cause disease, whereas only a few *Cryptosporidium* organisms will cause disease.

It is often difficult to determine the source of a waterborne disease outbreak. Many of the same disease-causing micro-organisms are found in wildlife, pets and human sewage. If testing finds the suspect organism in one location, its source cannot be automatically assumed. Testing many sources and using new diagnostic techniques to determine the strain of the organism are usually necessary to pinpoint the source of disease.

2.8 For More Information

Contact the following offices for the publications listed or for more information.

Alberta Agriculture, Food and Rural Development (AAFRD)
Agriculture Information Centre 1-866-882-7677
Publications 1-800-292-5697
www.agric.gov.ab.ca

- *A Primer on Water Quality: Agricultural Impacts on Water Quality.*
- *Managing Phosphorus to Protect Water Quality.*
- *Greenhouse Gas Emissions from Livestock in Alberta.*
- *GHG Emissions from Livestock in Alberta: Past, Present and Future.*
- *Impacts of Agriculture on Surface Water Quality in Alberta. Part I: Haynes Creek Study.*

Agriculture and Agri-Food Canada, Prairie Farm Rehabilitation Administration (AAFC-PFRA)
www.agr.gc.ca/pfra
AAFC-PFRA district offices:

Hanna	(403) 854-4448
Lethbridge	(403) 327-4340
Medicine Hat	(403) 526-2429
Peace River	(780) 624-3386
Red Deer	(403) 340-4290
Vegreville	(780) 632-2919
Westlock	(780) 349-3963
Dawson Creek	(250) 782-3116

- *The Health of our Air: Toward Sustainable Agriculture in Canada.*
- *The Health of our Soils: Toward Sustainable Agriculture in Canada.*
- *The Health of our Water: Toward Sustainable Agriculture in Canada.*
- *Nutrient Management Planning.*
- *Riparian Area Management.*
- *Soil Texture and Water Quality.*