NORTH DAKOTA
ENGINEERING PRACTICE PLANNING GUIDE
367 Roofs and Covers: Confinement Barns
October 13, 2023

TYPICAL PRACTICE STANDARDS: 367 (Roofs and Covers), 313 (Waste Storage Facility), 520 (Pond Sealing or Lining - Geomembrane or Geosynthetic Clay Liner), 521 (Pond Sealing or Lining – Compacted Soil Treatment), 561 (Heavy Use Area Protection), 558 (Roof Runoff Structure), 362 (Diversion), 560 (Access Road), 516 (Livestock Pipeline), 614 (Watering Facility), 642 (Water Well)

OVERVIEW

North Dakota open feedlots have traditionally been used for backgrounding and finishing beef cattle and sheep. Over the last two decades feeding livestock in a confinement barn with a bedded pack or slatted floor with below ground tank has become more common. Drivers of their increasing popularity have been lower operation and maintenance costs and higher weight gains for livestock in these systems, as opposed to open lots. The very tight labor market in the state also makes these systems attractive; manpower needs reportedly drop from an average of three workers for an open lot to one required to effectively operate a 700-900 head beef feeding operation using a confinement barn. These production benefits are attractive to operators but are not the reason that NRCS considers these structures as conservation practices. As outlined in the practice standard 367 Roofs and Covers, confinement barns are considered conservation practices in two scenarios: where feedlots are located above shallow glacial drift aquifers that have been rated by the ND Department of Environmental Quality as highly or moderately vulnerable to surface contaminants, or where a thorough economic analysis supports a confinement barn as being the most cost-effective long-term alternative to bring the current or future expanded operation into compliance with water quality standards. This is done to document a producer's decision that a confinement barn is the best alternative to address surface water concerns at the site.

As with all engineering practices, planning must be completed or approved by an NRCS employee with appropriate Planning Job Approval Authority. In many cases the majority of the planning process is completed by private consultants working under NRCS agreements with the ND Stockmen's Association or the ND Department of Agriculture or by Technical Service Providers (TSP) working through an Environmental Quality Incentives Program (EQIP) contract. In some cases, NRCS may provide all of the planning work via Comprehensive Nutrient Management Plan (CNMP) certified planners and engineers. Regardless of who does which portions of the planning process the steps outlined in this guide will be identical. The ND roles and responsibilities for engineering technical assistance to USDA program participants should be followed for each option which will review who is responsible for each portion of the project.

Note that ND NRCS does not offer EQIP financial assistance for loafing sheds in feedlots, i.e. facilities where livestock can move freely between an open lot and the roof structure. Therefore, this planning guide does not cover these types of roof structures. In addition, planning for roof structures related to carcass composting facilities is not discussed here.

REFERENCES

- Barrington, S., P. Jutras, R. Broughton, 1987. The sealing of soils by manure: preliminary investigations. Canadian Agricultural Engineering 29:99-103.
- Ellis, J., L. Mielke, G. Schuman, 1975. The nitrogen status beneath beef cattle feedlots in eastern Nebraska.
- Gerla P., P. Gbolo, 2018. Fate and consequence of nutrients at an abandoned feedlot, Glacial Ridge National Wildlife Refuge, Minnesota, USA. Elem. Sci Anth, 6:7.

- Hendry, M., S. Shaw, S. Barbour, T. Salamone, T. Fonstad, 2007. Impact of manure collection and storage facilities on groundwater in Alberta. Alberta Agriculture, Food, and Rural Development.
- Kohn J., M. Iwanyshyn, L. Miedema, B. Olson, A. Kalischuk, 2016. Shallow groundwater quality at a beef feedlot in southern Alberta. Canadian Biosystems Engineering 58:1.11-1.19.
- Maule C., T. Fonstad, 2002. Solute and moisture flux beneath cattle feedlot pens. Transactions of the ASAE 45: 73-81.
- Miller J., T. Curtis, F. Larney, T. McAllister, B. Olson, 2008. Physical and chemical properties of feedlot pen surfaces located on moderately coarse and moderately fine textured soils in southern Alberta. Journal of Environmental Quality 37(4): 1589-1598.
- Mrozinski, J.M.; Pritchard, R.H.; Holland, B.P.; and Warmann, G.W., "Cost Analysis of Cattle Feedlot Designs" (2012). South Dakota
- ND Department of Environmental Quality, 2019. Geographic Targeting System for Groundwater Monitoring.
- Olson B., J. Miller, S. Rodvang, 2002. Soil and groundwater quality monitoring under a research feedlot in southern Alberta. Alberta Agriculture, Food and Rural Development, Lethbridge, Alberta, Canada and Agriculture and Agri-Food Canada. 205pp.
- Euken, Russ; Doran, Beth E.; Clark, Christopher A.; Shouse, Shawn C.; Loy, Dan; and Schulz, Lee L., "Beef Feedlot Systems Manual" (2015). *Extension and Outreach Publications*. 95.
- USDA-NRCS South Dakota, 2011. Design Technical Note Number SD2011-1: Beef and Dairy Bedded Pack Barn Planning and Design with accompanying spreadsheet.
- USDA-NRCS North Dakota, 2023. ND Economic Analysis Spreadsheet
- USDA-NRCS Field Office Technical Guide, Section IV, North Dakota Practice Standards.

RESOURCE INVENTORY

Groundwater Resource Assessment

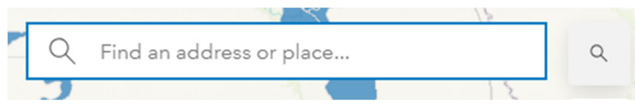
Beef manure that accumulates on lots or in waste storage ponds contains nitrogen in both organic forms (urea and a variety of compounds) and inorganic forms (ammonia). Ammonium converts to nitrite, and nitrite to nitrate (NO_3-N), an inorganic form of nitrogen which is very mobile and highly soluble in water. Many biological, chemical, and physical processes impact the attenuation, or retard the movement, of contaminants at the ground surface into subsurface soils, underlying geologic materials, and groundwater. High clay content increases the opportunity for attenuation of contaminants due to cation exchange capacity and its effect of reducing permeability. Clay particles hold a negative charge that gives them the capacity to interchange cations in solution, and thus absorb contaminant ions. Depth of soil, and underlying geology materials below the soil layer, increases the contact time a contaminant will have with mineral and organic matter thereby increasing the opportunity time for contaminant attenuation prior to reaching groundwater. Permeability and hydraulic conductivity of both soils and aquifer materials, hydraulic head, and hydraulic gradient are also noted to impact the rate and volume of contaminant movement from the surface to underlying groundwater.

Research on nitrate leaching below earthen-floor feedlots has been limited and findings are inconsistent. Development of a manure seal in feedlot pens may be caused by physical processes such as compaction, chemical processes such as dispersion of clay by Na or K, or biological processes such as gleiing, whereby slime from anaerobic decomposition clogs soil pores. Some studies have determined no evidence of leaching from feedlot floors, in a variety of soil textures, as a result (Barrington et al, 1987; Ellis et al, 1975). The presence and characteristics of a manure seal layer tends to vary not based on soil texture, but on climate, presence of water, density of animals within the pens, presence of manure piles within the pens, and duration of use (Miller et al, 2008). Likely due to these variables, other studies have documented contaminant leaching from feedlots either to subsurface soils or to groundwater directly (Kohn et al, 2016; Gerla and Gbolo, 2018; Maule and Fonsad, 2000; Olson et al, 2005; Hendry et al, 2007). Both NRCS and ND Department of Environmental Quality technical standards for confined animal feeding operations allow for open lots regardless of underlying groundwater aquifers, on the assumption of an effective manure seal. That said, a reduced risk to groundwater exists when livestock are fed on an impermeable floor such as concrete or soil cement/clay liner, under a roof structure that excludes precipitation. NRCS strongly supports the use of confinement barns in lieu of open lots to reduce the risk of nitrate transport to highly or moderately vulnerable groundwater aquifers.

The ND Department of Water Resources has identified 213 shallow glacial drift aquifers in ND, encompassing more than 11,000 square miles. The ND Department of Environmental Quality completed a Groundwater Targeting System to prioritize aquifers for water quality monitoring utilizing the EPA DRASTIC model, which assesses Depth to Water, Recharge, Aquifer media, Soil media, Topography, Impact of the vadose zone, and Hydraulic conductivity (ND DEQ, 2019). The outcome of the DRASTIC model is a quantitative scoring of aquifer vulnerability, which represents the physical ease at which surface contaminants may be transported to groundwater. Those scores are then utilized to rank aquifers as having low, moderate, or high vulnerability. Out of the 213 aquifers, 34 were designated as highly vulnerable and 129 as moderately vulnerable; these are the aquifers over which assistance for confinement barns(with impermeable floors) are a priority for NRCS. During planning, reference the ND GIS Hub website to determine if the site is located over a shallow aquifer and determine what it has been rated at: https://gishubdata-ndgov.hub.arcgis.com/datasets/ndgishub-drastic/explore. Navigate and zoom into the map on the website, click on the aquifer (if applicable), and read the “DRASTIC Rating”.

ND GIS Hub Instructions

To navigate to a site:

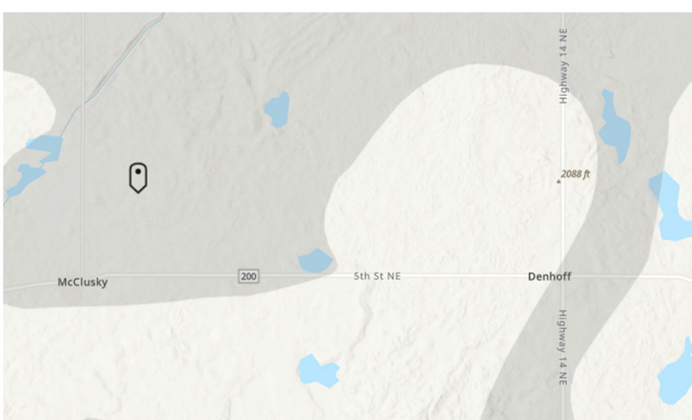


- Use the scroll on the mouse to zoom in and out, left click to pan on the map to the location.
- In the upper right corner, click on the magnifying glass and type in the address.

Site Located

- If there is an aquifer over the location of your site, left click on the aquifer.

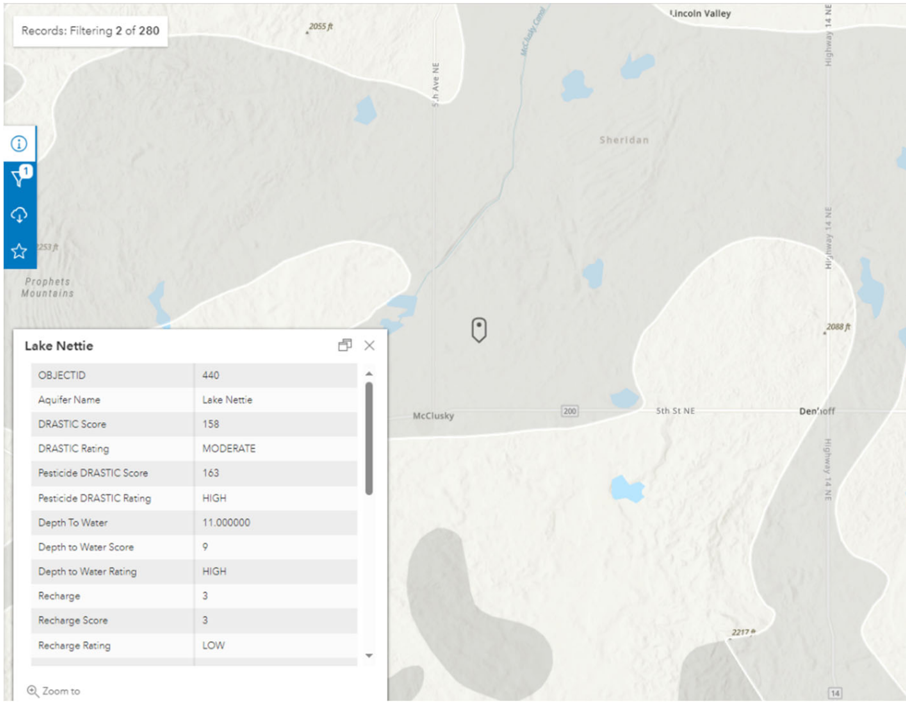
- New window opens with aquifer information. Check if the DRASTIC Rating is HIGH or MODERATE to meet criteria to be considered as a conservation practice. If LOW then proceed to Economic analysis



Lake Nettie

OBJECTID	440
Aquifer Name	Lake Nettie
DRASTIC Score	158
DRASTIC Rating	MODERATE
Pesticide DRASTIC Score	163
Pesticide DRASTIC Rating	HIGH
Depth To Water	11.000000
Depth to Water Score	9
Depth to Water Rating	HIGH
Recharge	3
Recharge Score	3
Recharge Rating	LOW

- Screen Shot the view of the site with the Information box, paste in word document, include in Producer folder for documentation.



When a site is located near the aquifer, additional consideration should be taken to verify that it is outside the aquifer. A location map, well logs and site information should be provided to the State Office engineering staff to evaluate the site and determine if the aquifer could be situated under the site.

The image to the right shows a site located near the boundary of the aquifer, but not located in or on the aquifer shapefile. This is a case where it is recommended to send to the State office engineering staff.

Surface Water Resource Assessment

Uncontrolled runoff of nutrients and pathogens to surface water is a typical resource concern associated with confined animal feeding operations of any kind. Both incoming waterways and receiving water bodies should be clearly identified for the existing and/or planned feeding operation sites. In closed basins or those with very flat topography it is recommended that GIS data on streams and rivers be augmented with an evaluation of LiDAR topographic data and a field evaluation of culverts, ditches, and drainage systems which can have a significant impact on the direction of water flow. Within the Red River and Sheyenne River Basins the International Water Institute has developed hydro-conditioned flow lines on the basis of LiDAR data, drains, and culverts that can be helpful (available at https://iwinst.org/tools/) in determining drainage area in low topographic relief areas. For streams and rivers, EQIP ranking criteria requires knowledge of whether they are on the 303(d) List of Waters Needing TMD, reference the most current integrated report available at: https://deq.nd.gov/wq/3_Watershed_Mgmt/2_TMDLs/TMDLS_IR.aspx The list can be found in Part VI. Section 303(d) List of Water Quality Limited Waters Needing TMDLs.

Wetland delineation is often required to develop or evaluate alternative site layouts for these projects. It is important to remember that wetland delineation procedures for evaluation under the National Environmental Policy Act are different than procedures utilized for Farm Bill Wetland Compliance purposes. If a private engineer or TSP is providing planning services on an AFO, they are not expected to complete wetland delineation work; they should, however, request assistance from NRCS field office staff as soon as possible so as to not delay the planning process. NRCS field office staff should request assistance through normal channels as needed to complete the delineation as outlined in US Army Corps of Engineers (USACE), Wetlands regulatory Assistance Program, Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Great Plans Region: https://usace.contentdm.oclc.org/utils/getfile/collection/p266001coll1/id/7613 and, if needed, complete a hydrogeomorphic assessment of wetland function losses using procedures outlined in: https://www.nrcs.usda.gov/conservation-basics/conservation-by-state/north-dakota/drainage-lateral-effects-and-drainage-water. It may also be necessary to guide the producer in working with the U.S. Army Corps of Engineers on a jurisdictional determination to determine if a Section 404 permit would be required to drain or fill wetlands. Purchase of wetland mitigation credits by the producer may be necessary, whether or not it is a USACE regulated wetland, to meet NEPA requirements which can add substantially to a producer's out-of-pocket costs (mitigation credits in ND run $20,000-$70,000/acre); hence the importance of completing this work during the planning process so it is well understood prior to entering into a contract. If snow cover and frozen soil conditions prevent adequate assessment of wetland during winter planning, it may be necessary to defer an EQIP application until this can be completed.

Field Inventory/Producer Interview

The NRCS National Engineering Handbook Part 651- Animal Waste Field Handbook, NRCS Engineering Manuals and Handbooks | Natural Resources Conservation Service (usda.gov), provides detailed suggestions for planning considerations in Chapter 2, the questions listed below are some of the commonly used for planning information to gather.

Facility Inventory:

- What are the producer's goals for improving the operation? What works well on the current operation and what could use improvement? What types of operation and maintenance issues have they dealt with at the existing site? How has it performed during major runoff events?
- What livestock (types, numbers, typical start/end weights) have been fed in the existing facility in recent years? How is that anticipated to change in the future? How does that compare to past use of the facility?
- What does use of the site look like, i.e. how long and when are animals in each part of the facility? Identify the lots and buildings include the number of livestock in each and length of time.
- Do they have access to the pasture? Are they moved to the pasture, when and for how long?
- What is used for bedding and how much? Identify lots and building and how much is used per lot and per building.
- How often and where is solid manure/bedding scraped? Is temporarily piled for storage in the lot or somewhere else such as on site or stockpiled at a field? Complete measurements on existing solid manure piles to determine approximate volume. Request the producer send in a sample for nutrient analysis if a recent one is not available.
- How often is solid manure applied to fields and what equipment is used for application? What application rate is typically used and where has it been applied recently? What is the capacity of the equipment? How many loads does it take to clean out the lots or buildings?
- Are they interested in composting manure?
- How often is liquid manure/runoff applied to fields and what equipment is used for application? What application rate is typically used and where has it been applied recently?
- Does the current operation have an existing CNMP and/or AFO permit from the ND DEQ? Obtain a copy, including manure application records, if possible.

- How does surface water route within and downstream of the facility? Where does surface runoff ultimately end up (stream, river, lake, wetland, etc.) in a small runoff event? Extreme runoff event? Draw on map, where water flows through and around the lots and buildings.
- Where are existing wells, pipelines, and watering facilities? Have there been any issues with adequate livestock water supply to the existing herd? Is there a well log, well test, and/or pump curve available? Are there existing monitoring wells at the site? What is the depth of the well? Do they have any concerns with high groundwater?
- If there is an existing storage pond or concrete tank, what is it's capacity and does it have any type of liner? Is there a solids settling or separation facility? Has the pond or diversions to it ever overtopped in a rainfall event? How is it agitated, emptied, and remaining solids managed?
- Air quality and Odor Assessment – the NAQSAT must be completed if they are over 300 animal units. Distance to neighbors,
- How are mortalities disposed of? Rendering, Burial (where), Composting (where), Incineration
- Note any observed safety issues at the site: confined spaces, warning signs, safety fence, etc.

Dairy Operations:

- Is there an existing free stall barn? how is it flush? Does it have a below ground concrete tank?
- Where does the milkhouse waste go? What is their rolling herd average? How much water is used for flushing, gallons/day? What is the bulk tank size? How many times a day to they milk?
- Are there silage bunks or feed storage areas onsite? Are they covered? Where does runoff or seepage go from these sites? Do you see any leachate?
- Consider waste separation infrastructure and waste transfer systems to effectively distribute liquid waste on fields.

Are they interested in a Confinement Barn?

- Type and what size? Bedded pack, slatted floor with concrete tank, or compost barn? Have they worked with a particular supplier already or seen an operation they particularly liked? Where do they visualize siting it on their property? How do they envision the layout – feeding and scraping lanes, waterers, manure storage, fences, etc. within the building? Access roads outside the building? Do they want to fully confine them, or still have open lots?
    - Reminder loafing sheds are not eligible for financial assistance.
- If compost building, how often will it be tilled or aerated?
- What bedding would be utilized?
- How often does the producer envision scraping bunk lanes? Do they envision scraped manure be stored in a solid storage area under the roof or in a separate outdoor facility?
- Will outdoor sick pens or handling facilities be necessary, if so, where will these be located? How will runoff be treated from them? Will any open lots remain and if so, what will be necessary to address surface water runoff? (All outdoor lots, except sick pens and working facilities, must be abandoned when lot is located over shallow aquifers) How will existing lots and waste storage facilities be decommissioned?

A producer may initially walk in the door with a solution to the issues at the site in mind, working through a thorough planning process with NRCS, a TSP, or a private engineer experienced in animal feeding operations may result in the plan looking much different in the end.

Preliminary Geologic Investigation

Onsite geologic investigation work may be required during planning for confinement barns, at the discretion of the engineer doing the planning. In some locations, this work can be delayed until the final design phase but in others it is critical to providing an accurate preliminary design and construction cost/EQIP estimate to the producer. In many cases some of these activities would take place during the planning process, often additional testing is done for final design.

- Soil borings below the floor of the proposed building to a depth of at least 10 ft below proposed bottom elevation of structural and 4 ft below the bottom of proposed poles or piers. Bore holes should be continuously logged and classified using the Unified Soil Classification System, along with soil colors, soil moisture conditions and the depth of any ground water indicators. Reference the ND DEQ Livestock Program Design Manual for all requirements at: https://deq.nd.gov/publications/WQ/2_NDPDES/AFO_CAFO/ND_Livestock_Design_Manual.pdf for state minimum sampling requirements and the NEM Part 531, Subpart B (Engineering Geology) and NEH Part 651 Chapter 7 (Animal Waste Field Handbook, Geologic and Groundwater Considerations) for NRCS guidance.
- Shear vane or pocket penetrometer testing to assess in-situ shear strength of soil, both for the building footprint and access roads.
- To determine cement quantity required for a soil-cement floor, a bulk soil sample of floor material should be collected and sent to a lab for wet-dry and freeze-thaw tests (ASTM D559 or D560, AASHTO T135 or T136) and optimum moisture and maximum density testing (ASTM D558 or AASHTO T134). To determine permeability of a proposed soil-cement or soil-bentonite-cement floor to be used over a shallow aquifer, a permeability test (ASTM D5084) should be completed on the proposed floor materials at the proposed moisture/density placement range.
- As needed, undisturbed samples for triaxial shear tests or permeability tests.

ALTERNATIVE DEVELOPMENT

Confinement Barn Alternatives

A variety of structural alternatives are available for confinement barns, each of which has initial construction, production, operation, maintenance, and lifespan issues unique to the individual site and operation. Given the extremely high cost of this conservation practice, it is important that the producer and engineer take the time to thoroughly investigate options. Structure types may be:

Monoslope Pole Buildings

Structural elements may be timber, steel, reinforced or a combination of these. Roofing is typically corrugated steel, which may or may not be underlaid with plywood or OSB sheeting. These may be pre-fabricated buildings from a supplier or may be custom designed. Typically, a supplier will have had a structural engineer design the building options and can supply P.E. stamped drawings. The issue is that those have been generated for a given set of foundation conditions as well as wind and snow loads which may not match to the actual site. In addition, that P.E. is not always licensed to practice engineering in North Dakota. In these cases, either the design engineer (private engineer, TSP, or NRCS) will complete the structural analysis and develop a site specific design which incorporates information provided by the supplier as applicable. A ND licensed P.E. is required to stamp the design drawings.

Pitched Roof Pole Buildings

Poles and trusses are typically timber or steel. Roofing is typically corrugated steel, which may or may not be underlaid with plywood or OSB sheeting. These are typically custom designed for the site rather than purchased from a supplier, which may be less expensive to construct but then all interior components of the structure must be designed and purchased separately. An ND licensed P.E. is required to stamp the design drawings. Below are photos of a 70 ft x 380 ft roof structure constructed through EQIP for a bedded pack barn:

Hoop Buildings

Structural elements typically steel and reinforced concrete, cover is fabric. Note that fabric is typically warrantied for only 15-years, so regular replacement is required which is an important consideration in future O&M cost. Typically purchased from a pre-fabricated building supplier. Typically, a supplier will have had a structural engineer design the building options and can supply P.E. stamped drawings. The issue is that those have been generated for a given set of foundation conditions as well as wind and snow loads which may not match to the actual site. In addition, that P.E. is often not licensed to practice engineering in North Dakota. In these cases either the design engineer (private engineer, TSP, or NRCS) will complete the structural analysis and develop a site specific design which incorporates information provided by the supplier as applicable. A ND licensed P.E. is required to stamp the design drawings. Below are photos of a 70 ft by 406 ft hoop building constructed through EQIP for a bedded pack barn for beef cattle:

▪

Confinement Barn Floor Alternatives

Considerations on selection of floor material include groundwater protection, operation and maintenance, and animal health. Slatted floor confinement barns have concrete floors in all cases. Bedded pack barn floors may be comprised of on-site soils, on-site soils mixed with soil cement or bentonite and re-compacted, imported soil or gravel compacted onsite (potentially with geogrid for foundation improvement), articulated concrete block, or reinforced concrete. It is not uncommon to have multiple floor materials within the same building for different elements. Considerations include:

- As outlined in the practice standard 367 Roofs and Covers and 313 Waste Storage Facility, an impermeable floor is required over highly or moderately vulnerable groundwater aquifers. Recognizing that regular scraping by heavy equipment will occur on these floors over time, use of in-situ soils alone is not allowed by the practice standard 367 Roofs and Covers in these locations. Tilling to incorporate soil cement and recompacting in place with moisture control would be the minimum treatment required. In some cases, an imported clay layer, geomembrane, or geosynthetic clay liner may be needed below the soil cement or concrete surface layer. No specific permeability target is listed in the practice standard, it is up to the design engineer and ND DEQ work to together to determine an appropriate permeability target for an individual site considering depth to groundwater, soils, underlying geology, and proposed design and operations of the structure. Decisions and rationale should be documented with the preliminary design notes during planning. For reference, the MN Pollution Control Agency allows a maximum of 10^{-7} cm/sec hydraulic conductivity post-construction at solid manure stacking facilities. Good quality reinforced concrete floors have an average hydraulic conductivity of 10^{-10} cm/sec and would be highly durable to repeated scraping over time, therefore are the highest level of groundwater protection available however a soil cement mix is a much more economical choice in the short-term.

- In locations not located over highly or moderately vulnerable groundwater aquifers consider the potential for subsurface contaminate transfer to be transported via shallow groundwater movement to adjacent surface waters. In these cases, selection of an impermeable floor may be advisable.
- If contaminant transport to groundwater is not a concern at the site, selection of flooring would be solely based on operation and maintenance and animal health considerations. Typical areas that will be scraped regularly, such as the slab adjacent to the feed bunks, are constructed of reinforced concrete. Feed lanes or other access roads under the roof are typically gravel or concrete, areas below the bedded pack are either native soils, articulated concrete block, or concrete.

Waste Storage Alternatives

A minimum of 270 days storage is required for bedding and manure, which may be either in a designated stacking area under the roof structure, in an outdoor waste stacking facility, or in a below ground tank below a slatted floor barn.

In a slatted floor confinement barn waste is stored below the floor in an 8 ft to 12 ft deep concrete tank located below the concrete slatted pen surface for liquid manure storage. This tank size is designed to be pumped twice yearly. To increase tank capacity, some newer barns have extended the tank dimension to include the area below the feed alley. The building is typically 40 feet to 60 feet wide, which accommodates manure agitation and pumping. (Euken, Russ; Doran, Beth E.; Clark, Christopher A.; Shouse, Shawn C.; Loy, Dan; and Schulz, Lee L. 2015) .

In bedded pack buildings the bedded pack portion of the barn (and associated walls) are typically designed to store manure/bedding to a depth of 24-36" prior to clean out, therefore that can provide a portion of the needed 270-day storage. Additional storage volume that would need to be created by removing portions of the bedded pack between turns of livestock, within the 270-day storage period, would require separate waste storage facilities. Likewise, solid manure/bedding from the concrete slab adjacent to the feed bunks is typically scraped every 3-12 days and therefore must be stored in a separate solid waste storage facility. Composting, degradation, and compaction of the manure/bedding mix should be considered in storage computations, as presented in SD NRCS Tech Note SD2011-1: Beef and Dairy Bedded Pack Barn Planning and Design and the accompanying spreadsheet tool.

Typical outdoor stacking facilities have reinforced concrete floors and 6 ft to 8 ft high walls. Shorter walls are often less cost effective given that a larger interior slab is required for the same storage volume, and they do not provide the wind protection of higher walls to prevent windblown manure. Walls over 8 ft may be infeasible for the producer to fully utilize with common farm equipment stacking capabilities and may require additional mats of reinforcing steel. Stacking facilities placed under the roof are convenient, but the cost of the roof is obviously high. Dependent on eave heights on the edge of the building, these may be designed with 6-8 ft high walls. Concrete stacking facilities may be designed with graded subgrades designed to impound collected water against the back wall which, while convenient in some locations, can make loading, hauling, and spreading the solid manure more difficult. Alternatively, a grated catch basin below the stacking facility can collect leachate and be routed via a pipeline to a vegetated treatment area (with either a curb or gated pipe to distribute on the top of the slope) or to a waste storage pond. Note that either are often needed to treat runoff from adjacent open lots, sick pens, or handling facilities at the site. If a catch basin is not included consideration should be given to containing the 25 year 24 hour rain fall on the pad and adding water stop.

Livestock Water

For bedded pack barns waters within the barn are often located centered within the bedded pack area if the floor of the building is concrete. For buildings with an earth floor below the bedded pack it would be more typical to place waterers either on a large concrete slab or on the opposite side of the feed alley from the bunk, in anticipation of spillage. The practice standards 516 Livestock Pipeline and 614 Watering Facility provide guidance on necessary perimeter space and flow rates based on livestock numbers; perimeter space is often the key consideration.

As with feedlots, a larger operation is often best served by a variable frequency drive than a pressure tank given the range of flow conditions and constant on/off demands of numerous waterers. In expansion situations it is particularly important to evaluate the feasibility of an existing well being able to supply the new operation; if the pump test on the well is old or was done during a wet cycle, it would be advisable for the producer to have a new pump test done to determine whether it will be adequate or a new one needs to be drilled.

Clean Water Diversions / Roof Runoff Structures

Confinement barns are typically placed on an 18-24” raised subgrade which provides some separation from surface water runoff, however on sloped sites construction of a diversion ditch or berm on the upstream side will be required to route water around the facility. Even when runoff is routing to the back of a building that will have a concrete wall to effectively block water from infiltrating manure, it is not advisable to allow standing water to pool next to the building foundation. In addition, any potential for localized erosion from flowing water in the foundation area should be mitigated; this is particularly true for water coming off the roof. Gutters or well armored diversions should be incorporated into the plan to address roof runoff, utilizing guidance in practice standards 362 Diversions or 558 Roof Runoff Structures. If needed, complete hydrologic analysis to determine peak flow rates for preliminary culvert sizing as outlined in ND Hydrology Manual on the ND NRCS Engineering website – NRCS Engineering Manuals and Handbooks: (https://www.nrcs.usda.gov/conservation-basics/conservation-by-state/north-dakota/nrcs-engineering-manuals-and-handbooks).

Access Roads

Planning should consider preliminary design of access roads, including any necessary drainage structures. Use of geotextile or geogrid to reduce future maintenance and/or decrease the amount of aggregate required should be considered in low bearing capacity soils or wet areas, as outlined in practice standard 560 Access Roads. Reference the practice standard for minimum horizontal and vertical curve requirements as well as aggregate design. In addition to feed roads, where outdoor waste stacking areas are planned, ensure an all-weather road between the building and the waste stacking facility. Consider snow drifting and ensure reasonable space for snow storage from plowing when locating access roads.

Heavy Use Area Protection

Additional surface protection may be needed at the doors of the confinement barns or where turn arounds for equipment maybe needed. Use practice standard 561 Heavy Use Area protection.

ALTERNATIVE EVALUATION

Step 6 of the NRCS conservation planning process, Evaluate Alternatives is an important part of the process and shouldn't be taken lightly with these systems. Decisions on confinement barns (or large feedlot projects), which often have construction costs nearing $1 million, merit a much higher level of technical service in providing the producer adequately detailed information and documenting that analysis/decision. Working with the producer to thoroughly analyze both short term and long-term economics of alternatives is a critical step in planning for confinement barns.

Planning for any confinement barn requires the following steps be completed and thoroughly documented by the engineer, prior to ranking, to evaluate alternative(s) under consideration. In situations where a highly or moderately vulnerable groundwater aquifer exists, a confinement barn is likely to be the only alternative that fully addresses the groundwater resource concern.

- Develop an accurate construction cost estimate. After completion of the preliminary design(s), the engineer completing planning work will detail out a construction cost estimate based on recent bid prices from similar projects, research with suppliers, and professional judgement. Ideally, the producer will also contact potential contractors and/or suppliers to get realistic cost estimates based on the preliminary design drawings and quantities provided by the engineer.
- Develop an EQIP estimate based on the preliminary design, payment schedule, and program guidance.

In situations where there is not a significant groundwater resource concern, there is typically a legitimate alternative to addressing surface water resource concerns with the existing and/or expanding AFO via outdoor lots rather than a confinement barn. To make an informed decision, the producer must balance initial construction costs, long term operation and maintenance costs, alternative land use profits, and expected profits from each alternative. Often the high initial cost of constructing a confinement barn, in comparison to addressing resource concerns on open lots, is offset by decreased operation and maintenance costs, increased livestock weight gains, crop production on land that would otherwise be taken up by a feedlot and associated infrastructure, and other considerations. ND NRCS has developed a spreadsheet tool, utilizing information from several published sources, designed for the engineer to cooperatively work with the producer to analyze their individual operation to make an informed decision. Economic analysis is a technical step undertaken during planning; it should <u>not</u> be misconstrued as being related to program eligibility.

At least one confinement barn and one open lot alternative should be evaluated, but in many cases multiple feasible alternatives would yield better information. A combination of some open lots and confinement building(s) may also be a good alternative at many sites.

The spreadsheet provides some base values from technical literature to start with, for convenience, however the engineer and producer working together on alternatives analysis are free to utilize their best professional judgement in selecting input values.

Input data for the ND Economic Anayalis Tool for open lot vs confinement barns:

- Animals – number, start weight, finished weight, cost and finished value
- Construction Cost for open lot and for confinement barn
- Number of acres needed for the open lot or confinement barn, will additional area need to be rented at what rate?
- Financial Information – how much will be borrowed, number of years and interest rate, how much financial assistance, will they be using a low interest low and how many years at what rate. What are the depreciable years and salvage value.

- Performance Health – do they have open lot and confinement animals to compare average daily gain, and pounds of dry matter feed per pound gain.
- Feed- feedstuff used, lbs, cost per unit, dry matter percent, percent ration on dry matter basis
- Manure – tons or 1000 gals per head, nutrient samples from manure, P, K, N values and $/lb of nutrient.
- Bedding – cost and pounds per head per day used
- Labor – number of hours for processing, sorting, daily care, cleaning and bedding and manure application., cost of labor
- Custom manure application cost
- Maintenance costs for roads, diversions, buildings ect
- Manure equipment operation - Operating costs (also called variable costs) include repairs and maintenance, fuel, lubrication.
- Manure equipment ownership costs - (also called fixed costs) include depreciation, interest (opportunity cost), taxes, insurance, and housing and maintenance facilities
- equipment operation for daily care/bedding - Operating costs (also called variable costs) include repairs and maintenance, fuel, lubrication.
- Equipment ownership costs for daily care and bedding - (also called fixed costs) include depreciation, interest (opportunity cost), taxes, insurance, and housing and maintenance facilities
- Will new feed storage or equipment need to be purchased? Feeding equipment cost, manure/ dirt handling equipment cost, bedding equipment costs, cattle handling equipment cost, feed storage area cost, insurance and tax on feed storage. Will this equipment or storage be financed, how much borrowed, number of years of note at what interest rate.
- Custom Feeding – will they be custom feeding, charge per day, feed markup per don dry matter, and percent of capacity custom fed.

Use of EQIP for financial assistance on 367 Roofs and Covers for confinement barns in ND has some past contentious history. Misinformation and speculation led to the removal of this practice for several years. Thorough planning to documenting that a confinement barn is the producer's best alternative to address surface water concerns or based on economics as outlined in the NRCS planning process, it will help to dispel misconceptions and ensure the practice is available for use into the future. By having the producer take the time to work through the economic analysis with their engineer, it will also ensure thoughtful consideration by producers and ideally result in fewer cancellations.