

4.0 MANURE HANDLING AND STORAGE

Solids Content

The type of equipment used in a manure handling system depends on the solids content. Livestock manure is classified as either a solid, semi-solid or liquid using the following criteria:

- 1) Solid – The manure’s solid content is greater than 20%. The use of bedding material further contributes to the solids content of the manure. To produce a solid manure, the liquid must be drained off and the manure dried or bedding added. At this consistency, the solid manure can then be stacked.
- 2) Semi-Solid (also referred to as slurry) – Contains 5% to 20% solids.
- 3) Liquid – Contains less than 5% solids. The additional liquid comes from washing and milking house waste water.

System Components

The elements of a manure management system include collection, transfer, storage, treatment, utilization and disposal. The components of the various systems for solid, semi-solid and liquid manure are summarized in Table 3 and further discussed below.

- 1) Solid Manure Systems:

Manure from tie stall or neck chain dairy operations is typically handled as a solid due to liberal amounts of bedding mixed with the manure. These barns normally have a gutter cleaner for collection and then either a conveyor or pump to transfer the manure outside to the storage area. Regular cleaning of the barn is also important to a successful fly control program. Other fly control measures include removing wet feed during fly breeding season, disposing of dead animals and afterbirth and keeping manure storing areas dark. You can also store manure in enclosed structures, protect ventilation inlets with screens and regularly spray with approved insecticides.

Manure from most types of beef operations is handled and stored as a solid, mostly on a slab or on the ground. The manure and bedding accumulates in the barn until it is periodically removed. Front end loaders are normally used to remove the manure from the barn and transfer it to the storage area.

Hogs are generally housed in barns with a pen system based on concrete floors. Hog manure can be handled as a solid because of the bedding mixture (sawdust, wood shavings, etc.) but commercial operations generally use a liquid manure system.

Fur farms generally house fox and mink breeders in outdoor pens with a wire base or inside small buildings or barns. In outdoor systems, the manure falls through the mesh to the ground below. The manure is then manually handled and taken to the manure storage areas, which is generally outdoors. Manure produced in indoor systems is handled in a similar fashion. Since the quantities of manure is small on fur farms, it is appropriate for farmers to compost the manure for spreading at a later date. In other situations, operators who are not running mixed enterprises may have other livestock operators handle their manure for spreading on farm land.

2) Liquid or Semi-Solid Manure Systems:

Manure systems for free stall dairy barns are usually designed for semi-solid or liquid manure. These systems do not involve the use of any bedding material. Manure is either collected under slatted floors or with the use of scrapers. It is then held in a pit under the floor or is transferred to long-term storage utilizing conveyors, gravity flow pits or pumps. Currently, only a small number of dairy farms are using free stall facilities in the province.

TABLE 3

**Components of a Manure Handling System
for Various Types of Wastes**

Operation	Solids	Semi-Solid/Liquids
Collection	Gutter Cleaners Front End Loaders	Slatted Floors Scrapers cable or hydraulic tractor
Transfer	Manure Wagons Open Tank Spreaders Dump Trucks Earth Moving Equipment Conveyors Pumps	Pumps submerged, open impeller piston pneumatic Augers Vacuum Tank Wagon Pipeline Gravity Continuous Flow Gutters Large Diameter Pipes
Storage	Stockpile Bunk Silo	In-Building Below Ground concrete (open/covered) earthen Above Ground concrete/glass lined steel

Operation	Solids	Semi-Solid/Liquids
Treatment	Aerobic compost dry incinerate	Aerobic pre-storage partial total Anaerobic Solid/Liquid Separation
Utilize/Disposal	Land Application Energy Production Bedding	Land Application Irrigation Energy Production

Source: Farm Practices Guidelines for Dairy, Beef and Hog Producers in Manitoba.

Equipment Selection and Maintenance

Regardless of the type of manure being transferred, it is important to use equipment designed for that purpose and to operate and maintain the equipment according to manufacturer's instructions. The equipment must be capable of functioning reliably in a corrosive environment. Equipment also requires proper maintenance if it is expected to have a long service life. Although maintenance of manure handling equipment may be unpleasant, a disruption of spreading due to major repairs is a greater inconvenience and may lead to problems with neighbours.

Preventative maintenance and the use of reliable equipment are critical for avoiding problems when handling manure. For example, a flat tire on a manure spreader may present serious problems. Often the spreader must be emptied before the tire can be repaired. Unless the flat happens near the manure storage it may be difficult to empty the spreader without dumping the manure in an unacceptable place. Another example could be a valve on a manure tank that does not close properly may allow manure to spill onto a public road during transportation.

Pumps used in liquid systems require some method of screening out solid materials. Problems occur when ear tags, hair, tails, teeth and other objects enter the pump. In slurries, solids will separate from liquids during storage, therefore, some agitation is required to bring the solids back into suspension. Chopper pumps are appropriate since they do not easily become plugged with hair, etc. These agitation pumps have capacities of about 200 litres (44 gallons) per second. Pumps used for irrigation, on the other hand, may range in capacity from 20-60 litres (4.4-13.2 gallons) per second and can transfer manure up to 1.25 kilometres (.775 miles) through irrigation pipe.

While liquids are transferred by gravity or pumps, solid manure is usually transferred by conveyors, augers, piston pumps or front end loaders.

Livestock Housing Management for Odour Control

Very little odour is given off by fresh manure. Once the manure starts to decompose, odour production begins. Inside a livestock building, even small deposits of manure are a likely source of odour. Solid manure tends to form fewer odours than liquid manure. By keeping conditions dry, the production of odour is reduced. Good housekeeping is the best management method.

The following guidelines for livestock housing management are recommended:

- ! collect and transfer manure from the barn to storage on a daily basis or every few days. Daily clean-out will significantly reduce the production of odours from manure in the building. If a hard-pack system of maintenance is used, ensure that sufficient bedding is added to absorb liquids;

Fur farms can minimize odours by regularly cleaning pen areas during the growing and furring periods in the summer and fall. However, the need to minimize disturbances during breeding and whelping in the late winter and spring makes regular cleaning more difficult. Fortunately, fewer animals on the farm during these times helps to minimize the potential for odour;

- ! avoid ponding of effluent due to poor drainage or bad concrete work. Maintain bedding in a dry condition to avoid mold and dust and loss of absorbing capacity;
- ! maintain watering systems to prevent water from being added needlessly to manure and bedding. Use an appropriate combination of hose, pressure and nozzle in order to clean buildings with a minimum amount of water. Low nozzle pressures require excessive amounts of water and high pressures cause manure to be sprayed onto building walls where they can remain and be a source of odour;
- ! if applicable, thoroughly clean and disinfect buildings between successive groups of livestock;
- ! do not surpass recommended animal densities for livestock buildings; and
- ! remove dust, clean ventilation fans and shafts. Keep dust levels low since odours are absorbed and carried in the air on dust particles.

Ventilation of farm buildings, in addition to controlling the temperature and humidity, also controls the production and build-up of poisonous and odourous gases. The following guidelines should be observed:

- ! maintain maximum air flow through livestock buildings. This will assist to keep conditions as dry as possible and will promote aerobic conditions so that fewer odours are produced. It is also effective in diluting odourous gases as they are released to the outside environment; and
- ! maintain and repair ventilation fans and check that they have the appropriate capacity for the number of livestock being housed in the building. For livestock comfort, low level winter ventilation must be continuous, and in summer, thermostats must be used to control the higher ventilation rates that will be necessary. Foxes and mink, which are generally raised outdoors, may produce stronger odours during mating season that can increase the chances of nuisance to nearby residences. While maintaining clean conditions for these animals will help to minimize this nuisance, good neighbour relations are very important in

avoiding conflicts*.

The position, design and height of exhaust outlets affects the dilution of odourous gases outside of livestock buildings. In general, higher outlets provide greater dilution of exhaust gases. Options for ventilation design may be discussed with experts in the field.

Exhaust gases from livestock buildings may be treated for odour control as part of the ventilation process. Treatment requires additional expenditure, but may be warranted in certain circumstances. For these methods to be effective they must be designed and installed correctly. Qualified professionals should be consulted.

** N.B. It is important the general public understand that from time to time, farm activities associated with commercial livestock farmers, will produce farm odours, noise, dust, etc. which are a normal part of farming.*

4.1 Planning A Manure Storage

A storage facility is a permanent structure or location designed and operated to contain manure in an environmentally sound manner for the period of time required to allow the manure to be used as an organic fertilizer. The design of the storage will depend upon:

- ! the location of the storage;
- ! the storage capacity required for the livestock operation;
- ! the characteristics of the manure (such as the amount of solids); and
- ! the methods of filling and emptying.

Although some design considerations are discussed, producers are advised to contact an agricultural engineer for complete design information. Manure storage structures must also provide the following:

- ! flexibility for timing manure spreading;
- ! sufficiently impervious to prevent leakage; and
- ! an appropriate level of odour control.

All manure storage systems must be evaluated to ensure pollution is not occurring and that the facility meets the requirements under the various acts and legislation existing in Newfoundland and Labrador. Furthermore, if there is insufficient land on the farm to handle the manure, the operator must supply written commitments ensuring that the manure will be removed and used in a fashion acceptable to the Government Services Centre. This issue is addressed in Section 5.4, Acceptable Application Rates.

4.2 Location

In order to minimize any risk of pollution, all manure storages are required to meet the minimum separation distances discussed in Appendix D. Groundwater and soil conditions must be evaluated to ensure that the site is suitable for the type of storage planned. For example, where the groundwater levels are near the bottom of the storage, do not use an earthen storage without a suitable liner (for example, a flexible membrane, concrete or equivalent material). Refer to Section 4.6, Liquid Manure Storage for further information on earthen manure storages.

The site for the storage must provide the following:

- ! the storage must be located close enough to the barns to allow for convenient filling and still permit expansion of the facilities;
- ! it must be accessible by an all weather road for field spreading equipment;
- ! if possible, it should be located out of sight of the road and dwellings;
- ! the storage must be located to avoid collecting surface and roof run-off; and
- ! manure storage systems must not be constructed on the banks of water bodies, including rivers, drainage channels, ponds and wetlands (bogs and fens). A buffer of 50 metres or more is recommended.

Despite the fact that it is generally accepted that manure from some types of livestock operations does not stockpile well, some producers have accumulated stockpiled manure that is not regularly spread on land or sent for other uses. This can lead to environmental problems. To avoid these problems:

- ! maintain proper separation distances to surface water and with neighbour's land uses;
- ! stockpile the manure in such a manner as to minimize the likelihood of leaching and run-off;
- ! do not be stockpile manure over field drainage tiles;
- ! ensure the length of time of field storage does not exceed six months (The Canadian Code for Environmentally Sound Hog Production, Canadian Pork Council); and
- ! do not dump manure in coastal waters or wooded areas (this is prohibited in Newfoundland and Labrador unless by special permit).

Install a groundwater controlling drain around the manure facility to prevent the entry of groundwater into both earthen or concrete storages. For earthen structures, this drainage prevents groundwater from entering the storage. Groundwater reduces storage capacity and weakens the manure sealing capacity by lowering the total solids content. For concrete structures, this drainage prevents frost heaving, reduces external groundwater pressure when the storage is empty and prevents water entry.

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4.3 Size

Manure storage requirements for livestock farms depend on:

- ! management practices and facilities;
- ! the type and number of animals;
- ! the amount of water from spillage or from washing;
- ! the length of storage time needed;
- ! the amount of precipitation and/or groundwater added to storage contents;
- ! the amount of dilution water added;
- ! the amount of evaporation;
- ! the amount of bedding material used; and
- ! additional freeboard, also known as unused manure storage space. (Newfoundland guidelines are 60 cm (2 feet) for earthen storages or 45 cm (1.5 feet) for concrete manure storages)

The storage must have some reserve capacity to allow for the accumulation of solids and for precipitation. When the storage is ready for clean out it must have enough capacity to handle a major rainstorm without overflowing. This is especially important for the east coast of Newfoundland which receives higher rates of precipitation.

In dairy operations, milkhouse (milk centre) wastewater may need to be considered in determining manure storage capacity. In farrowing and nursery operations where washing is performed regularly, the volume of liquid manure may increase by two or three times. Similarly the use of water conserving devices such as wet/dry feeders can decrease the amount of water used by livestock by up to 40% when compared with standard drinkers. If bedding is used in solid systems the weight of manure may increase by 20% and the volume may double.

It is important to estimate manure production rates accurately, especially for expensive covered concrete systems. An agricultural engineer should be contacted to assist in the evaluation of these systems. A useful guide in preparing your estimates is the following equation:

Storage Volume Required = (Manure Volume + Bedding Volume + Wastewater including Milk Centre Volume (The amount of milking centre wastewater generated depends on the cleaning methods for floors and udders and the milking system. Water conservation measures such as using effluent water from a milk tank pre-cooler can greatly reduce the amount of wastewater created in the milking centre. Source: Environmental Guidelines for Manure Storage, Newfoundland and Labrador Department of Forest Resources and Agrifoods.) x (days of storage period)...

+ Precipitation Volume (if an open storage)...

+ Runoff Volume (if applicable) from roofs...

less Evaporation Volume (approx. 10-20% of precipitation in Newfoundland and Labrador)

In preparing your estimate of storage requirements, consider the following:

- ! examine a facility similar to that being proposed;
- ! use the above formula and the guidelines for manure production shown in Appendix E; and/or
- ! contact one of the resource groups listed in Section 12 (Sources of Information).

Overflow of the manure storage is a serious environmental concern and therefore is prohibited. Livestock producers must construct sufficient storage capacity to eliminate the need for winter manure spreading. A minimum storage capacity of 180 days is required by the Department of Environment. Storage capacity of 200 or more days is recommended. (If the circumstances of lot layout and adjacent land use/land ownership prevent the construction of a manure storage with this capacity, the farmer will have to implement a manure management/storage plan acceptable to the Government Services Centre and the Agrifoods Branch in consultation with the local municipality.) This will also help to minimize the extra management time, labour time and equipment use associated with short term storage. It also provides flexibility in:

- ! poor weather conditions;
- ! labour shortages; and
- ! equipment breakdowns.

As mentioned earlier, manure production for fur or other small livestock operations is not great and therefore poses less environmental risk, especially if the manure is disposed of in an approved and appropriate manner.

4.4 Solid Manure Stockpiles

Solid manure containing larger amounts of bedding is often stored in stockpiles. These storages must:

- ! be constructed and managed to contain all seepage and runoff;
- ! be constructed to help divert away or contain runoff from surrounding areas (this has the added benefit of minimizing manure volume);

- ! contain a concrete bucking wall to assist filling the bucket if emptying with a front end loader;
- ! provide access for unloading and haul out equipment; and
- ! depending on soil conditions, be constructed with a sloping concrete slab to prevent seepage and facilitate collecting the liquid runoff which can then be collected for removal by vacuum tanker or transferred to a separate storage.

4.5 Semi-Solid Manure Storage

Wet manure and liquid runoff can be contained by a storage consisting of earthen dykes in combination with a reinforced concrete wall. Seepage can also be controlled by a concrete slab, depending on soil conditions at the site. By sloping the slab to the corner opposite the entrance ramp, excess liquids can be removed by vacuum tanker or transferred to a separate storage.

A ramp entrance provides access for the front end loader or other removal equipment. This entrance ramp must be crowned to prevent surface water from the yard entering the storage.

4.6 Liquid Manure Storage

Livestock manure is sometimes stored as a liquid by adding dilution water to facilitate pumping. Liquid livestock manure can be stored in three types of storages:

- ! concrete tanks below ground;
- ! lined earthen storages; or
- ! concrete or steel tanks above ground.

All barns with a proposed system of manure washdown should ideally have a water meter to monitor the volume of water used.

A) Concrete Tanks Below Ground

The two main benefits of a concrete manure storage include:

- ! reduced loss of valuable nutrients (see Appendix F for a comparison of losses from different systems); and
- ! odours are generally not released except when the manure is agitated before the storage is emptied.

Concrete tanks are more costly than earthen storages, but because they are impermeable, they are suitable for use in areas having sandy soils. In areas with a high water table level, above ground tanks are preferable. There are also a number

of synthetic materials designed for use in earthen storages that provide impermeable barriers without the high costs of concrete storages. These are discussed under the section on earthen storages.

Concrete tanks must be designed to withstand all earth, hydrostatic and live loads. In planning the design of the storage, carefully consider the following:

- ! how the manure is to be agitated (please note that minimizing agitation reduces odours produced during transfer);
- ! there must be sufficient access ports for the pump if the tank is to be covered;
- ! liquid manure tanks connected to animal buildings must have gas traps or valves between them to prevent gases from entering the building;
- ! openings must be covered with grills or covers (these covers must weigh at least 20 kilograms (44 pounds) so they cannot be removed by children or displaced by animals and be of sufficient design so they can not drop through the opening-permanently secure covers with a safety chain);
- ! open tanks must be surrounded with a fence (at least 1.2 metres or 4 ft high except where the tank walls extend this distance above the adjacent ground level) to prevent accidental entry into the pit;
- ! agitation is more effective when large tanks are divided into a series of compartments;
- ! warning signs must be installed near all covered tanks to warn about noxious gas hazards; and
- ! a groundwater controlling drain must be installed around the manure facility to prevent the entry of groundwater into the storage. Groundwater reduces storage capacity and weakens the manure sealing capacity by lowering the total solids content. For concrete structures, this drainage prevents frost heaving, reduces external groundwater pressure when the storage is empty and prevents water entry.

You must wear a self-contained breathing apparatus when entering indoor or covered storage tanks. The manure tank must be ventilated with a fan 30 minutes prior to entry and thereafter continuously while any person is in the tank. Wear a safety harness and have on hand two people capable of pulling you out in case of emergency. Never use open flames while inspecting or working in an unventilated storage tank-some manure gases, especially methane, can be explosive. The hazards of dangerous gases are described in Appendix G, Safety.

B) Earthen Storages

Earthen storages can be used for storing liquid manure. The attraction of an earthen manure storage is its low capital cost. Unfortunately, this type of structure is responsible for the most complaints since the manure in these facilities is kept under anaerobic conditions and the large exposed surface area permits large quantities of odourous gases to be released into the air. The odours are generally worst when the manure begins to warm up in the spring. Other disadvantages include:

- ! the risk of seepage if constructed in improper soil conditions;
- ! the nutrient loss and the maintenance requirements;
- ! they should not be used in densely populated areas (see Section 3, Site Selection);and
- ! open storages such as this can be dangerous to children and animals (although the crusted surface may appear solid, it will not support a person).

Several considerations in designing earthen manure storages include: (Siting criteria taken from Manure Management Guidelines for New Brunswick, New Brunswick Agriculture and Rural Development, November 4, 1996.)

- ! the storage must be constructed to be compatible with equipment used for emptying, agitating and maintaining the slopes;
- ! earthen storages for liquid manure must be lined. This applies to facilities constructed after the approval of these guidelines.
- ! A maximum permeability of 10^{-7} cm/sec. should be used as a criteria when considering a site for an earthen facility. A hydrological assessment must be conducted before such a facility is constructed.
- ! locate the earthen storage in areas where the depth to the bedrock exceeds one metre for clay soils and three metres for sandy or loamy soils;
- ! the base of the earthen storage should be a minimum of one metre above the level of the high water table;
- ! install a groundwater controlling drain;
- ! provide a berm width of at least 3.0 metres to allow access for tractors and pumps;
- ! the slope of the sides must not exceed 1.5:1 (run to rise) in parent soil or 2:1 where a clay liner exists (outside slopes must be seeded to grass and maintained);

- ! the lateral distance from an earthen storage to a subsurface drain must be a minimum of 15 metres (50 ft);
- ! install concrete pads below inlets and at agitation points to reduce erosion of the bottom;
- ! plant shelterbelts to screen the storage from view;
- ! install fencing around the storage for safety; and
- ! install a groundwater controlling drain around the manure facility to prevent the entry of groundwater into the storage.

Earthen manure storage facilities have been accepted as environmentally safe as long as the soil used to build them contains at least 15% clay content. However, as mentioned, new facilities must comply with the maximum permeability as previously stated. Coarse sands and gravel are not considered environmentally safe and must be lined with an artificial seal. Products composed of bentonite (a fine clay material which mixes with the soil to form a liner) or other materials such as synthetic and plastic membranes, geotextiles, bentonite-geotextile membrane, asphalt concrete and asphalt can be used as earthen manure storage liners. For more information on the various earthen manure storage liners contact the structural and environmental specialist within the Department of Forest Resources and Agrifoods. You can obtain more information on the various liners by contacting the Eastern Canada Soil and Water Conservation Centre in Grand-Falls, New Brunswick (506-475-4040) or the Agricultural Engineering Department of McGill University in Ste. Anne de Bellevue, Quebec.

C) Concrete Tanks Above Ground

Above ground tanks can be either circular silo type with an open or enclosed top or rectangular structures. Depending on the size, the silo structures are generally more expensive than in-ground concrete tanks. Because of the cost, these systems are generally not used to store diluted wastes. This type of storage may be the only choice in conditions where space is limiting or where soil conditions do not permit the use of an in-ground storage. A benefit of this type of structure is that the small surface area may permit formation of a crust on top which would reduce odour production considerably.

The storage may be constructed from concrete staves, reinforced cast-in place concrete, glass lined steel panels or spiral wound coated steel. Some tanks are equipped with filling and agitation equipment designed specifically for that purpose.

4.7 Milkhouse Waste

Milking house wastes contain many ingredients that may affect the environment. Milking house wastes may include manure deposited in the milking parlour, udder washings, spilled milk, and equipment wash water containing detergents, acids and chlorine.

Milking centre sanitation and the handling of dairy waste water are controlled by the Government Services Centre. Additional legislation which may have relevant sections is listed in Section 2. The following points are made to assist dairy producers in choosing a waste water handling system:

- ! on dairy farms where manure is handled as a liquid, milking house wastes should be directed to the manure storage facility. This volume can be significant, 8 to 20 litres (2 to 4 gallons) per milk cow per day. Therefore, care must be taken to ensure that sufficient storage space is available to handle this additional volume. See Section 4.1 Planning a Manure Storage;
- ! pretreatment guidelines for washwater before discharge from the milking centre include never allowing more than 4.5 litres (1 gallon) of milk per day into the milking house wastewater, no more than 13.5 litres (3 gallons) of water is used per cow per day for cleanup and the water must be tested once a year to balance the use of cleaning products and disinfectants; taken from Atlantic Environmental Farm Plan, Second Edition, Atlantic Farmers Council.
- ! on farms that currently handle wastes as a solid or semi-solid, additional liquid is not wanted in the manure storage facility. In these cases, separate liquid storage for milking centre wastes will be required; and
- ! Although suspended milk solids in milking centre wastes tend to clog the tile field and, as a result, tile fields often fail within five years of installation, at present this is still considered the best disposal system next to disposal in the manure storage facility.

4.8 Manure Storage for Odour Control

Most odour-causing gases are formed when manure is in storage. In practice, most manure storage is anaerobic (meaning in the absence of oxygen). The anaerobic conditions promote odour production. These gases either escape from the storage to cause immediate problems or are released later during spreading.

Typically fewer odours are produced by solid manure handling systems than by liquid systems. An undisturbed solid manure stack is self sealing so few odours are given off until the pile is disturbed. With open liquid storage, odours are common. Weather as well as the addition of manure can agitate the slurry causing gases to be given off.

Covered storages are an effective way to minimize odour generation. Storage covers:

- ! reduce occasional manure agitation caused by wind and rain;
- ! reduce the movement of odourous air from storage areas to neighbouring residences; and
- ! reduce the addition of water from rain and snow thereby also reducing the total volume of manure to be spread. While in most instances the cost may preclude covering storage areas, in certain circumstances this expense may be justified.

When evaluating manure storages, consider the following guidelines to reduce the potential for nuisance odours:

- ! provide additional storage volume for greater flexibility in the timing of manure application. This can reduce the likelihood of storage overflow and permit application to coincide with the most appropriate timing and weather conditions;
- ! with solid and semi-solid manure management systems, separate the liquid and solid portions of manure in storage to reduce the promotion of anaerobic conditions;
- ! avoid the addition of silage effluent and waste food products to the manure storage reservoir. These combinations create strong odours; and
- ! planting a buffer zone of trees around manure storage areas will reduce the movement of air over the manure surface, thereby lowering the amount of odour released. This has the added benefit of removing the storage from the sight of neighbours and improves the image of the farm by providing a pleasant, aesthetically pleasing appearance.

Treatment of manure before it enters long term storage avoids odour problems in storage and during spreading. Treatment systems must be designed to handle the manure volumes generated by the livestock operation. An improperly designed or managed treatment facility will prove unsatisfactory. Often treatment is performed in short-term storage so less expensive reservoirs can be used for the larger, long-term storage. Some treatment methods for odour control are listed in Appendix A. It is important to note these treatments are mostly used in rare cases when dealing with severe odour problems.

4.9 Alternative Manure Storage Systems

Most barns in livestock operations with liquid manure systems are presently designed with shallow pits that are emptied frequently. Other systems are available that have better odour control than shallow pits, but the equipment and labour costs have limited their acceptance in Newfoundland and Labrador. The following is a brief description of these alternative systems.

- 1) **Solid/Liquid Separation.** The rate of decomposition can be limited by separating the solid and liquid parts of the manure. Separation can be achieved through the use of:
 - a) specially designed manure pits, with the liquids continuously drained to storage and the solids scraped out of the barn each day; and/or
 - b) mechanical screens or filters.
- 2) **Bedding-Based Systems.** The use of bedding such as straw, sawdust or shavings can maintain aerobic conditions if enough material is used and the bedding is changed frequently. You must be aware that the labour requirements for materials handling is high but odours can be minimized effectively. Currently, little straw is

grown or used as bedding in the province of Newfoundland and Labrador. Many livestock producers instead use sawdust, wood shavings or in some cases, shredded paper as bedding. Peat may also have potential as a bedding material. Experiments in the poultry industry may help determine its applicability to livestock operations.

- 3) **Modification of Exhaust Air.** Attempts have been made to reduce the odour levels of exhaust ventilation air by removing the dust from the air. While odour levels can be reduced, such systems are expensive to construct and maintain.