Identification of Critical Nitrogen Source Areas in Lower Boeuf River Watershed

Basic Information

Title:	Identification of Critical Nitrogen Source Areas in Lower Boeuf River Watershed
Project Number:	2014LA95B
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Principal Investigators:	Zhi-Qiang Deng

Publications

1. Zahraeifard, V., Z. Deng, and R. F. Malone (2015). “Modeling Spatial Variations in Dissolved Oxygen in Fine-Grained Streams under Uncertainty.” Hydrological Processes, 29 (2), 212–224, DOI: 10.1002/hyp.10144.
2. Zhang, Zaihong, 2014, DEVELOPMENT OF REMOTE SENSING ASSISTED WATER QUALITY NOWCASTING AND FORECASTING MODELS FOR COASTAL BEACHES, Ph.D. Dissertation, Department of Civil & Environmental Engineering, College of Engineering, Louisiana State University, Baton Rouge, LA.
3. Deng, Z. and Zhang Z. “Bayesian Modeling and Predictions of Enterococci Levels in Gulf Coast Beach Waters.” World Environmental & Water Resources Congress, May 17 – 21, 2014, Austin, Texas.

Problem and Research Objectives

Nitrogen is identified in the latest (2012) Louisiana Water Quality Inventory - Integrated Report (305(b)/303(d)) as one of the most cited suspected causes of water quality impairment. Introduction of excess river-borne nitrogen can exacerbate surface water eutrophication, favor harmful algal blooms, and aggravate oxygen depletion. This is why Dissolved Oxygen (DO) and nutrients (primarily nitrogen) are commonly listed together as the most frequently cited suspected cause of water body impairment in Louisiana. While DO and nitrogen are the most suspected cause of impairment in Louisiana, their sources are mostly unknown. In fact, the top-ranked impairment source is unknown source according to the latest Louisiana Water Quality Integrated Report. This is particularly true in agricultural watersheds, such as the Boeuf River watershed, as shown in Figure 1. As a result, the latest Louisiana Water Quality Integrated Report listed the determination of critical source areas as one of the priorities for the development and implementation of Total Maximum Daily Load (TMDL) and the restoration of water quality. This is a critical regional and state water quality problem needing to be addressed.

The overall goal of this project is to develop an efficient and effective modeling approach to identification of critical source areas (CSAs) for contaminants (including nitrogen) and thereby to address the critical regional and state water quality problem. The proposed strategy is to test and demonstrate the new modeling approach by identifying CSAs for nitrogen in the Lower Boeuf River watershed. The Lower Boeuf River (LA080901_00) is impaired due to excess nutrients and primarily nitrogen from unknown sources. The primary objective of the project is to develop a tiered new approach to the determination of catchment-scale CSAs for contaminants. The tiered approach involves (1) identification of the critical tributaries controlling nitrogen loading at the watershed scale and (2) watershed modeling for identification of the critical subwatersheds or catchments controlling nitrogen loading.

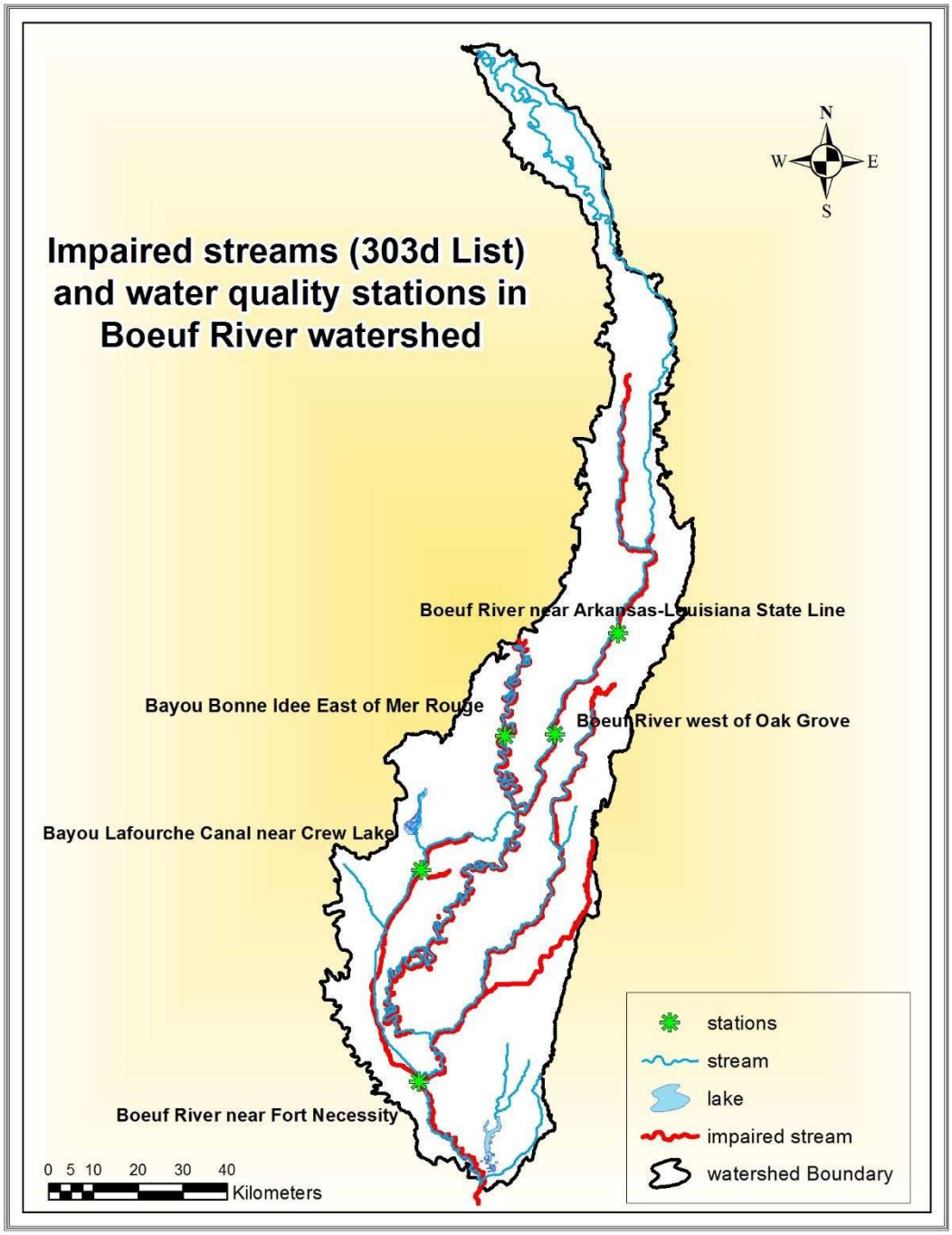

Figure 1. Study area map showing the Boeuf River watershed across the Louisiana-Arkansas border.

Methodology

The objectives are accomplished by executing three tasks: (1) watershed modeling for determining nitrogen concentrations in rivers in the watershed, (2) identification of the critical tributaries controlling nitrogen loading, and (3) mapping critical nitrogen source areas in the

watershed. The proposed tasks are implemented by combining watershed modeling tools, ArcGIS, and various data.

While this project focuses on the Lower Boeuf River Watershed, the methods developed in this study can be easily extended to other watersheds in Louisiana. Therefore, this project has broader implications for environmental restoration and sustainability in Louisiana and in the nation as well.

PRINCIPAL FINDINGS AND SIGNIFICANCE

1. Watershed modeling for determining nitrogen concentrations in rivers

(1) A HSPF-based watershed model has been presented for the Lower Boeuf River Watershed. Figures 2 and 3 below indicate that the model-simulated flow fit observed one reasonably well (correlation coefficient = 0.65). The practical significance of this model is that it provides an important modeling tool for governmental agencies like Louisiana Department of Environmental Quality to develop and implement TMDLs for the Lower Boeuf River Watershed and for restoration of impaired water bodies in the watershed.

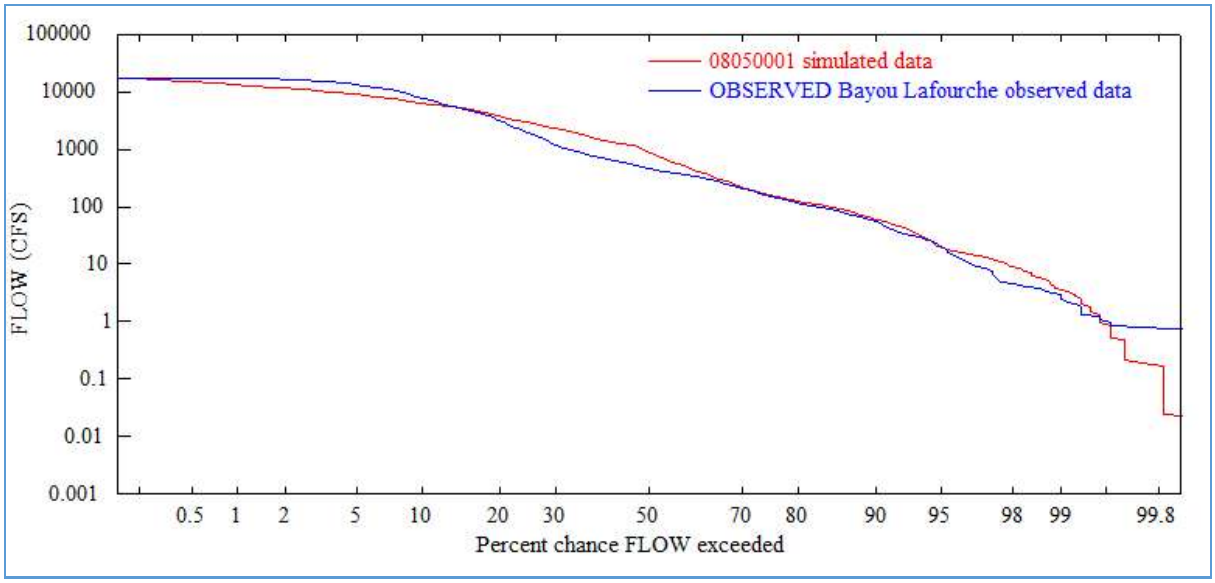

Figure 2. Comparison between simulated and observed flow of Bayou Lafourche in the Boeuf River system

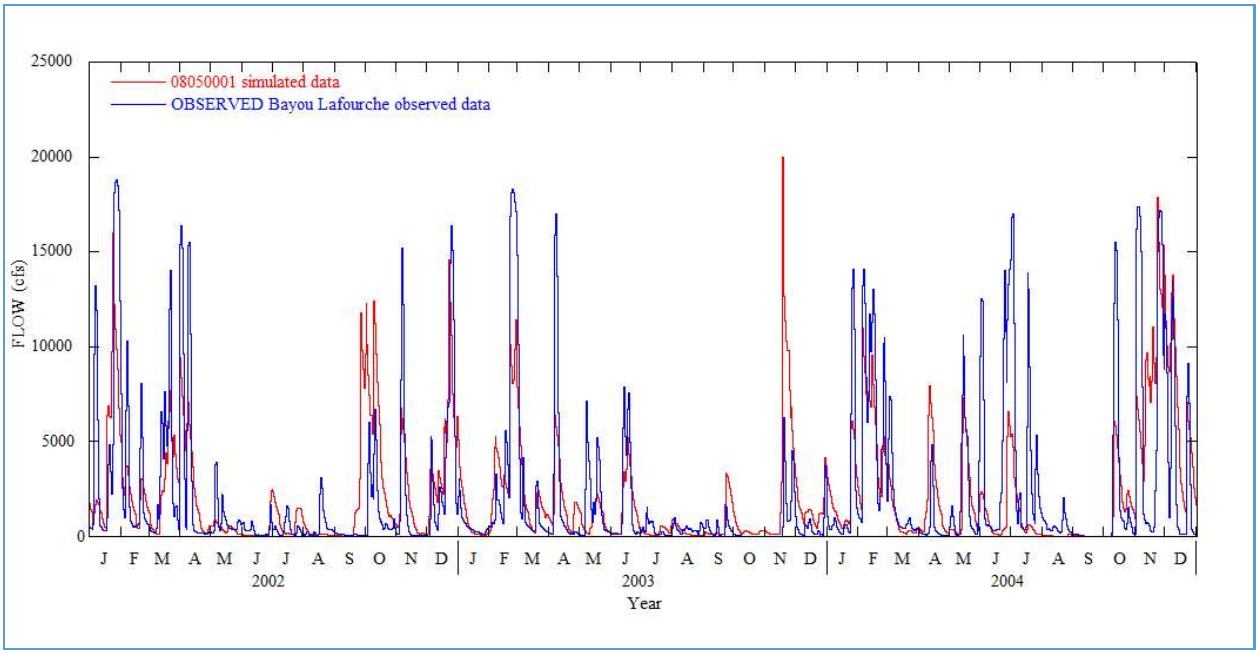

Figure 1. Comparison between simulated and observed flow of Bayou Lafourche in the Boeuf River system

(2) The HSPF-based watershed model was utilized to simulate the variation of nitrate-nitrogen concentration in the Lower Boeuf River. Figure 4 shows nitrate concentration variations in the Bayou Lafourche, a tributary of Lower Boeuf River. It can be seen from Figure 4 that the watershed model is capable of simulate nitrogen concentration in the Lower Boeuf River system. The significance of this result is that the watershed model could be employed to identify the **critical tributaries** which experienced nutrient impairment.

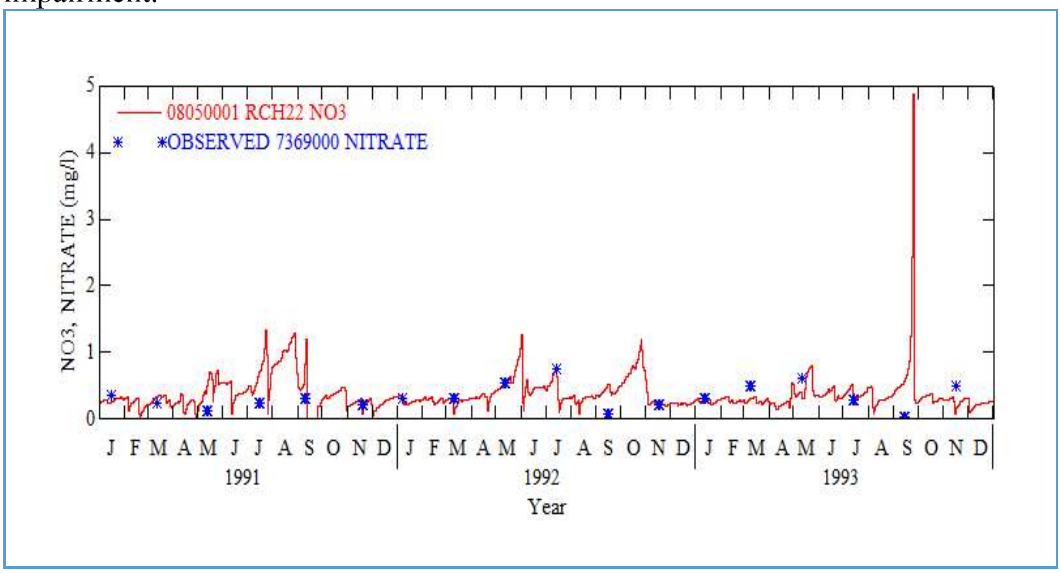

Figure 2. Comparison between simulated and observed nitrate concentration in the Bayou Lafourche

2. Identification of Critical Source Tributaries along the Boeuf River

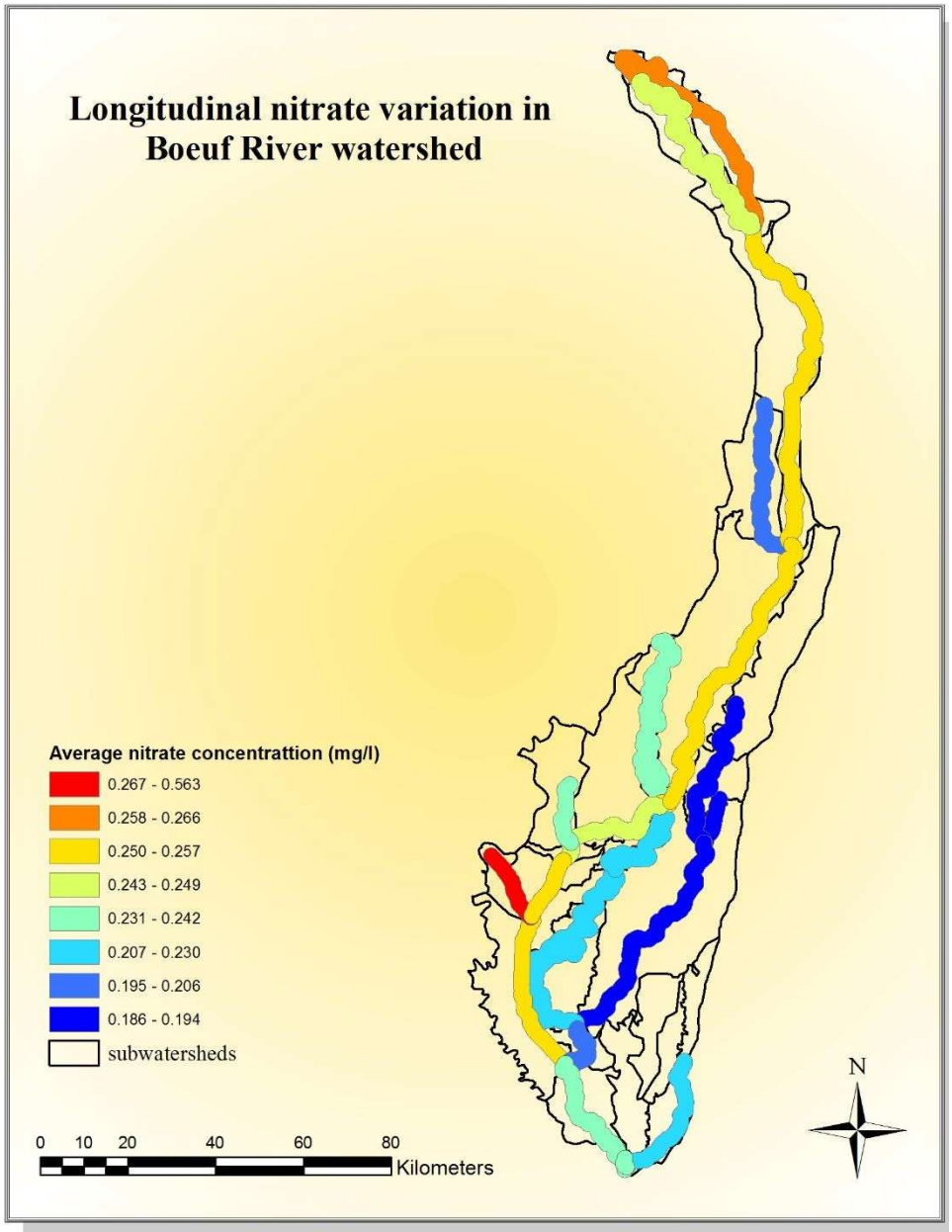

Figure 5. Map of Boeuf River watershed showing longitudinal variation in average nitrate concentration along the Boeuf River and its tributaries.

(1) Based on the simulated nitrogen concentrations, spatial variations in nitrogen concentration in rivers in the Boeuf River Watershed are mapped using ArcGIS and Google Earth to identify the critical tributaries which experienced high nitrogen concentration, as shown in Figure 5. The map indicates that elevated nitrate level in the Lower Boeuf River is primarily due to the high nitrate concentration in the Upper Boeuf

River in Arkansas while a small tributary (highlighted with red color) in the Lower Boeuf River Watershed is also a critical tributary to restore. It means that the Louisiana Department of Environmental Quality needs to work with the corresponding Arkansas Department of Environmental Quality in order to address the nutrient impairment problem in Louisiana rivers. This is an important finding for the Boeuf River watershed.

(2) Figure 6 shows temporal variations in nitrogen level at two sampling stations along the Boeuf River. It can be seen from the graphs that nitrogen level exhibits an increasing trend over the past decades in the watershed due to increasing agricultural activities. The significance of this result is that agricultural BMPs (Best Management Practices) should be implemented to prevent the increasing trend in nitrogen level in the watershed.

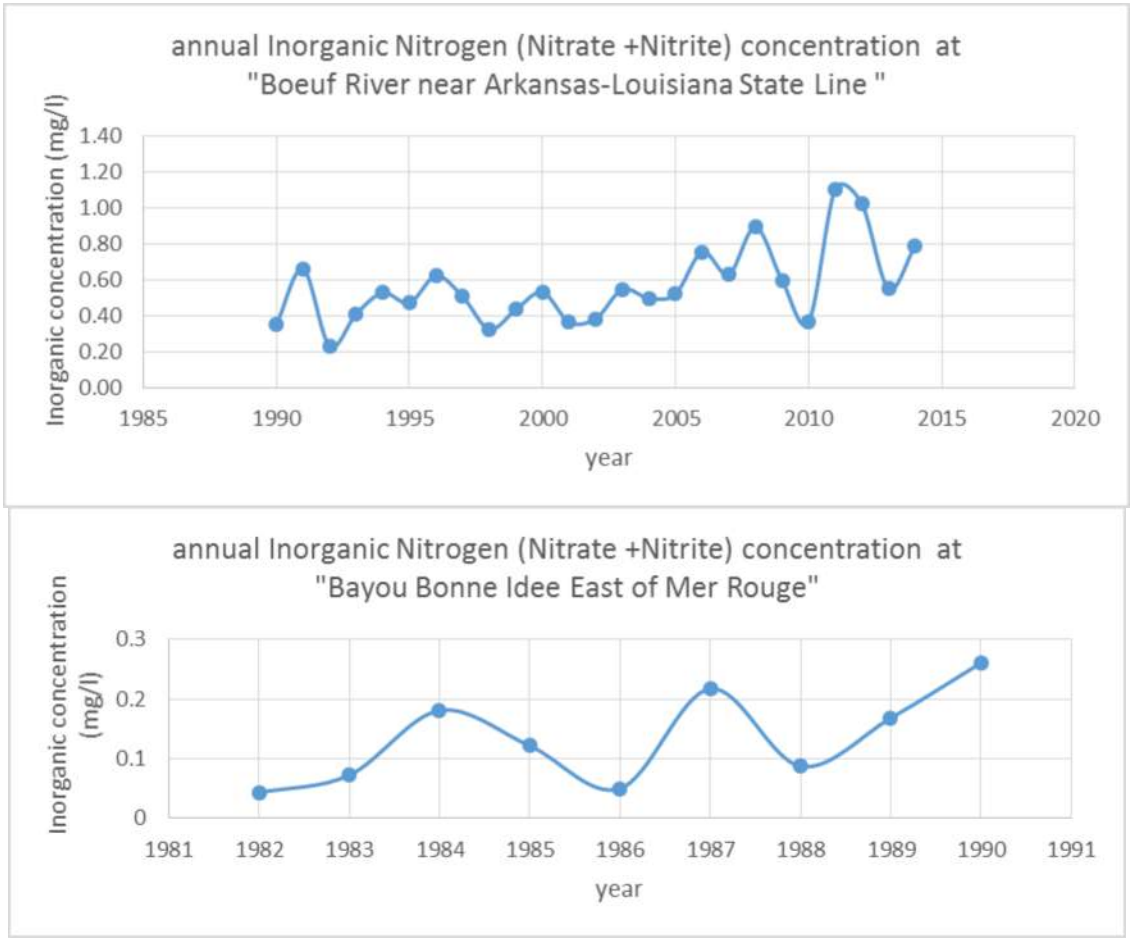

Figure 3. Temporal variations of nitrogen at three monitoring stations along the Boeuf River and its tributaries.

3. Identification of Critical Source Areas (CSAs) in the Boeuf River Watershed

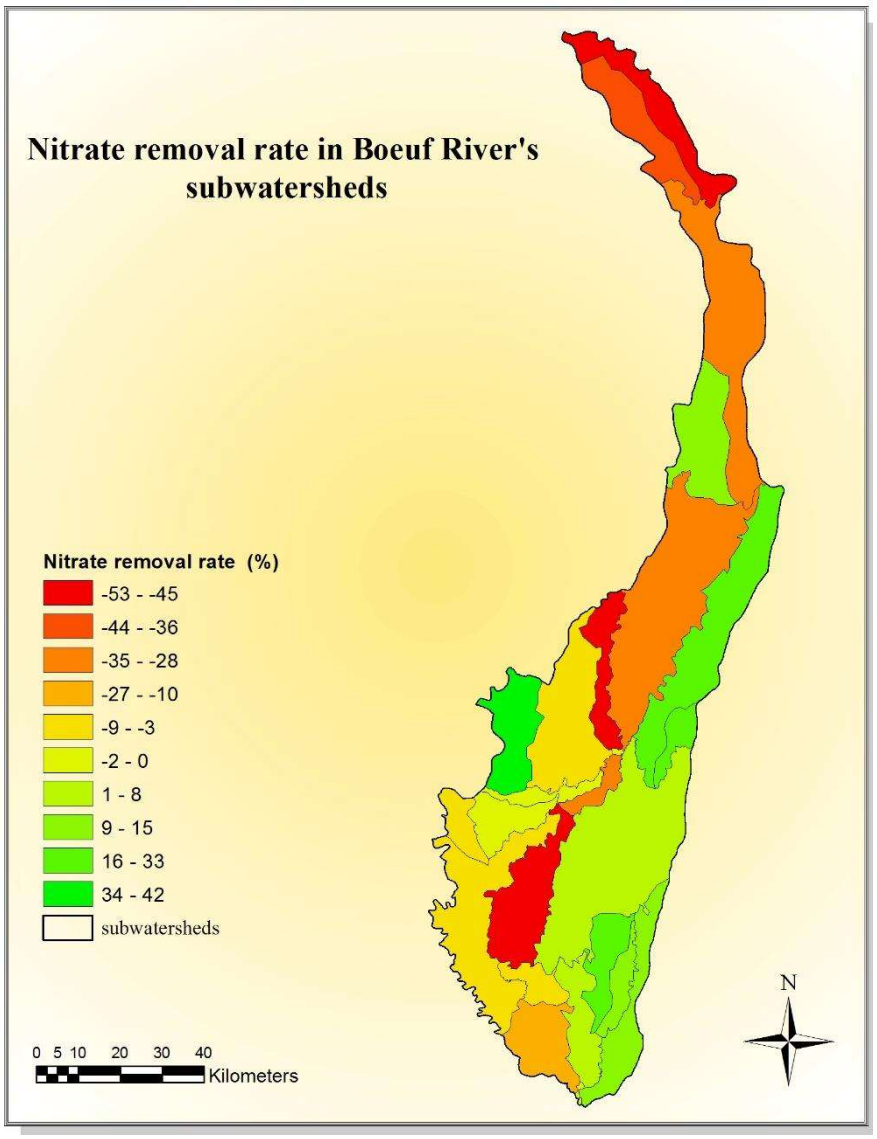

Figure 7. Map of Boeuf River watershed showing nitrate removal/release rate (%) in different subwatersheds.

The nitrate-nitrogen removal rates from all subwatersheds are mapped using simulation results from the new HSPF-based watershed model, as shown in Figure 7. ArcGIS and Google Earth are used to identify major nitrate source and sink areas in the Boeuf River watershed. The negative values show the nitrate production (release) rates, indicating nitrogen source areas, while the positive values display nitrogen sink areas. The areas highlighted with red and brown colors (particularly the red areas) are the critical sources areas of nitrogen in the Boeuf River Watershed. Again, the map demonstrates that the most critical sources areas of nitrogen are located in Arkansas while a couple of

subwatersheds in the southwest part of the watershed in Louisiana are also critical source areas. A joint and watershed-scale effort between Louisiana and Arkansas is needed to reduce nitrogen discharges to and restore water quality in water bodies in the Boeuf River Watershed. This finding is critical to both the Louisiana Department of Environmental Quality and the Arkansas Department of Environmental Quality.

INFORMATION TRANSFER

The findings and particularly the critical source areas, identified in this project, will be transferred to the Louisiana Department of Environmental Quality for nutrient TMDL development and implementation and thereby for the restoration of the nutrient-enriched or impaired Louisiana rivers.

STUDENT SUPPORT

Name of supported graduate student: Maryam Roostaee (Female)
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