Improving runoff water quality from small pork production facilities using vegetative treatment areas

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Improving runoff water quality from small pork production facilities using vegetative treatment areas

STATE NONPOINT SOURCE GRANT PROGRAM

TSSWCB PROJECT 16-50

Prepared for:

TEXAS STATE SOIL AND WATER CONSERVATION BOARD

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TEXAS A&M AGRILIFE RESEARCH

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TEXAS WATER RESOURCES INSTITUTE TECHNICAL REPORT 501
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Executive Summary

Federal law requires all animal feeding operations manage manures and wastewater by-products in a manner that is protective of U.S. waters. As a result, the Texas State Soil and Water Conservation Board (TSSWCB) encourages animal feeding operations to voluntarily participate in the agency's Water Quality Management Plan (WQMP) Program; however, limited participation of the pork industry has historically occurred largely due to logistical and operational issues on smaller operations. Smaller pork facilities generally operate on smaller tracts of land that do not support traditional animal waste management systems such as waste storage ponds, treatment lagoons, and significant expanses of land application acreage.

The U.S. Department of Agriculture–Agricultural Research Service (ARS) and Texas Water Resources Institute (TWRI) initiated this project with funding from the TSSWCB to evaluate an alternative manure treatment system, a vegetated treatment area (VTA), to treat runoff and wash water from small pork production facilities. This evaluation was designed to provide the scientific basis for considering this system for inclusion as an approved practice in the WQMP Program.

The demonstration and evaluation of the VTA system was initiated at three small pork production facilities in Bell, Brazos, and Robertson Counties. Water quality monitoring stations were established at: 1) adjacent control sites, 2) below pens and barns to quantify water quality leaving the facility prior to treatment in the VTA, and 3) at the VTA outlet to quantify effectiveness of the VTA in treating runoff. Runoff volume and event mean concentrations for *E. coli*, nitrogen (N), and phosphorus (P) were determined for each rainfall runoff event. Soil sampling was also conducted to assess nutrient accumulation and movement within the VTAs.

This 4-year evaluation found that VTAs reduced runoff volume by up to 29%, total N concentrations 47-76%, total P concentrations 65-88%, and *E. coli* concentrations 34-93%. Additionally, nutrient loads were reduced by 32-92%, and *E. coli* loads were reduced by 29-94%. Despite these reductions, with the exception of Robertson County, runoff from the VTAs had higher concentrations than control sites. This is attributed to alternative management of solids (i.e. solids removal) and enclosed barn pens used at the Robertson County site.

Based on evaluation results, VTAs were found to be a practical, environmentally-friendly waste management alternative for reducing nutrient and bacteria concentrations and loading from small pork production operations **<u>if</u>** proper consideration is given to design and management factors (e.g., solids management, perennial grass cover and subsequent haying and removal, and nutrient loads/VTA area).

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List of Acronyms and Abbreviations

AFOs	Animal feeding operations
ARS	United States Department of Agriculture – Agricultural Research Service
CNMPs	comprehensive nutrient management plans
CAFOs	Concentrated animal feeding operations
CFU	Colony forming units
CNMP	Comprehensive nutrient management plans
EPA	United States Environmental Protection Agency
EQIP	Environmental Quality Incentives Program
FOTG	Field Office Technical Guide
GBRA	Guadalupe-Blanco River Authority
N	Nitrogen
NH_4-N	Ammonium-Nitrogen
NMPs	Nutrient management plans
NO_2-N	Nitrite-Nitrogen
NO_3-N	Nitrate-Nitrogen
NPDES	National Pollutant Discharge Elimination System
NPS	Nonpoint source pollution
NRCS	United States Department of Agriculture - Natural Resource Conservation Service
P	Phosphorus
PO_4-P	Ortho-Phosphate
TCEQ	Texas Commission on Environmental Quality
TSSWCB	Texas State Soil and Water Conservation Board
VTA	Vegetated Treatment Area
WQMP	Water Quality Management Plan

Project Background and Goals

On December 15, 2002, the Administrator of the United States Environmental Protection Agency (EPA) signed the final rule regulating concentrated animal feeding operations (CAFOs). This rule reinforced the need for all animal feeding operations (AFOs), regardless of the definition as a CAFO and required to operate under the coverage of a National Pollutant Discharge Elimination System (NPDES) permit, to manage manures and wastewater by-products in a manner that is protective of U.S. waters. The requirement for nutrient management plans (NMPs) and the recommendation that all AFOs obtain comprehensive nutrient management plans (CNMPs) was a key strategy for achieving maximum protection. As EPA has delegated the NPDES program to the State of Texas, the Texas Commission on Environmental Quality (TCEQ) has adopted the Texas Pollutant Discharge Elimination System under administrative rule, and certain management practices and technical requirements specific to unpermitted AFOs in Texas Administrative Code §321.47.

In Texas, the Texas State Soil and Water Conservation Board (TSSWCB), the agency responsible for management, prevention, and abatement of nonpoint source (NPS) pollution from agricultural and silvicultural activities, administers a certified Water Quality Management Plan (WQMP) Program. The term NPS, as it relates to AFOs, is loosely used to differentiate between AFOs, which do not require written authorization from TCEQ, from point source CAFOs, which do require written authorization under a permit. Because of this, the TSSWCB's WQMP Program is applicable for any AFO not defined as a CAFO. An estimated 3000 such AFOs currently operate under the authority of a WQMP certified in accordance with Texas Agriculture Code §201.026. The technical elements of a WQMP are based on the United States Department of Agriculture - Natural Resource Conservation Service's (NRCS) Field Office Technical Guide (FOTG), which is the best available technology and the basis for many management practices and agricultural engineering standards incorporated into the permitting program. A certified WQMP developed for an AFO that meets the technical requirements of the FOTG is a CNMP. A WQMP is effectively a conservation plan that includes a functionally equivalent level of environmental protection from a voluntary perspective. Thus, the TSSWCB encourages as many AFOs as possible to voluntarily participate in the WQMP Program, even if they are not explicitly required to obtain permit coverage.

Historically, the dairy and poultry industries have had high levels of WQMP interest and make up the bulk of the AFOs currently participating. In contrast, limited participation of the pork industry has occurred largely due to logistical and operational issues on smaller operations. Smaller pork facilities generally operate on smaller tracts of land that do not support traditional animal waste management systems such as waste storage ponds, treatment lagoons, and sufficient land application acreage.

This project evaluated an alternative manure treatment system – a vegetated treatment area (VTA) designed by NRCS to treat runoff and wash water prior to leaving the VTA. This system is compatible with small pork producer operations and designed to function well with minimal management. The project was designed to demonstrate the system's effectiveness to the regulatory community and unpermitted pork producers, thus encouraging increased WQMP program participation. Finally, the project was designed to provide a scientific evaluation of VTAs for possible inclusion as an approved practice in the TSSWCB WQMP Program and NRCS Environmental Quality Incentives Program (EQIP).

Methods

VTA systems were evaluated on three small pork production (show pig) facilities in Bell, Brazos, and Robertson Counties (Figure 1) from December 2012 through December 2016. At each facility, three monitoring stations were established: 1) on a control site to represent typical rural/agricultural land use, 2) below pens and barns to quantify water quality leaving the facility prior to treatment in the VTA, and 3) at the VTA outlet to quantify effectiveness of the VTA in treating runoff from washing or rainfall. The control site conditions ranged from an ungrazed pasture and a garden area, to a rural residential area with a few animal pens, and to an ungrazed native prairie. These control sites were sampled to quantify water quality from benign, rural land uses for comparison with water quality from agricultural land (in this case, small swine facilities).

Rainfall depth, rainfall intensity, and flow were measured for each runoff event (dependent on rainfall at each facility site). Event mean concentrations for *E. coli*, N, and P were determined for each runoff event where sufficient sample volume was available. This sampling design allowed scientific evaluation of water quality entering (from runoff and washing) and exiting the VTAs. Soil sampling was also conducted to assess the spatial distribution and transport of nutrients within the VTAs.

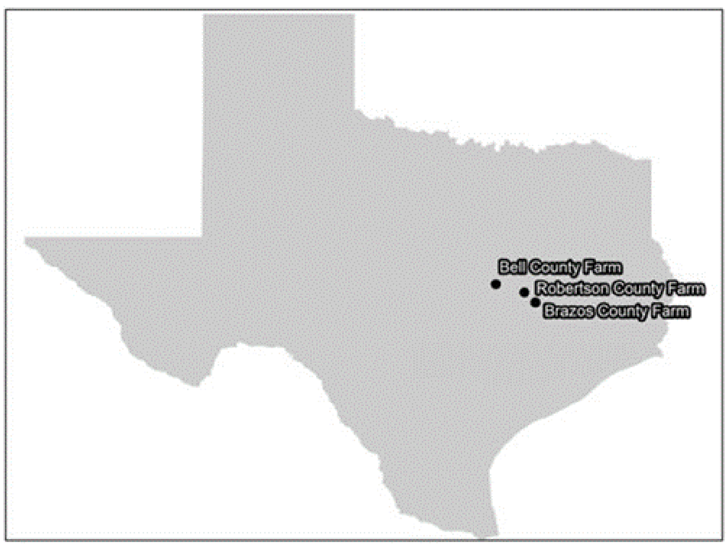

Figure 1. Locations of VTA Sites

A total of 9 water quality monitoring stations were established across the four VTA sites (Table 1; Figure 2). Eight of the water quality monitoring stations used an H-flume, which provide a stage discharge relationship for accurate flow rate measurement. One of the stations used an area-velocity sensor installed in a culvert to directly measure flow rate. Each of these 9 stations used a Teledyne ISCO® Avalanche refrigerated sampler to automatically collect water quality samples and to measure and store flow rate. A rain gauge was also installed at each facility to measure precipitation.

Figure 2. VTA "out" at the Bell County (a), Brazos County (b), and Robertson County (c) sites. Lateral distribution lines were installed below all VTA "in" sites (Brazos County site shown here) (d).

Table 1. VTA Sample Sites and Monitoring Frequencies

Station ID	Station Type	Nutrients & Bacteria	Sampling Entity	County
Bell In	VTA In	storm events	ARS	Bell
Bell Out	VTA Out	storm events	ARS	Bell
Bell Control	Control	storm events	ARS	Bell
Brazos In	VTA In	storm events	ARS	Brazos
Brazos Out	VTA Out	storm events	ARS	Brazos
Brazos Control	Control	storm events	ARS	Brazos
Robertson In	VTA In	storm events	ARS	Robertson
Robertson Out	VTA Out	storm events	ARS	Robertson
Robertson Control	Control	storm events	ARS	Robertson

For runoff events, water samples were stored at 4°C in the refrigerated samplers immediately following collection. Samples were retrieved from the field and analyzed within 24 hours of the first sample and were transported to the lab on ice. Approximately 100 mL was poured into a Nasco Whirl-Pak (NASCO, Inc., Fort Atkinson, Wisc.) sterilized bag and transported on ice to the Texas A&M University Soil and Aquatic Microbiology Laboratory for bacteria analysis. In addition, three separate 20 mL high density polyethylene bottles were filled and analyzed by ARS for dissolved nitrate + nitrite (NO_3+NO_2-N), ammonium (NH_4-N), orthophosphate (PO_4-P), total N, and total P.

To assess nutrient accumulation and movement in the VTAs, soil samples were collected throughout each VTA using a sampling grid. Soil samples were collected twice annually from each grid location and analyzed by Ward Laboratories, Inc. for inorganic P and N.

Results

Nutrient and Bacteria Concentrations

Overall, VTAs reduced N, P, and *E. coli* concentrations in runoff. Total N concentrations were reduced 47-76% (Table 2), total P concentrations were reduced 65-88% (Table 3), and *E. coli* concentrations were reduced by 34-93% based on the 4 yr average (Table 4). However, despite these reductions, runoff from the VTAs generally had higher concentrations than the control sites. The exception being the Robertson County VTA, which inlet and outlet produced low nutrient concentrations and loads that were similar to the control. This is attributed to alternative management of solids (i.e. solids removal) and enclosed barn pens used at the Robertson County site.

Table 2. Summary of total N concentrations in runoff (mg/L).

Site	Mean total N (VTA in)	Mean total N (VTA out)	Mean total N (Control)	% reduction
Bell	21.6	5.2	4.6	76
Brazos	145.6	39.5	4.3	73
Robertson	5.3	2.8	3.1	47

Table 3. Summary of total P concentrations in runoff (mg/L).

Site	Mean total P (VTA in)	Mean total P (VTA out)	Mean total P (Control)	% reduction
Bell	33.9	4.0	1.7	88
Brazos	85.2	27.2	2.2	68
Robertson	1.7	0.6	0.2	64

Table 4. Summary of *E. coli* concentrations in runoff (CFU/100 mL).

Site	Mean *E. coli* (VTA in)	Mean *E. coli* (VTA out)	Mean *E. coli* (Control)	% reduction
Bell	1.10E+07	7.69E+05	3.55E+04	93
Brazos	3.83E+07	4.28E+06	1.95E+04	89
Robertson	6.74E+04	4.44E+04	1.22E+04	34

Nutrient and Bacteria Loads

VTAs reduced N, P, and *E. coli* loads in runoff. Total N loads were reduced 34-86% (Table 5), total P loads were reduced 32-91% (Table 6), and *E. coli* loads were reduced by 29-94% (Table 7). However, despite these reductions, runoff from the VTAs generally had higher loads than the control sites. The exception being total N at the Bell County site.

Table 5. Summary of total N runoff loads (kg/ha).

Site	Mean total N (VTA in)	Mean total N (VTA out)	Mean total N (Control)	% reduction
Bell	2.7	0.5	1.7	81
Brazos	27.5	3.8	0.1	86
Robertson	2.2	1.4	0.4	34

Table 6. Summary of total P runoff loads (kg/ha).

Site	Mean total P (VTA in)	Mean total P (VTA out)	Mean total P (Control)	% reduction
Bell	4.0	0.4	0.2	91
Brazos	19.7	3.4	0.1	83
Robertson	0.38	0.26	0.02	32

Table 7. Summary of *E. coli* runoff loads (CFU/ha).

Site	Mean *E. coli* (VTA in)	Mean *E. coli* (VTA out)	Mean *E. coli* (Control)	% reduction
Bell	1.25E+13	8.03E+11	8.65E+10	94
Brazos	7.96E+13	5.32E+12	6.77E+09	93
Robertson	4.20E+11	2.97E+11	2.66E+10	29

Nutrient Accumulation and Movement in Soil

Soil N and P levels in the VTAs varied year to year (Figure 3-8). Most years had a reduction in inorganic N and inorganic P from the inlet to the outlet. In Bell County, inorganic N levels in the soil did build up at times, but crop removal and leaching/runoff removed N from the VTA (Fig. 3). In contrast, inorganic P levels in soil tended to be high near the inlet but were often substantially lower near the outlet (Fig. 4). Inorganic N levels in the Brazos County VTA exhibited much more variability with periods of high concentrations and periods with much lower concentrations (Fig. 5). Inorganic P tended to show a more insistent increase throughout the VTA, especially concrete floors and washing frequency were altered after May 2015 (Fig. 6). Soil inorganic N and P levels were typically low in the Robertson County VTA (Fig. 7, 8). We expected lower concentrations at Robertson County due to pre-treatment of solids as well as the sandy soils which drain quickly and allow rapid mobility of nutrients. In contrast, the clay soils at the Bell and Brazos county VTAs reduce the mobility of soil nutrients.

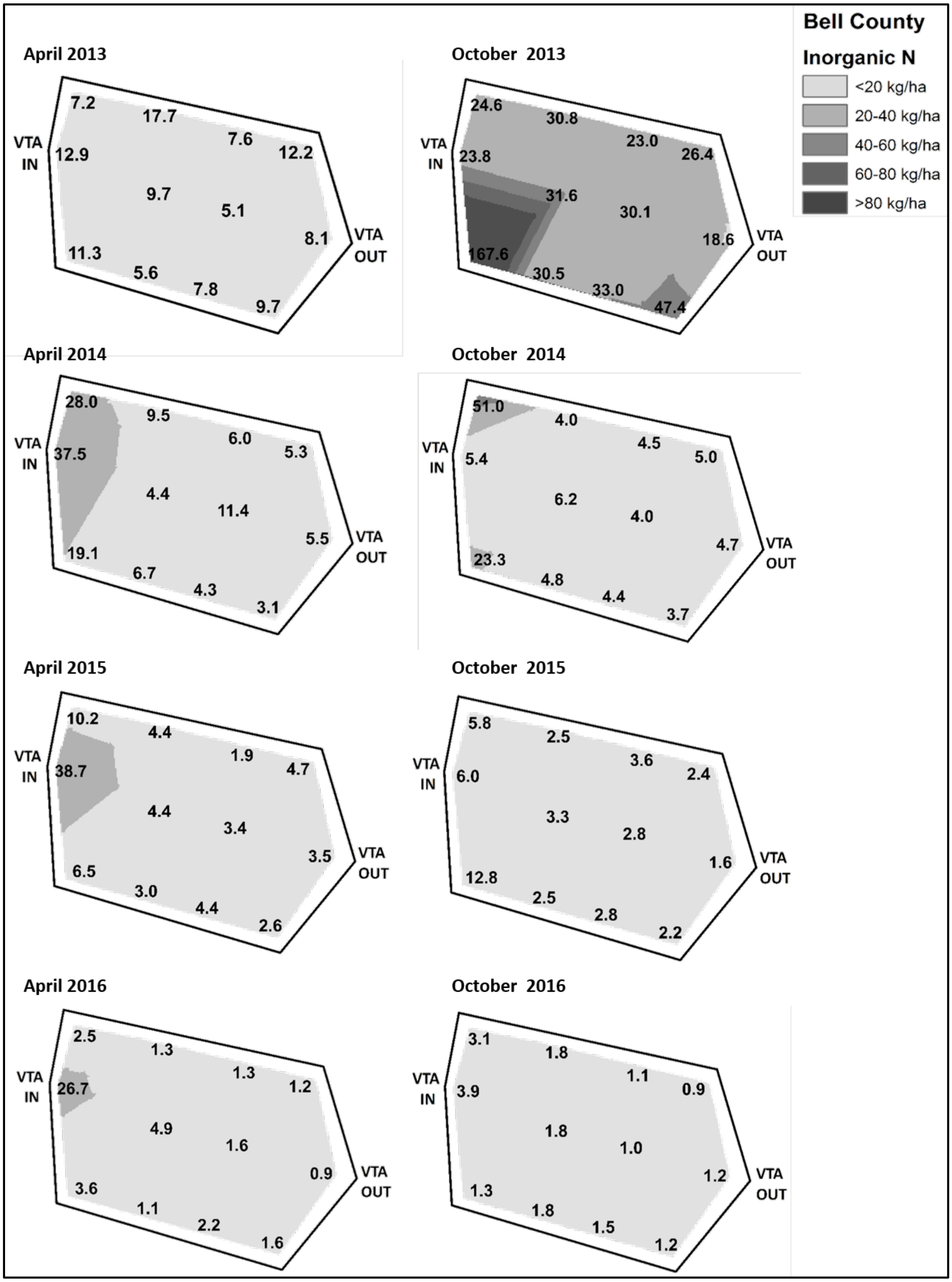

Figure 3. Inorganic N accumulation and movement in soil at the Bell County VTA site.

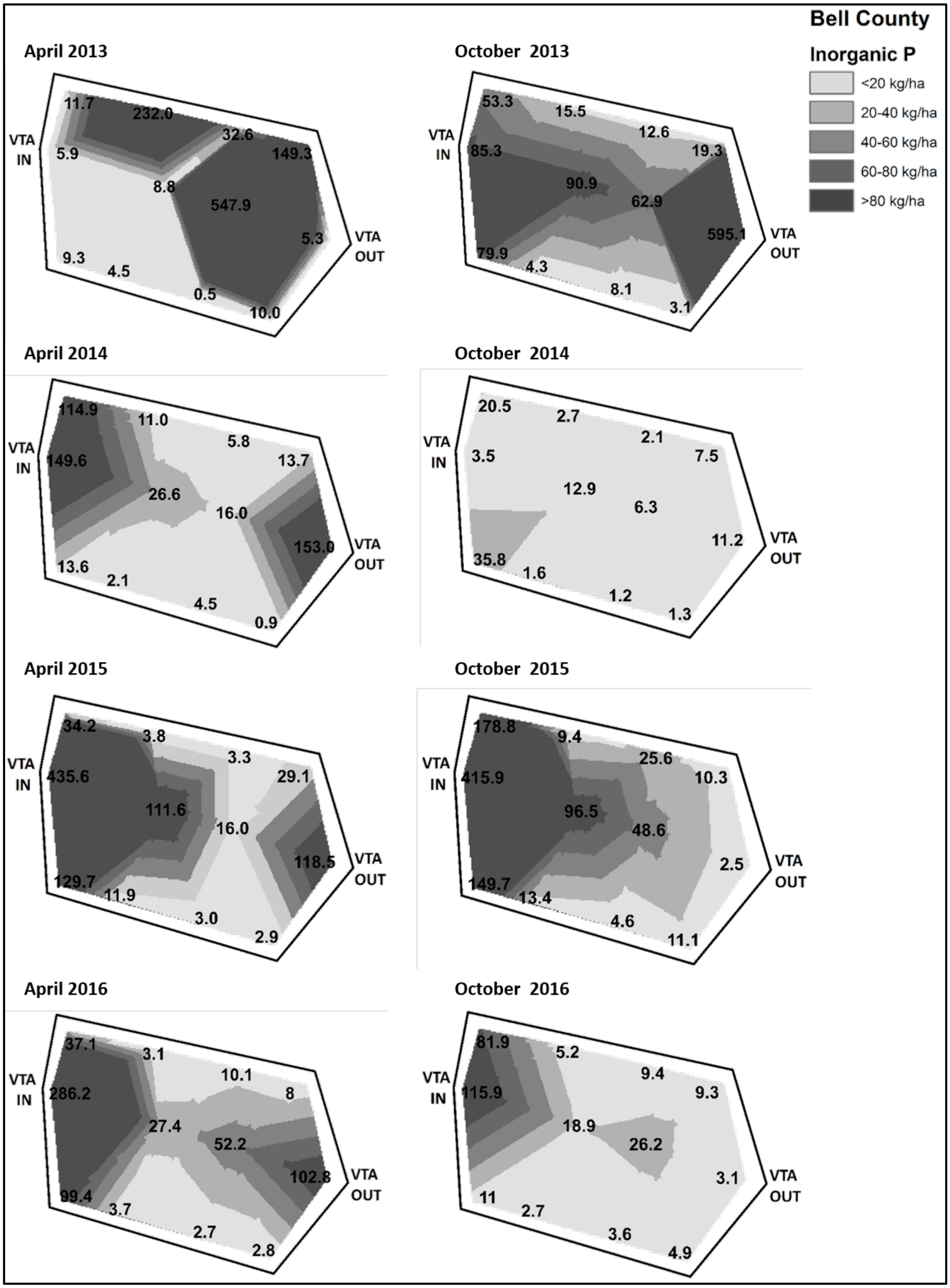

Figure 4. **Inorganic P accumulation and movement in soil at the Bell County VTA site.**

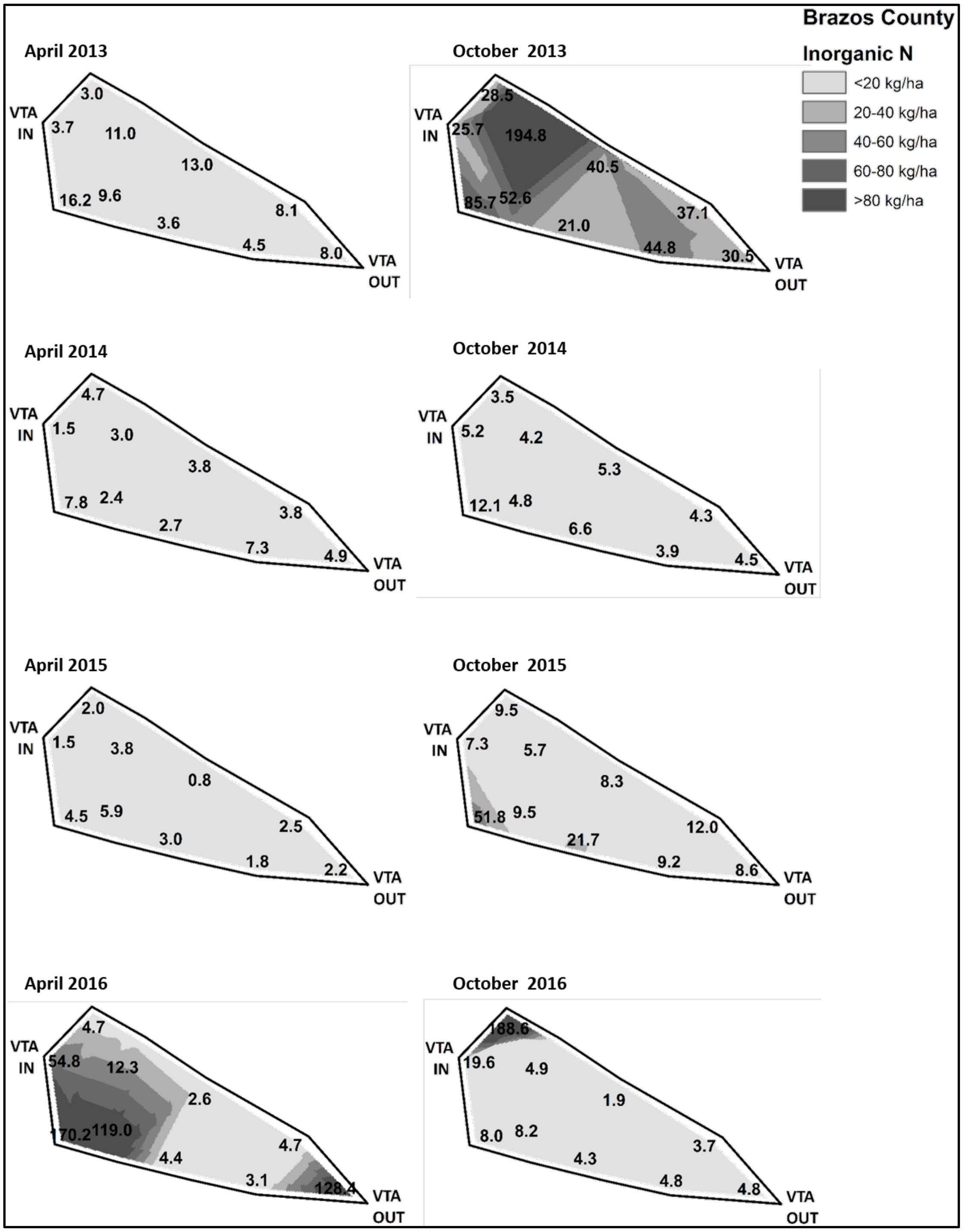

Figure 5. Inorganic N accumulation and movement in soil at the Brazos County VTA site.

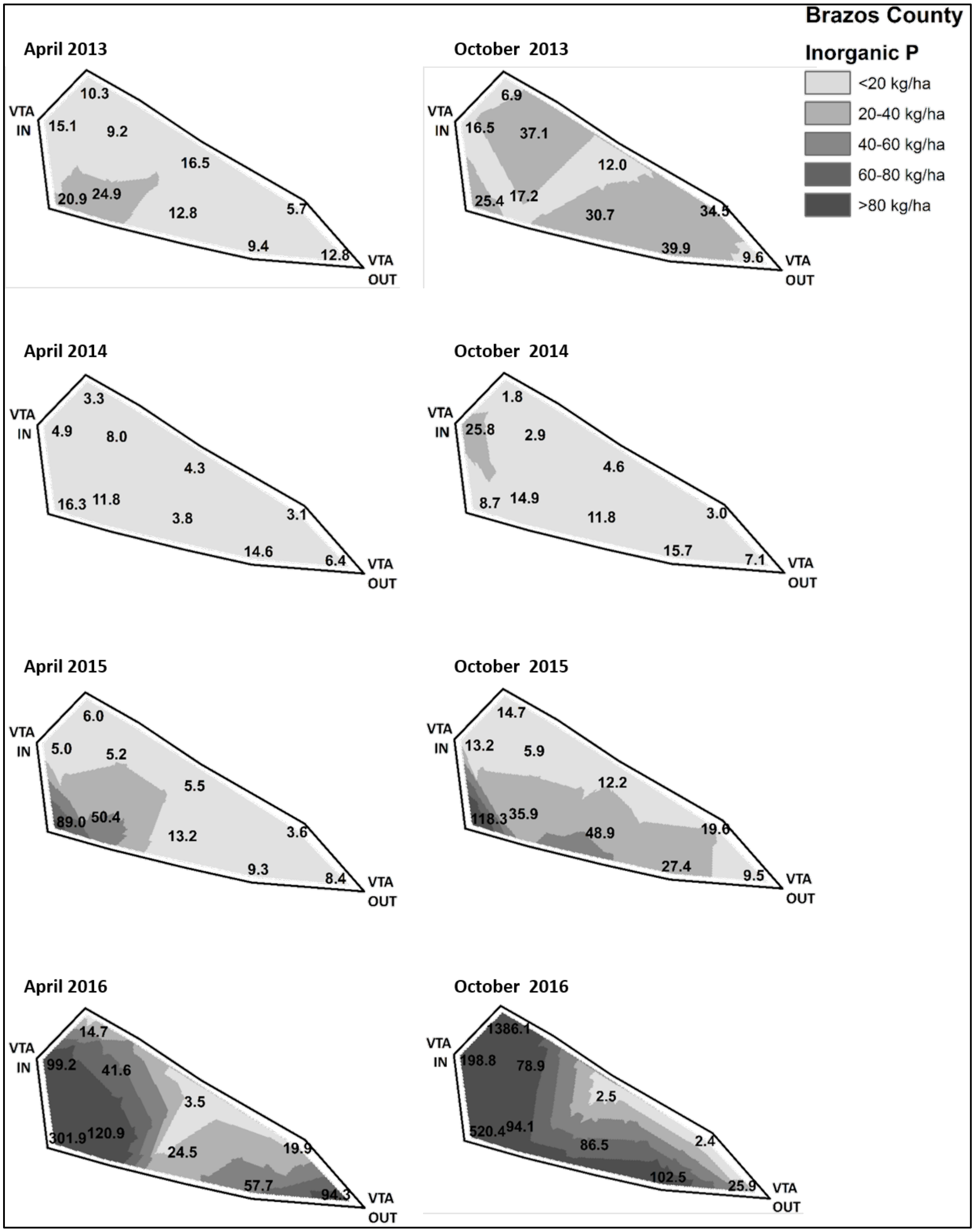

Figure 6. **Inorganic P accumulation and movement in soil at the Brazos County VTA site.**

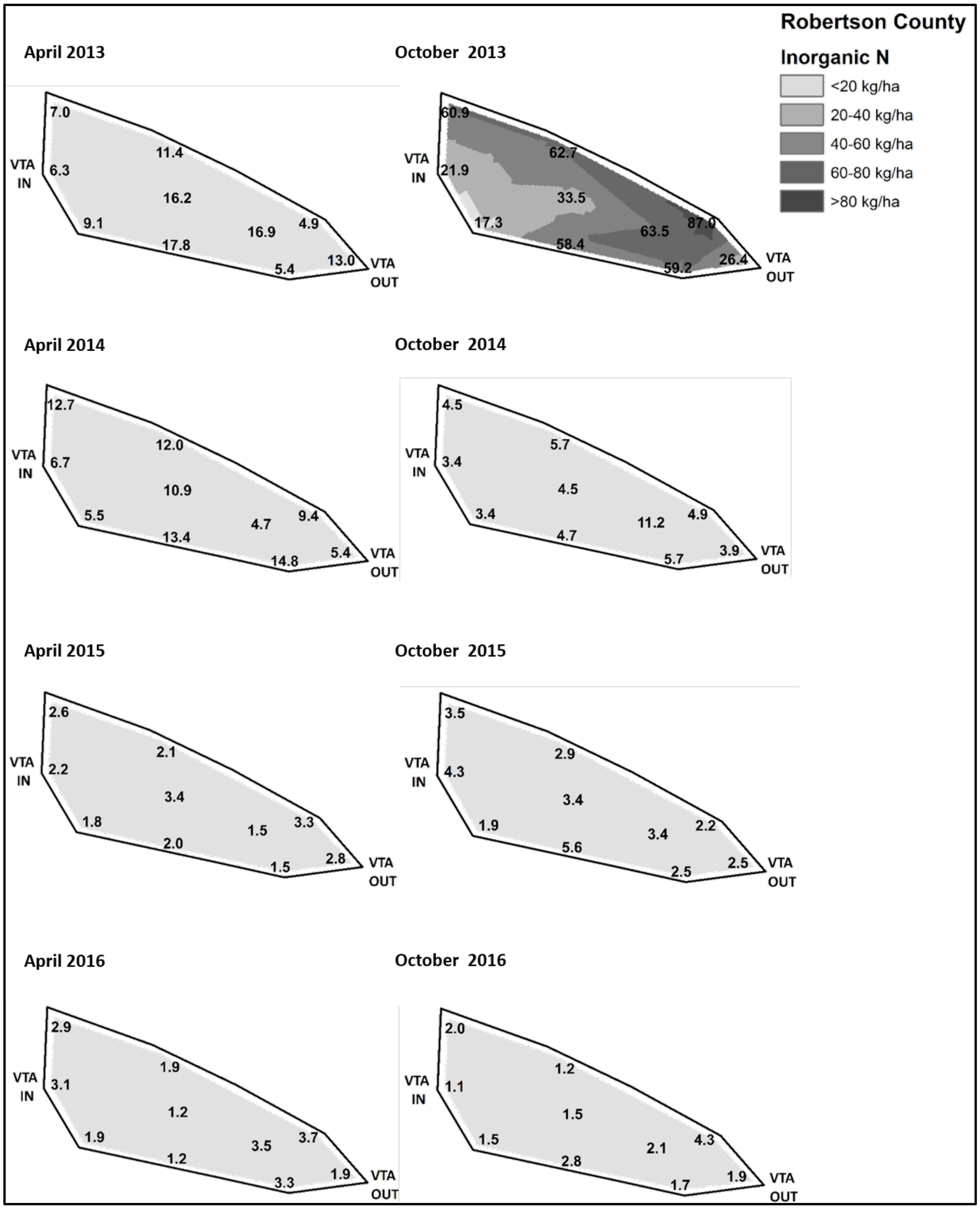

Figure 7. **Inorganic N accumulation and movement in soil at the Robertson County VTA site.**

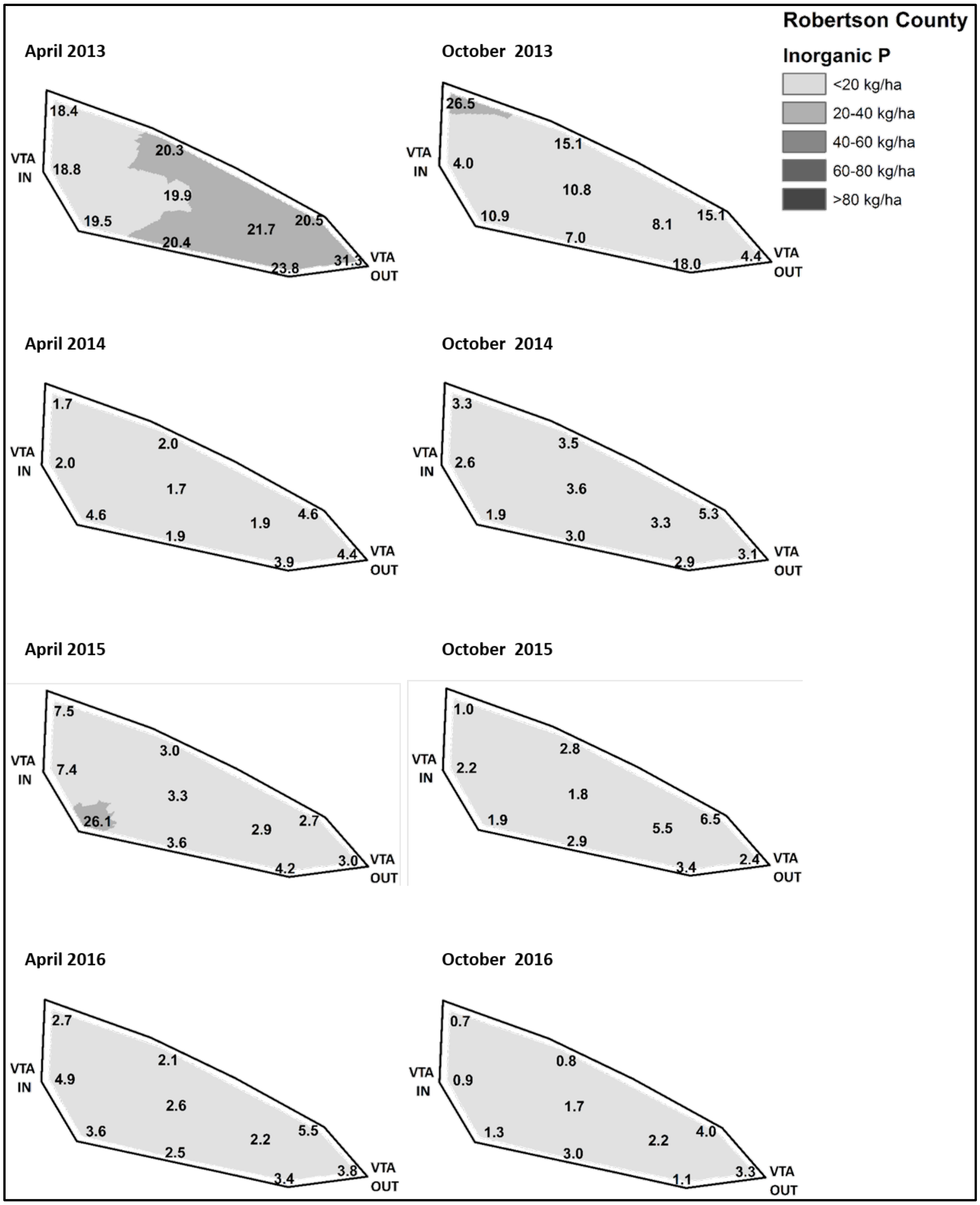

Figure 8. **Inorganic P accumulation and movement in soil at the Robertson County VTA site.**

Result dissemination

To disseminate results of the VTA evaluation, a journal article describing the effects of VTAs on nutrient and bacteria runoff will be submitted in 2017. The fact sheet developed in 2016 summarizing VTAs and their effectiveness was updated to reflect all four years of data (Appendix A). This will be disseminated to pork producers and others (i.e. NRCS, Extension, and TSSWCB). Finally, a presentation (Appendix B) and poster (Appendix C) were also developed for delivery to the Texas Pork Producers Association and others (e.g., NRCS and TSSWCB). These final products will be provided to the NRCS State Office for final determination of needed changes to standards and specifications.

Conclusions

VTAs installed below small pork production facilities in Texas were able to effectively reduce nutrient and bacteria runoff; however, runoff concentrations and loads from the VTAs typically exceeded those of nearby control sites representing typical rural land use (not in agricultural production). Based on evaluation results, VTAs were found to be practical, environmentally-friendly waste management alternatives for reducing nutrient and bacteria loading from small pork production operations **if** proper consideration is given to design and management factors (e.g., solids management, perennial grass cover and subsequent haying and removal, and nutrient loads/VTA area).

Appendix A – 2017 Fact Sheet

VEGETATED TREATMENT AREAS

Reducing soil, nutrient, & bacteria runoff from small hog farms

Background

Vegetated Treatment Areas (or VTAs) are composed of perennial grasses used to improve runoff water quality associated with livestock, poultry, and other agricultural operations. 70-75% of swine operations nationwide are considered 'small' with less than 100 head. Producers need practical, low-cost waste management options to protect local water resources. VTAs are inexpensive alternatives compared to standard waste management systems (i.e. lagoons, etc.), and they help reduce soil, nutrient, and bacteria runoff from small operations with small acreage.

Small swine operations need an inexpensive alternative to standard waste management systems.

Designing & Installing Your VTA

- Establish permanent grass vegetation in the VTA downslope of the operation.
- Take advantage of seedbed preparation, starter fertilizer, and/or irrigation if needed for establishment.
- Select warm and cool season grasses adapted to the soils and climate that can withstand wetting or brief submerged conditions.

The VTA size will depend on upon the number of animals, rainfall, slope, soils, and vegetation selection. A berm may be helpful in limiting outside water from entering the VTA. In Central Texas, we have found that having 500-1500 ft^2 of VTA area with year round vegetation per adult hog can significantly reduce nutrient loss in runoff; however, removal of solids may be required to achieve water quality objectives when VTA area/hog is less than 750 ft^2. Technical assistance for the design of VTAs may be available from your local NRCS Field Office or local TSSWCB Regional Office.

Winter oats and winter wheat are efficient cool season plants for your VTA.

Managing Your VTA

- Do not use additional fertilizer; instead utilize nutrients from water runoff to the VTA in order to ensure vigorous plant growth.
- Harvest vegetation as appropriate to encourage dense growth and to remove nutrients that are contained in the plant tissue.
- Time hay cutting and removal to allow grasses to regrow to a sufficient height to effectively filter effluent late in the growing season.
- Reseed cool season grasses seasonally if necessary to ensure perennial living cover.
- Exclude all livestock, including grazing, from the VTA.
- Take annual soil samples and compare them to previous years to provide information on available nutrients and may be used to help determine if the nutrients are accumulating.

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VEGETATED TREATMENT AREAS

Reducing soil, nutrient, & bacteria runoff from small hog farms

Vegetated Treatment Areas (or VTAs) are composed of perennial grasses used for the treatment of runoff.

Benefits

- Improves surface water quality[1]
    - Reduced total N concentration 47-76% (average = 65%)
    - Reduced total P concentration 64-88% (average = 73%)
    - Reduced *E. coli* concentration 34-93% (average = 72%)
    - Reduced N load 34-81% (average = 67%)
    - Reduced P load 32-91% (average = 69%)
    - Reduced *E. coli* load 29-94% (average = 72%)
- Provides and maintains food, cover, and shelter for wildlife

Estimated Installation Costs

- $275-$310/acre depending on seed mix
- Additional costs for initial dirt work may be required as well

Available Financial Assistance Programs

- Environmental Quality Incentives Program (EQIP): http://www.nrcs.usda.gov/wps/portal/nrcs/site/tx/home
- Conservation Stewardship Program (CSP): http://www.nrcs.usda.gov/wps/portal/nrcs/site/tx/home
- Water Quality Management Plans (WQMP): http://www.tsswcb.texas.gov/en/swcds

For Technical Assistance, Contact:

- Local Natural Resources Conservation Service: http://www.nrcs.usda.gov/wps/portal/nrcs/site/tx/home
- Local Soil and Water Conservation District: http://www.tsswcb.texas.gov/en/swcds
- Local County Extension Agent: http://counties.agrilife.org/

Helpful Links & References

- Higgs, K.D., R.D. Harmel, K. Wagner, P.K. Smith, R.L. Haney, D.R. Smith, and R. Pampell. 2015. Vegetated treatment area effectiveness at reducing nutrient runoff from small swine operations in central Texas. *Applied Engineering in Agriculture* 31(4):621-629.
- Texas NRCS Conservation Practice Standard design details: https://efotg.sc.egov.usda.gov/references/public/TX/VegetatedTreatmentAreaCode635.pdf.

[1] Wagner, K., R. Pampell, and R.D. Harmel. 2017. Improving runoff water quality from small pork production facilities using vegetative treatment areas. College Station (TX): Texas Water Resources Institute. TR-501.

Appendix B – Presentation

Vegetated Treatment Area Effectiveness in Reducing Nutrient Runoff from Small Swine Operations in Central Texas

R. Daren Harmel

Background

- Small swine operations
  - 70-75% of operations nationwide are "small" (1-99 head)
  - Need practical, low-cost waste management option to protect water quality and ***avoid potential regulation and litigation***
    - Texas Pork Producers Association, Texas State Soil and Water Conservation Board shared this concern and need for research.

Vegetated Treatment Areas

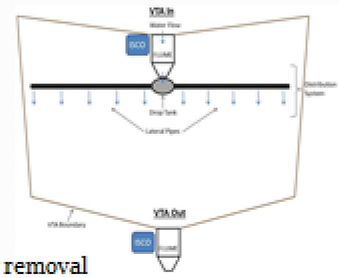
- Vegetative treatment area (VTA) - vegetative area composed of perennial grass or forages used for the treatment of runoff from an open lot production system or other process waters (USDA-NRCS, 2006)
  - Typically part of a vegetated treatment system (VTS) including solids pre-treatment
  - Previous research mostly on cattle AFOs
  - VTSs have been found to:
    - Reduce total N and P concentrations by up to 80%
    - Reduce nutrient loads by 60-99%
    - Retain 85-100% of runoff

Research Objectives

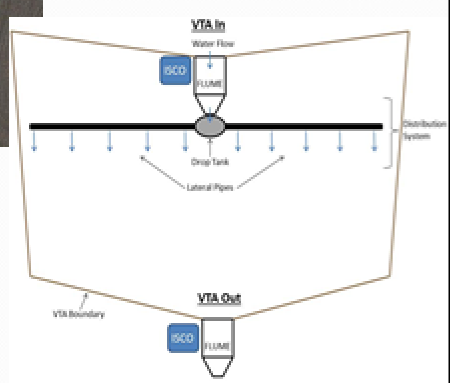
- Can sufficiently sized, standalone VTA effectively treat runoff from small swine AFO?
- Research objectives
  - Evaluate the efficiency of a standalone VTA at removing N and P from swine facility runoff
  - Compare the VTA runoff to local ambient water quality

VTA Design and Setup

- **Key components (Koelsch et al., 2006).**
  - Pre-treatment
  - Sheet flow
  - Siting
  - Sizing
    - Source/Treatment Area
  - Discharge control

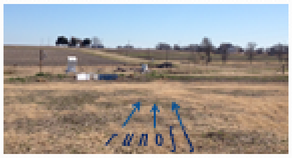


- **Established three VTAs with:**
  - Perennial vegetative cover and hay removal
  - No additional fertilizer
  - Each location also had rural/residential area as control



Bell County

Source Area (ha): 0.15
VTA area (ha): 0.34
Control area (ha): 0.48
VTA area/Source area ratio: 2.3
Avg. # animals: 50
Slope: 2.0%
Vegetation: Coastal Bermuda/Oats



VTA Out

VTA In



Bell, above VTA In

Brazos County

Source Area (ha): 0.03
VTA area (ha): 0.10
Control area (ha): 1.21
VTA area/Source area ratio: 3.3
Avg. # animals: 30
Slope: 2.5%
Vegetation: Native pasture/Oats


VTA In and pens


VTA In and VTA Out


Control

Robertson County

Source Area (ha): 0.03
VTA area (ha): 0.11
Control area (ha): 0.16
VTA area/Source area ratio: 3.7
Avg. # animals: 8
Slope: 1.6%
Vegetation: Native pasture/Oats

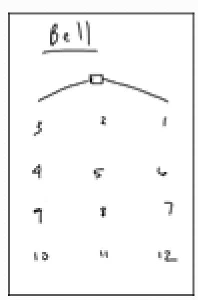

VTA In


VTA In, VTA Out, and Control


VTA Out

Data Collection

- Water quality monitoring January 2013 – December 2016
  - Automated, flow-weighted, composite sampling
    - Event mean concentration (EMC)
    - Load = EMC x flow volume
  - Analyzed for:
    - NO_3-N, NH_4-N, PO_4-P, TP, TN, *E. coli*
- Soil sampled in April, October each year
  - 0-15 cm and 15-30 cm depths
  - Analyzed for:
    - Inorganic P and N



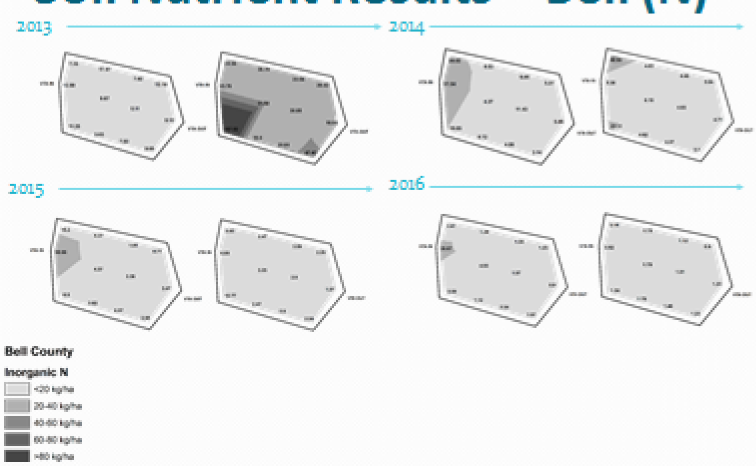
Water Quality Results

- **VTAs reduced:**
  - runoff volume by 0-30%
  - nutrient concentrations by 0-88%
  - nutrient loads by 32-92%

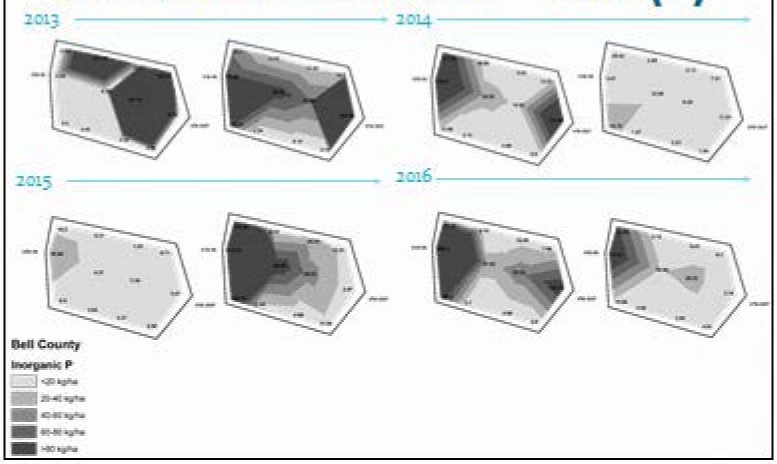
Summary of *E. coli* (cfu/100 mL) measurements

Site	Mean *E. coli* (VTA in)	Mean *E. coli* (VTA out)	Mean *E. coli* (Control)	% reduction
Bell	1.10E+07	7.69E+05	3.55E+04	93%
Brazos	3.83E+07	4.28E+06	1.95E+04	89%
Robertson	6.74E+04	4.44E+04	1.22E+04	34%

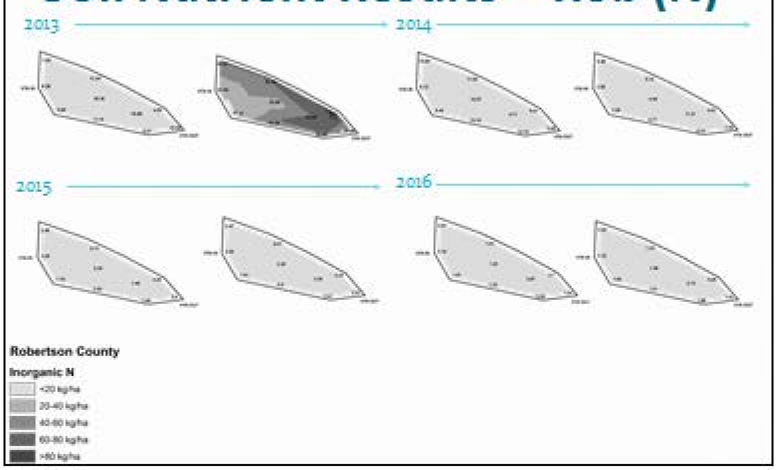
Soil Nutrient Results – Bell (N)



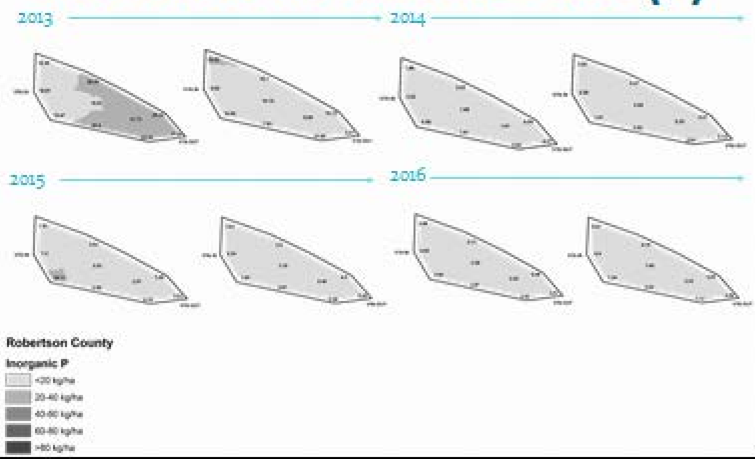
Soil Nutrient Results – Bell (P)



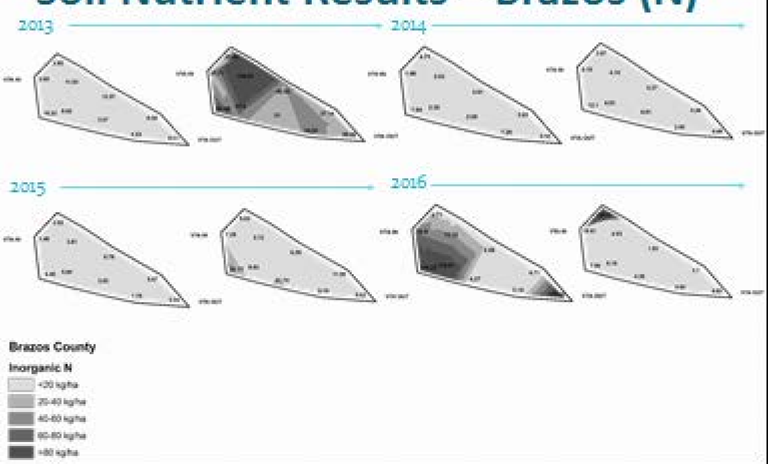
Soil Nutrient Results – Rob (N)



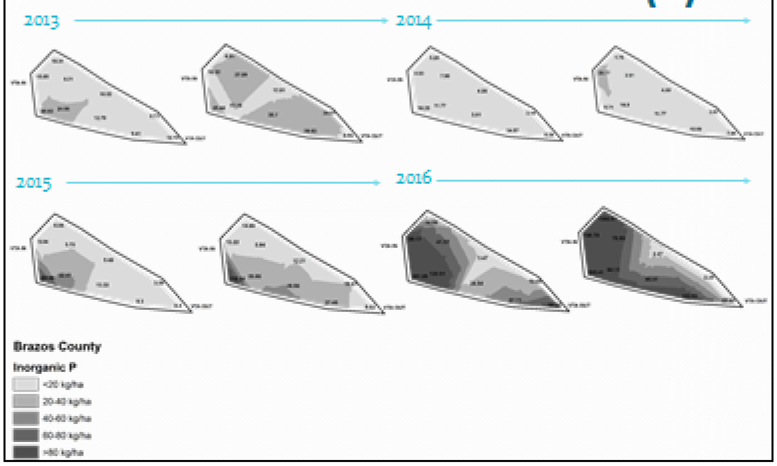
Soil Nutrient Results – Rob (P)



Soil Nutrient Results – Brazos (N)



Soil Nutrient Results – Brazos (P)



Summary of Results

- The Bell Country VTA reduced nutrient concentrations 51-88%, nutrient loads 73-92%, E. coli concentrations 93%, and E. coli loads 94%; however, actual treatment efficiencies were likely higher
- The Brazos Country VTA reduced nutrient concentrations 68-73% (except for NO3-N which increased), nutrient loads 83-89%, E. coli concentrations 89%, and E. coli loads 93%; however, increased animal numbers and management changes over time decreased VTA effectiveness.
- The Robertson County VTA reduced nutrient concentrations 46-85%, nutrient loads 32-69%, E. coli concentrations 34%, and E. coli loads 29%. This VTA utilized an intense solids management strategy, which reduced nutrient and E. coli runoff to near ambient levels.
- Although VTAs typically reduced runoff volume, flow from the VTAs occasionally exceeded flow entering the VTAs in extreme wet periods.

Conclusions

- Three years of data showed:
  - most years had a reduction in inorganic N and inorganic P from the VTA inlet to the VTA outlet
  - little/no buildup of soil N, P in sandier soils
- These results highlight the importance of:
  - solids management
  - perennial grass maintenance and subsequent haying/removal
  - consideration of nutrient loads relative to VTA area
- Increased treatment area ***potentially*** makes up for lack of solids pretreatment.
- VTA is ***potentially*** effective waste management option for small swine facilities.

THANK YOU

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Appendix C – Poster

Vegetated Treatment Area Effectiveness at Reducing Nutrient and *E. coli* Runoff from Small Swine Operations in Central Texas

Daren Harmel[1]; Kori Higgs[(formerly1,4)]; Rehanon Pampell[2]; Kevin Wagner[3]; Patricia Smith[4]; Rick Haney[1]; Terry Gentry[4]; Doug Smith[1]

[1]USDA-ARS, Temple, TX; [2]Texas A&M AgriLife Research, Blackland Research Center, Temple, TX; [3]Texas Water Resources Institute, Texas A&M Univ., College Station, TX; [4]Texas A&M Univ., College Station, TX

Background

- Runoff from animal feedlots is a contributor of bacteria and nutrients to surface water bodies.[1] Animal waste management, therefore, is a key component of protecting water quality.
- Well designed and maintained vegetative treatment systems, usually consisting of solids settling pretreatment in addition to the VTA, can be an effective means of reducing the pollutant loads leaving animal feeding operations (AFOs).[2]
- The purpose of this study is to determine the effectiveness of stand-alone VTAs in treating runoff from small swine operations.

Project Scope

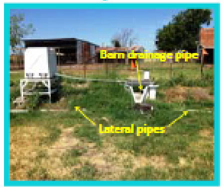
- Three small swine operations in Central Texas were chosen based on site layout and project feasibility.
- VTAs were hydrologically isolated, and runoff quantity and quality were monitored at the inlet and outlet.
- At each operation, runoff from a nearby control site was monitored to compare VTA runoff with ambient water quality.

References

1. USEPA. 2002. 2000 National Water Quality Inventory. EPA-841-R-02-001. Washington, D.C.: EPA, Office of Water.
2. Koelsch, R.K., J.C. Lorimor, &K.R. Mankin. 2006. Vegetative treatment systems for management of open lot runoff: review of literature. *Appl. Eng. Agric.* 22(1): 141-153.
3. Higgs K.D., R.D. Harmel, K. Wagner, P.K. Smith, R.L. Haney, D.R. Smith, & R. Pampell. 2015. Vegetated treatment area effectiveness at reducing nutrient runoff from small swine operations in central Texas. *Appl. Eng. Agric.* 31(4): 621-629.

VTA Site Information

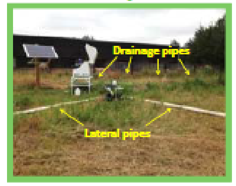
Bell County



Runoff from open pens and wash water from barns flows through 1.5' flume. Flow is distributed across VTA width via 4" gated lateral pipes.

Control site is rural area that drains through grassed area into 2' flume.

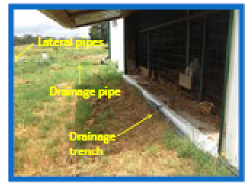
Brazos County



A series of 4" pipes drains hog pens into area above 1' flume. Flow is then distributed across VTA via gated lateral pipes.

Rural residential control area drains through 12" culvert with area/velocity meter.

Robertson County



Barn wash water carried via drainage trench and 4"pipe to 1' flume and distributed across VTA via gated lateral pipes.

Non-grazed native pasture control site flows through 1.5' flume.

- All sites were equipped with ISCO Avalanche refrigerated samplers.
- Discharge monitored by bubbler flow meter (except the above culvert site).
- For each rain event producing more than 1.32 mm of runoff, flow-weighted composite sample taken, analyzed for NO_3-N, NH_4-N, PO_4-P, TN, TP, *E. coli*.

Site County)	Source area (ha)	VTA area (ha)	Control area (ha)	VTA/Source ratio	Animals (#)	Vegetation in VTA
Bell	0.15	0.34	0.48	2.3	30-100	Coastal bermuda
Brazos	0.04	0.16	1.2	4.0	10-30	Native pasture
Robertson	0.03	0.11	0.16	3.7	5-20	Native pasture

Results (Jan 2013 - Mar 2016)

- The Bell Country VTA reduced nutrient concentrations 58-91%, nutrient loads 74-92%, *E. coli* concentrations 88%, and *E. coli* loads 88%; however, actual treatment efficiencies were likely higher.
- The Brazos Country VTA reduced nutrient concentrations 70-84% (except for NO_3-N which increased 7%), nutrient loads 28-92%, *E. coli* concentrations 92%, and *E. coli* loads 95%; however, increased animal numbers and management changes over time decreased VTA effectiveness.
- The Robertson County VTA reduced nutrient concentrations 58-88%, nutrient loads 23-81%, *E. coli* concentrations 33%, and *E. coli* loads 30%. This VTA utilized an intense solids management strategy, which reduced nutrient and *E. coli* runoff to near ambient levels.
- Although VTAs typically reduced runoff volume, flow from the VTAs occasionally exceeded flow entering the VTAs in extreme wet periods (contrast with previous results[3]).

Concluding Remarks

- Stand-alone VTA needs to be practical, cost-efficient, and low maintenance for use by small swine producers.
- Size of VTA field must be sufficient to treat total waste stream if solids pretreatment is not utilized.
- For maximum effectiveness, runoff must be distributed across entire VTA width to ensure sheet flow.
- A good stand of "nutrient hungry" vegetation is also critical for optimal VTA performance.

Acknowledgements:
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