

Animal Waste Management on the University of Kentucky Animal Research Center in Woodford County

The University of Kentucky, College of Agriculture's Animal Research Center (ARC) is a 1440 acre farm in Woodford county. The ARC is a former horse and beef cattle farm that was purchased by the Commonwealth of Kentucky for the University in 1991. The ARC is a facility designed to meet the goals of the College of Agriculture for animal research. Facilities have been designed and constructed to assess the impact of animal agriculture on surface and ground water resources and the control of odors. The initial planning for research structures at the ARC facility was initiated in 1996 after funding was approved by the Kentucky General Assembly.

PLANNING PROCESS

The planning process goals included meeting the requirements of the Agricultural Water Quality Authority which was established under the 1994 Kentucky Agricultural Water Quality Act. These requirements were to utilize structural and management practices (Best Management Practices -BMPs) that minimize the impacts of animal production on water quality. The applied practices are to meet the following criteria:

1. zero discharge of wastes and wastewaters to water resources by application of these wastes to land, as a source of nutrients (N, P, and K) for grain and forage production within the farm property;
2. nutrient application to the soil at rates which will not exceed their uptake by crops grown on the soil.

Further, the waste management planning process included the regulatory requirements of Kentucky Division of Water emergency regulations for Swine Feeding Operations that were issued in both 1997 and 1998. These regulations established distance separations between swine production facilities/waste application areas and property boundaries of cities/towns, property owners and other public facilities. Although the proposed swine population on the ARC was below the regulatory threshold, the College of Agriculture chose to apply the emergency regulations to swine as well as all other animal species that were to be grown on the ARC.

Soil tests for the ARC indicated that the soils contained a level of available P that did not require P supplementation. This is typical of the soils found on the farm (Maury-McAfee series) because the parent material is a phosphatic limestone. This would indicate that the maximum annual average P loading would be limited by the P removed in harvested biomass. This level of P would maintain long-term sustainability and would be a conservative estimate. Maximum loading of nitrogen would also be limited by N contained in the harvested biomass which is adjusted upward for normal soil N losses to leaching and denitrification; and downward for N additions from soil organic matter mineralization.

ANIMAL SPECIES RESEARCH UNITS

The ARC will be the research center for beef, sheep, dairy and swine. The ARC animal populations are shown in Table 1 and are based on capacity of buildings constructed in Phase I and the proposed Phase II buildings. Table 1 also contains the estimated animal manure nutrients that are available for crop production from the confinement buildings and pastures. These numbers are adjusted for estimated losses on the production floors, in the storage structures, and field losses during application. ARC animal population expansion will be capped at a level based on the crop production land resources' capability to absorb only an additional 7,400 lbs. of P (See Table 2).

Table 1. Animal Populations and Plant Available Nutrients

Unit	Phase	Resident Population		N	P	K
Beef	I	466	150 cows	23,400 lbs.	20,300 lbs.	47,000 lbs.
Sheep	I	1183	413 Rams and Ewes	4,900 lbs.	2,400 lbs.	13,500 lbs.
Swine	I	1055	120 Sows	32,800 lbs.	8,900 lbs.	9,100 lbs.
Dairy	II	560	250 Lactating Cows	<u>74,400 lbs.</u>	<u>16,800 lbs.</u>	<u>60,300 lbs.</u>
		Subtotals:		135,500 lbs.	48,400 lbs.	129,900 lbs.

The research production systems, that have been developed, are based on the research needs for each species. Beef production required both partially roofed concrete feedfloors, pasture systems, and an additional intensive basic research building where animals are totally confined under roof. The wastes from the confinement facility will be handled as solids scraped from the feedfloors. Rainwater from the unroofed concrete portions of the feedfloors and alleyways will be collected and directed to a settling basin. The scraped settled solids will be composted and returned to pastures. The supernatant will be applied to a grass filter. Forage from the grass filter will be harvested and used as feed or a carbon source for the composting operation. The sheep facilities also required both a partially roofed feedfloor confinement facility and pasture. The under roof feedfloor will be bedded with straw and will be handled as solids. Nutrient (N, P, and K) accumulation below the gravel in the unroofed pens will be monitored. If they accumulate the confinement lots are designed to be fitted with an impervious layer at a 30 in. depth and drained to an appropriate grass filter or treatment facility. Rainwater on unroofed confinement lots will infiltrate through dense packed gravel on the feedlot. Swine research facilities are totally confined under roof. Wastes are accumulated in shallow pits below slats called a shallow pull-plug flush gutter system. Plugs are pulled after one or two weeks to empty the pits. The pits are refilled to a depth of at least 4 in. with fresh water. The management of these pits is a key to minimizing the odors generated from the confinement buildings. The fresh

water covers and dilutes the manure. The plugs are pulled at a frequency based on the indoor temperature of the facility; one week for warm/hot temperatures and two weeks for cool/cold temperatures. More frequent emptying of the pits during for the warmer temperatures is required since bacteria will degrade the manures and generate odorous by-product gases more rapidly. Dairy facilities will have confinement feedfloors totally under roof and loafing pastures. The milking herd and parlor wastes will be handled as high solids liquids while the calf and heifer confinement facilities will be bedded and handled as a solid waste.

FARM LAND RESOURCE BASE USE

The farm acreage was assigned to the various animal units based on the soil capabilities, research requirements, stream protection, and requirements for facilities and infrastructure. Land resources were assigned (see Table 2) for grains, silage, forage production and pasture grazing. The zones, designated as riparian, will be grazed utilizing stream protection strategies. There are unassigned areas for buildings, roads, infrastructure, waterways, and lakes. Nutrient requirements were based on soil capabilities under intensive crop management.

Table 2. Land Uses and Average Annual Nutrient Requirements and Utilization

Land Use		Area	N	P	K
			<u>Requirements:</u>		
Row Crop	corn/wheat/soybean*	350 ac.	105,000 lbs.	18,900 lbs.	108,500 lbs
Forage	alfalfa*	150 ac.	45,000 lbs	6,800 lbs.	37,500 lbs
Pastures	fescue	740 ac.	74,000 lbs.	25,900 lbs.	222,000 lbs.
Riparian	fescue	120 ac.	12,000	4,200 lbs	36,000 lbs.
Unassigned	buildings, roads, lakes and waterways	<u>80 ac.</u>	<u>0 lbs</u>	<u>0 lbs</u>	<u>0 lbs</u>
Subtotals:		1440 ac.	236,000 lbs.	55,800 lbs.	404,000 lbs.
			<u>Available from animals:**</u>		
			<u>135,500 lbs.</u>	<u>48,400 lbs.</u>	<u>129,900 lbs.</u>
Commercial Fertilizer Supplementation:			100,500 lbs.	7,400 lbs.	274,100 lbs.

* Fertility management for legumes will include addition of N from the animal manures and may require further inorganic N supplementation to achieve maximum yields.

** Adjusted for losses from feedfloors, storage, and application.

WASTE MANAGEMENT STRATEGIES

Several criteria and limitations were used to select the waste management system that was designed for the ARC. These were:

1. the proximity of the city of Versailles and the use of adjacent properties dictated that the animal manures be managed to minimize the generation of odors during the collection, storage, transport, and field applications,
2. the efficient utilization of ARC land resources,
3. to minimize stream and groundwater impacts by the use of riparian areas,
4. to manage the application of the manure nutrients by precision farming strategies,
5. to link the waste management system choices to areas of need in research,
6. to provide opportunities to assess the impacts of waste management strategies on air and water resources,
7. to provide flexibility to incorporate new waste management processes.

Waste management system design limitations were determined as the animal research goals and facility designs were developed. There were four limitations identified:

1. row crop fields were to be used for injection of liquids,
2. injection of liquid wastes in pastures and alfalfa production fields was not acceptable because of root system disruption and resultant field roughness,
3. spreading fresh waste or anaerobic manures on research grazing pastures was not acceptable because it would inhibit animal foraging,
4. earthen lagoons or storage ponds were not acceptable because of karst limestone geology present on the ARC and the potential for odors.

Animal manures, that are to be collected from animal confinement facilities as solids, are to be transported to a site for composting while the liquids will be hydraulically transferred to covered above ground storage structures. Manure nutrients deposited by the animals in the pasture were taken into account when determining balances for pasture areas. The following is a general description of the waste management system for confinement facilities at each animal unit on the ARC.

Beef Research Unit (Figures 1 and 5)

Solids are scrapped from the curbed concrete confinement feedfloors with a skid loader and loaded onto a spreader wagon and transported to the site for composting. Rainwater runoff from unroofed confinement feedfloors, handling areas, and alleyways are collected in troughs and transported by gravity through buried pipelines to a concrete settling basin. The liquids drain from the basin through a perforated riser and flow by gravity to a grassed infiltration area.

Sheep Research Unit (Figures 2 and 6)

Manure and bedding solids are removed from the pens by a skid loader and placed on a wagon for transport to the composting site. The pens are cleaned two times per year. Any surface flow of rainwater from the unroofed pen areas will travel to a grassed infiltration area. Infiltrated water will be collected in curb drains which discharge at a grass filter area.

Swine Research Unit (Figure 3 and 7)

Swine waste flows by gravity through underground pipes from the shallow pull-plug

flush pits inside the confinement buildings to a covered receiving tank. Wastes are pumped into above-ground covered storage tanks which have a capacity to store the wastewater for at least 6 months. Gases, evolved from the collection pit and the storage tanks, will be piped to a biofilter to remove odorous compounds. The collection pit and the storage tanks are equipped with agitators to suspend settled solids before and during pumping operations. The waste management storage area is surrounded by a dike to contain any catastrophic failure or spillage. The layout of the storage facility allows for expansion of storage and/or additional treatment processes. The possible additions could be storage tanks, solids-liquid separation, or aerobic treatment.

Room air in all the swine research buildings will be exhausted vertically at high velocity axial flow fans through 40-foot tall stacks. This strategy will elevate odorous gases both to increase dispersion and mixing and to exhaust air above most atmospheric temperature inversions.

Dairy Research Unit

The waste management for the dairy research unit is in a conceptual form since design for the building complex will begin when funding becomes available. Currently the concept is to manage the milking herd wastes and wastewaters from the parlor, holding area and free stall building as a liquid. The milking herd will be confined under roof so that there will be no stormwater runoff to manage. The liquids will be managed using the same strategy as the swine wastes. Solid manure from bedded calf and heifer housing will be transported to a site for composting.

Composting Site

The composting site consists of a one acre concrete pad with a 6% slope. The pad is curbed with runoff collected in a pit. The runoff liquids will be recycled back to the compost for moisture control utilizing a manure spreader tanker that will have a boom discharge outlet to spread wastewater onto compost windrows. The carbon source will be leaves collected from University of Kentucky campus grounds and sawdust from the campus woodshop. Additional leaves will be collected from nearby communities if necessary. The carbon biomass will be stored under roof to keep the moisture content low. Windrows will be constructed using a side discharge spreader/transport wagon. Windrows will be mixed using a tractor-towed compost turner. Finished compost will be stored under roof until hauled to the field in a side-discharge solid spreader wagon.

Land Application

The nutrients from the liquid and solid forms of the animal wastes will be applied using precision farming strategies. Toward meeting these goals, detailed soils map, a field and farm boundary map, and a topographic map on 2-foot contours were generated and stored in an ARC/INFO GIS data management system. Grain yield maps have been generated using GPS and grain yield monitors. Evaluation and utilization of silage and forage harvester monitors and pasture biomass measurements will need to be part of future research efforts on the ARC since most of the biomass produced and used on the farm will be non-grain.

Solids. Solid manures and some wastewaters will be composted. The liquid wastes are used as a water source for moisture control of the composting process. The objective is to produce a plant

nutrient source that can be spread on research and riparian pastures and alfalfa fields utilizing precision farming strategies. The composting scheme is to produce a solid material that is stable for odor control and nutrient retention, and have a moisture content and a particle size that allows ease and uniformity of spreading using a spreader wagon. Nutrient content (N, P, and K) of the compost will be determined before land application.

Liquids. All liquid wastes not used at the composting site will be injected into row crop fields using a towed hose injector system. During waste application operations in the spring and fall, liquid wastes will be pumped from the swine and dairy research units storage tanks through underground pipes to a field storage tank adjacent to the row crop fields. The tank will contain a volume of liquid that can be injected in one day. This tank may also be used as emergency backup storage as required. The field tank will be covered with a dome and equipped with agitation for continuous solids suspension. Gases evolved within the liquids will be piped to a biofilter to remove odorous compounds. A high pressure, high-volume pump will move liquids from the tank through an underground pipe to the injection field. A towed hose will transport the liquids continuously to wide sweep injectors pulled behind a tractor. Liquids will be injected to a depth of six to eight inches to enhance nutrient retention in the soil and odor elimination

Nutrients will be applied utilizing precision farming strategies. Nutrient content delivery will be controlled based on soil and crop requirements. Nutrient content flow of the liquid manure will be measured by determining the volumetric flow rate and solids concentration. Solids content measurement during the pumping operation is under development. Two alternatives are:

1. pressure drop of a flowing liquid through a test pipe section under known flow conditions,
2. infrared reflectance measurement of the flowing liquid.

Solids content has been shown to be a measure of the fertility in the liquid wastes. The fertility (N, P, and K) correlation to solids content of the stored liquids will need to be calibrated for dairy and swine wastes immediately prior to the Fall and Spring application periods.

ASSESSING ANIMAL PRODUCTION AND WASTE MANAGEMENT IMPACTS ON ARC WATER QUALITY

Assessment of the ground and surface water quality at the ARC began in the Fall of 1991 when a project was funded by a USDA Research Initiative grant. Intelligent hydrologic protection planning is incumbent upon a detailed knowledge of the hydrologic system as well as the influences of land uses upon that system. A series of surface water weirs in streams (12 in total) and three groundwater monitoring well nests (4 to 6 wells at each nest) were constructed to assess soil water, perched shallow ground water and deep groundwater. Figure 4 indicates the location of the surface water weirs and the well nests. A detailed soil map and topographic map (2-foot contours) were constructed. It was found that storm water runoff on 37% of the land area would drain into sinkholes (using a 2-foot contour map). A reconnaissance of the ARC identified the location of springs (both perennial and wet weather) and seeps. There are 18 perennial springs (flowing at least 10 months per year) and 26 wet weather springs that have been identified plus numerous seeps. These are the major outflows of the groundwater to the surface

water and a direct reflection of near surface groundwater quality during base flow conditions. In 1995 four, surface flow weirs were constructed in row crop fields for storm event surface runoff.

A minimum, ongoing water quality monitoring program was instituted in October of 1996 to determine the impact of ARC operations on water quality. This early phase of water quality testing will be considered the background level. Commercial fertilizers have been used for the crop fertility needs since the farm was acquired in 1991. All relevant surface and groundwater water quality, stream and field flows, well water levels, and spatial data have been archived on Biosystems and Agricultural Engineering (BAE) computer system. Water quality data, and surface water flows have been collected for at least 8 years, with the most intensive monitoring occurring in the last 3 years.

ARC crop and animal production impacts on water quality can be assessed with the above monitoring system. Also, off-farm contaminants can be monitored if they enter the farm. Data collection has been initiated in 1999 to determine if contaminants in the surface water exit the ARC primarily in the storm flow or the base flow.

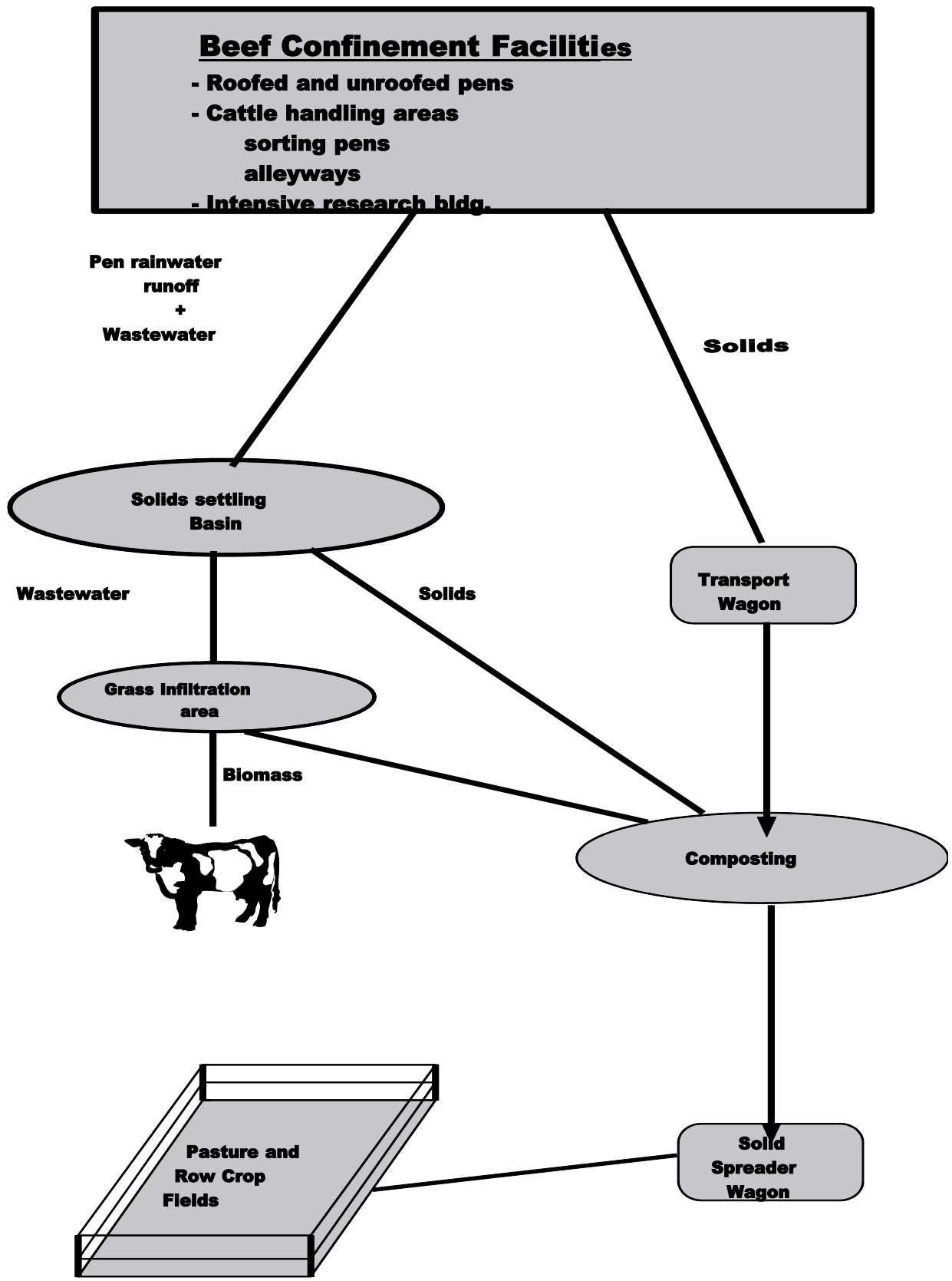


Figure 1. Beef Research Facilities Waste Management System.

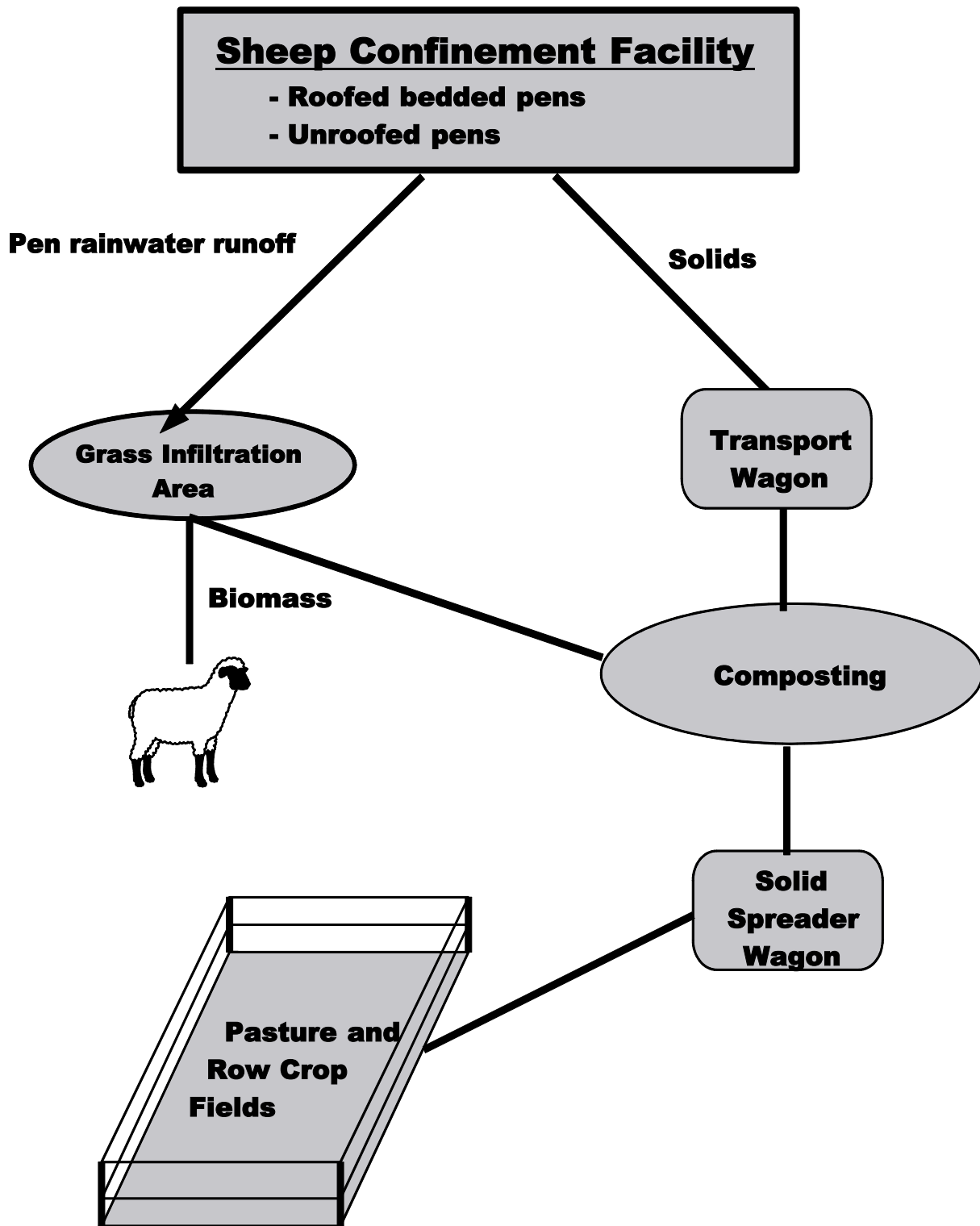


Figure 2. Sheep Research Facility Waste Management System.

Figure 3. Swine Research Facilities Waste Management System.

