

Beef Feeding Operation Siting and Design Basics

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One of the most important decisions when planning any livestock facility is site selection. The site for the feedlot operation must not only be suitable for housing, handling and feeding cattle, but also must ensure that surface and ground waters are protected and the impact from odors is minimized. Whether you are planning a new facility or modifying an existing one, the following information may help avoid costly mistakes.

This publication complements information available in NDSU Extension publication [NM-1297, "Producers Guide to Livestock Manure Management Systems."](#) NM-1297 is a more in-depth look at the planning and construction phase of manure management systems for animal feeding operations (AFOs).

For further clarification on any topics referenced in this publication, please refer to the "Beef Housing and Equipment Handbook" (MWPS 6), "Livestock Waste Facilities Handbook" (MWPS 18) or the NDSU Extension Service.

Regulatory Requirements

All animal feeding operations (AFOs), regardless of size, must abide by the Federal Clean Water Act and North Dakota Century Code, which both prohibit discharging pollutants into "waters of the state" or to a location where pollutants are likely to enter those waters. Waters of the state in North Dakota include lakes, rivers, streams, sloughs and gullies. North Dakota also has odor regulations that pertain to AFOs.

Regulation of AFOs in North Dakota is the responsibility of the North Dakota Department of Health, as well as local governments. Local governments have the right to regulate the nature and scope of an animal feeding operation. Regulations vary across the state, depending on the level of animal feeding operation ordinances adopted by the entity. Therefore, having all feedlot owners/operators become familiar with their local county and township policies is imperative.

For more information on the level of risk a site has for impacting waters of the state, consult NDSU Extension publication [NM-1284, "Assessment Tool for New or Existing Animal Feeding Operations."](#)

Space Requirements

Table 1 summarizes the pen and area requirements for cattle in a range of weight classes (from MWPS 18).

Increasing pen space per head beyond adequate may increase the size of runoff containment beyond economical or manageable size.

Table 1. Sizing pens and barns.

Class of Stock	Feeder Calves	Finisher Cattle	Cows
	400-800 lb	800-1,200 lb	1,000-1,300 lb

Pen*

• unpaved, with mounds (ft ² /head)	150-300	250-500	300-500
• unpaved, no mounds (ft ² /head)	300-600	400-800	500-800
• paved (ft ² /head)	40-50	50-60	60-75

Barn

• with lot (ft ² /head)	15-20	20-25	20-30
• without lot (ft ² /head)	20-25	30-35	35-50

*The amount of space per head of animal also is affected by the slope in the pen.

Slope

Pens should drain freely to prevent boggy conditions in spring, yet should not be so steep that the surface erodes or the manure washes from the pens. Manure is easier to handle scraped up as a solid than as a sludge or liquid. The optimum slope for pens is between 2 percent and 6 percent. Pens should slope away from the feed bunk and roadway. Keep pen length to less than 250 feet to control erosion (the steeper the slope, the shorter the pen should be).

Pen slope affects pen size in open lots. Minimum requirements are 150 to 250 feet²/head (ft²/hd), with 4 percent or greater slopes, and 250 to 400 ft²/hd, with 2 percent to 4 percent slopes. To compensate for slower drainage, pens require more space with less slope.

Collection drains should be outside the pen and sloped at less than 1 percent. Below-pen drains usually are 0.5 percent to 0.75 percent, while main drains are 0.2 percent to 0.5 percent. Drains designed to separate solids from the runoff stream may require slopes between 0.1 percent and 0.3 percent. Alternatively, a settling basin or solid separator can be constructed.

Bunk Space

Table 2 summarizes the bunk space requirements for various sizes of animals (from MWPS-6).

Feed bunks can be wooden or concrete, while none are needed for ground feeding. When selecting a bunk type, take into account manure buildup, drainage, snow accumulation, clean out and preferred feeding style.

Table 2. Bunk space requirements.

Class of Stock	Feeder Calves	Finisher Cattle	Cows
	400-800 lb	800-1,200 lb	1,000-1,300 lb
Bunk Space per Head	18"-22"	22"-26"	26"-30"

Heavy-use Areas

Feed alleys and aprons around feed bunks and waterers need to be designed to withstand heavy use. They can be concrete, gravel, pavement or fly ash compounds. Typically, heavy-use pads are 10 to 12 feet wide along feed bunks and around waterers. Equipment width, as well as drainage and snow accumulation, needs to be taken into account when deciding the width of feed alleys.

Soil Type

Soil types should match the requirements of the activities in the feeding operation.

- **Pen surfaces and roadways.** Locate pens and roadways on a stable, compacted, well-drained site. Expansive clays are undesirable.
- **Manure collection and runoff control.** North Dakota has design specifications for storage and collection areas. These specifications are referenced in the North Dakota Livestock Program Design Manual.
- **Manure utilization.** Land application of manure and effluent is suited to all soils used for crop production. Silty and clayey soils with high productivity are best at retaining manure nutrients for crop use throughout the growing season. Sandy soils offer good drainage but have the poorest nutrient retention. Therefore, application rates must be managed more closely to meet crop nutrient removal rates.

Working with soil types not suited to these activities will add significantly to facility construction and management costs or environmental risk.

Orientation

The preferred orientation for an AFO is having the pens facing south or east to offer some protection from the prevailing winds and maximize the sun's drying effect. However, the orientation of an AFO should best fit the natural slope, windbreak availability or other on-site constraints. If the AFO is not designed to fit the natural lay of the land, it may result in excessive construction costs.

Surface Water

Preventing all nutrient-laden runoff from entering waters of the state is critical. Typically, this requires structures such as sedimentation basins, storage ponds or containment of some type. The choice among different options depends on distance to the water, slope, soil type and vegetation preceding the water, and size of operation.

Typically, a diversion is constructed to prevent clean water from entering the site. Natural site drainage should be taken into consideration during the design phase of the operation to minimize the extent of earth moving and diversion construction to keep the clean water separate from the nutrient-laden water.

Runoff and leachate from high-moisture feeds, such as silage or beet tailings, also must be controlled or contained to prevent it from impacting waters of the state. Dry baled hay or straw is not a concern.

Runoff from the pens and piled manure will carry nutrients and contaminants off site unless contained. Typically, a storage pond is constructed for nutrient-laden runoff with a capacity designed to hold:

- 270 days' worth of runoff storage
- The runoff from a 24-hour, 25-year storm
- Any sludge that may accumulate and otherwise reduce pond capacity, as well as a 1-foot freeboard

Typically, runoff containment ponds are designed to maintain capacity through evaporation during the summer months. In instances of excessive rainfall, the liquid can be pumped for crop application via irrigation.

Groundwater

Groundwater protection is regulated much like surface water in North Dakota. Therefore, to protect groundwater, AFOs and manure storage structures are required to be a minimum horizontal distance of:

- 100 feet from a public water supply
- 50 feet from a private water supply well
- 500 feet from any water supply well not owned by the facility and downslope from the facility

If at all possible, AFOs and manure storage structures should avoid sites:

- Within one mile of a glacial drift aquifer (refer to maps from the North Dakota State Water Commission)
- That have usable groundwater within 30 feet of the ground surface
- That predominantly have sand, sandy loam, loamy sand or gravel soil types
- Are within a designated wellhead protection area

If you cannot avoid these sites, an extra investigation or groundwater monitoring may be necessary. Facilities also should provide a buffer of at least 300 feet between holding pens or manure stockpiles and the facility's water supply well.

Odor

Odor management of AFOs is very important. Odorous air contaminants are regulated in North Dakota under North Dakota Century Code Chapter 23-25 and North Dakota Administrative Code 33-15-16. Management to minimize the impact of odor is a combination of:

- Frequent pen scraping and manure removal for odor control. The largest contributor to odor is manure on pen surfaces or in piles. If stockpiled, scraped pen manure should be stored in a location to minimize odor dissemination.
- Providing good pen drainage. Standing water or wet manure contributes significantly to odors. Pen design that allows for quick drainage and surface drying after precipitation is very important for odor control.
- Recognizing the prevailing wind direction. In North Dakota, this usually is from the northwest or southeast (or north/south in the Red River Valley).
- Using topography to your advantage. Odor tends to "drain" down slope in the evening in summer.
- Having windbreaks to help cause odors to rise and disperse and break up odor plumes, as well as provide stock protection and reduces visual impact.
- Being a good neighbor. Avoid spreading manure near a residence, or on weekends or during other special occasions.
- Providing a buffer distance to the neighbors. In counties and townships that do not regulate nature and scope, the North Dakota Department of Health has regulations governing the setback distance of animal feeding operations based on the size of the operation. The setback distances are in North Dakota Century Code 23-25-11. This setback has easement options, but cooperation of the resident(s) within the setback area is needed. Be sure to check with the local authorities on ordinances that may dictate setback distances. In a county or township that does regulate nature and scope, the local ordinance takes precedence over state law.

Zoning

Zoning is different than ordinances or regulations. Zoning dictates what type of use is allowed for specific areas and is enacted at the local level. Ordinances and regulations are zoning tools that dictate how a certain type of use is managed. Confirm with your local branch of government that the site is zoned appropriately for agricultural or industrial use, depending on the size of the animal feeding operation. Local zoning is enforced either at the county or township level.

Winter Protection

Windbreaks provide shelter for stock and control snow drifts, reducing time spent removing snow from roads and bunks. Twelve-foot-high slat fences handle snow efficiently but are more costly than trees. Three rows of 20-foot-high trees with a density of 50 percent to 60 percent will handle as much snow at less cost and improve visual aesthetics. Allow 150 feet between the windward row and the pens, and extend the rows 100 feet past the ends. Give thought to where the drainage from the melting snow will go. It should be clean water and may be diverted. If possible, plan feed storage in areas with a low risk of heavy snow drifting.

Mounding

Mounds can be used to improve drainage within pens. In new facilities, soil for the mounds can come from the lot itself or from soil removed to make debris basins or holding ponds. On sites with less than a 2 percent slope away from bunks, soil may have to be hauled in to provide adequate mounds. Use of composted or aged manure to build mounds is not

recommended because hoof action of the cattle will loosen the material, leading to flattening of the mound.

Typical mounds have short, relatively steep slopes on the mound itself, with less slope in the valley. Maintaining good drainage out of the pen is important. Otherwise, water and manure will accumulate within the pen, creating an environment for odor and insect production. Locating pen fences on the crest of the mound results in manure working away from the fence. This makes pen cleaning easier, as well as eliminating manure buildup, thereby decreasing insect breeding during the summer months.

Future Changes, Expansion, Change in Markets

The operation will change through time - for example, expanding in numbers or concentrating on different markets. Take all possible scenarios under consideration when designing a feeding operation. Money spent up front in the planning process usually saves significant dollars in future expansion/alteration projects.

Nutrient Management

If you have an existing AFO, you should have manure samples tested to determine nutrient content. In the absence of your own data, several references provide typical manure volume and composition analyses. Be aware that the nutrient content will vary significantly from site to site. Table 3 outlines beef cattle manure nutrient estimates.

Table 3. Beef waste characterization without bedding.*

	Finishing Beef	Beef Cow
	lbs/finished animal	lb/day-animal
Nitrogen	55	0.42
Phosphorus	7.3	0.097
Potassium	38	0.3
Manure Production	9,800	63

*Source: American Society of Agricultural Engineers Standard D384.2
MAR2005 Manure Production and Characteristics

While scraping pens, try to maintain the manure interface layer and leave a level pen surface. A box scraper is better than a dozer or tractor-mounted blade for pen maintenance. Since manure spreading occurs less frequently than pen cleaning, you may need a stockpile area. If it is outside the pen, ensure that any runoff is directed to the storage pond and over an impervious surface. Composting will reduce the volume of manure to be spread and decrease manure odors. However, composting will require turning of the stockpiled manure to maintain aeration.

All AFOs should develop a nutrient management plan that meets the minimum requirements outlined in the North Dakota Livestock Program Design Manual.

Additional Resources

North Dakota Livestock Program Design Manual

www.health.state.nd.us/WQ/AnimalFeedingOperations/Final%20Rules/Design%20Manual.pdf

Mid West Plan Service, (1987). Beef Housing and Equipment Handbook. MWPS-6, 4th Edition

Mid West Plan Service, (1993). Livestock Waste Facilities Handbook. MWPS-18, 3rd Edition

USDA-NRCS. Agricultural Waste Management Field Handbook. www.wcc.nrcs.usda.gov/awm/awmfh.html

For more information on this and other topics, see: www.ag.ndsu.edu

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