NPDES Compliance Inspection Manual

Appendix AD

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Appendix AD –
Animal Industry Overview

OVERVIEW OF LIVESTOCK AND POULTRY INDUSTRY PRACTICES

A. Overview of Livestock Agriculture

The poultry, swine, dairy, and beef industries constitute the principal sectors of U.S. animal agriculture. The vast majority of AFOs that are by definition CAFOs and subject to NPDES permit requirements are in one of these four sectors. A limited number of veal calf, sheep, duck, and horse AFOs are also CAFOs subject to NPDES permit requirements. In this section, we will provide a general overview of the principal sectors, including descriptions of production and waste management practices, with the objective of providing the CAFO inspector with a general understanding of the nature of each of these industries. The production and waste management practices described in this section are those most likely to be encountered at large CAFOs. It is not intended to describe all the possible practices and combinations of practices that may be encountered, since that number is sizable. Thus, CAFO inspectors must expect to encounter operations and practices that are atypical and should seek additional guidance when necessary. The CAFO inspector should feel comfortable asking an operator to clarify or describe an operation, practice, or piece of equipment.

A.1.0 Poultry

The poultry sector has three principal segments: broilers, laying hens, and turkeys. In each of these segments, production and waste management practices are probably more uniform than in the swine, dairy, and beef industries.

A.1.1 Broilers

Broiler refers to a meat-type chicken typically slaughtered at about 7 weeks of age at a live weight of about 5 pounds. This size of bird is the principal product of the broiler sector within the poultry industry. However, there is also some production of younger birds, identified as squab broilers, Cornish game hens or Rock-Cornish crosses, as well as older birds known as roasters. Squab broilers are typically slaughtered at about 4 weeks of age at a live weight of about 2.25 to 2.5 pounds. Roasters are generally slaughtered at about 8 to 10 weeks of age at a live weight of 6 to 8 pounds. Typically, 5 to 6 flocks of broiler chickens will be produced annually. Because squab broilers and roaster boilers differ in the length of their grow-out cycle (the time to reach slaughter weight), more flocks of squab broilers and fewer flocks of roasters are produced annually. Broilers are typically fed corn-soybean-based diets, which may also include various cereal grains and a variety of other ingredients. Grain sorghum may be substituted for corn.

Broiler-type chicken production tends to be vertically integrated with contracts between grower and integrator. The integrator supplies the birds, the feed, and any pharmaceuticals required. The grower supplies the production facility and labor. With vertical integration, the integrator retains ownership of the live birds, but disposal of the manure and dead birds generated is the responsibility of the grower.

A.1.1.1 Broiler Confinement Facilities

Broiler chicken production typically occurs in either totally or partially enclosed structures. Partially enclosed structures have partially open side walls that can be covered by curtains during periods of cold weather. A combination of natural and mechanical ventilation removes heat and moisture from partially enclosed structures. Mechanical ventilation is used with totally enclosed structures, known as controlled environment housing, or, more commonly, tunnel-type housing.

Broiler houses are normally divided into three chambers. One chamber, referred to as the brood chamber, is used to house day-old chicks (biddies). Until the age of about 2 to 3 weeks, chickens are unable to maintain a constant body temperature and require supplemental heat. Thus, brood chambers are heated at the beginning of the grow-out cycle. As the birds grow and heating requirements are reduced, the second and third chambers are opened sequentially to provide more floor space per bird. In cold weather, broiler houses are heated throughout the grow-out cycle to maximize feed conversion efficiency and the rate of weight gain.

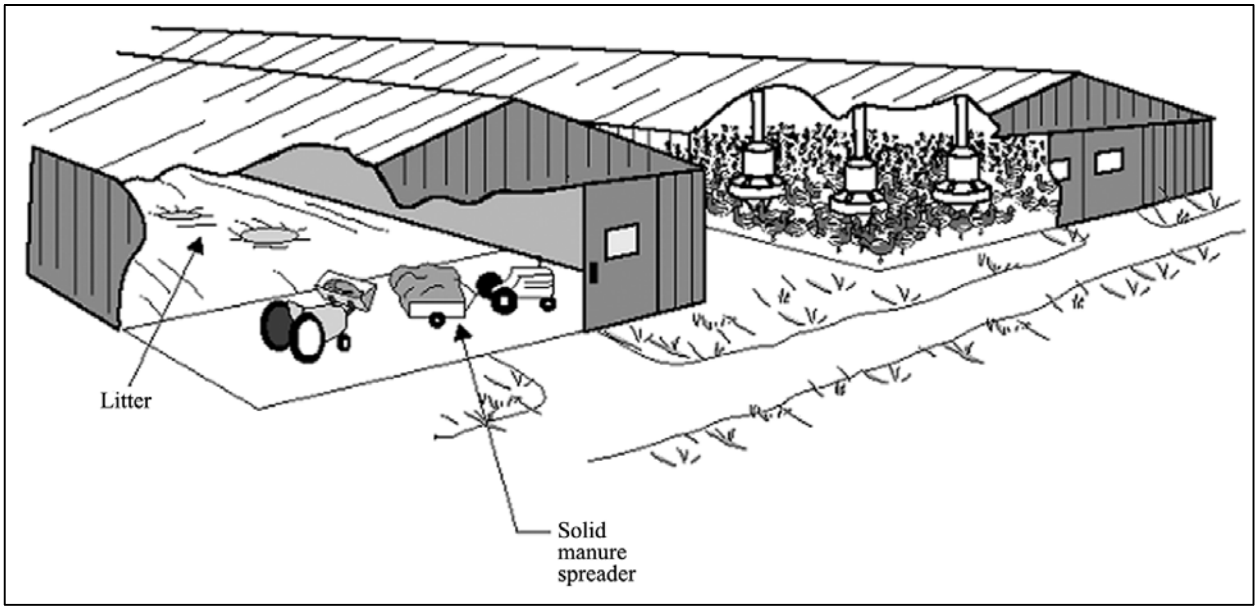
A.1.1.2 Broiler Manure Management

All broiler-type chickens are raised unconfined within the production facility on litter, which has the primary function of absorbing the moisture in the excreted manure. Litter materials vary depending on availability and cost, but they are usually sawdust, wood shavings, peanut hulls, or rice hulls.

Normally, litter and accumulated manure, also commonly called litter, are only removed from the entire house every 1 to 3 years after 5 to 15 or more flocks of birds have been produced. The industry refers to this as a total clean-out. When total clean-outs do not occur on a yearly basis, litter and accumulated manure may be removed annually from the brood chamber. This is known as a brood chamber clean-out. Following both total and brood chamber clean-outs, the litter is replaced.

During each production or grow-out cycle, a material known as crust or cake will form along feeder and water lines. In these areas, the amount of manure excreted is higher than in other areas of the house, and moisture from the manure and waterers tends to bind the mixture of litter and manure together, forming large clumps. As watering systems have improved, the amount of crust formed during each grow-out cycle has decreased. Crust is usually removed after every flock of birds produced. The remaining litter and accumulated manure may be covered (top dressed) with a relatively thin layer of new litter if the amount of crust removed is high. Some poultry operations may use in-house windrowing to treat the cake following each flock, and these poultry operations may only remove cake after several flocks.

Historically, total and brood chamber clean-out litter and crust have been either applied to crop land immediately, if crop production activities permitted, or stored in uncovered piles until land was available for disposal. Over the last several years, structures have occasionally been used to store crust. However, construction cost has generally precluded the use of such storage structures for litter generated by total and brood chamber cleanouts some producers use. The timing of these clean-outs has shifted somewhat from late fall and early winter, as the industry has become more sensitive to the impact on water quality of litter stored in uncovered piles. It is generally acceptable for litter to be stored under a tarp as long as rain and runoff is diverted around the pile in lieu of constructing covered storage facilities. Temporary short-term stacking of litter (i.e., 2 weeks) on or near a field where it will be applied may also be an acceptable handling method provided manure is applied in a timely manner. For example, Maryland Agriculture Extension allows litter stacked at the field for no longer than two weeks.



Litter System for Broilers and Turkeys (Source: USDA Agricultural Waste Management Field Handbook)

A.1.1.3 Broiler Mortality Management

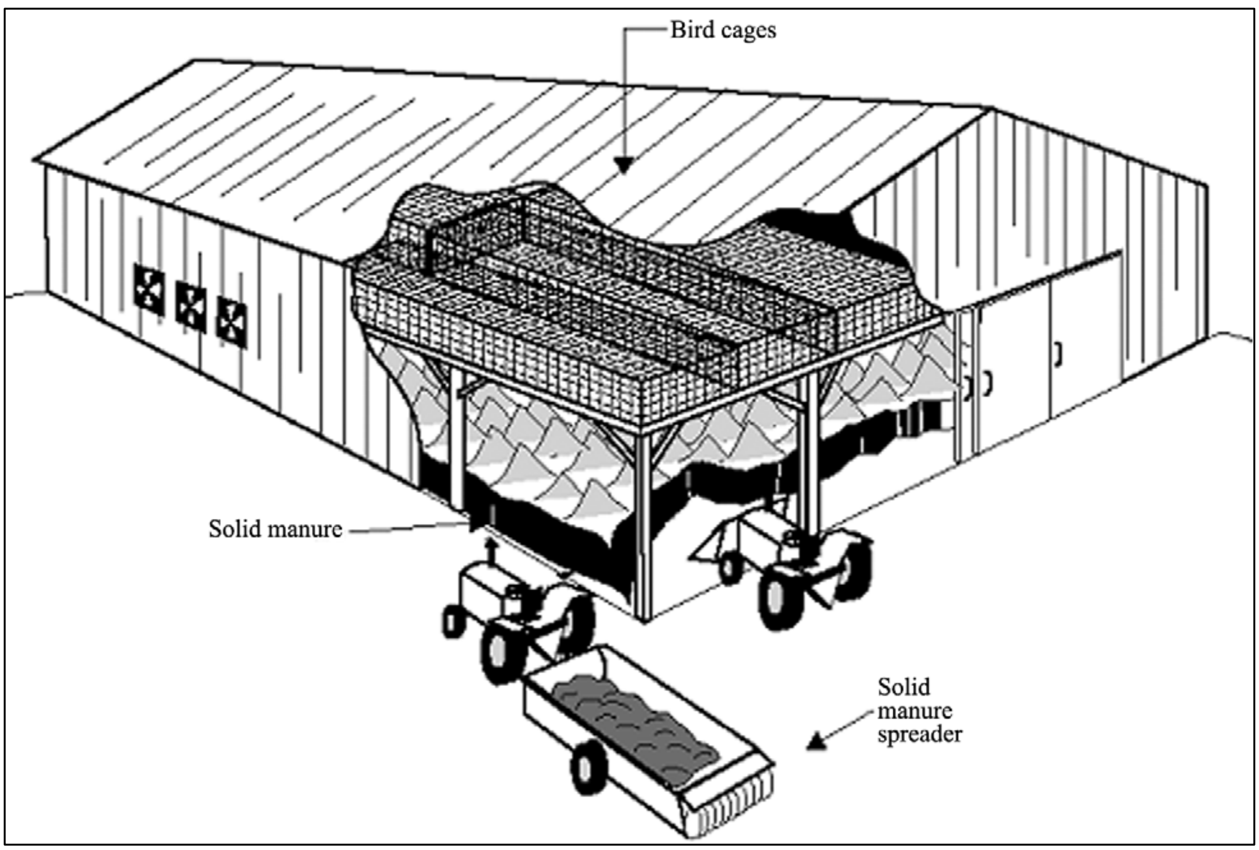
With broilers, the highest rate of mortality normally occurs during the first 2 weeks of the grow-out cycle, but continues at a lesser rate throughout the rest of the cycle. Typically, about 4.5 to 5 percent of the birds housed will die during the grow-out cycle although the typical mortality for roasters is about 8 percent. To prevent the possible spread of disease, dead birds must be removed at least daily, if not more frequently. As mentioned earlier, the disposal of dead birds is the responsibility of the grower. Several options are available for dead bird disposal. Composting is one of the more desirable approaches and has been heavily promoted by the industry. As an alternative to composting or burial, at least one integrator has been distributing freezers to preserve carcasses for subsequent disposal by rendering.

Catastrophic losses of broiler chickens also occur, especially during periods of extremely hot weather but also during weather events such as hurricanes, tornadoes, and snow or ice storms. Catastrophic losses of broilers from excessive heat are usually more severe with older birds. Several options are available for disposal of catastrophic losses, with burial being the most common practice. (Note that burial is prohibited or highly regulated in some states.) Large-scale composting is another, and probably more desirable, option from a water quality perspective.

A.1.2 Laying Hens

A laying hen is a chicken maintained for table egg production. The production cycle begins with the placement of young birds, normally 14 to 16 weeks of age, in the production facility and ends 11 to 12 months later when the birds are removed. These birds, known as spent hens, may be slaughtered for meat for human or pet foods or disposed of by rendering. More than three-fourths of layer farms molt their birds followed by a second period of egg production. Routine molting by withholding or restricting feed is the most common method. Placement and removal of birds are on an "all in–all out" basis. Typically, laying hens are also fed corn- and soybean-based diets, which may also include various cereal grains such as wheat and barley and a variety of other ingredients.

Although the table egg segment of the poultry sector is less vertically integrated than the broiler sector, vertical integration is becoming more common. However, the egg producer is typically responsible for both manure and dead bird disposal if under contract with an integrator or an independent operator. Slightly more than 10 percent of all layer farms have pullet raising facilities on the farm. Pullets are young chickens, usually less than 20 weeks of age, often raised for the purpose of egg production. Traditional pullet houses are similar in construction to broiler houses.



Traditional "High-Rise" House for Layers (Source: USDA Agricultural Waste Management Field Handbook)

A.1.2.1 Laying Hens Confinement Facilities

Most egg production occurs in totally enclosed facilities with mechanical ventilation for temperature control and moisture removal, but partially open-sided houses may be encountered in warm climates. Unlike broilers, laying hens are usually confined in cages and no litter or bedding material is used. However, modern changes in the layer industry are resulting in more diverse housing arrangements, including larger cages, designs with “enriched housing” where hens can freely move within a large cage from laying areas to perches to scratching areas, and designs that allow hens to fly between the floor of the barn to multiple levels in the building for perching and laying.

A.1.2.2 Laying Hens Manure Management

Manure produced by laying hens is handled both as a liquid or slurry and as a solid, with handling as a solid being much more common. Liquid or slurry systems are more common in older production facilities. When laying hen manure is handled as a liquid or slurry, flushing or scraping is used to remove manure from the production facility. With scraping systems, a tank or an earthen structure is often used for storage if the manure is not applied directly to crop land, while flush systems use an anaerobic lagoon for stabilization and storage. Typically, the lagoon is the source of the water used for flushing, although fresh water may be used in rare instances.

Traditionally, to handle laying hen manure as a solid, a two-story production facility, known as a high-rise house, is used. In a high-rise house, the caged hens are located on the second floor of the building, with the manure dropping to the first floor where it is dried and stored. The primary factor responsible for drying is biological heat production in the accumulating mass of manure that causes evaporation of the moisture in the manure. Ventilation systems for high-rise houses are designed to move air from intakes along the eaves of the house roof down through the caged hens and over the mass of accumulating manure before exiting the house, thus removing the moisture evaporated from the manure. Critical to the successful operation of a high-rise house is the avoidance of leaks in the bird watering system and proper exterior grading to direct surface runoff away from the building. Because of the microbial activity in the accumulating mass of manure, which is responsible for the heat generated and the evaporation of manure moisture, stabilization occurs and storage for 1 or more years is provided. Typically, manure is removed from high-rise houses yearly between flocks of hens, but storage for 2 to 3 years is possible.

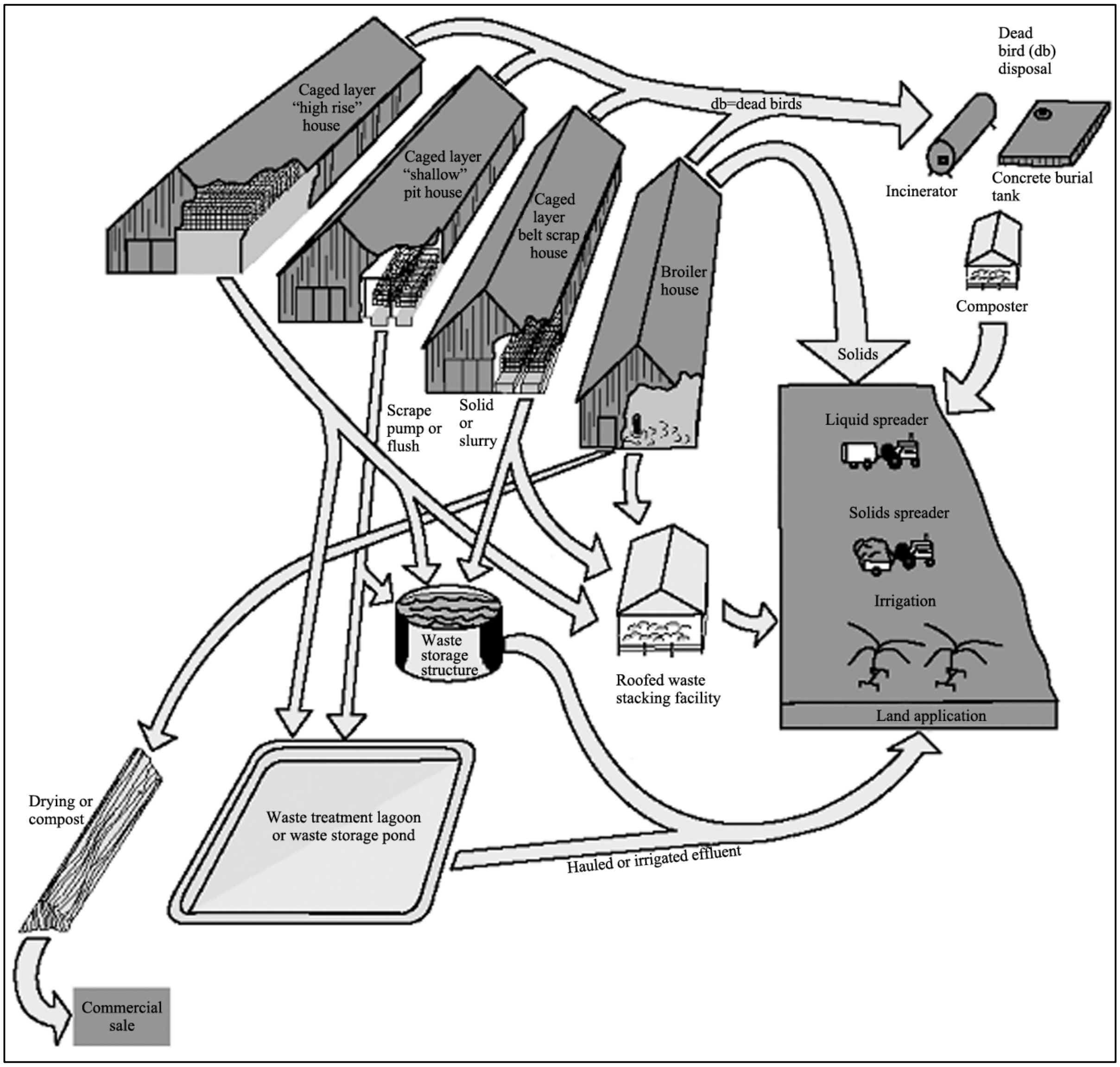
Modern housing for laying hens, and the type that is currently most often built, is a “manure-belt” system where the manure from caged hens drops onto conveyor belts that move through the house and transport the manure into a separate drying unit or storage structure. The manure may be dried for easier storage or transportation. This housing design and manure management system is beneficial for the health of the birds, as the air quality is improved by the removal of the litter.

The majority of eggs marketed commercially in the U.S. are washed using automatic washers. Cleaning compounds such as sodium carbonate, sodium metasilicate, or trisodium phosphate, together with small amounts of other additives, are commonly used in these systems. Wash water is contaminated with shell, egg solids, dirt, manure, and bacteria washed from the egg surface into the recycled water. Eggs may be washed either on farm or off farm. Over three-fourths of layer farms process eggs on farm, though one-third of the largest farms are likely to wash eggs off farm. Operations that wash their eggs on farm may do so in-line or off-line. Larger operations commonly collect and store egg wash water on-site in large tanks or lagoons for treatment and storage.

A.1.2.3 Laying Hens Mortality Management

It can be expected that about 1 percent of the started pullets housed will die each month through the laying cycle. To prevent the possible spread of disease, dead birds should be removed from cages daily, if not more frequently. As mentioned earlier, disposal of dead birds is the responsibility of the grower. Several options are available for dead bird disposal. Of these options, composting is one of the more desirable approaches.

Catastrophic losses of laying hens also occur. Loss of power and mechanical ventilation during periods of extremely hot weather is the most common cause of loss. Weather events such as hurricanes and tornadoes can also cause catastrophic losses. Several options are available for the disposal of catastrophic losses, with burial being the most common. (Note that burial is prohibited or highly regulated in some states.) Large-scale composting is another, and probably more desirable, option from a water quality perspective.



Poultry Waste Handling (Source: USDA Agricultural Waste Management Field Handbook. Note that burial is prohibited or highly regulated in some states.)

A.1.3 Turkeys

Turkey production is similar to broiler chicken production in many respects. The grow-out period for female or hen turkeys is usually about 14 to 16 weeks, resulting in a live weight at slaughter of between 13 and 20 pounds. However, the usual grow-out period for toms or male turkeys is longer, ranging from 17 to 21 weeks, resulting in a live weight at slaughter of between 30 and 37 pounds. Typically, two flocks of turkeys are produced annually because of the longer grow-out cycle and the somewhat seasonal demand for turkey. Turkeys are primarily fed corn- and soybean-based diets, which may also include various cereal grains and a variety of other ingredients.

Vertical integration is also extensive in the turkey sector of the poultry industry, with the same distribution of responsibilities between the integrator and grower as in the broiler sector.

A.1.3.1 Turkey Confinement Facilities

Like broiler production, essentially all turkey production occurs in partially or totally enclosed facilities that are divided into two or three chambers. Initially, only one chamber, also known as the brood chamber, is used; this is the area where the newly hatched turkeys, known as poults are placed. Like broiler chicks, poults are unable to maintain a constant body temperature until about 6 to 8 weeks of age and thus require supplemental heat. Brood chambers for turkeys, therefore, are also heated at the beginning of the grow-out cycle. As with broiler chickens, the second or the second and third chambers are opened to provide more floor space per bird as the birds grow. In cold weather, some heat may be provided throughout the grow-out cycle.

Some turkey producers use separate brood and growing houses and move the birds from the brooding house to the growing house after about 6 to 8 weeks. Another production practice is to use the brood chamber in a house exclusively for brooding and use the remainder of the house for grow-out after the birds reach the age of 6 to 8 weeks. These management systems are known as two-age management systems. Such systems produce more flocks each year than single-age farms.

A.1.3.2 Turkey Manure Management

Turkeys are raised unconfined in the production facility on litter, typically sawdust or wood shavings. Total clean-out of brood chambers and brood houses after each flock is common, as is total clean-out of growing chambers or houses annually. Crust removal between flocks followed by top dressing with new litter also occurs in the production of turkeys.

In the turkey sector, the use of litter sheds to store crust and total clean-outs from brood chambers or brood houses is also emerging. When land is not available for disposal, storage of these materials in uncovered piles is common.

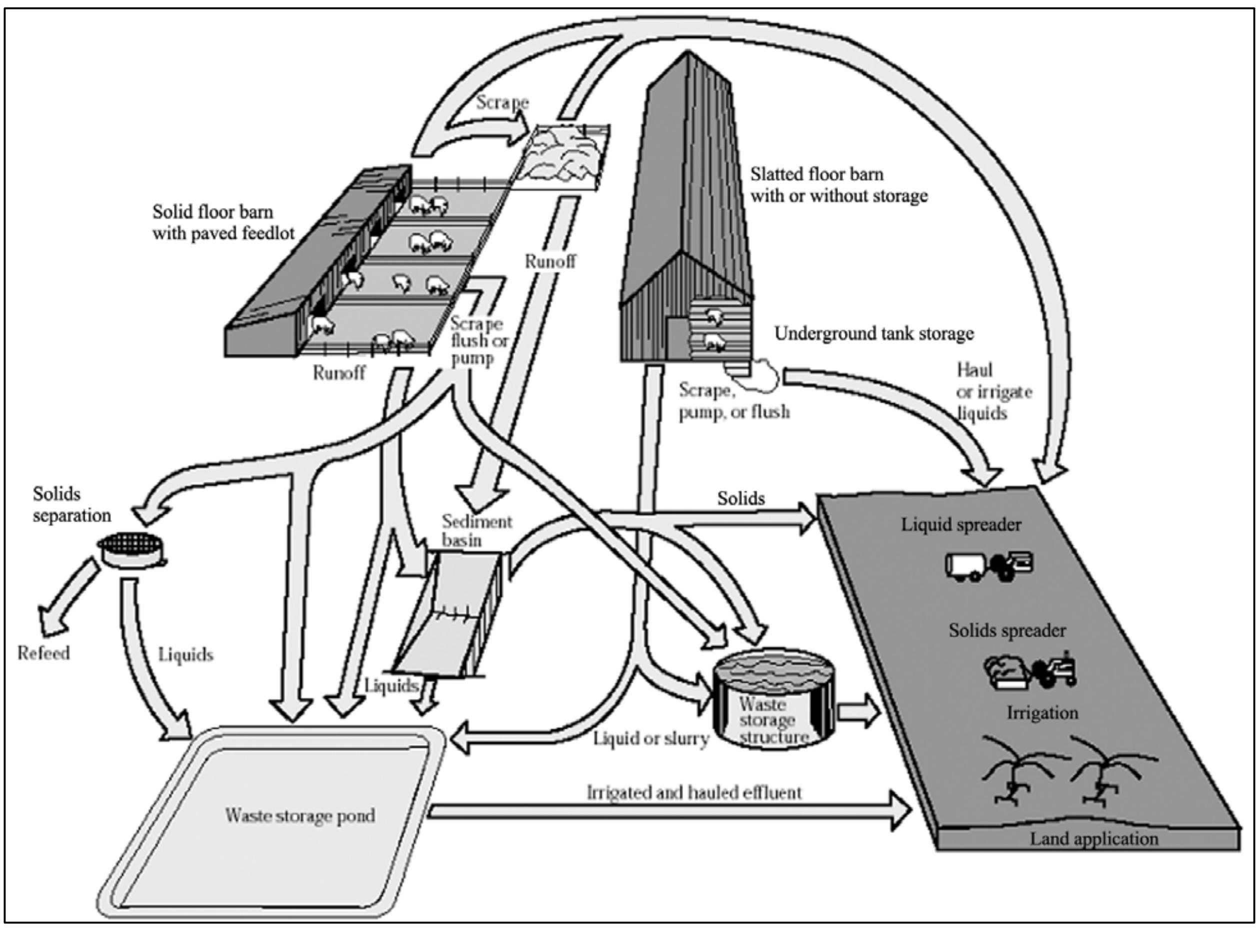
A.1.3.3 Turkey Mortality Management

Typically, about 5 to 6 percent of hens and 9 to 12 percent of toms will die during the grow-out cycle, with the highest rate of loss occurring during the initial weeks. As with broilers and laying hens, dead birds should be removed daily, if not more frequently, with dead bird disposal being the responsibility of the grower. Again, several options for dead bird disposal are available; composting is one of the more desirable approaches from a water quality perspective.

Catastrophic losses of turkeys occur during periods of extremely hot weather, but they may also be due to weather events such as hurricanes, tornadoes, and snow or ice storms. Older turkeys, like older broilers, are more susceptible to catastrophic losses during periods of extremely hot weather. Several options are available for disposal of catastrophic losses, with burial being the most common practice. (Note that burial is prohibited or highly regulated in some states.) Large-scale composting is another, and probably more desirable, option from a water quality perspective.

A.2.0 Swine

The production cycle for hogs has three phases. It begins with gestation and farrowing (birth). After farrowing, the newly born pigs or piglets are normally nursed for a period of just under 3 to 4 weeks until they reach a weight of 10 to 15 pounds. The average pig weaning age is 17 days, but may approach 4 weeks at smaller operations. Over 97 percent of large farms wean at less than 21 days. The production phase after weaning is known as the nursery phase where pigs are fed a starter ration until they reach a weight of 40 to 60 pounds. At this point, they are 8 to 10 weeks of age. The average age for leaving the nursery is 63 days. The third phase of swine production is the growing-finishing phase in which the gilts (young females) and young castrated boars (males) not retained for breeding are fed until they reach a market weight, typically between 240 and 280 pounds. In this phase of swine production, hogs are fed a growing ration until they reach 120 pounds in weight, which is then followed by a finishing ration. Growing-finishing usually takes between 15 and 18 weeks. Hogs are normally slaughtered at about 26 weeks of age. After weaning, swine are typically fed a corn- and soybean-meal based diet which may include small grains such as wheat and barley and other ingredients until slaughtered.



Swine Waste Handling (Source: USDA Agricultural Waste Management Field Handbook. Note that burial is prohibited or highly regulated in some states.)

Swine operations can be of several types. The most common is the farrow-to-finish operation that encompasses all three phases of swine production. Other operations specialize in either feeder pig production or the growing-finishing phase of swine production. Although not common, specialization in either the gestation-farrowing or the nursery phase of the swine production cycle may also occur. Larger grow-finish operations are more likely to obtain feeder pigs from off-site sources. Vertical integration is becoming more common in the swine industry.

A.2.1 Swine Confinement Facilities

The swine industry uses confinement systems ranging from pasture without and with shelters to total confinement, where pigs are confined in pens or stalls. Open paved or unpaved lots with access to a building or huts for shelter are also used, but larger operations will use total confinement 99 percent of the time because of higher feed conversion efficiency and weight gain as well as lower labor costs.

Total confinement facilities for swine are similar in many respects to facilities used for broiler production, except that the pigs are confined in pens. These pens may be totally enclosed or they may have partially open side walls that can be closed with curtains during cold weather. Totally enclosed facilities are mechanically ventilated, whereas facilities with partially open side walls use a combination of natural and mechanical ventilation.

A.2.2 Swine Manure Management

Four principal types of waste management systems are used with total confinement housing in the swine industry: deep pit, pull plug pit, pit recharge, and flush systems. The deep pit, pull plug pit, and pit recharge systems are used with slatted floors, whereas flush systems can be used with either solid or slatted floors.

Deep pits are normally sized to collect and store 6 to 8 months of waste. When they are emptied, the accumulated manure may be disposed of directly by land application or transferred to either storage tanks or earthen storage ponds for later disposal by land application.

Pull plug pit systems use relatively shallow pits to collect manure. These pits are usually drained to a storage tank or an earthen storage pond every 1 to 2 weeks.

Pit recharge systems also use relatively shallow pits that are drained periodically to an anaerobic lagoon. Although the frequency of draining varies, between 4 and 7 days is standard. After the pit is drained, the empty pit is partially refilled with supernatant from the anaerobic lagoon, which differentiates this system from the pull plug pit system—hence, the name pit recharge.

Flush systems use either fresh water or, more commonly, supernatant from an anaerobic lagoon to transport accumulated wastes to that lagoon daily or more frequently. Because pigs will defecate as far away from their feeding and resting areas as possible, facilities with solid floors will usually have a flush channel formed in that area. Facilities with slatted floors usually form a series of parallel flush channels in the shallow pit under the slatted floor.

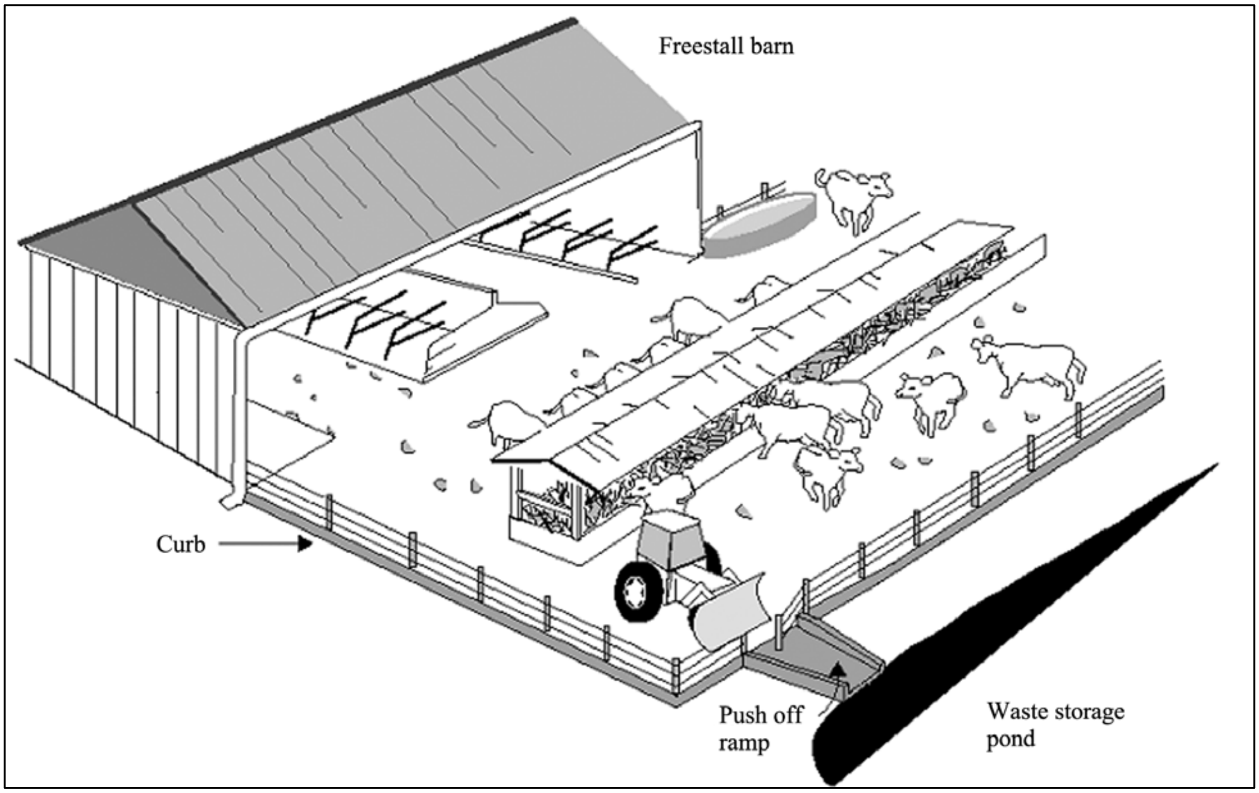
A.2.3 Swine Mortality Management

In swine production, the highest rate of mortality occurs in young piglets within 3 to 4 days of birth. Typically, about 10 to 12 percent of piglets will die before weaning. Typically, 2 to 4 percent of the pigs die during the nursery stage and during the grow-finish stage. Several approaches are used for dead pig disposal, with burial being the most common. Composting and incineration are also used but primarily for piglets. Although older pigs can be disposed of by composting, disposal through rendering is the more common alternative to burial.

Catastrophic losses of swine also occur but they are primarily due to extreme weather events such as hurricanes, tornadoes, and the like. Heat losses are less common in the swine industry, because pigs, unlike birds, possess sweat glands that help to regulate body temperature. The primary effects of periods of high temperatures on swine production are reduced feed conversion efficiency and a reduced rate of weight gain. Burial is a practical option for the disposal of large numbers of swine carcasses, although rendering could be feasible as well. (Note that burial is prohibited or highly regulated in some states.)

A.3.0 Dairy Cattle

The production cycle in the dairy industry begins with the birth of a calf, which causes the onset of lactation or milk production. A period of between 10 and 12 months of milk production is normally followed by a 2-month dry period to allow for physiological preparation for calving. At the time that milking is normally stopped, a cow will be in the seventh month of a 9-month pregnancy. Thus, a mature dairy cow produces a calf every 12 to 14 months. This frequency of calf production is necessary to maintain a cost-effective level of milk production. Average U.S. milk production is about 17,000 pounds per cow per year. However, herds with averages of 22,000 to 24,000 pounds of milk per cow per year or higher are not unusual.



Dairy Confinement Area (Source: USDA Agricultural Waste Management Field Handbook)

About 25 percent of a milking herd is typically replaced each year, but replacement levels can be as high as 40 percent for intensively managed herds. Mature cows are replaced or culled for a variety of reasons, including low milk production and diseases such as mastitis, which is an infection of the udder. Lameness, injury, belligerence, and reproductive problems are also reasons for culling. Nearly all culled dairy cows are slaughtered for beef used in processed foods or in higher quality pet foods.

Roughly 50 percent of the calves produced by dairy cows are bulls unless the livestock producer is using sexed semen (to produce more heifer calves). Because most dairy cows are bred using artificial insemination, the industry has little demand for bull calves. Although some dairy farms will have one or more breeding age bulls for cows that will not conceive by artificial insemination, most bull calves are sold for either veal or beef production.

Because of the continuing need for replacement cows, approximately 50 percent of the female calves born are raised as replacements. Those animals selected as replacements are usually progeny of cows with a record of high milk production. Female calves not raised as replacements are also sold for either veal or beef production.

Female calves retained as replacements are either raised on-site or transferred off-site to an operation that specializes in producing dairy cattle replacements. In this second scenario, the calves may be sold to the replacement operation with the same or other animals purchased back at a later date or raised under contract. In the dairy industry, both male and female animals are called calves up to an age of about 5 months. From the age of 6 to 24 months, females are called heifers, with first calving typically occurring at 24 months of age. Replacements raised off-site may be purchased or returned either as unbred or open (not pregnant) heifers at an age of about 13 months or as bred heifers at an age usually of 22 to 23 months. Three groups of animals will be present on dairy farms that raise replacements on-site: calves, heifers, and mature lactating and dry (mature nonlactating) cows. Usually, the total number of calves and heifers present will be between 50 and 60 percent of the size of the milking herd.

Lactating dairy cows are milked at least twice per day, but milking three times a day has become more common, especially with higher milk producing herds. With the exception of young calves until weaning, dairy cattle are fed a roughage-based diet or ration composed primarily of silages and hays supplemented with feed grains and by-product feedstuffs to ensure adequate levels of energy, protein, minerals, and other essential nutrients. Citrus pulp, beet pulp, meat and bone meal, and cottonseed meal are examples of by-product feedstuffs. Young calves are initially fed colostrum, which is the milk produced during the first 4 to 5 days after calving that cannot be marketed, and then a milk replacer until weaning and a complete shift to a roughage-based ration.

A.3.1 Dairy Confinement Facilities

The free-stall barn is the predominant type of housing system used on larger dairy farms for lactating cows. In a free-stall barn, cows are commonly grouped by stage of lactation in large pens with free access to feed bunks, waterers, and stalls for resting. The standard free-stall barn design has a feed alley in the center of the barn separating the two feed bunks on each side. Each side of the barn has an alley between the feed bunk and the first row of free-stalls and an alley that extends between the first row of free-stalls facing the feed bunk and a second row of free-stalls facing the side wall of the structure. These are the primary areas of manure accumulation, with little manure defecated in the free-stalls. There may or may not be access to an outside dry lot for exercise or to a pasture for exercise and grazing. In warmer climates, cows may simply be confined in a dry lot with unlimited access to feed bunks, waters, and usually an open structure to provide shade.

With both free-stall barns and dry lot production facilities, milking occurs in a specialized facility known as a milking center. A milking center has three components: a holding area where cows are held prior to milking, a milking parlor where the cows are milked, and an area where milk is stored in refrigerated tanks, known as bulk tanks, until picked up for processing and the milking equipment is cleaned. Holding areas may be either enclosed or open areas depending largely on climate.

There are two predominant housing systems for young unweaned calves: individual pens in an enclosed building and hutches that tend to reduce disease problems. Hutches are small, lightweight structures, typically of fiberglass or plywood construction, that can be easily moved. Individual hutches, sized for one calf, are located in a small fenced area to provide shelter from inclement weather as well as access to fresh air and sunlight. Hutches are routinely relocated to reduce disease transmission. Older calves are either housed in pens as groups in a totally or partially enclosed building or in portable super hutches in a small fenced area.

Heifers are most commonly raised on dry lots with or without shelter, but may also be raised on pasture or in dedicated free-stall barns. Dry cows may be removed from the milking herd to dry lots, pasture, or dedicated free-stall barns.

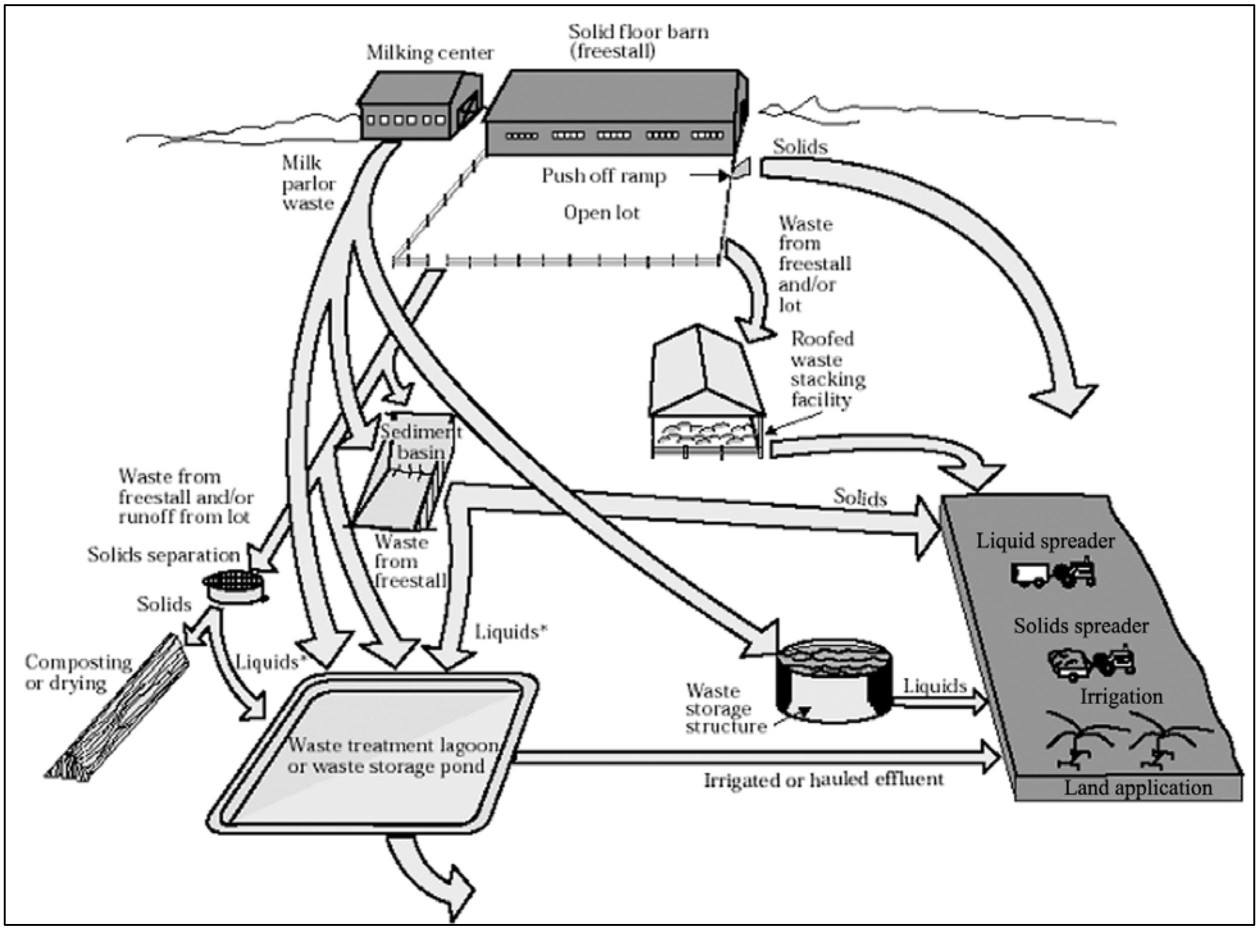
A.3.2 Dairy Manure Management

Manure is usually removed from free-stall barn alleys at least twice daily, and often more frequently, by either scraping or flushing. A mechanical scraper or a tractor-mounted blade is used to move the manure to a collection pit at one end of the barn. From the collection pit, manure is transferred by pump or gravity to a tank or an earthen pond for storage until disposal by land application. Milking center wastewater may be added to these collection pits to facilitate pumping or gravity flow, since scraped dairy cow manure is quite viscous with a total solids content of around 12 to 13 percent. With scrape systems, other options for managing milking center wastewater, which is generated when the milking parlor and milking equipment are cleaned, are transfer directly into the manure storage structure or transfer to a dedicated lagoon.

Flush systems are the most common in warmer climates where flush water is unlikely to freeze. Flush systems for dairy cattle operate like flush systems for swine and laying hens, with the manure and flush water discharged into an anaerobic lagoon, which is normally the source of the water used for flushing. With flushing systems, milking center wastewater usually is transferred to the lagoon used for manure stabilization and storage.

The type of manure management used by a particular dairy is often a function of the bedding choice for the lactating cows. Common bedding materials include sand, sawdust, rubber mattresses, and water beds. As sand is very abrasive on manure pumps, flush systems are rarely used when sand is the chosen bedding material.

When sand bedding is used, it accumulates in the waste storage facility and must be eventually mechanically removed every several years or else the volume of available manure storage becomes greatly diminished. Some larger dairies will install sand removal systems, typically either a sand lane (gravity removal of sand with flush systems) or a mechanical sand separation system consisting of a cyclone filter or screw auger. Both systems require a high volume of flush water which is usually secured from the waste storage pond.



Dairy Waste Handling (Source: USDA Agricultural Waste Management Field Handbook) (Note that burial is prohibited or highly regulated in some states.)

In the nation's southern and western states dry lots are more common than the totally enclosed free stall barns common in the Midwest. Manure accumulations on dry lots for lactating cows are typically removed by scraping with a tractor-mounted blade and handled as a solid, similar to the beef feedlot industry. Areas by feed bunks may be scraped daily, with longer intervals between manure removals in other areas of the lot. Areas by feed bunks may also be flushed. Manure accumulations in dry lots used for heifers and dry cows are usually removed by scraping and are handled as a solid. If manure removed from dry lots by scraping is not land applied immediately, it is stored by stacking on a section of the lot or at a separate site. Calf and heifer manure may be transferred from a scraped free-stall barn to the storage structure used for manure, or the lagoon used for flushed manure, or it may be handled as a solid, depending on the methods of calf and heifer confinement and the handling system used for the manure from the lactating cows.

Dry lots should have runoff collection and retention basins to prevent the discharge of manure-contaminated runoff to adjacent surface waters.

Treatment of the manure before land application using large anaerobic digesters (AD) will be seen more frequently on CAFOs, thanks in part to the work of EPA's Ag STAR program. These large anaerobic digester vessels can be either completely in-ground or above-ground but in either case the goal is the same – to create electricity or compressed natural gas using the biogas that develops naturally when the temperature of the manure is raised. The typical retention time for the manure is 21 days or less. Livestock producers like the benefits of ADs such as odor reduction, pathogen reduction, and easier transport of the manure nutrients to the field, such as with center pivots (ability to pump depends on the amount of solid separation completed by the treatment system.) See EPA's Ag STAR website for more information at: https://www.epa.gov/agstar

As cattle manure is rather weak in terms of its energy production potential, most ADs will import substrate material to boost the energy production. Common substrate materials include waste food, grease, food processing wastes, etc. The addition of a substrate material increases the energy production and decreases the payback period for the initial investment.

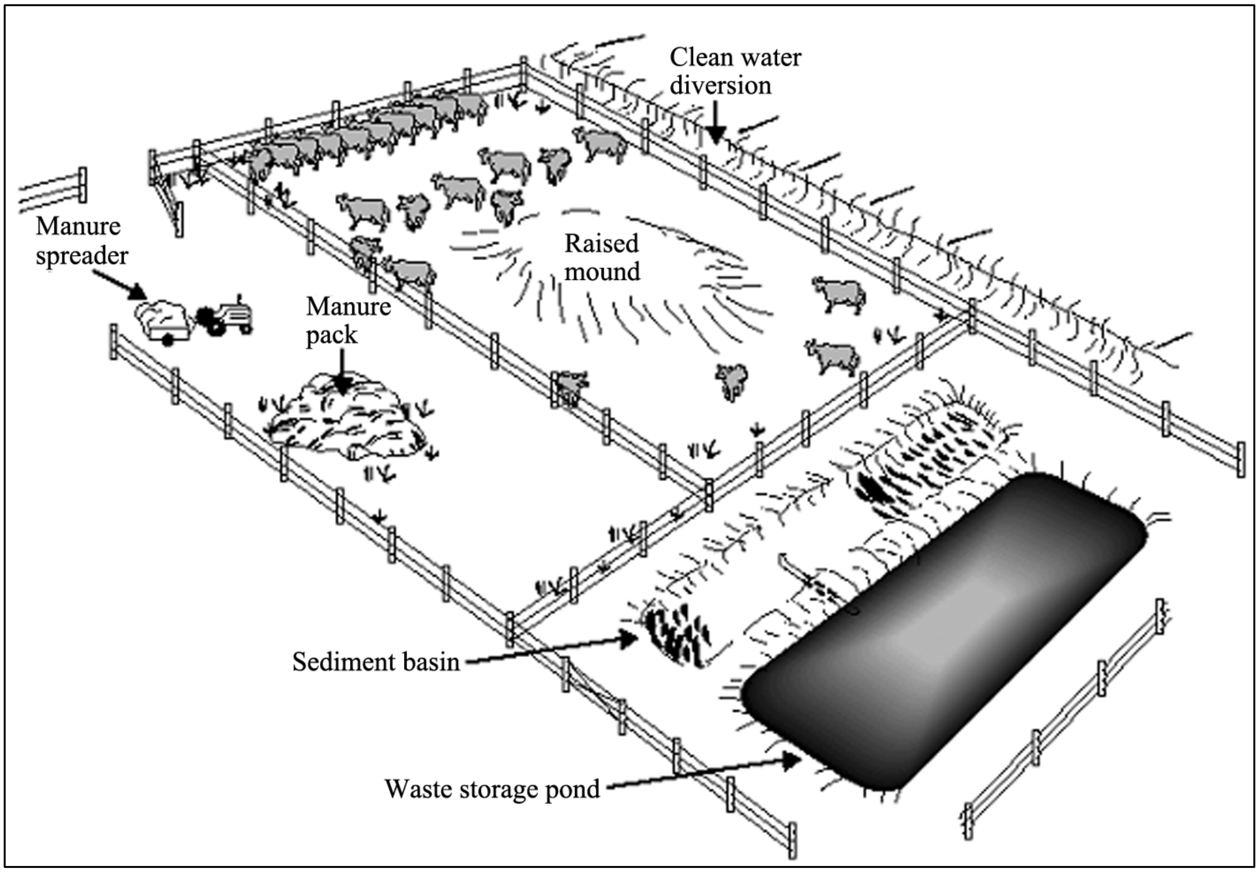
It is not uncommon for large dairy CAFOs to have their AD systems operated by a third party.

A.3.3 Dairy Mortality Management

Although the frequency of mortality in the dairy industry is much less than in the poultry and swine industries, deaths do occur. Usually, carcass disposal is by rendering, with burial being the only other realistic option if no rendering facility willing to accept dead animals is located within a reasonable distance of the farm. (Note that burial is prohibited or highly regulated in some states.) Carcass composting is also an option, particularly for the disposal of young calf carcasses, but can be done with adult animals too if the compost operation is properly sized and managed.

A.4.0 Beef Cattle

There are three different types of operations in the beef industry, with each type corresponding to a different phase of the production cycle. The first is the cow-calf operation that is the source of the heifers and steers (castrated males) fed for slaughter. Cow-calf operations typically maintain a herd of yearling heifers, brood cows, and breeding bulls on pasture or range land to produce a yearly crop of calves for eventual sale as feeder cattle. In colder climates and during drought conditions, cow-calf operations using pasture or range land will provide supplemental feed, primarily hay but also some grain and other feedstuffs. Confinement on dry lots is also an option used in some cow-calf operations when grazing will not satisfy nutritional needs. Although pasture or range-based cow-calf operations are most common, operations that exclusively use dry lots may be encountered. In colder climates, cow-calf operations may have calving barns allowing cows to calve indoors to reduce calf mortality.



Beef Feedlot Waste Collection (Source: USDA Agricultural Waste Management Field Handbook)

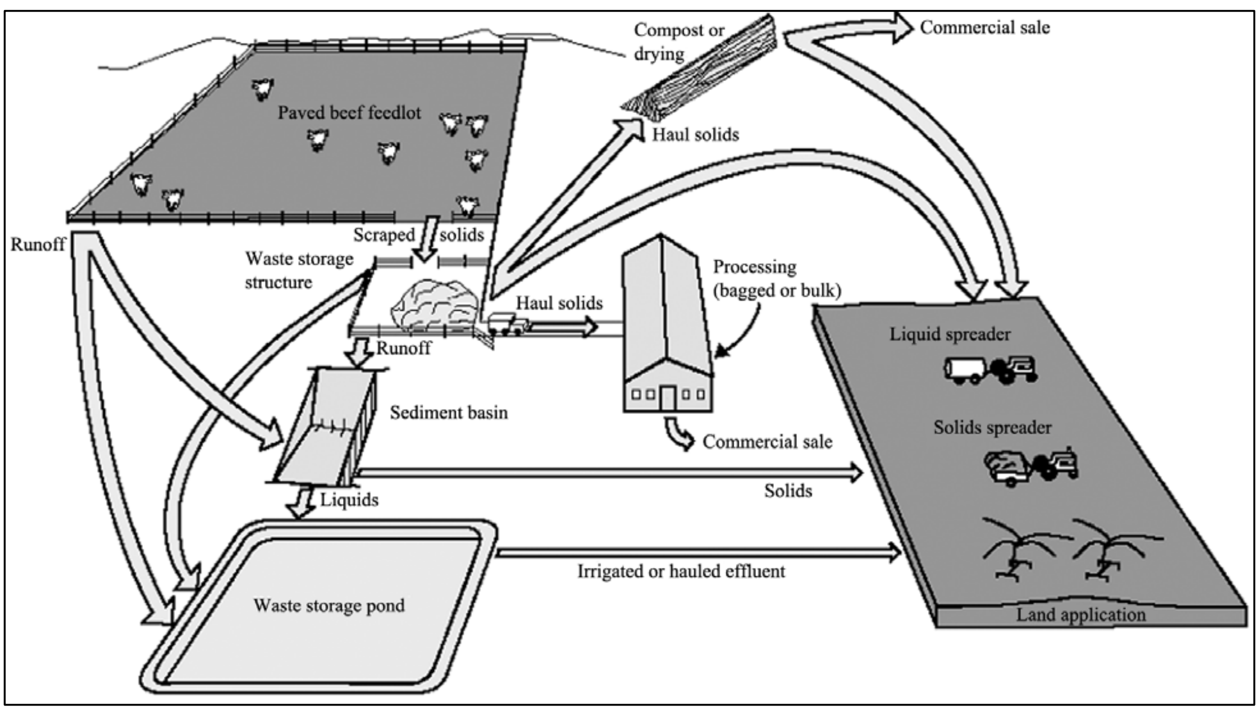
The second type of operation in the beef industry is known as a backgrounding or stocker operation. These operations prepare weaned calves for finishing. Backgrounding operations may be pasture or dry-lot based, or some combination thereof. Relatively inexpensive forages, crop residues, and pasture are used as feeds, with the objective of building muscle and bone mass without excessive fat at a relatively low cost. The length of the backgrounding process may be as short as 30 to 60 days or as long as 6 months. The duration of the backgrounding process and the size of the animal moving on to the finishing stage of the beef production cycle depend on several factors. High grain prices favor longer periods of backgrounding by reducing feed costs for finishing or fattening, while heavier weaning weights shorten the finishing process. Backgrounded beef cattle may be either sold to a finishing operation as "feeder cattle," usually at auction, or raised under contract with a finishing operation. It is common for large finishing operations to have cattle backgrounded under contract to ensure a steady supply of animals. In some instances, cow-calf and backgrounding operations will be combined.

The final phase of the beef cattle production cycle is the finishing or feedlot phase where a high energy, grain-based ration with only a small amount of roughage is fed to produce rapid weight gain and desirable carcass characteristics. The larger commercial finishing operations usually feed a complete ration that is a mixture of feed grains, roughage, and other ingredients. Usually, the finishing phase begins with 8 to 9-month old animals weighing about 700-800 pounds. Somewhere between 150 and 180 days, these animals will reach the slaughter weights of 1,250 to 1,350 pounds for heifers and 1,350 and 1,450 pounds for steers, and a new finishing cycle begins. Some feedlot operators will immediately start with younger animals weighing about 275 pounds or older and heavier animals. This will either extend the finishing cycle to about 270 days or shorten it to about 100 days. Beef cattle in the finishing phase are known as "cattle on feed." Finished cattle are "fed cattle."

A.4.1 Beef Confinement Facilities

In addition to pasture or range-based cow-calf and backgrounding operations, beef cattle may be raised on unpaved or partially paved open lots or in bedded and slatted confinement barns with pits. When feedlots and dry lots on cow-calf and backgrounding operations are partially paved, it is the areas around feed bunks and sources of drinking water that will be paved. These are high animal traffic areas and have high rates of manure accumulation.

A typical beef cattle feedlot is divided into a series of large pens to allow animals to be grouped by age. In each pen, there are feed bunks, sources of drinking water, and probably shaded areas in warm climates. Feed bunks located along one side of a pen are known as fence line feed bunks, and feed is delivered with specially equipped trucks or tractor-drawn feed wagons from a feed alley. Mechanical feed bunks may be located in the center of a pen or used as a divider between two pens. Although mechanical feed bunks allow cattle to feed on both sides of the feed bunk, their use is generally limited to smaller operations. Feed bunk space per head is an important parameter in beef cattle feedlot design. The large commercial feedlots may also have a feed mill and an area for treating sick animals.



Beef Waste Handling (Source: USDA Agricultural Waste Management Field Handbook. Note that burial is prohibited or highly regulated in some states.)

A.4.2 Beef Manure Management

Manure produced by beef cattle on open lots is primarily handled as a solid, with removal by scraping and storing the collected manure in mounds on the lot. Manure accumulation is typically highest around feed bunks and sources of drinking water. The complete removal of manure from open lots used for beef cattle production may only occur annually during summer months to take advantage of natural drying to facilitate handling as a solid.

Open lots for beef cattle should also have runoff collection and retention basins to prevent the discharge of manure-contaminated runoff to adjacent surface waters.

A.4.3 Beef Mortality Management

As in the dairy industry, the frequency of mortality in the beef cattle industry is much lower than in the poultry and swine industries; however, deaths do occur. Carcass disposal by rendering is the primary option. Additionally, composting may be used to manage mortalities. Given the size of most beef cattle operations, burial cannot generally be considered a realistic alternative in the context of water quality protection.

A.5.0 Land Application of Manure

Livestock and poultry manures have value as sources of plant nutrients for crop production. Historically, livestock or poultry production and crop production have been integrated activities. As animal production units have been consolidated into fewer but larger operations, a decoupling of animal and crop production activities has gradually occurred. As a result, some livestock and poultry producers do not have adequate land under their ownership or direct control for the proper utilization of all the manure that is generated. In this case, producers may sell or give away manure to nearby crop farmers.

Manure handled as a solid, such as broiler, turkey, and solid cattle feedlot manure, is typically surface applied to cropland using either tractor-drawn or truck mounted box-type manure spreaders. To reduce potential pollutant transport in surface runoff, disking or plowing may follow application to incorporate the manure into the soil. Manure handled as a semi-solid or slurry, such as dairy cattle manure scraped from free-stall barns, is typically applied to cropland using tractor-drawn or truck-mounted tanks. This type of manure typically can be surface applied and may be subsequently incorporated into the soil by disking or plowing. Manure handled as a semi-solid may also be directly injected into the soil using specially designed spreading equipment. Manure handled as a liquid, such as flushed dairy and swine manure, and effluent from open cattle feedlots may be applied to cropland using tractor-drawn or truck-mounted tanks or irrigation systems. Due to the volume of manure when handled as a liquid, irrigation is a fairly common method for land application of liquid manure due to the reduction in labor requirements. Like semi-solid or slurry manure, liquid manure may be incorporated into the soil after application or may be directly injected into the soil.

Livestock and poultry manure has many beneficial properties in addition to the nitrogen and phosphorus needed by growing crops. As opposed to chemical fertilizers, manure improves soil quality and increases the soil’s ability to absorb and retain moisture. Unfortunately, there are some areas in the country where the land available on farms for manure application is insufficient to accept all of the manure produced. In the USDA report, *Manure Nutrients Relative to the Capacity of Cropland and Pastureland to Assimilate Nutrients*, Kellogg et al. (2000) used estimates of livestock populations and land available for manure applications from the Census of Agriculture. They found in some counties the production of recoverable manure nutrients exceeds the assimilative capacity of all the cropland and pastureland available for manure application (without excessive build-up of nutrients) in the county. The number of such counties has significantly increased since their initial analysis conducted in 1982. Figures 1-1 and 1-2 show the regions of the country with excess manure nitrogen and phosphorus assuming no export of manure from the farm, respectively (Kellogg et al., 2000).

A.6.0 Environmental Impacts

Livestock and poultry manure, if not properly handled and managed by the CAFO, can contribute pollutants to the environment and pose a risk to human and ecological health. The components of manure most commonly associated with animal waste include nutrients (including ammonia), organic matter, solids, pathogens, and odorous compounds. Animal waste can also be a source of salts and various trace elements (including metals), as well as pesticides, antibiotics, and hormones. These manure components can be released into the environment through spills or runoff if manure and wastewater are not properly handled and managed.

A CAFO's process wastewater and manure can enter the environment through a number of pathways. These include surface runoff and erosion, overflows from lagoons, spills and other dry-weather discharges, leaching into soil and ground water, and volatilization of compounds (e.g., ammonia) and subsequent redeposition on the landscape. Manure and wastewater can be released from an operation's animal confinement area, treatment and storage lagoons, and manure stockpiles, and from cropland where manure is land-applied.

EPA's *National Water Assessment Report* provides information on water quality conditions reported by states to EPA under Sections 305(b) and 303(d) of the Clean Water Act. Data submitted in 2010 indicates that the agricultural sector including crop production, pasture and range grazing, and CAFOs is the leading probable source contributing impairments to the nation's rivers and streams. The top causes of impairments in assessed rivers and streams are pathogens, sediment, nutrients, and organic enrichment/oxygen depletion – all of which are environmental impacts associated with over application or accidental spills of livestock manure, among other agricultural point source and non-point sources such as wildlife and rural septic tanks. The agricultural sector is also the fourth leading contributor of impairments for the nation's lakes, ponds, and reservoirs and the fifth leading contributor for probable water quality impairments in assessed coastal shorelines (EPA 2012b).

Among the reported environmental problems associated with excess nutrients are surface water (e.g., lakes, streams, rivers, and reservoirs) and ground water quality degradation, and adverse effects on estuarine water quality and resources in coastal areas. Scientific literature documents how this degradation might contribute to increased risk to aquatic and wildlife ecosystems; an example is the large number of fish kills in recent years. A literature survey conducted for the 2003 CAFO Rule identified more than 150 reports of discharges to surface waters from hog, poultry, dairy, and cattle operations. Human and livestock animal health might also be affected by excessive nitrate levels in drinking water and exposure to waterborne human pathogens in manure (EPA 1998).

While most livestock producers understand the economic value of manure and many CAFOs follow individual nutrient management plans tailored to their farm conditions and the crops being grown, incidents can result from over application (too much), improper application (too close to surface waterways), unpredictable precipitation events, poor management, and accidental spills. Assistance for CAFOs in developing site-specific nutrient management plans is available through NRCS, private advisors and many state programs.

A.6.1 Nutrients

Animal wastes contain significant quantities of nutrients, particularly nitrogen and phosphorus. The nutrients provide a valuable resource that can save money by replacing chemical fertilizer. It is desirable to minimize nutrients lost from improper storage and land application. Manure nitrogen occurs in several forms, including ammonia and nitrate. Ammonia and nitrate have fertilizer value for crop growth, but these forms of nitrogen can also produce adverse environmental impacts when they are transported in excess quantities to the environment. Ammonia is of environmental concern because it is toxic to aquatic life and it exerts a direct biochemical oxygen demand (BOD) on the receiving water, thereby reducing dissolved oxygen levels and the ability of a water body to support aquatic life. Excessive amounts of ammonia can lead to eutrophication, or nutrient over-enrichment, of surface waters.

While nitrate is a valuable fertilizer because it is biologically available to plants, nitrate is mobile in soil and can leach to ground water. Excessive concentrations of nitrate in drinking water can produce adverse human health impacts such as methemoglobinemia in infants. Generally, people drawing water from domestic wells are at greater risk of nitrate poisoning than those drawing from public water sources, because domestic wells are typically shallower and not subject to wellhead protection monitoring or treatment requirements. Note that nitrate is not removed by conventional drinking water treatment processes but requires additional, relatively expensive treatment units.

Phosphorus is of concern in surface waters because it can lead to eutrophication and the resulting adverse impacts—fish kills, reduced biodiversity, objectionable tastes and odors, increased drinking water treatment costs, and growth of toxic organisms. Phosphorus is primarily sorbed to soil colloids and transportation to surface water occurs with soil erosion. Soluble phosphorus exists especially when soil is saturated with respect to P and has been found to leach in very sandy soils after many years of manure application. At concentrations greater than 1.0 milligrams per liter, phosphorus can interfere with the coagulation process in drinking water treatment plants thus reducing treatment efficiency. Phosphorus is of particular concern in fresh waters, where plant growth is typically limited by phosphorus levels. Under high pollutant loads, however, fresh water may become nitrogen-limited. Thus, both nitrogen and phosphorus loads can contribute to eutrophication.

A.6.2 Dissolved Oxygen

Livestock manures contain many carbon-based, biodegradable compounds. Once these compounds reach surface water, they are decomposed by aquatic bacteria and other microorganisms. During this process dissolved oxygen is consumed, which in turn reduces the amount of oxygen available for aquatic animals. Severe reductions in dissolved oxygen levels can lead to fish kills. Even moderate decreases in oxygen levels can adversely affect water bodies through decreases in biodiversity characterized by the loss of fish and other aquatic animal populations, and a dominance of species that can tolerate low levels of dissolved oxygen.

A.6.3 Solids

Solids from animal manure include the manure itself and any other elements that have been mixed with it. These elements can include spilled feed, bedding and litter materials, hair, and feathers. In general, the impacts of solids include increasing the turbidity of surface waters, physically hindering the functioning of aquatic plants and animals, and providing a protected environment for pathogens. Increased turbidity reduces penetration of light through the water column, thereby limiting the growth of desirable aquatic plants that serve as a critical habitat for fish, shellfish, and other aquatic organisms. Solids that settle out as bottom deposits can alter or destroy habitat for fish and benthic organisms. Solids also provide a medium for the accumulation, transport, and storage of other pollutants, including nutrients, pathogens, and trace elements.

A.6.4 Pathogens

Pathogens are defined as disease-causing microorganisms. A subset of microorganisms, including species of bacteria, viruses, and parasites, can cause sickness and disease in humans and are known as human pathogens. EPA's *National Water Assessment Report* indicates that pathogens are the leading stressor in impaired rivers and streams and the second leading stressor in impaired estuaries, coastal shorelines, and wetlands (EPA 2012b). Livestock manure may contain a variety of microorganism species, some of which are human pathogens. Multiple species of pathogens can be transmitted directly from a host animal's manure to surface water. Pathogens already in surface water can increase in number because of loadings of animal manure nutrients and organic matter.

A number of pathogens are associated with livestock and poultry manure but only a few pose a known or potential threat to humans. The six human pathogens that account for more than 90 percent of food and waterborne diseases in humans are found in livestock manure. These organisms are: *Campylobacter* spp., *Salmonella* spp. (non-typhoid), *Listeria monocytogenes*, *Escherichia coli* O157:H7, *Cryptosporidium parvum*, and *Giardia lamblia*. All of these organisms may be readily transmitted from one animal to another in CAFO settings. Pathogens from animal wastes can enter water sources, resulting in contamination of surface waters. In addition to threats to human health through drinking water exposures, pathogens from animal manure can also threaten human health through shellfish consumption and recreational contact such as swimming in contaminated waters. An important feature relating to the potential transmission for disease for each of these organisms is the relatively low infectious dose in humans. The protozoan species *Cryptosporidium parvum* and *Giardia lamblia* are frequently found in animal manure and can cause infection in humans. Bacteria such as *Escherichia coli* O157:H7 and *Salmonella* spp. are also often found in livestock manure and have been associated with waterborne disease. The bacteria *Listeria monocytogenes* is ubiquitous in nature and is commonly found in the intestines of wild and domestic animals.

A.6.5 Salts

The salinity of animal manure is directly related to the presence of dissolved mineral salts. In particular, significant concentrations of soluble salts containing sodium and potassium remain from undigested feed that passes unabsorbed through animals. Other major constituents contributing to manure salinity are calcium, magnesium, chloride, sulfate, bicarbonate, carbonate, and nitrate. Especially in arid soils salt buildup deteriorates soil structure, reduces permeability, contaminates ground water, and reduces crop yields. In fresh waters, **increasing** salinity can disrupt the balance of the ecosystem, making it difficult for resident species to remain. Salts also contribute to degradation of drinking water supplies, primarily from runoff containing manure.

A.6.6 Trace Elements

EPA's *National Water Assessment Report* indicates that metals (other than mercury) are the fourth leading stressor in impaired wetlands and the fifth leading stressor in impaired lakes (EPA 2012b). Trace elements of environmental concern in manure include arsenic, copper, selenium, zinc, cadmium, molybdenum, nickel, lead, iron, manganese, aluminum, and boron. Of these, arsenic, copper, selenium, and zinc are often added to animal feed as growth stimulants or biocides. Trace elements can also end up in manure through use of pesticides used to suppress houseflies and other pests. Trace elements have been found in manure lagoons and drainage ditches, agricultural drainage wells, and tile line inlets and outlets. They have also been found in rivers adjacent to hog and cattle operations. Trace elements in agronomically applied manures are generally expected to pose little risk to human health and the environment. Most crops, for example, beneficially use a small amount of copper and zinc to complete their life cycle but any amount not assimilated through plant uptake can accumulate in the soil (Novak et al., 2004). Repeated manure application in excess of agronomic rates could result in cumulative metal loadings to levels that potentially affect human health and the environment.

A.6.7 Antibiotics

Antibiotics are used in AFOs for the prevention, treatment and control of animal diseases and can be expected to appear in animal wastes. Antibiotics are used both to treat illness and as feed additives to promote growth or to improve feed conversion efficiency. Between 60 and 80 percent of all livestock and poultry receive antibiotics during their productive lifespan. The primary mechanisms of elimination are in urine and bile, so essentially all of an antibiotic administered is eventually excreted, whether unchanged or in metabolite form. The use of the same antibiotics for humans and livestock has been noted by the World Health Organization (WHO) and others who are concerned that the effectiveness of these antibiotics in treating human diseases could decrease. The emergence of resistant bacteria is of particular concern because such infections are more difficult to treat and require drugs that are often less readily available, more expensive, and more toxic. The Food and Drug Administration issued a guidance in 2012 encouraging the judicious use of antimicrobial drugs in food animals. They are continuing to work with the pharmaceutical industry to phase out the use in livestock and poultry of medically important antibiotics for human health.

A.6.8 Pesticides and Hormones in CAFOs

Hormones and pesticides are chemicals commonly found in CAFO manure, and both have been linked with endocrine disruption of fish and invertebrates in the surrounding environments. Several forms of estrogens, androgens, or a combination of both have been detected in dairy waste (Zheng et al. 2008), and poultry litter (Jenkins et al. 2006). Pesticides, especially those that are used for treatment of parasites, have also been detected in the environment following manure application (Floate et al. 2005).

Hormones are naturally occurring chemicals produced by animals to regulate physiological processes such as metabolism, growth, and reproduction. Natural steroid hormones include estrogen, progesterone, and testosterone. Synthetic steroid hormones, which mimic the actions of the naturally occurring compounds, may be administered to livestock to promote better muscle growth, produce leaner meat, improve feed conversion efficiency, and improve breeding. Other types of hormones (non-steroid hormones or protein hormones) may also be given to promote growth and increase milk production. Hormones categorized as progestins and gonadotropins may be administered via injections or other means to improve breeding efficiency. A complete list of FDA approved steroid hormones used as implants and their specific use for growth promotion can be found in the Code of Federal Regulations (CFR), Title 21, Parts 522 and 556.

Feedlot effluents containing hormones have been shown to affect fish in adjacent streams causing decreased synthesis of testosterone, smaller testis size, and general demasculinization of those fish (Orlando et al. 2004). Other effects of hormones in the aquatic environment may include feminization or intersex condition in fish and increases in concentrations of proteins related to egg laying in both male and female fish.

Varieties of pesticides are approved for use in feedlot animals for control of insects and parasites, and can enter process wastewater via runoff from topical applications or from manure. These compounds are administered via injection, insecticidal ear tags, or oral consumption in feed/minerals. They may also be applied directly to the skin as pour-on formulation or when animals (especially cattle) pass under a backrubber/oiler or dust bag where insecticides are dispensed to the skin. Ivermectin is a common pesticide that can be applied by several methods to livestock for control of roundworms, lung worms, cattle grubs, mites, lice, and horn flies. Some pesticides are used in CAFOs specifically to control flies. For example, the insecticide methoprene is sometimes used as a feed or mineral additive to control horn flies. Methoprene passes through the digestive tract of animals and remains in the manure where horn flies lay eggs. The pesticide mimics an insect growth regulator called juvenile hormone, and disrupts the life cycle and development of the larval flies.

Insecticides are often designed to interfere with hormonal processes like molting, growth, or reproduction in invertebrates. Residues of some insecticides are well documented for adversely affecting other non-target populations of insects. Additionally, effluent from CAFOs or runoff resulting from spreading manure on pastures or cropland introduces pesticides into the soil and aquatic environment where aquatic insects may be affected. Parasiticides like ivermectin and some insecticides are known to cause mortality to aquatic insects (Schweitzer et al. 2010).

Careful use of hormones, pesticides, insecticides, and antibiotics for production agriculture is important to protect the animals, the livestock producers, the public and the environment. Because these substances are often present in manure, careful management and land application of manure and process wastewater is equally important.