

Vegetative Treatment Systems for Barnyard and Open Lot Runoff Webcast

Question and Answer Summary (November 17, 2007)

What is an AFO?

Author: Chris Henry, Biological Systems Engineering, University of Nebraska

Animal feeding operations (AFOs) are agricultural enterprises where animals are kept and raised in confined situations. As defined by the Environmental Protection Agency (EPA), and your state regulatory agency, an AFO is a lot or facility where animals are stabled or confined and fed for a total of 45 days or more in any 12-month period. Feed is brought to the animals rather than the animals grazing or otherwise seeking feed in pastures or fields or on rangeland. Animals are not considered to be stabled or confined when they are in areas such as pastures or rangeland that sustain crops or forage growth during the entire time that animals are present.

According to the EPA, there are approximately 450,000 AFOs in the United States. (Answer taken from <http://www.eXtension.org>, FAQ #27108 see also for more information, http://www.lpes.org/cafo/14FS_Pasture.pdf)

A decision process used for determining which animal production systems are AFOs is illustrated in the CAFO Fact Sheet “Do I Need an NPDES for my Livestock or Poultry Operations?” (http://www.lpes.org/cafo/02FS_Permit.pdf)

What is a CAFO?

Author: Rick Koelsch, Biological Systems Engineering, University of Nebraska

A concentrated animal feeding operation (CAFO) is an animal feeding operation (AFO) that is required by the Clean Water Act to maintain a National Pollutions Discharge Elimination System (NPDES) permit. An AFO can be defined as a Large CAFO based strictly on size, defined as a Medium CAFO based upon size and the risk of manure contaminated water reaching waters of the US, or designated as a Small CAFO by the permitting authority. A decision process used for determining CAFOs is illustrated in the CAFO Fact Sheet “Do I Need an NPDES for my Livestock or Poultry Operations?” (http://www.lpes.org/cafo/02FS_Permit.pdf)

What do you need to do to a VTS to keep the system operational in the winter? If you only hold water in a basin for 7 days without a liner, what happens over the winter season?

Authors: Lara Moody, Iowa State University, Rick Koelsch and Chris Henry, University of Nebraska

Winter Conditions, Conventional versus VTS

Winter conditions can provide challenges for both traditional systems (holding pond and irrigation system onto cropland) as well as the VTA. Large precipitation events or snow melts can result in holding pond levels requiring winter or early spring runoff applications to maintain the required capacity to hold a 25-year, 24-hour storm. A continuously vegetated VTA has many advantages

over a corn or soybean field under these conditions. Erosion is less, infiltration is generally better, and grasses and alfalfa have a longer growing season for utilizing water and nutrients. So while winter or early spring precipitation events are problematic for VTAs, they can present an even greater risk for our traditional systems.

In the Winter for Iowa permitted CAFOs

In Iowa, there are earthen basins, concrete basins, and basins with concrete bottoms and earthen walls. For permitted CAFOs with a Vegetative Treatment System, unlined basins can hold water for 7 days. This is a variance above general CAFO permits which only allow unlined basins to hold water for 3 days. During chronic wet weather in Iowa, some sites have received intermittent rain for 3-4 days and creating saturation soil conditions in the VTAs during that period. Release from the basin during saturated conditions can lead to runoff of feedlot effluent. And, it is for this reason that we contain feedlot runoff in the basin until the end of a rainfall event.

For CAFOs in Iowa, site operators are required to hold all liquid off of the VIB or VTA during the winter. This means any lot runoff during the winter should be held in the basin. Iowa permits state “During frozen conditions, also called non-growing season (November 1 through March 31), the applicant is required NOT to release any manure, settled effluent, or runoff or process water into the VIB or VTA”. Aggressive snow removal from feedlots to keep clean snow out of the system is necessary for maintaining empty basin volume capable of handling spring melting. The 7-day limit for holding liquid in the basin is only in affect for non-frozen conditions considered to be April 1 – October 31.

In the Winter for Non-permitted CAFOs in Nebraska

In winter, when the ground is frozen, usually the runoff water is also frozen. Our experience suggests that air temperature and surface soil temperature rises to above freezing several times each winter. So even during winter, it is possible to use a VTA. The critical time for a VTS is just after snowmelt that has occurred after a long hard freeze. The ground is completely frozen but the snow has melted. In this situation, the producer must hold the liquid in the sediment basin until the ground dries and thaws enough for distribution to the VTA.

For the pump and sprinkler VTS, cold temperatures are especially problematic. Such systems must be capable of operating at near freezing temperatures. The approach we have taken is to either bury the system below frost to protect the pump and motor or to provide very simple ways of draining the susceptible components. In all of the systems we have designed, we only need to evacuate about 20-50 gallons from the system to protect the pump and risers.

How is the sprinkler system you describe different from a conventional wastewater irrigation system?

Author: Chris Henry, Biological Systems Engineering, University of Nebraska

Traditional irrigation systems that apply wastewater and freshwater are designed to provide supplemental water to a growing crop when it is most opportune for the crop. This is not the purpose of the sprinkler VTS.

Design principles between a sprinkler VTA and a conventional irrigation system are the same (pressures, friction loss, etc.). However, there are a few additional criteria to consider in the design of a sprinkler VTA that would not be applicable to a conventional system. First, the system must have the ability to operate near freezing temperatures (in cold climates) and be easy to drain between uses. Second, the distribution system must be able to operate when the soil is at or near field capacity (thus the reason for the selection of the solid set and K-line). While operation under such circumstances is not desirable, extended wet periods can make this necessary. Next, the system must have the ability to distribute the runoff from the production area in a short period of time, yet not at a rate that will generate runoff. We try to design our system so that they can be empty from a 25 year 24 hour storm in less than 48 hours (this is our self imposed criteria). In addition, the VTA is sized to uptake the nitrogen generated and to store the liquid in the root zone (AWC).

The system must also be able to withstand the corrosive effects of being in contact with manure. Equipment made of galvanized steel, for example, will deteriorate over time from use only with feedlot runoff. A conventional system applying wastewater and freshwater will not deteriorate since components are flushed out with clean water. We make sure the pumps, pipes, sprinklers can withstand exposure. Our risers are galvanized and will need to be replaced periodically. However, the cost of replacement for those items is far less than a small pivot (one reason a pivot is not used in our systems).

What additional Operation and Maintenance is needed for these types of systems?

Author: Rick Koelsch, University of Nebraska

Vegetation management is critical to the success of a Vegetative Treatment Area (VTA). Soil fertility may vary with the length of the VTA. A soil and fertility sampling program should be designed to capture that variability and where appropriate provide supplemental nutrient applications. Additional vegetation management considerations include periodic harvesting, weed control, and soil moisture management.

Environmental management considerations are essential for maintaining environmental performance. Soil sampling for regions of excess nutrient accumulation, forage harvesting for nutrient removal, VTA inspection and repair of conditions impacting sheet flow, and active management (or possibly passive management) of the release of runoff into the VTA are all key to environmental performance.

Records for monitoring performance are essential for both permitted and non-permitted facilities. Records should include a 1) precipitation log, 2) indicators of good management (e.g., records of vegetative treatment system inspections and resulting repairs, timing of solids harvest for settling basin, soil samples, crop and nutrient harvesting), and 3) records of any discharges associated with runoff additions to VTA.

Chapter 8 of the NRCS collaborative report on Vegetative Treatment Systems for Open Lot Runoff discusses these operation and maintenance considerations in detail

(<http://www.heartlandwq.iastate.edu/ManureManagement/AlternativeTech/vtsguidance/chapter8.htm>).

Is anyone looking at long term groundwater issues underneath these systems?

Author: Lara Moody, Iowa State University

At all of the research sites in Iowa, we are collecting monthly groundwater samples from locations up-gradient of the VTA, within the VTA, and down-gradient of the VTA. With the additional funds we are in the process of procuring, we will be able to collect a total of 3 years monitoring data. Obviously, the longer we monitor, the better our understanding of long term performance will be. And, for that reason we are continuing to try to identify funding that will enable us to do so.

Is there a zero discharge regulation?

Author: Lara Moody, Iowa State University

The regulatory language for Alternative Treatment systems states that the systems (in this case Vegetative Treatment Systems) must perform equal to or better than the effluent limitation guidelines. The February 2003 rules and regulations for the National Pollution Discharge Elimination System (NPDES) and Concentrated Animal Feeding Operation (CAFO) Point Sources identified species specific effluent limitation guidelines. For beef cattle, Part 412 Subpart C allows for development and use of alternative technologies (ATs) that meet or exceed performance of traditional systems, including containment of wastewater and runoff from a 25-year, 24-hour rainfall event. For an AT system to comply with the required Voluntary Alternative Performance Standard, the design must include a site specific comparison to a representative traditional containment system. Technical analysis in the comparison must include site specific system inputs and outputs: predicted median annual overflow based on a 25-year period of applicable site rainfall data, site specific pollutant data, and predicted annual average pollutant discharge (http://www.epa.gov/npdes/regulations/cafo_fedrgstr.pdf).

So, to answer your question, a Vegetative Treatment System is allowed to discharge but only if the discharge is less than or equal to what is predicted for a traditional containment basin designed and managed according to the Effluent Limitation Guidelines. Currently, discharge from traditional containment is evaluated using a computer model developed originally at Kansas State University by Dr. James Koellicker and adapted by Iowa State University.

How do you know if you have a release from VTA during the rainfall event that is from VTA?

Author: Chris Henry, Biological Systems Engineering, University of Nebraska

For the two systems in Nebraska that I showed monitoring results, they were a sloped VTA and a level VTA system. The level VTA, surrounded by a 1 foot high berm, impounds any runoff from the sloped VTA. We have a water level logger in the level VTA's and know the berm elevation with respect to the logger elevation. We also log the rain events at each site, so we compare the precipitation event to the depth logger and know when, and if, the level VTA is inundated (water

goes over the berm). While we don't know the volume, it is a simple way to evaluate our design for potential discharges.

ISU is monitoring CAFO sites, and those systems are being monitored for inflow and outflow, using flumes, and pipe flow sensors to measure flow. They are also measuring nutrient content of the flow with ISCO samplers and with this data can estimate nutrient mass going into and out of the VTA. For the Iowa sites, we can differentiate from a discharge related to direct rainfall runoff from the VTA and runoff coming from the feedlot because our settling basin valves are normally closed during rainfall events. And, the monitoring equipment puts a time stamp on all collected flow data.

Because the permitted CAFOs are required to record and sample all discharges, the ISU project includes development of a low cost method for meeting this need.

What soil properties are preferred for VTAs?

Author: Rick Koelsch, University of Nebraska

Chapter 4, Siting Criteria for Vegetative Treatment Areas

(<http://www.heartlandwq.iastate.edu/ManureManagement/AlternativeTech/vtsguidance/>) provide a risk assessment tool for VTA characteristics including preferred soil properties for minimizing both surface and groundwater risks. This document recommends the following for surface water protection:

“Soils with moderate permeability are best for VIBs and VTAs. Soils with high permeability will reduce potential for discharge from a VTA, but increase the risk to ground water. Soils with a low permeability improve protection of ground water, but increase the potential for a discharge from the VTA. For VIBs, soils with 0.6 to 2 inches per hour to a 5-foot depth are recommended. For VTAs, soils with 0.2 to 2 inches per hour to a 5-foot depth are suggested.”

This reference further suggests the following for ground water protection:

“Many biological, physical, and chemical processes break down, lessen the potency, or otherwise reduce the volume of contaminants moving through the root zone of surface soils. These processes, collectively called attenuation, retard the movement of contaminants into deeper subsurface zones. The soil's attenuation potential increases as clay content increases, the soil deepens, and distance increases between the contaminant source and the well or spring. The cation exchange capacity of clay soils limits movement of positively charged contaminants such as ammonium (NH_4^+). Clay also has a very low permeability, thus slowing contaminant movement and increasing the contact time that allows more opportunity for attenuation. Deeper soil increases the contact time a contaminant will have with mineral and organic matter of the soil. Longer contact time provides greater opportunity for attenuation.”

Do the settling basin, VTAs, and VIBs have to meet requirements in Appendix 10D of NRCS Agricultural Waste Management Field Handbook?

Author: Rick Koelsch, University of Nebraska

The document referenced pertains to construction of earthen lined storage to minimize runoff infiltration. This reference has valuable information for determining if local soils are appropriate for construction of a settling basin. The reference has modest value in vegetative treatment areas (VTA) and vegetative infiltration basins (VIB), both of which are designed to encourage moderate infiltration rates.

The value of a liner in a settling basin is debatable. Settling basins should be designed to maintain shallow depths, possibly no more than three feet. Thus, the driving force for seepage is small. Settling basins should be maintained dry except for a few days after a precipitation event and possibly during periods of frozen soils. These situations should not cause significant seepage.

Of greatest value in Appendix 10D is the discussion of soil types and other siting conditions. These are directly applicable to settling basins. Group III soils (e.g., CL or CH unified classification) have low permeability and low to moderate shrink-swell characteristics making them preferred for settling basins.

Chapter 4 of the NRCS collaborative report on Vegetative Treatment Systems for Open Lot Runoff further discusses siting considerations (<http://www.heartlandwq.iastate.edu/ManureManagement/AlternativeTech/vtsguidance/chapter4.htm>).

I work in a clay pan area with perched water tables. How would these systems operate if put on clay pan situations?

Author: Chris Henry, University of Nebraska

For any livestock waste control facility (or any waste control facility for that matter), the siting, design and construction are governed by good engineering design and applicable regulations. A good geological investigation is warranted and should be conducted unless it is known with good certainty that the particular facility has little risk to groundwater resources.

We have approached the geology of our small facilities as follows. In most cases we can establish depth to groundwater and soil texture readily from well logs and soil surveys. From this initial investigation we decide if there is a risk to groundwater; if there is, we do a subsurface investigation to establish soil types and the local depth to groundwater (and perched water) so that we can provide a reasonable separation. Every site is different, and the local geology must be well understood. We interview or consult the local experts or state geologist if we have any questions about the geology of a site.

My definition of reasonable separation means there is adequate rooting depth and a reasonable separation between the bottom of the root zone and groundwater. Additionally, your state regulatory authority may dictate this. Potential VTA sites where groundwater is within ten feet of the finish graded surface should be considered problematic, and approached with caution. One of the challenges of designing a VTA in a sensitive area such as a site with a perched water table or clay pan, is weighing the risk of ground water impact from a VTA versus a pond. I don't think we have a definitive answer for you on this yet.

Will the data from these studies be used to verify the SPAW model for feedlot runoff and VTA systems?

Author: Lara Moody, Iowa State University

First, the SPAW model was never designed to be used to assess the hydrology of a VTS. Components of SPAW are useful for assessing components of a VTA, but it is not a design tool. At Iowa State University, we have a graduate student analyzing results from SPAW versus results of the ISU developed ELG and VTA models for with Vegetative Treatment Systems. Two papers covering this topic will be available through ASABE following the international meeting in June 2008.

Any work on nutrient concentrations? Do the VTAs get overloaded with phosphorus?

Author: Rick Koelsch, University of Nebraska

The risk of significant phosphorus loss from a VTA is very low. Typically, only 3 to 5% of the phosphorus excreted by livestock is transported with runoff from the feedlot. Most phosphorus remains in the open lot and is harvested with solids during lot cleaning. Of that which is transported with runoff, much of this will settle out in the settling basin never reaching the Vegetative Treatment Area (VTA). The risk of overloading a VTA is generally small.

It may be possible to see some overloading of the headlands of a VTA with P. Soil monitoring will provide a good indicator of possible overloading of the headlands. However, overloading of the headlands will provide minimal risk for P loss from a VTA. Permanently vegetated areas such as a VTA typically have very low soil loss (primary means of P transport).

Nitrogen leaching is generally a greater concern than phosphorus runoff from a VTA. USDA Meat Animal Research Center has carefully monitored for nutrient concentrations in a VTA over many years with a focus on nitrogen. In a 2005 paper, it was reported that:

"The estimated total nitrogen load entering the VTA was equivalent to/or less than the total nitrogen load removed by the hay crop harvested from the VTA. No water was measured exiting the VTA, either by deep percolation or by direct release, during the four-year study period. As a result, the discharge water from the basin was effectively used for hay crop production.... Soil analyses in these zones indicated that surface soil NO₃-N levels, particularly closest to the discharge tubes, had increased. Currently nitrogen is contained near the surface, and has not started to infiltrate deeper into the VTA soil."

Source: <http://asae.frymulti.com/abstract.asp?aid=18569&t=1>

Have any of the VTA's been implemented for feed storage and feed handling areas?

Author: Chris Henry, University of Nebraska

We think that VTS has potential for the runoff from feed storage areas. However, from our experience, one of the challenges for forage storage areas is that loose finely ground fibrous materials (such as ground hay) are a challenge for some solid separating structures. Such fibrous

materials cause bridging when carried with runoff, often plugging some settling structure types. This is especially troublesome with inlets for pumping stations, such as the sprinkler VTS. An inline pressure filter (which would include the use of a large opening inlet strainer) has some potential to overcome this obstacle. The design constraint for a VTS for this application will be the management of the water, as the nutrient concentration is expected to be very low relative to an open lot. There is very little data available on this, and to my knowledge, few if any have been built for this application.

What basin storage design capacity is used for the IOWA VTAs and is the overflow from those being considered in the modeling comparisons with conventional holding pond systems?

Author: Lara Moody, Iowa State University

The systems were designed by engineers selected by the feedlot operators. In some cases, the basin were designed to hold the capacity from a 25 yr – 24 hr storm, and in other cases, the capacity for the 25 yr-24 hr storm was build within the whole VTS system.

Do you plant wetland plants in any of these basins to help absorb nutrients?

Author: Chris Henry, University of Nebraska

From our experience, producers prefer plants that have forage value, which is also an incentive for the producer to harvest the VTA annually. Wetland plants such as cattails and bulrush could work well, and are the recommended vegetation in the literature for constructed wetlands. We have used cattails in two constructed wetland projects with marginal success.

For level VTA's (or VIB's), grass species that are successful at surviving wet soils conditions are preferred. ISU has used reeds canary grass in their VIB and we have used creeping foxtail, both species are more tolerate of wet soil conditions. Eastern gammagrass has been used successfully at a VTS in Kansas, but is more difficult to establish. Every region is different; so what works here may not be as successful in another part of the country. In Nebraska, we are evaluating the use of some other lesser known species, such as orchard grass, switchgrass (warm season), and timothy in one of our projects.

For additional information, see:

- √ Chapter 6 of the collaborative report on Vegetative Treatment Systems for Open Lot Runoff
- √ USDA Conservation Plants Pocket Guide at <http://plant-materials.nrcs.usda.gov/pubs/mopmcpuidguide.pdf>
- √ USDA VegSpec Web site at <http://vegspec.sc.egov.usda.gov/vegSpec/index.jsp>

Has it been demonstrated, and how has it been demonstrated, that any of the VTS's achieve runoff control equivalent to the federal effluent guideline requirement that there be no discharge from a CAFO except for the overflow from a system designed and operated to retain the 25 year-24 hour storm event due to an event in excess of the 25 year-24 hour event?

Author: Lara Moody, Iowa State University

To demonstrate VTS's achieve the runoff control equivalent to the effluent limitation guidelines, the results are compared to ELG model runs using the weather files generated at the site in question.

It is incorrect to assume that traditional systems designed and managed according to the Effluent Limitation Guidelines of the CAFO regulations overflow only during storm events in excess of the 25-year, 24-hour event. Chronic wet periods are the primary reason for discharges in many wetter regions. Several published modeling studies for traditional system design suggest that no discharge except for storm events greater than the ELG is effective only in the western regions of the High Plains (e.g., western Kansas and Nebraska). Chronic rainfall events over a several day period (none exceeding the design storm event) cause discharges from traditional well-designed and managed systems in many Corn Belt states,