Surface Water Impacts of a Swine CAFO with a Capped Lagoon in Eastern North Carolina

[1,2,3] Richardson, L., Moysey, S., Iverson, G., O'Driscoll, M., Humphrey, C., Hoben, J., Vaughan, B., Nolan, M., Discepolo, A., Willis, J.D.
[1]Department of Geology, East Carolina University
[3] Water Resources Center, East Carolina University
[3]Cape Fear Public Utility Authority, Current Laboratory Technician



ABSTRACT

Concentrated animal feeding operations (CAFOs) traditionally store waste in open lagoons and periodically apply the liquids to nearby sprayfields. Capping lagoons with an impermeable cover has been proposed to reduce environmental impacts by inhibiting the release of odors and accidental overflows, but there is a lack of data evaluating how capping a lagoon affects surface water quality. This study investigates nitrogen exports to a stream adjacent to a CAFO with a capped lagoon. Total dissolved nitrogen (TDN) and other constituents were measured in samples collected monthly between October 2019 to January 2021 at locations upstream and downstream of the study area. The median TDN concentration downstream of the site (6.7 mg L^{-1}) was 13 times greater than upstream (0.5 mg L^{-1}) and the downstream median TDN mass flux (32.1 kg ha^{1} yr^{-1}) was 12 times greater than upstream (2.6 kg ha^{1} yr^{-1}). In-situ, high frequency monitoring performed over 2 weeks showed elevated concentration and range of TDN downstream of the site (1.9-137.9 mg L^{-1}) compared to upstream (0.1-4.8 mg L^{-1}), which was attributed to spray events that occurred 6 days after deployment. A groundwater seep initiating near the lagoons and discharging to the stream accounted for nearly 23% of the annual TDN exports from the study area. These data suggest that despite capping of the lagoon, spray practices likely maintain the farm as a source of nitrogen to the watershed. Nitrogen amelioration targeting subsurface and surface discharge from the CAFO, such as constructed wetland or bioreactor, may reduce net nitrogen exports.

INTRODUCTION

Why do we care?

- Increased nitrogen loading is a major issue in coastal areas and have been correlated with eutrophication, algal blooms, and fish kills.
- Agriculture has been cited as the largest nonpoint source of nitrogen to coastal waters in NC (US EPA, 2017).

The goal of this project is to gain a better understanding of the nitrogen contributions to surface water from a confined animal feeding operation (CAFO) with a capped lagoon.

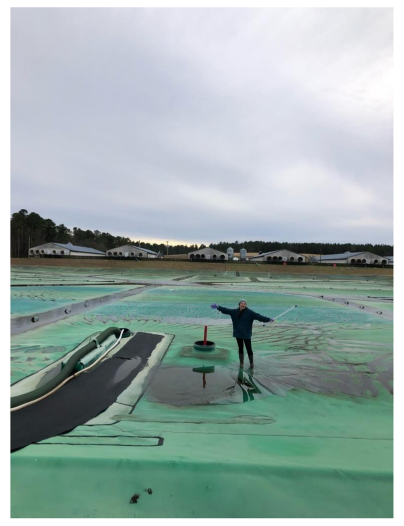

Figure 1. One of two capped waste lagoons.

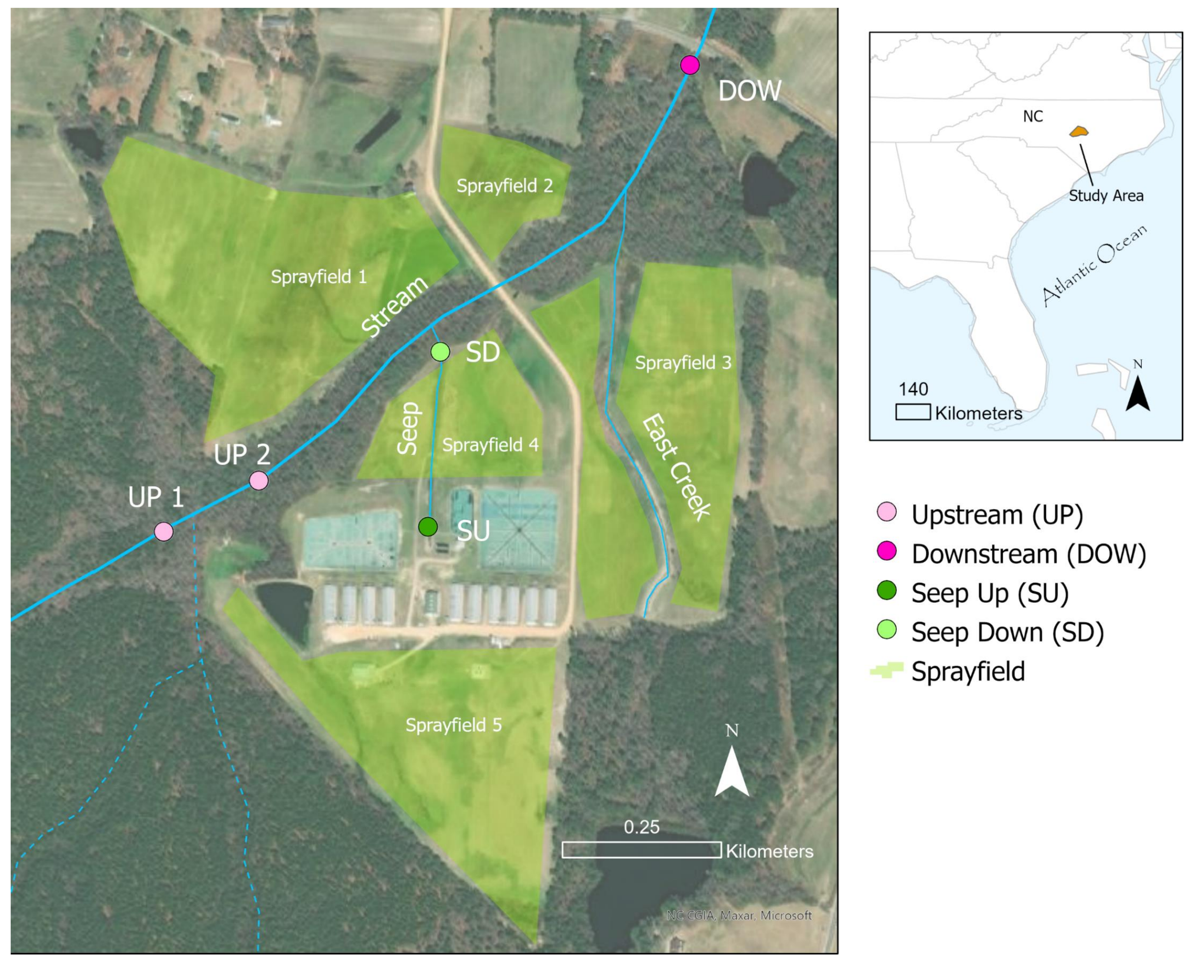

Figure 2. Study area map showing swine CAFO location in Harnett County, NC and sampling locations. Adjacent stream drains to Cape Fear River

METHODS

- Monthly sampling events were conducted December 2019-January 2021.
- Water samples collected were analyzed for total dissolved nitrogen (TDN), nitrate, and ammonium in the Environmental Research lab at ECU.
- TDN exports were calculated by multiplying the TDN concentration and discharge calculated. Exports were normalized by watershed area if area was known.
- High frequency data was collected with Eureka Manta Probe that measured nitrate and ammonia every 15 minutes from 8/14/21-8/31/21.
- Physical and chemical characteristics of surface water locations were measured with the Hanna Instruments 9829 (specific conductivity, temperature, pH, oxidation reduction potential, dissolved oxygen, and turbidity)
- Kruskal Wallis with a Wilcoxon pairwise was used to determine significant differences.

RESULTS

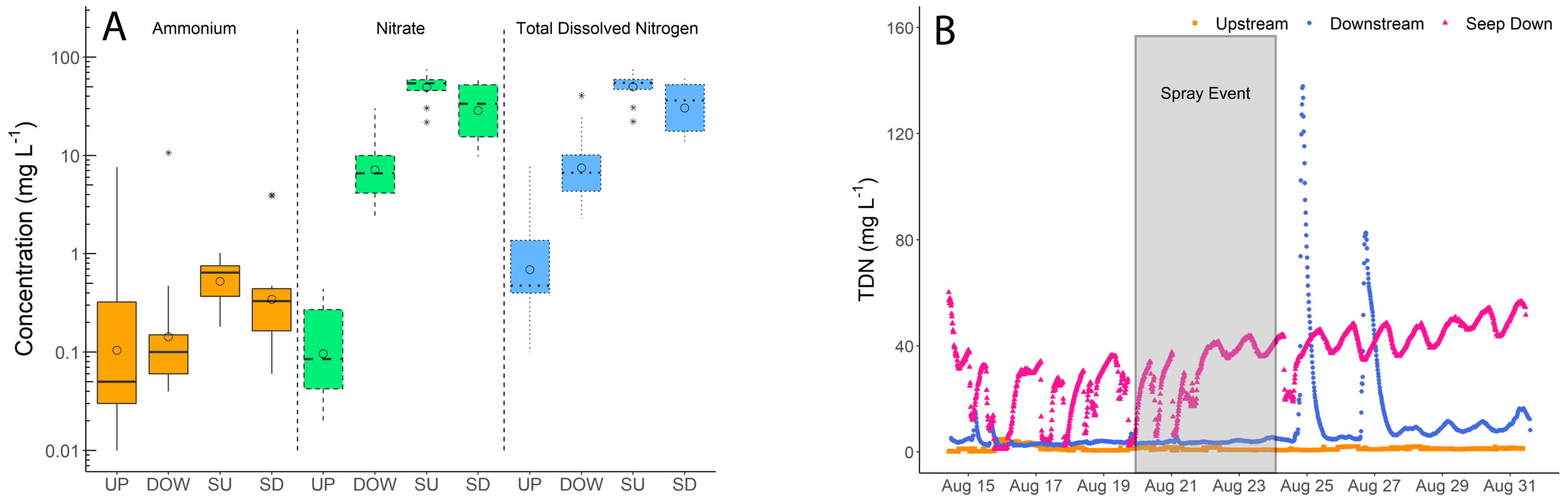

Figure 3. A) Nitrogen speciation concentrations for each surface water location. **B)** High frequency TDN data before and during a spray event.

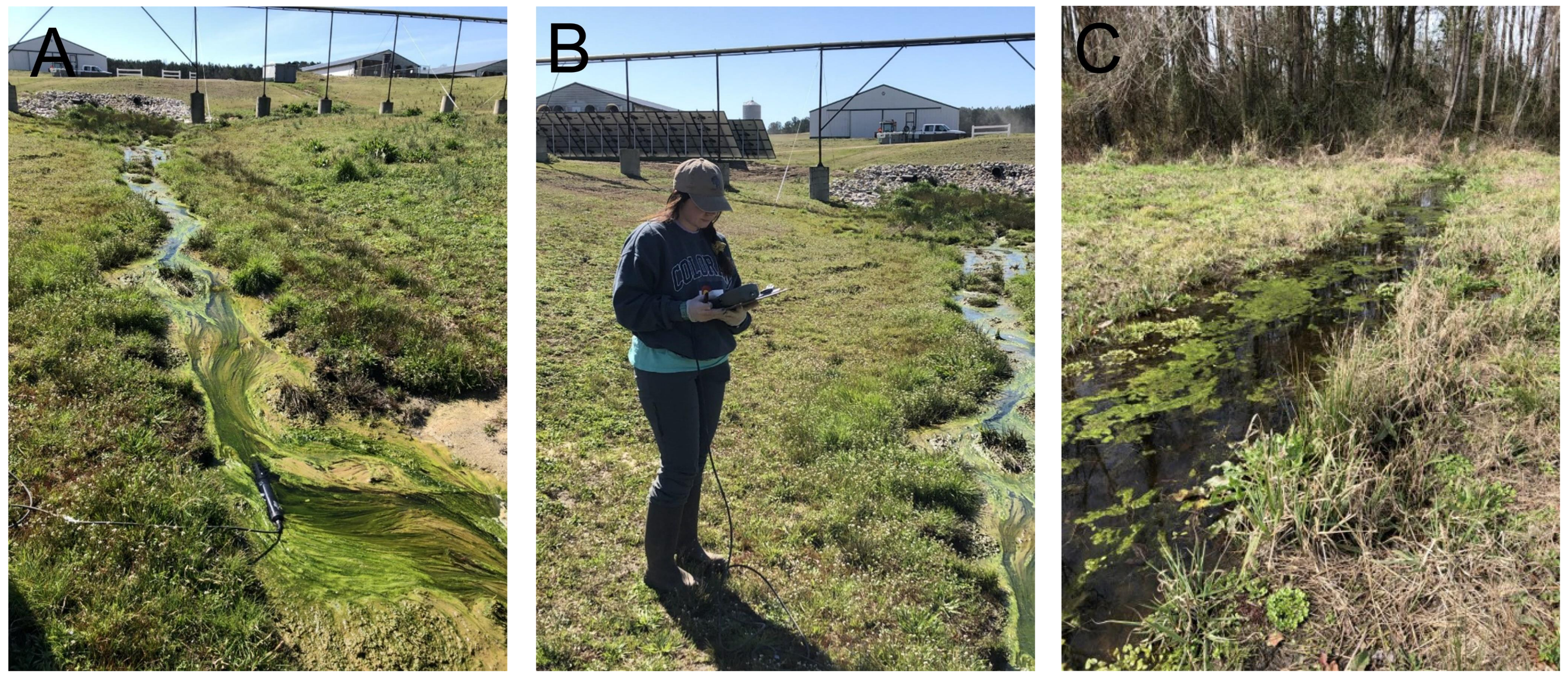

Figure 4. SU **(A and B)** and SD **(C)** that runs through the farm and discharges into the adjacent stream.

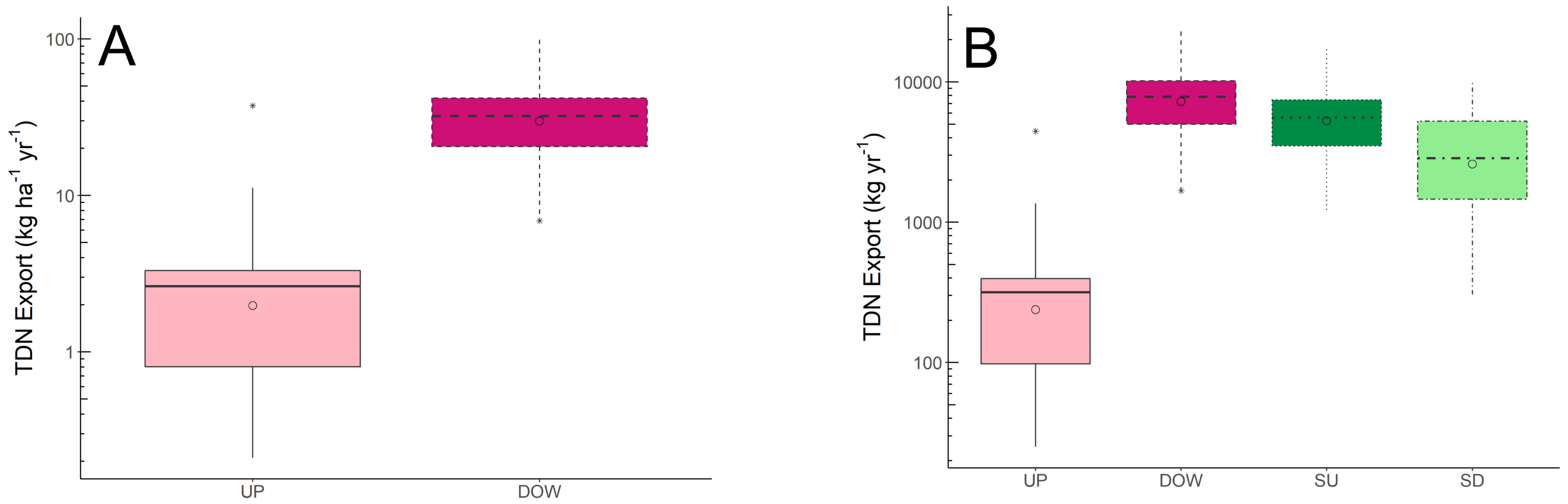

Figure 5. Area-normalized TDN exports **(A)** and TDN exports **(B)** from the stream and seep locations

Table 1. Physical and chemical parameters measured at the farm through monthly sample events. Median (range) of pH, temperature, specific conductivity (SC), dissolved oxygen (DO), turbidity, oxidation reduction potential (ORP), discharge (Q), and watershed area (WA).

Site	pH	Temp. (°C)	SC (µS/cm)	DO (mg/L)	Turb. (FNU)	ORP (mV)	Q (L/sec)	WA (ha)
UP	3.6 (2.78-5.05)	11.4 (8.5-23.4)	29 (0-48)	7.70 (4.98-11.10)	9.3 (0-30.5)	276.65 (122-496)	1011 (93-2948)	0.47
DOW	5.2 (4.65-6.59)	13.3 (9.2-24.7)	144 (86-805)	8.67 (5.70-12.5)	12.2 (4.6-28.5)	220.6 (101-614)	2141 (136-8495)	0.94
SU	4.17 (3.77-5.37)	16.6 (9.5-26.6)	720.5 (356-985)	8.60 (5.19-10.95)	0.9 (0-15)	229.3 (119-447.5)	238 (68-544)	NA
SD	4.67 (4.04-7.57)	17.4 (8.2-28.9)	658.5 (191-793)	9.28 (4.83-13.15)	4.70 (0-32.8)	229 (73.8-439)	153 (34-1019)	NA

DISCUSSION

Nitrogen Concentrations (Figure 3A and 3B)

Monthly TDN Concentrations

- TDN was 93%-99% nitrate in DOW, SU, and SD.
- Median concentration of TDN at DOW (6.7 mg/L) location was 13 times greater than UP (0.5 mg/L), and this difference was statistically significant (p= <0.01).
- TDN concentrations were elevated in SU (Figure 4A and 4B) and SD (Figure 4C) with median values of 54.77 and 36.38 mg/L, respectively.
- TDN median concentrations in the stream were similar to other studies where TN ranged from 3.6-38.5 mg/L. However, SU and SD (Figure 4) were elevated compared to other studies (Harden, 2015 and Stone et al., 1995)
- DOW TDN concentrations exceeded UP TDN concentrations 92% of the time, indicating the CAFO may degrade downstream water quality.

High Frequency Concentration Data

- TDN spikes of 137.9 mg/L and 82.6 mg/L were observed in DOW after the spray event.
- Median TDN increased from 25.3 mg/L to 41.9 mg/L in SD and 3.4 mg/L to 6.2 mg/L in the DOW while UP remained stable and did not show a response
- Responses in DOW and SD indicate spray events may cause rapid changes in TDN for several days following a spray event.

Nitrogen Exports (Figure 5A and 5B)

- Median TDN exports in the DOW (32.1 kg/yr/ha) were 12 times higher than UP (2.6 kg/yr/ha) and were statistically different (p=<0.01).
- Increased TDN exports DOW indicate the farm as a possible source of TDN loading to the stream.
- SD accounted for about 23% of annual TDN exports

Physical and Chemical Parameters (Table 1)

- Median SC levels were greater in DOW (144 µS/cm) compared to the UP (29 µS/cm) and were statistically different (p=<0.01).
- Elevated SC levels were found in the seep with median concentrations of 720 µS/cm and 685 (µS/cm) in SU and SD, respectively.
- SC was significantly different between all locations except for SU and SD (p=0.5).
- Discharge was increased DOW (2141 L/sec) relative to the UP (1011 L/sec) indicating inputs to the stream. These inputs are likely from the seep that intersects the stream and possibly groundwater.
- The median temperature in the stream (11.4 °C and 13.3 °C in UP and DOW, respectively) differ from the seep (16.6 °C and 17.4 °C in SU and SD, respectively) likely due to less tree cover over the seep.

CONCLUSIONS

Results suggested that the studied CAFO contained elevated nitrogen concentrations and masses in surface waters downgradient from spray fields.

Major Findings

- Concentrations of TDN downstream if the farm were 13 times greater than upstream.
- Area-normalized mass exports of TDN downstream of the farm were 12 itmes greater than upstream.
- Nitrogen attenuation (34%) was observed in the seep; however, it was likely a source of nitrogen to the stream.
- This study suggests that CAFOs may be a substantial source of nitrogen to receiving waters and the Cape Fear River Basin has CAFOs and/or land application sites that may be contributing elevated nutrients. Therefore, future work should assess the efficiency of alternative management practices (e.g., riparian buffers, denitrifying bioreactors, wetlands, etc.) installed in agricultural settings. These statistically significant findings may help nutrient management goals, especially in watersheds with numerous CAFOs and/or land application sites.

REFERENCES AND ACKNOWLEDGEMENTS

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