

HOG ENVIRONMENTAL MANAGEMENT STRATEGY

SITUATION ANALYSIS

Hog Environmental Management Strategy Steering Committee
February 1998

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INTRODUCTION

Environmental issues are one of the greatest challenges faced by Canada's fast growing hog industry. Through innovation and investment, industry has set out to meet these challenges in a positive, constructive way. Provincial hog marketing boards have been very active, developing codes of practice, promoting better management practices amongst producers and also working with municipalities to increase understanding. Provincial governments have been instrumental in assisting industry in this regard, working both with producers and municipal governments to find solutions. To date, much of the federal activity in this area has been through research related to building design and manure storage, handling and application.

Recognizing that continued growth hinges on finding environmental solutions that are acceptable to regulatory bodies, the public, and the industry itself, the Canadian Pork Council, asked Agriculture and Agri-Food Canada (AAFC) to re-examine its role and determine if it could work with industry and the provinces to develop a more comprehensive and coordinated approach on this issue.

In response, AAFC is investigating the development of the Hog Environmental Management Strategy (HEMS), proposing the following vision for this initiative:

Vision for the Hog Industry

Environmental constraints to hog production in Canada will be significantly reduced within the next three years through the joint efforts of government, industry, and other interest groups. Effective, affordable solutions will be developed and implemented for each of the key environmental issues associated with the industry: odours, soil and water quality, and air pollution.

The **Hog Environmental Management Strategy (HEMS) Steering Committee** was formed to launch this initiative, bringing together representatives of industry and several branches of AAFC. It defined the following course of action:

1. Analyse the current situation in the hog industry, defining the environmental challenges; describing the pertinent regulatory issues; determining current activities of industry, universities and provincial governments in addressing the challenges; listing the current activities in research and technology development that could help meet these challenges; and define the gaps that still exist.
2. Cognisant of the gaps identified in the situation report, develop a list of activities which could possibly constitute the federal contribution to this initiative.
3. Consult with provincial governments and industry about the potential for joint work in addressing hog environmental issues.
4. Hold a national workshop where representatives from industry and the federal, provincial and municipal governments can meet to discuss the issues, and decide on concrete steps for implementing a three year coordinated strategy for addressing the issues.

This report began as an attempt to assemble information on the current situation (discussed in Step 1 above) and was distributed at the provincial consultations held in December 1997 and January 1998. It has since been updated with comments and revisions from the provinces, in particular regarding regulations, guidelines and industry actions.

With its up-to-date information on what is happening in the industry, both on the research side and the regulatory side, this document is now a useful background document for the national workshop.

EXECUTIVE SUMMARY

Importance of the Issue

The Canadian hog industry is important because of both the \$3 billion in farm income it generates annually and the contribution to employment of the pork-processing industry. Pork and hog exports currently represent \$1.5 billion or 8% of all agri-food exports.

The hog and pork industries also demonstrate some of the best growth potential of all the agri-food sectors. Fuelled by increasing international market opportunities for pork, expansion difficulties for traditional competitors, and advantageous grain prices, the Canadian hog industry is undergoing considerable expansion. In the prairies in particular, this expansion is seen as an important part of the move to a more diverse agricultural economy.

This expansion coincides with a very significant shift in the technology and management organization of the industry. Operations are changing from the traditional farrow-to-finish farms with 100 to 300 sows, to larger units with 1,200 or 2,400 sows (or more), in which piglets are farrowed at one site, raised in a nursery at another, and finished at a third. These larger units require considerably more capital and organizational sophistication than traditional farms, and often draw these resources from outside the family-farm structure.

Environmental issues are among the most important factors limiting the expansion of the hog industry. A number of expansion projects have already been delayed or cancelled because of environmental considerations, and there is

the potential for this constraint to become more restrictive in the future. The significance of this current expansion is sufficient to warrant a considerable commitment by both industry and governments to ensure that limiting factors are addressed.

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Environmental Issues

Environmental issues in hog production pertain primarily to the storage, handling and application of manure. The three key concerns are:

- **Odours:** Odours are generally regarded as a nuisance to other residents and are often the largest obstacle to obtaining municipal approval. In addition to nuisance, there can be some related health effects, particularly for agricultural workers.
- **Soil and Water Quality:** The accumulation of nitrates, phosphates, heavy metals, and other potentially harmful substances have implications for soil and water quality.
- **Air Emissions:** Ammonia emissions pose a risk to human health under certain conditions and can contribute to smog. Methane and nitrous oxide are potent greenhouse gases that contribute to climate change.

Role of Government and Industry

The environmental challenges faced by the hog industry invite activity on the part of the industry itself, as well as of federal, provincial, and municipal governments to ensure a proper balance between the interests of farmers and affected community members. Regulation at the provincial and municipal levels is the one of the most powerful instruments used to ensure environmental protection and respect for community standards; however, there is considerable work by government and producer groups to ensure that regulation is complemented with education and technology transfer.

Regulation

All provinces have environmental protection legislation. The lead role for administration and enforcement of provincial environmental protection legislation usually lies with the provincial ministry responsible for environment, frequently in partnership with other resource ministries, such as agriculture. The degree to which this legislation influences behaviour at the farm level varies from province to province, but in general its goal is to prevent pollution and to hold polluters responsible for mitigating adverse environmental effects. Most provinces also have "right-to-farm" legislation, and many that do not are in the process of laying the foundations to enact such legislation. (This legislation is intended to protect hog producers from unwarranted "nuisance" lawsuits provided that they operate in accordance within "normal farm practices").

Regulations important to the hog industry also exist at the municipal level, with wide variation among municipalities and regions. They affect the industry mainly through the issuance of site permits.

Research, Technology Transfer, and Community Education

There are a number of excellent examples of work being done by producer organizations and governments to assist producers in complying with regulations and to assist municipalities in implementing their regulations in a

consistent and scientifically based fashion. At the national level, the Canadian Pork Council has published the *Canadian Code of Practice for Environmentally Sound Pork Production*, prepared in consultation with governments, university researchers, and financial institutions. In Quebec, "La federation des producteurs de porcs du Quebec" has engaged representatives of the provincial and municipal governments and environmental groups in a three-step agro-environmental plan that will use certification as a means to ensure environmental sustainability and thereby overcome resistance to future expansion of production. Ontario Pork is establishing a data base on production practices and technologies and a resource centre to assist municipal governments to draw up reasonable and effective regulations. Many provincial governments have established services to provide technical support to producers investing in the hog industry, particularly in relation to their conformity to environmental standards. Most provinces have developed a code of practice for use by producers to ensure that they conform to environmental standards and also to assist them in proving to municipalities and lenders that they have shown "due diligence".

Technical Services

Many technical services are, or can be, provided to the municipal officials charged with considering site permit applications and to producers who are required to meet municipal requirements. These services range from providing technical advice to educating communities about the benefits of hog developments. Those individuals or associates who assist or advise producers and municipal officials include federal and provincial governments, private consultants, formal producer organizations (e.g., pork marketing boards) and informal producer or resident associations in a particular location.

Such technical services may be offered to, for example:

- Those individual or associates involved in facility construction, regarding:
 - technical aspects of particular technologies and their economic benefits;
 - site selection (perhaps using some form of GIS mapping) .
- Farmers, to ensure that their management practices conform to requirements for sound environmental management. This could include:
 - provincial codes of practice;
 - technical information on a website;
 - direct assistance from those involved with extension;
 - software programs to be used on the farm;
 - literature specifically targeted to farmers.
- Municipalities, for the development and implementation of their bylaws. This could include:
 - a compendium of environmental standards in the province;
 - literature and advice on technical specifications required for facility construction; and
 - site selection based on GIS mapping.
- Municipalities or counties, for development of land-use plans for particular regions involving siting of hog-production facilities.
- Officials monitoring environmental standards at the watershed level.

Incentive and Infrastructure Programs

Low-interest loans or tax concessions could possibly be extended to those adopting desired technologies.

Community Relations

Producer groups are working with individual communities to address concerns over hog expansion, using public seminars and information dissemination.

Certification and Recognition

In some provinces, new proposals must undergo a peer review process. Certification of producers, either for applicants for new facilities or for all producers, with the focus specifically on environmental considerations, may be carried out by government or industry. Certification under the ISO 14000 program could also include initiatives to enhance the marketability of particular products because of their conformity to particular codes of practice. Awards and recognition could be given to producers who develop new methods or are exemplary in their management practices.

Current Knowledge and Ongoing Research

Considerable advances in the technologies of hog production, combined with an apparent willingness on the part of producers to adopt these technologies, have improved the industry's ability to address environmental issues. Current areas of research include:

- ***Manure Management (Storage and Application):***
 - Manure Storage:*** reducing nitrogen loss and minimizing emission of gases, by developing proper storage facilities; developing technologies for separation of liquid and solid manure; examining different covers for storage containers to reduce emissions; and studying the feasibility of combining manure with other wastes from forestry and agriculture.
 - Manure Application:*** reducing build-up of excess nutrients, such as phosphorus and nitrogen, which can adversely affect water quality; improving methods and equipment for handling and spreading liquid manure; developing materials to ensure producers do not contaminate groundwater supplies; examining alternative crops and cropping methods to utilize excess nutrient levels; and studying the impact of manure on soils.
- ***Feeding Modifications:*** modifying feeds and feeding systems to reduce nitrogen levels and make minerals in the manure more available for plant use.
- ***Building Design:*** improving ventilation and dust control; reducing the time excretions are exposed to the air; using bedding to reduce ammonia emissions.
- ***Soil Capacities for Manure Loading (Agronomic Practices):*** assessing the capacities of diverse soil types and cropping systems to absorb manure nutrients.
- ***Manure Processing (Including Composting):*** developing techniques to make composting economically feasible; assessing the feasibility of other manure processing techniques, such as anaerobic digestion, artificial wetlands, etc.

Gaps to be Addressed

Despite government and industry efforts to deal with the environmental constraints on expansion of the hog industry, the challenge remains. Several provincial governments have ambitious targets for expanding their industry, which will necessitate considerable work with municipalities, hog producers, and affected citizens. Areas where

further work could be done include:

- Establishing a long-term strategic approach to determining priorities in research, technology development and dissemination, as they relate to hog environmental issues. The long-term aspects of hog production and the associated aspects of manure handling and disposal are multifaceted. To fully address environmental issues, an integrated plan that deals with the whole system of hog production must be developed. This approach involves both technical and economic research and requires the participation of the private sector, producers, agricultural economists, and agricultural engineers, along with the research groups;
- Working with professional associations, at the national and provincial levels to ensure that the results of technical improvements are properly evaluated and disseminated;
- Developing a national information base of those individuals and associates with technical and public relations expertise who can assist both producers and municipalities in addressing environmental issues;
- Promoting joint development among the provinces of technical information for farmers, where there are common issues;
- Determining what services could be developed within the private sector to provide farmers and municipalities with the technical assistance required for site determination and establishment of bylaws and codes of practice;
- Developing strategies to improve public understanding of the hog industry at the national level and correct inaccurate perceptions of environmental performance at the regional and local levels.

Chapter 1

OVERVIEW OF THE HOG INDUSTRY

Introduction

The hog industry is an important component of Canada's agri-food industry, generating almost \$3 billion in farm revenue and contributing to Canada's competitive meat-processing industry. The industry is currently expanding significantly to respond to increased global prospects for pork and to capitalize on Canada's highly competitive situation within that global market. It is also undergoing a technological revolution that is allowing operations to become many times larger and more sophisticated in their management than ever before. Although this expansion will result in a concentration of animal wastes in fewer and larger sites, managers of these operations will often have better access to the capital and expertise needed to ensure that the attendant environmental issues can be addressed in a responsible manner. Still, environment remains one of the most important issue in the development of the industry, and it is an area where governments can assume an important role.

Importance of the Industry

The hog industry in Canada generated about \$3 billion of farm revenue in 1996, representing 21.6% of the total livestock production and 10.4% of all farms in 1996 (20% of the entire food industry and the largest sector of the Canadian food-manufacturing industry) and employed almost 32,000 people. Although these statistics are not available for the pork-processing industry alone, it is known that about 30% of the combined shipments are pork, and that pork makes up a large share of an additional 30% of shipments of processed meat products.

Export revenues from live hogs and processed pork exceeded \$1.5 billion in 1996, representing about 8% of the

export value of all agricultural products. About 30% of Canadian pork production is exported, with almost 80% of these exports going to the U.S. In addition to pork, Canada exports about one sixth of the pigs it produces, either as hogs ready for slaughter or as weanlings for further feeding..

In 1996, Quebec and Ontario were the largest hog producers, accounting for 30% and 26% of total hog marketings, respectively, followed by Manitoba (18%) and Alberta (15%) (Fig. 1). After 15 years of stable production levels, Quebec's marketings have risen by 13% over the last two years. Alberta and Manitoba have showed steady growth in hog marketings since the 1980s, at an average rate of 3–4% per year (Fig. 2). (The regional distribution of hog production within particular regions is depicted in the maps at the end of this chapter.)

Expansion of the Industry

Expansion is taking place in both the pork and hog industries. Three major pork processors in western Canada have announced significant expansion and/or upgrading of their facilities to achieve the advantages of world-scale production. There are also announcements or impending announcements of other new processing facilities. Expansion of the hog industry is reflected in the increased marketings discussed earlier and also the investment in new facilities, which will fuel even greater expansion in the future. Net new investment in hog farms increased steadily from 1991 to 1995 to reach \$300 million by 1995. In that year, Ontario accounted for about \$100 million of investment, and Quebec and Manitoba for about \$75 million each (Fig. 3). Although figures are not yet available for current investment, it is known that there is particularly strong expansion in the prairie provinces and continued construction in central Canada.

There are good prospects for the expansion of the Canadian hog industry to continue over the next decade. Provincial governments in the prairie provinces have established objectives to increase their production two- or three-fold, and other regions are also expected to undergo growth. Factors behind this expansion include:

- **Export markets:** World trade in pork has doubled since 1980, growing annually at a rate of 4.4% during the 1990s. Although domestic pork markets are relatively stable, there are good prospects for continued market expansion in areas, such as the Asia Pacific region, where demand will continue to grow in response to rising incomes but domestic production capacity remains limited or in decline.
- **Competitively priced feed grains:** Canada is part of the North American feed-grain market, positioning it advantageously in relation to virtually all other regions of the world. In addition, abandonment of the grain transport subsidy under the *Western Grains Transportation Act* has made it significantly more expensive to export grains from the prairies, and they have become a low-cost region for feed-grains even within North America.
- **High-quality product:** Canada has a mandatory inspection and carcass merit grading (indexing) system that helps promote quality. The price received by producers is based on the carcass index, encouraging producers to raise high-quality hogs.
- **Production efficiency:** Canada's production efficiency has always been high and is steadily increasing. Over the past 20 years, average warm dressed carcass weights of market hogs have increased from an average of 76 kg to 82 kg, and the quality of the meat as represented by the hog grading index, has improved from 101 to 105. The average number of market hogs produced per sow also exhibited a 12% upward trend from 13.5 to 15.2 between 1978 and 1992. Much of this progress in efficiency can be attributed to a progressive hog breeding industry.
- **Reduced incidence of disease:** Canadian hogs and pork are considered free from many diseases prevalent elsewhere. Hogs have not been subject to the disease outbreaks that have devastated other countries.

Expansion of the hog industry is made possible by a technological and management revolution sweeping the

industry. Once dominated by the family farm, with most production taking place in farrow-to-finish operations with 100 to 300 sows, the industry now commonly features 1,200- to 2,400-sow operations, with producers specializing in different phases of production. This trend is leading to a much higher concentration of the industry, with a relatively low proportion of producers accounting for the bulk of production (Fig. 4).

Historically, there has always been very high attrition rates among the smaller hog operations and a continued concentration of production by the larger producers, and the technological revolution driving the industry will accelerate this trend. From 1991 to 1996, the number of farms reporting hogs declined from 29,600 to 21,100, while the proportion of hogs on farms with inventories of more than 4,700 hogs increased from 10.9 to 23.3 percent (Fig. 5). From 1991 to 1996, the number of farms reporting from 500 to 1,000 sows increased from 137 to 249 and those reporting more than 1,000 sows increased from 13 to 81. By 1996, hog farms with annual sales of more than \$1 million represented only 2% of all farms but earned one-third of the total hog revenue. Just over 50% of total swine revenue was received by specialized farms in 1996 (those receiving 90% of their total farm revenue from swine), and the significance of specialized farms is expected to increase in the future.

In all provinces, especially Quebec and Manitoba, feed companies are involved in primary production, providing capital at reduced rates, technical assistance, and guarantees that they will assume ownership of pigs produced by farrowing units or supply pigs to nurseries or finishing units. In exchange for such services, the feed companies receive commitments from growers to purchase feed and, in some cases, breeding stock and other supplies, or to produce hogs on a specific schedule and market them through their organization. About 20% of Quebec production is controlled by integrators, with another 10% controlled through the use of financial arrangements with producers. Much of the growth in Manitoba hog production is the result of feed companies integrating into production through contracts with existing producers and new entrants to produce weanlings and finished hogs.

Vertically coordinated, turn-key operations are also being developed by a number of management companies who supervise the design and construction of facilities; contract for the genetics, herd health, manufactured feed (or at least feed supplements to be used with on-farm grain), and professional farm managers; and arrange for the sale of hogs on a predetermined schedule to selected slaughter-packers. These operations are financed by farmer-investors, who often benefit from having either a market for their grain or the option to finish some of the pigs produced. These types of operations tend to involve 600, 1,200, or more sows.

In some cases, producers have organized among themselves and have not been so dependent on others in the production chain. The structures they have developed can vary from formal cooperatives to "groups" that are involved in either input purchase, marketing, or production sharing arrangements. To reduce the risk of there being no market for weanling pigs or to ensure a supply of weanling pigs for nurseries and finishing units, specialized cooperatives have been formed. Increasingly, direct contracts covering supply as well as price are being arranged between farrowing units and finishing units. Another form of organization is Hutterite colonies, which currently account for about one-third of the production in Manitoba and about 25-30% in Saskatchewan.

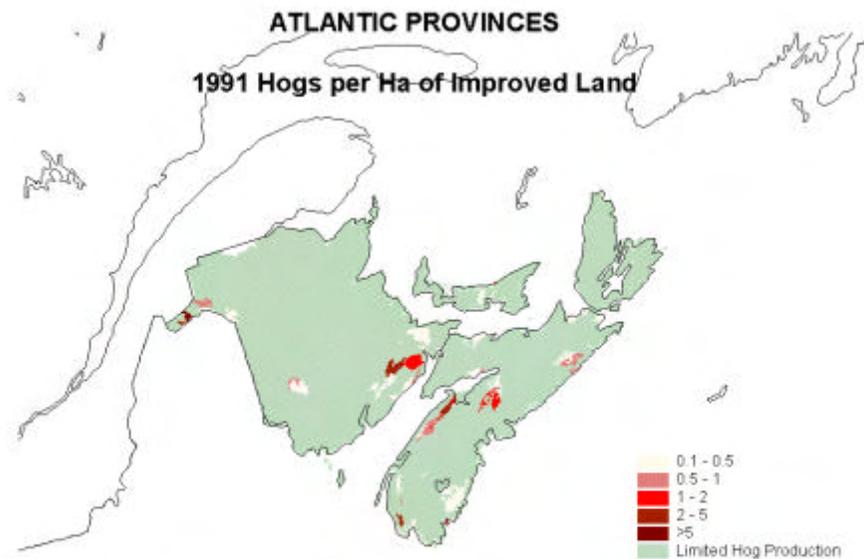
Issues Related to Industry Expansion

Many of the issues related to the expansion of the hog and pork industry are listed below. Of these, environmental issues are considered the most important and also have significant impacts on some of the other issues.

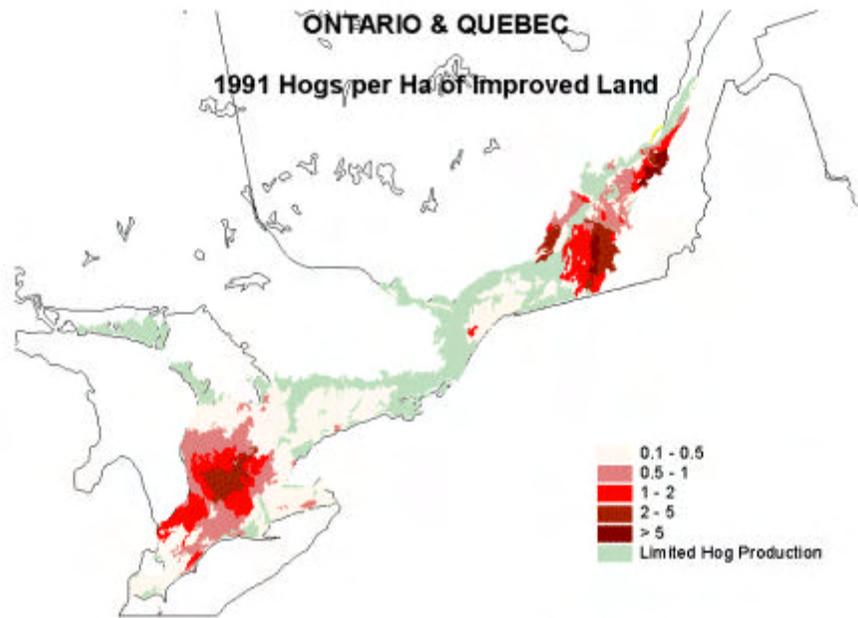
- **Environment:** Environmental issues are particularly important given the growing number of applications for new or expanded sites that have been rejected or delayed at the municipal level. The adoption of environmental best management practices, based on effective and affordable technologies, will enable hog producers to demonstrate due diligence to the domestic financial sector and to create the environment necessary to attract foreign investment. These practices may become even more important in the future if

adherence to production protocols and standards, such as ISO 14000, has a greater influence on the marketability of Canadian pork abroad and in satisfying technical import standards.

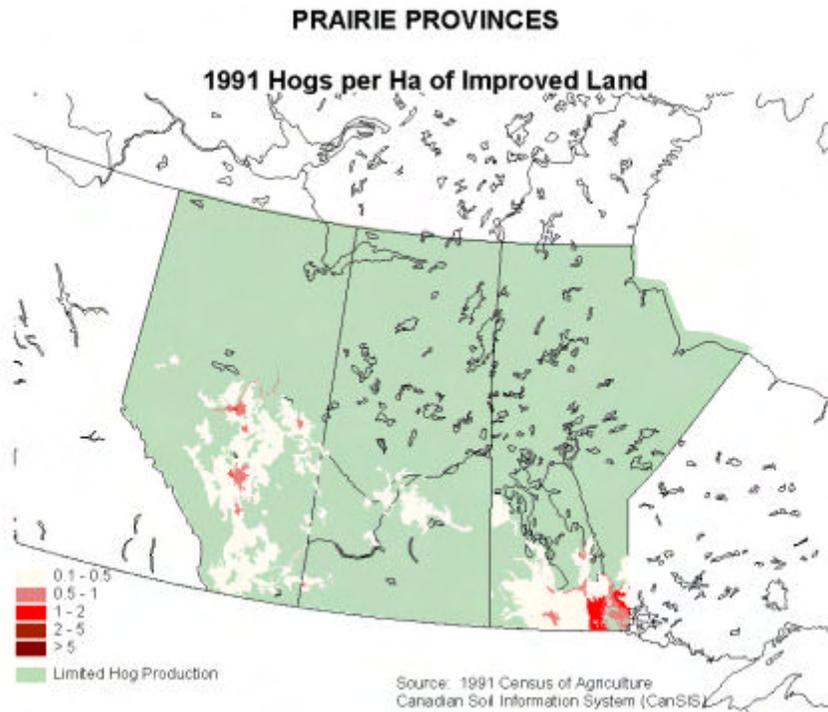
- **Financing:** The current size of operations demands far more capital than was required previously. It is estimated that it costs in excess of \$5,000 per sow to build a barn and purchase breeding stock; therefore, even a moderate-sized operation will cost many millions of dollars.
- **Labour:** The introduction of the new larger-scaled operations and attendant managerial and technical requirements requires a level of skill not previously demanded. Community colleges may be able to provide the right type of training, but it is anticipated that they will not be able to produce the number of skilled workers needed in the expanding industry.
- **Foreign investment:** There is a growing presence of foreign investors in both the hog and pork industry. Limitations on expansion in other countries combined with recent disease problems have made Canada a particularly attractive place to invest. There will be an increasing need for Canada to address the particular needs of foreign investors and resolve impediments to immigration to realize the full potential from this source of capital and expertise.
- **Export Marketing:** With a saturated domestic market, the anticipated increase in production must be exported. The industry is already experienced in export markets and it has developed Canada Pork International to continue to facilitate export expansion. Issues related to trade access will continue to be important, as countries continue to use non-tariff barriers to inhibit trade.



Source: 1991 Census of Agriculture,
Canadian Soil Information System (CanSIS)
Research Branch



Source: 1991 Census of Agriculture,
Canadian Soil Information System (CanSIS)



Source: 1991 Census of Agriculture
Canadian Soil Information System (CanSIS)



Chapter 2

ENVIRONMENTAL ISSUES

Introduction

The environmental issues of greatest concern for the hog industry all relate in some way to the handling, storage, and use of manure. Expansion and intensification of the industry within existing production areas have the potential to increase the environmental effects of hog production, because they concentrate a greater amount of production waste, including manure, in these areas.

Manure is a natural byproduct of livestock operations. Depending on how it is managed, it can be either an asset or a liability. Figure 1 illustrates what happens when manure is applied to land. Some gases, such as ammonia and methane move directly from the manure into the air. This happens not only when manure is applied to land, but whenever manure is exposed to the air, such as on barn floors and in open storage containers. Other gases, such as carbon dioxide, nitrous oxide, and hydrogen sulphide are produced as the manure decomposes in the soil and are then emitted from the soil into the air. Some of these gases give rise to the unpleasant odours associated with hog manure. Others cause air pollution and contribute to climate change through the greenhouse effect.

Manure also contains organic matter, important crop nutrients (such as nitrogen and phosphorus), heavy metals, salts, and bacteria. Organic matter benefits the soil by helping to build up soil structure (tilth) and protect against

compaction and erosion, which in turn enhances crop production. Crop nutrients are taken up by the crop, contributing to their growth. When more nutrients are added to the soil than can be used by the crop, there is the potential for them to move out of the soil system in surface water and groundwater. Bacteria and salts found in manure can also enter water in this way. Water polluted by nitrates, phosphates, salts, and bacteria poses a risk to the health of humans, animals, and aquatic ecosystems. Soil quality may also be adversely affected by the presence of heavy metals, salts, and bacteria from manure. These substances may alter the ability of soil to produce a good crop, or may be taken up by the crop itself, thus posing an additional health risk to humans and livestock.

From this description of manure management, three environmental issues emerge:

- The emission of unpleasant odours which, aside from some health effects which primarily affect workers on the farm, do not pose an actual environmental threat; however, they have led to opposition from neighbours and have jeopardized approval of new and expanded production sites.
- Declining soil and water quality, related to the application of manure to soil and the resulting accumulations of nitrates, phosphates, and other potentially harmful substances.
- Air pollution, resulting mainly from the emission of ammonia from manure, with implications for ecosystem and human health, and the emission of methane and nitrous oxide, two greenhouse gases that contribute to climate change.

Insert Figure 1 EFFECTS OF MANURE ON THE ENVIRONMENT (AIR SOIL & WATER)

Odours

Odour control is the issue of highest public profile for hog producers in Canada, the U.S., and the European Union. The expansion of hog production next to urban areas and the outward growth of residential sites into the rural landscape in recent decades have given rise to some conflict at the interface of these two ways of life. In some regions, odour emissions from hog operations have restricted the growth of the industry.

Odorous gases are generated by the microbial breakdown of plant and animal proteins. They arise mainly through the production, handling, and processing of animal manures and become accentuated with confined rearing of livestock under high-density conditions. Odour intensity varies with the size and type of hog production facilities, production practices, location of the unit and local topography, season, climate, time of the day, direction and speed of the wind, and air turbulence.

With so many variables, it is often difficult to determine which compounds, or combination of compounds, give rise to specific odours. Humans have a highly developed sense of smell, but not everyone smells the same thing. Thus the response to odour intensity is highly variable, influenced by people's background, perception of hog production, and sense of smell, among other factors.

Until recently, odours were thought of as a nuisance. There is new evidence, however, that the substances that give rise to odours can also affect human health, causing nausea, headaches, sleep disturbances, upset stomach, loss of appetite, and depression. Health problems can be more serious for farm workers who are continuously exposed to the dust and noxious gases that cause odours. Some farm workers have developed respiratory problems, such as chronic bronchitis, occupational asthma, or farmer's lung disease. As swine operations become larger, more workers are exposed to the conditions that give rise to these diseases. Health problems associated with odour-causing substances are the leading grounds for disability claims among hog producers in the Netherlands. In

Denmark, lung disease is a growing health concern among hog barn workers.

Nature of Odours

The nature of odours is complex. Odours in animal housing are produced mainly by volatile compounds and dust. Researchers have identified more than 150 volatile compounds arising from wastes associated with animal production. These compounds originate largely from manure slurry, wet floors, and dirty animals. They do not all cause odours unpleasant to humans, and some found in the highest concentrations are of the least concern.

Dust from hog production facilities — composed of fine particles, such as feed, dried faecal material, hair, skin cells, mold, fungi, viruses, and bacteria — amplifies perceived odours. The concentration of some odorants may be 40 million times greater on dust particles than in an equal volume of air. Dust particles can carry odours over long distances.

Odours from manure storage result from the anaerobic degradation of the organic fraction of the slurry. They are very intense when the manure is stirred and when the slurry is loaded into the manure spreader. Volatile compounds are released rapidly when manure is applied to the land, and strong odours are emitted in the field area. Odour emissions may reach levels that are unacceptable to neighbours. A Quebec study, for example, found that 10% of complaints about odours related to farm buildings, 20% to manure storage, and 70% to land application activities.

Soil Quality

Application to cropland is an obvious method of recycling the nutrients found in manure — plant nutrients removed from the soil by harvesting are fed to farm animals and then returned, in part, to the soil as manure. Soil benefits the hog industry by acting as a repository and filter of hog wastes that would otherwise be difficult to use. Conversely, soil can also benefit from manure application. These benefits to soil depend on manure composition and other factors, such as management practices and soil characteristics.

The effects of hog manure on soil physical properties are not well known, but are probably similar to those reported for cattle manure. Cattle manure improves soil aggregation, lowers bulk density, and improves structure and water-holding capacity of soils by increasing the soil's organic matter content. Changes in the chemical composition of the soil due to application of manure are influenced by factors such as soil texture, rate, time and method of application of manure, the amount of local precipitation, and the crops grown.

Adding manure to soil raises soil levels of nitrate nitrogen, phosphorus, potassium, and sodium, in some cases more rapidly than inorganic fertilizers. Accumulation of these substances in the subsoil increases with the rate of application and with the number of years that manure application is repeated.

Although application of manure to soil has many benefits, there are some concerns about this practice related to soil management, including:

- optimizing the amount of nitrogen retained in manure (i.e., preventing nitrogen losses through ammonia emission and other processes);
- optimizing the amount of manure nitrogen retained in soil and the availability of this nitrogen to crops;
- minimizing soil surpluses of nutrients (especially phosphorus) and salts;
- minimizing the build-up of bacteria and heavy metals that may pose a health risk to humans and livestock if taken up by crops;

- minimizing the soil compaction that results from using heavy machinery to apply manure to fields, especially when the soil is wet.

Optimizing the amount of nitrogen retained by hog manure involves reducing ammonia emissions from manure, which reflect a significant loss of nitrogen from soils. In a Saskatchewan study, estimates of nitrogen lost directly from hog manure ranged from 15% (using covered lagoons to store manure and injecting liquid manure into the soil) to 65% (using open lagoons, and spreading manure on the soil surface and incorporating it more than 24 hours later). Ammonia has a short residence time in the air, most being deposited as particles of ammonium nitrate or ammonium sulphate close to the source of production. Therefore ammonia emitted from manure plays a significant role in supplying nitrogen to lands adjacent to the hog production site.

Optimizing the availability of manure nitrogen to crops is related to manure application practices. Proper application will consider such factors as timing and rate of application, crop type, and the suitability of the land to receive manure.

Minimizing the amount of substances such as salt, heavy metals, and bacteria in soil will involve altering the composition of manure (through such measures as refining hog feed composition and treating the manure itself), as well as ensuring that manure is applied to a sufficiently large land base. Minimizing soil surpluses of crop nutrients has direct implications for the protection of water quality.

Water Quality

Ecological concerns arise when the amount of nutrients (especially nitrogen and phosphorus) added to soil in manure exceed crop requirements and the retention capacity of soil. When this happens, surplus nutrients can leave the soil system and enter surface water and ground water, where they pose a risk to human and ecosystem health. This is of particular concern with lands within classes 4 and 5 for agriculture, which commonly have sandy to loamy textures, overlie various types of shallow aquifers, and are sensitive areas with respect to maintaining soil and water quality. The need to match manure's fertilizer value with plant nutrient requirements is a regulatory and policy challenge common to all developed countries.

Nitrogen: Manure is a key agricultural source of nitrogen in soil. Nitrogen is present in manure in organic forms, and must be converted to inorganic forms, such as ammonium and nitrate, before it can be used by plants. Up to 50% of the nitrogen in hog manure is available to crops within three to six weeks of incorporating manure in the soil. In composted manure, more of the nitrogen is held in an organic form, and crop nutrients are not released as quickly as they are from fresh manure. When more nitrate exists in the soil than can be taken up by crops, it may run off in surface water or leach below the root zone into ground water, where it may reach levels that are harmful to humans and animals.

The level of nitrate leaching following heavy application of manure depends on factors such as the rate and period of application, soil type, type of crops grown and length of growth, and rate and amount of precipitation. In temperate regions, nitrate nitrogen concentrations in the soil solution are generally highest in May and decline during the growing season due to nitrogen uptake by the crop and to leaching. Increasing the carbon content of manure may increase the level of denitrification in the soil, resulting in more nitrogen being emitted as nitrous oxide and less leached as nitrate. Nitrate leaching to lower parts of the soil profile may be of particular concern when manure is applied by injection than when broadcast on the soil surface.

Phosphorus: Phosphorus exists in organic and inorganic forms in hog manure but, unlike nitrogen, is not lost to the atmosphere. Only 40–50% of the phosphorus in manure is available to crops in the first year after application.

Unused phosphorus builds up in the soil year after year, reaching high levels if manure is applied at high rates over long periods of time.

As soil levels of phosphorus rise, so does the potential for water pollution. Phosphates that derive from manure can enter waterways where they promote the growth of algae, which in turn uses up oxygen in the water and makes the aquatic environment less fit for fish and other organisms. Phosphates can enter water in run-off from manure storage areas, in surface run-off from fields where manure has been applied, and in the drainage water from tile-drained level fields. Plot studies have shown high levels of phosphorus in run-off water even when manure was applied at the recommended rate. Crop type also affects how much phosphorus leaves the soil. Much more is lost under forage crops than under corn, because the use of no-till with forage crops makes the large cracks and worm holes in the soil more accessible to conduct phosphorus-laden water down through the soil.

In the Atlantic provinces, phosphorus accumulation in soil poses little concern, because hog manure is not very abundant. In Ontario, Quebec, and British Columbia, phosphorus levels in soil are a concern. Most hog producers in Quebec and B.C. face a constant challenge in acquiring sufficient land for environmentally sound land application of manure (about 3,000 Quebec farms are in this situation). Studies in Quebec illustrate this concern. Quebec watersheds with a high concentration of hog production units show a large increase in phosphorus levels in the soil, as well as decreased ability of the soil to hold on to this phosphorus. At least six watersheds have a surplus of more than 1 million kg of nitrogen and phosphorus compared to crop needs. Phosphorus concentrations much greater than the accepted safe limit have been found in drainage outlets, and stream and river waters. Sediments of the Boyer River watershed, very important for smelt spawning, are saturated with phosphorus. A significant relationship between the amount of suspended solids and the total river phosphorus concentration at the outlets was found in 16 major rivers in the St. Lawrence Lowlands. This finding suggests that erosion from phosphorus-enriched soils is an important process along the slopes, as is movement of phosphorus-laden water from level tile-drained soils .

In the prairies, there is a sufficient land base to handle the hog manure generated. There, soils are considered deficient in nitrogen and phosphorus and require annual inputs of both nutrients for optimal crop growth. The calcareous nature of these soils restricts the mobility of inorganic phosphorus, but only 40–50% of the phosphorus in manure is mineralized during the first year following application. Poorly managed manure application poses a risk of pollution to surface waters from phosphate run-off on sloping land or from leaching of organic phosphate into shallow aquifers.

Air Pollution

Air quality issues originate with the release of gases from hog manure and from the hogs themselves. These gases include ammonia, amines, hydrogen sulphide, and methane. Besides causing the odour issue described above, these gases can affect human and environmental health.

Ammonia Emissions

Ammonia is a localized pollutant, not likely to act as an atmospheric toxin, but it is also a precursor for ammonium compounds, which are delocalized pollutants. As much as 94% of ammonia emitted into the air combines with acidic nitrates and sulphates from industrial activities and automobile exhaust to form airborne particles. These microscopic particles are thought to pose a significant human health risk because they can bypass the normal defences of the respiratory system. High concentrations of these particles are usually found where intensive livestock production borders urban industrial areas. In extreme conditions, such as may be found in the eastern Fraser Valley of B.C., these compounds may comprise up to 70% of the fine particles in the air during the

summer, resulting in impaired visibility.

Deposition of ammonia and ammonium particles may cause eutrophication in surface waters and local nitrogen loading of soils. The degree of these effects depends on how far, and in what direction, these compounds move from the source. Models for determining wind dispersal of pollutants, used for environmental assessment of industrial activities, could be used to predict the widespread environmental effects of ammonia.

Greenhouse Gases

Another air quality issue associated with hog production is its contribution to climate change through the emission of two greenhouse gases, methane and nitrous oxide. The hog industry contributes less than 5% of total agricultural emissions of these gases, and less than 1% of Canada's emissions.

Hogs emit methane directly, and manure produces both methane and nitrous oxide. Hogs produce much less methane than other farm animals due to the fact they are not ruminants. Methane emitted from hogs accounts for approximately 2% of the total methane emitted by livestock in 1991. The majority of hog-origin methane comes from hog manure; hogs accounted for about a third of methane from animal manure in 1991.

Chapter 3.

Government and Industry Efforts to Meet the Challenge

Introduction

Sustainable production is a goal of the hog industry. Achieving this goal involves adopting environmentally sound management practices (notably those related to the handling, storage, and land application of manure), maintaining flexibility within a changing regulatory environment, and working to meet the high public expectations of the industry.

Government regulation is the primary means of ensuring environmental protection in Canada. For the most part, the regulation of livestock operations to control adverse environmental effects falls to provincial and municipal governments. All provinces have environmental protection legislation, usually administered and enforced by the provincial ministry responsible for the environment, sometimes with the assistance of other resource ministries, such as agriculture. In general, the goal of this legislation is to prevent pollution and to hold polluters responsible for any environmental damage their actions have caused. This legislation is fairly consistent across the provinces with respect to agriculture and manure management, although it may vary in the extent to which farming practices are controlled and in some administrative details, such as permit issuance. Partnership with the hog industry during the process of developing and amending environmental legislation ensures that industry views are heard and that the provinces understand to what extent this legislation acts as a constraint to industry expansion.

Most provinces also have "right-to-farm" legislation, and those that do not are in the process of laying the foundations to enact such legislation. The intent of this legislation is to protect agricultural producers, including hog

producers, from unwarranted "nuisance" lawsuits. Producers are protected provided that they operate in accordance with "normal farm practices." However, the definition of normal farm practices is the subject of some debate. To clarify this question, many provinces have adopted agricultural codes of practice that outline acceptable management practices. These codes are often built right into right-to-farm or other agriculture-related legislation. Many provinces have in place boards, made up of producers and other experts, to evaluate any submissions under the acts. Most provinces encourage voluntary compliance with established codes and intervene only in cases where the code is breached.

Municipalities and other regional authorities may also make regulations that control, limit, constrain, or otherwise affect hog production within the local municipality or region. The extent to which this takes place varies across the provinces for two main reasons. First, the actual environmental risks associated with hog production vary with the local agronomic and physical characteristics of the landscape. Secondly, municipal authorities are subject to pressures from many interest groups (e.g., environmental groups, community groups, and hog producers) and respond by making trade-offs among these interests. Many examples exist of effective municipal legislation that balances all interests, but in some cases this balance can be tipped to one side based on predominant concerns. New regulations appearing in municipalities throughout the country highlight the growing concern about hog farming with respect to urban–rural relationships. The shifting focus in the rural economy in many areas, from primarily resource-based industries such as agriculture and forestry to service-based industries such as tourism and recreation, is related factor. Policy makers will be faced with an ever greater array of environmental issues, such as non-point source water pollution, that the public will demand action on.

Recent technological advances and the current potential for growth within the Canadian hog industry underline the need for new approaches that go beyond traditional "command-and-control" methods. Such innovative approaches are being explored across the country. For example, one alternative already being applied in the western provinces is for governments to work with industry and community groups to anticipate and prevent problems through proactive planning for land use and resource care. This approach both offers environmental benefits and protects the competitiveness of the hog industry.

Members of the hog industry have, themselves, already done significant work to encourage sustainable development. Industry-led initiatives in several provinces are looking at improved farming practises and developing regional approaches that accommodate variations in the level of consciousness of the environmental problems and readiness to adopt solutions. These innovations are an attempt to address public, environmental, and agricultural interests in a way that allows industry expansion to continue. Industry organizations throughout the country, often working with provincial governments, have also examined legislation and environmental control options and have reported on ways to improve the transfer of technologies that will enhance environmental performance.

The industry also plays an important role in providing information on environmental management to hog producers, government decision makers, and communities affected by industry expansion. In the latter case, opposition to expansion of hog operations from community members who wish to avoid nuisance and ensure protection of the environment is forcing the industry to do a better job of planning to minimize risks and informing the community and local government of the benefits of expansion.

The following discussion of regulation, other government activity, and industry activity related to hog production in the country as a whole and in each of the provinces illustrates the common themes described above, as well as the different stages of regulatory development and proactive planning evident in the different jurisdictions.

National

Sustainable Development Strategy

All departments of the federal government are currently involved in developing and implementing sustainable development strategies. Agriculture and Agri-Food Canada's sustainable development strategy, "Agriculture in Harmony with Nature" was released in 1997. This strategy identifies four strategic directions for achieving environmental sustainable agriculture in Canada:

Increasing understanding: improving the capacity of departmental and sectoral decision makers to integrate environmental factors into day-to-day decision making. In relation to environmental work relevant to the hog industry, this begins with a good overview of the industry itself, underlining its importance to the Canadian economy and potential for growth.

Promoting environmental and resource stewardship: promoting the stewardship and sustainable use of the environment and agricultural resource base by the agriculture and agri-food sector. This involves identifying the environmental challenges for the hog industry and supporting the industry in its efforts to practice good stewardship through the use of best management practices.

Developing innovations and solutions: focussing research, development, and technology transfer to address environmental challenges and foster sustainability in the agriculture and agri-food sector. This begins with a review of recent hog environmental research that may have already provided solutions to these challenges, highlights areas where additional research and technology are needed, and evaluates the success with which promising developments are transferred to industry users.

Seizing market opportunities: encouraging agriculture and agri-food marketing and trade that promote environmental quality and sustainable growth. For the hog industry, this will reflect how well the industry is able to meet the growing global demand for high-quality agricultural products produced in an environmentally acceptable way and will be a measure of the industry's success in acting on the findings of this situation analysis.

Federal Regulation

At the federal level, the *Fisheries Act* is the main law that addresses agricultural pollution. This Act prohibits the unauthorized deposit of a harmful substance into water frequented by fish, or into water that may eventually enter water frequented by fish. Livestock manure and run-off from overwintering and feedlot areas may be considered such substances. The Act also prohibits the harmful alteration, disruption, or destruction of fish habitats. Environment Canada leads enforcement of the pollution-control portion of this Act.

Industry Activity at the National Level

The Canadian Pork Council (CPC) has led in the development of national guidelines for the hog industry through publication in 1996 of the *Canadian Code of Practice for Environmentally Sound Hog Production*. This code is the result of a cooperative effort among the CPC, federal and provincial governments, universities, agricultural organizations, and environmental groups. Objectives of the code include providing hog producers with a national framework for production and marketing decisions to ensure the continued availability of the resource base for hog production in Canada. The code also provides a starting point for provincial and regional regulation of hog production.

British Columbia *Legislation*

Two key pieces of legislation that affect hog production and manure management in B.C. are:

1. *The Farm Practices Protection (Right to Farm) Act*;
2. *The Waste Management Act*.

The fundamental policy of the *Farm Practices Protection (Right to Farm) Act* is that farmers have the right to farm in B.C.'s important farming area, particularly the Agricultural Land Reserve, provided they use "normal farm practices" and follow other legislation listed in the act. This act also establishes an improved complaint resolution process for people who live near farms and have concerns about farm practices which create dust, odour, noise or other disturbances.

In addition, this act amends the *Municipal Act* and *Land Titles Act* to encourage local governments to support farming by ensuring local bylaws reflect provincial bylaw standards. Although local governments have the authority to enact and enforce a variety of land use plans and zoning bylaws, they can only do so with the approval of the Ministry of Agriculture, Fisheries and Food. Municipalities may regulate:

- areas within a region where hog production is permitted;
- setback distances from lot lines and watercourses from farm buildings;
- building requirements in flood plains;
- nuisance, such as excessive noise and odour.

If changes are made to a zoning bylaw, existing hog operations are protected under the non-conforming section of the municipal act. That is, hog operations can be considered legally non-conforming but limited to existing size unless expansion can meet the requirements of the new bylaw.

The Waste Management Act is designed to control pollution in the province. Under this act, the Agriculture Waste Control Regulation and Code of Agricultural Practices for Waste Management apply, specifying requirements for managing the collection, storage, handling and use of manure. Hog producers who conform to the Code are exempt from holding a Waste Management Permit, but not from other provisions of the act.

BC: Other Government Activity

BC Ministry of Agriculture, Fisheries & Food has prepared a booklet entitled "Investment Information on the British Columbia Hog Industry" . It was prepared to encourage producers and potential investors to move industry expansion away from the heavily populated Fraser Valley to the Peace River and North Okanagan areas. In those areas there is greater opportunity to use manure as a fertilizer, and there is ready access to low-cost feed.

BC: Industry Activity

B.C. Pork Producers Association

Most B.C. hog farms produce more manure than they can use, face high costs of transporting manure to other disposal sites, and have inadequate manure storage facilities. These factors sometimes result in over application of manure to some fields and application during the non-growing season. In the summer of 1997, B.C. Pork Producers Association ran a survey of hog farms in the Central Fraser Valley to evaluate the need for waste-treatment systems. As a result of the survey, the association has launched a project to search out and evaluate affordable waste management technologies.

There are currently 77 hog farms in the Fraser Valley. This represent 85% of the estimated 300,000 hogs produced annually in BC. Land is limited in the Fraser Valley for manure spreading. The intensity of livestock development in this region motivated the B.C. Ministry of Environment, Lands and Parks to work with the B.C. Pork Producers Association to prepare an Environmental Transition Plan" for the Fraser Valley pork industry. This plan works at the farm level and is intended to bring hog producers in compliance with the Code of Agricultural Practice for Waste Management.

Peer Advisory Service

The B.C. Agricultural Council maintains and supports an Agricultural Peer Advisory Service (APAS). The Council uses a peer-producer approach to resolve concerns at the local level. The pork industry has representation on APAS. Usually, education and mitigation are the preferred first step in resolving a farm practice concern. When these fail, provisions are in place to redirect the concern to a regulatory agency for resolution.

Alberta Regulation

The legislation regulating most of the affects of human activity on the environment are the *Alberta Environmental Protection and Enhancement Act* and the *Alberta Public Health Act*. The *Environmental Protection and Enhancement Act* prohibits the contamination of water supplies and the release of certain substances into the environment. It also regulates the storage, collection, transportation and treatment of waste products. It requires environmental accidents to be reported and those responsible, to bear the cost of clean-up. There are no specific standards outlined in either Act for agricultural operations. Alberta Environmental Protection may issue an environmental protection order to deal with offensive odors, but such an order may not be issued if the offensive odor results from an agricultural operation that is carried out in accordance with generally accepted agricultural practices.

The *Agricultural Operation Practices Act*, similar to other right-to-farm legislation, provides protection from nuisance lawsuits if the operator is following generally accepted practices and is not breaking any provincial regulations. The siting and development of intensive livestock operations is the responsibility of municipal governments working with Alberta Agriculture, Food and Rural Development (AAFRD), as well as industry associations.

The Alberta government is also undertaking consultations to draft a new *Water Act*. Currently, the existing legislation is under review to ensure that water resources are managed responsibly. Under the existing *Water Resources Act*, hog operations with 100 or more sows, farrow-to-finish operations, or those with 1,000 or more feeder pigs require a licence. These guidelines are expected to change when the new *Water Act* comes into effect.

Development of new or expanding livestock operations is controlled at the municipal level. Municipalities familiar with intensive livestock development generally have well-defined procedures in place, whereas others have none. Some municipalities have developed bylaws that reference criteria established in the *Code of Practice for the Safe and Economic Handling of Animal Manures*, developed in Alberta by an industry/government committee in 1995. This information assists municipalities in reducing potential nuisance conflicts by, for example, recognizing that normal odour production can be accommodated by meeting minimum separation distances. All municipalities are currently reviewing their bylaws as required under the Municipal Government Act.

Alberta: Other Government Activity

Livestock Expansion and Development Team

AAFRD is committed to accomplishing agricultural development in an environmentally responsible manner. A new working group, the Livestock Expansion and Development Team, is working with municipalities and developers to address issues and concerns associated with the growth of the livestock industry. A key objective for the group is to provide unbiased technical information on manure management and odour control practices required for the protection of soil and water and for the quality of life in rural communities. The team will develop partnerships and networks for conducting research where accurate information is lacking. In addition, AAFRD is working with industry to implement measures aimed at protecting the environment, facilitating the responsible expansion of agricultural industries, and identify appropriate environmental regulations. Several studies will be released between October 1997 and March 1998.

Geographic Information Systems (GIS) Mapping

AAFRD has integrated soil, water and agricultural production databases available from various partner agencies, including the Prairie Farm Rehabilitation Administration (PFRA), to produce maps that identify areas (at the township scale) of livestock concentration and potential environmental risk. The report identified areas in the province where natural resources and lower population densities coincide to offer opportunities for building new hog production facilities. With the help of GIS, municipalities can map areas that pose constraints or opportunities for the development of intensive livestock operations (ILOs), such as:

- existing and future rural residential development,
- environmentally sensitive areas,
- areas with limited surface and ground water supplies,
- permeable soils,
- shallow or important aquifers,
- ground water recharge areas,
- truck routes, and
- land that is available and suitable for manure application.

Criteria for land-use decisions and development plans can then be developed.

Alberta Agriculture District Offices

AAFRD is working to make each of our district offices the first and best stop for specialized agricultural information. AAFRD supplies a wide range of technical, financial, planning and market development support for farmers, agri-businesses, agricultural organizations and value-added enterprises. The specialist positions focus on nine information areas: beef, pork, crops, engineering, farm management, food processing development, 4-H, marketing, and rural development.

Alberta: Municipal Activity

GIS-Based Regional Planning for ILOs in the County of Lethbridge: The County of Lethbridge, along with other federal and provincial partners, has identified a need for a regional planning approach to ILO development. The project will use guidelines contained in the recently adopted *Code of Practice for the Safe and Economic Handling of Animal Manures* to develop a GIS-based regional constraint and opportunity map for ILOs in the County of Lethbridge as a tool for decision making regarding land use and development. So far, the project has generated several single-theme maps, and the next step is to overlay the themes to identify any overlapping

constraints to, or opportunities for, development. This scale of mapping does not take into account localized and site-specific issues.

Alberta: Industry Activity

Alberta Pork

Alberta's livestock associations have participated in the development of voluntary guidelines to assist municipalities and producers in the siting, design and management of new and expanding livestock facilities. *The Code of Practice for the Safe and Economic Handling of Animal Manures* provides developers with detailed information on siting to reduce odour nuisance and avoid contamination. Additional information is offered on manure storage and application of manure to the land.

Alberta Wheat Pool

The Alberta Wheat Pool has produced a *Farm Environmental Risk Assessment Guide*, a voluntary self-directed tool for producers to measure their environmental performance and assess areas where their practices may put them at potential risk under existing Alberta legislation.

Alberta: Community Involvement

Two examples illustrate how community involvement shapes the development of the hog industry.

Mountain View Agricultural Planning Group

In response to several development permits for hog operations in the County of Mountain View, the Mountain View Agricultural Planning Group was formed. This group has held a series of open houses to provide technical information to area residents. The group's main concern is that insufficient information is available to regulate large scale pig developments effectively.

Grimshaw Aquifer Management Plan

The Grimshaw aquifer occupies an area of about 595 km² in the Peace River Region, an area currently being considered for significant expansion of the hog industry. As use of the aquifer increases, it is a priority to protect it from potential contamination deriving from septic systems; barnyards; agricultural, chemical and fuel storage sites; dugouts; disposal pits; gravel pits; and landfill sites.

Besides provincial regulations, there were no clearly defined goals for the development and protection of the aquifer. Local groups and individuals were concerned about maintaining its quantity and quality, recognizing that pollution of the aquifer would have implications for agriculture, health, urbanization and tourism. They also saw the economic potential of the ground water as an export commodity, the value of which has not yet been fully realized. The people worked with the town of Grimshaw and federal and provincial agencies to develop a proactive, locally driven plan for allocation and protection of the aquifer, allowing stakeholders to protect water quality and ensure sustainable aquifer levels for future uses. The plan emphasizes community health, as well as the need for a quality water supply to support agricultural activities and communities.

Saskatchewan *Regulation*

In Saskatchewan, certain classes of intensive livestock operations, including hog operations, must obtain approval of waste storage and waste management plans under the intensive livestock provisions of the *Agricultural Operations Act* in order to protect surface and ground water resources from pollution. Waste storage and waste management plan approvals are required for any ILO that:

- contains an earthen manure storage area;
- involves the rearing, confining or feeding of 300 or more animal units; or
- confines more than 20 animal units for more than 10 days in any 30-day period, and is within 300 metres of surface water or 30 metres of a domestic water well not controlled by the operator.

The act also protects farmers from unwarranted nuisance lawsuits and provides a mechanism for resolving nuisance disputes between agricultural producers and their immediate neighbours.

As part of the process to get approval from Saskatchewan Agriculture and Food for a proposed ILO development, applicants must complete a workbook requiring a description or calculation of animal inventory; manure production, storage, and utilization; nitrogen, phosphate, and potassium production; nitrogen utilization; land areas available for manure utilisation; and management of dead animals. The package includes a map of soil climatic zones in the province and tables of manure production, nutrient production, death loss, and crop nitrogen values. A completed workbook includes all the information needed to determine the quantity of manure generated from an ILO, the size of manure storage required, and how the manure will be utilised.

In Saskatchewan, most new hog barns include an earthen manure storage area (EMS). A site plan forms part of the waste storage plan application. Besides completing the workbook described above, the applicant must undertake a geotechnical investigation at the proposed site, usually performed by an engineering consultant. Some developers hire a consultant to assist in the development of a manure utilisation plan. The consultant ensures that the soil and proposed crops on the designated land are suitable for the amount and type of nutrients in the hog manure.

Two aspects that are not part of the regulations respecting the development of ILOs in Saskatchewan are nevertheless important in the overall development process as far as the public is concerned. The first, which receives strong provincial support, is a "public process" by which the applicant informs the public in the area of a proposed development knowledgeable about the development by, for example, sending out mailings to the community and holding public information meetings. The second is separation distances between ILOs. If there are no rural municipality bylaws respecting separation distances, the province publishes preferred separation distances as guidelines. If the developer has followed the separation distance guidelines and a subsequent nuisance complaint is made, the operator would find it easier to make the claim that the ILO meets normally accepted agricultural practice.

Under the *Saskatchewan Planning and Development Act*, rural municipalities in Saskatchewan have the authority to develop zoning bylaws governing all types of developments within the municipality, including ILOs such as hog barns. About half of the municipalities have bylaws to this effect. They have no regulatory responsibility in the environmental area regarding ILOs, but they can and do influence the siting and establishment of hog barns within their boundaries. Thus, from an environmental perspective, no area of the province has an advantage over another. Developers of an ILO must meet the requirements of both the land-use bylaw and the *Agricultural Operations Act*. Municipal bylaws usually reflect the level of community support of development, and where support is lacking, the bylaws may be restrictive. Some municipalities have a discretionary use bylaw that allows their councils to grant project approval on a case-by-case basis, adding conditions as they see fit. Conditions may include distance between ILOs in the rural municipality, areas considered unsuitable for ILOs, and

minimum distances from other rural residences.

In relation to manure management, most ILO developments usually only deal with the provisions of the provincial *Agricultural Operations Act* and a municipal land-use bylaw. However, other provincial legislation may be pertinent, including the *Environment Management and Protection Act*, *Pest Control Products Protection Act*, *Rural Municipality Act*, *Clean Air Act*, and *Public Health Act*. If it is considered necessary for other agencies, such as Saskatchewan Environment and Resource Management or Saskatchewan Water Corporation to be involved, the developer's proposal is given to these agencies for review and comment by the regulatory group in Saskatchewan Agriculture and Food.

Saskatchewan: Other Government Activity

Saskatchewan Pork Central

Saskatchewan Pork Central raises public awareness of pork production in Saskatchewan by providing information to communities, potential investors, key members of the service industry, and the general public. It also offers technical services to the industry, raises awareness of opportunities, and coordinates the "Provincial Pork Strategy".

Centre for Studies of Agriculture, Law and the Environment

The Centre for Studies of Agriculture, Law and the Environment recently completed a macro-level study on the opportunities for hog development in the province, combining some environmental parameters with information gathered through a survey to highlight areas of opportunity at a 1:1M map scale.

Saskatchewan: Community Involvement

Environmental Non-Government Organizations

A public Hog Forum is being proposed for December 1997 in Saskatoon to present information on the current state of the hog industry and the concerns surrounding future development and to engage participants in discussion of these issues. Participants include the general public, health sector, scientists, producers, business people, government officials (federal, provincial, local), farmers, hog industry representatives, and politicians.

Recent development of the hog industry in Saskatchewan has been characterized by the requirement of wide community support for a given development. In the regional municipalities of Grant and Victory, committed groups of individuals from the communities who believed a large hog barn would provide benefits to the community were the major driving force behind development projects. They contacted neighbours and local government people to discuss their plans, ensuring that, as much as possible, local concerns were met during the planning process. A development partner was brought in to help the group arrange financing, deal with the securities commission for raising funds, construct the barn, and take part in the management. As a result of these efforts, the hog barns received both community and local government support. A 600-sow farrow-to-finish barn has been built in each area. The communities have seen the benefits of the barns in their areas, and both barns are expected soon to double in size.

Carlton Trail Regional Economic Development Authority

The Carlton Trail Regional Economic Development Authority (REDA) is composed of 11 regional municipalities, which are considering a number of opportunities for economic development in the region, especially increased hog

production. The authority needs additional information on resources and infrastructure to make informed decisions for sustainable regional development. To meet this need, a pilot project has been initiated: The Prairie Farm Rehabilitation Administration (PFRA) of AAFC will work with Carlton Trail REDA to conduct a regional analysis of the opportunities and constraints for various types of development in their area. PFRA will provide a spatial analysis of the opportunities and constraints for sustainable development, integrating resource care and rural growth. Carlton Trail REDA, and the communities it comprises, will use this analysis to identify environmental areas, not specific sites, for locating ILOs.

Manitoba

Regulation

At the onset of the livestock industry's planned expansion in the province, Manitoba Agriculture initiated an action plan to ensure the sustainable development of this industry. In 1992, the Agricultural Guidelines Development Committee was created, chaired by Manitoba Agriculture and pooling representatives from other ministries, municipal authorities, universities, producers and consumer's associations. The mandate of the committee was to develop tools and assume a leadership role in addressing livestock waste management issues in the province. The government, often in partnership with federal counterparts and the industry, spearheaded research, development and technology transfer initiatives to develop best management practices and technologies to foster better stewardship with respect to manure management, inclusive of odour control. The *Livestock Waste Regulation* was passed in 1994 to specifically address the issue of potential environmental pollution from livestock manure management as well as to deal with the issues of livestock mortality disposal.

Guidelines for Sustainable Stewardship of Animal Manure Management

The Agricultural Guidelines Development Committee fostered the production of the *Farm Practices Guidelines for Hog Producers in Manitoba* (1994), where emphasis is placed on agronomically and environmentally sound manure management practices. This publication was followed by similar stewardship manuals for Beef, Dairy and Poultry producers. These guidelines were designed to help producers adopt manure management systems and land application methods known to prevent adverse environmental impacts from livestock production.

The guidelines address the issues of odour nuisance and environmental pollution control. Incremental recommendations for setbacks between residential housing and livestock operations of different animal unit size are presented to minimize potential nuisances from odours. As well, recommendations for setbacks from property lines, residences/residential area and watercourses are presented for various manure application methods. Finally, the guidelines present a "calculator" method to estimate the required land base for a new or expanding hog operation.

Technical Review Process

The Agricultural Guidelines Development Committee soon expressed the need to provide assistance to local municipal authorities in evaluating the technical aspects of livestock operation projects in relation to the recommended livestock operation and manure management practices. A Technical Review Process, consisting of regional committees of bringing together professionals from Provincial Departments of Agriculture, Environment, Natural Resources and Rural Development was devised to provide advice and comments to municipal councils, and to assist in addressing the concerns of the general public about the perceived impacts of new livestock projects in rural Manitoba. Either a municipal council or the proponent of a livestock project can request a review.

The committee addresses both the issues of compliance to the *Livestock Waste Regulation*, the local specificity

of the resources (aquifer sensitiveness, surface water problems, soil types, crops, etc.), and compares the technical details of a hog operation proposal with the recommended practices prescribed in *Farm Practices Guidelines for Hog Producers in Manitoba*. The review also covers considerations with respect to existing rural residences, zoning bylaws and any other local land use issue. The committee will comment on the degree of compliance of a proposal with the above considerations and may propose additional requirements for consideration by municipal officials for a conditional use permit. The noncompulsory nature of this process seems to be a drawback as potentially contentious projects may not always be subjected to a review.

The same committees are also actively involved in the organization of open houses on "Intensive Livestock Operations and the Environment". These public relations events are meant to provide rural residents an opportunity to become more familiar with the characteristics of modern intensive livestock operations, the nature of the potential environmental impacts or health risk, techniques or practices designed to reduce or prevent these impacts, and risks or nuisances associated with livestock operations. The open houses bring together representatives from the industry, agricultural services, provincial Departments of Agriculture, Environment, Health, Natural Resources, Rural Development, and AFFC's Research Centres and the Prairie Farm Rehabilitation Administration. Opponent groups are also invited to participate in these open houses, providing them with a chance to present their point of view to the community.

Farm Practices Protection Act

The *Farm Practices Protection Act* was assented in 1992 but only enacted in 1994, after "normal practices" for livestock mortality and manure management methods were defined in the Farm Practices Guidelines series. The purpose of the act was to reciprocally protect producers and neighbours from abusive law suits, be it unfounded suits associated with agricultural nuisances such as odours, or inconsiderate manure management practices.

The *Farm Practices Guidelines* series have since been used by the Farm Practices Protection Board, to determine the legitimacy of nuisance complaints in relation to agricultural producer practices. The Farm Practices Protection Board comprises representatives from producer associations, municipal authorities and the Consumers' Association of Canada, with the assistance of Manitoba Agriculture. An amendment to the act was passed in 1997, allowing the Farm Practices Protection Board to file in court any order for compliance sent to a producer who has ignored an order to modify or cease practices resulting in a nuisance complaint.

Livestock Waste Regulation

The *Livestock Waste Regulation* under the 1988 *Environment Act* was passed in 1994. It came out of the Code of Practice for Livestock Waste Management, developed by industry stakeholders in cooperation with the provincial government. This regulation deals with the use, management, and storage of livestock waste from all agricultural operations, as well as the disposal of dead animals. It particularly focuses on the regulation of earthen manure storage and includes requirements for siting, investigation, design, and construction of all new, modified or expanded facilities. At present, the regulation does not contain a certification requirement for aboveground storages but may be amended to this effect. Neither does it explicitly take into account concerns related to inappropriate spreading of manure on agricultural land, although Section 11(1) states that "no operator shall apply (manure) to the land in an agricultural operation except as fertilizer and the rate of application should not exceed the amount necessary to meet nitrogen crop requirements."

Consultations are currently under way to amend the *Livestock Waste Regulation*. Issues being examined include:

- adding mandatory manure management plans to be registered by new and large existing operations;
- adding a regulation prohibiting the winter application of manure;

- adding a regulation to ensure that livestock operations have specific manure storage capacity;
- adding a clause to allow for innovative agricultural practices that are not covered in the regulation but are deemed to be environmentally acceptable and that encourage and accommodate innovative sustainable agricultural practices.

While these basic practice guidelines and mitigation tools were being developed, Manitoba Agriculture brought the emerging concerns facing livestock producers in the province to the attention of the various stakeholders associated with the livestock industry, to coordinate and support or co-support a wide range of activities designed to deal with various obstacles to the sustainable development of this industry. Manitoba Agriculture thus promoted the high priority ranking of these needs for consideration by various federal (e.g., Canada-Manitoba Agreement on Agricultural Sustainability), provincial (e.g., Sustainable Development Initiative Fund), as well as private industry funding programs (technology development corporations and producer groups). A multidepartment Technical Advisory Group on Waste Management was formed to evaluate the numerous proposals on research, development and extension activities presented for consideration.

Many of these projects are now completed, while a few are still in progress. The research topics addressed ranged from studies on the fate of nutrients contained in manure in soils and water to the measurement of nuisance odours. Considerable emphasis was placed on the adaptation of technologies for the reduction of odours associated with manure storage (e.g., composite or straw covers for earthen manure storage structures, evaluation of odour suppressants), and land application techniques (pipeline injection systems, etc.) as well as decision aids for producers (economic planning software, manure management plans, etc). Numerous extension and technology transfer activities were carried out, ranging from practical demonstration efforts such as the purchase and on-farm demonstration of a straw blower for covering earthen manure storage structures to extension presentations to producers. Amongst specific activities, many environmental stewardship training sessions were organized for producers and professional staff. Local council members were also made aware of the reach of regulations as well as of the decision making resources offered by the Technical Review Process, environment monitoring projects were initiated, concerned citizen groups were met and informed, and new manure application techniques were introduced in the province.

The **Pork Information Alliance** was formed in late 1994 in response to the need to fill information gaps within the industry itself. The PIA brings together representatives from the private industry, municipal and provincial governments, financial institutions and the University of Manitoba. For example, PIA has prepared informational fact sheets on the topics of the economic benefits associated with the pork industry, the role of this industry in the environment, guidelines for developing municipal land use policies and video material on the advantages of Manitoba's pork industry.

A Manure Management Symposium held in March, 1996 brought together the leading experts in North America to share state of the art information on technologies and manure management planning principles with producers. As a direct spinoff, a user-friendly manure management planning software package is being developed to assist producers in calculating manure application rates for a variety of manure types and crops, taking in to account past manure applications. Various fact sheets on manure management were produced and others are in preparation. Manitoba Agriculture also sponsored the development of a cost of operation calculator-spreadsheet software application for a manure management system under Western Canadian conditions. The focus of these activities was to prepare producers to adopt sound manure management planning approaches.

Since 1994, more than \$1.3 million was devoted to the above manure management activities by Manitoba Agriculture and partners such as AAFC Research Centres and the Prairie Farm Rehabilitation Administration, local conservation districts and private industry.

Manitoba: Industry Activity

In June 1997, Manitoba Pork approved an Environmental Stewardship Program, designed to encourage hog producers to use sustainable farming practices. The program's primary focus will be to develop and promote activities responsive to the needs of most hog producers in the province and compatible with the principles of sustainable development. These measures must be practical, affordable, consistent with established regulations and guidelines, and acceptable to the farming community. The program will be developed and delivered in partnership with industry stakeholders, educational institutes, and municipal, provincial, and federal governments. It has four major components:

- The *Stewardship Awards Program* recognizes hog producers and organizations that have made an outstanding contribution to the environmental sustainability and overall performance of Manitoba's pork industry.
- The *Environmental Peers Program* assists hog producers to address on-farm environmental issues by connecting them with peer advisors.
- The *Nutrient Management Manual* and related fact sheets, all still to be developed, will promote the use of hog manure as a valuable plant fertilizer and soil conditioner by both crop and livestock producers. This work will involve a survey of all hog producers in Manitoba to determine levels of adherence to farm practices guidelines, type of manure management systems, acceptance of a manure auditing program, and environmental problems being encountered, as well as an assessment of the effectiveness of manure management programs in other hog-producing provinces.
- The *Environmental Project Fund* has funded environmental research projects in 1997 on manure management, composting, nitrates, fact sheets development, and manure spreading under winter conditions.

Ontario *Regulation*

The *Ontario Environmental Bill of Rights* gives the public the means to ensure that the goals of environmental protection and conservation are achieved by the provincial government in an effective, timely, and fair manner. It sets out minimum levels of public participation respecting government decisions on environmental matters and allows the public to request the review of environmental policies, acts, regulations, or instruments. Ontario residents may bring a private legal action where an individual has contravened environmental requirements causing significant harm to a public resource of Ontario.

As a result of growing conflicts between farmers and their urban neighbours, farmers have sought greater consideration of their right to farm since this act was passed in 1994. In response, a new act, the *Farming and Food Production Protection Act*, has been created to replace the *Farm Practices Protection Act* that was passed in 1988. The new act, designed to protect farmers from nuisance lawsuits resulting from normal farm practices, has received first reading in the provincial legislature. It is subject to the *Environmental Protection Act*, the *Pesticides Act*, and the *Ontario Water Resources Act*. Disputes will be submitted to the Farm Practices Protection Board, which will review the submission and make the necessary inquiries and orders to ensure compliance with its decisions.

Ontario municipalities can create bylaws under the *Municipal Act* and the *Planning Act* regulating issues affecting health, land use, and building construction. Bylaws vary between counties and often within counties at the township level. Currently, there is no appeal process under the *Municipal Act*, although there is under the *Planning Act*. One of the controversial issues discussed during the consultation process for the new *Farming and Food Production Protection Act* was the need to ensure a balanced approach between the interests of municipalities facing lobby

pressure from the public and environmental groups and the rights of producers to farm in accordance with normal farm practices. As a result, the new bill states that "no municipal bylaw applies to restrict normal farm practice carried on as part of an agricultural operation." Any disputes on this issue will be brought before the board for resolution.

Ontario: Other Government Activity

The Ontario Ministry of Agriculture, Food and Rural Affairs has developed, in partnership with other levels of government and industry, a number of non-regulatory measures to promote the sound environmental management of agricultural resources. A series of Best Management Practice booklets has been published which address management options for producers on a wide range of topics, including Livestock and Poultry Waste Management, Nutrient Management, and Water Management.

An Agriculture Code of Practice on the siting and management of livestock operations was replaced in 1995 by the Guide to Agricultural Land Use, Minimum Distance Separation I Minimum Distance Separation II. The Guide to Agricultural Land Use is a guideline, while the MDS documents are provincial policy. MDS I applies to new non-farm uses in agricultural land and the MDS II to new or expanding livestock operations.

Municipalities must adopt the MDS formula as they revise their official plans. Because Official Plans must be revised every five years, the MDS will be consistently applied within a few years.

In addition, a Certificate of Compliance Program has been in place since 1972. This program is voluntary unless adopted by a township as part of the building permit process. To obtain a certificate, an applicant must meet the requirements for manure storage, MDS, land base for manure spreading and dead animal disposal.

Ontario: Industry Activity

Ontario Farm Environmental Coalition

The Ontario Farm Environmental Coalition, comprising provincial farm organizations, has been the driving force behind the Ontario Environmental Farm Plan Program. Recently it has developed initiatives on nutrient management that focus on developing a science-based, provincial strategy to ensure that the agricultural industry grows in an environmentally sustainable fashion. A nutrient management planning policy accepted by all affected organizations is expected to be finalized early in 1998.

Ontario Pork

Ontario Pork's Environmental Committee has initiated a project to establish a database and technical resource centre on environmental issues. This initiative is aimed at providing the background needed by municipalities to formulate bylaws related to agricultural production. The centre also provides information on sound environmental practices to producers.

Ridgetown College, University of Guelph, conducted a study in 1997, sponsored by Ontario Pork, which compared zoning regulations in 177 townships in southwestern Ontario, focussing on separation distances and manure storage capacity requirements. This study, which has now been released, analysed the impact of the separation distances on the growth of the hog industry in the survey area. Preliminary results suggest that the restrictiveness of local bylaws is not a decisive factor in limiting growth in hog production.

Producer Peer Group Review

In Perth County, the Perth Agricultural Review Committee has been formed with 12 members from the agricultural community. It meets on-site with those who register complaints about farming practices and the affected farmer and explores solutions.

Quebec

Regulations

The Regulation for the Reduction of Pollution from Agricultural Sources, which took effect on July 3, 1997, replaces the Regulation for the Prevention of Water Pollution from Livestock Operations.

The purpose of the new regulation is to protect water and soil quality through provisions that prohibit the spreading of manure after October , as well as the application of inorganic fertilizers containing phosphorus on phosphorus-rich soils. The regulations also include provisions that prohibit the spreading of manure in protected areas (streams, urban areas, etc.). Producers are required not only to have an authorization certificate (as provided under the former regulation) but also an agri-environmental fertilization plan (PAEF) for the spreading of fertilizers. The PAEF determines the rates and periods of application for each plot. The PAEF must be prepared and signed by an agrologist or professional technologist under an agrologist's supervision. Producers may prepare their own PAEF provided that they are certified as having taken a Department of Education training course.

The time frames for PAEF enforcement range from October 1, 1998 to October 1, 2002. The first deadline applies to producers of manure surpluses in the L'Assomption, Chaudière and Yamaska river basins.

Producers must keep records of their manure spreading and export activities. These records complement the PAEF and must be kept for two years. They must show manure volumes and spreading dates.

The new regulation also include changes to manure storage capacity. It has been fixed at 250 days for facilities built after the regulation takes effect. In the case of facilities existing before July 3, 1997, the capacity remains at 200 days, subject to certain conditions.

Limited activity areas are identified. In these areas, farm establishment or herd increase supported by a liquid manure management system is not allowed unless the producers own the land on which the manure is to be spread. Producers may also contract with a surplus manure management organization certified by the Department of the Environment for the disposal of their manure.

Certain transitional measures are provided, including those concerning spreading after October 1. Water guns and sprinklers will be prohibited after October 1, 1998.

Act to amend the Act to Preserve Agricultural Land and Other Legislative Provisions in Order to Promote the Preservation of Agricultural Activities

The Act to Amend the Act to Preserve Agricultural Land and Other Legislative Provisions in Order to Promote the Preservation of Agricultural Activities took effect on June 20, 1997. Its main purpose is to allow farms to establish, develop and diversify their production within the agricultural area using environmental sustainable practices. The Act covers the management of three nuisances of agricultural origin, i.e. noise, dust and odours.

Municipalities will now have a new reference framework for management and development of farmland. The Government Guidelines will serve as their basic guide for review of development plans. The purpose of the

Government Guidelines is to plan farmland use and development by giving priority to activities and enterprises in the agricultural area, on an environmentally sustainable basis, in order to promote the economic development of Québec regions. The Government Guidelines identify parameters for determining separation distances for the management of odours in an agricultural area.

To promote the establishment of a suitable planning framework, the regional county municipalities located in agricultural areas are required to appoint members of the advisory committee, at least 50% of which must be farmers. This committee will study any question relating to land use planning, agricultural practices and related environmental aspects. It will provide a forum for discussion between the various stakeholders concerned with development in agricultural areas.

Some municipal councils have a tendency to take a more restrictive stand in the case of hog production applicants. The Act provides for a mediation process to assist in settling cases where a farm claims that its activities or development are constrained by a municipal by-law adopted after June 1997. In the case of regulations existing before this date that prove restrictive, the Act provides for the intervention, at the producer's request, of the Complaints Commissioner, who is responsible for investigating the matter in dispute.

To prevent situations that may cause problems of co-existence, the Act requires new non-agricultural buildings in agricultural areas to comply with the distance standards imposed on farms with regard to agricultural facilities.

The Act gives producers whose activities comply with provincial standards for noise and dust and municipal regulations for odours immunity from civil suits because of these nuisances.

Agro-Environmental Investment Assistance program

The new regulatory provisions have a major financial impact on producers. The agri-environmental investment assistance program, which took effect in June 1997, is designed to help producers.

This program focusses on the adoption of resource conservation and environmental protection practices and technologies. It should resolve the problem of manure storage over a period of five years and improve the management of both manure and inorganic fertilizers. A sum of \$319 million has been planned for this purpose. The program, administered by the Department of Agriculture, Fisheries and Food, has four components, i.e. manure storage structures, manure treatment processes, manure spreading equipment, and agro-environmental consulting services.

Industry initiatives

In 1996, the Fédération des producteurs de porcs du Québec launched the agro-environmental hog production plan in collaboration with the Table filière porcine du Québec, a leading organization in the hog industry in Québec. The plan has two main objectives: to promote environmentally sustainable hog production practices compatible with social and economic requirements, and to improve the public image of the hog industry.

The plan will be carried out in three phases. The first phase consists in obtaining an environmental picture of hog production sites in the province. The site inventory was successfully completed in the summer of 1997, with a 95% producer response rate. The inventory will serve as a reference to track changes in the hog industry, measure industry progress, set sustainable environment objectives for the industry, and establish public and private investment priorities to maximize environmental benefits.

The second phase of the plan is to provide technical support to producers. A best management practices guide will

be prepared to facilitate the adoption of new manure management practices and the application of conservation measures such as soil analysis, the establishment of a fertilization plan, record-keeping of manure spreading activity, and evaluation of the crop/soil nutrient balance. The main objective of the second phase is to establish environmental criteria in support of technological transfer, technical support and eventual certification. These criteria will take account of the progressive adoption of good practices by farmers. Technological transfer plays a key role in this phase of the plan in that better management practices may be presented in a dual perspective, i.e. the eventual adoption of new legislation, and the development of new techniques.

The third and last phase of the FPPQ initiative involves the certification of hog farms to encourage producers to adopt more environmentally sustainable practices.

New Brunswick

Regulation

The *New Brunswick Agricultural Operations Practices Act* protects producers from nuisance lawsuits provided that they conform with acceptable farming practices. Manure storage facilities must be approved by the department prior to commencing construction of any other part of the livestock operation. Further legal requirements related to environmental issues associated with livestock production can be found in the *Clean Environment Act*, the *Clean Water Act*, the *Health Act*, and the *Agricultural Land Protection and Development Act*.

Currently, there appears to be no municipality in New Brunswick that has made regulations or bylaws specifically targeted at encouraging or discouraging hog production. There are, however, a number of regions in the province facing the possibility of expanding hog production. Some communities have expressed resistance to these investments. Municipalities are faced with the need to balance pressures from the public (and, in one case, the local Chamber of Commerce) with hog producer's desires to invest in enhanced production capacity. In other areas, hog expansion is encouraged by local communities for the economic benefits generated from the investment, provided that environmental regulations and separation distances are respected.

New Brunswick: Other Government Activity

The Manure Management Guidelines for New Brunswick were developed in 1996 by the New Brunswick Department of Agriculture and Rural Development in consultation with other government agencies and farm organizations. The guidelines include land-base standards for the siting of new livestock facilities or the expansion of existing facilities and outline practical alternatives for manure storage and land application of manure that will reduce the potential for odour nuisance and environmental risks. These guidelines are based on minimum recommended practices, or better.

New Brunswick hog producers require a Certificate of Compliance in order to receive government loans or assistance. This certificate is an evaluation of a livestock production unit, its manure management system, and the quality of management. Certificates are issued to all producers whose practices adhere to the provisions and recommendations of the Manure Management Guidelines for New Brunswick.

It was recently announced that the New Brunswick Department of Agriculture and Rural Development is now accepting applications for funding under the 97-98 Farm Environmental Stewardship Program. Projects submitted under this program must demonstrate that they assist farmers in the adoption of management practices that will enhance the economic and environmental sustainability of the New Brunswick agri-food sector.

New Brunswick: Industry Activity

Hog producers are seeking the participation of rural communities in addressing environmental issues. A new public information action plan has been launched, focusing on building public confidence and support for the benefits of an environmentally sound hog industry.

The action plan is intended to demonstrate the hog industry's commitment to conserving and enhancing the environment and to plan effective responses to opposition based on misinformation. Medium-term initiatives to support these objectives include adoption of a quality assurance program, production of Farm Practices Guidelines for Hog Producers, a producer workshop on guidelines and technology advancements, and a publicized process for handling complaints relating to hog operations that would involve "peer review" of the complaint (peers would be trained and informed local hog producers).

Nova Scotia

Regulation

The *Nova Scotia Environment Act* is designed to support and promote the protection, enhancement, and prudent use of the environment. This act established the Nova Scotia Round Table on Environment and Economy to identify, explain, promote, and encourage the principles and practices of sustainable development. A recent report of the Consultation Committee of the Round Table recommended changes to the *Environment Act* to ensure that those producing waste, such as manure from livestock, pay for the costs associated with its management and disposal. In 1995, the Nova Scotia Department of Environment passed a law that made "adverse effects" on the environment an offence under the *Environment Act*, superseding Nova Scotia right-to-farm legislation. However, in 1996, the Nova Scotia Federation of Agriculture negotiated a memorandum of understanding that prevents prosecution of farmers who use normal farming practices.

Municipalities have authority to develop regulations affecting land use, zoning, and building construction. Currently, there are no known municipalities that have enacted bylaws or regulations that discourage hog farming, although guidelines have been published regarding separation distance, and one community has introduced agricultural zoning.

Nova Scotia: Other Government Activity

The Nova Scotia Department of Agriculture and Marketing has worked with industry to establish Guidelines for the Management and Use of Animal Manure. Key components of these guidelines include recommendations for the appropriate storage, spreading, and management of manure.

Nova Scotia: Industry Activity

Pork Nova Scotia has just passed a motion accepting new manure siting standards, but is still waiting for municipalities to disallow further residential development on lands between hog facilities and the nearest existing dwellings. This action would protect hog producers from complaints that could eventually come from people who build in these buffer areas.

Prince Edward Island

Regulation

The *Environmental Protection Act* prohibits pollution of the environment, with no exception for farmers. A

number of sections of this act are particularly relevant to hog producers. Producers cannot establish a waste management system without obtaining written approval from the Minister, may not contaminate the environment, and are responsible for the repair, restoration, and remediation of any environmental damage they incur.

There has been some recent legislative activity in response to conflicts over land ownership. With the support of farm groups and the general public, a number of amendments were made to the *Lands Protection Act* to restrict the size of farm holdings. Any intensive livestock operation with more than 40 animals is required to conduct an environmental impact assessment prior to establishment of expansion. In addition, special planning areas have been established under the *Planning Act* to restrict development in zones located around the perimeters of cities and towns.

Prince Edward Island is one of two provinces in Canada that does not have right-to-farm legislation. A report of the P.E.I. Round Table on Resource Land Use and Stewardship, released in September 1997, lays the foundation for the establishment of this type of legislation. The Round Table recommended establishing a Farm Practices Review Board as a first step in the process. This board may also act to protect the farm community from forthcoming stricter environmental nuisance legislation by establishing, reviewing, approving, and amending agricultural codes of practice.

P.E.I. is also somewhat unique with respect to the approach of municipalities in regulating agricultural activities. No municipalities have enacted bylaws or regulations that specifically discourage hog production. The Round Table examined the extent to which municipal governments could regulate farm practices under the authority of the *Municipalities Act* and the *Planning Act*, finding that municipalities cannot pass bylaws that are more restrictive of farm practices than provincial legislation and that the authority of the municipality to define land use (e.g., agricultural, residential) does not extend to include the authority to define management practices. However, municipalities may create, and have created, bylaws that affect "the general welfare, health, safety, and convenience" of municipal residents and address the issue of nuisance control. The municipalities of Stratford and Cornwall have addressed the issue of agricultural land use as it related to health and nuisance in their respective zoning and subdivision bylaws.

Producers have historically opposed the zoning of agricultural land. Recent activities, however, point to situations where these individual property rights have yielded to collective rights.

P.E.I.: Industry Activity

The P.E.I. Hog Commodity Group's environmental committee is in the process of adopting a new action plan, but information on the plan is not currently available.

Newfoundland

Regulation

Hog production is limited in Newfoundland, with less than 10,000 hogs in production as of December 31, 1996. Municipalities are largely responsible for land use regulations. Permits are needed for most development proposals. A general requirement is that a new livestock production unit must be located at least 610 metres from existing operations.

Conclusions

Regulations exist in all provinces to protect the environment from the adverse effects of intensive livestock operations, including hogs. The provinces that are furthest along in developing workable regulations have, in most cases, reached this position through careful consideration of scientific information related to manure management; recognition of the need for a balance among environmental, economic, social, and political interests; collaboration with industry partners; good communication with all parties involved, including the communities affected by expansion of the industry; and pursuit of non-regulatory measures that further the goals of regulation. Provinces in the early stages of regulatory development can perhaps learn something from the experience of these others.

Today's emphasis on sustainable development, with its attendant environmental regulatory controls, has created a dilemma for the hog industry. On the one hand, the industry is committed in principle to sustainable development. They have, in fact, demonstrated this commitment by seeking improved management methods, promoting formalized codes of practice, and undertaking activities related to information analysis, communication, regulatory development, and research. On the other hand, environmental regulatory requirements are growing more stringent, in some cases outstripping the industry's abilities to comply with them and still remain viable. In some provinces court action is being taken by citizens' groups opposed to proposed new hog operations. Like all enterprises, hog operations receive the both the benefits of acceptable environmental performance (e.g., regulatory compliance and the competitive advantage in international markets of producing hogs and pork in an environmentally acceptable way) as well as the economic drawbacks (e.g., the competitive disadvantage, at least in the short term, of making large capital investments in environmental protection).

This dilemma clarifies the role that government can play in assisting the hog industry to reach its environmental objectives. There is clearly a continuing need for government to support the industry by providing good information and analysis, advising during the planning and development of new or expanded operations, promoting good public relations for the industry, and developing cost-effective technologies and methods to reduce the industry's adverse effects on the environment. Although these activities are already taking place to some extent, especially at the provincial level, additional efforts are needed to find solutions quickly enough to meet the needs of the industry. A strategy is needed that identifies what still needs to be done to allow the industry to comply with regulations, how these needs can be met, and who is best positioned to meet the various needs.

Summary of Regulatory Tools in Place for Hog Production in Canada			
Region	Key Acts, Regulations, and Legislation	Responsible Ministry	Related Industry Initiatives
Federal	Fisheries Act	Environment Canada	
	Sustainable development strategies	Agriculture and Agri-food Canada (<i>Agriculture in Harmony with Nature</i>)	Canadian Pork Council: <i>Canadian Code of Practice for Environmentally Sound Hog Production</i>
	Environmental Assessment Act	Environment Canada	
British Columbia	Agriculture Protection Act	B.C. Ministry of Agriculture, Fisheries, and Food	
	Waste Management Act	BC Ministry of Environment, Lands, and Parks	Environmental Guidelines for Pork Producers in BC (1994)

	Agricultural Waste Control Regulation	BC Ministry of Environment, Lands, and Parks	Code of Agricultural Practice for Waste Management
Alberta	Agricultural Operations Act	Alberta Agriculture, Food, and Rural Development	Code of Practice
	Alberta Environmental Protection and Enhancement Act	Alberta Environmental Protection	Code of Practice for the Safe and Economic Handling of Animal Manures
	Water Act	Alberta Environmental Protection	
Saskatchewan	Agricultural Operations Act	Saskatchewan Agriculture and Food	Guidelines for the Safe Handling of Livestock
	Saskatchewan Planning and Development Act		
	Environment Management and Protection Act	Saskatchewan Environment and Resource Management	
	Pest Control Products Protection Act		
	Rural Municipality Act		
	Clean Air Act	Saskatchewan Environment and Resource Management	
	Public Health Act	Saskatchewan Environment and Resource Management	
Manitoba	Farm Practices Protection Act	Manitoba Agriculture	
	Environment Act: Livestock Waste Regulation	Manitoba Environment	Code of Practice for Livestock Waste Management
		Manitoba Agriculture	Farm Practices Guidelines for Hog Producers in Manitoba
Ontario	Ontario Environmental Bill of Rights	Ontario Ministry of Environment	
	Farming and Food Production Protection Act	Ontario Ministry of Agriculture, Food, and Rural Affairs	Agricultural Code of Practice Best Management Practice booklets
	Environmental Protection Act	Ontario Ministry of Environment	
	Pesticides Act	Ontario Ministry of Environment	
	Ontario Water Resources Act	Ontario Ministry of Environment	
	Municipal Act		
	Planning Act		

Quebec	The Regulation for the Reduction of Pollution of Agricultural Origin		
New Brunswick	New Brunswick Agricultural Operations Practices Act	New Brunswick Department of Agriculture and Rural Development	Manure Management Guidelines for New Brunswick Certificate of Compliance
	Clean Environment Act	New Brunswick Department of Environment	
	Clean Water Act	New Brunswick Department of Environment	
¹ This regulation replaces the Regulation for the Prevention of Pollution of Water by Livestock Establishments			
	Health Act	New Brunswick Department of Environment	
	Agricultural Land Protection and Development Act	New Brunswick Department of Agriculture and Rural Development	
Nova Scotia	Environment Act	Nova Scotia Department of Environment	
		Nova Scotia Department of Agriculture	Guidelines for the Management and Use of Animal Manure
PEI	Environmental Protection Act		
	Lands Protection Act		
	Planning Act and Municipalities Act		
Newfoundland	Lands Act - Agricultural Development Regulations	Newfoundland Department of Forest Resources & Agrifoods	

Chapter 4.

Environmental Solutions: Current Knowledge and Ongoing Research

Introduction

Many solutions already exist to deal with the environmental challenges faced by the hog industry. The industry has

already met with some success in working with government to identify best management practices, write codes of practice, and develop regional approaches that recognize the unique environmental, social, and economic features of each region as they relate to hog production. In some cases, solutions are not yet in the hands of the users — they may await a cost analysis or an effective means of communicating them to hog producers and regulatory bodies.

In European countries where a limited land base has forced the industry to respond quickly to these challenges, adoption of environmental solutions is more advanced. Considerable research on hog-related issues is also occurring in the U.S.

Canada is in a position to learn from the experience of these countries. This chapter describes the current state of knowledge and practice with respect to improving the environmental performance of the hog industry in Canada and mentions some research in Europe and the United States. This description is organized around four main research areas: Manure Management (storage, application and processing), Feeding Modifications, Building Design, and Soil Capacities for Manure Loading (agronomic practices).

Following the description of current knowledge and practices is a summary of research being carried out in these areas. Some of this research has a regional focus. For example, the impact of land application of manure on water quality is being studied mainly in Quebec and Ontario, phosphorus loss is a particular concern in Quebec, and air quality issues, notably ammonia emission, are the subject of ongoing research in Ontario and British Columbia.

Much of the current work is being undertaken through partnerships between Agriculture and Agri-Food Canada, universities, and provincial governments. Projects are identified by a number that corresponds to a detailed project descriptions (agency, project title and status, project leaders, and funding source) given in the appendix.

Odours

Current Methods

The first step towards reducing odours is to develop and recommend best management practices and guidelines for managing livestock buildings and manure slurry, such as measures to reinforce the cleanliness of farm buildings and recommendations for the appropriate weather and soil conditions for land application of manure slurry. Until new technologies are available, farmers should employ the best management practices for manure management that have already been identified in several provinces. These include:

- keeping animals and facilities clean;
- adding manure to the storage pit when it is transferred by pipeline from the barn;
- injecting or incorporating manure below the soil surface;
- applying manure when the wind is blowing away from neighbours and dwellings;
- applying manure in the morning or on cloudy days.

The second step is to identify and recommend cost-effective technologies used in other provinces and other countries, relevant to odour control and air quality and applicable under Canadian climatic conditions to hog facilities and management practices. Some pertinent research findings include:

Manure storage

- covering the manure storage tank can reduce odours by 90%;

- adding alkaline material (e.g., by-products from power plants or cement plants) to stored manure can substantially reduce odours by increasing the pH above 9.5, thus reducing hydrogen sulphide production;
- adding sphagnum peat moss or other acidifying amendments to manure lagoons can reduce odours;
- manure from anaerobic digestion systems can be less offensive than undigested waste;
- bubbleless oxygenation reduces hydrogen sulphide production to levels non-detectable by a GasTec Sensidyne dosimeter tube;
- a floating permeable blanket allows a 90% reduction in ammonia and hydrogen sulphide.

Land application of manure

- inject or incorporate manure within 24 hours of spreading. Various injection systems are being researched for injection/incorporation of liquid manure into row and field crop systems.

Research in Canada

The following Canadian research projects relate to controlling the odours associated with hog production. The numbers in brackets accompanying the respective projects refer to the appendix to this chapter entitled Research Activities in the Provinces.

Feed amendments

(3) A study is being planned in Atlantic Canada to assess the use of feed additives in hog diets to reduce odours. If successful, this method could be used to reduce odours emanating from hog barns and manure storage systems.

Reducing barn odour

(41) Researchers in Alberta are looking at a method to reduce barn odour in swine units. (39) A Saskatchewan study assessed the effectiveness of canola oil in reducing dust concentrations in animal buildings.

Reducing odour of stored manure

(40) In a Saskatchewan study, low-cost balloon-type lagoon covers were used and evaluated for odour reduction.

(34) An Alberta study evaluated oligolysis for odour control under laboratory and field conditions, aimed at reducing the odour of stored swine manure. (16) Results of a survey of Ontario hog producers who used manure additives to control odour and make manure easier to handle, as well as of a test of the effectiveness of a few commercially available manure additives, showed that none of the additives was effective in controlling odour adequately. (14) Quebec researchers used the technique of biofiltration with an organic substance to deodorize and add value to hog manure. This technology holds good marketing promise because it is simple and relatively inexpensive, but is more effective than many more complex and expensive alternatives.

Composted manure is less odourous than manure slurry. Composting research is described later in this chapter

Research in Other Countries

Researchers at Iowa state university have designed biomass filter chambers that effectively remove dust particles and thereby reduce odours from hog barn ventilation exhaust. A recent University of Minnesota study involved the measurement of odours from four different manure storage systems: indoor deep pit, outdoor concrete/metal structure, earthen basin, and second stage earthen basin. No storage type proved to be consistently superior in

terms of odour dilution.

Soil Quality and Water Quality

Current Methods

Reducing the build-up of phosphorus from hog manure in soils and preventing water pollution by phosphates from hog manure begins with reducing phosphorus levels in the manure itself and then refining manure land-application methods.

Current methods to reduce the amount of phosphorus in manure include:

- adding phytase to the hog diet; this method may increase the utilization of feed phosphorus by 50–70 % and reduce the requirement of mineral phosphorus supplements (mono- and di-calcium phosphate) in hog rations;
- adding cellulase to the feed and improving processing techniques; these steps may decrease the phosphorus content of manure 5–30 %;
- adjusting feed composition to meet the nutrient requirements at defined stages of growth; this measure will decrease phosphorus excretion but may have some impact on maximum animal growth;
- increasing feed digestibility by using new processing techniques; this method will reduce the excess nutrients fed to achieve maximal growth and thereby decrease excreted phosphorus by up to 5%.

New guidelines may be needed to apply liquid manure on the basis of phosphorus, not just nitrogen, content. More land will be required to dispose of the same amount of manure as crop uptake of phosphorus is lower than nitrogen. Site-specific soil tests, based on soil type characteristics important for P movement (ex. slope, tile drainage, susceptibility to soil cracking, etc) are needed. Soil information system and GIS technology may assist in developing an integrated computerized decision-making support system that can be used easily by agronomists and farmers.

Current agronomic methods to monitor and manage manure phosphorus levels in soils include:

- managing manure on a watershed basis; farmers' associations coordinate and prioritize the use of manure over all other sources of nutrients, identify specific application rates, and monitor the long-term impacts of repeated additions;
- removing the solids (5% in volume) from hog manure; this measure reduces the phosphorus content by 50%, and the liquid phase can be further treated to obtain a concentrated solution;
- reacting manure with aluminum sulphate to precipitate the phosphate, as it is done with urban sewage sludges;
- raising hogs on litter with a high carbon:phosphorus, or adding liquid manure to carbon-rich materials (e.g., wood chips, pulp and paper sludges) to produce composts for off-site soil conditioning.
- Land management practices that contribute to reduced phosphorus losses include:
- avoiding fall applications of manure without incorporation; this practice may result in significant contamination of water and sediments under heavy rainfall conditions;
- calibrating manure-spreading equipment to ensure that nutrients are added consistently to soil;
- using strip-cropping systems with perennial grasses or planting multi-storied hedgerows to act as buffers along waterways; these systems help to reduce phosphorus losses in runoff on sloped land and may also remove phosphorus from lateral subsurface water flow on shallow soils and retain windblown particles.
- employing minimum tillage; this practice may reduce phosphorus losses in runoff on sloped land and

increase phosphorus uptake in the prairies, where phosphorus losses in drainage water are limited. (Conservation tillage may also increase the proportion of phosphorus that is bioavailable both in soluble and particulate forms. Therefore, management decisions should consider total and bioavailable P loss from the manure by using appropriate methodology to estimate the bioavailability of phosphorus and assessing soil residual phosphorus with or without crop rotations after short- or long-term manure applications.)

- strategically applying nitrogen in ammonia form; this method increases phosphorus uptake either directly or by increasing soil phosphorus solubility — recommendations would be based on the use of residual soil phosphorus coupled with small amounts of starter soluble phosphorus.
- planting companion crops in spring cereal production to allow safe manure fall application in areas of low rainfall.
- planting crops with a high capacity for phosphorus uptake (e.g., silage corn in areas with >2,500 corn heat units (CHU), or canola in cool climate areas with < 2,500 CHU);
- planting alternative crops, such as forage or forests (e.g., sugar maple).

Research in Canada

Composition and benefits of manure

(7) Quebec researchers evaluated the nutrient value of manure, including hog manure, with the aim to more accurately determine fertilizer requirements. Two other Quebec studies currently under way are (9) determining the long-term impact of hog manure on metals solubility and pools, aimed at ensuring a safe and nutritious food supply, and (12) evaluating the possibility of using hog manure in corn–soybean rotations. (32) Saskatchewan researchers have determined standard nutrient values of manure and (35) are determining the agronomic response and soil chemical response to using hog manure, as well as the economics of using manure as a source of fertilizer.

(20) An Ontario study tracked nitrogen and carbon components in the feed, bedding, and excrement of livestock during handling and storage, allowing predictions of manure nitrogen availability to plants and losses, including those to the atmosphere, of environmental significance. (22) Another Ontario study compared the mineralization/immobilization and availabilities of N from five different manures following fall and spring applications on one site. It also used feeding trials and characterization of the manure to develop models for predicting manure nitrogen content of manures from animals given different feeds. (26) & (27) Manitoba researchers are also studying the effects of feeding different cultivars of hull-less barley on physical and biochemical characteristics of swine manure, and are assessing the energy utilization and fertilizer value of this manure.

Another strategy to reduce nutrient entry into water is to reduce the amount of these nutrients in manure. (28) Manitoba researchers have proposed a study to test the efficacy of phytase enzyme and dietary ideal protein amino acid rations in reducing phosphorus and nitrogen in swine manure.

Manure Composting

(21) A review of manure composting techniques has been carried out by Ecologistics in Ontario with a view to better understanding nitrogen and carbon conservation. This review presents information on carbon, nitrogen, and other nutrient transformations and losses; the economic and physical limitation of optimizing manure carbon to nitrogen rations; the evaporative potential of composting manure; the relative nutrient-leaching potential of manures and compost; a comparison with composting techniques promoted by the Ecological Farmers of Ontario; the practicality of recycling finished compost as livestock bedding; the quantification of greenhouse gas production; and databases to establish labour, energy, and capital requirements in each process.

Composting is a relatively fast and low-odour aerobic biological process in which organic matter is broken down

by bacteria and fungi to produce humus, carbon dioxide, water, and heat. For composting, most manures require the addition of dry bulking material with a high carbon content. (13) Quebec researchers added sawmill waste to hog manure to create a compost. (6) In an ongoing study in PEI, researchers are working to identify the optimum content of a similar compost (hog manure and sawmill waste) in a potting mix, as well as to minimize nitrogen losses during composting. (4) A Nova Scotia study is being planned to examine co-composting of hog manure and municipal solid waste, possibly leading to reduced land-fill loading and a market for hog manure compost. (47) In a B.C. study, hog manure was composted with poultry manure in an enclosed composting system, resulting in rapid evaporation of the moisture using energy from the waste. This method allows more liquid manure to be processed. Although ammonia emissions are high, they can be captured with this type of design.

(15) In an Ontario study, low-cost, low-technology passively aerated static piles were used to compost swine manure and achieved excellent odour control. Dilute slurry was added periodically to the hot composting material. (42) An Alberta study of cold climate composting systems looked at the dynamics of composting processes under various temperature regimes, the microbiological processes involved and their thermal requirements, and the application of compost to frozen soils. The study enhanced the ability to compost and recycle manures all year long.

(43) An Alberta study of the physical properties of composting materials will benefit designers and manufacturers of composting facilities and equipment. Enhanced knowledge of these properties will lead to the production of more efficient machinery (e.g., windrow turners, sieves, and shredders) and better selection of components (e.g., aeration fans and ducting).

Land application methods

(5) An ongoing New Brunswick study is looking at a way to improve systems for incorporating liquid hog manure in the soil in potato systems. (11) Quebec researchers studied the influence of the timing of hog manure applications on nutrient uptake by corn. Results can be used to help refine the use of manure to supply crop nutrients while decreasing environmental effects. (25) An Ontario study investigated methods (soil injection, side dressing, top dressing) of integrating liquid manures into a cropping system, generating information about the effectiveness of manures from different types of livestock and the importance of the timing of application. (30) In a Saskatchewan study, a low-odour, low-cost method was used to add hog manure, and thus nutrients, to poorly drained soils. (33) Saskatchewan researchers also studied improved methods of injecting liquid manure on agricultural land, and (36) demonstrated shallow injection of hog manure on grassland. (45) B.C. researchers are currently examining the nutrient value of different rates of hog manure applied repeatedly to a stand of grass in terms of yield, nutrient uptake, and residual soil nutrients relative to the nutrient value under mineral fertilization. They are also testing the effectiveness of different methods of application (broadcast vs. subcanopy band application) and soil aeration on the effectiveness of manure.

(8) Quebec researchers are currently investigating the contribution of hog manure to phosphorus losses in surface and subsurface runoff. (11) They are also working to identify optimal times of manure application to maximize nutrient uptake by crops and minimize that lost from the soil system. (25) Application timing was also a focus of an Ontario study that investigated methods of integrating liquid manures into a cropping system and the subsequent effects on soil and water quality. (48) A B.C. study of the influence of time and rate of liquid manure application on yield and nitrogen utilization of silage corn found that a spring manure application can replace the nitrogen fertilizer requirement, contribute to optimal yields, and introduce little excess nitrogen into the soil that could pose a threat to water quality. (46) B.C. researchers are also looking at levels of phosphorus from manure in soils that have received short-term and long-term manure application. (23) Another Ontario study of the impact of manure application methods on water quality will enable prediction of environmentally safe rates of liquid manure application and the development of methods for manure application in no-till systems.

(24) An Ontario study assessed the influence of manures in the control of soil-borne pests, including nematodes, fungi, and bacteria. Treatments found effective in the laboratory were field-tested, and field observations included measurements of pathology, soil microbiology, and agronomic changes in the crop plants tested.

Manure management systems

(19) An Ontario report on manure and nutrient management provides a literature review, bibliography, and consensual information to summarize the current state of knowledge of these subjects and identify gaps that may be addressed by further research. (31) Saskatchewan researchers have produced a guide, with accompanying software, for making environmentally sound manure management plans based on soils, water, climate, and landscaping characteristics of specific locations in Saskatchewan. (38) They have also created a computerized manure management module to better identify the costs and benefits of competing technologies for hog manure storage, handling, and disposal.

Production systems

(10) An ongoing Quebec study is developing better models of hog production that will allow for improved economic and environmental decision making.

Construction

(18) An Ontario study sought to improve the design of liquid hog manure storage tanks.

(1) Researchers in Nova Scotia are currently evaluating the performance of artificial wetlands in the treatment of waste-water from hog operations. (34) Saskatchewan researchers determined the safe operating lifetimes for earthen animal manure lagoons and (36) assessed the performance of Saskatchewan soils for the construction of such lagoons.

Air Pollution

Current Methods to Control Ammonia Emission

Phase feeding and balancing amino acids in the diet is the primary strategy to reduce ammonia emissions during hog production. This reduction can be achieved in most existing production facilities. Improving diets has resulted in a 26% reduction in nitrogen excreted and a 25% reduction in ammonia emitted. Including bacterially fermentable substrates in the ration has reduced ammonia emissions by 18% during pig finishing.

Decreasing the time that excretions are exposed to air can contribute to odour abatement. Reducing exposure can be achieved by frequent barn cleaning using manure scrapers with separate urine channels. This lowest-cost conventional manure management system has resulted in low ammonia emissions. Using slurry collection pans has contributed to a 30% decrease in ammonia emission. A combination of improved diets, phase feeding, and optimal housing has reduced ammonia emission from the barn by 45% compared to conventional feeding and housing systems.

Using deep bedding facilities for growing and finishing hogs may help reduce ammonia emissions by up to 70% compared to conventional housing. However, this practice also results in a net increase in nitrous oxide, a greenhouse gas.

Unlike liquid dairy cattle manure, hog manure rarely forms a crust during storage. Without this crust, ammonia emissions from stored hog manure are high. Estimated nitrogen losses in the US during storage and handling of manure were 60–80% from anaerobic lagoons and 30–65% from an underground pit with liquid spreading. Nitrogen losses of up to 95% from lagoons storing liquid manure were observed in the eastern US.

Reducing ammonia losses during manure storage may require a large investment to change storage systems. In a laboratory experiment, ammonia losses of 24% of the total nitrogen in manure were recorded with the use of artificial covers on liquid hog manure, compared with a 76% loss with uncovered storage. In Canada, most new hog operations in the prairies use large lagoons for storage. In contrast, in the Netherlands, the trend is to store liquid hog manure in enclosed pits or containers in order to minimise ammonia loss.

Current methods to reduce ammonia loss from stored manure include:

- adding sphagnum peat moss, sulphuric, and phosphoric acids to stored manure slurry; this method may contribute to reduce ammonia emission from stored manure by at least 75%;
- cooling the manure, or separating, aerating, and recirculating it;
- covering manure with straw or plastic; this may reduce ammonia emissions by 65–70% and 77–84%, respectively;
- covering stored manure with mineral oil; this may reduce ammonia emission by 34–95%;
- composting separated hog slurry solids, solid hog manure from shallow or deep bedded hog facilities, or slurry bulked with peat or straw (however, significant emissions of ammonia and nitrous oxide are produced during composting of hog wastes).

Ammonium-nitrogen constitutes up to 90% of the nitrogen in anaerobically stored hog manure. Following surface application of manure to a field, short-chain fatty acids in the manure are oxidized, resulting in an increase in the pH. This pH increase, in combination with exposure to the air, results in a loss of nitrogen as ammonia. Ammonia emission increases when manure is applied on impermeable or acidic soils and on hot, windy days. A wide range of emission values has been recorded. In France, ammonia emission from pig slurry applied to grassland or arable land ranged from 37 to 63% of the ammonia-nitrogen in the slurry. Most ammonia volatilization occurred within hours after application: 25% after 1.5 hours, 50% after 4 hours, and 83% after six hours when the manure was applied at midday. In the Netherlands, loss of ammonia-nitrogen was 36–78% following application to pasture. In the UK, 24–39% of the ammonia lost was emitted during the first hour and 85% during the 12 hours following slurry application. All these values represent a significant loss of N.

Current field methods to reduce ammonia loss after manure application include:

- liquid injection of manure into the soil;
- using a sleigh foot on grasslands; this method has resulted in higher recovery of manure N in the grass;
- immediate incorporation of the hog manure following surface application of manure;
- tilling the soil before manure application; ammonia emission was 1.5 times higher following slurry application to grassland than application to arable land.
- selecting crops that hold and use the nutrients from manure (e.g., perennial species, such as non leguminous forages, and corn at post-emergence stage); however, this may also lead to problems related to animal feeding and to preferential flow of water on flat lands.

Agricultural greenhouse gas emissions are currently being reduced through:

- feeding supplements that reduce the time required for maturation of hogs;
- planting fall cover crops to utilize excess nutrient levels in fields to which manure has been applied;

- increasing use of covered manure storage facilities.

Research in Canada

(2) Nova Scotia researchers have measured the micro-meteorological ammonia flux from surface-applied swine manure, identifying climatic conditions that are optimal for the greatest retention of ammonia-nitrogen for crop use. This information will help producers schedule manure applications when they are most beneficial. (17) Ontario researchers determined manure gas concentrations at commercial hog farms to improve the characterization of gas hazards, particularly during slurry mixing. It was determined that hydrogen sulphide was the main gas released at hazardous concentrations. Other gases (methane, ammonia, carbon dioxide) were not released at hazardous concentrations. Recommendations were made regarding management strategies to reduce hazardous conditions. (21) An Ontario report (described more fully below) quantifies greenhouse gas production during composting.

Research in Other Countries

Dutch and Danish researchers are exploring dietary and building design approaches to reducing ammonia emissions from hog slurry. Acidification of soils is a serious environmental concern in these countries. Scientists in the Netherlands has used improved pen design (convex floor with underlying slurry channel) and the addition of acid salts to feed to reduce ammonia emissions. A recent Danish study showed that ammonia emissions from hog barns with totally slatted floors were significantly higher than barns with partially slatted floors.

Conclusions

The plan to address the environmental issues associated with hog production must deal with the whole system of production. Components of this plan should include feeds and feeding, hog buildings, hog health, manure production and storage, manure odours and gas production, manure handling and disposal, nutrient cycling, cost-effective ways of processing and, in some cases, packaging manure for subsequent use.

Researchers have already identified many methods and technologies that will improve the environmental performance of the industry, but in many cases these alternatives are too expensive. This means that future research must concentrate on providing affordable, practical technologies and land management practices. A close working relationship with industry representatives will allow scientists and engineers to direct their work more effectively and to ensure that promising developments reach the people who will use them.

Appendix: Research Activities in the Provinces				
Project No.	Participating Agencies	Project Title and Status	Project Leaders	Project Funding
Newfoundland (In 1996, marketed 9,300 hogs or 0.05 % of national production)				
Nova Scotia (In 1996, marketed 218,800 hogs or 1.2 % of national production).				
1	AAFC, NSDAM, NSAC	Evaluation of artificial wetlands for treatment of agricultural wastes in Nova Scotia (<i>ongoing</i>)	V. Rodd, R. Gordon, L. Cochrane	MII: Producers

2	NSAC, NSDAM, AAFC	Micro-meterological ammonia flux measurements from surface applied swine/dairy manure (<i>completed, thesis being written</i>)	T. Hartz, R. Gordon, V. Rodd	Canada-Nova Scotia Green Plan, Agri-Focus 2000
3	AAFC, NSDAM	Assessment of feed additives to reduce hog odour (<i>planning</i>)	T. Vanlunen, R.Gordon, V. Rodd	MII: Producer, feed companies
4	AAFC, NSAC, NSDAM	Evaluation of source separated municipal solid waste composted with hog manure (<i>planning</i>)	V. Rodd, R. Gordon, P. Warman, J. Cline	MII: Producer, consulting company
New Brunswick (In 1996, marketed 141,100 hogs 0.8 % of national production)				
Prince Edward Island (In 1996, marketed 190,600 hogs or 1.1 % of national production)				
5	AAFC	Manure application strategies for environmental safety and efficient crop production (<i>ongoing</i>)	A. J. Campbell, J.A. MacLeod	A Base
6	AAFC?	Minimizing N loss in composting and identification of optimum compost content of potting mix (<i>ongoing</i>)	J. MacLeod	MII: Producer
Quebec (In 1996, marketed 5.5 million hogs or 30.2 % of national production)				
7	AAFC	Evaluation of the nutrient value of manure (including HLM) (<i>completed</i>)	R. Simard, C. Hamel, A. Legere	A Base/ Green Plan
8	AAFC, INRS	Impact of HLM on P losses in surface and subsurface runoff (<i>ongoing</i>)	R. Simard, G. Barnett, A. Pesant, D. Cluis	MII: Producer assoc.
9	AAFC, INRS?	Impact of hog manure (long-term) on metals solubility and pools (<i>ongoing</i>)	R. Simard, S. Beauchemin, D. Wang	A Base
10		<i>Use of a computerized mathematics model to provide an optimization methodology that will improve the economic returns and environmental acceptability of hog production systems (ongoing)</i>	C. Pomar	A Base
11	MAPAQ	Environmental code for spreading hog slurry on corn in spring and autumn. (<i>completed</i>)	D. Cote	
12	MAPAQ, AAFC	Evaluation of the possibility of using HLM on P base in corn-soybean rotations (<i>ongoing</i>)	C. Hamel, R. Simard, A. Legere, D. Angers	MAPAQ
13	U. de Q. (RIMOUSKI)	Production of compost from hog slurry and wood shavings.(Status of the project?)	B. Maheux	MAPAQ
14	CRIQ, U de L	Reduction of odour, treatment and increasing the economic value of hog slurry by filtration through organic bio-filters.(<i>completed</i>)	G.Buelna, Y. Bernard, R. Dube, S.Savard, P.Lessard	MAPAQ, Producer association
Ontario (In 1996, marketed 4.6 million hogs or 25.3 % of national production)				
15	AAFC	Swine manure composting (<i>completed</i>)	N. Patni, R. Kinsman	AAFC, Ont. Pork
16	AAFC, producers	Effectiveness of manure additives (<i>completed</i>)	N. Patni, P. Jui	AAFC, OPPMB

17	AAFC	Hazardous manure gases (<i>completed</i>)	N. Patni, S. Clarke	AAFC, Pork indus. Improv. Plan
18	U. of Guelph	Design criteria for cylindrical liquid manure tanks (<i>completed</i>)	J. Jofriet	NSERC
19	U. of Guelph	<u>Current state of the art on manure/nutrient management</u> (<i>completed</i>)	M. Goss	Canada/ Ont. Green Plan
20	Environ. Soil Services	<u>Nitrogen and carbon transformations in conventionally-handled livestock manures</u> (<i>completed</i>)	G. Kachanoski	Canada/Ont. Green Plan
21	Ecologistics	<u>Manure composting techniques: Understanding N and C conservation</u> (<i>completed</i>)	R. St. Jean	Canada/Ont. Green Plan
22	U. of Guelph	<u>Transformations in soil: Crop response to nitrogen in manures with widely different characteristics</u> (<i>completed</i>)	E. Beauchamp	Canada/Ont. Green Plan
23	U. of Guelph	<u>Impact of manure application methods on water quality, focusing on nitrogen and bacteria transport in soil</u> (<i>completed</i>)	G. Wall	Canada/Ont. Green Plan
24	AAFC	<u>Assessment of the influence of manures for the control of soilborne pests including nematodes, fungi and bacteria</u> (<i>completed</i>)	G. Lazarovits	Canada/Ont. Green Plan
25	Ecolog. Services for Planning	<u>Investigating methods of integrating liquid manures into a cropping system and the effect on soil and water quality</u> (<i>completed</i>)	D. Charlton	Canada/Ont. Green Plan
Manitoba(In 1996, marketed 3.3 million hogs or 17.8 % of national production)				
26	AAFC	Effects of feeding different cultivars of hulless barley on physical and biochemical characteristics of swine manure (<i>ongoing</i>)	R.R. Grandhi, M. C. Therrien	Western Grains Research Foundation
27	AAFC	Efficiency of energy utilization and fertilizer value of swine manure from pigs fed hulless barley diets supplemented with enzymes and amino acids (<i>ongoing</i>)	R. R. Grandhi, C. Grant, L. Bailey	PERD
28	AAFC	Efficacy of phytase enzyme and dietary ideal protein amino acid ratios for reduction of phosphorus and nitrogen in swine manure (<i>proposed</i>)	R.R. Grandhi	MII: Producers assoc., private co.
29	U. of Manitoba	Movement, mineralization, and fate of nutrients from manures (<i>completed</i>)	C.M. Cho, C. Flynn	Canada-Man. Agreement on Agric. Sustainability
Saskatchewan (In 1996, marketed 934,000 hogs or 5.2 % of national production).				
30	U. of Sask	Adding and supplying nutrients to poorly drained soils with hog manure, using a low odour and low cost method (<i>ongoing</i>)	M. Grevers, J.Schoenau, S. Dormer	SDAF, Agric. Dev. Fund,(ADF), Green Plan
31	U. of Sask	Livestock managers — Guide to effective manure management (<i>completed</i>)	C. Hilliard	Sask. Pork Internat. (SPI)

32	SAF	Determination of standard nutrient values of manure in Saskatchewan (<i>completed</i>)	SAF	SPI
33	Prairie Ag. Machinery Institute (PAMI)	Improved methods of injecting liquid manure to agricultural land (<i>completed</i>)	G. Hultgreen	SPI
34	U. of Sask	Determination of safe operating lifetimes for earthen animal manure lagoons (<i>completed</i>)	C. Maule	SPI, ADF
35	PAMI. U. of Sask. Envirotest Labs	Crop response to variable rates of manure (<i>ongoing</i>)	G. Hultgreen, J. Shoenau	Agricultural Food Innovative Fund (AFIF)
36	PAMI	Shallow injection of liquid hog manure on grassland (<i>ongoing</i>)		AFIF
38	UMA Engineering	Performance of Saskatchewan soils for the construction of earthen hog manure storages (<i>completed</i>)	T. Fonstad	ADF
39	PAMI	Creation of a computerized manure management module (<i>ongoing</i>)		ADF, Green Plan
40	Prairie Swine Centre (PSC)	Odour emission reduction (<i>completed</i>)	Y. Zhang	Green Plan
41	PSC	Manure lagoon cover for swine facilities (<i>completed</i>)	Y. Zhang	Green Plan
	PAMI	Development of Application Methods for Manure Lagoon Coverings (<i>completed</i>)		Sask Ag.
	Miles Jorgenson	A Blueprint for the Design and Operation of a Modern Swine Facility With Straw Bedding and Composting of Solid Wastes (<i>completed</i>)		Sask Ag.
	Jim Morris	Identification of environmental issues confronting the Saskatchewan Pork Industry (<i>completed</i>)		Sask Ag.
	Norman Janssen	Lagoon odour control using long straw cover (<i>completed</i>)		Sask Ag.
	PAMI	Environmentally improved manure lagoon agitator (<i>completed</i>)		Sask Ag.
	UMA Engineering Ltd.	Performance of Saskatchewan soils for construction of earthen hog manure storages (<i>completed</i>)		Sask Ag.
	Saskatchewan University	Amending and supplying nutrients to poorly drained soils with hog manure, using a low odour and low cost method (<i>signed</i>)		Sask Ag.
	PAMI	Improved methods of injecting swine manure to agricultural land (<i>completed</i>)		Sask Ag.

	Saskatchewan University	Determination of safe operating lifetime for earthen animal manure lagoons (signed)		Sask Ag.
	Gerald P. Bayne	Use of constructed wetlands for treatment of swine manure (completed)		Sask Ag.
	PAMI	Completion of a new manure agitator concept (completed)		Sask Ag.
	PAMI	Creation of a computerized manure management module (signed)		Sask Ag.
	PAMI	Shallow injection of liquid hog manure on grassland (signed)		Sask Ag.
	PAMI	Manure management for Saskatchewan hog producers (signed)		Sask Ag.
	Prairie Swine Centre Inc.	Reducing odour from manure (signed)		Sask Ag.
	District No. 21 ADD Board	Investigation of alternative equipment for low disturbance injection of swine manure (signed)		Sask Ag.
	Saskatchewan University	Effect of manure application on incidence of soil borne plant human pathogens (approved)		Sask Ag.
	Saskatchewan University	The long-term effect of repeated application of hog manure on soil productivity and on the quality of the environment in semi-arid regions (approved)		Sask Ag.
	PAMI	Low disturbance injection of swine manure into alfalfa produced for dehy (approved)		Sask Ag.
	Ag & Agri-Food Canada	Development of new technologies for minimization of nutrient excretion losses and odours in swine manure (approved)		Sask Ag.
	Prairie Swine Centre Inc.	Evaluation of three pit additives for swine manure odour control and handling ease (approved)		Sask Ag.
	PAMI	Straw chopper system for manure pipelines (approved)		Sask Ag.
	Saskatchewan University	Maximizing the economic and environmental benefit of land application of animal manures (signed)		Sask Ag.
	Saskatchewan University	Long term performance and safety of earthen hog manure storages (signed)		Sask Ag.
	PAMI	Development of a hog manure pipeline control system (signed)		Sask Ag.
Alberta (Marketed 2.8 million hogs in 1996, or 15.5% of national production)				
42	AAFC	Control of barn odour in swine units (<i>ongoing</i>)	A.L. Schaefer	

43	U. of Alberta, ADE	Cold climate composting systems (<i>completed</i>)	J. Leonard, J. Feddes, R. Janzen, R.B. McGill	Canada-Alta Agree-ment on Environ-mentally Sustainable Agriculture
44	U. of Alberta	Physical properties of composting materials (<i>completed</i>)	J. Leonard	NSERC
45	U. of Alberta	Evaluation of oligolysis for odour control under laboratory and field conditions (<i>completed</i>)	J. Feddes	ADARD
British Columbia (336,400 hogs marketed in 1996 or 1.8 % of national production)				
46	AAFC	Effect of swine manure on grass swards — Using conventional and alternative manure spreading practices (<i>ongoing</i>)	S. Bittman, G. Kowalenko	MII: Companies, Producer Association
47	AAFC	Response of soil residual phosphorus from manure-amended soil after short or long term manure application (<i>ongoing</i>)	J. Hountin, J. Paul	A Base
48	AAFC	Enhancing moisture removal during composting of liquid hog manure with shavings or poultry litter (<i>completed</i>)	J. Paul	Producer Assoc., ECCO, local cos., NRC, PERD
49	AAFC	Influence of the time and rate of liquid manure application on yield and nitrogen utilization of silage corn in south coastal British Columbia (<i>completed</i>)	B. Zearth, J. Paul	Producer org., Canada-B.C. Soil Conservation Prog., NSERC

Chapter 5

Directions for Future Action - Potential AAFC/CPC Inputs

A key objective in preparing this report was to locate areas where AAFC and the CPC could make useful contributions to finding solutions to hog-related environmental issues within the next three years. Some of these "gaps" could be filled by new research, analysis and coordination efforts; others could be addressed by assisting or augmenting work already underway by provincial governments marketing boards and other parties.

Potential Research Inputs

Overview

The review of research activities in Chapter 4 indicates that solutions to some hog-related environmental issues are already available. Other issues are less well understood and require further work on problem specification prior to

attempts at mitigation.

In general, it appears that contributions can be made in the following areas:

- The development of a comprehensive approach to feeding and manure handling. To fully address the problems, an integrated plan which deals with the whole system of hog production should be developed, including: feeds and feeding; hog buildings; hog health; manure production and storage; manure odours and gas production; manure handling and spreading for the conservation of valuable nutrients; cost effective ways of processing and /or packaging manure for subsequent usage; and impact of manure on the environment;
- The prioritization of research in the environmental area could be improved. Currently, there is a relatively comprehensive list of the types of research that should be conducted; however, there needs to be an assessment of what is the most important. One area in particular that warrants further investigation is whether more effort should be afforded diets and breeding hogs that can better utilize phosphates or whether the more efficacious use of research resources is in manure storage, handling and application;
- A more coordinated approach is required in monitoring research that is being conducted in other countries, particularly the US and EU, and in assessing how efforts abroad can be coordinated with Canadian research;
- Communications need to be improved among those conducting hog environmental research, as well as between researchers and officials involved in regulatory, policy and extension activities; this will reduce risks of duplication in research and ensure that regulatory standards, policies and advisory services reflect current understanding of environmental issues.
- Some of the new equipment and management practices need cost analysis and an evaluation of the benefits from actual adoption; and
- Solutions need to be better communicated to hog producers and municipalities.

AAFC Research Proposals

Agriculture and Agri-Food Canada has identified the following short-term research needs: Establish standardized methodology for evaluating additives, air, soil and water quality, and offensive odours;

- Develop techniques for field monitoring of ammonia emissions;
- Improve practices for manure land application to reduce ammonia emissions;
- Reduce ammonia losses during storage;
- Develop manure management guidelines which incorporate information on the interaction between the soil and manure nutrients, impact of soil characteristics, seasonal factors, mineral interactions, surface and subsurface water movement, etc.
- Investigate the effect of addition of carbon rich materials to manure slurries to improve the handling characteristics of the manure nutrients.
- Evaluate adaptability and economics of implementing existing technologies.
- Evaluate phase feeding, diet composition and diet amino-acid balance to reduce manure ammonia emissions, modify manure composition, reduce odours emanating from the manure.
- Optimize technologies for separating manure liquid and solids, and for composting the solids to reduce gas emissions.
- Modify hog facility design to improve manure management and control gas emissions.
- Obtain information on cycles for the nutrients present in manure and the effectiveness of their use by annual crops (also a longer-term research objective).

- Identify crops that, under Canadian climatic conditions, use nutrients in the fall, because they would allow fall application of manure, and therefore decrease the total storage period.
- Continue evaluating soil types and their suitability for various methods of application.
- Increase the efficiency of dietary phosphate (phytase, cellulase, dietary formulation) utilisation to decrease the over supplementation to meet basic requirements.

AAFC has also proposed a comprehensive long-term research program on hog environmental issues

This program would include a number of components.

Feeds and Feeding -

- Develop feed systems to maximise growth, minimise feed costs and maximise profits to the producers. Producers are looking for ways of optimising production efficiency and other problems can be addressed through diet formulation.
- Modify the amino-acid balance in rations to reduce nitrogen levels in faeces. Increasing the efficiency of animal feed can decrease feed costs and the amount of manure that must be handled. Modifying the composition of the manure will have implications for the types of fermentation that develop in the manure pit, the odours (the compounds responsible are by-products of manure ingredients), and the gas production (gases are fermentation by-products of manure nutrients, mineral recycling, etc.)
- Examine the role of mineral complexes. Minerals in feeds are normally in the form of organo-mineral complexes. Mixing feeds may cause new organo-mineral complexes to form which may make certain minerals less available to the animal and also make those same minerals in manure less available to the plant in the field.

Animal Environment and Buildings -

- The key factor is adequacy of ventilation. Hogs have very specific requirements for adequate fresh air. This is essential for maintaining animal health, regulating body temperature, minimising dust in their atmosphere, maintaining growth rates through well regulated metabolism, etc. Most of the technology concerning this part of the environment is understood, but it has to be applied to have the desired effects.

Manure Storage -

- Determine the most suitable types and sizes of storage facilities for each operation, and do a cost analysis. Much work has already gone into establishing the proper conditions for storage of manure. Many different types of storage systems are available depending on the type of barn, the number of animals, the natural topography, the annual rainfall, etc.
- Investigate the storage and separation of manure. Storing liquid hog manure means handling of large quantities of water for much of the year. If the manure could be separated into liquid and solid fractions, each would be handled differently. The liquid can be concentrated, fermented, dried, used as a hydroponic medium, added to irrigation water, etc. The solids can be dried and stored at much less cost, composted, bagged, spread with conventional equipment, etc.
- Investigate combining other wastes with manure in the storage pit. Many wastes from forestry, fisheries and agriculture could be effectively combined with manure to increase the stability of the manure, or to add more nutrients to the final product.

Manure spreading -

- Determine optimum time and method for spreading manure and determine crop species that tolerate some frost and grow in the fall to allow manure to be spread in the fall. When the crops stop growing in the fall, application of manure is likely to result in lost nutrients because of rain and surface runoff, and with spring snowmelt. Hog producers need to empty their manure storage tanks in the fall to accommodate the winter and spring production. Annual storage requirements can be as much as 400 days in some parts of Canada.
- Improve handling methodology for wet and dry manure ingredients. This will evolve with the decision about the best methods for handling whole liquid manure or separation of the manure into solids and liquid with soluble ingredients.
- Study the impact of soil and weather conditions on the loss of volatile components from manure. The impact of temperature, time of day, impending precipitation, wind, relative humidity, soil type, soil surface, topography, type of manure, cropping, type of spreading equipment, size of tractor, etc. can play a significant role in determining the efficacy of manure application.
- Adapt manure application systems for croplands under conservation tillage. Conservation tillage does not open up the soil. As a result, manure is not buried and is not protected from loss of volatile components. Adaptations to spreading technology are needed for spreading on perennial crops, such as forages.
- Improve the understanding of the effects of accumulation of manure borne bacteria. The impact of bacteria of animal origin spread with the manure is not well understood. Do they have long-term accumulated impacts on the soil and/or crops? Are the pathogens anaerobic and hence killed when spread into an aerobic environment? Is composting necessary to avoid reinfesting animals that are fed the crops fertilised with their own manure? The problem of bacteria is also an issue from the point of view of food safety.

Water-

- Improve the handling of liquid manure. This portion of the manure contains high quantities of soluble nutrients which are readily available to plants, but can also easily contaminate the environment. As processes are developed for separating the liquid and solid portions of the manure, techniques for transporting and applying this water must also be addressed.
- Evaluate the potential for soluble nutrients and other elements (e.g. Zn, Cu,...) to enter groundwater. Much of the basic data on movement of water and dissolved chemicals through different soil types is known. This needs to be summarised in an easily understandable form and presented to producers so they do not unwittingly contaminate their groundwater. This will have also implication for human water supplies and recycling of nutrients to livestock.
- Learn techniques to prevent nutrient run-off into surface waters, onto adjacent fields, farm dugouts or environmentally sensitive streams and rivers. This will involve learning parameters such as time of application, carrying capacity of soils, height of the water table, rate of incorporation of water into the soil matrix, metabolic activity of the soil, mineral interactions, soil pH, etc.

CPC Research Agenda

The CPC is about to fund short term research on odour reduction. Its other research priorities are:

- Optimal timing of manure application according to soil type and crop requirements.
- Alternate ways of storing and handling manure.
- Alternate uses of manure.
- Feeding management practices that minimize the impact of hog production on the environment.
- Development and evaluation of feed and manure additives that are said to improve manure quality, odour production and manure quantity per animal (including testing of additives for cost-effectiveness).
- Evaluation of the impact of the built environment on both animal and human health and the impact of other aspects of the swine production environment and working conditions.

CPC research priorities, while more directly focussed on odours, are wholly compatible with AAFC's identified short and long term research needs. Each set of items reflects a systems approach to research on hog-related environmental problems.

Other Potential Inputs: Information and Technical Service

The range of government, industry and community responses to the environmental issues associated with hog production presented in Chapter 2 of this report suggests that there may be a national coordination role for AAFC and the CPC in facilitating access to technical information and professional services. The results of scientific research and information on effective new technologies and management practices would be useful to producers as well as to provincial and municipal regulators. This information could be provided through use of software packages, Internet sites or more traditional means, such as provincial extension workers or literature. There could be a role for university extension to provide better access to the expertise it has in engineering, animal science and agronomy.

A national inventory of firms offering professional services would assist the hog industry in evaluating and adopting new technologies. There may be other work which can be done with professional associations to ensure that their members are fully informed of improvements in environmental management techniques.

There may be assistance which AAFC and the CPC can, through provincial government mechanisms, afford municipal governments in the development of regulations concerning the hog industry and in their relations with interest groups. In addition to the technical information discussed above, these governments may benefit from more information on the nature of regulations in other provinces, the basis on which they are formed and the technologies available to ensure their proper enforcement (eg. computerized mapping). They may also find it useful to organize community fora that provide perspectives on the role of the municipalities in enforcing environmental standards and in working with industry associations and citizens' groups to ensure balanced development.

Public receptiveness to hog industry expansion proposals at the community and regional levels may be dependent on the understanding of hog production and associated environmental risks. Strategies could be developed to improve public understanding at the national level and to correct inaccurate perceptions of performance at the regional and local levels. Consultation approaches that proved effective in one region or municipality could be shared so as to assist other municipalities and producers in avoiding conflicts and achieving consensus.

In some provinces, a peer review process is part of the required approval process for new or expanded facilities. A certification scheme, focussed specifically on environmental considerations, could be carried out by government or industry. It could apply to new applicants or to all hog producers. Certification under the ISO14000 program could also include initiatives to enhance the marketability of particular products because of their conformity to particular codes of practice. Awards and recognition could be given to producers who develop new methods or are exemplary in their management practices.

The federal government and the CPC could approach financial institutions, such as banks, trust companies and caisses populaires, with an investment incentive proposal for hog producers. Under the proposal, an interest discount would be offered on loans for the acquisition of equipment and facilities that would improve environmental performance. The financial institution would benefit from reduced risk of a degraded asset in the event of default.

The Prairie Farm Rehabilitation Administration (PFRA) of AAFC is directly involved in the provision of technical services, including planning and infrastructure development, in the prairies region. It already provides advice to

producers and communities on siting decisions and water management. PFRA has the potential to play a larger role in assisting provincial governments, municipalities and producers in dealing with hog-related environmental issues.

A final potential input is to develop decision support tools using integrated scientific, economic, demographic and regulatory data bases to assist siting and investment decisions by producers and permitting decisions by local municipal councils. This activity would require the participation of provincial governments and producer groups to ensure that the underlying data bases reflect local operating and regulatory situations.

This chapter has provided an overview of a number of possible inputs by AAFC and the CPC under the proposed HEMS initiative. Resource constraints dictate that only some of these inputs can be offered. A listing and description of proposed AAFC and CPC deliverables are provided in the companion document to this report, entitled Hog Environmental Management Strategy: Potential AAFC and CPC Inputs. Consultations with provincial governments and industry associations will confirm whether these potential inputs are indeed needed and will also identify opportunities for collaboration.