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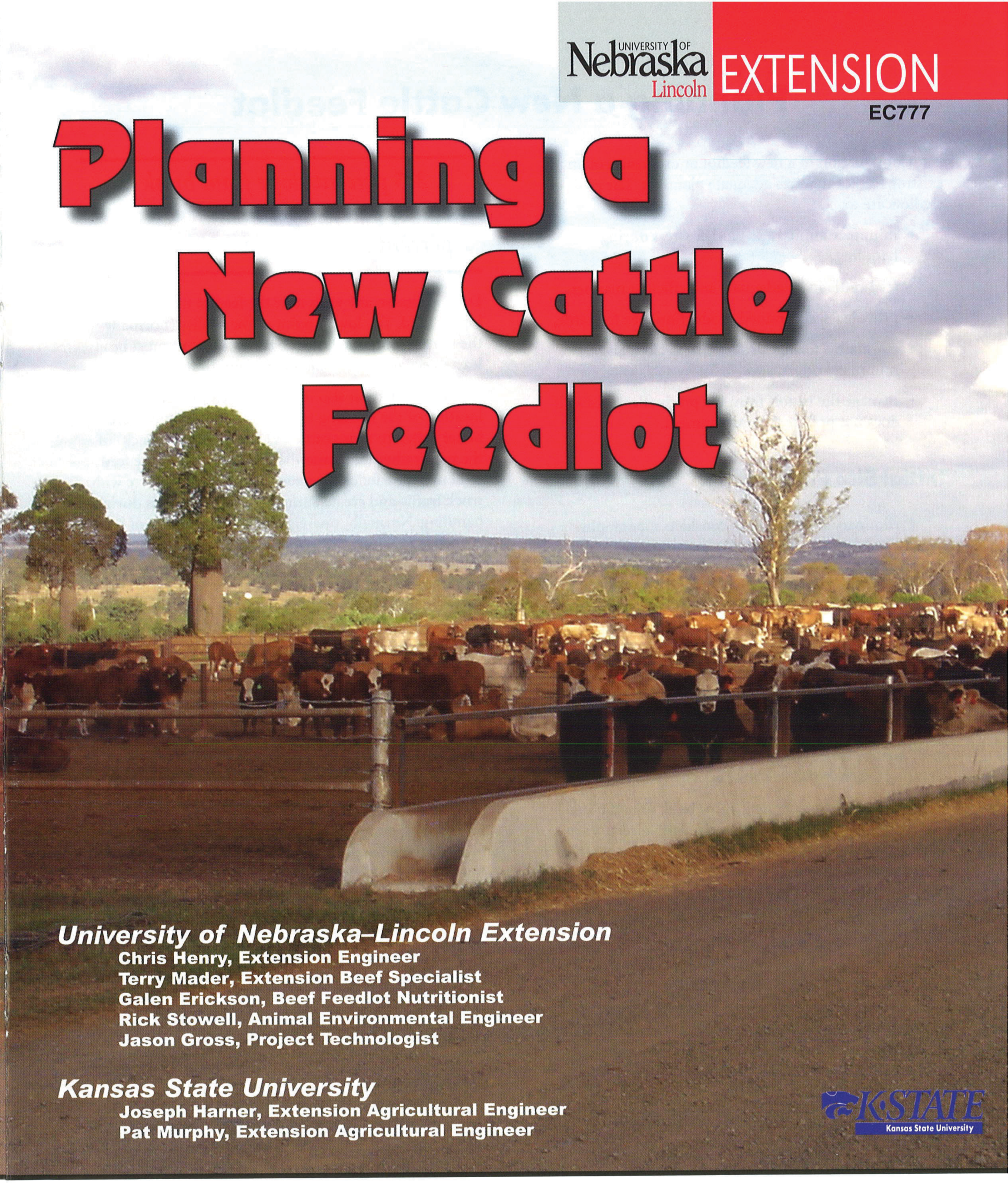

Planning a New Cattle Feedlot

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Planning a New Cattle Feedlot

Construction of a new feedlot or expansion of an existing feedlot requires adequate planning. The goals of feedlots are to:

- minimize animal and worker stress during handling,
- feed cattle in an adequate and efficient manner,
- provide a well-drained production area for cattle,
- maintain a feedlot surface that is clean and minimizes odors, and
- manage the runoff from the production area so it does not pollute the environment.

Initial Site Planning

Preliminary site evaluation considers topography, present and future cattle numbers and accessibility. A 2 to 5 percent lot slope from bunk to end of pen is recommended, with a 3 percent pen slope being ideal. A soil with 25 percent or more clay is preferred to sand or fractured rock structures. Approximately 1 acre of land is required per 100 head of cattle for pen space, alleys and feed roads and 1/4 to 1 acre of land per 100 head of cattle is required for the waste control facility, depending on the type of system. All extraneous runoff needs to be diverted away from the feedlots and roads. For new sites, this is most easily accomplished by siting the feedlots on a ridge or elevating the feed road to construct a diversion channel.

Terrain and drainage determine bunk orientation. Bunks should be oriented in a north-south direction on an east-west sloping lot. Bunks oriented east-west can have ice accumulate on the north side of the bunks in winter. North-sloping lots will not dry as quickly during wet weather and cattle may be exposed to more severe winds.

Generally, most producers find 300 square feet per head to be adequate pen space. Space may be reduced in the western third of the state and may need to be increased slightly in the extreme southeast corner of Nebraska and northeast corner of Kansas. In dry climates, space is often reduced to 200 to 250 square feet per head. Local zoning governs setbacks from property lines, neighbors and roads. Before constructing any facilities, seek conditional use permits or approvals from county zoning. In the absence of local zoning locate runoff control structures a minimum of 100 feet from property lines and 50 feet from rural water lines. Runoff control structures must be at least 100 feet from the nearest well and preferably downhill from the well.

A 2-5 percent slope from bunk to end of pen is recommended; a 3 percent slope is ideal.

Decommission any wells near the feedlot that are no longer used. The lowest point of the facility (normally the bottom of the sediment basin or lagoon) must be at least 4 feet above seasonal high groundwater.

Site evaluation also includes development and location of the working facilities. Most operations are better suited to move cattle out the lower end (back) of the pens rather than onto the feed road. Using the feed road may save fence construction, but can interfere with truck traffic and create animal and worker stress during handling. Normally, one-eighth to one-half acre of land is needed for siting the working facilities. Additional space may be needed for sick or receiving pens. Trucks and stock trailers must have easy access to the working facilities, including a circular turning area at the end of dead-end feed and access roads. Allowing a semi-truck to enter and circle back out the entrance road requires a turning area 130-150 feet in diameter. Similar space is required for many fifth-wheel stock trailers pulled by farm trucks.

Pen Arrangement

Common pen configurations are single or double row arrangements. A double row arrangement requires locating the pens along a ridge with lot construction on both sides of the feed road. *Figure 1* shows pen arrangements with mounds and *Figure 2* shows pen arrangements without mounds. The decision to use mounds or a constant slope pen configuration *(Figure 3)* is discussed later. In a double row arrangement, the feed road is at the highest elevation, and the pens slope away from the road. A single row arrangement typically has feed bunks located on one side of the road and a diversion channel on the other side to carry away extraneous drainage. Often, a single row arrangement is used for operations with less than 800 head and may follow the top of a hill around a hillside. An advantage of the single row arrangement is that only one runoff control structure is required. With a double row arrangement, the runoff must be contained from both sides of the ridge using either two structures or channels to bring the runoff back to a common runoff containment structure. An advantage to the double row arrangement is that the cost of the feed road is

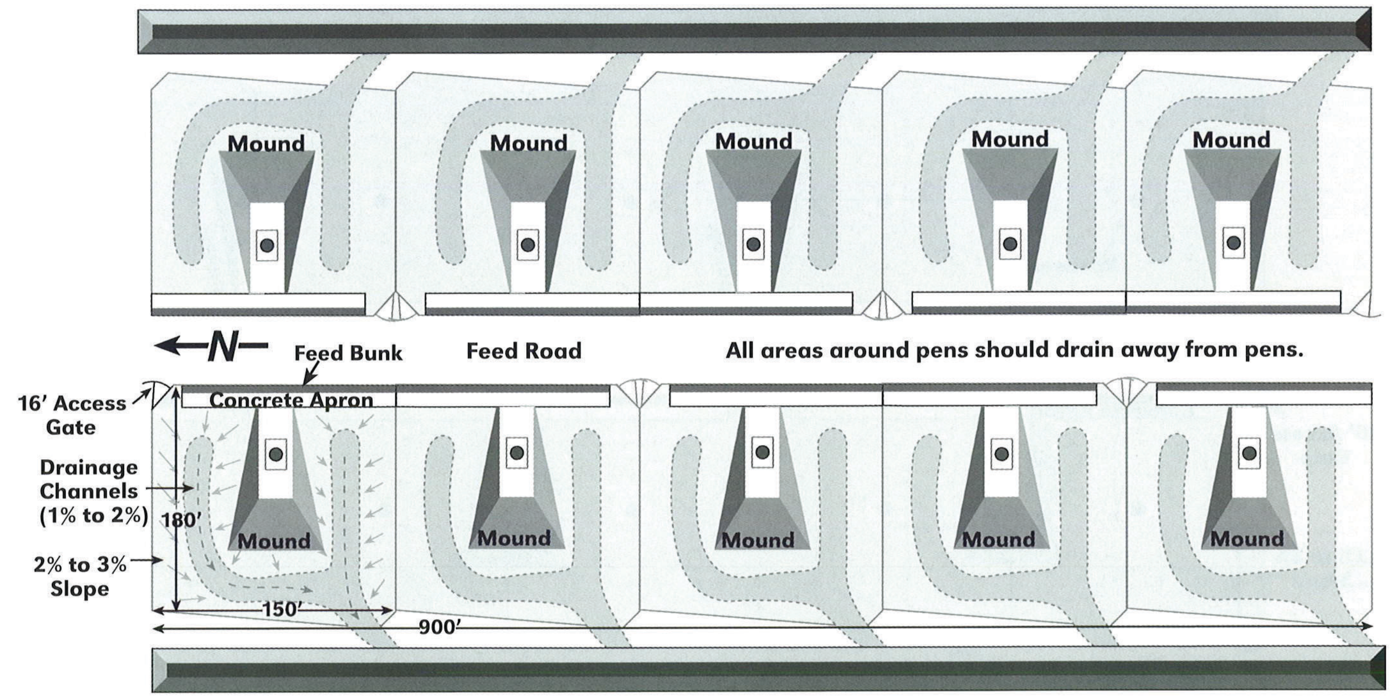

Figure 1. Typical feedlot layout with mounds and channels for drainage (100 head per pen).

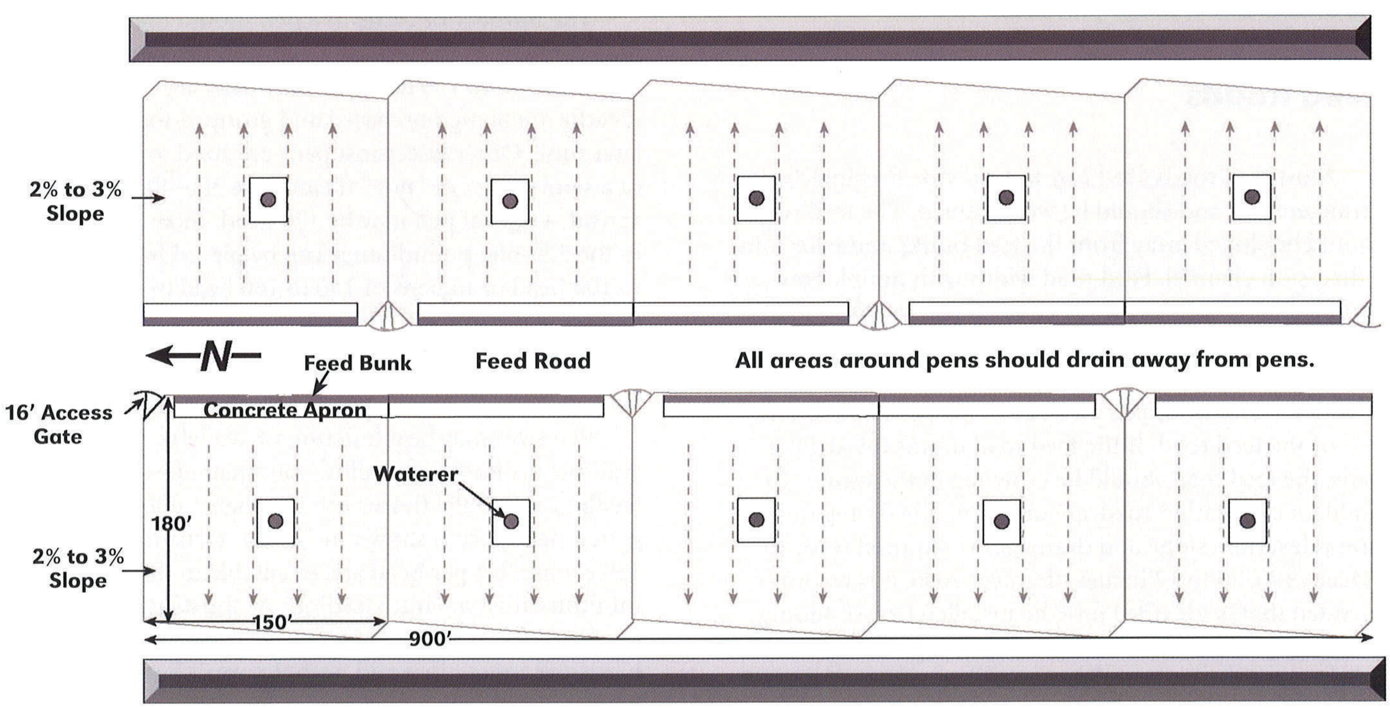

Figure 2. Typical feedlot layout using uniform slopes for drainage (100 head per pen).

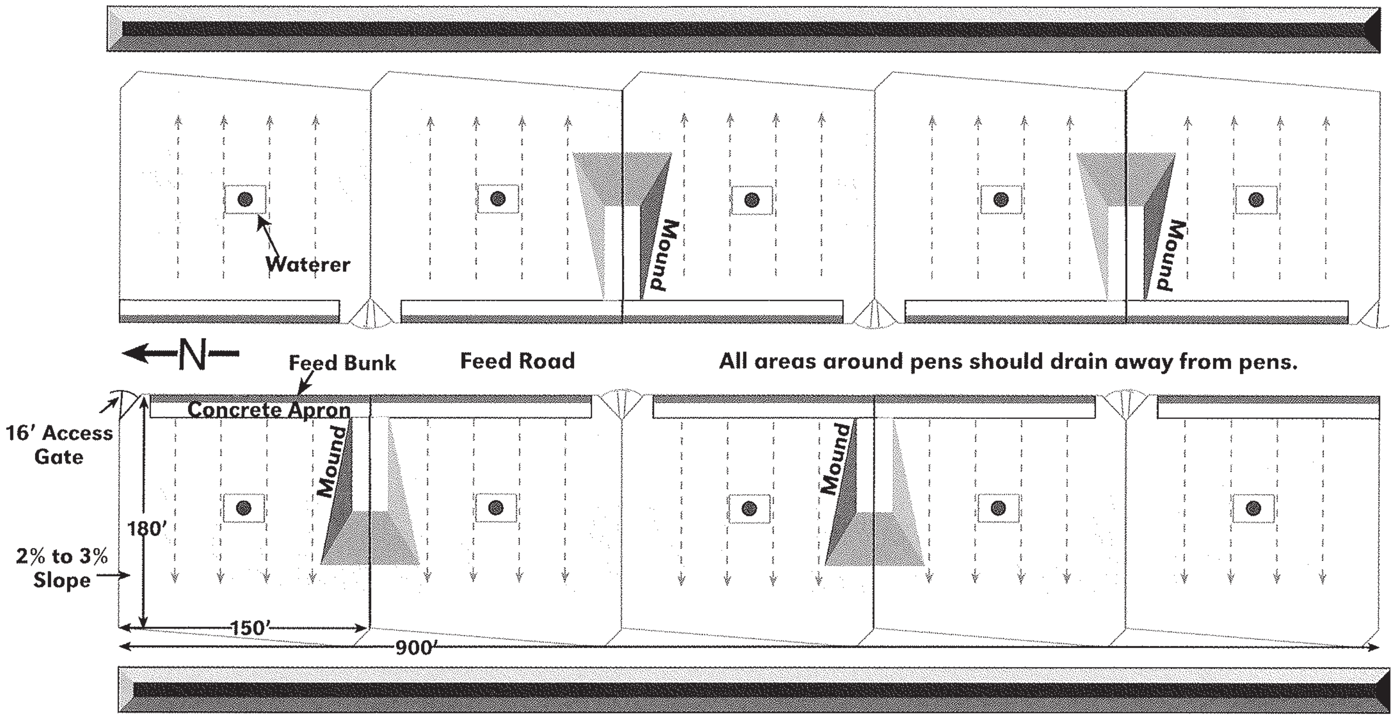

Figure 3. Typical feedlot layout using uniform slopes for drainage and mounds on the fence lines (100 head per pen).

distributed between two pens rather than one. In larger operations, a wider feed road may be required and thus the cost savings is not as prevalent.

Feed Roads

Most feed roads are 12 to 16 feet wide for single row arrangements and should be well drained. The feed road should be sloped away from the feed bunks and pens into a diversion channel. Feed road width with double row arrangements can vary from 16 to 30 feet. A wider road is required if snow or runoff from the road is drained or stored in a center channel of the feed road. The center channel normally drains away from the pens and to one end of the feed road. If the feed road drains toward the pens, the feed road should be crowned in the center. To build an all-weather road, adequate road bed preparation (elevation, slope and drainage) is required prior to placement of 8 to 12 inches of gravel. Also, it is recommended that geotextile fabric be installed before adding the gravel. Although this fabric can be expensive, it can reduce potholes and minimize gravel additions. To install geotextile fabric, smooth the road surface, roll out the fabric, tack it down with landscape staples and then add 8-12 inches of gravel over the top. Geotextile roads are very stable and solid when installed correctly.

Pen Size

The number of cattle in a pen should match the management of the feedlot. Common pen capacities vary from 60 to 150 head. Smaller pens are suggested if cattle are being purchased and grouped together at a later time. Otherwise, most pens are sized to the capacity of a semi-trailer or "pot." If cattle are 300-400 pounds on arrival, a typical pen may be 120 head. Incoming cattle in the 500-600 pound range can be placed in pens of 80 to 100 head or in pens of 140 to 160 head by combining two semi-trailer loads. Receiving pens should be sized to handle no more than one truckload since it is easier to identify stressed animals in smaller groups.

Pen sizes may be a function of available space. A general rule of thumb is to allow 300 square feet per head for feedlots, especially those with less than 1,000 head. Suggested pen space is shown in *Table 1.* Densities as low as 150 square feet per head are acceptable in dry climates to minimize dust in larger feedlots. As the density increases, the level of management increases (i.e manure must be harvested more often and potholes must be maintained more frequently).

Table 1. Suggested pen space requirements.

Type of Animal		*Earthen lot, ft^2 per head*	*Paved lot, ft^2 per head*
Beef			
Cow-calf		500	75
Calf	(600 lbs)	250	50
	(600-1,400 lbs)	350	60
Dairy			
Calf	(250 lbs)	200	30
	(250-400 lbs)	300	35
	(400-600 lbs)	400	40
	(600-800 lbs)	500	45
	(800-1,000 lbs)	600	50

Bunk Space per Animal

Recommended bunk space for backgrounding feedlots (500 to 700 pounds) is 18 inches per head. Younger cattle prefer to eat together and thus require more bunk space than finishing cattle. Finishing cattle operations typically provide 8 to 12 inches per head of bunk space, with the current amount being a function of feeding style and management. Less bunk space is needed when bunks are kept full. Frequency of feeding also can influence bunk space. Once-a-day feeding requires more bunk space for containing the feed than operations feeding two or more times a day. Allow 24 inches per head in receiving pens to avoid crowding and to ensure feed intake upon arrival.

Fence-line bunks are preferred to in-pen bunks. Operating feeding equipment in pens during wet weather can damage the pen surface, resulting in reduced feed efficiency, and in some cases, equipment damage. If in-pen bunks are used, a concrete or gravel-packed base should be constructed with the bunks in the center of the pens. A minimum width for the concrete or gravel base is 24 feet, which allows room for cattle to stand on both sides of the bunk and feeding equipment to distribute feed. The concrete or gravel base should be extended to allow room at the end of the bunks for turning around equipment to exit the pen.

Pad Construction (Pen Surface)

Cattle need a solid firm surface on which to stand. The feedlot pad or pen surface must withstand cattle traffic and manure harvesting operations. A properly constructed pad is very solid, compacted and well drained. Feedlot surfaces should be graded evenly and all earthwork completed before any aprons or fences are constructed. Less pen maintenance is expected for pen areas that are properly sloped and uniformly graded and compacted before placement of fences and concrete (*Figure 4*).

Figure 4. A pad or pen surface that has been properly graded and compacted before placement of apron and fence.

Pen areas should be compacted with several passes of a sheepsfoot roller (wheel tire compaction is appropriate in some soils, see *Figure 5*) in two or three 4- to 6-inch lifts or layers of soil. If the soil can be ribboned and squeezed without water being expelled, it is just right for compaction. The same geotechnical information about the soils that is used for constructing the holding pond liner can be used to compact the feedlot surface. Although not a state regulatory requirement for NDEQ, this construction technique, if done correctly, will minimize pad imperfections and provide a solid uniform surface for cattle. Imperfections are not conducive to good drainage or manure harvesting and will cause problems throughout the life of the lot. Take measures to prevent them.

Figure 5. Water addition and wheel tire compaction of feedlot pad (pen surface).

Minimizing Mud

In feedlots without a concrete pad the bunk must be raised to allow for manure accumulations, changing the geometry of the animals' approach to the bunk and reducing feed intake (*Figure 6*). Studies show 4 inches of mud reduces feed efficiencies up to 10 percent per day. Mud makes it harder for cattle to move around and reduces their ability to access all parts of the bunk. A tremendous amount of energy must be expended to walk through just 2 inches of mud. That energy loss can reduce gain. Firm standing areas near the bunks and waterers are necessary.

Manure should be harvested monthly (or when manure depth is 3 inches) by a pull type blade such as shown in *Figure 7* to minimize mud caused by excessive manure accumulation. Cleaning of pens includes removing manure collected under fence lines. Time-saving devices such as those shown in *Figure 8* can be used to clean fence lines. Feedlot surfaces should be built and groomed to drain after rainfall events. Holes should be filled so they do not hold water, and fence rows should be kept clear of manure accumulation so they do not back up water into the lot. No part of a pen should hold or back up water. Feedlot surfaces should be free of standing water within 12 hours after a rain.

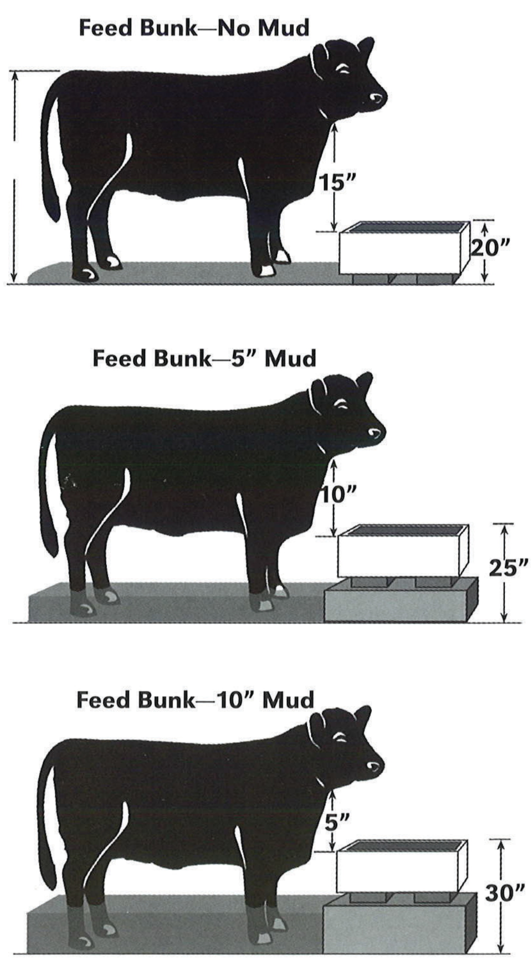

Figure 6. Effect of mud on efficiency and access to bunk.


Figure 7. Pull-type blades are best for manure harvesting.


Figure 8. Skid steer loader fitted with attachment for cleaning fence lines.

Concrete Apron

The concrete apron adjacent to the fence-line bunk provides the cattle a firm place to stand while eating. A 12-foot wide apron is recommended on the cattle side of the bunk, although 10-foot aprons are standard in most feedlots. The additional 2 feet minimizes the wet muddy area that develops near the apron due to defecation and traffic. If the feed bunks are resting on the apron, the total apron width needs to be at least 15 feet. A firm base is key to producing a durable apron. Thicken the slab (shallow footing) at the rear of the apron to prevent base material from eroding underneath the apron base. Along the back side of the apron, a 10- to 20-foot wide section, 8 to 12 inches thick, of gravel screening is recommended. This provides some additional solid ground for the cattle

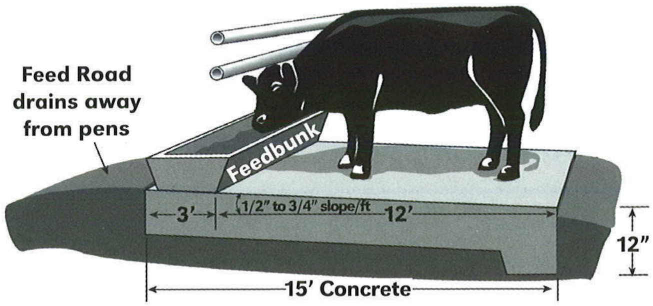

Figure 9. Typical cross section of feedbunk and apron.

to stand on during wet weather. A cubic yard of concrete will construct approximately 3 to 4 linear feet of apron if the apron is 15 feet wide, 6 inches thick and has a 12-inch-deep back-edge footing *(Figure 9)*. All concrete used for feedlots should be air entrained to protect it from weathering.

Concrete bunks are more economical and durable than wooden bunks. Concrete bunks can have either a round or flat bottom. Normally, the type of bunk selected is based on economics and type of equipment used to clean snow or old feed out of the bunk (*i.e.* flat-bottom versus round-bottom bunks). Movable steel bunks are similar in cost to concrete bunks on a per-foot basis, but steel bunks normally are used with in-pen feeding and where cattle feed from both sides. Bunk life is increased by removing old feed and maintaining open drain ports in steel bunks. Provisions for mounting the neck rail must be considered when using posts anchored into the concrete apron, bolted on to the feed bunks or positioned in the feed bunk base.

Figure 10. Bunkline and apron layout. Note that the pad has been extended, and that while the waterer is located in the centerline, it is not far enough from the bunks.

Water

In Nebraska, full time feedlots should have frost-free waterers. Manufacturer's recommendations for number of head per opening must be followed. Frost-free waterers need to be installed according to manufacturer's recommendation to avoid frozen waterers in winter. To avoid cross-pen water contamination and allow better access to water, waterers should be located in the centerline of the pen and not in the fence lines. Also, waterers should be placed approximately 30 feet or more away from the feedbunks to avoid cattle carrying excess feed to the waterer *(Figure 11)*. At a minimum waterers should be cleaned weekly in the summer and twice monthly in the winter.

It is advisable to have a 10-foot concrete apron around the waterer and a 10- to 20-foot wide concrete apron from the feeding apron to the waterer if located near the feed bunk. Having an open water trough for newly arrived cattle can aid initial water consumption until the cattle learn to drink from small automatic waterers. Open tanks or trough waterers require additional consideration for handling the overflow water to avoid mud holes and ice around the waterer. All water pipes should be insulated to reduce heat loss where water pipes pass through the concrete slab. Refer to the manufacturer for the capacity of waterers to be used and make sure they can accommodate the stocking density planned for each pen. If manufacturer information is not available, one linear inch of water space access per head is a good rule of thumb.

Water consumption varies from 8 to 20 gallons per 1,000-pound animal unit, depending on the weather. *Table 2* shows daily water consumption based on size and temperature. Daily water supply should be based on hot-weather needs.

Figure 11. Bunk and waterer locations.

If overflow waterers are used, consider where the overflow water is discharged. Current state and federal regulations consider the overflow water to be "process wastewater," which must be controlled and contained by the waste facility. The obvious alternative is to use electric heated waterers or similar waterers that do not produce overflow water. For runoff control systems that use Vegetative Treatment Systems, do not use overflow waterers as these systems are not suitable for accepting a daily inflow of wastewater. Overflow waterers use 30 percent of their consumption for freezing protection. Typical consumption is about 11 gallons per head per day, overflow waterers will use 3 gallons per head per day in winter for freezing protection and about 0.5 gallon per head per day overflow in warm climate use. Do not drain overflow water to a French drain or leach field. This practice could be considered an injection well, which is banned.

Overflow water should be collected in a holding pond. Electric heated waterers that are well insulated with concrete, earth or a synthetic material require minimal power. A 200 watt heater in a waterer operated continuously for three months would use 430 kwh. At $0.07/kwh, it would cost $30 to operate the waterer for the year.

Table 2. Water system requirements for beef cattle.

	Approximate daily need, gallons per head	
	50°F	*90°F*
400 lb calves	5	10
800 lb feeders	7	15
1,000 lb feeders	8	17
Cows and bulls	8	20

Overflow waterers use 30 percent of their consumption for freezing protection.

A substantial water supply is needed if a sprinkler system is desired to control dust and odor; therefore, larger water supply pipes will be needed. To minimize dust and odor, pen surfaces must be managed at 25-40 percent moisture (wet basis). When pads are dry, dust is generated and when pads are wet, odors are emitted. Sprinkler systems should be designed similarly to irrigation systems and require the expertise of a competent design professional.

Table 3 shows the water requirements for one type of feedlot. Dust control measures are generally implemented only in summer; however, the water supply must be able to meet the summertime demands for best management practices utilizing water for dust control.

Mounds

Not all feedlots need mounds. Mounds may not be needed in dry climates and in feedlots with greater than three percent slope. Mounds provide places for cattle to rest and get away from the mud in pens that do not have good drainage or when weather conditions keep the pens wet for an extended time. Mounds are not places to stack manure. Proper mound construction requires 20 to 40 square feet of mound space per head on each side of the mound.

If mounds are used, the entire pen of cattle should be able to rest on one side of the mound without laying on each other. Cattle should be able to step off a mound and onto the feeding apron without having to move

Table 3. Water requirements for a 100-head pen of 1,000 lb feeder cattle provided 300 square feet of space per head.

Drinking Water Only With No Dust Control		*Drinking Water and Dust Control*[1]	
Daily Water Requirements	*Minimum Well Capacity (gpm)*[2]	*Daily Water Requirements*	*Minimum Well Capacity (gpm)*[2]
1,700 gal/day/100 head	2.6 gpm/100 head	9,990 gal/day/100 head	14 gpm/100 head

[1]Water usage demand is only during periods when dust control is required. A 0.25 inch per day was assumed to be applied over the feedlot for dust control.

[2]Well capacity is based on continuous pumping for 12 hours a day.

Table 4. Typical mound pen configurations.

	Advantages	*Disadvantages*
Mounds and Channels *(Figure 1)*	• Fewer cleaning intervals needed as animals will likely be able to find dry pen space	• Greater chance of mud impacting cattle performance • Additional time needed to perform manure cleaning activities • More difficult and time-consuming to maintain pen surface, which will affect drainage and odor potential • Gouging of pen surface often occurs, requiring regular additions of fill dirt
Uniform Slope Pens *(Figure 2)* (Preferred)	• Easiest to maintain pen surface and fence lines; best drainage; minimizes odor • Laser-guided cleaning equipment can be used to harvest manure • Least amount of time to clean pens, fence lines and harvest manure from pens	• Heavy accumulations of manure will impact animal performance
Mounds on Fence Line *(Figure 3)*	• Fewer cleaning intervals needed as most animals will likely be able to find dry pen space	• Moderate probability of mud impacting cattle performance • Additional time needed for manure cleaning due to uneven surfaces, especially mound fence line manure accumulations • More difficult and time-consuming to maintain pen surface which will affect drainage and odor potential

through mud. Mounds should be 4 to 6 feet tall and the top of the mound should be less than 5 feet wide with side slopes that are 5:1 or 4:1 ratio (see *Figure 12*). Mounds oriented east-west will encourage cattle to use the mound as a windbreak by laying on the south side. Mounds should be constructed to allow cattle to lay on the sides rather than on the top. Resting on the top often causes areas where rain water or urine can accumulate rather than drain off the sides. Mounds should not impede natural pen drainage and should be constructed so that pen shaping and leveling equipment can travel over and maintain the shape of the mound.

Over time it will be more difficult to harvest manure and maintain good drainage from mounded pens than from evenly sloped pens. They should be used in situations where mud and poor drainage develop and not as a substitute to good pen cleaning practices. The decision to use mounds and mound placement essentially dictates the feedlot pen style *(Table 4)*. There are three styles — mounds and channels *(Figure 1)*, uniformly sloped pens *(Figure 2)*, and uniformly sloped pens with fence mounds *(Figure 3)*. The decision of which style to use depends on the management style of the operator, the landscape and topography of the site, soils, labor requirements and availability, animal performance and personal preference.

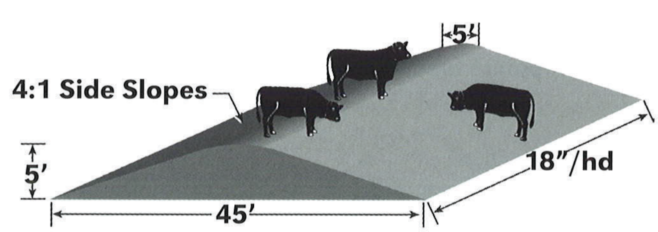

Figure 12. Typical cross section of a mound.

Fly Ash

Fly ash produced from coal combustion in power plants is known to have cement-type properties. These properties will allow up to 20 percent fly ash to be substituted for cement in concrete mixes. The use of fly ash by itself has been shown to be effective in building pads and stabilizing soils in livestock pens. Benefits derived from the use of fly ash include reductions in both mud and dust in feedlot pens in which cattle are concentrated. Fly ash is most often used to build pads on feedlot surfaces; however, pure fly ash is a very fine powder that can be extremely dusty.

To build pads, surface manure and mud need to be removed to obtain a firm base. Adding water and compaction are critical to insure that pad strength and life are not reduced. During installation, the final moisture content should be about 25 percent and the material should be moist to the touch with little or no water seeping from the mix. If the mixture is too wet, add more ash or let the material dry a day or two before compacting. To insure adequate strength and compaction, place the material in 6- to 8-inch layers. Generally, cattle traffic can occur shortly after construction; however, a 12- to 24-hour cure is recommended if wet conditions exist. The long-term integrity of a fly ash pad is not clearly known. Most studies indicate that if applied properly, it will hold up well. Concerns and questions regarding long-term integrity, particularly under wet conditions, still exist as well as questions as to whether all fly ash products are similar in composition and cementing characteristics. In addition, if it does begin to break-up, how difficult will it be to clean out the pen and dispose of the fly ash.

Existing feedlots should not add fly ash to pen surfaces as more runoff will be generated. Less runoff is generated from dirt pen surfaces than impervious surfaces such as those made from concrete or fly ash. The additional runoff from a feedlot that has an existing runoff control structure could violate permit conditions. Producers would need to expand their runoff control system to accommodate the additional runoff. Check with your state regulatory authority and a professional consultant before adding fly ash to an existing feedlot surface. For new facilities, sizing the runoff control structure for the possible addition of a fly ash surface or other hard surfacing material is easily accomplished if the design professional is informed and accounts for the additional runoff in the design.

Fencing and Gates

Kinds of fencing available include sucker rod, pipe, cattle panels, steel cable, continuous fence panels, high tensile steel, electric and wood. *Table 5* and *Table 6*

Table 5. Typical feedlot perimeter fences.

Fencing Material	*No. of Members*	*Member Spacing (inches)*	*Remarks*
2 x 8	3	16	Pressure treated
Poles, wood	4	12	Minimum diameter 2 1/2 inches
Pipe	4	12	Minimum diameter 1 1/2 inches
Sucker rod	4	12	Weld or thread joints
Cable, tension	5	10	Minimum diameter spring 1/2 inch
Cattle panel or woven wire and 1 barbed wire	1	—	Barb 3 inches above panel

Posts — 72 inches on center, 3-foot minimum depth in ground, 4-inch minimum top diameter, pressure treated wood or equivalent.

Table 6. Typical feedlot interior fences.

Fencing Material	*No. of Members*	*Member Spacing (inches)*	*Remarks*
Poles, wood	3	16	Minimum diameter 2 1/2 inches
Pipes	3	16	Minimum diameter 1 1/2 inches
Cable, tension	4	12	Minimum diameter spring 1/2 inch
Wire, barbed	4	12	

Posts — Same as perimeter fences (see *Table 4*).

provide recommendations on typical feedlot perimeter and interior fences. No single fence type appears better than another. Selection depends on producer preference and availability of local materials. Access to the pens may require one or two gates. Consideration should be given to moving cattle, cleaning pens, removing manure and accessing downed cattle. Normally it is better to use "saw-tooth" gate arrangements or hinged gates at a 45-degree angle in a corner. This allows easier access to the pens for equipment and movement of cattle. Minimum gate width is 12 feet with 16-foot gates recommended. Along the back or lower side of the pens, an additional gate may be needed for cleaning the area where runoff drains through the pens. Many feedlot operators are using high-tensile electric fences. Ice accumulation or an electrical short circuit can cause the fence to fail. Therefore, perimeter fence of more permanent construction is recommended to prevent cattle from escaping. Neck rail heights should not exceed 18 inches for calves less than 800 pounds or 24 inches for yearlings (animals greater than 800 pounds).

Wind Protection

Metabolic heat generated for cattle on high-energy finishing diets aids in maintaining body heat, therefore wind protection in the winter is not always necessary. However, cattle that are within 30 days of slaughter and new cattle arriving in the feedlot often experience the greatest feed intake irregularities under cold stress. Incoming cattle and cattle that are to be slaughtered in January and February benefit from wind protection. Therefore windbreaks are only essential for starting and finishing pens.

Windbreaks protect an area approximately 10 times the height of the windbreak. Windbreaks should be located along the north and west sides of the pens. Options include leaving a gap between pens and planting a windbreak or placing a nonliving windbreak in the fence line. Nonliving windbreaks include wooden, metal or plastic materials. Windbreaks need 20 percent open area to function properly. Solid windbreaks create undesirable air currents near the structure and cattle tend to use the windbreak only on calm days. If 24-inch wide metal roofing material is used, a 4-inch gap between sheets is recommended. Maximum gap width is 6 inches. Plastic windbreak fence can be attached directly to the fence and removed after cold weather.

Windbreaks will drop snow in an area four times the windbreak height. Plant trees so that when fully grown, snow will not be deposited in the feed bunks or in the pens. Avoid putting windbreaks too close to cattle or placing windbreaks in areas that block airflow in the summer.

Lighting

Benefits of feedlot lighting include:

- less trouble with predators and cattle theft,
- increased animal safety from the quieting effect of night lighting,
- cattle eat during cool summer nights,
- reduced stress on newly arrived cattle agitated by darkness,
- better feed availability for timid cattle, and
- reduced feed bunk space per head due to 24-hour feed availability.

Lighting should provide 1 footcandle in a 30- by 50-foot strip along the feed bunks. Additional light will be required in the receiving and working areas. The lights can be over the center of a feed alley between two rows of bunks. Automatic controls and electric eyes permit the lights to come on at dusk and go off at dawn with a photo cell or timer.

In open lots, high-pressure sodium lamps are economical. With these lamps 35-foot tall poles can be spaced 225 feet apart and 20 to 30 feet from the feed road. Mercury vapor and metal halide light sources also are adequate for area lighting. Light poles should be located in a fence line away from the feed bunk and waterer to avoid bird droppings in feed and water.

Before building a new feedlot, plan and build the waste control facility. Controlling and managing the runoff from an open lot is the responsibility of every feedlot owner.

Runoff Control Regulations

Controlling and managing the runoff from an open lot is the responsibility of every feedlot owner. Do not build a new feedlot without building the waste control facility first. Facilities need to be constructed so environmental compliance can be obtained. The first step to determine if you are in compliance with local, state and federal regulations is to request an inspection from NDEQ and obtain permission from your local zoning board, no matter what size feedlot is planned. Before beginning any expansions or additions, ask NDEQ or KDHE to determine if controls will be required. The feedlot size and location will determine the type of runoff control system that can be used. Feedlots with over 1,000 head are designated automatically as Large Concentrated Animal Feed Operations (CAFO) and are required to obtain permit coverage. The National Pollutant Discharge Elimination System (NPDES) permit program is under the jurisdiction of the U.S. Environmental Protection Agency and is administered in Nebraska by the Nebraska Department of Environmental Quality (NDEQ) and in Kansas by the Kansas Department of Health and Environment (KDHE).

Feedlots with 301 to 999 head are considered either a Medium Animal Feeding Operation (Medium AFO) or a Medium Concentrated Animal Feeding Operation (Medium CAFO). Medium-size operations that have a connection to surface water — either directly or through a man-made conduit such as a pipe or channel to surface water — will be designated a CAFO. This designation requires application for permit coverage under the NPDES program. Few operations will be able to avoid being designated a medium CAFO without installing runoff control or a treatment structure to eliminate their connection with surface water.

Feedlots with 300 head or less are considered either small AFOs or small CAFOs. The same connection to surface water criteria apply, except that the regulatory authority, NDEQ, must designate the feedlot a CAFO. Small and medium operations should manage their facilities so they are considered AFOs and do not meet the definition of a CAFO. Owners and operators of all sizes of feedlots, who are not aware of their regulatory obligations should seek the advice of a professional (private consultant, Natural Resource Conservation Service, University Extension, etc.) who is knowledgeable about livestock waste regulations. Small and medium operations should obtain assurance from NDEQ or KDHE that they do not meet the definition of a CAFO. Good planning, siting and design of small and medium operations can substantially reduce the need for future compliance costs for poor planning and siting of a feedlot. The costs to comply with and obtain an NPDES permit (above and beyond the construction of the runoff control system) can be expensive and may not be cost effective for smaller operations.

Configuring a Runoff Control System

First, determine the drainage area of the livestock facility. Carefully plan how the collected runoff is to be handled. Consider how drainage from other areas such as fields, roads, paths and the rest of the farmstead will drain into the structure. Elevation and slope direction are the most important factors in determining how the system should be constructed in relationship to the livestock yard. Take notice of proximity to streams, animal density and how much area is paved versus non-paved.

Paved areas contribute more runoff than unpaved lots. The basic components of a runoff control system are: diversions, collection channels, solids separation devices or outlets, a detention/storage basin and a liquid disposal area or a vegetative treatment system. Runoff retention structures should not be constructed within the 100-year floodplain.

Diversions

Diversions are waterways, ditches or terraces that are used to keep "clean water," water that does not come into contact with the feedlot, from entering the runoff control system. This reduces the amount of water that must be handled with the runoff control structure. Diversion terraces, road ditches, pipes, curbs and channels can be used to redirect clean water runoff from entering the feedyard. Gutters and downspouts from buildings should be used to direct and divert collected rain away from the runoff control system.

Collection Channels and Drains

Collection channels *(Figure 13)* are used to convey runoff from the pens to sediment basins. The pen surface should be graded at the fence posts so that manure cannot accumulate at the posts. Collection channels need to have a firm base if used as a road or a cattle lane.

Figure 13. Collection channel used to move runoff.

Solids Separation

Settling or debris basins are the most common forms of solids separation. They collect the runoff and hold the liquid long enough for most of the solids to settle out (50-85 percent). Most solids that will settle do so in under 30 minutes so most debris basins are designed according to this assumption. They can be concrete, earthen or both. If a debris basin is not used, the solids are collected in the holding pond. The holding pond must then be dredged annually to remove the solids so the basin does not lose its capacity to contain a 25-year 24-hour storm (typically a 3.5-inch event in western Nebraska or a 5.5-inch event in eastern Nebraska). A debris basin is designed to route all liquid from the collection channels, settle out the solids, and deliver the liquid to the holding pond or vegetative treatment area.

Figure 14. A debris basin collects runoff and slowly releases liquids so that solids settle and dry for easy clean out.

Locate and design settling basins and channels with traffic flow in mind. Cleaning equipment should have ample room to operate and should be in close proximity to the loading area. If a sediment basin is too deep to clean out with a front-end bucket loader, it will have to be dredged or excavated. Determine ahead of time what type of dredging equipment will be required to remove the settled solids from the basins. Typically, backhoes can reach basins that are less than 40 feet wide. Wet solids weigh much more than dry solids, so it will be more challenging to clean out a wet basin than a dry basin. Stockpile wet solids and allow them to dry before land application. The runoff from this stockpile or manure storage area drainage also must be controlled.

Earthen basins are the most economic type of debris basin. While concrete is more expensive, it is much easier to clean out with bucket, front-end loaders. Depending on the size of basin needed, consider using both earth and concrete. For example, a concrete wall can be used as a buckwall for the loader to aid in cleaning out the debris basin. A concrete channel with curbs can be used to line the floor of the debris basin which makes it easier for equipment to clean out the basin.

Outlets

Outlets regulate the flow of liquids from a debris basin to a holding pond or vegetative treatment area. There are several ways to regulate flow from the basin. Tile risers, porous dams or porous screens, and weir notches are the most common devices. A tile riser outlet is designed very much like a tile riser pipe for a tile terrace. It is important to protect the riser pipe so that equipment and floating debris does not damage the riser. This can be done by setting the riser in a corner and protecting it with heavy posts on four sides of the riser.

Next, porous dams or porous screens can be constructed from spaced boards, welded wire fabric or expanded metal. The purpose of the porous material is to slow the flow of water and promote settling of the solids. Porous dams and screens can be placed in channels or between sediment basins and holding basins.

Holding Ponds

The purpose of a holding basin is long-term storage of runoff water. It is commonly referred to as a full containment system *(Figure 15)*. A properly designed system allows the producer to collect runoff and apply the collected water, or effluent, to land where crops can use the nutrients in the liquid. Holding basins are typically earthen structures. Dewatering of the ponds will occur through two principal methods — evaporation and irrigation. Some water will evaporate from the basin. The remaining liquid must be land-applied in a manner that keeps sufficient storage in the basin so that it does not overflow during the next storm. It is critical to

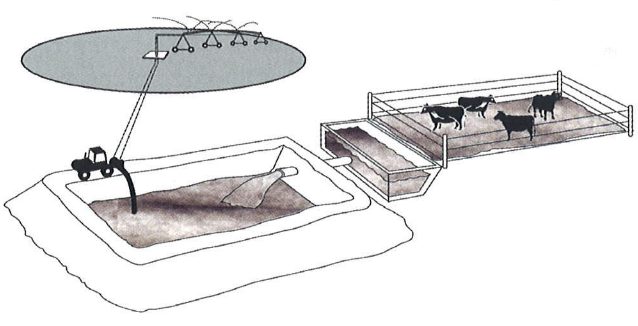

Figure 15. Holding pond system (full containment).

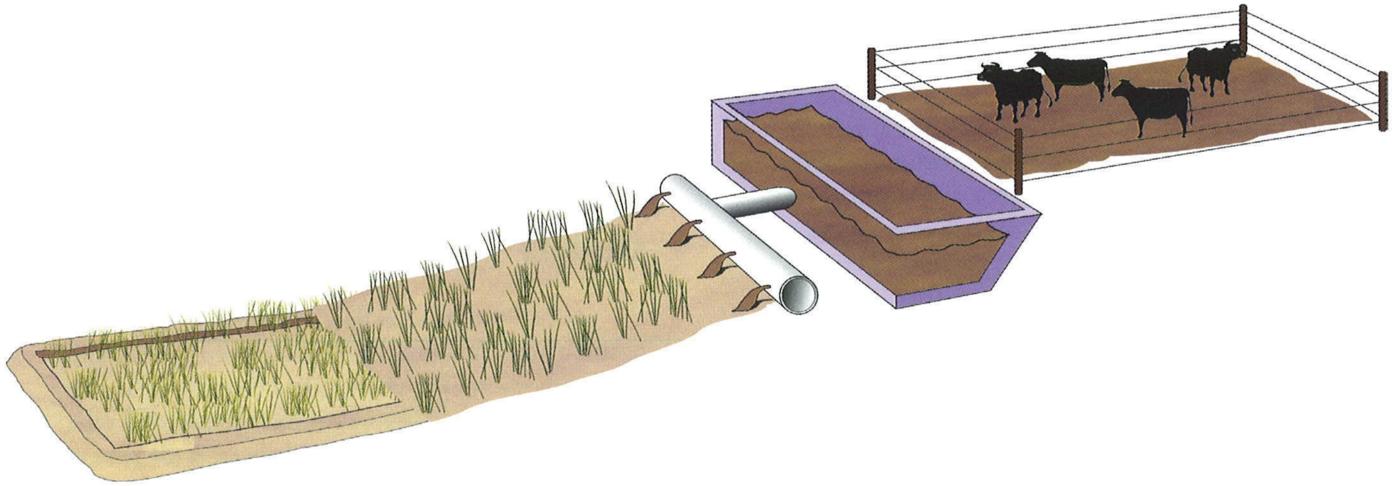

Figure 16. Vegetative treatment system.

empty the basin in the spring, after snow melt and heavy spring rains. Holding ponds should be dewatered when land conditions allow the effluent to be applied without generating runoff. A holding pond should never be full and should always have sufficient storage for the next precipitation event. The volume of the 25-year 24-hour storm event should be marked with a depth gauge and this depth (plus freeboard) should always be available.

Holding ponds are required to be constructed with a 12-inch minimum clay liner so that seepage from the sides and bottom is less than 1/8 inch per day. Some soils may require amendments such as bentonite or soda ash to be mixed with the soil to meet the seepage requirements. High density polyethylene (black plastic commonly referred to as HDPE) may need to be used where native soils are not suitable to make earthen liners, and can be installed on side slopes to prevent wave action from destroying the liner.

Land Application

Liquid from a holding pond and solids from a debris basin must be applied to land. The three most common methods for land-applying the supernatant (liquid portion) include center pivot, gated pipe and traveling gun irrigation systems. The liquid should be sampled for nutrient content and credited toward crop needs. A good rule of thumb when crediting manure nutrients is that you will need 0.5 acre of cropland (assuming 150 bu/ac corn) for every head to manage the total manure nitrogen. For solid manure, one acre of cropland (assuming 150 bu/ac corn) will be needed for every head of full time space, and 1.5-3.0 acres per head will be needed to manage phosphorus long-term. More land may be needed for feedlots feeding ethanol byproducts such as distiller grains and corn gluten feed. All feedlots should have a nutrient management plan for managing manure and runoff nutrients even if it is not required by NDEQ or KDHE. Contact your local Extension office or Natural Resource Conservation Service (NRCS) for assistance with a nutrient management plan.

Solid manure should be stockpiled either 1) on a manure storage area adjacent to the feedlot where the runoff is controlled by a holding pond or vegetative treatment system or 2) at the field where it is to be land-applied.

Vegetative Treatment Systems

Another method of runoff control is a Vegetative Treatment System (VTS). This system uses a sediment basin (or other sediment reduction system), but substitutes a Vegetative Treatment Area (VTA) in place of the holding pond. It tends to be more suitable for feedlots located in smaller areas, such as production areas with less than 1,000 head, and can be especially appropriate for feedlots with fewer than 300 head.

Vegetative treatment systems require an area one to three times the feedlot area depending on stocking density, average cattle weight, soil characteristics, land slope and length and normal rainfall events. The runoff water must be collected and distributed uniformly across the vegetative treatment area. *Figure 16* shows a feedlot draining into a debris basin, with an outlet and a distribution system uniformly distributing runoff to a sloped vegetative treatment area. A properly designed vegetative treatment system manages the nutrients and liquids from an open lot.

Groundwater Issues

Groundwater contamination is a concern in some geologic areas in Nebraska. For feedlots in sandy and loamy soils and in areas less than 50 feet above the seasonal high groundwater level (general rule), the potential to contaminate groundwater is much higher. For CAFOs, NDEQ will conduct a groundwater monitoring review during the permit process, and if deemed a sensitive area, a groundwater monitoring plan will be required. Groundwater monitoring usually requires one well up-gradient of the holding pond or vegetative treatment system and two down-gradient. Monitoring can be expensive and will continue bi-annually during the life of the facility. Selecting a site that is low risk and will not require monitoring will reduce capital and operating costs. Good planning and siting of the waste treatment system can significantly impact the total cost of the feedlot. Sites with risk to ground and surface water resources, soils that are not well suited for waste control facilities, and scenarios that must use pumps because of elevation challenges, significantly increase the cost of feedlot construction. The design and siting of the waste control facility is the most challenging part of constructing a new feedlot.

Odor and Air Quality

In general, dust emissions occur when feedlot pads are dry and odors are generated when surfaces are wet. Maintaining pad moisture content near 30 percent moisture (wet basis) minimizes both dust and odors. Tools exist to assist with the siting of a new feedlot and assessing the potential impact of odors on neighbors. Contact your local extension office for more information on the Odor Footprint Tool.

Larger operations need to consider ways to reduce air quality problems. Sprinkler systems may be needed to control dust (a substantial water supply is needed to support a sprinkler system, see *Table 3*). Dust and odor problems are most easily minimized through proper site selection and cleaning frequency. Prevailing winds and habitable structures must be considered to avoid impacting neighbors. In the future, large feedlots may need to report ammonia, particulate matter, hydrogen sulfide and other air pollution contaminates; however, currently fugitive emission regulations do not directly apply to open lots.

Summary

Whenever you're expanding or constructing a new feedlot, consult a licensed professional engineer and other relevant consultants. Depending on the size of the facility and the potential hazard to surface water and groundwater, a licensed professional engineer may be required by NDEQ or KDHE. (Even if not required, it is always a good idea to use one.) Do not build a new feedlot without planning for a waste control facility. Check with your local USDA Natural Resource and Conservation Service (NRCS), Natural Resource Districts, private consultants, or University of Nebraska–Lincoln Extension for more information before constructing any system. Check local zoning regulations before constructing a facility and observe required setback requirements.

Careful planning and forethought are needed to insure the facility is environmentally sound and becomes a useful and long-term component in your farming operation. Producers must address human, cattle and environmental issues to provide safe, efficient and productive feedlots. Proper planning and the advice of a professional can go a long way toward making a new feedlot an environmentally friendly and economical enterprise. Lack of planning has placed many feedlots in risky problematic situations.

Acknowledgment

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