Feed Storage Areas and Vegetated Treatment Areas (VTAs) at CAFOs
Guidelines Discussion– 10/29/2015
Draft – Not for Distribution
Wisconsin Dept. of Natural Resources Runoff Mgmt. Section

INTRODUCTION

There have been recent concerns on the part of the U.S. EPA that Vegetated Treatment Areas (VTAs) do not control contaminated runoff from feed storage areas to a level which would satisfy the requirements of Concentrated Animal Feeding Operation (CAFO) production areas. (Although this document focuses on feed storage area runoff control, most of the issues raised herein similarly apply to animal lot runoff controls using VTAs.) Field observations from Wisconsin DNR staff also indicate many VTAs have not performed well, however VTAs that appear to be performing very well have also been observed.. This document outlines design and operation guidelines to improve the performance of VTAs. The first section lists methods to improve implementation of the current practice standard (Wis. NRCS Standard 635) which are being addressed now in DNR engineering review. The second section describes certain proposed revisions to NRCS Standard 635, intended to address perceived loopholes and gaps. The third section discusses results of feed storage VTA runoff sampling, including a University of Wisconsin (UW) Discovery Farms study, and results from samples taken during EPA/DNR inspections, which help inform how well these systems are working. The fourth section provides VTA design concepts intended to treat all runoff flow (up to the 25-year, 24-hour storm). The fifth section provides VTA design concepts intended to be “zero discharge” systems.

We are in the process of learning more about feed storage runoff contaminant dynamics and VTA treatment performance. The UW Discovery Farms study of feed storage runoff control systems is not yet complete, in that their data analysis is expected to continue through the end of 2015. Their staff has helped review this document. The University of Wisconsin-Madison Biological Systems Engineering Department has also been studying the effectiveness of VTAs. It is hoped that their staff will be able to review and comment on this document in the near future. More results from these types of studies will further inform the design of feed storage runoff control systems.

1. IMPROVED IMPLEMENTATION OF CURRENT REQUIREMENTS

Under the current CAFO requirements in Wisconsin, feed storage leachate must be diverted to a waste storage facility and feed storage runoff must either be diverted to a waste storage facility or treated in a VTA. Treatment of contaminated runoff from a CAFO feed storage is typically accomplished using a leachate/first flush runoff collection system and a VTA designed according to NRCS 635 Vegetated Treatment Area (10/2014). On a site specific basis the DNR may require a greater first flush collection volume or a larger VTA than is specified by NRCS 635 for water quality protection purposes. According to NR 243.13, all portions of the production area are prohibited from pollutant discharge to navigable water except if proper containment is provided and a precipitation event occurs that is greater than the design storm (25-yr, 24-hr storm for most CAFOs in Wisconsin, including dairies). Discharges from the production area also must not cause exceedance of surface water or groundwater standards. These requirements apply to both direct and indirect pollutant discharges to surface water or groundwater. The current NRCS 635 criteria for CAFOs were expected to achieve compliance with ch. NR 243 and the WPDES Permit in most circumstances, but DNR staff is aware there are difficulties implementing the operation and maintenance requirements, and additional criteria may be necessary. The owner remains responsible for compliance, regardless of DNR approval of the system design and operation.

Field observations and DNR engineering plan review have indicated there are a number of common issues that cause VTA design or operation to not meet the all of the criteria in NRCS 635, or to not meet what is considered to be the intent of the standard (a significant level of water quality protection). These common issues are listed below (#1-16). In some cases, the recommendations go beyond what is in the NRCS standard and may be required by the DNR under the authority of NR 243, the WPDES Permit, Wis. Stats., or Condition of Approval for a VTA.

Numbering here attempts to begin with siting and design issues, and end with operation and maintenance.

1. Additional Buffer: A buffer of at least 35 feet length is needed after the VTA, if the end of the VTA is within 100 feet of concentrated flow.

   This is generally consistent with NRCS 635. NRCS 635 uses the term "surface water feature" and defines that term as having a discernable bank or side slope, while concentrated flow is defined more broadly in ch. NR 243.

2. Vegetation Establishment: Vegetation must be well established (high percentage groundcover adequate to maintain stability and prevent erosion) prior to discharge of feed area runoff onto the VTA. This also pertains to reestablishing vegetation if required after initial construction.

   This is specified in NRCS 635. If runoff is released to the VTA before vegetation is established, channelized flow and erosion occur, and vegetation establishment becomes more difficult. NRCS 629 requires that contaminated runoff shall be delivered to a VTA or collected for land application. During vegetation establishment all runoff up to the 25-yr, 24-hr storm (or up to the design overflow rate) cannot be discharged as untreated storm water or discharged onto the VTA (and vegetation re-establishment, when needed). The plan and specifications submittal must include documentation of how this will be performed. For the higher frequency, lower flow runoff events, running the pump to storage without the timer shutoff may be adequate, but for the lower probability, higher flow runoff events enhanced pumping and/or storage capacity may be required to meet the discharge requirements.

   The following are recommended measures to ensure full groundcover and may be required by DNR for CAFOs under the authority of NR 243. These include; applying mulch per NRCS Tech. Note 5 if the VTA slope exceeds 3 %; watering seeded areas weekly if weekly rainfall does not exceed 0.25 inches until vegetation is established; and, adding a nurse crop to the "Traditional" seed mix in NRCS Standard 342. Post-Construction documentation of well-established VTA vegetation (100% groundcover) may be required including photographs of the VTA along the entire upper edge of the VTA.

3. Cropped Field VTA: If the VTA is a cropped field, a cover crop planted each fall.

   A Condition of Approval to require a cover crop is appropriate for a VTA that is a cropped field. If a cover crop cannot be planted (such as due to a wet fall or early winter) feed storage area runoff cannot be discharged onto the VTA until the next crop is re-established and the runoff must be collected in storage. An important component of the treatment process in VTAs is the nutrient uptake from plants. NRCS 635 requires that vegetation be well established prior to introducing wastewater.

4. VTA Separation: All portions of the VTA must be at least 2.5 feet above saturation and bedrock.

   This is specified in NRCS 635. Seasonal saturation must be considered. Soil fill may be used to achieve the separation distance, and to achieve the specified minimum % fines. **In accordance with ch. 30, Wis. Stats.**, a wetland cannot be filled or used as a VTA, unless the necessary specific approval or permit is obtained to do so.

5. Keep Solids Off VTA: Remove feed solids upstream from the VTA.

   This is specified in NRCS 635.V.D.b. Feed solids contain a high concentration of nutrients/pollutants, so keeping solids off the VTA is important to complying with the Production Area Discharge Limitations. The following are recommended measures to ensure adequate removal of solids and may be required by DNR for CAFOs under the authority of NR 243.

   - Flow spreaders should not also do double duty as the required solids collection feature. Those that do often get clogged and don't spread flow uniformly. The solids collection feature should be separate and upstream from the flow spreader.
   - If screens are used there should be recommended design parameters including: a minimum screen area for a given flow rate (screen approach velocity of 1.25 to 3.3 fps and a screen opening velocity < 3 fps); appropriate screen materials which are easy to clean such as wedge wire screens, perforated stainless steel plate screens, or other similar materials (wooden "picket fences" may not be appropriate); a maximum opening size (1/2" to 1"); a screen orientation at a shallow angle or parallel to flow rather than perpendicular. A self-cleaning "Coanda" wedge wire screen could also be used if there is substantial fall from the feed storage to the VTA.
   - If sedimentation basins are used they should hold a pool of liquid and have an outlet flow path which goes below the liquid surface to skim off floating solids. Sediment basins should have the ability to trap neutrally buoyant material. There should be the ability to drain the pool so accumulated solids can be dried and removed and to avoid attracting flies if they become a problem.
   - Materials removed from solids removal or sedimentation areas should be disposed of properly either by land spreading per the approved NMP or delivery to an approved waste storage facility. Solids removal protocol should be described in the Plans and Specifications Operation and Maintenance manual.

6. Year Round Collection: Leachate and first flush runoff must be collected all year.

   This is specified in s. NR 243.15(2) and (9), the WPDES Permit, NRCS 635, and NRCS 629. All leachate must be collected and runoff must be controlled, without regard to seasonality. Leachate must be collected and conveyed to storage year round. During the winter months the VTA vegetation is dormant and treatment levels decline so it is important to deliver the runoff during warm ups to storage. If the system freezes-up or the pumps are pulled during winter, measures must be taken such as; pumping during warm ups to tanker trucks with temporary pumps or, storing removed snow in areas which drain to a waste storage facility or temporary storage areas which can regularly be pumped out. Where possible, the collection tank and pump system should be designed to prevent freezing, so it is operable throughout the year.

7. Spreaders and Erosion Control: Runoff must be evenly distributed across the top of the VTA width; runoff may need re-distribution each 100-200 feet of VTA slope length. Erosion control is also needed at the top spreader.

   This is specified in NRCS 635. Reliable distribution can be achieved using permanent structures with the ability to maintain an accurate flow discharge elevation such as slotted concrete spreader curbs, or an above ground pipe manifold, with either device discharging onto a gravel splash pad to control erosion at the top of the VTA. A potential new method to distribute flow evenly would be an irrigation "bubbler" system if properly designed and installed. A gravel spreader may be effective to re-distribute runoff mid-VTA, but a gravel spreader used alone to distribute flow along the top of the VTA often results in channelized flow and erosion. Sediment and other solids also build up in the gravel and can't be removed, making gravel replacement necessary. These problems occur after a relatively short service period, resulting in the need for increased maintenance. DNR may not approve gravel spreaders for the primary flow distribution system at the head of the VTA; although in some cases flow spreaders constructed with 4 to 6-inch round stone with a highly effective solids separation system have proven to be effective.

8. Flatness Tolerances for Spreaders and VTAs: **NRCS 635 specifies uniform flow across the VTA.** Construction tolerances are recommended to ensure even flow across and down the VTA. DNR may require construction tolerances for CAFOs under the authority of NR 243.

    a. For construction of non-pressurized flow spreaders the discharge invert elevations such as concrete slots or pipe manifold slots, apply a construction tolerance limit to ensure even flow across the VTA width. For this purpose, the recommended minimum tolerance is plus or minus 1/2 inch over a 50-ft width. Flow spreaders utilizing an elevated pipe manifold with splash spreaders should be designed so that flow is evenly distributed across all the manifold outlets.

    b. Similarly for the VTA, apply a construction tolerance limit to ensure the VTA is graded evenly. For this purpose, the recommended flatness tolerance is plus or minus 0.10 foot from side to side. (Reference: USDA National Engineering Handbook, Part 645, Appendix E).

9. Limit Infiltration: Flow spreaders must not be infiltration sinks.

    This is generally consistent with NRCS 635. The DNR considers these components to be transfer systems and requires liquid-tight designs. To protect groundwater quality, all feed leachate must be collected, and contaminated runoff infiltration beyond the VTA root zone must be limited. Systems that infiltrate significant pollutant quantities are also regulated under ch. NR 214, Wis. Adm. Code.

10. Improved mid-VTA Flow Spreader: **NRCS 635 requires flow spreaders every 200 feet to ensure sheet flow and prevent rilling.**

    The stone berm flow spreaders typically used at mid-points in VTAs tend not to distribute flow evenly. A recommended spreader design has stone spreaders dug into the ground as shallow trenches, underlain by an impermeable membrane liner with the lip of the liner even with the ground and the rocks protruding just above the ground to catch debris. Stone should be large enough to not move in high flows such as 2"-4" round stone. Such a design would allow farming equipment to drive over it. The purpose of the liner is to limit infiltration and to provide a pool which will more evenly distribute the flow. It is also recommended to provide 100 foot spacing, which is less than the 200 foot spacing in NRCS 635. DNR may require a mid-VTA flow spreader designed as described above under the authority of NR 243.

11. Keep Flows Separate: The runoff volume to be routed to the VTA must not overflow out of the system.

    This is specified in s. NR 243.15(2) and (9), the WPDES Permit and NRCS 635. Reliable containment of the VTA runoff volume can be achieved by installing a concrete floor and perimeter curbs at the spreader area, along with a slotted concrete spreader bar (described above). Earthen berms used to contain runoff in the flow spreader area may become denuded, erode and allow contaminated runoff to flow outside of the flow spreader system and VTA unintentionally.

12. Remove Nutrients from the VTA and Avoid Compaction: Cut and remove vegetation from the VTA, and keep animals and equipment (except for mowing) off the VTA.

    This is generally consistent with NRCS 635. Turf or grass vegetation must be mowed and removed frequently enough to prevent the grass from falling over. At least twice per year mowing is normally needed. If the VTA is a cropped field, nutrients are removed with crop harvest. Mowing (and other equipment access, if needed) should be done when the VTA is dry enough to avoid compaction and rutting. Mowing and removal frequency or criteria must be described in the Plans and Specifications Operation and Maintenance manual.

    Controlled grazing is allowed by NRCS 635 as a method to harvest vegetation from the VTA, but NRCS 635 is not intended to achieve no pollutant discharge. If grazing the VTA is proposed, it must be addressed in the Plans and Specifications for the VTA. However, grazing the VTA is unlikely to be approved by DNR under the authority of NR 243, because it can be expected to recycle nutrients back onto the VTA, rather than ensure nutrient removal.

13. Repair VTA As Needed: Channelized flow and erosion on the VTA must be promptly repaired. If channelization and erosion reoccur, action should be taken to correct the cause.

    This is specified in NRCS 635. Excessive or reoccurring channelized flow and erosion on the VTA may be caused by the following:
    - Solids build-up on the spreader.
    - An uneven spreader bar or uneven slots in the spreader bar. (Tolerance limits are needed.)
    - An ineffective spreader type or design.
    - Uneven grade across the width of the VTA.

14. Waste Feed: Waste feed, including plowed snow containing feed, must be stored within the feed storage area (or other approved containment area) to provide leachate collection and runoff control.

    This is specified in s. NR 243.15(9), the WPDES Permit and NRCS 629, waste feed must be stored within a facility approved for storage of feed, solid manure or liquid manure, until the waste feed is properly disposed by land application in accordance with an approved NMP. Significant quantities of feed are typically found in snow that has been removed from feed storage areas. Snow piles containing feed must be managed as feed / waste feed.

15. Snow Plowing: Snow pile placement must not interfere with clean storm water diversions or feed leachate collection and runoff control systems.

    This is specified in s. NR 243.15(2) and (9) the WPDES Permit, feed leachate collection and runoff control must be provided, and clean water must be diverted away from the feed storage area. Snow piles are sometimes mistakenly placed in locations that block drainage paths, resulting in the following problems:
    - Reduced ability to collect leachate and control runoff.
    - Clean storm water might not be effectively diverted away from feed storage areas.
    - Feed storage areas could become inundated, creating increased feed spoilage and greater volumes of contaminated runoff.

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2. STRENGTHENING CURRENT DESIGN STANDARD

There are a couple of provisions in the current NRCS 635 Design standard described below which could be considered "loopholes" and should be changed to meet the intent of the standard. In addition, the standard does not differentiate between VTAs planted with annual row crops and those planted in permanent vegetation. The design criteria should recognize the differences between these vegetation types.

No VTA Sizing Discount for Steep VTAs

Eliminate the provision allowing the reduction of the VTA area by half if the flow depth over the VTA is maintained at 1 inch or less. This provision has merit if the reduced flow depth is achieved by having a low flow rate, which would result in better treatment. However, in practice the reduced flow depth is often achieved by having an increased flow velocity as the result of a steep slope or reduced flow roughness, which would result in a reduced level of treatment.

Pros: Eliminate a perceived loophole in the standard and prevent undersizing of the VTA.

Cons: May increase required VTA size.

Longer Minimum VTA Flow Through Length

Require a minimum flow length of 100 feet, replacing the current minimum of 20 feet. This is consistent with the National NRCS 635 Standard and the Wisconsin NRCS 635 criteria for animal lot VTA design using the overland flow process.

Pros: Consistency with National Standard and will provide longer flow through contact times, increasing the opportunity for runoff to infiltrate into the root zone for treatment.

Cons: May increase required VTA size.

Cropland VTA Design and Management Requirements

The National NRCS 635 states that "Permanent vegetation consisting of single species or a mixture of grasses, legumes and/or other forbs adapted to the soil and climate shall be established in the treatment area". The Wisconsin NRCS 635 standard for feed storage runoff states that the VTA "shall consist of grassed, wooded, or cropped areas" – implicitly allowing annual row crops like corn. There is no differentiation between the grass and cropland VTAs in the Wisconsin NRCS 635 design criteria. Since row crops do not offer full soil coverage, there is more potential for soil movement and flow channeling in the VTA than with grass. Cropland VTAs should have additional design/management criteria to address this. While most VTAs are grass VTAs and only one or two CAFOs in Wisconsin have cropland VTAs, the potential exists for more VTAs to be vegetated with row crops, making these additional criteria a priority. There are no known CAFO VTAs which are wooded, and it is proposed that they not be allowed for CAFOs due to the likely difficulty in achieving distributed flow across such a VTA.

Additional design and management for cropland VTAs include: **a)** Require the last 15% of the VTA length (minimum 15 feet) to be planted in permanent vegetation per NRCS 342; **b)** Require a minimum vegetated buffer length of 50 feet (rather than 35 feet) at the end of the VTA if the discharge point is within 100 feet of concentrated flow; **c)** Require the VTA area be increased by 20% over that determined in Table 2 of NRCS 635 (excluding the permanent vegetation at the end); **d)** Require annual soil testing for nutrients (minimum 2 locations at top and bottom of VTA) to monitor nutrient application rates and adjust fertilization rates, first flush collection or VTA size if necessary. Per Item 3 of Section 1 above, cropland VTAs will be required to have cover crops established if runoff discharges are planned for when there are no established annual crops. The numeric criteria in this paragraph are subject to change. It may also be better for the permanent vegetation referred to in **a)** above to be at the upper end of the VTA or maybe even have it at both ends.

3. FIELD STUDIES AND TESTING

UW Discovery Farms First Flush Analysis Results

The ongoing UW Discovery Farms Bunker Silage and Runoff Management Study has provided valuable information which can inform how to design more effective feed storage collection and treatment systems and to assess how well the current systems are operating.

The UW Discovery Farms Final Report "Evaluating the Ability of Wisconsin Farms Storing Silage and/or High Moisture By-Products to Meet the No Discharge Criteria" (1/20/2014 with final revision 3/24/2015) gives an indication of how effective the "first flush" collection system could be at delivering nutrients to storage. For the initial 10 month study period, the Farm A collection system delivered 74% of Total Phosphorus and 77% of Total Kjeldahl Nitrogen to storage. The total drainage area to this VTA is 4.16 acres and the feed bunker area is 2.89 acres. The "first flush" collection averaged 0.12" per storm event and represented 23% of total runoff volume. For this particular site, the "first flush" volume was actually a low flow pumping regime with pumping over a large portion of the runoff hydrograph due to constricting orifices and pipes, which is not typical for this design feature. It must be noted that this high level of nutrient collection may not be indicative of a typical first flush collection system due to the atypical low flow pumping regime and other site and weather specific conditions.

UW Discovery Farms is also investigating pumping schemes to optimize nutrient collection further while minimizing the stored volume. They have found that nutrient concentrations are often high during the receding flow of the runoff event as well as during the beginning flow. Preliminary concepts include either a pump to storage of low flow during the entire runoff event (preliminarily recommend 1% of the peak 2-yr flow rate) or a pump to storage only during low flows and not during the peak of the event (possibly controlled by a conductivity meter). Such systems could potentially increase the efficiency of nutrient collection but could also be more complicated to design and operate than the current "first flush" approach.

April 2015 VTA Discharge Testing

On April 24 and 25, 2014 the Wisconsin DNR and/or the US EPA collected runoff samples from the discharge end of three CAFO VTAs in Brown County. The three VTAs were known to have design and/or operational deficiencies and were designed and constructed prior to the implementation of major revisions to the NRCS 635 Vegetated Treatment Area Standard in 2012. The collections were completed during or shortly after a rain event. The Green Bay Climate Data Report from the National Climate Data Center shows that there was 0.43" of rainfall on April 24^{th} and a trace of rainfall on April 25.

Below is a table summarizing the testing results for Total Phosphorus (TP) as well as some key VTA design parameters. The VTAs would be significantly undersized according to the 2012 design standard sizing criteria. In addition, the slope of 0.5% is at the bottom end of the allowable slope range and could be contributing to poor sheet flow characteristics. It would be reasonable to expect that VTAs constructed according to the current standard would provide better treatment than that provided by these three VTAs.

Name	Date	TP Conc. (mg/l)	VTA Ratio*	VTA Slope	First Flush Collection**	VTA Ratio with Current Standard
BR1	4/24	3.12	35%	0.5%	0.2"	70%
BR2	4/24	10.1	13%	0.5%	0.2"?	55% based on deeper separation
BR3	4/25	2.08	10%	0.5%	0.05"	Not allowed – at least 100%

***VTA area to contributing area ratio**
****First flush collection depth as designed and approved by DNR. 2008 Design Report for BR2 was not available so collection depth is assumed.**

There are additional design and operation deficiencies in these VTAs described as follows:
BR1: The leachate/first flush pumping is turned on and off manually and may not be meeting the 0.2" first flush collection goal. The VTA exceeds the 10:1 length to width ratio maximum now required by the current standard.
BR2: Flow on the VTA is concentrated. There is no flow spreader at the top end and the VTA is unevenly graded. The leachate/first flush pumping is turned on and off manually and may not be meeting the 0.2" first flush collection goal.
BR3: The leachate/first flush pumping is turned on and off manually and may not be meeting the 0.05" first flush collection goal. There is a berm at the end of the VTA and much of the vegetation is dead.

To provide some perspective on these VTA discharge TP concentrations, runoff from vegetated areas without wastewater being applied to them would be expected to be less than the concentrations coming off a VTA but not zero either. Based upon one year's worth of preliminary data from a USGS study of a CRP field in St. Croix County, the annual flow-weighted concentration of TP is approximately 0.6 mg/L and TKN is approximately 1 mg/L. This CRP field has been in CRP for approximately 10 years.

4. POSSIBLE REVISED HYDRAULIC DESIGN OF VTAs FOR 25-YEAR STORM

The current NRCS 635 Design Standard (10/14) allows feed storage runoff from storms greater than 25% of 25-yr peak flow to be bypassed untreated and uncollected. However, NR 243 prohibits any discharge from the production area up to the 25-year storm event (for dairy cows and cattle). One reason to allow this bypass is that these higher flows typically contribute a relatively small amount of the total nutrient loading on an annual basis. Of the three farms in the UW Discovery Farms study over a 2 year period, only one rain event produced a flow exceeding 25% of the 25-year peak flow so it would be reasonable to expect that bypassing of untreated flow would be relatively infrequent. While nutrient concentrations during high flows are often lower than the low flow events, it cannot be assumed that nutrient concentrations in runoff flows above 25% of the 25-year storm are negligible. The one measured event in the UW Discovery Farms Study which had a flow greater than 25% of the 25-year storm had a <u>Total Phosphorus concentration of 16.8 mg/l</u> at the peak flow. It should be noted that during this event the system was overtopping and the water sample collected was from a location which would have been mixed with higher concentrated runoff from the low flow portion of the runoff event, so it is likely that the overtopping runoff had a TP concentration less than 16.8 mg/l.

Sizing VTAs for runoff up to and including the 25-year storm event would be a move toward providing no surface water discharge as required by NR 243. The current feed storage VTA sizing table in NRCS 635 was based somewhat on hydraulic calculations for a <u>maximum flow depth</u> and <u>minimum flow through time</u> for the design flow rate of 25% of the 25-year storm peak flow. A simple spreadsheet can be made to calculate a VTA's length and width based upon the design flow rate, slope, roughness, and target flow depth and flow through time. VTA area remains the same regardless of the slope if other parameters are kept equal, but the length and width vary proportionately. The VTA area could be reduced based upon the quantity of first flush collection, similar to that done in the current NRCS 635 sizing table.

<u>As a starting point the maximum flow depth could be 1-inch and the minimum flow through time could be 12.6 minutes.</u> These are the same parameters specified when using the overland flow process for animal lot VTAs in NRCS 635. Using the 1-inch flow depth results in unreasonably wide VTAs so a deeper flow depth may be desirable. The target flow through time can be adjusted up to keep the same area ratio. <u>A hypothetical case with these parameters results in a VTA to contributing area ratio of approximately 1.4:1. A hypothetical adjustment for first flush collection could result in an area ratio of 0.8 for a 0.25-inch collection and an area ratio of 2.0 for a 0.05-inch collection.</u> Design flow rates could be reduced with detention basins or high flow collection as discussed below.

Concept 1 - Basic VTA Hydraulically Sized for 25-year storm

Size the VTA based on the 25-year peak flow and a target minimum flow through time and maximum flow depth as discussed above. These calculations take into account the peak design flow rate (25-yr storm), and the VTA slope, length, width, and surface roughness. The minimum flow through time is used to calculate the length and the maximum flow depth is used to calculate the width. For example, a minimum flow through time of 22 minutes and a maximum flow depth of 1.75 inches would result in a VTA to contributing area ratio of 1.4:1. A method to allow reduction of VTA size according to how much first flush runoff was collected would be devised.

Pros: Takes into account the 25-year peak flow. More transparent and flexible method than using a table. Can be regionally specific based upon design flow rates.

Cons: It is more complicated to use equations than to use a table. Prescribing the length and width of the VTA will make it more difficult to site than if just the area is prescribed. Without some type of storage and/or end of VTA collection system (discussed below) it is unlikely that a VTA can treat a 25-yr peak flow without a pollutant flow.

Concept 2 - VTA with Sediment Basin Pre-treatment

Require a large sediment basin pre-treatment using a methodology similar to that used in NRCS 632 Waste Separation. This standard requires the basins to have a volume 65% of the peak inflow rate from a 25-year storm over 15 minutes. Such a basin would have two benefits; it would improve pre-treatment for the VTAs; and it would reduce the peak flow rate going to the VTA, increasing the VTAs ability to treat flows without a discharge. The sediment basin volume could reduce the 25-yr peak flow by approximately 45%. During smaller storms (~ 1 inch or less) the basin may provide full containment and then could act as a "Sunny Day" release system as described below. An even larger volume could be built if the desire was to decrease the peak flow even more. Sizing would be based on maximum flow depth and minimum contact time as discussed above but with using the reduced peak flow.

Pros: Could possibly reduce problems from solids accumulation in flow spreaders and the VTA. Would reduce peak flows and therefore improve VTA effectiveness. Could provide for "Sunny Day" release for the more common storm events.

Cons: Possibly need additional design criteria to address the neutrally buoyant solids in feed storage area runoff. May still have discharge during a 25-year storm event. One would have to weigh whether the peak flow attenuation and resultant VTA size reduction is worth the cost of adding the basin. There may not be room to include a sediment basin within the production area.

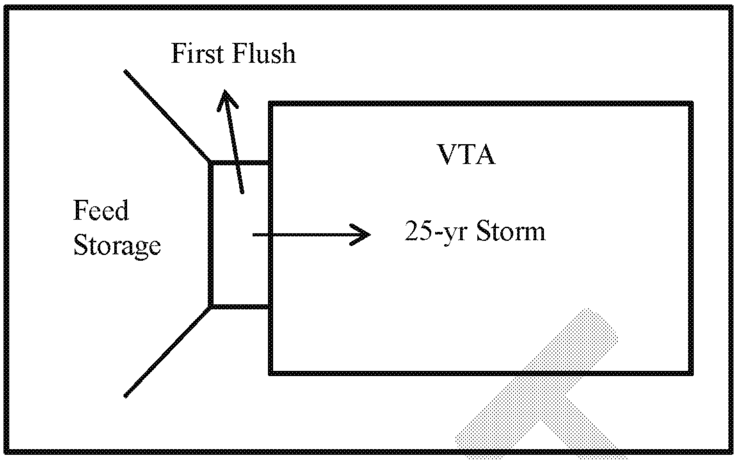
Concept 3 - VTA with First Flush/Low Flow Collection combined with High Flow Collection:

This concept is to collect a low flow, allow intermediate flows onto the VTA, and then collect high flows up to the 25-year flow. The runoff collected in the high flow collection basin could be released back onto the VTA after the storm event (sunny day release), pumped to manure storage, or directly field applied. VTA would be sized based on maximum flow depth and minimum contact time as discussed above but using the high flow cutoff flow.

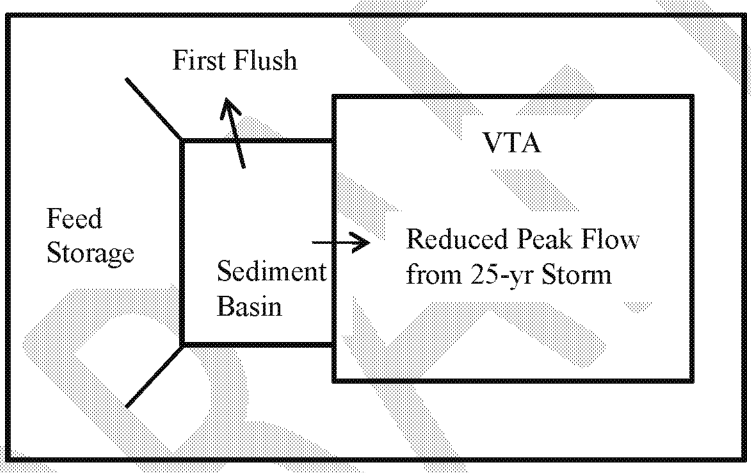
Pros: Avoids bypass of the 25-year storm. Reduces VTA size.

Cons: May end up diverting much of the runoff to storage. One would have to weigh whether the VTA size reduction is worth the cost of adding the basin.

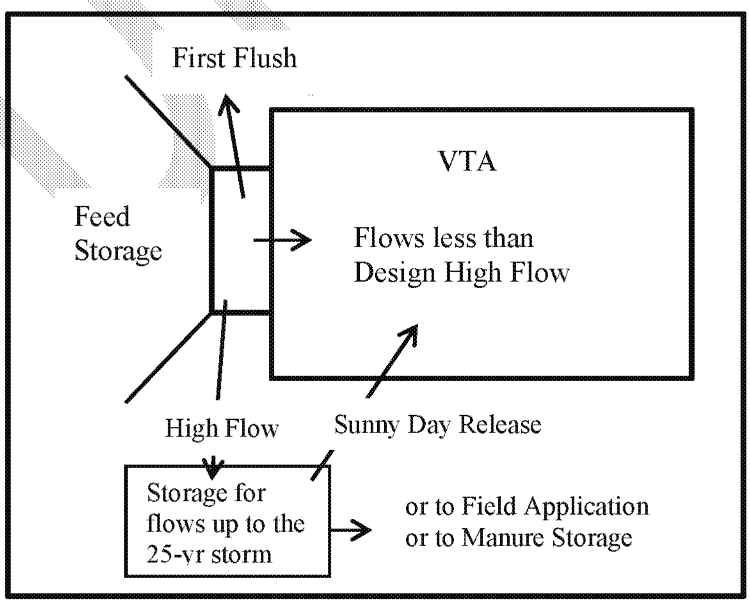
Concept 1 - Basic VTA Hydraulically Sized for 25-year storm



Concept 2 - VTA with Sediment Basin Pre-treatment



Concept 3 - VTA with High Flow Collection



5. POSSIBLE "ZERO DISCHARGE" SYSTEMS

The design concepts below are thought to provide zero discharge up to and including the 25-yr storm from feed storage areas.

Concept 4 - Full Runoff Collection and Storage Systems

An alternative to a VTA system would be full collection and storage of all flows up to the 25-year storm. If separate from the manure storage, then the 180 days storage requirement is not specified by rule (NR 243.15(3)(d)) but an extended storage period would be needed to meet NMP requirements. The storage would be sized to contain the 25-yr runoff volume, have 1-ft. of freeboard, and the capacity required for storage between land application events as specified in the NMP. The waste storage would need to meet the requirements of NR 213. NR 243.14.(2)(c) allows application of process wastewater on frozen or snow covered ground if it meets the requirements of NR 214.17(2) to (6). Hypothetical sizing of such a waste storage for a three-acre feed storage drainage area with a 4.8" 25-yr rainfall depth would be 1,574,990 gal. for 180 days of storage and 616,419 gal. for 60 days of storage.

Pros: Avoid the complexities of constructing and operating a VTA. Avoid the uncertainty of whether VTAs discharge in a 25-year storm. Less land area requirement than a VTA.

Cons: Added difficulty of field applying the wastewater.

Concept 5 - "Cropped Field" VTA/Sunny Day Release System

The VTA would no longer be considered part of the production area but would be considered a Cropped Field managed with a nutrient management plan. The Cropped Field would be sized according to the calculated annual nutrient loading and the calculated crop requirements. Nutrient loads would have to be measured or estimated with "typical" loading results from the UW Discovery Farms study. The operation and maintenance plan for the Field would include monitoring nutrient content of harvested vegetation, and annual soil sampling. A sampling protocol would be developed with multiple samples progressively moving away from the upstream edge. Increasing concentrations of P and/or K in the soil over time may indicate that the Field should be expanded or more runoff should be collected. Surface water discharge out of the end of the Field would be considered agricultural storm water.

To comply with the NMP requirements of NR 243, feed storage runoff could not be discharged onto the Cropped Field during rain events or when the soil is saturated. This would likely require a Sunny Day release system where runoff up to and including the 25-year storm would have to be collected in a storage basin and released onto the Cropped Field some period after the rain event. This allows the VTA to dry out and more readily infiltrate the collected runoff into the root zone and the discharge rate can be slowed down to approximate the infiltration rate of the VTA. The storage basin would be sized to contain the entire 25-yr runoff volume with 1-ft. of freeboard and the means to collect runoff during the winter season while the VTA vegetation is dormant would also be required.

The size of the Field would depend on the quantity of feed storage and also how much flow is collected to storage in the first flush. A hypothetical case was assessed using UW Discovery Farms nutrient loading data for the Farm A system discussed in Section 3 above (note that this may understate the nutrient loading for many systems). Snap + indicated that the Field to drainage area ratio ranged from 0.65:1 for a Reed Canary Grass cropping, 0.97:1 for a corn/alfalfa rotation, and 1.4 for smooth brome grass. Seed mixes with smooth brome grass have been commonly used for VTAs in Wisconsin. Reed Canary Grass has been used for wastewater treatment due to its high nitrogen uptake and tolerance of inundation. However, it is listed as a non-regulated invasive species by DNR and is not in the NRCS 342 Critical Area Planting Standard.

Pros: Better assessment and monitoring of nutrient uptake and accumulation on the Field. Runoff discharge onto the Cropped Field after the storm event allows for better infiltration into the root zone.

Cons: There could still be flow off the Field. Past research studies of animal lot VTAs indicate that the amount of nutrients being removed with harvesting vegetation from the VTA is generally much less than the quantity discharged onto the VTA. Requires more management.

Concept 6 - Infiltration Basin:

This concept is to construct an infiltration basin capable of containing the full 25-year runoff volume. The infiltration basin would be constructed based on the DNR Conservation Practice Standard 1003 Infiltration basins. Absorption pond criteria in NR 214 should be abided by as well (including groundwater monitoring). The infiltration basin would be sized according to the infiltration capacity of the infiltration basin soils with a target design storm and drawdown time. Both the runoff from the feed storage area and the direct precipitation on the infiltration basin must be infiltrated. DNR Conservation Practice Standard 1003 requires a maximum drawdown time of 24 hours but this design standard was intended to target smaller more frequent storms. The maximum drawdown time is intended to limit plant mortality due to prolonged inundation. It may be reasonable to use a more frequent storm for sizing. With many soils the 25-year rainfall just from the direct precipitation on the infiltration basin will not infiltrate within 24 hours. In any case the basin would be deep enough to contain the 25-yr rain event. The infiltration rate of the VTA would be based on DNR 1002 or in situ field measurements. Typically the in situ field measurements provide much higher infiltration rates. Multiple discharge points may be necessary to ensure even distribution of runoff over the basin since full utilization of the basin area usually requires a flat bottom. Soil amendment may be necessary and deep rooted vegetation may be necessary to maintain infiltration capacity. A hypothetical sizing scenario for an infiltration basin using a DNR 1002 infiltration rate for silt loam (0.13"/hr), a 1-yr storm and a 24 hrs drawdown time results in a infiltration basin to contributing area ratio of 3.1:1

Pros: Full containment of the 25-year storm event.

Cons: Potential for groundwater contamination. Track record of clogged infiltration basins in Minnesota. Potentially long drawdown times or large basin area.

Concept 7 - Infiltration VTA with Discharge End Collection System:

In this concept the VTA would be designed to infiltrate the runoff from the feed storage but would allow the direct precipitation on the VTA to be discharged first. A berm with a flow gate on the downslope end of the VTA would could alternately allow outflow or contain flow. There would also be a Sunny Day release storage. During the storm event runoff from the feed storage area would be collected in the Sunny Day release storage and the VTA flow gate would be open so that direct precipitation can runoff from the VTA. After the storm the gate would be closed and the collected runoff from the feed storage would be released onto the VTA. Collected runoff at the berm could either be manually pumped or an automatic pumping system which recirculates the runoff back to the head of the VTA could be installed. It would be expected that runoff would frequently reach the end of the VTA and would require an automatic pumping system to keep up with recycling the runoff back to the head of the VTA. The VTA would be sized according to the infiltration capacity of the VTA soils with the target to infiltrate the 25-year runoff volume within 24-hours. The infiltration rate of the VTA would be based on DNR 1002 or in situ field measurements. Hypothetical sizing of a

VTA to infiltrate the 25-yr runoff volume using a DNR 1002 infiltration rate for silt loam results in a VTA to contributing area ratio of 1.35:1. This assumes pumping from the discharge end back to the head of the VTA.

Pros: There would be no discharge during the 25-year storm.

Cons: Unproven design. VTA could become oversaturated during large rain events. High pumping costs if cycling time is long. Potential for groundwater contamination. Additional operation and maintenance with opening and closing gates before and after rain events.

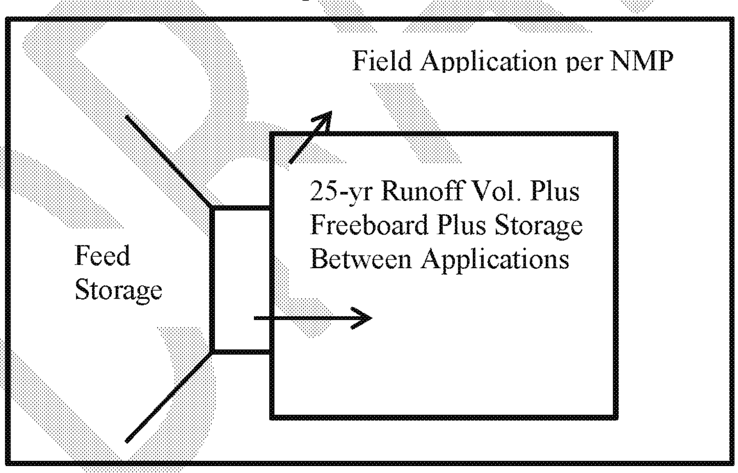
Concept 8 - Feed Storage Full Coverage:

This concept is to cover the feed storage area so that rainfall cannot come into contact with stored feed. This includes the area in front of the working face of the feed where feed has spilled on the feed pad. Currently rainfall sheds off plastic tarps down bunker walls and comes in contact with feed or runoff on flat feed pads goes between the rows of covered feed and can seep into the feed piles. This may require some larger structure which can cover the entire area. Non-rainfall related leachate collection would still be required. A variation of this is to store feed in feed storage bags on a paved pad. Leachate would still have to be collected, but if housekeeping of the pad is highly effective, it could be argued that rainfall runoff would be clean and not need to be collected or treated.

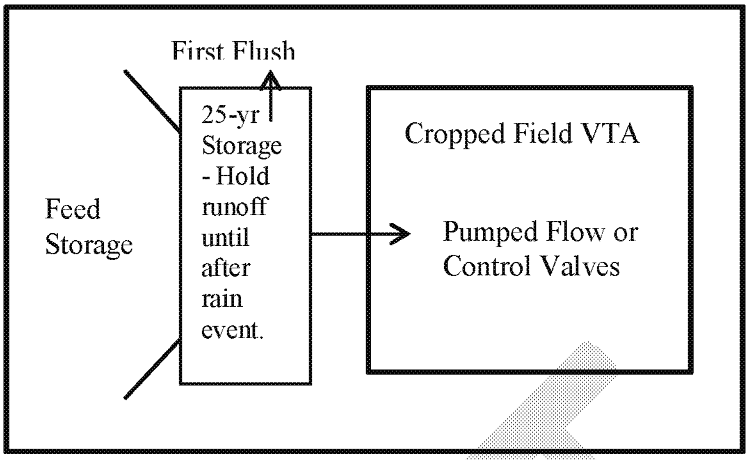
Pros: No runoff collection, storage, or treatment required since runoff would be "clean".

Cons: Uncertain how to do this without a huge roof. Tall covering structures potentially subject to large wind shear.

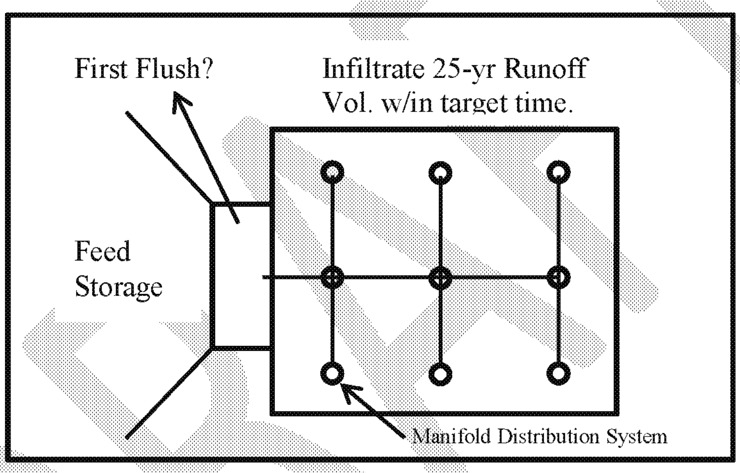
Concept 4 – Full Collection



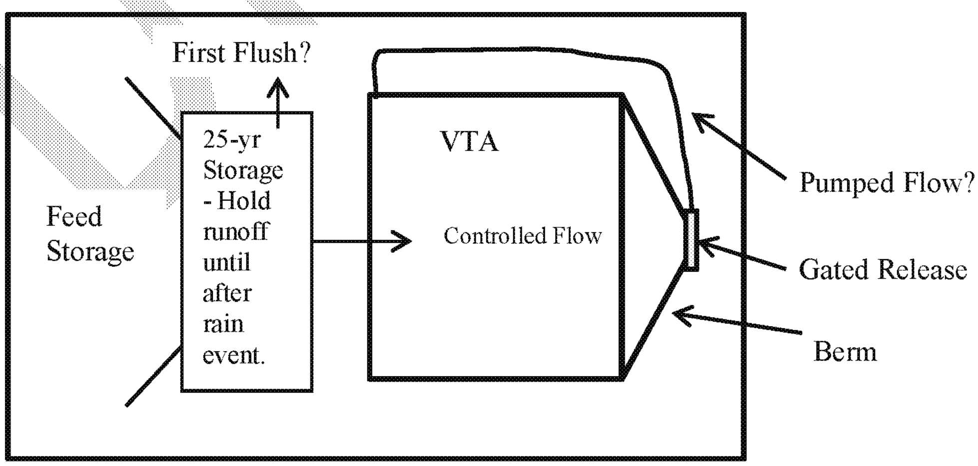
Concept 5 – "Cropped Field" VTA with Sunny Day Release System



Concept 6 – Infiltration Basin



Concept 7 – Infiltration VTA with End Collection System



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