Evaluation of Vegetative Treatment System Performance of CAFO Beef Feedlot Runoff Control

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Summary and Implications
Rules released by EPA in 2003 require beef feedlots defined as Concentrated Animal Feeding Operations (CAFO) to control rainfall runoff from their feedlots. The rules included verbiage that allowed for the design and use of "Alternative Technologies" and require that any "Alternative Technology" be modeled to show they are at the least as effective as traditional storage systems. The objective of this project is to evaluate, through field monitoring, the performance of vegetative treatment systems (VTSs). Six Iowa beef feedlots are being monitored, and through additional funding and partnering organizations, four other sites are being monitored in Nebraska, Minnesota, and South Dakota. Results from the Iowa sites thus far have shown nutrient mass release reductions 40 – 99% as compared to a settling basin only system.

Introduction
A Vegetative Treatment System (VTS) is a feedlot runoff control system that is designed to infiltrate the runoff and utilize the nutrients flowing from the feedlot. A VTS can be one of two types; a solids settling basin (SSB) followed by a vegetated infiltration basin (VIB) and a vegetative treatment area (VTA) or a solids settling basin followed by a stand alone VTA. Schematics of the two system options are displayed in Figure 1.

Operation of the solid settling basin followed by a stand-alone VTA system involves discharging settled feedlot effluent evenly across the top width of the vegetative treatment area and allowing the effluent to slowly flow down slope of the VTA. Pollutant removal may occur by several methods, including filtration as the runoff flows through the vegetation, attachment of pollutants to roots and soil as runoff waters infiltrate, and plant uptake of nutrients. Vegetation is maintained and harvested from the VTA as the weather and soil conditions permit.

The VIB-VTA system involves discharge of settled feedlot effluent into relatively flat areas that have been bermed to prevent outflow of effluent and planted to permanent vegetation. Pollutant/nutrient removal from these systems would occur through filtration of runoff waters through the soil, plant uptake of nutrients, and pollutant degradation. Drainage tile lines ~ 4 ft below the soil surface allow movement through the treatment system. This drainage is meant to encourage movement through the soil profile and not meant to reduce treatment process. Determining soil suitability is essential. The filtered discharge from the infiltration basin is delivered to a secondary VTA for further treatment. Vegetation is maintained and harvested from both the VIB and the secondary VTA.
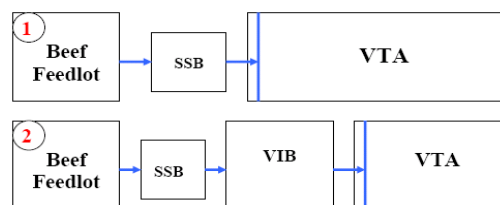
Figure 1. Schematic showing two different types of vegetative treatment systems.

A three-year evaluation of these systems includes a feasibility assessment of vegetative treatment systems throughout the Midwest as an alternative to traditional containment to control feedlot runoff. Additionally, an assessment of the Iowa State University VTS models' ability to serve as a design tool for these systems is also being evaluated.

Materials and Methods
Assessment of the system performance is being made by quantifying contaminant concentrations and effluent volume releases from each component of the VTS. These data are used to determine the annual mass of nutrients exiting each component of the VTS, allowing assessment of both the quality improvements of the effluent as it is treated by the system and the overall mass reductions achieved. The effluent is monitored for ammonia-N, nitrate-N, total Kjeldahl nitrogen, total phosphorus, orthophosphate, biochemical oxygen demand, total solids, chloride, pH, and fecal coliforms. In addition to the effluent samples at the end of each treatment component, monthly groundwater samples and groundwater elevations are also collected, as are annual surface water samples. Surface soil sampling of both the vegetative treatment area and the vegetative infiltration basin area collected on an annual basis, while deep soil samples are collected on a biennial basis.

Each of the ten sites is equipped with automated sampling and monitoring equipment. This equipment monitors flow volumes with effluent quality sampling occurring on a flow event basis. An example of the monitoring setup for the VTA system at Central Iowa 1 Feedlot is shown in Figure 2. As can be seen, at this location there are three groundwater sampling locations, these are located up-gradient of the treatment system, in the system, and down-gradient of the treatment system. Additionally 13 soil surface (0 – 6" in depth) sampling locations are identified. In addition to the soil surface sampling, which is conducted annually, deep soil cores (0 – 48") are collected biennially to assess nutrient movement through the soil profile. Finally, the stars identify the locations in the treatment where effluent volumes and qualities are sampled, these include after treatment in the settling basin and after treatment in the VTA.
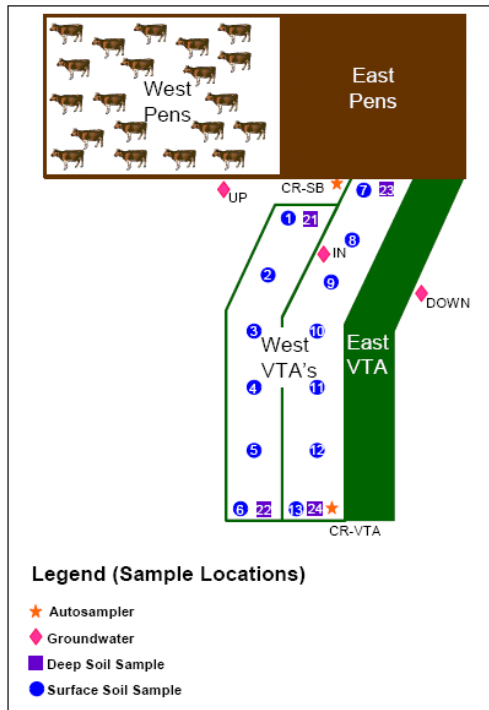

Figure 2. Diagram of the sampling locations for the feedlot runoff treatment system located at the Central Iowa 1 Feedlot.

Results and Discussion

The monitoring results from this study are utilized by regulatory authorities to determine whether VTSs can be used on NPDES permitted CAFO beef feedlots. Thus far, monitoring results have shown that typically the mass of nutrients exiting the system the system is reduced by 40 – 99%, with typical reductions of 90%. Furthermore, there has been a general trend of system performance improving as management techniques have evolved and vegetation on the system has matured. In addition to the overall nutrient mass reduction obtained by the VTS system, substantial nutrient concentration reduction in the runoff effluent is obtained.

As part of this project three different models have been developed, these include the Iowa State University – Effluent Limitations Guideline (ISU-ELG) Model, the Iowa State University – Vegetative Treatment Area (ISU-VTA) Model, and the Iowa State University – Vegetative Infiltration Basin / Vegetative Treatment Area (ISU-VIB/VTA) Model. These models are required to serve as permitting tools for those facilities wishing to utilize VTSs as a runoff control systems. In addition, these models also serve as design tools that can be used to size different components on both traditional containment control systems and vegetative treatment systems.

Initial data from monitoring on the six VTSs located in Iowa have shown that the ISU-VTS models do not adequately predict the performance of VTSs resulting in a review and modification of the ISU models. Specifically, this review is targeting issues dealing with modeling of groundwater levels under the VTA and handling of soil water redistribution after infiltration events.

In addition to modeling VTSs with the ISU models, the ability to predict VTA performance with Soil-Plant-Air-Water (SPAW) has also been investigated. Results from the SPAW model thus far have been positive, with modeling results predicting total release volumes from the VTA within 25% for three of the four locations investigated. Specifically, the SPAW model has shown promise for predicting when VTA performance may be limited by the presence of a high water table.

Acknowledgements