# Water Quality of Episodic Flow through Isolated Wetlands Embedded in a Long Leaf Pine / Wiregrass Ecosystem

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**Abstract.** Isolated, depressional wetlands are common on the karstic Dougherty Plain in Southwest Georgia, where dissolution of the underlying limestone has resulted in a landscape that is largely devoid of headwater streams. Stormwater runoff collects in these wetlands, and occasionally spills into perennial streams following major storms. In this study, we report water-quality data collected during a three-week stormflow event (Feb 15 to Mar 9, 2014) which resulted from over 203 mm of precipitation between February 13th and March 5th, 2014. Data were collected along two flowpaths at the Joseph W. Jones Ecological Research Center, a private, 11,700-ha property on the Dougherty Plain of southwest Georgia. Sampling of both flowpaths began where upstream agricultural stormflow first enters the site. Inflows plus additional onsite contributions were then monitored as they migrate across the forested site through and between normally isolated wetlands. A suite of physical water quality parameters, nutrients and pathogen indicators (total coliform, *E. coli*) were monitored daily at 5 sites along the first flowpath, and at 2 sites along the second flowpath. A general trend of decreasing sediment, nutrient, and pathogen concentrations was observed as water moved between and through isolated wetlands. The mechanisms producing these results are unclear but are probably attributed to a combination of dilution from soil water/upland runoff and biogeochemical activity/sedimentation.

## INTRODUCTION

Episodic flows are somewhat common features in agricultural landscapes in response to storm events. These upland runoff generated features can connect the uplands they are derived from to perennial aquatic ecosystems, provide connections through time between isolated aquatic ecosystems embedded within the uplands they flow through, and connect isolated and perennial aquatic environments through time (Wilcox et al. 2011, McDonough et al. 2015). Isolated wetlands are common aquatic features embedded in uplands that can be connected through time by episodic flows to perennial streams. These commonly occurring but distinct landscape features provide important habitat for plants and animals, and help regulate and influence physicochemical composition of surface water systems.

While many wetlands are directly connected to other aquatic systems by continuous or frequent hydrologic flows, isolated depressional wetlands are often less obviously connected, because connections occur through animal ontologenetic shifts (Subalusky et al. 2009), hydrologic flow in the subsurface (Rains et al. 2006; Min et al. 2010) or through episodic stormwater flows (Wilcox et al. 2011), yet it is possible for isolated wetlands to have an important role in providing habitat and influencing water composition, both quantity and physicochemical components.

Despite the high number of wetlands in the southeastern United States, relatively little data has been published on water their quality. This is especially true regarding isolated wetlands set in agriculturally dominated parts of the southeast where many wetlands are impacted by or drained for agricultural production. The southeastern United States also has an abundance of water quality issues from urban sources as well as agricultural sources. The Dougherty Plain is a physiographic province in southwest Georgia that has an abundance of wetlands (Hicks et al. 1987; Martin et al. 2012) and is intensively developed for agriculture. Episodic flows generated in agricultural fields often flow through isolated wetlands on before emptying into perennial waters (Flint River, Ichawaynochaway Creek, Spring Creek, etc).

## METHODS

This study focuses on three wetlands located at the Joseph W. Jones Ecological Research Center that are centrally located on the Dougherty Plain in southwest Georgia (Fig. 1). This 6,690-$km^2$ region is characterized by karstic topography with deep sands and interbedded clay lenses over highly permeable, vuggy limestone bedrock. Our study wetlands are located within Ichawaynochaway Creek watershed and become connected to Ichawaynochaway Creek during episodic flow events. Two episodically flowing channels that originate off-site from agricultural runoff were the focus of this study. The larger, more extensive of these two flow paths is designated "Ichauway Drain" and flows through two wetlands, (Wetland 04 (W04) and Wetland 68 (W68). The smaller flow path is designated Parmalee Drain and flows through a single wetland, Wetland 27 (W27).

In the field daily triplicate samples were collected at each episodic flow sampling site for the first three weeks of flow. After the initial three weeks of sampling additional non-replicated samples were collected the two most downstream sites of Ichauway Drain when flow occurred there. At the time of sampling measurements of specific conductance and temperature using a Quanta device and turbidity using a Hatch turbidity meter were recorded at each sampling site.

Each water sample was analyzed for the amount of $NH_4$, $NO_3$, $PO_4$. Filtering took place within 72 hours of collection due to logistical constraints in this study. Nutrient parameters were measured from samples using a Lachat Quikchem 8500, using standard colorimetric methods, in the analytical laboratory at the Joseph W. Jones Ecological Research Center.

Water samples obtained for coliform levels were analyzed in the lab using standard methods for IDEXX Colilert defined substrate technology (Desai and Rifai 2013). Water samples were mixed with deionized (DI) water to reach a dilution of 2:1, mixed with Colilert growing media and poured into Quanti-tray 2000 (97 well format) growing trays once media was dissolved. Samples were incubated for one week at 38°C before quantifying coliform presence.

Statistical analysis and data manipulation was completed in the software package MATLAB R2014a. Boxplots were used to show longitudinal patterns in parameters behavior in each drain. ANOVA and Tukey HSD post hoc tests were used to determine differences in mean parameter values among sites within a drain.

## RESULTS

A general pattern of improved water quality was observed across parameters from upstream to downstream locations. This was especially evident in the Parmalee drain where significant reductions in most parameters were observed from the inflow to the outflow of W27 (Fig. 2). The two wetlands in Ichauway drain showed similar patterns but often with a lower magnitude of change or statistically insignificant reductions. In W27 there was a significant decrease in *E. coli* from the inflow to the outflow. In contrast there no significant differences in *E. coli* between inflows and outflows in W68 or 04 (Fig. 3). There was a significant decrease in *E. coli* between the top of the drain (TID) and the outflow of W68.

Ammonium, nitrate and phosphate decreased significantly between the inflow and outflow of W27 (Fig. 2). Between the top of Ichauway drain and the inflow of W04 there was no significant change in ammonium, nor was there a significant change within a given wetland in this drain (Fig. 3). However, significant decreases were measured between the top of Ichauway drain and the outflow of W04 as well as a further significant decrease from the outflow of W04 to the outflow of W68 (Fig. 3). In contrast to Parmalee Drain there was no difference in nitrate along Ichuaway Drain. Similar to Parmalee Drain there was a significant decrease in phosphate between W04 inflow and outflow (Fig. 3).

Specific conductance and turbidity decreased significantly between the inflow and outflow of W27 (Fig. 2). In Ichauway Drain there was an overall decrease in specific conductance between the top of the drain and the outflow of W68, however all other pairwise comparisons were insignificant (Fig. 3). Overall turbidity significantly decreased in Ichauway Drain between the top of the drain and the inflow and outflow sites of W68 (Fig. 3).

## DISCUSSION

Overall, it is unclear if biogeochemical processes (ammonification, denitrification, nitrification, phosphate adsorption to sediments etc.), physical processes or dilution from unknown hydrologic inputs drive the water quality patterns observed. Regardless of the mechanism, improvement of water quality is evident longitudinally along each flow path. Improvement across biological, chemical and physical water quality parameters is evidence that episodic flow paths may collectively be an important temporal component of the water quality of perennial hydrologic features in the Dougherty Plain.

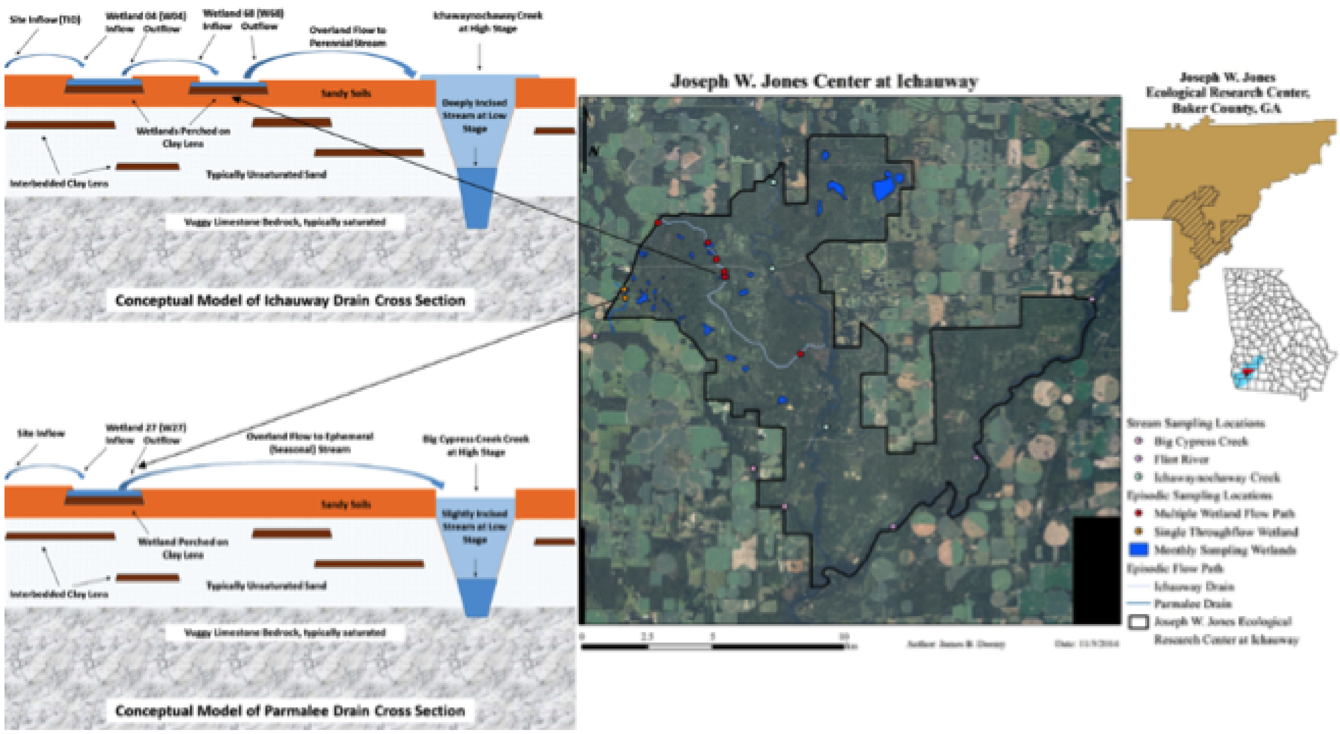


Figure 1: The J.W. Jones Ecological Research Center is located within the Dougherty Plain of southwest Georgia. Episodic-flow sampling sites are denoted in red and orange along each respective drain which have been mapped through heads-up-digitizing. A conceptual cross section of each drain also shows geology and hydrology of these episodic-flow channels.

Ammonium decrerases longitudinally along both drains may be indicative of either biogeochemical processing or dilution from soil water inputs. The Parmalee drain showed a much greater magnitude in nutrient parameter decrease than Ichauway drain, which could be a result of increased biogeochemical processing of this nutrient in Parmalee drain. Alternatively it could also be due to a higher magnitude of dilution. Ichauway drain showed smaller decreases that are likely the result of dilution from soil water inputs. These trends may be indicative of different processes governing biogeochemical processes in each drain. Nitrate trends were specific to each drain. It appears that biogeochemcial activity could be responsible for the significant decreases observed in the Parmalee drain.

In Ichauway drain, there was no significant longitudinal decrease in nitrate concentrations and this may be indicative of biogeochemical activity being limited by an unknown factor (perhaps phosphate). Phosphate decreases significantly in both drains which could be indicative of biogeochemcial activity or dilution. The greatest decrease in Ichauway drain occur between the inflow and outflow of W04. In this wetland phosphate is either being processed by the biological community or substantially diluted by soil water inputs. In the Parmalee drain phosphate significantly decreases between the two sampling locations (inflow and outflow of W27).

Specific conductance decreases longitudinally along the channel which is likely due to dilution from lower conductance water stored in wetlands (Fig. 2, Fig. 3). Soil water may also dilute conductance and contribute to the trends observed along both channels. It is also possible that conductance is decreasing due to biogeochemical activity of unconservative ions. Turbidity decreases could also be accounted for by either sedimentation or dilution. In either case it is still important to aquatic ecosystems of receiving waters. The reduction in turbidity is important to the functioning of downstream receiving waters because high turbidity can limit photosynthesis in aquatic systems. In turn, limited photosynthesis limits DO production in the water column and uptake of nutrients in the water column. Meaning that aquatic consumer activity could be reduced and increased nutrients will be transported further downstream. Therefore episodic flow paths in naturally maintained settings can improve the physical environment of downstream receiving waters regardless of the mechanism behind reductions in turbidity.

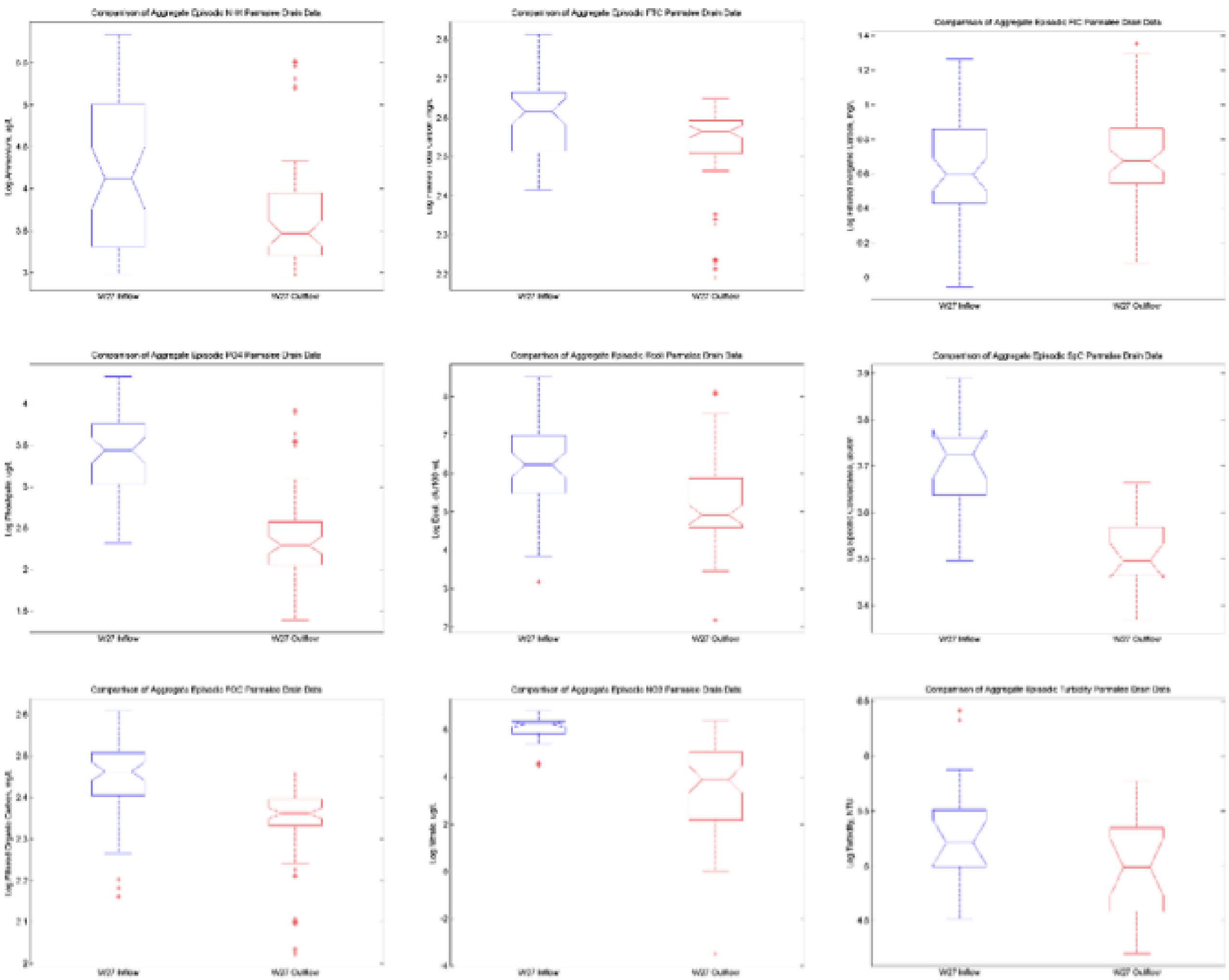

Figure 2: T-Tests were used to determine differences among means for each sampling location. There were significant changes longitudinally among sites, indicated by letters. Decreases occurred for $NH_4$, $NO_3$, $PO_4$, *E. coli*, specific conductance, and turbidity.

Differences in parameter behavior between the two drains may also be the result of biogeochemical processing prior to water entering the site. The raw runoff (defining raw as having had very little residence time in channel) entering W27 appears to have more drastic changes in water quality overall than the water in Ichauway drain (Fig. 2, Fig. 3). This drain consists of considerable channel length and multiple wetlands upstream of the site in addition to its onsite channel lengths.

## CONCLUSIONS

The most important conclusion from this study is that water quality of episodic flows generated by agricultural runoff can improve when flow passes through isolated wetlands. Additionally, it is also concluded that episodic flow water quality improves due to the cumulative effects of flow through isolated wetlands and channels surrounded by naturally maintained uplands. Improvements occurred across biological, chemical and physical aspects of water quality. The magnitude of water quality improvement seemed to be related preprocessing that may occur within the channel prior to passing though isolated wetlands. More rapid changes in wetland water quality occurred when runoff passing through wetlands had experienced little channel residence time (thus potentially lower preprocessing) and more gradual changes occurred when runoff had more channel residence time (thus potentially higher preprocessing) prior to flow through wetlands.

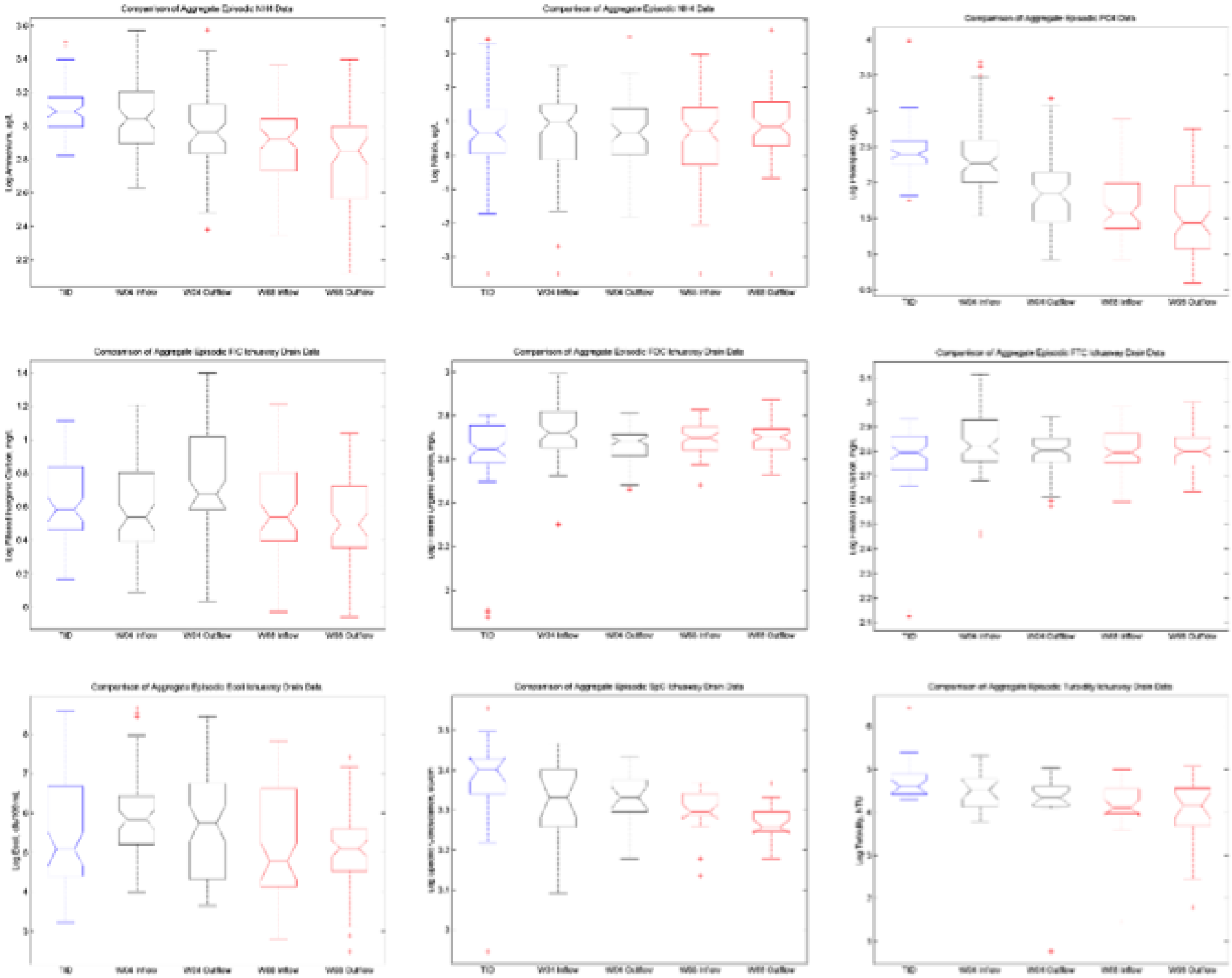

Figure 3: ANOVA was used to determine differences among means for each sampling location. Decreases occurred for $NH_4$, $PO_4$, *E. coli*, specific conductance, and turbidity, but no significant change in $NO_3$.

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