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Agricultural Waste Management
Field Handbook

Chapter 9 Agricultural Waste Management Systems

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Chapter 9 was originally prepared and printed in 1992 under the direction of **James N. Krider** (retired), national environmental engineer, Soil Conservation Service (SCS), now Natural Resources Conservation Service (NRCS). **James D. Rickman** (retired), environmental engineer, NRCS, Fort Worth, Texas, provided day-to-day coordination in the development of the handbook. Authors for chapter 9 included **L.M. "Mac" Safley**, North Carolina State University, Raleigh, NC; **William H. Boyd**, environmental engineer, Lincoln, Nebraska; **A. Ralph Schmidt** (retired), assistant State conservation engineer, NRCS Spokane, Washington.

This version was prepared under the direction of **Noller Herbert**, director, Conservation Engineering Division (CED), Washington, DC. Revisions to the chapter were provided by **Jeffrey Porter**, environmental engineer, East National Technology Support Center (ENTSC), Greensboro, North Carolina; **William H. Boyd**, manure management team leader, ENTSC, Greensboro, North Carolina; **Nga Watts**, environmental engineer, Gainesville, Florida; **Darren Hickman**, national environmental engineer, CED, Washington, DC; and **Barry Kintzer** (retired), national environmental engineer, NRCS.

It was finalized under the guidance of **Darren Hickman**, national environmental engineer, CED, Washington, DC. The editing, illustrations, and formatting were provided by **Lynn Owens**, editor; **Wendy Pierce**, illustrator; and **Suzi Self**, editorial assistant, National Geospatial Management Center (NGMC), Fort Worth, Texas.

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Chapter 9 Agricultural Waste Management Systems

651.0900 Introduction

An agricultural waste management system (AWMS) is a planned system in which all necessary components are installed and managed to control and use by-products of agricultural production in a manner that sustains or enhances the quality of air, water, soil, plant, animal, and energy resources.

651.0901 Total systems

AWMSs must be developed using the total systems approach. A total system accounts for all the waste associated with an agricultural enterprise throughout the year from production to utilization. In short, it is the management of all the waste, all the time, all the way.

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651.0902 Interface with other systems

The primary objective of most agricultural enterprises is the production of marketable goods. To be successful, the farm manager must balance the demand on limited resources among many complicated and interdependent systems, often including, but not limited to:

- cropping system
- livestock management system
- irrigation and drainage system
- nutrient management system
- pest control system
- resource conservation system
- equipment maintenance and replacement system
- produce storage, transport, and marketing system
- financial management system

For an AWMS to be practical, it must interface with these other systems. Chapter 2 of this handbook gives detailed descriptions of the factors to consider when planning an AWMS.

651.0903 Waste consistency

Waste of different consistencies requires different management techniques and handling equipment. Agricultural waste may be in the form of a liquid, slurry, semisolid, or solid. Waste, such as manure, can change consistency throughout the system or throughout the year. The total solids (TS) concentration of manure is the main characteristic that indicates how the material can be handled.

Factors that influence the TS concentration of excreted manure include the climate, type of animal, amount of water consumed by the animal, and the feed type. In most systems, the consistency of the waste can be anticipated or determined. The TS concentration of the waste can be increased by adding bedding to the waste, decreased by adding water, and stabilized by protecting it from additional water. Figure 9–1 illustrates how varying the TS concentration for different animal manures affects consistency. Additional information is found in chapter 4 of this handbook.

The consistency of the waste should be selected and controlled for several reasons. Solid waste management systems have a reduced total volume of waste because of the reduction in the amount of water. Solid waste handling equipment may have lower cost and power requirements; however, the labor required for operation and management generally is greater than that for other methods.

Liquid waste management systems are often easier to automate and require less daily attention than those for solid wastes. However, the additional water needed increases the volume of waste requiring management, and the initial cost of the liquid handling equipment may be greater than that for solid waste systems.

Operator preference is also a factor. A landowner may select a method for managing waste because that method is popular in the community. It will be easier to learn from and share experiences with neighbors and, in case of equipment failure or other emergencies, the landowners can more easily assist each other.

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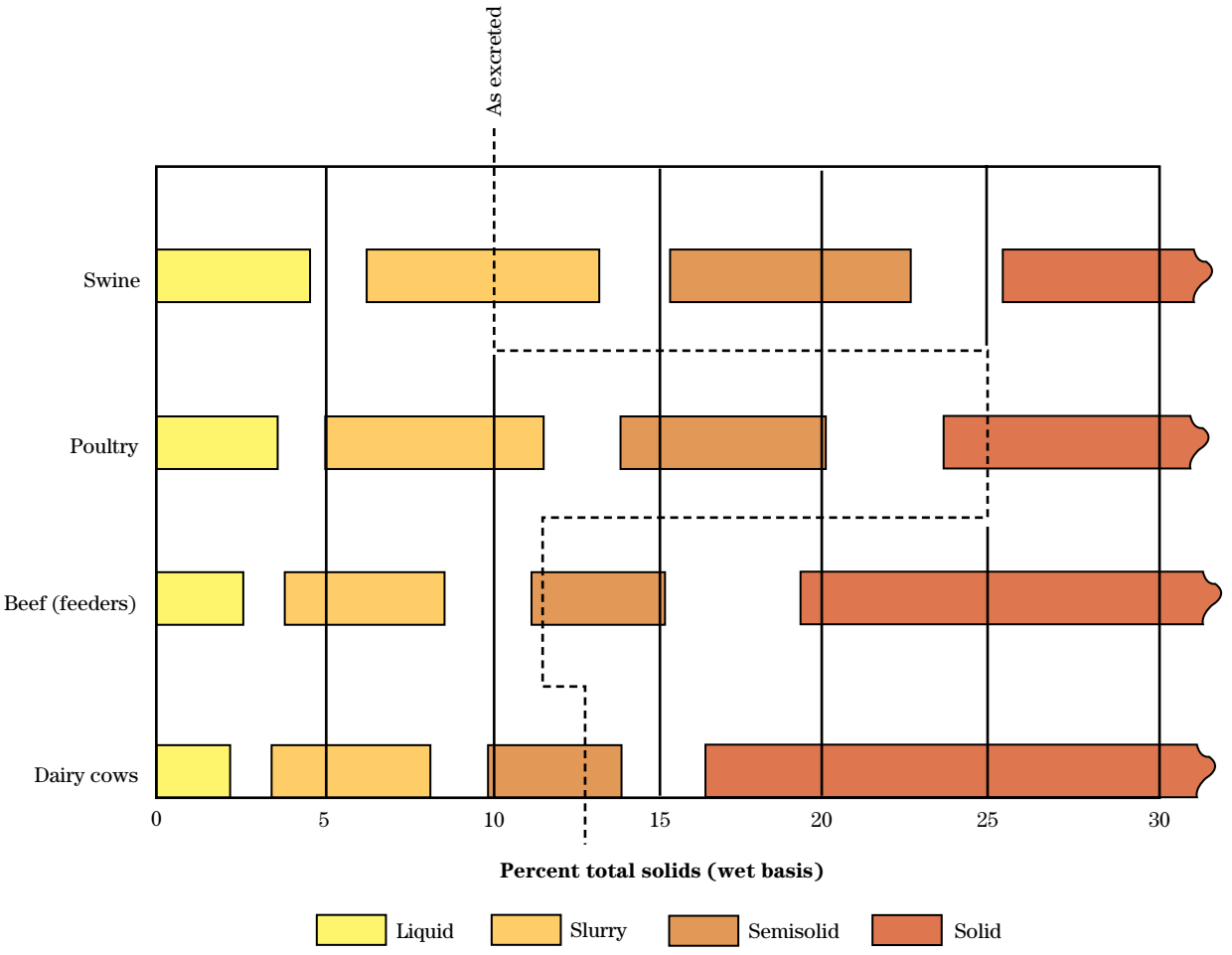
Figure 9–1 Relative handling characteristics of different kinds of manure and percent TS (ASAE 1990)



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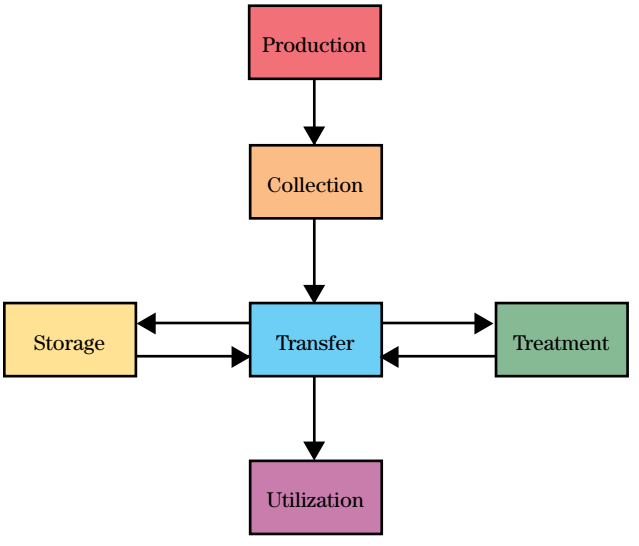
651.0904 Waste management functions

An AWMS consists of six basic functions (fig. 9–2):

- production
- collection
- transfer
- storage
- treatment
- utilization

For a specific system, these functions may be combined, repeated, eliminated, or rearranged as necessary.

Figure 9–2 Waste management functions



(a) Production

Production is the function of the amount and nature of agricultural waste generated by an agricultural enterprise. The waste requires management if the quantity produced is sufficient enough to become a resource concern. A complete analysis of production includes the kind, consistency, volume, location, and timing of the waste produced.

The waste management system may need to accommodate seasonal variations in the rate of production.

The production of unnecessary waste should be kept to a minimum. For example, a large part of the waste associated with many livestock operations includes contaminated runoff from open holding areas. The runoff can be reduced by restricting the size of open holding areas, roofing part of the holding area, and installing gutters and diversions to direct uncontaminated water away from the waste. In other words, whenever possible, “Keep the clean water clean.”

Leaking watering facilities and spilled feed contribute to the production of waste. These problems can be reduced by careful management and maintenance of feeders, watering facilities, and associated equipment.

A record should be kept of the data, assumptions, and calculations used to determine the kind, consistency, volume, location, and timing of the waste produced. The production estimates should include future expansion.

(b) Collection

Collection refers to the initial capture and gathering of the waste from the point of origin or deposition to a collection point. The AWMS plan should identify the method of collection, location of the collection points, scheduling of the collection, labor requirements, necessary equipment or structural facilities, management and installation costs of the components, and the impact that collection has on the consistency of the waste.

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(c) Transfer

Transfer refers to the movement and transportation of the waste throughout the system. It includes the transfer of the waste from the collection point to the storage facility, to the treatment facility, and to the utilization site. As shown in figure 9–2, the waste may actually be transferred several times before utilization.

For example, a liquid or slurry waste may be collected, transferred to a storage facility, and then to a solid/liquid separator (treatment). From there, the solid portion may be transferred to another storage facility for additional treatment or reutilized as bedding, while the liquid portion is applied (transferred) to a crop field to supply plant nutrients (utilization). The waste may require transfer as a solid, liquid, or slurry, depending on the TS concentration.

The system plan should include an analysis of the consistency of the waste to be moved, method of transportation, distance between transfer points, frequency and scheduling, necessary equipment, and installation and management costs of the transfer system.

(d) Storage

Storage is the temporary containment of the waste. The storage facility of a waste management system is the tool that gives the manager control over the scheduling and timing of the system functions. For example, with adequate storage, the manager has the flexibility to schedule the land application of the waste when the spreading operations do not interfere with other necessary tasks, weather and field conditions are suitable and the nutrients in the waste can best be used by the crop. The storage period should be determined by the utilization schedule.

The waste management system should identify the storage period; required storage volume; type, estimated size, location, and installation cost of the storage facility; management cost of the storage process; and impact of the storage on the consistency of the waste.

(e) Treatment

Treatment is any function designed to reduce the pollution potential or modify the physical characteristics of the waste, such as moisture and TS content, to facilitate more efficient and effective handling. Manure treatment is comprised of physical, biological, and chemical unit processes. It also includes activities that are sometimes considered pretreatment, such as the separation of solids.

The plan should include an analysis of the characteristics of the waste before treatment; a determination of the desired characteristics of the waste following treatment; selection of the type, estimated size, location, and installation cost of the treatment facility; and management cost of the treatment process. Some manure management treatment options include solid/liquid separation, anaerobic digestion, thermo-chemical conversion, and anaerobic and aerobic treatment lagoons.

(f) Utilization

Utilization includes reusing and/or recycling of waste products. Agricultural wastes may be used as a source of energy, bedding, mulch, organic matter, or plant nutrients. Properly treated, they can be marketable.

A common practice is to recycle the nutrients in the waste through land application. A complete analysis of utilization through land application includes selecting the fields; scheduling applications; designing the distribution system; selecting necessary equipment; and determining application rates and volumes, value of the recycled products, and installation and management costs associated with the utilization process.

See chapter 10 of this handbook for detailed information the collection, storage, treatment, and transfer functions, and see chapter 11 for information on utilization through land application.

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651.0905 Waste management systems design

An AWMS design will:

- describe the management, operation, and maintenance of the waste from production to utilization
- list the practices to be installed
- locate the major components on a plan map
- include an installation schedule

AWMSs are highly varied, and many alternatives are available. The various processes mentioned above are usually interdependent. For example, if a landowner wants to store waste as a dry material, the waste cannot be collected using a flush system unless some type of solid/liquid separation process is included with the system. If limited land is available for utilization, the landowner may need to select a treatment process that reduces the nutrient content of the waste.

Because of the variety of situations into which an AWMS must be incorporated, no one procedure can be followed to arrive at a system design; however, the following guidelines may be helpful.

- **Determine decisionmaker's concerns and needs**—Landowner objectives along with social and environmental concerns must guide the planning of the AWMS.
- **Determine the characteristics and annual production of the waste requiring management—**The waste characteristics and amount could limit alternatives and influence management decisions. Future changes in operation size and management must also be considered.

  The nitrogen and phosphorus content of the waste, as well as heavy metals, toxins, pathogens, oxygen demanding material, or TS, must be known. Knowing what is produced, how much is produced, when it is produced, and where it is produced helps the planner understand the existing agricultural enterprise into which the waste management system must be integrated.
- **Determine the alternatives the decisionmaker is willing to consider for utilization—**This helps the planner know what to work toward. Some alternatives may have specific limitations or requirements for the characteristics of the waste, and the system must be designed to deliver waste with those characteristics. If the utilization alternative involves land application, a quick check needs to be made to determine if sufficient land is available and when the spreading operations can take place. This helps determine whether treatment will be necessary and what the storage period should last.
- **Determine the landowner's preferences for equipment and location of facilities—**The landowner may desire specific features in the system or may have specific equipment available. These features and site characteristics detailed in chapter 2 of this handbook should be identified and discussed with the landowner so that their impact on the total agricultural enterprise and their effect on onsite and offsite natural resources are fully understood. Existing equipment and the opinions of the decisionmaker should not limit the discussion and consideration of other alternatives.
- **Design the system beginning with production and ending with utilization—**At this point, the entire system begins to take shape. The management requirements and safety concerns should be fully addressed and understood. The previous decisions may need to be adjusted or refined.

A good way to document the decisions of the landowner is to list the major processes in the order in which they occur in the system and then record under each heading the pertinent information associated with that process. Chapter 2 of this handbook, Planning Considerations, provides assistance in planning a waste management system design.

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651.0906 Typical agricultural waste management systems

(a) Dairy waste management systems

Dairy operations vary, and each operation presents its own unique problems (fig. 9–3). Many older dairy operations were not designed with sufficient consideration given to waste management. As a result, the design of a waste management system may require major modifications or alterations of existing facilities.

The dairy industry generally is concerned with the overall appearance of the dairy farms. Dairy operations require high standards of sanitation and must prevent problems associated with flies. Operations near urban areas must manage the waste in a manner that minimizes odors.

Small dairy operations are commonly managed on pastures in partial confinement. While animals are on pasture, their waste should not be a resource concern if stocking rates are not excessive, grazing is evenly distributed, manure from other sources is not applied, and grazing is not allowed during rainy periods when the soils are saturated. To prevent waste from accumulating in feeding, watering, and shade areas, the feeding facilities can be moved, the number of watering facilities can be increased, and the livestock can be rotated between pastures. To reduce deposition of waste in streambeds, access to the stream may be restricted to stable stream crossings and access points (fig. 9–4).

The manure in paved holding areas generally is easier to manage, and the areas are easier to keep clean. If the holding areas are unpaved, the traffic of the livestock tends to form a seal on the soil that prevents the downward movement of contaminated water. Care must be taken when removing manure from these lots so that damage to this seal is minimized.

Most medium and large dairy facilities are managed as total confinement. All of the manure and associated waste components must be included in the AWMS.

(1) Production

Waste associated with dairy operations includes manure, contaminated runoff, milking house waste, bedding, spilled feed, and silage leachate.

(2) Collection

The collection methods for dairy waste vary depending on the management of the dairy operation. Dairy animals may be partly, totally, or seasonally confined. Manure accumulates in confinement areas and in areas where the dairy animals are concentrated before and after milking.

Unroofed confinement areas must have a system for collecting and confining contaminated runoff. This can be accomplished by using curbs at the edge of the paved lots (fig. 9–5) and reception pits where the runoff exits the lots. Paved lots generally produce more runoff than unpaved lots. On unpaved lots, the runoff may be controlled by diversions, sediment basins, and underground outlets. The volume of runoff can be reduced by limiting the size of the confinement area, and uncontaminated runoff can be diverted if a roof runoff management system and diversions are used.

The manure and associated bedding accumulated in roofed confinement areas can be collected and stored as a solid. The manure can also be collected as a solid in unroofed lots in humid climates where the manure is removed daily and in unroofed lots in dry climates. Manure can be removed from paved areas by a flushing system. The volume of contaminated water produced by the system can be greatly reduced if provisions are made to recycle the flush water.

(3) Transfer

The method used to transfer the waste depends largely on the consistency of the waste. Liquid and slurry wastes can be transferred through open channels, pipes, or in a portable liquid tank (fig. 9–6).

Pumps can be used to transfer liquid waste as needed. Solid and semisolid waste can be transferred by mechanical conveyance equipment, in solid manure spreaders, and by pushing them down curbed concrete alleys. Semisolid waste has been transferred in large pipes through the use of gravity, piston pumps, or air pressure.

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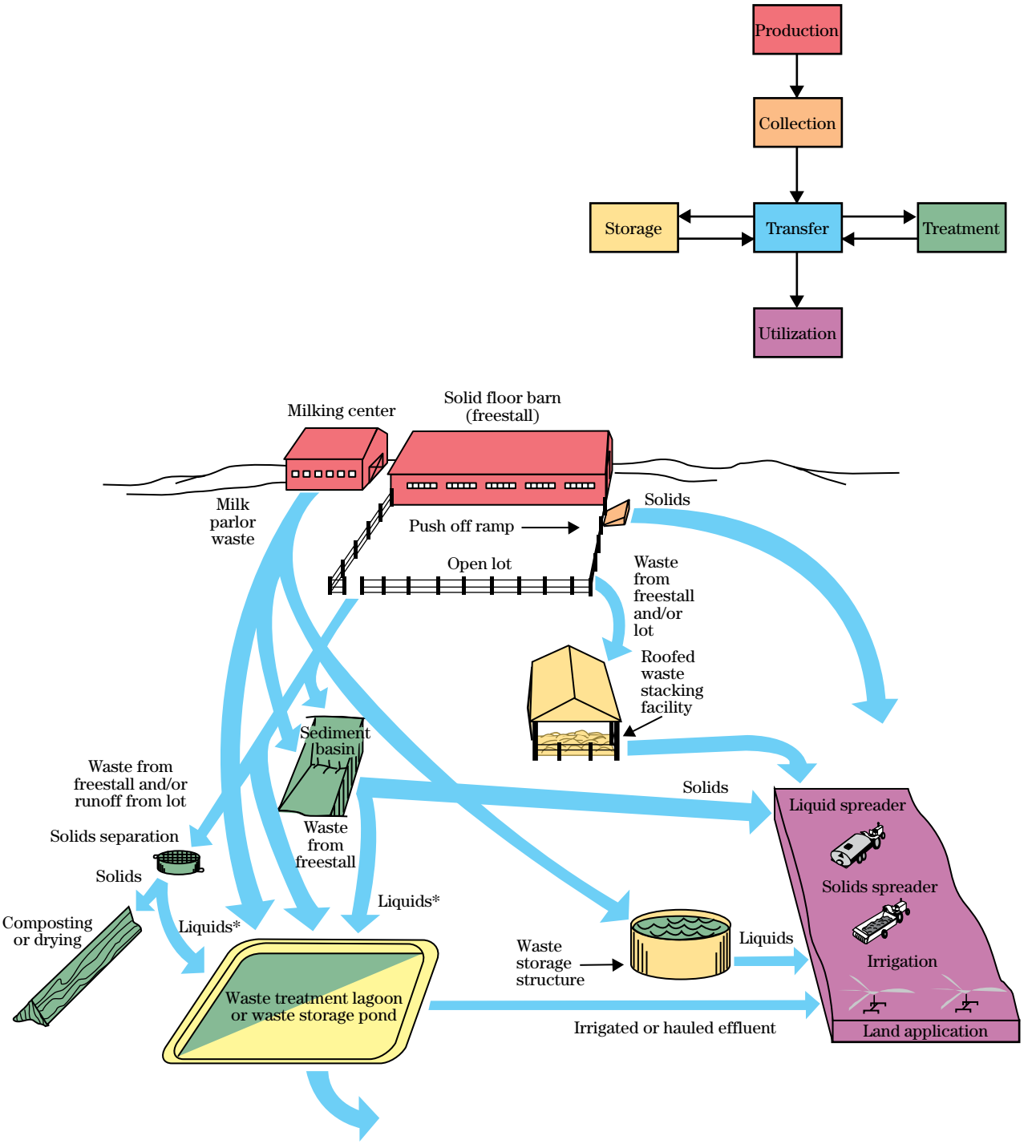
Figure 9–3 Waste handling options—dairy



*Liquids from lot runoff discharged to waste storage pond only

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Figure 9–4 Waste management for dairy or beef on pasture

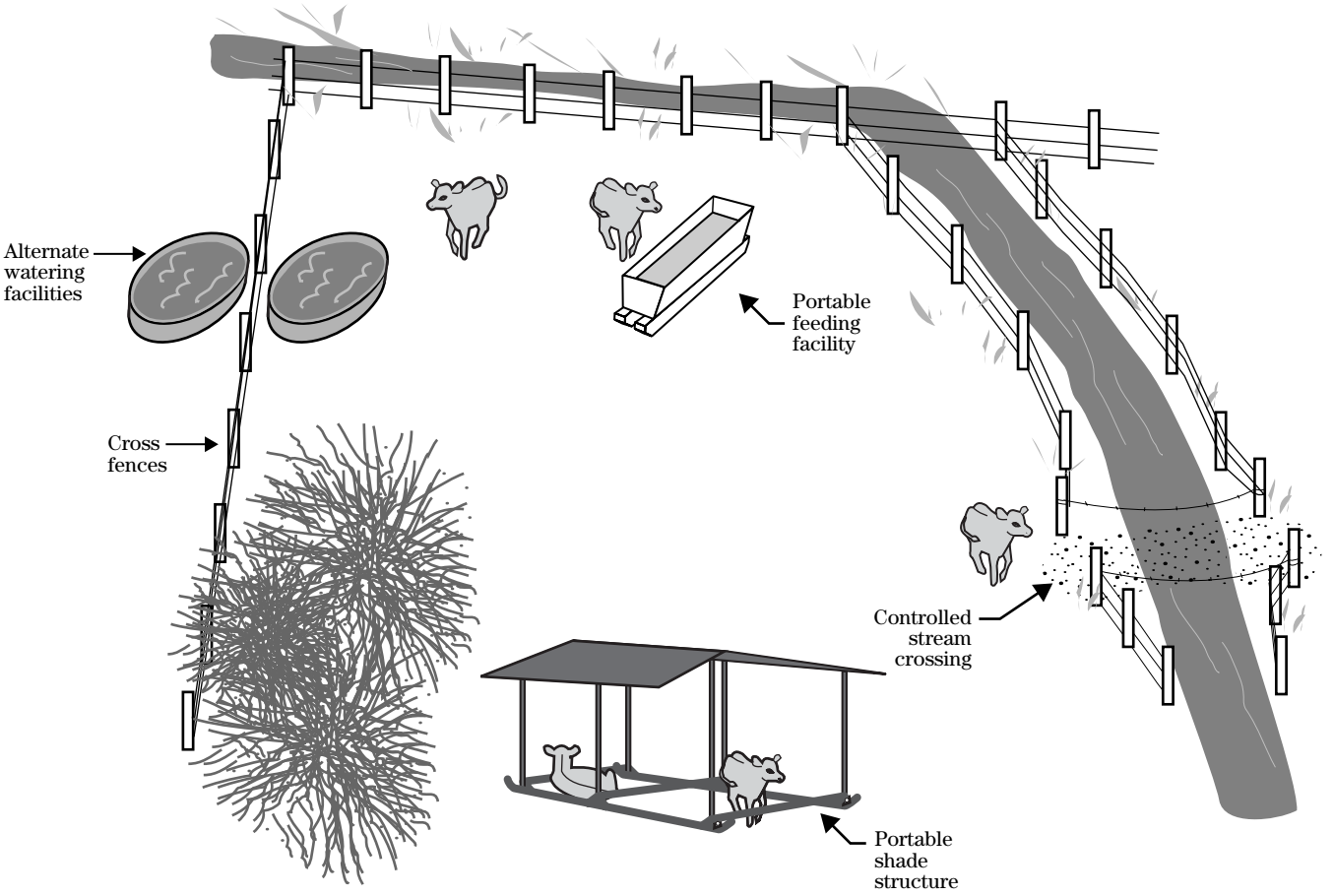

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Figure 9–5 Confinement area with curbing

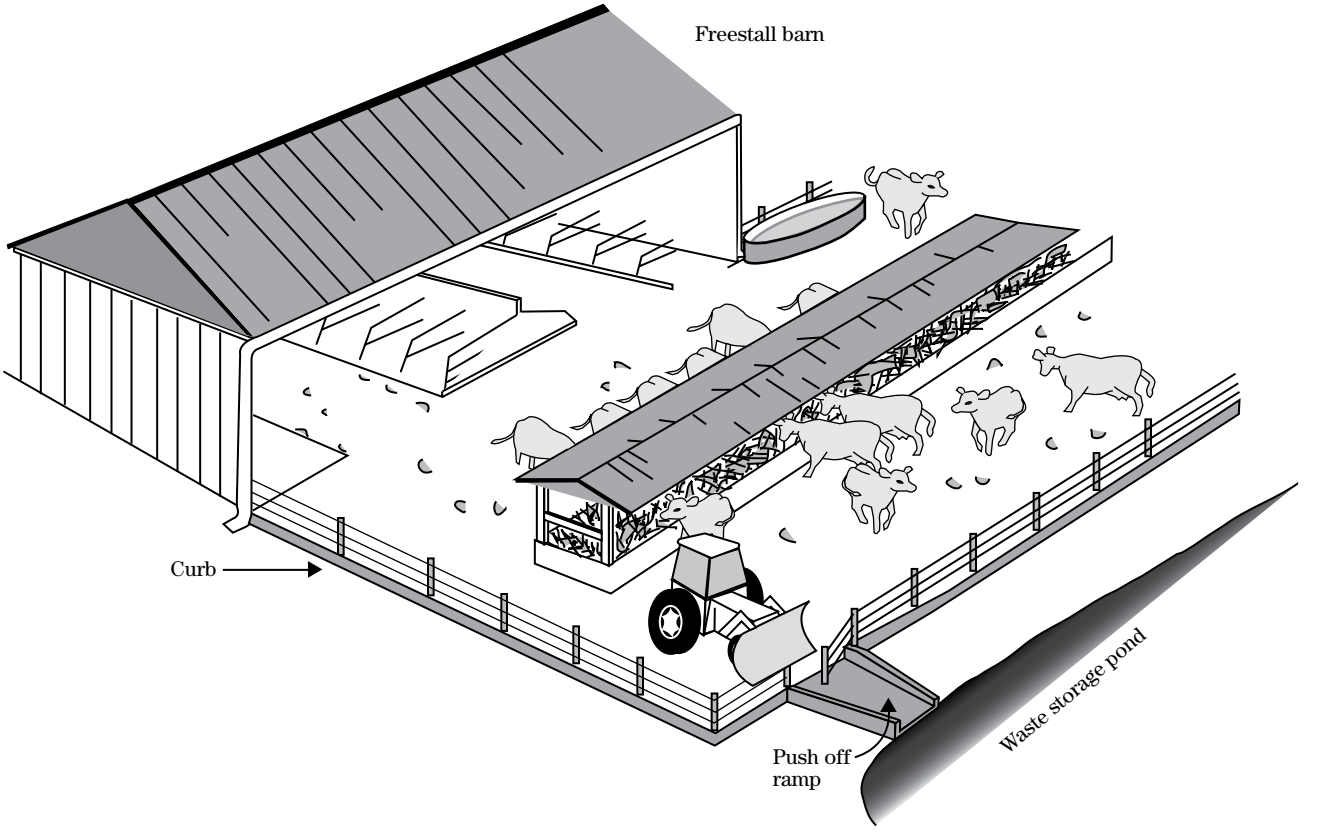

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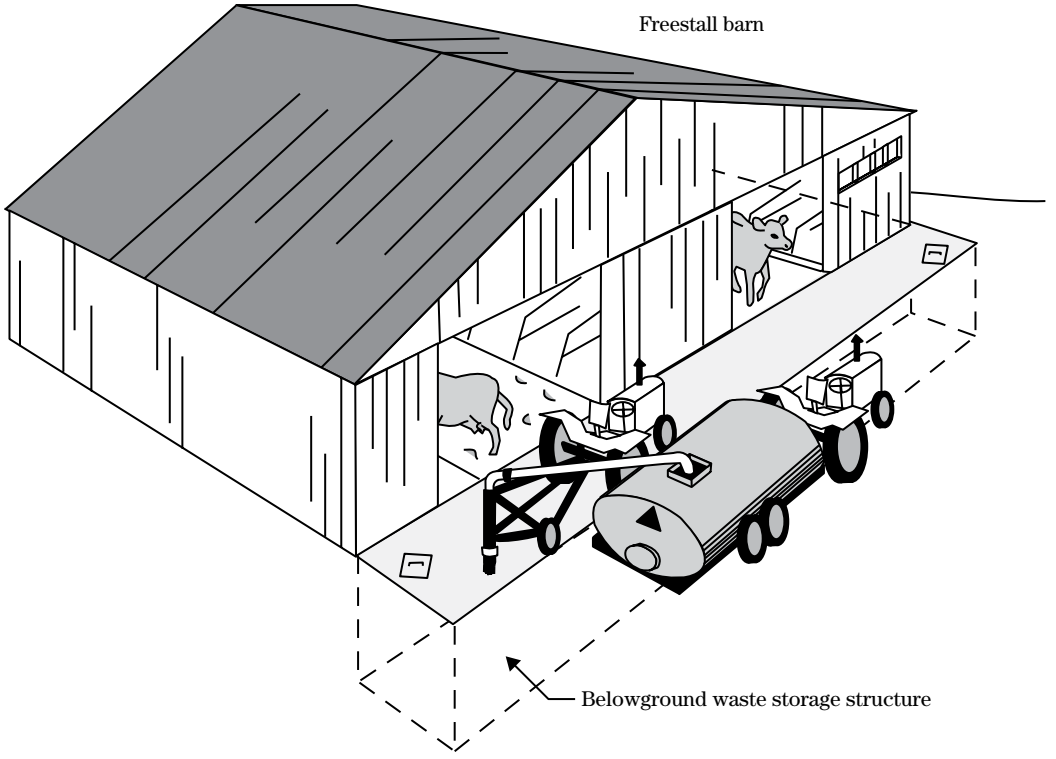
Figure 9–6 Tank wagon used to spread liquid wastes from belowground storage structure



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(4) Storage

Milking house waste and contaminated runoff must be stored as a liquid in a waste storage pond or structure. Manure may be stored as a slurry or liquid in a waste storage pond designed for that purpose or in a structural tank (figs. 9–7 and 9–8). It can be stored as a semisolid in an unroofed structure that allows for the drainage of excess water and runoff or as a solid in a dry stacking facility. In humid areas, the stacking facility should have a roof.

(5) Treatment

Liquid waste can be treated in an aerobic lagoon, anaerobic lagoon, or other suitable liquid waste treatment facilities. Solid material can be separated from the waste stream through various solid/liquid separation technologies. Energy production and odor abatement can be accomplished through anaerobic digestion or thermo-chemical conversion. Following solid/liquid separation, solids from the waste can be composted or used as bedding.

Figure 9–7 Aboveground waste storage structure

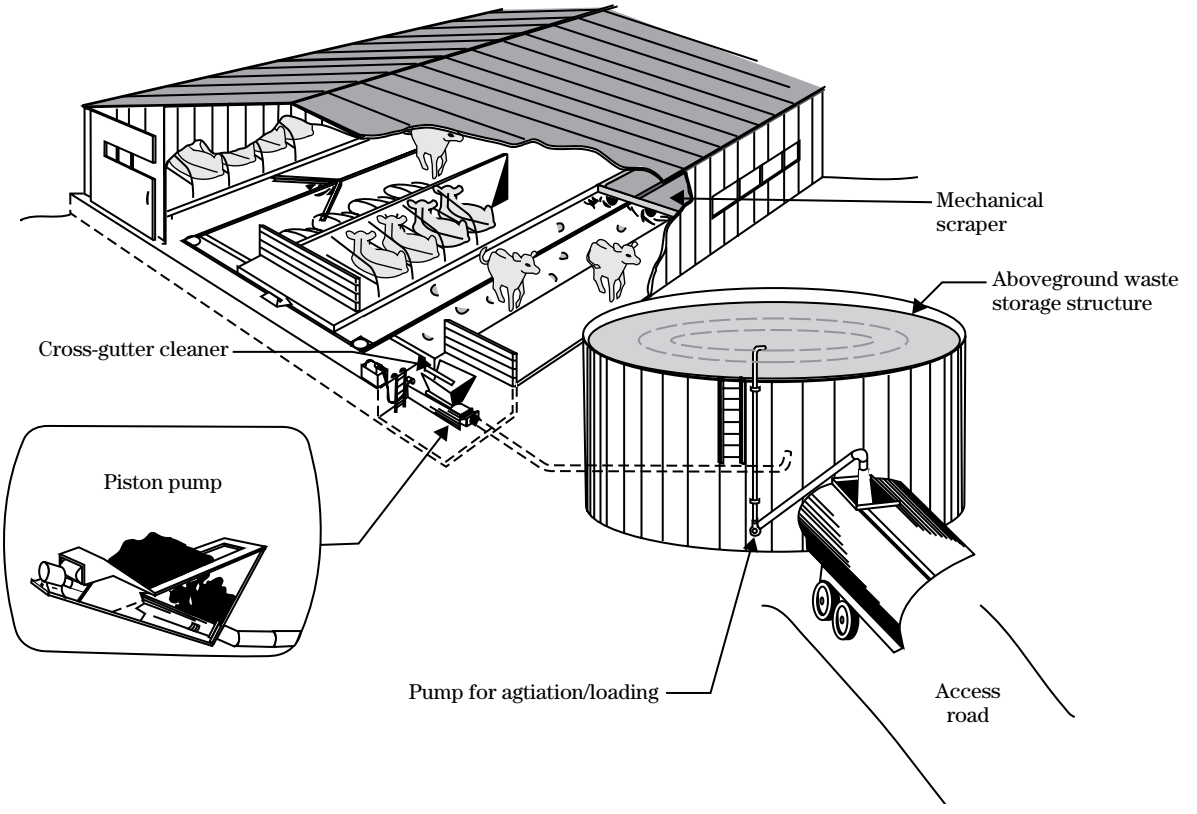

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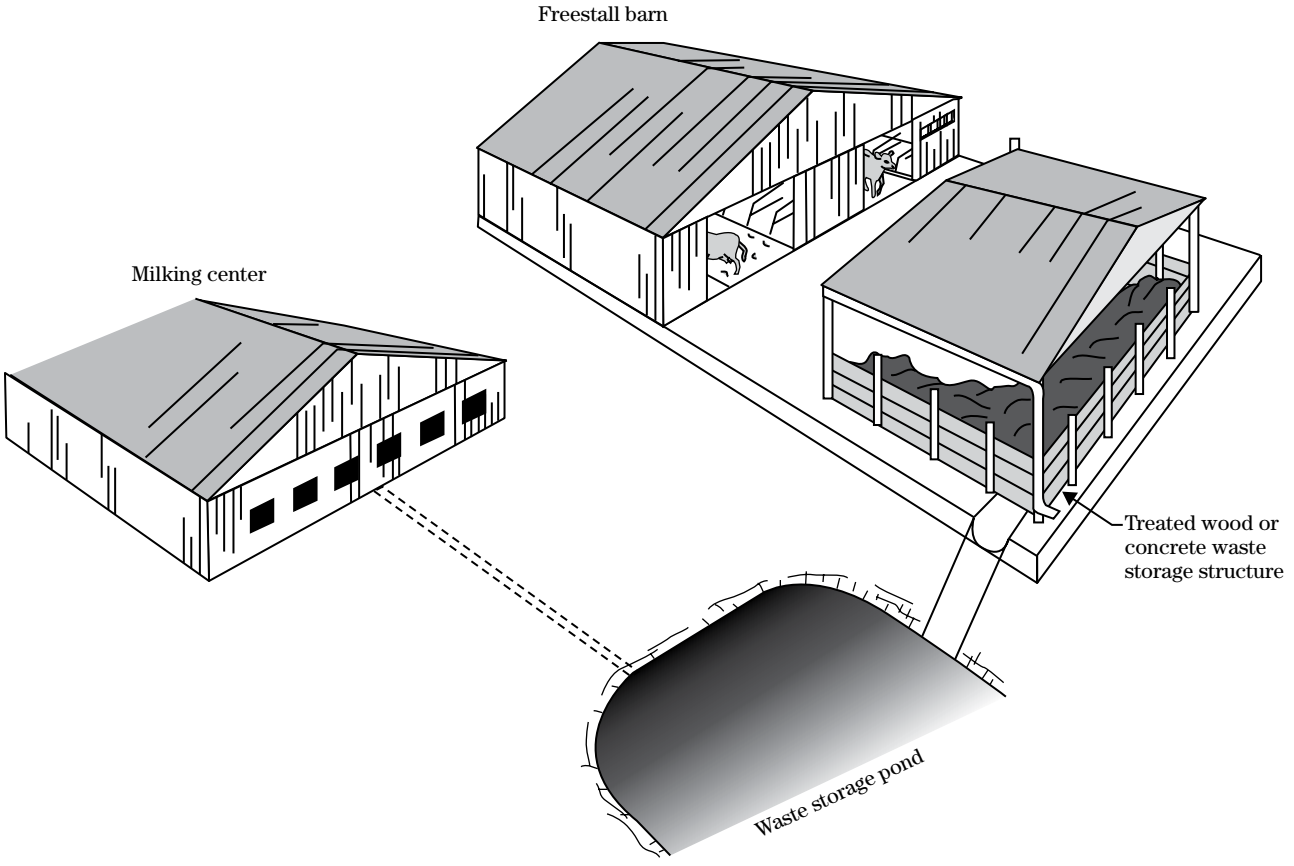
Figure 9–8 Storage facilities



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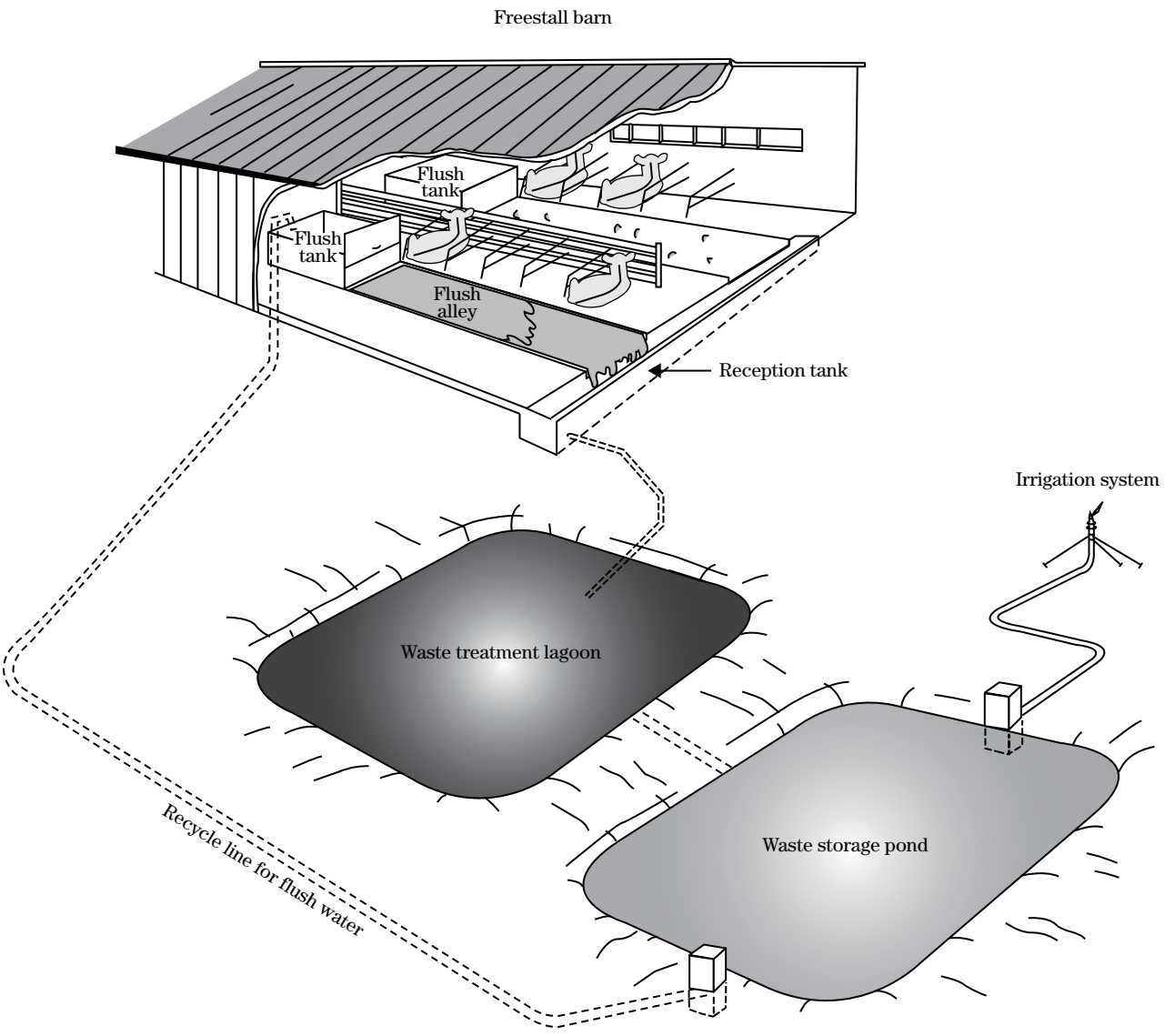
(6) Utilization

Dairy waste is used as bedding for livestock, marketed as compost, and used as an energy source, but the most common form of utilization is through land application. Waste may be hauled and distributed over the land in a dry or liquid manure spreader. Liquid waste can be distributed through an irrigation system. Slurries may be distributed through an irrigation system equipped with nozzles that have a large opening (fig. 9–9).

Figure 9–9 Freestall barn with flushing alleyway and irrigation system



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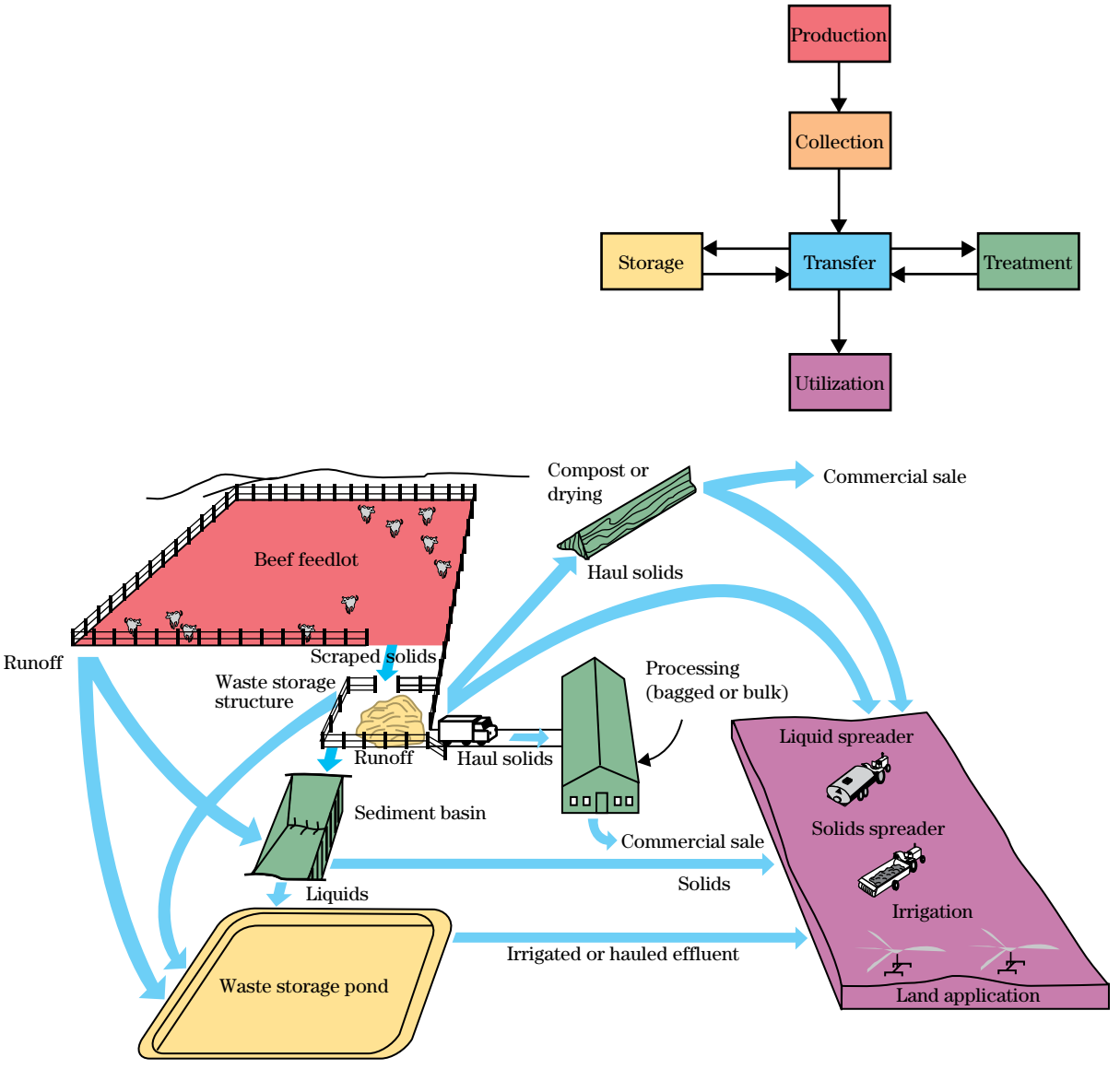
(b) Beef waste management systems

Beef brood cows and calves less than a year old are usually held on pastures or range. The calves are then finished in confined feeding facilities. While the animals are on pastures, their waste should not become a resource concern if the stocking rates are not excessive and the grazing is evenly distributed. To prevent waste from accumulating in feeding, watering, and shade areas, the feeding facilities can be moved, the number of watering facilities can be increased, and the livestock can be rotated between pastures. To reduce deposition of waste in streambeds, access to the stream may be restricted to stable stream crossings and access points. Figure 9–10 shows a typical beef feedlot operation.

Figure 9–10 Waste handling options—beef



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(1) Production

Waste associated with confined beef operations include manure, bedding, and contaminated runoff.

(2) Collection

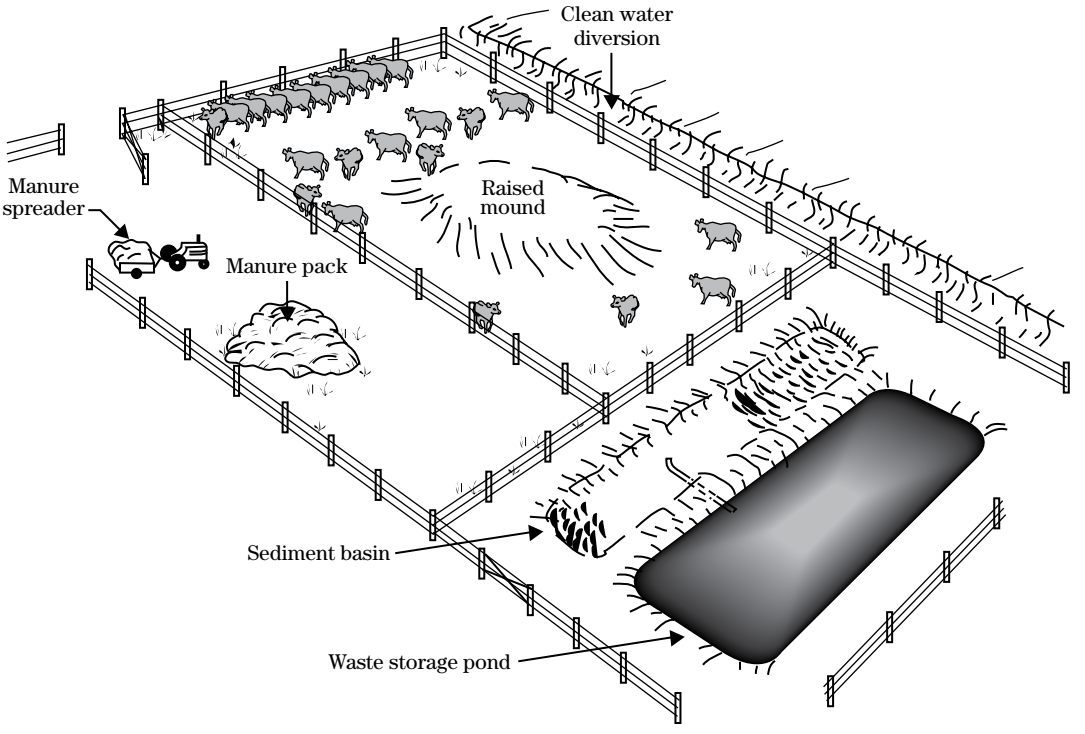
Beef cattle can be confined on unpaved (fig. 9–11), partly paved, or totally paved lots. If the cattle are concentrated near wells, adequate protection must be provided to prevent well contamination. Because much of the waste is deposited around watering and feeding facilities, paving these areas, which allows frequent scraping, may be desirable.

On unpaved lots, livestock traffic may cause the soild surface to seal, preventing the downward movement of contaminated water. Depending on soil characteristics, soil enhancements or amendments may be required to eliminate the leaching potential that could lead to water quality concerns. Care must be taken when removing manure from these lots so that damage to this seal is minimized. The seal tends to break down after livestock are removed from the lot. To prevent possible contamination of groundwater resources, all the manure should be removed from an abandoned lot.

Unroofed confinement areas must have a system for collecting and confining contaminated runoff. On unpaved lots the runoff can be controlled by using diversions, sediment basins, and underground outlets. Paved lots generally produce more runoff than unpaved lots, but curbs at the edge of the lots and reception pits where the runoff exits the lots help to control the runoff. Solid/liquid separators or settling basins can be used to recover some of the solids in the runoff. The volume of runoff can be reduced by limiting the size of the confinement area, and uncontaminated runoff can be excluded by use of diversions.

The manure in confinement areas that have a roof can be collected and stored as a solid. It may also be collected as a solid or semisolid from open lots where the manure is removed daily and from open lots in a dry climate.

Figure 9–11 Waste collection from an unpaved beef feedlot



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(3) Transfer

The method used to transfer the waste depends largely on the consistency of the waste. Liquid waste and slurries can be transferred through open channels or pipes or in a portable liquid tank. Pumps can be used as needed. Solids and semisolids may be transferred by using mechanical conveyance equipment, by pushing the waste down curbed concrete alleys, and by transporting the waste in solid manure spreaders. Piston pumps or air pressure can be used to transfer semisolid waste through large pipes.

(4) Storage

Manure can be stored as a bedded pack in the confinement area if bedding is added in sufficient quantities. Manure removed from the confinement area can be stored as a liquid or slurry in an earthen pond or a structural tank, as a semisolid in an unroofed structure that allows drainage of excess water and runoff to a waste storage pond, or as a solid in a dry stacking facility designed for storage. In areas of high precipitation, dry stacking facilities should be roofed (fig. 9–12). Contaminated runoff must be stored as a liquid in a waste storage pond or structure.

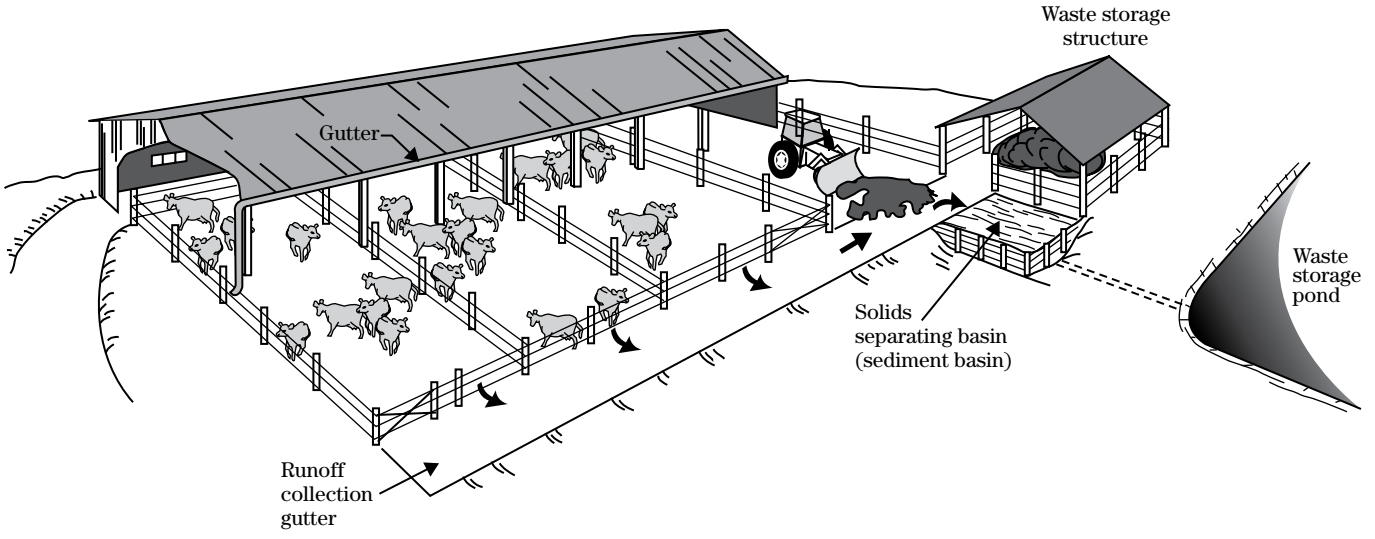
(5) Treatment

Treatment of the waste in a lagoon is difficult for some livestock systems because of the volume of solids in the waste, but many of the solids can be removed with settling basins or mechanical solid/liquid separators. Liquid waste may be treated in an aerobic lagoon, an anaerobic lagoon, or other suitable liquid waste treatment facilities. Solid waste can be composted.

(6) Utilization

Beef cattle waste can be used as bedding for livestock, as an energy source, or it can be marketed as compost, but the most common form of utilization is land application. The waste can be hauled and distributed over the land in appropriate spreading devices. Liquid waste can be distributed through an irrigation system, and slurries can be applied using irrigation equipment with nozzles that have a large opening.

Figure 9–12 Storage facilities for wastes from paved feedlot in high precipitation area



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(c) Swine waste management systems

Swine are typically raised in total confinement. Open systems (pastures and woodlots) and feedlot systems are less common than in the past, but are still used in swine production for specialty markets and on small farms and sometimes in combination with partial confinement (fig. 9–13).

Raising hogs in an open system may appear to have a low initial investment, but often results in animal health and pollution control problems. Even if sufficient land is available, hogs tend to congregate and concentrate their waste. This can be prevented by moving the feeding, watering, and housing facilities and by rotating the hogs through a series of open lots. Hogs raised in an open system should not have unrestricted access to streams. Runoff is difficult to manage in an open system because of the large area and topographic limitations. Rather than invest the capital and time necessary to install and manage an extensive runoff management system, it may be more efficient to convert to a more concentrated operation.

Manure in feedlot systems can be handled as a solid if the feedlots are cleaned regularly, sufficient bedding is added to the manure, and the collected manure is protected from excessive precipitation. It can also be handled as a slurry or liquid, but measures must be taken to manage contaminated runoff (fig. 9–14). Total confinement systems eliminate the need to manage contaminated runoff and may allow for more automation in waste management. Waste from these types of operations is nearly always handled as a liquid with either temporary or permanent storage under the production facility. Longer term storage and/or treatment is often handled in an adjacent anaerobic lagoon or holding pond.

Undesirable odors are often associated with swine operations. A swine waste management system should incorporate odor control measures where possible. A clean, neat appearance; efficient management system (fig. 9–15); and positive public relations with those affected by the odors eliminates many complaints.

(1) Production

Waste associated with swine operations include manure and possibly contaminated runoff. In some systems, provisions must be made to manage flush water. Hogs tend to play with watering and feeding facilities, which can add to the waste load. The disposal of dead pigs may be a resource concern in some operations.

(2) Collection

Swine manure can be collected by scraping or flushing. Scraped manure is collected as a solid or slurry, and flushed manure must be handled as a liquid. The flush water should be recycled if possible so that the volume of contaminated water is kept to a minimum. The collection process can use automated equipment, or it can be as simple as raising swine on slatted floors over waste storage pits (fig. 9–16).

(3) Transfer

The method used to transfer the waste depends largely on the consistency of the waste. Liquid waste and slurries may be transferred through open channels, pipes, or in a portable liquid tank. Pumps can transfer liquid waste as needed. Solids and semisolids can be transferred by mechanical conveyance equipment. Piston pumps or air pressure can be used to transfer semisolid waste through smooth pipes.

(4) Storage

Swine manure can be stored as a solid, slurry, or liquid. If stored as a solid, it should be protected from precipitation. Above or belowground tanks (fig. 9–17) or an earthen waste storage pond can be used to store slurries or liquid waste.

(5) Treatment

Liquid waste from a swine operation is commonly treated in an anaerobic lagoon (fig. 9–18), but it can also be treated in an aerobic lagoon or solid/liquid separation processes. Solid waste and swine mortalities can be composted.

(6) Utilization

Swine waste can be used as an energy source through anaerobic digestion or thermo-chemical conversion processes. With proper ventilation and sufficient bedding, the solid manure can be composted in confinement facilities, and the heat generated from the composting process can be used to supplement heat in the buildings.

The most common use of the nutrients in swine waste is through land application. The waste can be hauled and distributed over the land by spreading devices. If

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odors are a problem, liquid waste can be injected below the soil surface. It can also be distributed through an irrigation system. Slurries can be distributed through an irrigation system equipped with nozzles that have large openings.

Figure 9–13 Waste handling options—swine

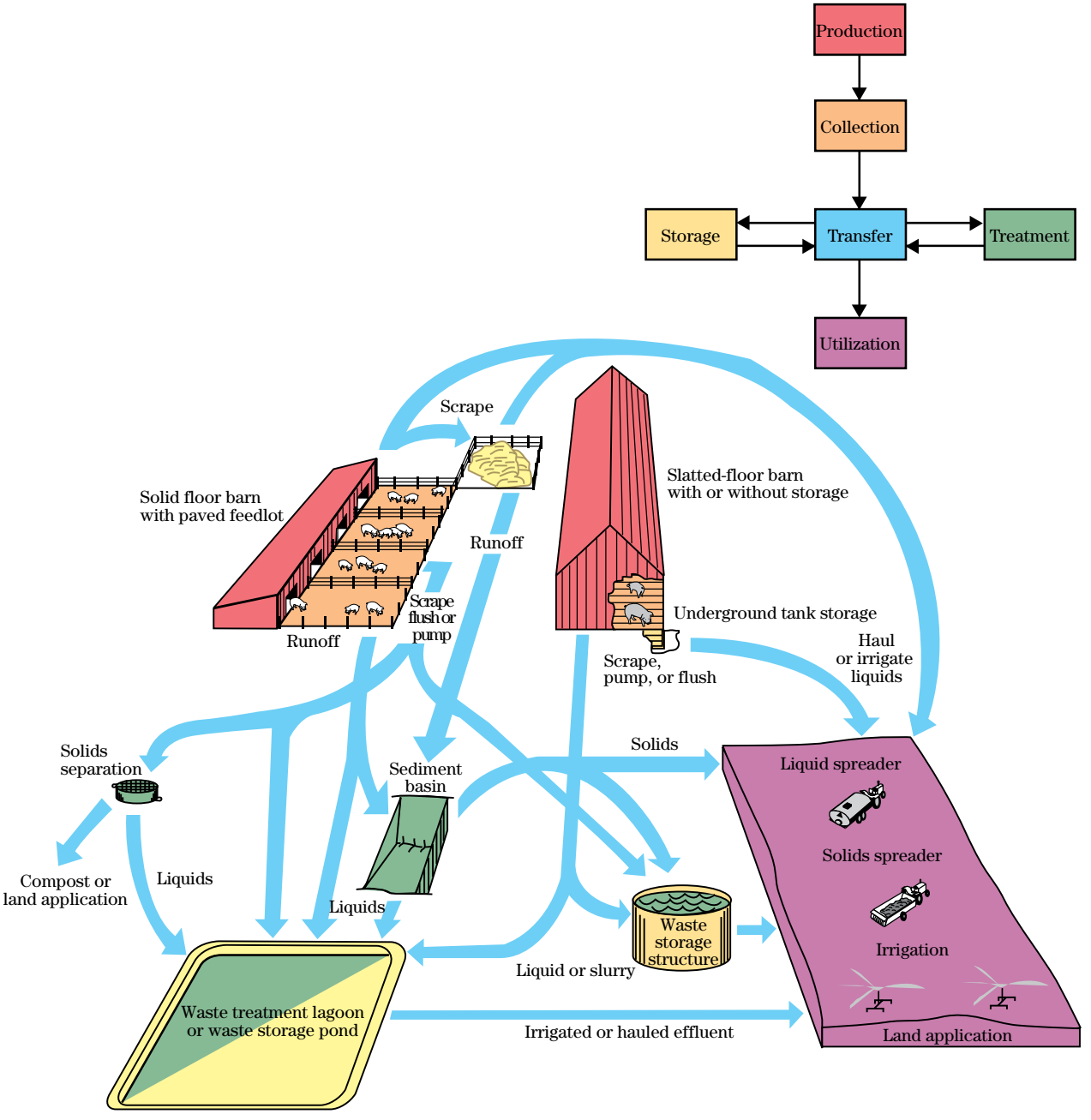

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Figure 9–14 Runoff control

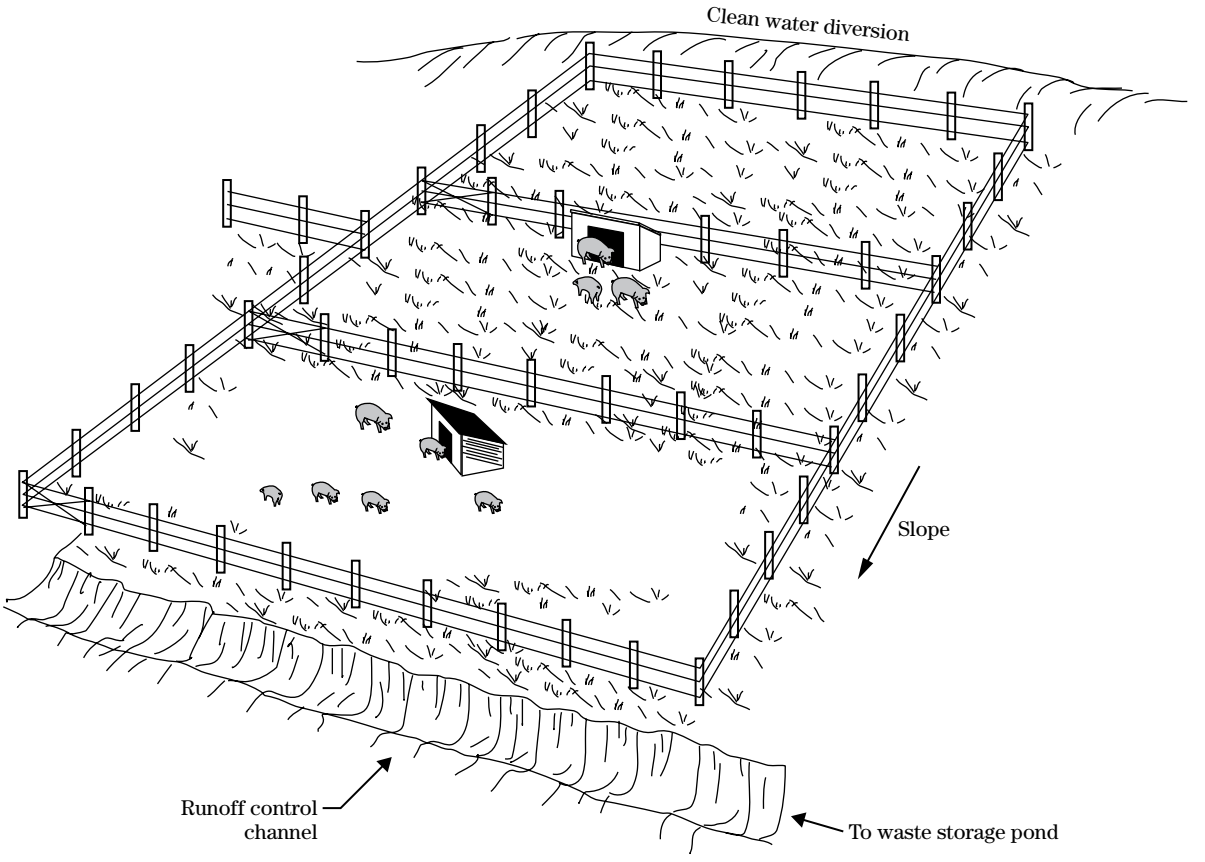

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Figure 9–15 Manure scraped and handled as a solid on paved lot operation

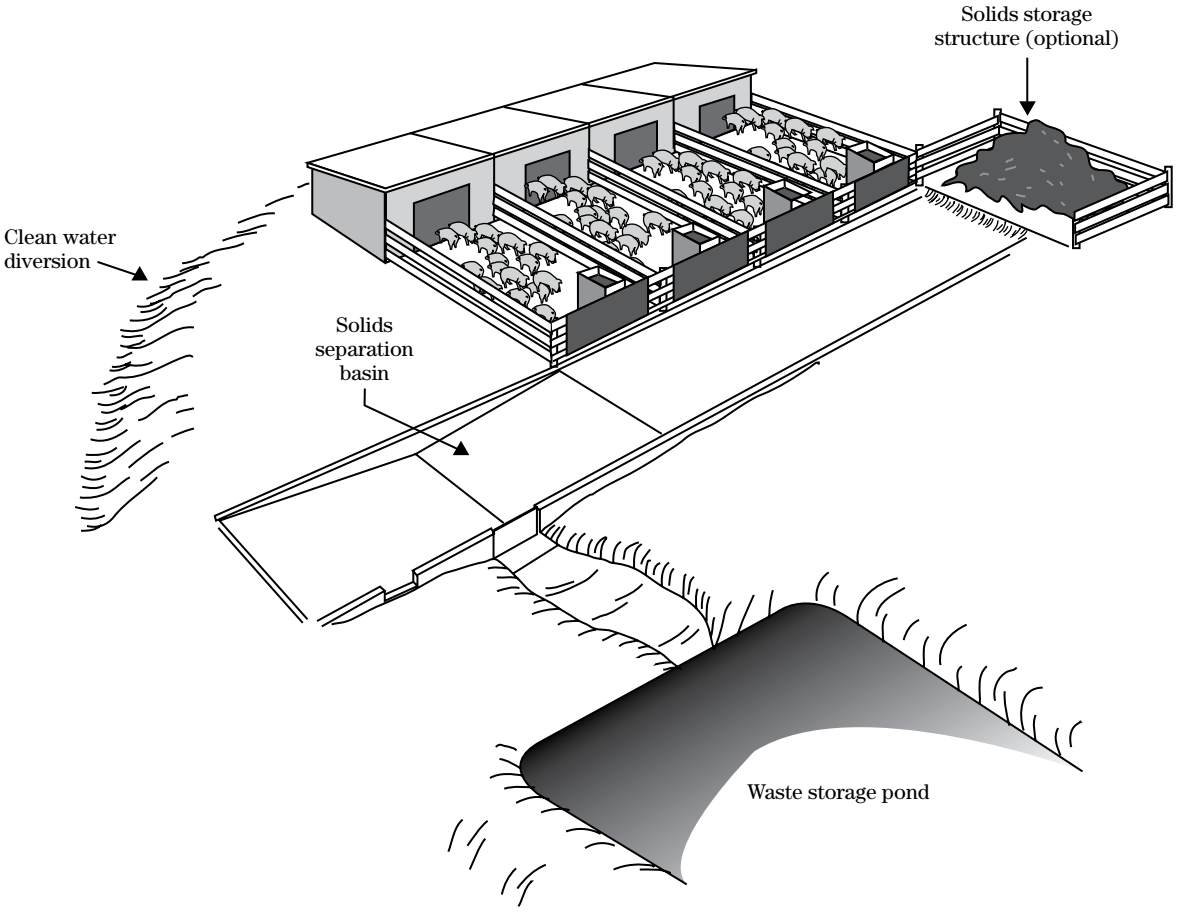

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Figure 9–16 Confined housing with farrowing crates, partly slatted floor, pit storage, and liquid manure handling

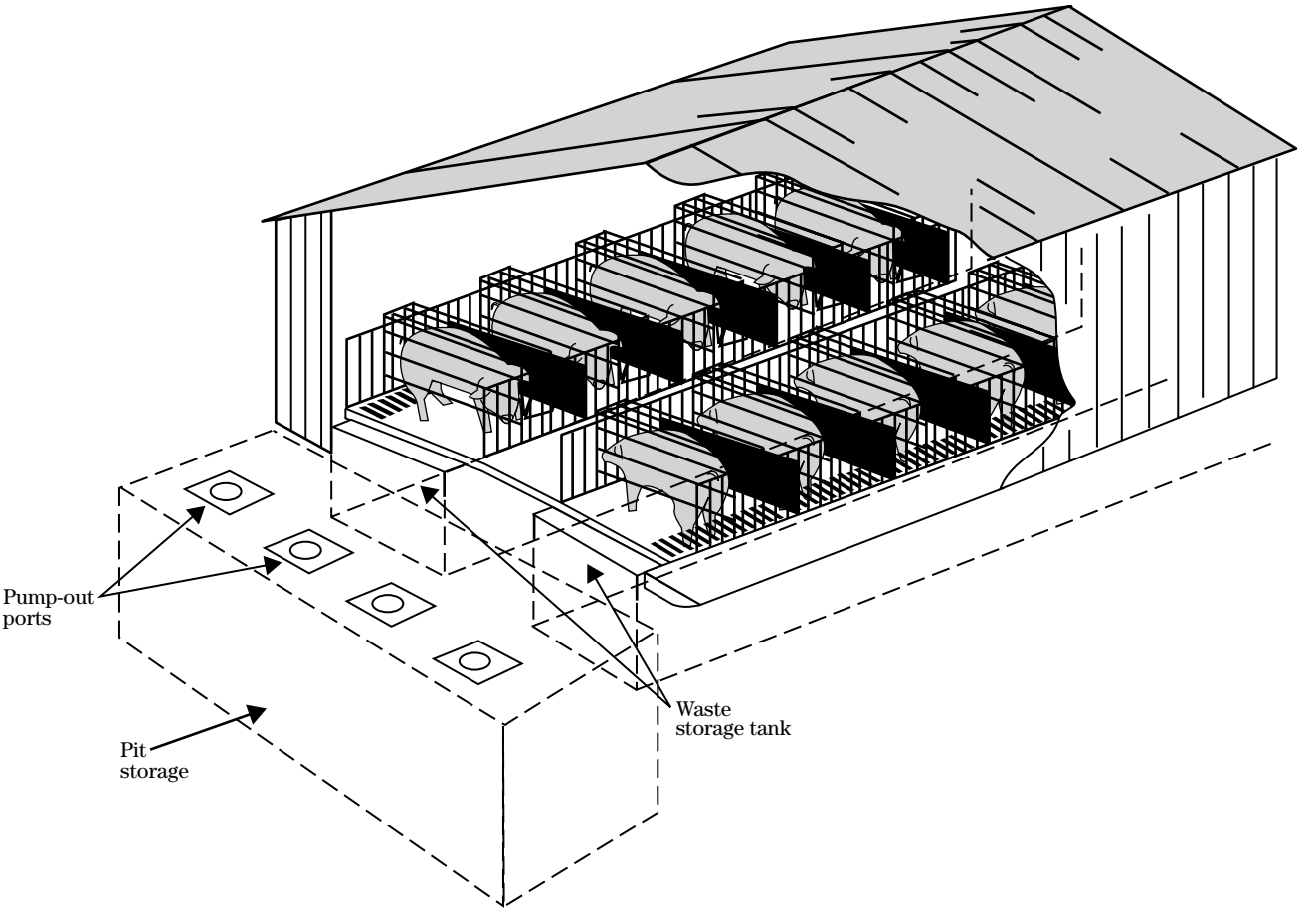

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Figure 9–17 Fed hogs in confined area with concrete floor and tank storage liquid manure handling

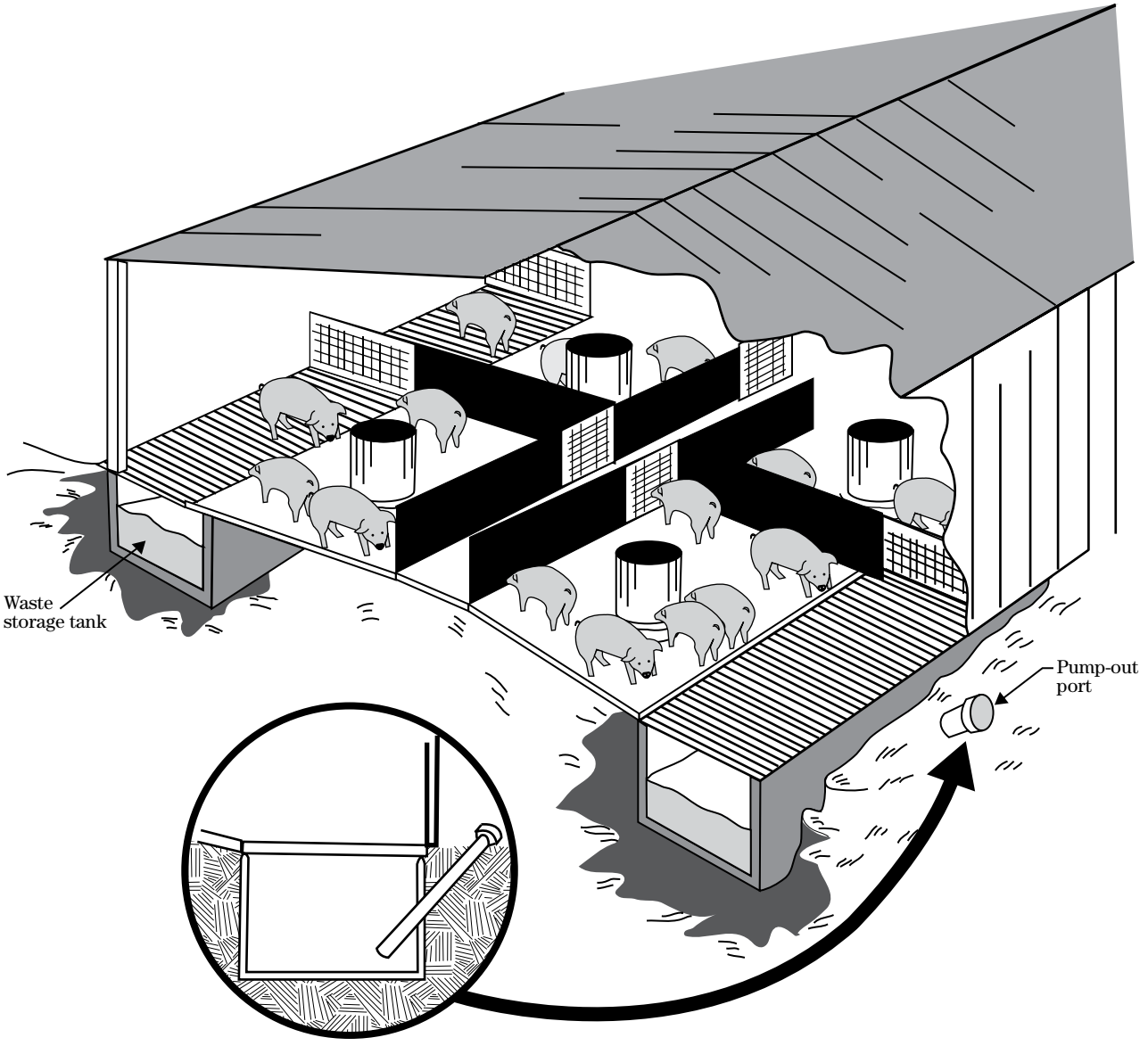

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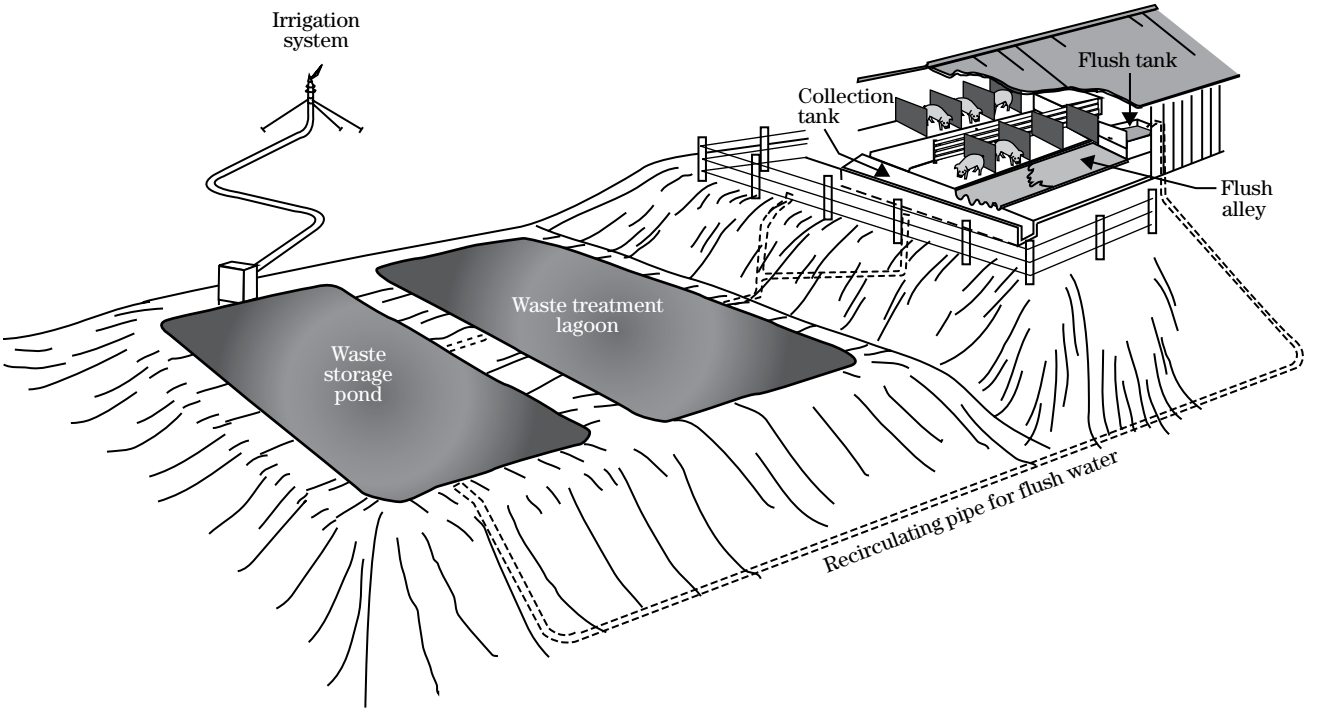
Figure 9–18 Two-stage anaerobic lagoon system for treatment of waste flushed from swine building



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(d) Poultry waste management systems

The two basic poultry confinement facilities include those to raise turkeys and broilers used for meat (fig. 9–19) and those to house layers. Broilers and young turkeys are grown on a bed of litter shavings (fig. 9–20), sawdust, or peanut hulls. Layers are generally confined to cages. Fly control around layers is important to prevent spotting of the eggs. Disease control is important in both systems.

(1) Production

Waste associated with poultry operations includes manure and dead poultry. Depending upon the system, waste can also include litter, wash-flush water, and wasted feed.

(2) Collection

The manure from broiler and turkey operations is allowed to accumulate on the floor where it is mixed with the litter. Near watering facilities the manure-litter pack forms a "cake" that generally is removed between flocks. The rest of the litter pack generally has low moisture content and is removed once a year in the spring. The litter pack can be removed more frequently to prevent disease transfer between flocks.

In layer houses, the manure that drops below the cage collects in deep stacks (fig. 9–21) or is removed frequently using either a shallow pit located beneath the cages for flushing or scraping or belt scrapers positioned directly beneath the cages.

(3) Transfer

The method used to transfer the waste depends on the TS content of the waste. Liquid waste can be transferred in pipes, gutters, or tank wagons, and dried litter can be scraped (fig. 9–22), loaded, and hauled as a solid. If the distances between the poultry houses and the fields for application are great, the litter may need to be transported in a truck.

(4) Storage

Litter from broiler and turkey operations is stored on the floor of the housing facility (fig. 9–23). When it is removed, it can be transported directly to the field for land application. If field conditions are not suitable or spreading is delayed for other reasons, the litter must be stored outside the housing facility. In some areas, the litter may be compacted in a pile and stored in the open for a limited time; however, it generally is better to cover the manure with a plastic or other waterproof cover until the litter can be used. If the spreading is to be delayed for an extended period of time, the litter should be stored in a roofed facility.

If the manure from layer operations is kept reasonably dry, it can be stored in a roofed facility. If it is wet, it should be stored in a structural tank or an earthen storage pond.

(5) Treatment

Litter amendments have been successfully used in poultry houses to reduce ammonia emissions. Studies have shown that amendments improve animal health, increase production, and improve working conditions.

Broiler and turkey litter can be composted. This stabilizes the litter into a relatively odorless mass that is easier to market and also helps to kill disease organisms so that the litter can be reused as bedding or sold commercially. The litter can also be dried and thermally converted as a renewable energy source.

Liquid manure may be placed into an anaerobic digester to produce methane gas, or it can be treated in a lagoon. The high volatile solid content of the layer manure may require an anaerobic lagoon of considerable size.

(6) Utilization

The waste from poultry facilities can be applied to the land. If the owners of the poultry houses do not have enough land suitable for application, they should arrange to apply the waste to their neighbors' land. Because of the high nutrient value of the litter, many landowners are willing to pay for the litter to be spread on their land. Poultry litter spread on the surface may be subject to transport from runoff during heavy rainfall events. Special equipment is being developed that will inject litter preventing its movement from the application area.

Whether on the owner's land or the neighbor's land, the waste must be spread according to an appropriate nutrient management plan. Poultry waste can also be used for the production of methane gas, thermally converted as a fuel source, or reused as bedding.

(7) Dead poultry disposal

Because of the large numbers of mortalities associated with large poultry operations, the disposal of dead birds is a resource concern. Poultry facilities

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Figure 9–19 Waste handling options—poultry

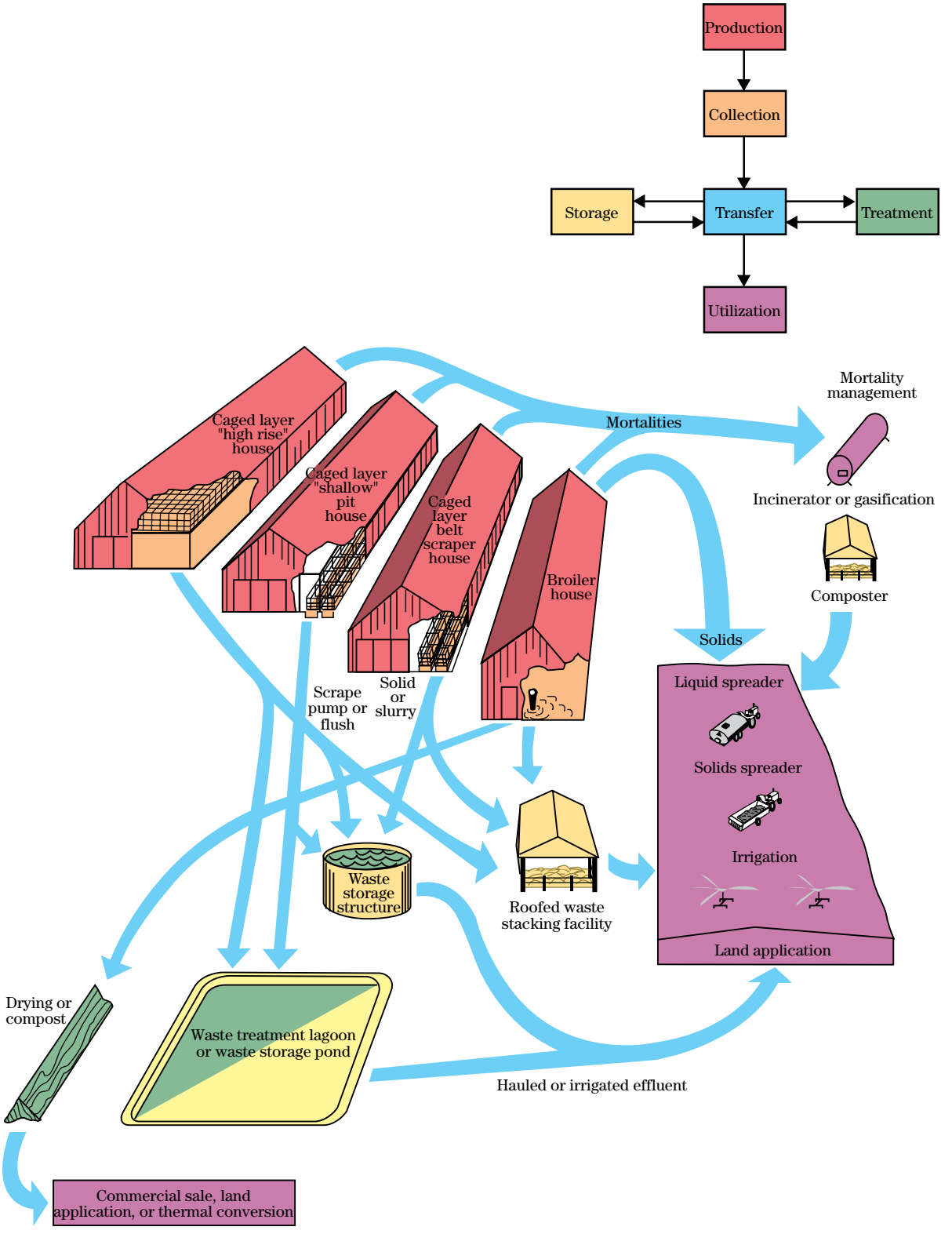

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Figure 9–20 Litter system for broilers and turkeys

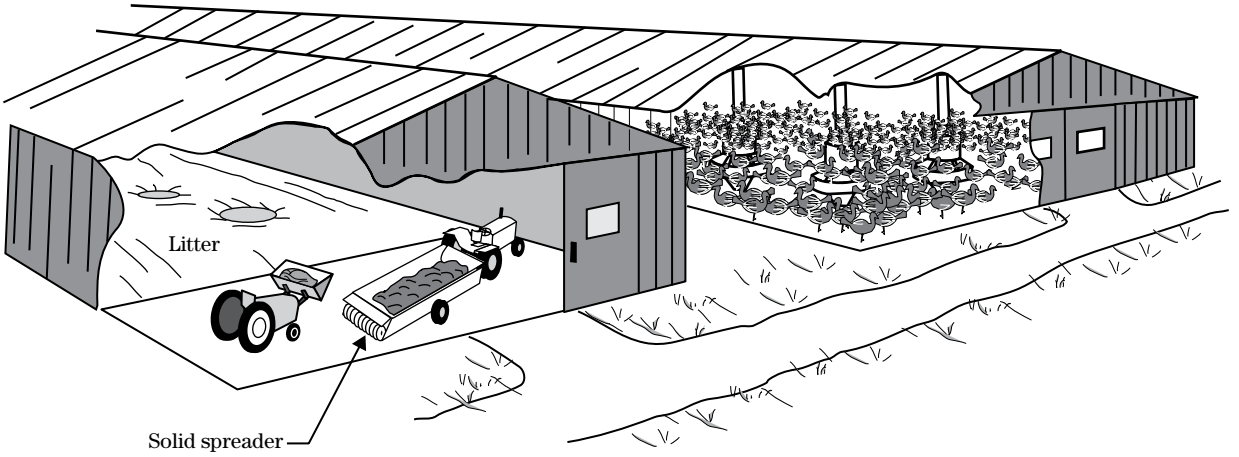

Figure 9–21 Manure accumulates under cages in “high rise” house for layers

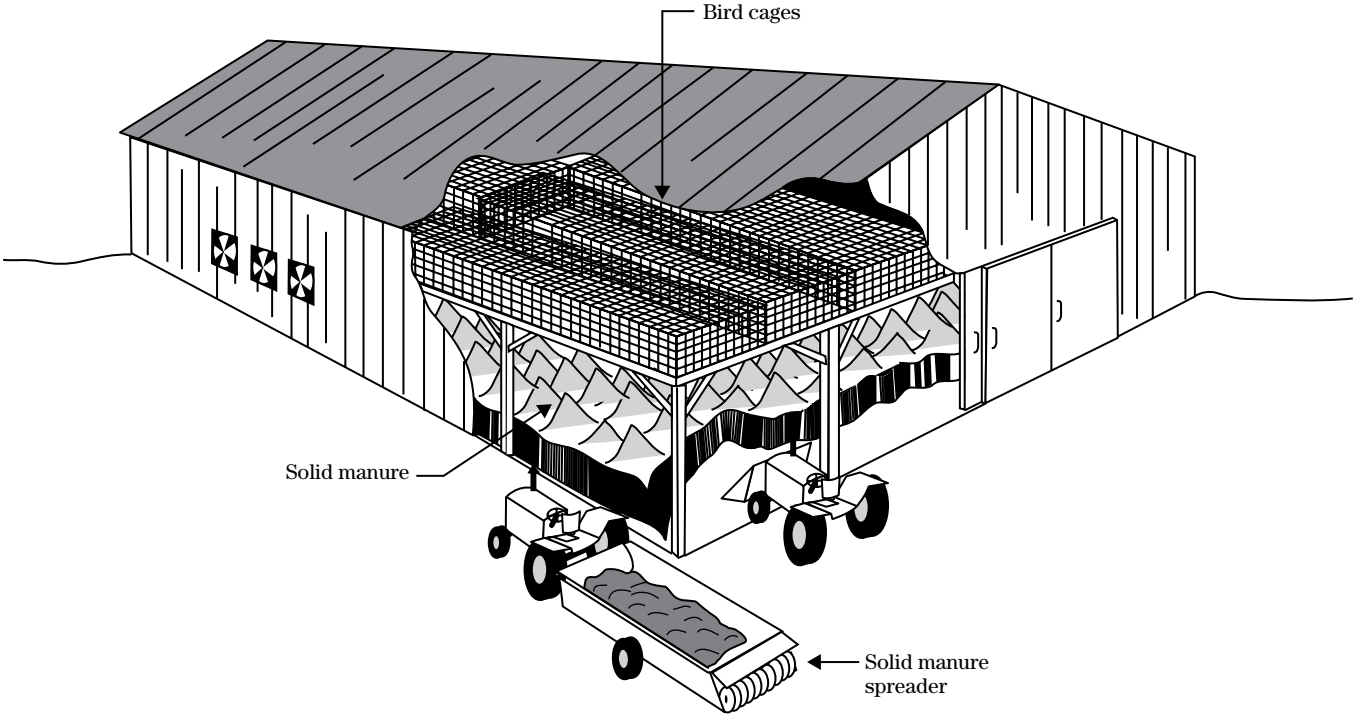

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Figure 9–22 Solid waste may be scraped regularly (possibly by mechanical scraper) from facility for transport to the field

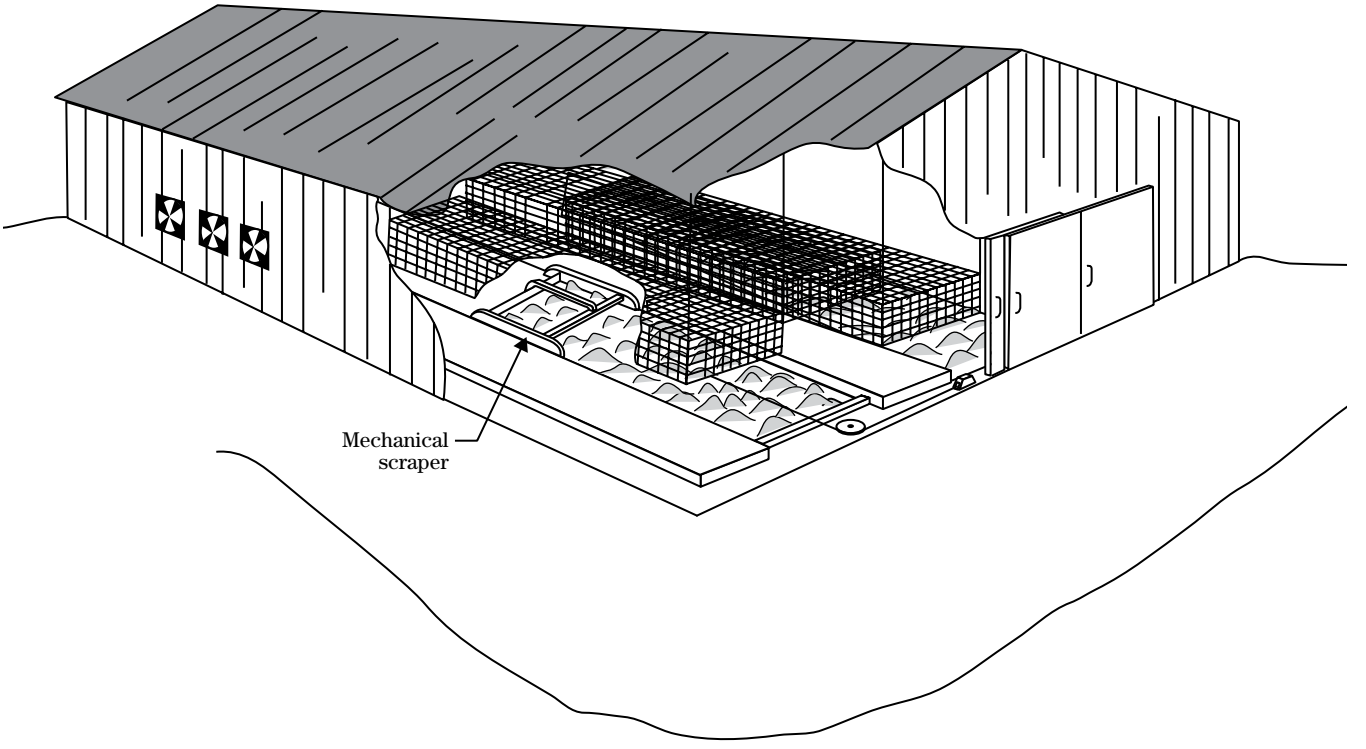
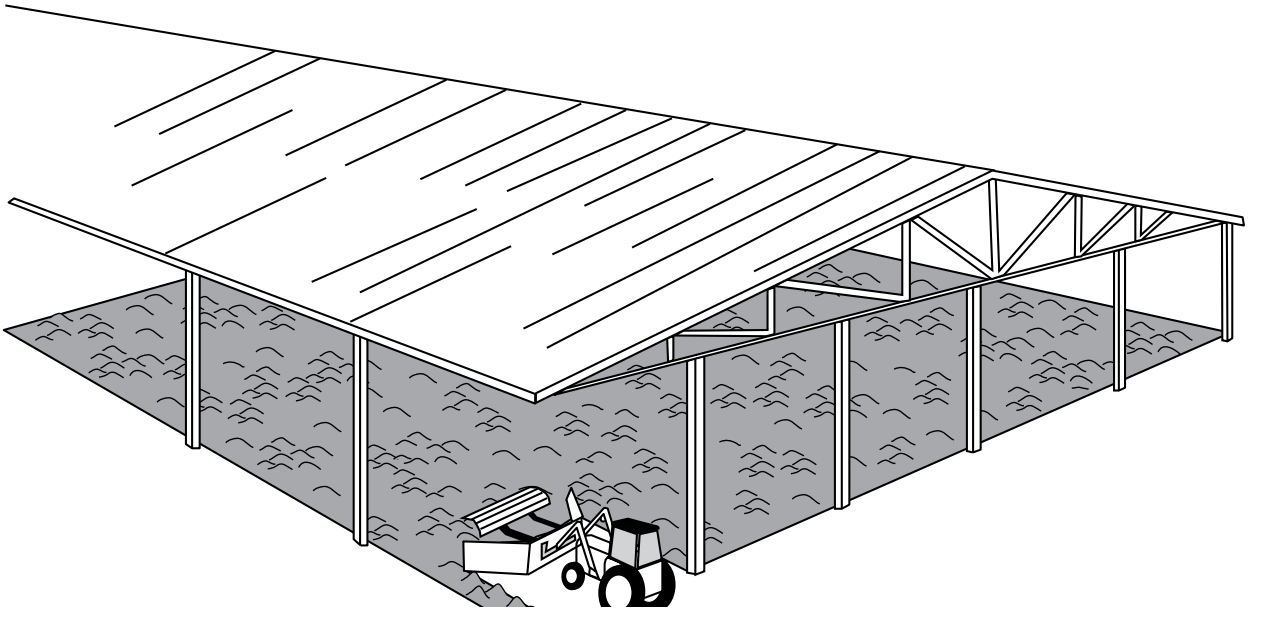


Figure 9–23 Litter from poultry operations may be stored on the floor of the facility until scraped after several cycles of birds



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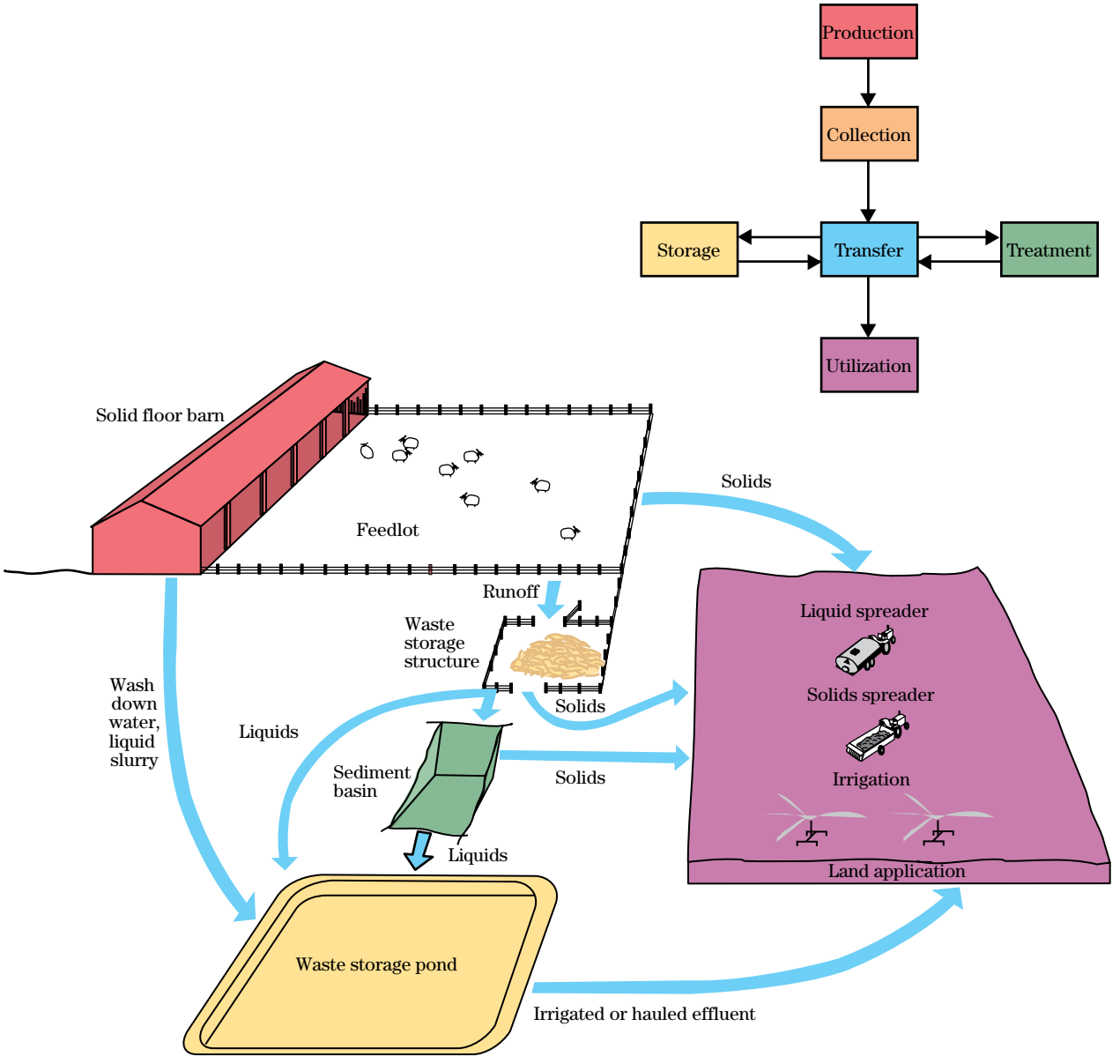
must have adequate means for disposal of dead birds in a sanitary manner. To prevent spread of disease, the dead birds are often collected daily by hand. Disposal alternatives include incineration, rendering, burial, or composting. The dead birds are mixed with litter and straw, composted, and the finished material is stored until it can be applied to the land.

(e) Other animals

(1) Sheep and goat waste management systems

Sheep or goats produced in confinement are grown either in feedlots or pasture (fig. 9–24). Their manure can be managed as a solid material. Where the animals are on pasture, waste management includes controlling stocking rates and periodic pasture renovation. In

Figure 9–24 Waste handling options—sheep



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feedlots, the manure is periodically removed by scraping for immediate land application, storage in a solid manure storage facility, or treatment in a lagoon.

(2) Horse waste management systems
Management of a horse operation near urban areas must include methods to keep flies and odors to a minimum. Horses are housed in confinement in paddocks or they are on pasture. Horse paddocks or stalls receive liberal amounts of bedding; therefore, most horse manure is handled as a solid. It should be removed from stalls daily, if possible, and can be land applied, stored in solid manure storage structures, or processed by composting. Some precautions should be taken if the manure is land applied to pastures because this can result in internal parasites spreading to other horses. The manure can be used in gardens, greenhouses, nurseries, and by mushroom growers.

(3) Veal waste management systems
Veal calves are produced using a liquid diet; therefore, their manure is highly liquid. It is typically removed from housing facilities by scraping or flushing from collection channels. The manure is then flushed or pumped into either liquid waste storage structures or ponds or into lagoons.

(4) Small animals
Small animals include dogs, cats, rabbits, commercial fur-bearing animals, and laboratory animals. Keeping waste material dry and regular clean-out and disposal of waste help to prevent odor and pest problems. The system should not allow the accumulation of waste materials that can become breeding, feeding, or nesting sites for rodents or insects. Waste from small animals may contain disease organisms that can be transmitted to humans.

(f) Municipal and industrial sludge and wastewater application systems

The land application of sludge is regulated by State, Federal, and, in some cases, local laws. Only sludge that meets certain criteria regarding degree of treatment can be applied. Sludge must be treated to kill pathogens before it is land applied. The sludge and wastewater should not be stored on the farm, but should be applied immediately to the land.

Municipal sludge (and wastewater to a much smaller degree) contains heavy metals that can be detrimental to crops and human and livestock health. (See table 6–2 in chapter 6 of this handbook). The sludge needs to be analyzed for certain metals, such as mercury, lead, zinc, cadmium, and nickel. The annual application rate for cadmium is regulated. Specific cumulative applications for the life of the site have been established by the U.S. Environmental Protection Agency (EPA) for all of these metals. The application rates are dependent on the soil characteristics. State regulations should be consulted for specific metal loadings.

The production of certain crops, such as root crops, is prohibited on land receiving sludge. Because sludge and wastewater can have objectionable odors, caution should be exercised during application to minimize offensiveness.

(g) Food processing waste

Food processing facilities produce large amounts of waste, some of which are suitable for land application. Food processing waste can be solid, slurry, or liquid. The chemical properties of the waste must be determined before a waste handling system can be designed. If the waste is biological in nature, it can be treated and handled much the same as livestock waste.

Waste treatment lagoons can be used for some food processing waste. The material must be analyzed for its volatile solids content or its biochemical oxygen demand (BOD) concentration so that volumetric or areal loading rates can be determined. Because some canneries are seasonal, lagoons may need to be oversized to accept anticipated periodic heavy organic loading.

Co-mixing food waste with animal manure can significantly increase methane production in an anaerobic digester. Acceptable animal manure to food waste mixture ratios are regulated by each State.

State and local regulatory personnel must be contacted and necessary permits obtained before land application. Many permits require ongoing monitoring of groundwater and possibly soil and plant matter. Hydraulic loading is often ignored. If the site has a high water table or low permeability, the amount of water that can be applied generally is reduced. In some food processing waste, the level of salt is too high or the pH

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is too high or too low for land application. Most food processing waste land application sites should be designed by a professional who has experience in these type systems.

(h) Agricultural chemical waste management

Many agricultural enterprises use large amounts of agricultural chemicals. The use of these chemicals seems to increase as the cost of labor increases. With this increased usage comes the potential for surface and groundwater contamination as a result of improper storage of chemical residue, rinse water, and unused chemicals and the improper disposal of empty containers. State and local regulations should be considered before planning any chemical handling system.

The chemicals and solids in rinse water should be concentrated. This can be done by collecting the material in an evaporative pond. Once the sludge has dehydrated, it should be placed in a leakproof container. If possible, the container should be disposed of by local or State officials or by private businesses that specialize in this activity. Proper clothing and breathing equipment should be used when handling spent chemicals and sludge from settling/drying basins. Precaution should be taken to prevent animals and children from gaining access to such facilities.

Rinse water may be collected in belowground pits. This liquid can then be used as a part of the make-up water when the chemical is needed again. Separate storages are needed for different chemicals.

Purchase and use only the amount of material actually needed. This requires accurate determination of the amount of pesticide solution needed and careful calibration and operation of application equipment. Once a chemical solution is prepared, all of the material needs to be used for the purpose intended. This reduces the amount of waste material to be processed.

Chemical containers can be disposed of properly in one of two ways. They can be turned over to authorities or businesses that have the responsibility of handling them, or they can be buried, if allowed by law. Before the containers are buried, they must first be triple rinsed. The containers must be opened, and adequate time must be allowed for the liquid to evaporate. Burial is practical only in locations where the burial site will always be above the groundwater level.

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