Louisiana Water Resources Research Institute
Annual Technical Report
FY 2007

Introduction

This report presents a description of the activities of the Louisiana Water Resources Research Institute for the period of March 1, 2007 to February 29, 2008 under the direction of Dr. John Pardue. The Louisiana Water Resources Research Institute (LWRRI) is unique among academic research institutions in the state because it is federally mandated to perform a statewide function of promoting research, education and services in water resources. The federal mandate recognizes the ubiquitous involvement of water in environmental and societal issues, and the need for a focal point for coordination.

As a member of the National Institutes of Water Resources, LWRRI is one of a network of 54 institutes nationwide initially authorized by Congress in 1964 and has been re−authorized through the Water Resources Research Act of 1984, as amended in 1996 by P.L. 104−147. Under the Act, the institutes are to:

"1) plan, conduct, or otherwise arrange for competent research that fosters, (A) the entry of new research scientists into water resources fields, (B) the training and education of future water scientists, engineers, and technicians, (C) the preliminary exploration of new ideas that address water problems or expand understanding of water and water−related phenomena, and (D) the dissemination of research results to water managers and the public.

2) cooperate closely with other colleges and universities in the State that have demonstrated capabilities for research, information dissemination and graduate training in order to develop a statewide program designed to resolve State and regional water and related land problems. Each institute shall also cooperate closely with other institutes and organizations in the region to increase the effectiveness of the institutes and for the purpose of promoting regional coordination."

The National Water Resources Institutes program establishes a broad mandate to pursue a comprehensive approach to water resource issues that are related to state and regional needs. Louisiana is *the* water state; no other state has so much of its cultural and economic life involved with water resource issues. The oil and gas industry, the chemical industry, port activities, tourism and fisheries are all dependent upon the existence of a deltaic landscape containing major rivers, extensive wetlands, numerous large shallow water bays, and large thick sequences of river sediments all adjacent to the Gulf of Mexico.

History of the Institute

Louisiana has an abundance of water resources, and while reaping their benefits, also faces complex and crucial water problems. Louisiana's present water resources must be effectively managed, and the quality of these resources must be responsibly protected. A fundamental necessity is to assure continued availability and usability of the state's water supply for future generations. Specifically, Louisiana faces five major issues that threaten the quality of the state's water supply, which are also subsets of the southeastern/island region priorities:

Nonpoint sources of pollution are estimated to account for approximately one−half of Louisiana's pollution. Because of the potential impact of this pollution and the need to mitigate its effects while maintaining the state's extensive agricultural base and coastal zones, continued research is needed in the area of nonpoint issues. Louisiana's regulatory agencies are addressing non−point source problems through the development of waste load allocation models or total maximum daily load (TMDL) calculations. There are serious technical issues that still require resolution to insure that progress is made in solving the non−point source problem.

Louisiana's vast *wetlands* make up approximately 40% of the nation's wetlands. These areas are composed of very sensitive and often delicately balanced ecosystems which make them particularly vulnerable to contamination or destruction resulting both from human activities and from natural occurrences.

Understanding these threats and finding management alternatives for the state's unique wetland resources are priority issues needing attention.

Water resources planning and management are ever−present dilemmas for Louisiana. Severe flooding of urban and residential areas periodically causes economic loss and human suffering, yet solutions to flooding problems can be problems in themselves. Water supply issues have also recently a focus of concern. Despite the abundance of resources, several aquifers have been in perennial overdraft, including the Chicot aquifer. Louisiana passed its first legislation that restricts groundwater use in the past year. Water resources and environmental issues are intricately interconnected; therefore, changes in one aspect produce a corresponding responsive change in another. Further study is needed to understand these relationships.

Water quality protection, particularly of ground water resources, is an area of concern in Louisiana. Researchers are beginning to see contamination in drinking water supplies that was not present in the past. Delineating aquifer recharge areas, understanding the impacts of industrial activities on water resources, evaluating nonpoint sources of pollution, and exploring protection alternatives are issues at the forefront.

Wastewater management has been a long−standing issue in Louisiana. The problem of wastewater management focuses primarily on rural and agricultural wastewater and the high costs for conventional types of wastewater treatment as found in the petrochemical industry.

The Institute is administratively housed in the College of Engineering and maintains working relationships with several research and teaching units at Louisiana State University. Recent cooperative research projects have been conducted with the University of New Orleans and the EPA's Hazardous Substance Research Center− South &Southwest.

Research Program Introduction

The primary goal of the Institute is to help prepare water professionals and policy makers in the State of Louisiana to meet present and future needs for reliable information concerning national, regional, and state water resources issues. The specific objectives of the Institute are to fund the development of critical water resources technology, to foster the training of students to be water resources scientists and engineers capable of solving present and future water resources problems, to disseminate research results and findings to the general public, and to provide technical assistance to governmental and industrial personnel and the citizens of Louisiana.

The priority research areas for the Institute in FY 2007 focused on selected research themes developed in conjunction with the advisory board. These themes corresponded to the major water resource areas affecting Louisiana described in the Introduction above. Projects selected were from a range of faculty with different academic backgrounds including geological scientists, environmental engineers and water resource engineers and scientists. Supporting research in this priority area has increased the visibility of the Institute within the State.

The selected research projects full synopsis included in this report are designated as Projects 2005LA38G, 2007LA50B, 2007LA51B, and 2007LA52B, as listed below.

- Project 2005LA38G, Tsai &Singh − Saltwater Intrusion Management with Conjunctive Use of Surface Water and Ground Water
- Project 2007LA50B, Deng − Scale Dependent Behavior and Modeling on Nitrogen Retention in Streams
- 2007LA51B, Fearnley – Discerning Nutrient Limitations to Phytoplankton Growth in Rivers and Bayous on the North Shore of Lake Pontchartrain
- 2007LA47B – Pardue &Korevec, Information Transfer Symposia: Mitigation of Storm Surge using Vegetation (Spring 2007) and Resilient Environmental Infrastructure for Coastal Communities (Fall 2007)

These projects include one project that focuses on ground water flow and transport and solute transport (2005LA38G). Also included are two projects which focus on water quality issues (2007LA50B &2007LA51B), and one project (2007LA52B) which focuses on information transfer, management and planning, methods, and technical transfer. The physical study also supports the Institutes' long−standing commitment to computer modeling of water resources processes.

LWRRI researchers have been involved in a range of response activities to the 2005 hurricanes which has substantially increased the Institute's visibility. In addition to our early floodwater research we have conducted studies on sediment, air, microbiological and landfill research that will lead to further peer−reviewed publications on the issues raised by the impacts of the storms. This year, LWRRI continued to build on our research relationship with the LSU Hurricane Center on several issues such as, flood protection policy and administration, flooding processes, non−structural approaches to managing flood risk and flood control, and structural controls. We continue to partner with LSU Hurricane Center and others on planning and evacuation work for the upcoming 2008−2009 Hurricane season.

Saltwater Intrusion Management with Conjunctive Use of Surface Water and Ground Water

Basic Information

Title:	Saltwater Intrusion Management with Conjunctive Use of Surface Water and Ground Water
Project Number:	2005LA38G
Start Date:	9/1/2005
End Date:	8/31/2009
Funding Source:	104G
Congressional District:	Louisiana
Research Category:	Ground−water Flow and Transport
Focus Category:	Groundwater, Management and Planning, Solute Transport
Descriptors:	Management modeling, Saltwater Intrusion, Optimization, Conjunctive Use
Principal Investigators:	Frank Tsai, Vijay P. Singh

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SYNOPSIS

Problem and Research Objectives

Due to the complexity of real aquifer systems and insufficiency of available data, we often encounter the situation that several simulation models agree satisfactorily to the same observation data. Nevertheless, these models can differ substantially from each other in model structure and in embedded model parameters. They can lead to substantially different predictions. This is the non-uniqueness problem in groundwater inverse modeling [Yeh, 1986]. Selection of a single "best" model is not sufficient when several competitive models are available. To take into consideration in model uncertainty, Bayesian model averaging (BMA) [Hoeting et al., 1999] was introduced to draw inferences (predictions) from multiple models. In BMA, model importance is represented by the posterior model probability, which is evaluated by the likelihood function and the prior model probability. The total prediction variance in BMA considers the within-model variance and the between-model variance. Evaluation of the likelihood function can be achieved by either the Monte Carlo (MC) simulation methods [Madigan and Raftery, 1994] or the Laplace approximation such that the model weights are calculated in terms of the Bayesian information criterion (BIC) [Raftery, 1995]. The latter approach is especially beneficial in groundwater modeling because the MC approach is usually too expensive for large-scale real-world groundwater models.

The objective of this study is to use the BMA technique to develop a Bayesian multi-model multi-parameterization (BMMMP) scheme to predict groundwater heads and evaluate head prediction uncertainty. In this study, we consider the uncertainty in the groundwater model as well as the uncertainty in the parameterization method to investigate the propagation of these uncertainties to the uncertainty of groundwater head predictions in the “1,500-foot” sand in East Baton Rouge Parish, Louisiana. The “1,500-foot” sand contains the Baton Rouge Fault, a distinct geological structure that restricts groundwater flow through the fault. According to different considerations on the Baton Rouge Fault characteristics, we develop three conceptual groundwater models: one model with a leaky fault, one model with an impermeable fault, and one model without a fault. For each groundwater model, we consider seven grain-size methods to estimate hydraulic conductivity at electrical resistivity-log sites. Different hydraulic conductivity distribution is then obtained through the GP method that combines the ordinary kriging (OK) method and the Voronoi tessellation (VT) method [Tsai 2006].

Methodology

(1) Bayesian Multi-Model Multi-Parameterization (BMMMP) Method

Consider a set of groundwater models denoted as $\left\{M^{(p)}, p=1,2,\cdots\right\}$, for groundwater simulation. In each groundwater model, $M^{(p)}$, a set of parameterization methods for estimating hydraulic conductivity is denoted as $\left\{\theta_q^{(p)}; q=1,2,\cdots\right\}$, where $\theta_q^{(p)}$ represents the parameterization method in groundwater model $M^{(p)}$. According to the law of total probability, the posterior probability of groundwater head predictions for given data **D**, parameterization methods, and simulation models is

$$\begin{aligned}\Pr\left(\mathbf{h} \mid \mathbf{D}\right) &= \mathrm{E}_M\left[\mathrm{E}_\theta[\Pr(\mathbf{h}|\mathrm{M}^{(p)},\theta_q^{(p)},\mathbf{D})]\right] \\ &= \sum_p \sum_q \Pr(\mathbf{h}|\mathrm{M}^{(p)},\theta_q^{(p)},\mathbf{D}) \Pr(\theta_q^{(p)} \mid \mathrm{M}^{(p)},\mathbf{D}) \Pr(\mathrm{M}^{(p)} \mid \mathbf{D})\end{aligned} \quad (1)$$

where $\Pr(\mathbf{h} \,|\, \mathrm{M}^{(p)}, \theta_q^{(p)}, \mathbf{D})$ is the posterior probability of groundwater head predictions for given data, groundwater model $M^{(p)}$ and parameterization method $\theta_q^{(p)}$. $\Pr\left(\theta^{(q)} \,|\, \mathrm{M}^{(p)}, \mathbf{D}\right)$ is the posterior method probability of parameterization method $\theta_q^{(p)}$ for given data and groundwater model $M^{(p)}$. $\Pr\left(\theta^{(q)} \,|\, \mathrm{M}^{(p)}, \mathbf{D}\right)$ also represents the method weight. Consider the equal prior method probability. The posterior method probability can be approximated using the Bayesian information criterion (BIC):

$$\Pr\left(\theta^{(q)} \,|\, \mathrm{M}^{(p)}, \mathbf{D}\right) = \frac{\exp\left[-\frac{1}{2}\mathrm{BIC}_q^{(p)}\right]}{\sum_j \exp\left[-\frac{1}{2}\mathrm{BIC}_j^{(p)}\right]} \tag{2}$$

where

$$\mathrm{BIC}_q^{(p)} = -2\ln\Pr\left(\mathbf{D} \,|\, \mathrm{M}^{(p)}, \theta_q^{(p)}, \hat{\boldsymbol{\beta}}_q^{(p)}\right) + m_q^{(p)} \ln n \tag{3}$$

where $\hat{\boldsymbol{\beta}}_q^{(p)}$ are the maximum-likelihood (ML) estimated parameters in the method $\theta_q^{(p)}$, $m_q^{(p)}$ is the number of the parameters $\hat{\boldsymbol{\beta}}_q^{(p)}$, and *n* is the number of data $\mathbf{D}$. $\Pr\left(\mathbf{D} \,|\, \mathrm{M}^{(p)}, \theta_q^{(p)}, \hat{\boldsymbol{\beta}}_q^{(p)}\right)$ is the likelihood function value of the heads for given model $M^{(p)}$, method $\theta_q^{(p)}$. Considering the equal prior model probability, the posterior model probability $\Pr\left(\mathrm{M}^{(p)} \,|\, \mathbf{D}\right)$ given the data is calculated through the Bayes rule:

$$\Pr\left(\mathrm{M}^{(p)} \,|\, \mathbf{D}\right) = \frac{\Pr\left(\mathbf{D} \,|\, \mathrm{M}^{(p)}\right)}{\sum_i \Pr\left(\mathbf{D} \,|\, \mathrm{M}^{(i)}\right)} \tag{4}$$

where $\Pr(\mathbf{D}|\mathrm{M}^{(p)}) = \sum_q \Pr\left(\mathbf{D} \,|\, \mathrm{M}^{(p)}, \theta^{(q)}\right)\Pr\left(\theta^{(q)} \,|\, \mathrm{M}^{(p)}\right)$. $\Pr\left(\mathrm{M}^{(p)} \,|\, \mathbf{D}\right)$ also represents the model weight. Using the law of total expectation, the means of the groundwater head predictions are

$$\begin{aligned} \mathrm{E}\left(\mathbf{h} \,|\, D\right) &= E_{\mathrm{M}}\left[E_\theta\left[E\left(\mathbf{h} \,|\, \mathrm{M}^{(p)}, \theta^{(q)}, \mathbf{D}\right)\right]\right] \\ &= \sum_p \sum_q E\left(\mathbf{h} \,|\, \mathrm{M}^{(p)}, \theta^{(q)}, \mathbf{D}\right)\Pr\left(\theta^{(q)} \,|\, \mathrm{M}^{(p)}, \mathbf{D}\right)\Pr\left(\mathrm{M}^{(p)} \,|\, \mathbf{D}\right) \end{aligned} \tag{5}$$

The total covariances of the groundwater head predictions are

$$\begin{aligned} \mathrm{Cov}\left(\mathbf{h} \,|\, \mathbf{D}\right) &= \mathrm{E}_{\mathrm{M}}\mathrm{E}_\theta\left[\mathrm{Cov}\left[\mathbf{h} \,|\, \mathrm{M}^{(p)}, \theta^{(q)}, \mathbf{D}\right]\right] + \mathrm{E}_{\mathrm{M}}\mathrm{Cov}_\theta\left[\mathrm{E}\left[\mathbf{h} \,|\, \mathrm{M}^{(p)}, \theta^{(q)}, \mathbf{D}\right]\right] \\ &\quad + \mathrm{Cov}_{\mathrm{M}}\mathrm{E}_\theta\left[\mathrm{E}\left[\mathbf{h} \,|\, \mathrm{M}^{(p)}, \theta^{(q)}, \mathbf{D}\right]\right] \end{aligned} \tag{6}$$

The means of heads can be approximated by $\mathrm{E}\left[\mathbf{h} \,|\, \mathrm{M}^{(p)}, \theta^{(q)}, \mathbf{D}\right] = \mathbf{h}\left(\boldsymbol{\pi}_{GP,q}^{(p)}\right)$. Using the linearization approach [Dettinger and Wilson, 1981; Tiedeman et al., 2003], the covariance matrix of heads is $\mathrm{Cov}\left[\mathbf{h} \,|\, \mathrm{M}^{(p)}, \theta^{(q)}, \mathbf{D},\right] = J_{\pi,q}^{(p)}\left[\mathrm{Cov}_{GP,q}^{(p)}\right]\left[J_{\pi,q}^{(p)}\right]^T$, where $J_\pi = \partial\mathbf{h}/\partial\boldsymbol{\pi}\big|_{\boldsymbol{\pi}_{GP}}$ is the Jacobian matrix and $\left[\mathrm{Cov}_{GP}\right]$ is the covariance matrix when the GP method is used.

(2) Methodology Application to “1,500-foot” Sand, Baton Rouge, Louisiana
The methodology is applied to groundwater head prediction on January 1, 2020 in the “1,500-foot” sand in East Baton Rouge (EBR) Parish, Louisiana. The study area is shown in Figure 1.

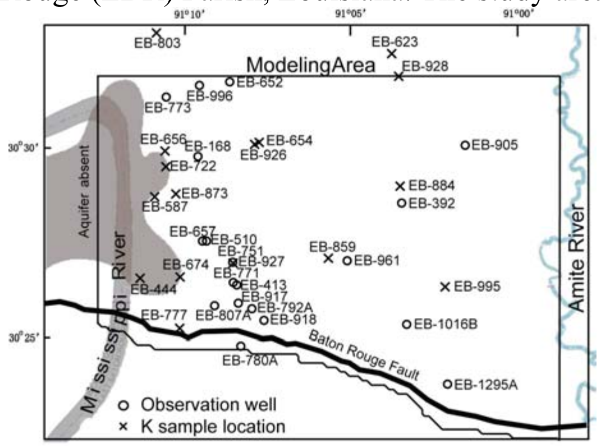


Figure 1. The study area: the “1,500-foot” sand.

The “1,500-foot” sand is one of the sand aquifers in Baton Rouge and is the major freshwater source to the public. The Baton Rouge Fault historically restricted saltwater south of the fault moving northward. However, groundwater levels in the East Baton Rouge Parish have declined by as much as 91 meters since the 1940’s. The large cone of depression in the northern area of the Baton Rouge Fault has induced saltwater encroachment across the fault toward the pumping centers. In this study, we focus on groundwater head prediction using the BMMMP scheme. The study area in Figure 1 extends about 300 km^2 and includes a major part of the Baton Rouge metropolitan area.

To develop the regional groundwater model, we collected 706 groundwater observation records from 18 observation wells (see Figure. 1) for the period from January 1990 to December 2004 (15 years) from the USGS National Water Information System website. We also collected 21 electrical log data (see Figure 1) to determine the hydraulic conductivity and the aquifer thickness. The Capital Area Ground Water Conservation Commission provided monthly pumping data for 16 production wells that screen the “1,500-foot” sand. In this study, we developed a two-dimensional groundwater model using MODFLOW-2000 [Harbaugh et al., 2000]. The time-varied constant head boundary condition was used.

(3) Development of Three Groundwater Models and Seven Parameterization Methods
There is no direct information about the Baton Rouge Fault permeability that affects groundwater heads significantly. We adopted the Horizontal Flow Barrier [Hsieh and Freckleton, 1994] to estimate the fault hydraulic characteristic (HC), the hydraulic conductivity per unit width of fault. Using the observation data at EB-917 (north of the fault) and EB-780A (south of the fault), we estimated the hydraulic characteristic (HC) of the Baton Rouge Fault to be 0.000519 day^{-1}, which indicates a leaky fault with low permeability. For the comparing purpose, we built two additional groundwater models based on two extreme cases of the fault permeability. One is the impermeable-fault model, where the fault is impermeable. The other model is the no-fault model, where the fault is not considered in the model. Therefore, three groundwater models are:

(1) Leaky-fault model (M_1)
(2) Impermeable-fault model (M_2)
(3) No-fault model (M_3)

To estimate the hydraulic conductivity in the study area, we used the electrical resistivity data from the 21 electrical resistivity wells obtained from Louisiana Water Science Center. Using Archie's law, we interpreted the resistivity reading into porosity. Then, we applied 7 grain-size empirical methods to calculate hydraulic conductivity at the E-log sites. The seven methods are listed in Table 1 [Kasenow, 2002].

Table 1. Seven grain-size methods to calculate the K value under the general expression of empirical formula, $K = b(g/v)f(n)d_e^2$, where $g = 9.8 m/s^2$, $d_e = 0.22 mm$, and the water kinematic viscosity, $v = 8.007 \times 10^{-7} m^2/s$ at $30^o C$.

Grain-size method	b	Function of porosity f(n)	Domain of applicability
Kozeny-Carman	1/180	$\frac{n^3}{(1-n)^2}$	Fine to large grain sands
Sauerbrei	3.75×10^{-3}	$\frac{n^3}{(1-n)^2}$	Sand and sandy clay
Slichter	0.01	$n^{3.287}$	Fine to large grain sands
Terzaghi	6.1×10^{-3}	$\left(\frac{n-0.13}{\sqrt[3]{1-n}}\right)^2$	Large-grain sands
Kruger	4.35×10^{-3}	$\frac{n^3}{(1-n)^2}$	Medium-grain sands
Zunker	1.2×10^{-3}	$\left(\frac{n}{1-n}\right)^2$	Fine and medium-grain sands
Zamarin	8.2×10^{-3}	$\frac{n^3}{(1-n)^2}(1.275-1.5n)^2$	Large-grain sands

Once the hydraulic conductivity values are determined by the grain-size methods at the E-log locations, we use the generalized parameterization (GP) method [Tsai, 2006] to estimate the spatially correlated log-hydraulic conductivity ($\boldsymbol{\pi} = \ln \mathbf{K}$). The GP method in this study combines the ordinary kriging (OK) and Voronoi tessellation (VT), a zonation method. Therefore, seven GP methods are considered and denoted as (1) GP-Kozeny-Carman (θ_1), (2) GP-Sauerbrei (θ_2), (3) GP-Slichter (θ_3), (4) GP-Terzaghi (θ_4), (5) GP-Kruger (θ_5), (6) GP-Zunker (θ_6), and (7) GP-Zamarin (θ_7).

Principal Findings and Significance

(1) Estimation of Model Weights and Method Weights

The model weights and method weights play a very important role in the BMMMP because they represent the model and method importance. Using the BIC to calculate model weights in the

BMA reveals the model selection result using Occams' window [Raftery, 1995]. Occam's window determines if the model would be selected based on the log posterior ratio of the considered model against the best model. The problem of using Occam's window is the too narrow window size, which easily rejects good models. We developed a variance window, which defines the window size to accept models based on the variance of the error chi-squares [Tsai and Li, 2007]. In this study, we use a 5% significance level in Occam's window and two times of the standard deviation of chi-squares as the window size. The scaling factor is 0.0798.

Table 2 lists the weights of the seven GP methods in each groundwater model. The GP-Kozeny-Carman method is the best GP method in the leaky-fault model and impermeable-fault model while the GP-Sauerbrei method is the second best method. However, the GP-Slichter method is the single best method when the no-fault model is used.

Table 2. Posterior probabilities of GP methods (method weights) in groundwater models.

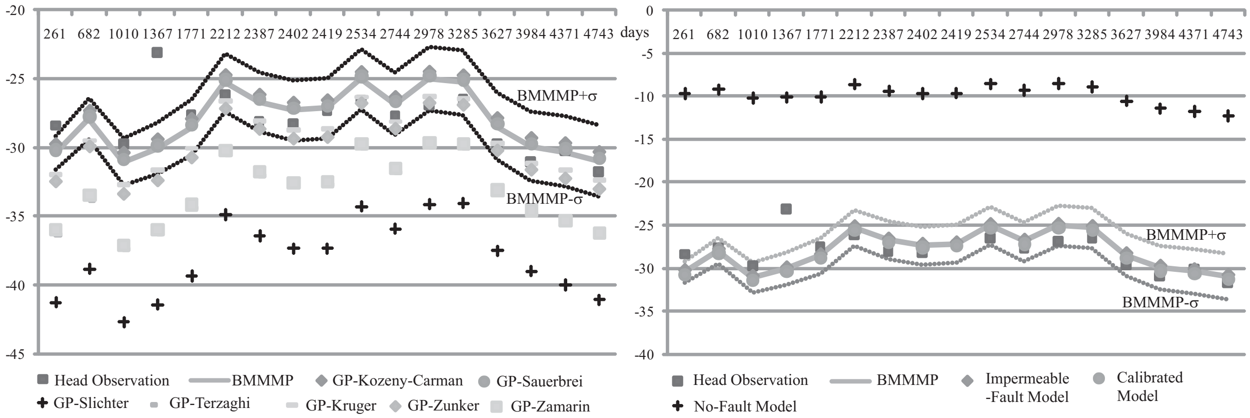
GP Methods	Posterior Method Probabilities in Leaky-Fault Model	Posterior Method Probabilities in Impermeable-Fault Model	Posterior Method Probabilities in No-Fault Model
GP-Kozeny-Carman	57.01%	73.48%	0.00%
GP-Sauerbrei	29.31%	23.40%	0.00%
GP-Slichter	0.00%	0.00%	100%
GP-Terzaghi	0.00%	0.00%	0.00%
GP-Kruger	6.29%	1.61%	0.00%
GP-Zunker	7.38%	1.51%	0.00%
GP-Zamarin	0.00%	0.00%	0.00%

Table 3 lists the model weights for three groundwater models. The leaky-fault model is the best model with a weight of 67.01%. The impermeable-fault model gains about one third of the total weight. The no-fault model is rejected.

Table 3. Posterior probabilities of groundwater models (model weights).

	Leaky-Fault Model	Impermeable-Fault Model	No-Fault Model
Posterior Model Probabilities	67.01%	32.99%	0.00%

Figure 2(a) shows that the BMMMP is able to fit well the head observations at EB-168, which are bounded by the one-standard deviation bounds of the BMMMP. Figure 2(b) demonstrates that the leaky-fault model and impermeable-fault model are good models. The no-fault model is unacceptable.



(a) **(b)**

Figure 2: Comparisons to the observed groundwater heads at observation well EB-168 (a) BMMMP against individual GP methods using the leaky-fault model, and (b) BMMMP against individual groundwater models.

(2) Head Predictions Using BMMMP

We predicted the groundwater head on January 1, 2020 by using the monthly averaged pumping rate and head boundary conditions in the three years (2002-2004). In Figure 3, we compared the head predictions on January 1, 2020 using the best GP method (GP-Kozeny-Carman) in the leaky-fault model against that using the BMMMP. Because the GP-Kozeny-Carman has more than 50% of the total weight, the BMMMP and the best single model result in similar predicted groundwater heads.

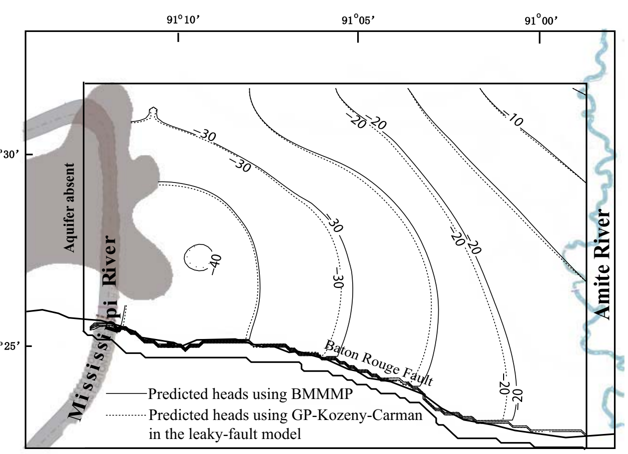


Figure 3: Predicted groundwater heads on January 1, 2020.

The variances of head predictions on January 1, 2020 using the BMMMP is shown in Figure 4, which include the within-method variances, between-method variances, between-model variances, and total variances. The large head prediction variances come from the GP methods. The between-method variances are small because the GP-Kozeny-Carman dominates in both leaky-fault model and impermeable-fault model. The between-model variances are slightly higher than the between-method variances. The head prediction variances increase toward the middle-east area near the fault due to less hydraulic conductivity samples and fewer head observations in this area. More K measurements and head observations can significantly reduce the prediction uncertainty in this area.

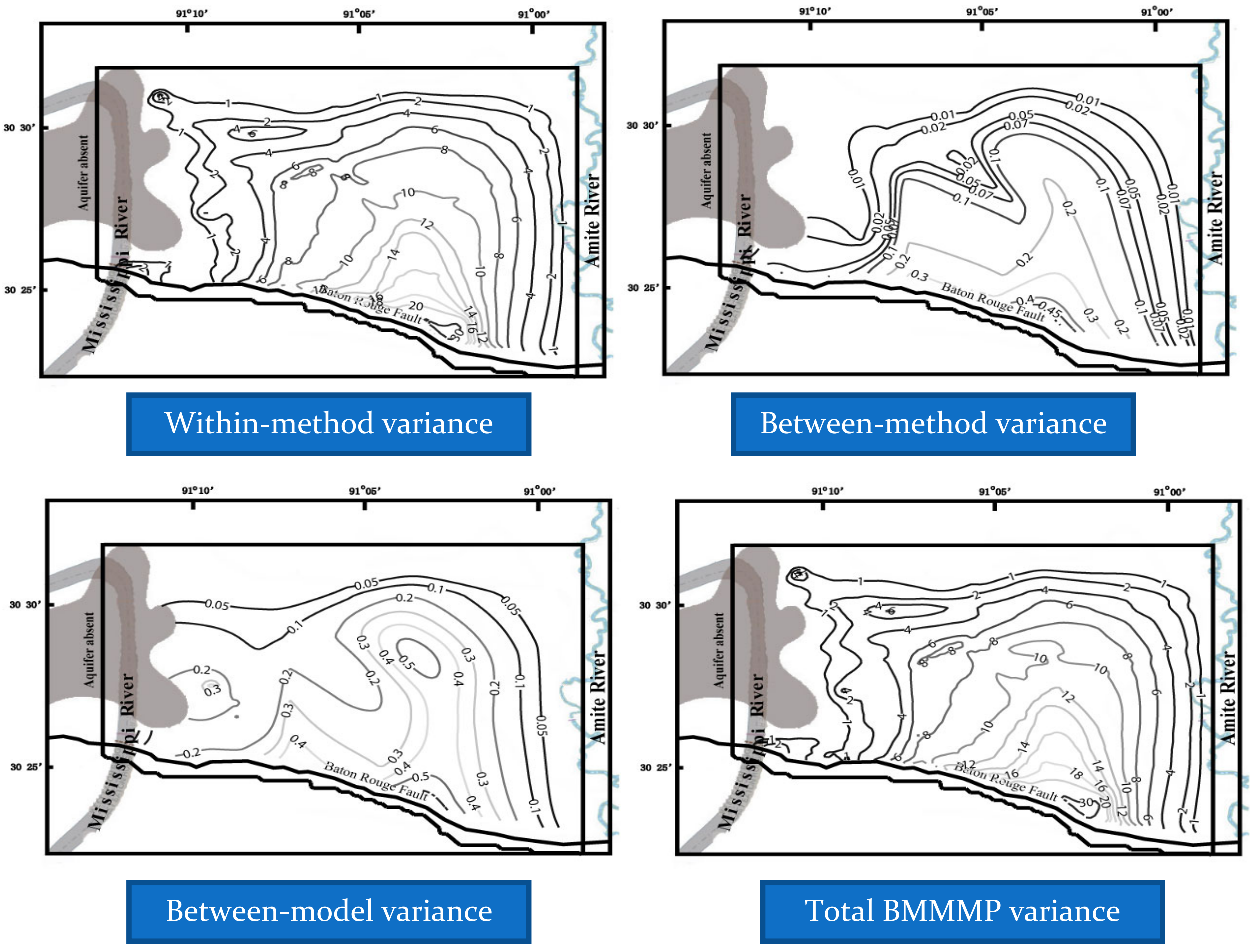


Figure 4: Head prediction variances.

In conclusion, the BMMMP scheme provides a rigorous approach to estimate the head predictions and to evaluate prediction uncertainty by incorporating multiple groundwater models and multiple parameterization methods. This approach can avoid overconfidence in using a single method and a single simulation model and gain more trust in the predicted results.

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Scale−Dependent Behavior and Modeling of Nitrogen Retention in Streams

Basic Information

Title:	Scale−Dependent Behavior and Modeling of Nitrogen Retention in Streams
Project Number:	2007LA50B
Start Date:	3/1/2007
End Date:	2/29/2008
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Congressional District:	06
Research Category:	Water Quality
Focus Category:	Water Quality, Solute Transport, Models
Descriptors:	Nitrogen Retention, Scale−Dependent Behavior, Streams, TMDL
Principal Investigators:	Zhi−Qiang Deng, Donald Dean Adrian

Publication

1. Deng, Z.−Q. and Jung, H.−S. (2008). “Variable Residence Time Based Model for Solute Transport in Streams: Part I. Model Development.” Water Resources Research (in review).
2. Deng, Z.−Q. and Jung, H.−S. (2008). “Variable Residence Time Based Model for Solute Transport in Streams: Part II. Model Application.” Water Resources Research (in review).
3. Deng, Z.−Q. and Jung, H.−S. (2008). “Scaling Dispersion Model for Pollutant Transport in Rivers.” Environmental Modelling and Software (in review).

Scale-Dependent Behavior and Modeling of Nitrogen Retention in Streams

RESEARCH

Problem and Research Objectives

Streams play an important role in retaining and removing nutrients during passage through a stream network. A modeling tool for predicting nitrogen retention and uptake in streams is needed to understand how nitrogen loading from watersheds can be reduced in an efficient and cost-effective way. Although extensive investigations into in-stream nitrogen retention have been conducted, there are few mathematical models which are capable of reproducing nutrient attenuation process in natural streams without resorting to field tracer tests. The primary difficulty of developing such a model lies in the scale-dependent behavior of nutrient removal process in streams.

The overall goal of this project is to develop an efficient and effective mathematical model for predicting scale-dependent nitrogen retention and uptake in natural streams. Specific objectives of this project are therefore (1) to develop a mathematical model (VART) for predicting nitrogen transport and fate in river systems with transient storage zones, (2) to determine parameters involved in the model, (3) to test the model using conservative tracer (Rhodamine WT dye) experiment data and measured nitrogen concentration data, and (4) to apply the VART model to the Amite River, Louisiana.

Methodology

The control volume approach is employed in combination with mass conservation principle for the development of the VART model. In order to include the scale effect on solute transport, two types of transient storage zones, an advection-dominated transient storage zone in upper/shallow sediment layer and a diffusion-dominated transient storage zone (A_{dif}) in lower/deep sediment layer, are introduced in the VART model. The area A_{dif} is scale-dependent and calculable using the equation derived in the new model. The longitudinal dispersion coefficient involved in the VART model is determined using a modified version of the PI's method published in ASCE *Journal of Hydraulic Engineering* (Volume 127(11)). To estimate nitrogen removal in the Amite River hydrological, hydrometeorological, and water quality data for the Amite River were collected from various sources. Daily discharges at Darlington and Denham Springs for the periods of 1980 - 1990 were obtained from U.S. Geological Survey (http://la.water.usgs.gov/). Water quality data were gathered from the Louisiana Department of Environmental Quality. The water quality data included monthly average water temperature and monthly mean concentrations of total Kjeldahl nitrogen (TKN), nitrate-nitrogen (NO_3), dissolved oxygen (DO), and total organic carbon (TOC). The water quality data covered the period of 1980 - 1990 and were measured at the three stations Darlington, Grangeville, and Magnolia along the Amite River, as shown in Figure 1. It should be pointed out that the water quality data were obtained by taking water samples on a monthly basis or taking one sample per month. Therefore, the so called monthly mean concentrations are actually the measurements at the instant when the water samples were taken. In order to find more reasonable monthly mean concentration values for the water quality parameters, HSPF model was used to

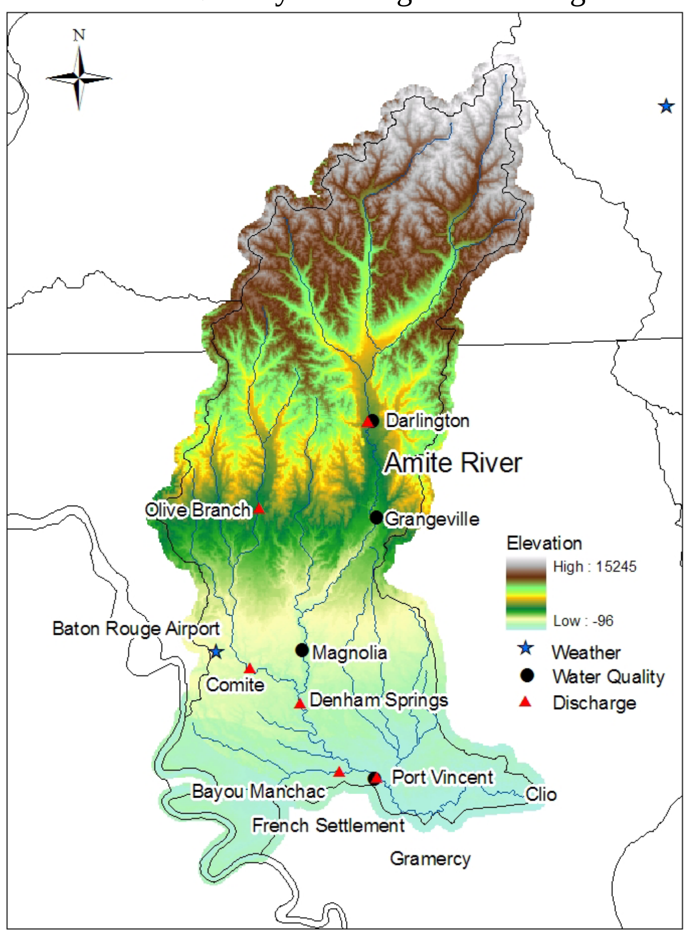


Figure 1. Map of the Amite River watershed.

generate more detailed water quality data for determination of the nitrogen removal rate involved in the VART model.

The HSPF Model, Hydrologic Simulation Program Fortran, is a U.S. EPA program for simulation of watershed hydrology and water quality for both conventional and toxic organic pollutants. The HSPF modeling domain is the Amite River watershed including Darlington, Grangeville, and Magnolia stations. Application of HSPF involves the segmentation of the Amite River watershed, preparation of input data, and model calibration. The sub-watersheds were generated using the delineation tool in BASINS. Sub-watershed delineation and creation of river-reach segments utilized the NED (national elevation dataset) digital elevation model (DEM) for computing watershed boundaries, overland flow-path length and slopes, and stream segment slopes. The national land cover data (NLCD) representing land use type in 1992 was used for the determination of pervious and impervious surface areas and forested areas in each delineated sub-watershed, as shown in Figure 2.

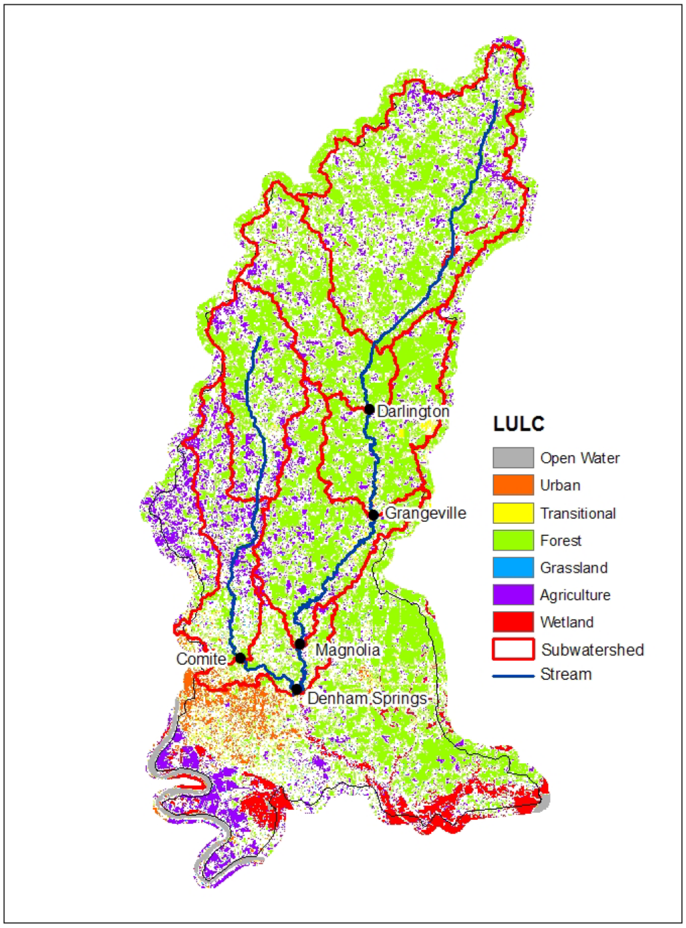


Figure 2. Land use and land cover data and sub-watersheds used in HSPF model

PRINCIPAL FINDINGS AND SIGNIFICANCE

1. Development of VART (Variable Residence Time-based) Model.

$$\frac{\partial C}{\partial t} + U\frac{\partial C}{\partial x} = K_S\frac{\partial^2 C}{\partial x^2} + \frac{A_{adv} + A_{dif}}{A}\frac{1}{T_V}(C_S - C) - kC \quad (1a)$$

$$\frac{\partial C_S}{\partial t} = \frac{1}{T_V}(C - C_S) - kC_S \quad (1b)$$

$$A_{dif} = 4\pi D_S t_S \quad (1c)$$

$$T_V = \begin{cases} T_{\min} & \text{for} \quad t \le T_{\min} \\ t & \text{for} \quad t \ge T_{\min} \end{cases} \quad (T_{min} \ge 0) \quad (1d)$$

$$t_S = \begin{cases} 0 & \text{for} \quad t \le T_{\min} \\ t - T_{\min} & \text{for} \quad t \ge T_{\min} \end{cases} \quad (1e)$$

where C denotes solute concentration; U refers to cross-sectionally averaged flow velocity in x direction; t stands for time; C_S = solute concentration in storage zones; K_S = longitudinal Fickian dispersion coefficient excluding the transient storage effect; k is the first-order decay coefficient for non-conservative solute (NO_3 removal rate in this application); D_S is the effective diffusion coefficient for solute within the sediment/hyporheic zone; and T_V is the actual varying residence time of solute. The parameter T_{min} is the minimum net residence time at which solute starts releasing from the transient storage zone. Due to the adoption of the actual residence time, T_V, there is no need to assume a power-law or exponential or lognormal residence time distribution (RTD), avoiding the use of user-specified RTDs. This is an essential advantage of the VART model over the models requiring user-specified RTDs. The second term on the right hand side of Eq. (1) represents the combined effect of the advection, dominated in the upper bed sediment layer, and the diffusion, dominated in the lower bed sediment layer, on mass exchange between the surface stream flow and subsurface hyporheic flow. The VART model reduces to the widely used transient storage model (TSM) if A_{dif} = 0 and T_V = a constant. The VART model was tested using 181 data sets of tracer experiments conducted on 51 river reaches by USGS. Figure 2 shows comparisons between tracer concentration breakthrough curves simulated using the VART model and observed in a natural stream. The VART model was also compared with three other representative models (TSM, Advective-Storage-Path, and STAMMT-L). Results of the testing and comparisons show that the VART model is a simple yet effective tool for predicting solute dispersion and transport in natural streams and rivers.

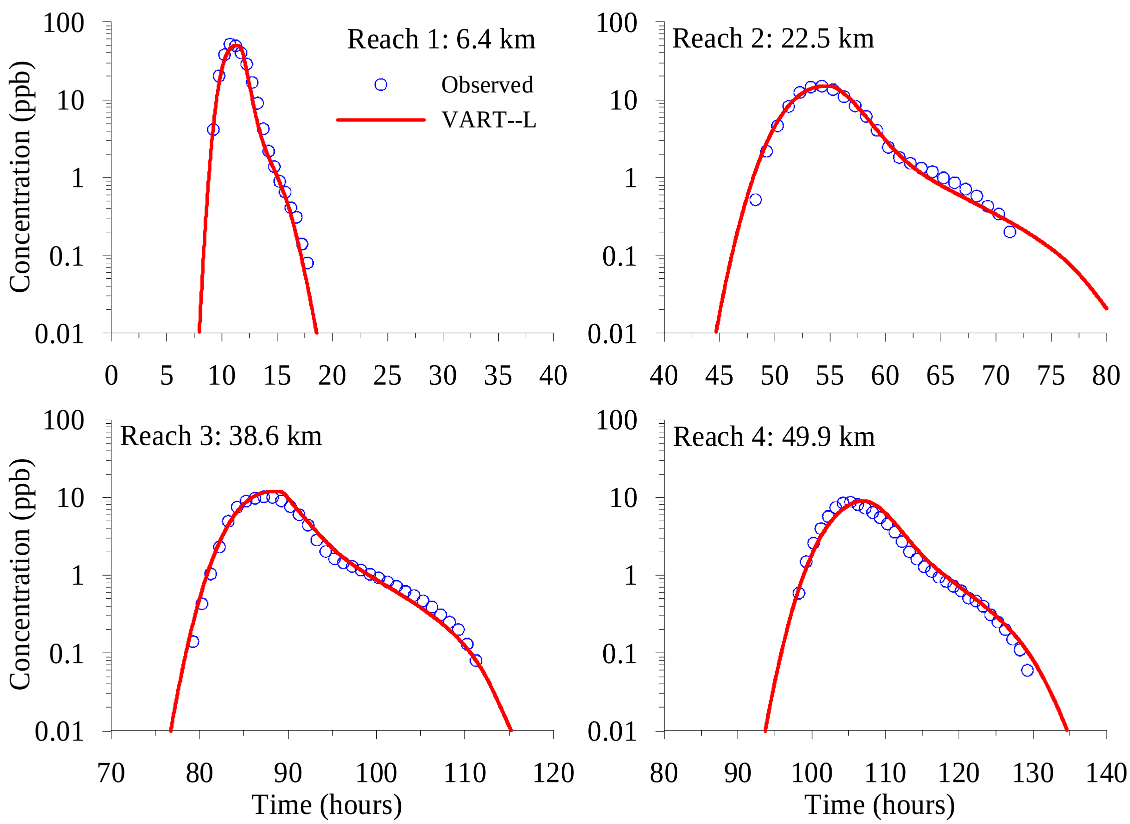


Figure 3. RWT concentration breakthrough curves observed on October 8, 1968 in four sampling reaches in series along the Tickfau River, Louisiana and simulated using the VART model for an instantaneous dye addition.

2. Equation for Estimation of Longitudinal Dispersion Coefficient Ks:

$$\frac{K_S}{Hu_*} = \frac{0.04}{8\varepsilon_{t0}}\left(\frac{B}{H}\right)^{5/3}\left(\frac{U}{u_*}\right)^2 \quad \text{or} \quad \frac{K_S}{Hu_*} = \frac{0.005}{\varepsilon_{t0}}\left(\frac{B}{H}\right)^{5/3}\left(\frac{U}{u_*}\right)^2 \qquad (2)$$

where u_* = shear velocity, ε_{t0} = transverse mixing coefficient, B = surface width of flow, H = cross-sectionally averaged flow depth. The parameter Ks is involved in the VART model.

3. Method for Determination of Nitrate-Nitrogen Removal Rate *k*:

$$k = 0.14\ln(T_W) - 0.28 \qquad (R^2 = 0.82) \qquad (3)$$

where T_W is water temperature. The equation is established based on monthly mean nitrate-nitrogen concentration data and monthly mean water temperature data measured at Darlington, Grangeville, and Magnolia.

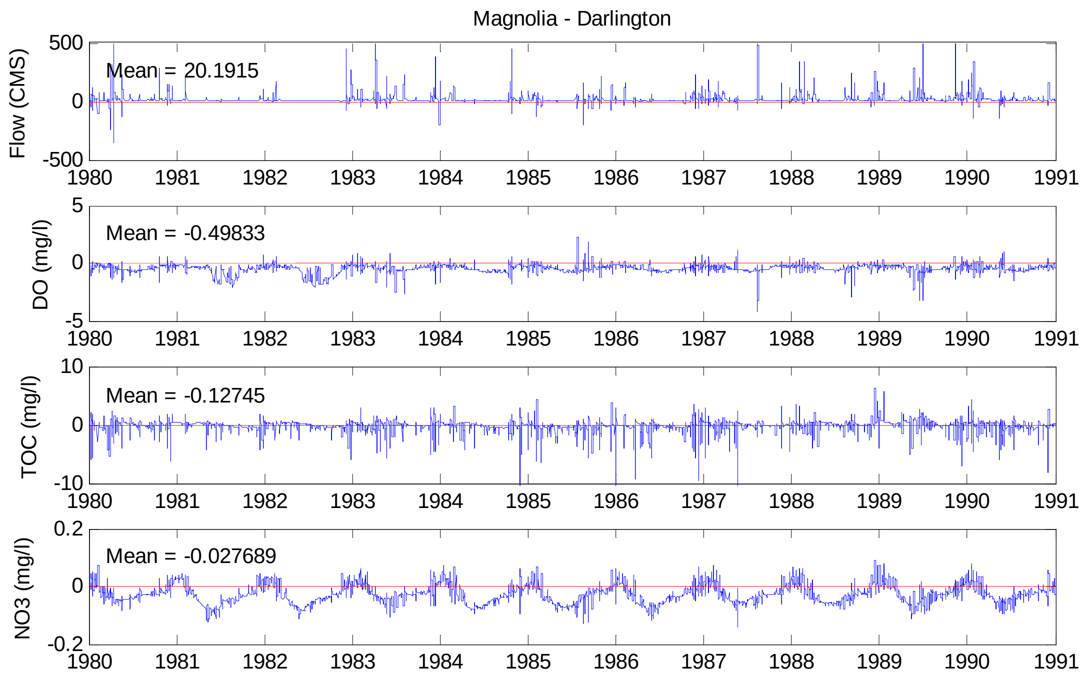


Figure 4. Changes (concentration value at Magnolia - concentration value at Darlington) in flow and water quality parameters (determined using HSPF model) along the Amite River.

Both Eq. (3) and Figure 4 indicate that NO_3 removal is highly temperature-dependent. The highest NO_3 removal occurs in summer and NO_3 removal in winter is negligible. Eq. (3) is the first kinetics equation for description of denitrification in the Amite River watershed. Equation (3) in combination with the VART model provides a useful tool for estimation of seasonal variations in TMDLs and for BMP implementation.

4. Simulated and Measured Variations in Water Temperature and Concentrations of Water Quality Parameters at Darlington and Magnolia:

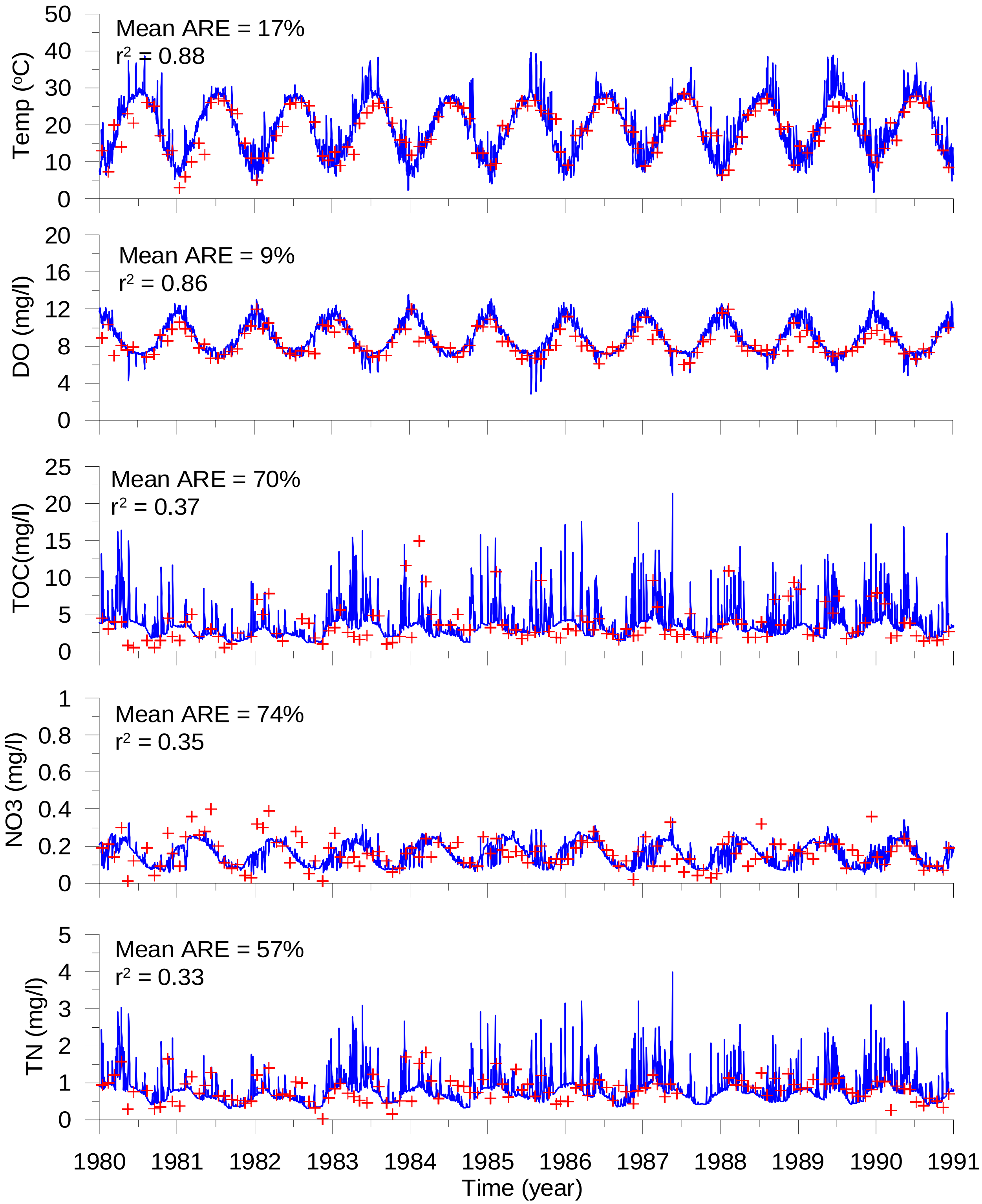


Figure 5a. Seasonal and annual variations in water quality parameters at Darlington.

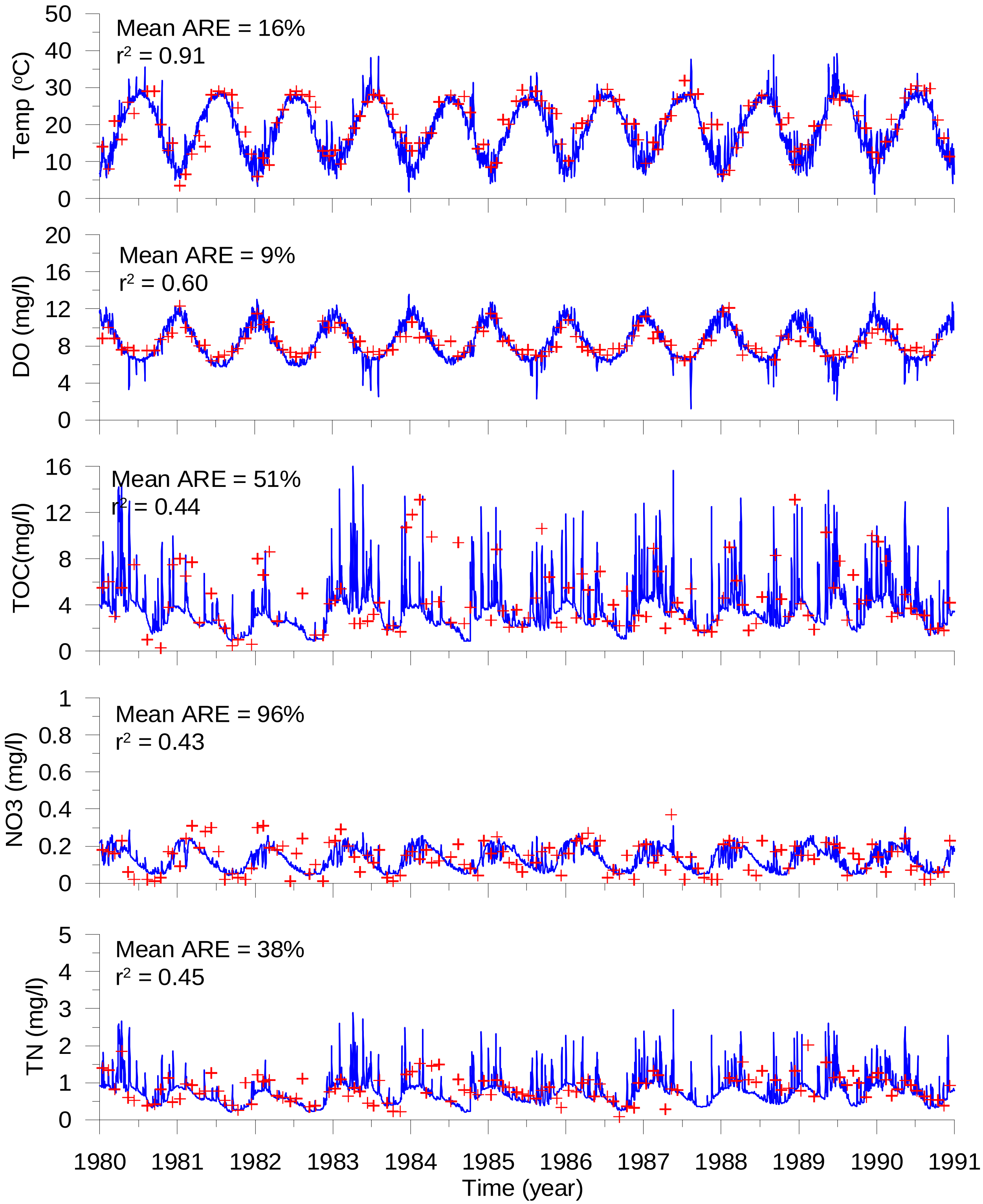
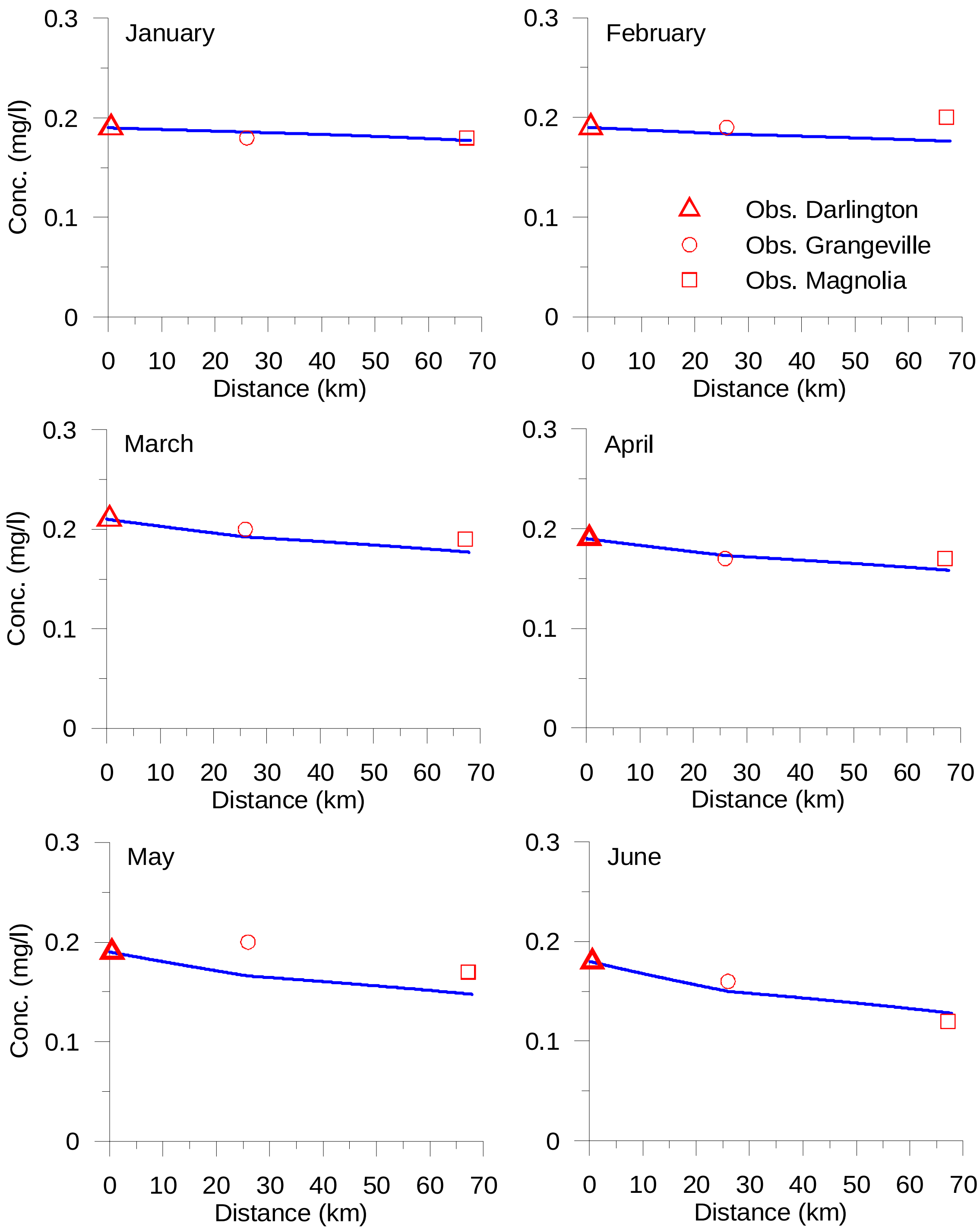


Figure 5b. Seasonal and annual variations in water quality parameters at Magnolia.

The results shown in Figures 5a and 5b were used in the determination of the nitrate-nitrogen removal rate *k*.

5. Spatial (Longitudinal) and Temporal (Seasonal) Variations in NO_3 Concentration in the Amite River.



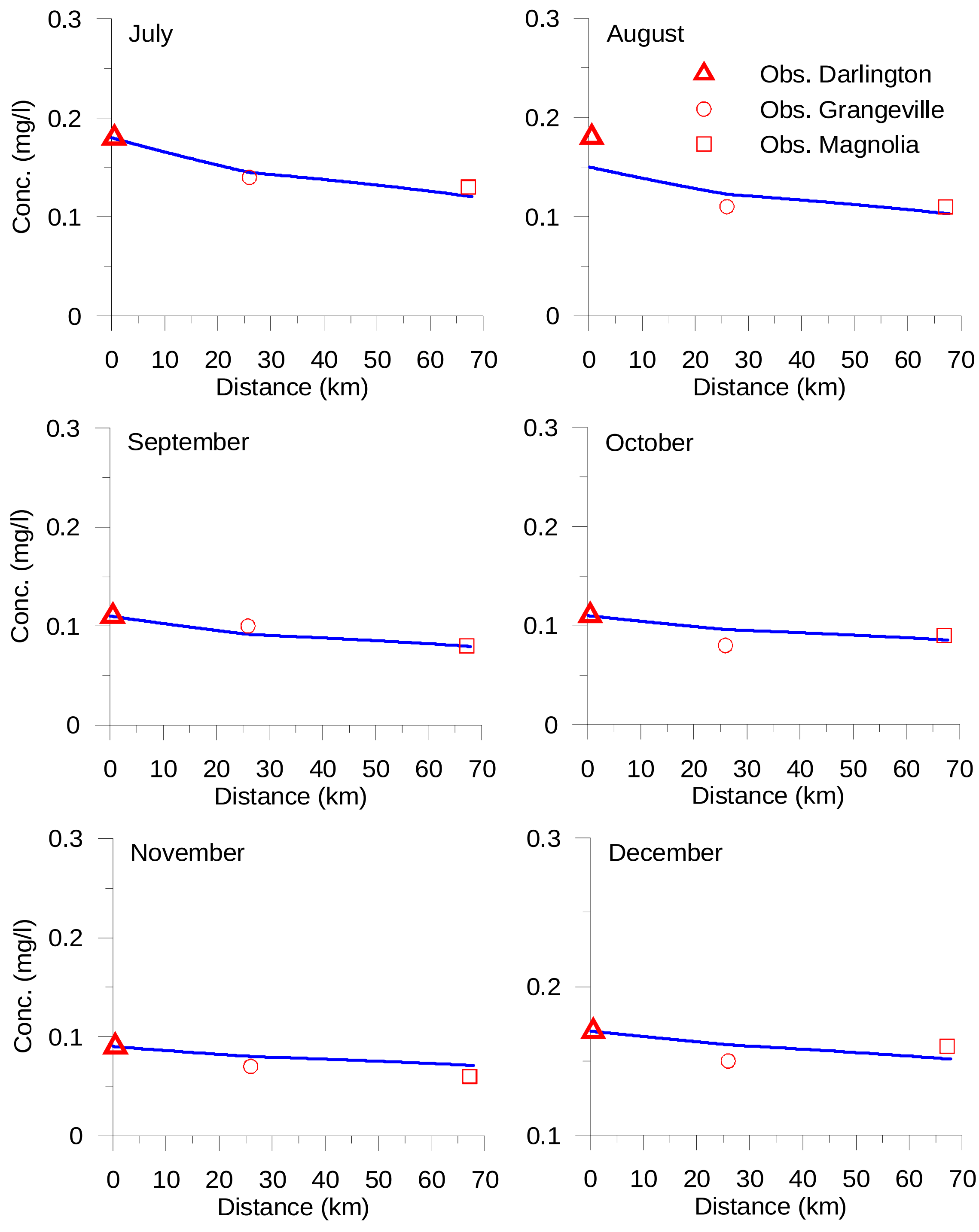


Figure 6. Monthly mean nitrate-nitrogen (NO_3) concentrations predicted using the VART model and measured at Darlington, Grangeville, and Magnolia along the Amite River. The vertical coordinate represents NO_3 concentrations and the horizontal axis denotes the longitudinal distance from Darlington.

This finding will provide useful data for establishment of water quality standard for nitrogen and for watershed restoration.

Discerning nutrient limitations to phytoplankton growth in rivers and bayous on the North shore of Lake Pontchartrain, Louisiana

Basic Information

Title:	Discerning nutrient limitations to phytoplankton growth in rivers and bayous on the North shore of Lake Pontchartrain, Louisiana
Project Number:	2007LA51B
Start Date:	3/1/2007
End Date:	2/29/2008
Funding Source:	104B
Congressional District:	02
Research Category:	Water Quality
Focus Category:	Hydrogeochemistry, Water Quality, Geomorphological Processes
Descriptors:	nitrogen, phosphorus, eutrophication, estuary
Principal Investigators:	Sarah Fearnley

Publication

1. Fearnley, Sarah and Carl Bohling, 2007, Discerning the limiting nutrient to phytoplankton growth in rivers and bayous on the north shore of Lake Pontchartrain “in” Geological Society of America – Abstracts with Programs, Vol 39(6), Geological Society of America, Boulder, Colorado, 427.

A. RESEARCH

SYNOPSIS

Title Discerning nutrient limitations to phytoplankton growth in rivers and bayous on the north shore of Lake Pontchartrain, Louisiana

Problem and Research Objectives

Rapid population growth and development along the north shore of Lake Pontchartrain has resulted in high concentrations of nutrients in surface waters that flow into the lake (Lake Pontchartrain Basin Foundation (LPBF), 2006; Fearnley *et al.*, 2006; Xu and Viosca, 2005). Eutrophication (excess nutrients) ranks among the most pressing water quality problems facing this area (LPBF, 2006) because it can lead to algal blooms (extreme rates of phytoplankton growth), which results in anoxic conditions in the water and can lead to wide spread fish kills. Sources of nutrient contamination to surface waters in the northern Pontchartrain Basin include dairy farm wastes, agricultural fertilizer, and sewage outflow from overburdened sewage treatment plants and from poorly maintained, highly concentrated individual residential septic systems (LPBF, 2006; Fearnley *et al*, 2006; Xu and Viosca, 2005).

In freshwater systems such as most rivers, the total inorganic nitrogen to total inorganic phosphorus (TIN:TIP) ratio is usually greater than 16:1, indicating that phosphorus is the limiting nutrient to phytoplankton growth (Turner *et al.*, 2003 and Kocum *et al.*, 2002). In marine and estuarine systems such as sea water in the Gulf of Mexico or the Lake Pontchartrain Estuary; the TIN:TIP ratio is usually less than 16:1, indicating that nitrogen is the limiting nutrient (Turner *et al.*, 2003 and Kocum *et al.*, 2002). Optimal phytoplankton growth will occur when the ratio of TIN:TIP is exactly 16:1 (Turner *et al.*, 2003).

The objective of this study was to monitor nutrient concentrations in two rivers and four bayous on the Northshore of Lake Pontchartrain to assess the limiting nutrient to phytoplankton growth in these water bodies that drain directly into Lake Pontchartrain.

Methodology

<u>Sample Collection in the Field</u>

Surface water samples from two rivers and four bayous on the north shore of Lake Pontchartrain (Figure 1) were sampled a total of nine times during a one year period from March 2007 to February 2008. Each waterway was sampled at three locations along its course; at the head waters, mid point, and discharge point into Lake Pontchartrain for a total of 18 samples per sampling date. Surface water samples were collected using a fishing rod and reel attached to a sampling device engineered especially for this project (Figure 2).

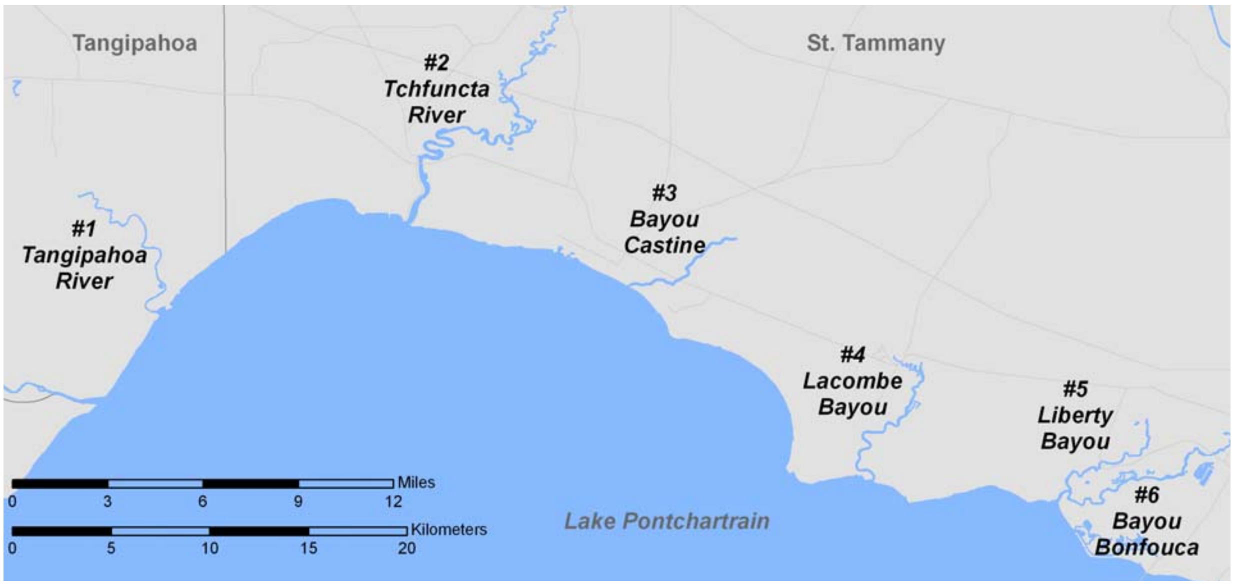


Figure 1: The location of two rivers and four bayous on the north shore of Lake Pontchartrain included in this monitoring project.

A. B.

Figure 2: (A) Surface water sampling device and (B) transferring the sample into bottles to take back to the Geochemistry Laboratory at the University of New Orleans.

Laboratory Analysis

Samples were kept cool until they arrived at the University of New Orleans (UNO) Geochemistry Laboratory for analysis. Samples were filtered and alkalinity measured immediately using standard titration procedures with Hydrochloric acid (HCl). The filtered samples were split into three for measurement of total carbon and nitrogen using a Flash Elemental Analyzer, anions and cations using a Liquid ion Chromatograph (LC). Cation samples were preserved with one drop of concentrated HCl to prevent precipitation prior to analysis using the LC.

Precipitation Data

Daily precipitation data from five locations in St. Tammany parish, Louisiana were downloaded from the website, http://waterdata.usgs.gov/la/nwis/rt, which is maintained by the U.S. Geological Survey (USGS). These data were then averaged to determine the amount of precipitation received in the area for the six week time interval between sampling dates and for six weeks prior to the first sampling date. The total average precipitation for each sampling date was then determined using data from all five recording stations in St. Tammany parish and these data were plotted with the nutrient results to investigate the effect of precipitation on nutrient concentrations in the waterways.

Principal Findings and Significance

Correlation with Precipitation

The nutrient concentrations at all of the sites monitored are highly influenced by precipitation and other anthropogenic activities occurring nearby. Concentrations of ammonium (NH_4^+) and nitrate (NO_3^-) were highly correlated with precipitation (Figures 3 and 4). Concentrations of nitrite and phosphorus were very low at all sites monitored and therefore exhibited little variation to correlate with precipitation.

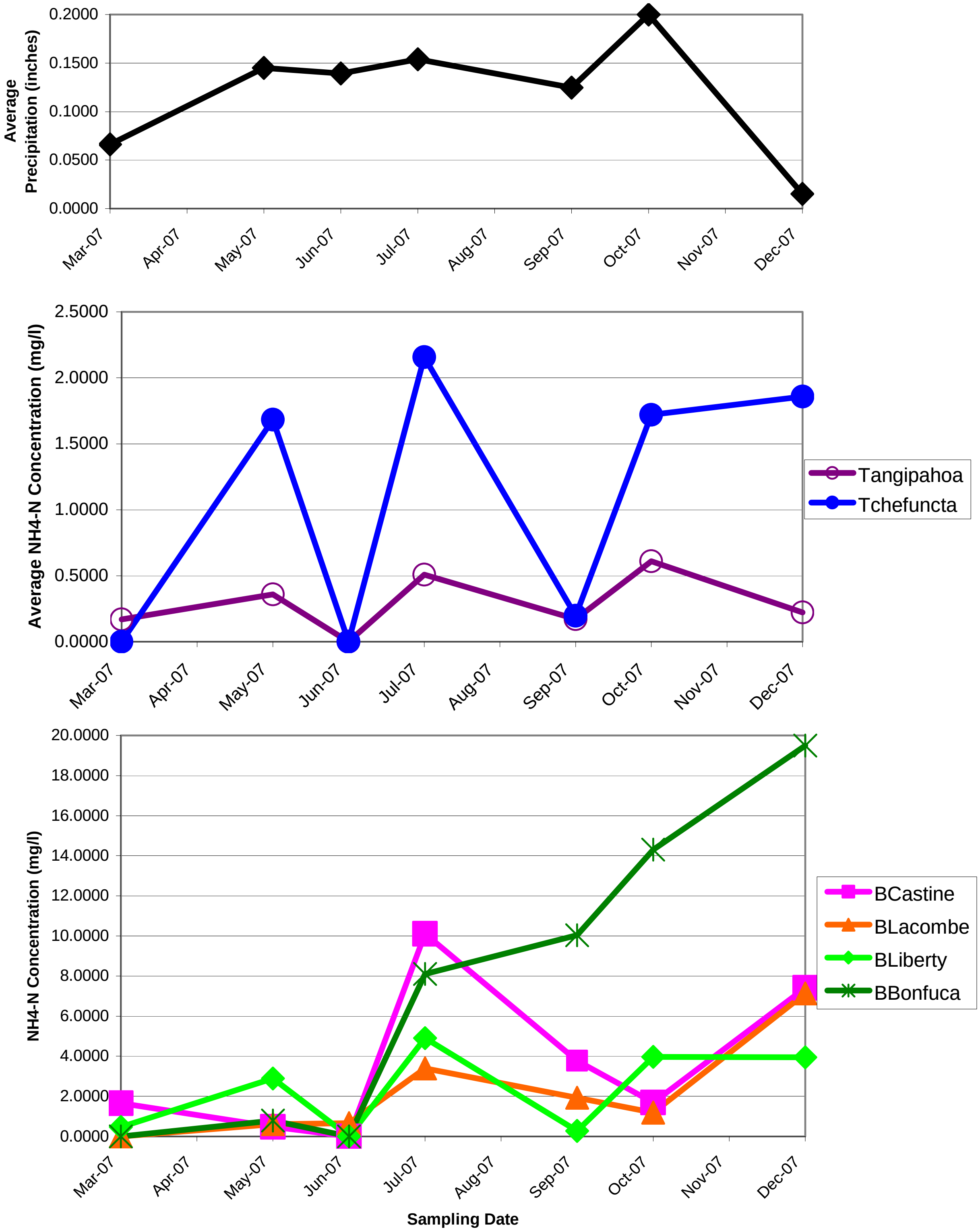


Figure 3: Variations in the average concentrations of ammonium in surface waters, which correlates with variation in precipitation amounts

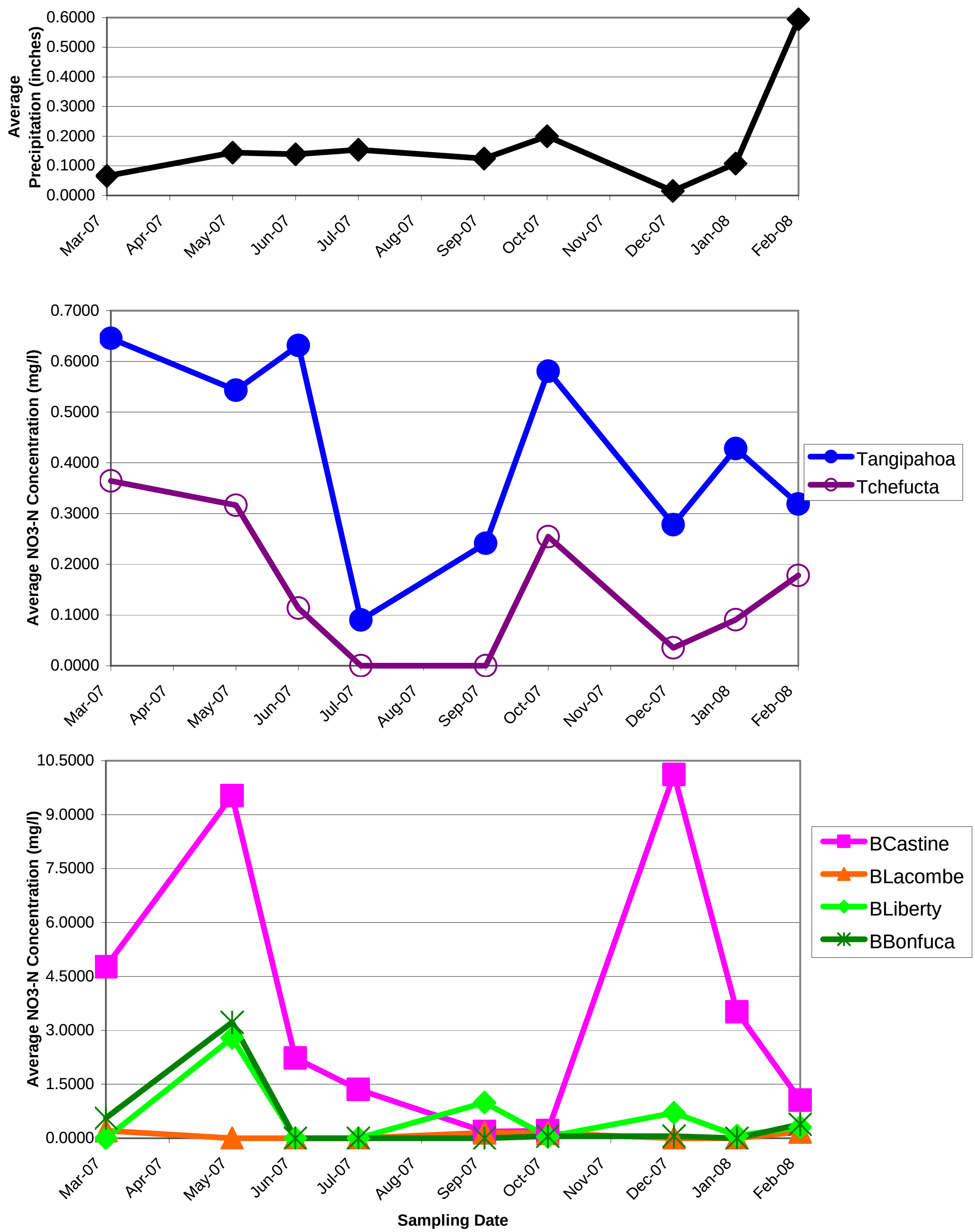


Figure 4: Variations in the average concentrations of nitrate in surface waters, which correlates with variation in precipitation amounts

The correlation of high concentrations of inorganic nitrogen with heavy precipitation indicates that the source of the nitrogen is likely outside of the waterbody's normal, daily drainage area and is being swept in during high rainfall events. In St. Tammany parish, roadside drainage ditches collect runoff from urban areas, as well as septic effluent in neighborhoods that employ individual residential septic systems, and drain into larger waterways, such as those monitored during this project, that eventually drain into Lake Pontchartrain. During high rainfall events two sources of nitrogen are evident. Nitrogen from urban non point sources is transferred with runoff into the roadside drainage ditches and then into the waterways. Nitrogen collecting in the ditches during low flow conditions is also transferred into the waterways during high flow events. Fearnley *et al.* (2006) established extremely high concentrations of nitrogen in roadside drainage ditches in St. Tammany parish, especially in neighborhoods employing individual residential septic systems.

Concentrations of phosphorus further substantiate that nutrient concentrations in the waterways are correlated with precipitation and thus urban sources from which nutrients are transferred to the waterway during high rainfall events. Phosphorus was detected in October at the northern Tangipahoa and Tchefuncta sites during a period of high precipitation. This was the only time phosphorus was detected in these waterways.

Limiting Nutrient to Phytoplankton Growth

All six of the waterways monitored are phosphorus limited at all times of the year. The Tangipahoa and Tchefuncta Rivers are large freshwater bodies and are expectedly low in phosphorus. The four bayous however, are tidally influenced and much more brackish especially at their southern sites near Lake Pontchartrain. Nitrogen is typically the limiting nutrient to growth in brackish and salt water environments such as Lake Pontchartrain (Turner *et al.,* 2003 and Kocum *et al.,* 2002). In the four bayous monitored, nitrogen has become so plentiful despite the brackish environment that growth has flourished until very little phosphorus remains in the environment. Nitrogen is still available and phosphorus has become the limiting nutrient to growth.

Influence of nearby Urban Activities-Bayou Castine Example

Bayou Castine is a small bayou that runs through highly urbanized residential neighborhoods near the city of Mandeville in St. Tammany parish, Louisiana. The neighborhood surrounding the northern most sampling site is completely dependant on individual residential septic systems for sewage treatment. Effluent from the septic systems drains into the roadside ditches (Figure 5A), which empty into Bayou Castine via a long ditch beside a dirt trail and semi-wooded area (Figure 5B).

A. **B**.

Figure 5: (A) A roadside drainage ditch in the nearby neighborhood depicting a pipe that transfers sewage effluent from the individual residential septic system on private property to the ditch and (B) the drainage ditch that transfers runoff from neighborhood roadside drainage ditches directly into Bayou Castine.

The St. Tammany parish government is responsible for maintaining the functionality of the ditch that drains runoff into Bayou Castine and had recently dredged the area to restore flow prior to the December sampling date. The concentrations of phosphorus, NO_3^-, and NH_4^+ are elevated at both the north and mid Bayou Castine sites during December and January and begin to return to previous concentrations by February. It is likely the high concentrations are the result of the dredging activity and subsequent increase in runoff received from the neighborhood. These results indicate that the recovery period for nutrient loading into Bayou Castine is approximately twelve weeks.

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Information Transfer Program Introduction

One of the Institute's objectives is to make research results available to the general public and to interested researchers and institutions through publications and other information transfer activities. Although the information transfer component of the program budget of Section 104 funds is relatively small (10%), LWRRI attempts to meet this goal in many ways which include actively participating in conferences and workshops, distributing summaries and other Institute information to the public and governmental agencies, maintaining internet access and web sites, and maintaining a library of water research materials. In addition to the program budget, LWRRI was funded for project 2007LA52B – Information Transfer Symposium: Mitigation of Storm Surge Using Vegetation (Spring 2007) and Resilient Environmental Infrastructure for Coastal Communities (Fall 2007). The Institute requests that its investigators participate in reporting and information transfer activities such as publications in professional journals, workshops, and seminars.

The Institute's information transfer program is a subset of its administration program. Assisting with LWRRI's information transfer activities is one undergraduate student worker, and two program coordinators (part−time LWRRI support), and one research associate (half−time LWRRI support). Two research associates are also available to assist in information transfer activities of the Institute. The Director, Dr. John Pardue, attends the annual National Institutes of Water Resources meetings in Washington, D.C., to discuss Institute and Program activities.

Further assisting in information transfer, the Engineering Incubation Research Center (EIRC) has given LWRRI access to image processing, GIS, and computing systems. This access provides the Institute with the necessary tools to transfer information in visual graphic format, utilize Internet resources, and develop state−of−the−art presentations. Because of the Institute's expanding development, more emphasis is being placed on updating the public and other organizations about activities and objectives using electronic media and presentation tools.

The Institute's staff continues to maintain emphasis on acquainting Louisiana's research community with the research−funding opportunities through the U.S. Geological Survey Section 104 research program. 104 G program announcements, Mississippi SE−TAC RFPs, and Section 104 RFPs were widely distributed: 250 email addresses, 250 regular mail addresses, and 150 email addresses on the user−subscribed list, totaling 650. We also distributed the RFP through the USGS newsletter and to Louisiana colleges and universities and to research organizations throughout the state. In addition, public announcements were made at professional and faculty meetings to encourage wide participation in the program. We send out notifications of meeting and events for the American Water Resources Association, The Capital Area Ground Water Conservation Committee, and the Louisiana Rural Water Association.

Research grants FY 2007−08 technical transfer. *Project 2007LA51B*, Fearnley − Results from this project will be incorporated with other St. Tammany parish water quality data, unpublished and collected by the primary investigator and transferred to both the St. Tammany Parish Government and the greater scientific community. The Parish will receive an easy to understand brochure that can be used to inform the public of pressing water quality issues in their area. The scientific community will be informed through publication of these data in a scientific journal, such as Water, Air, and Soil Pollution. A manuscript for submission is currently being prepared by the primary investigator. The local scientific community will be further informed through the completion of Mr. Bohling's MS thesis and defense. *Project 200750B*, Deng − The VART model along with the findings and methods for estimation of nitrogen removal rate and other parameters will be transferred to the Louisiana Department of Environmental Quality for applications in TMDL developments and stream restoration.

Other Information Dissemination Activities

1. Dissemination of Requests for Proposals for the following Programs:
    - ♦ CREST Request for Proposal
    - ♦ Request for Proposal for the Southeastern
    - ♦ Regional Small Public Water Systems
2. Technical Assistance Center (SE TAC)
    - ♦ BTNEP Mini Grants Program Request for Proposal
3. Dissemination of Information:
    - ♦ Breaux Act Newsflash
    - ♦ LWRRI PEER REVIEWED PUBLICATIONS

• LWRRI Digital Water Resources Archive • LSU Hurricane Center Seminars • Wiki for research collaboration

Collaboration with major university research initiatives. LWRRI have collaborated extensively with other campus research centers during this cycle. These have led to other funded centers and center proposals. Through these activities we have continued to leverage our resources by collaborating with other faculty. These collaborations include a Biotechnology Center (funding from Governor's Biotechnology initiative) within HSRC (use of molecular techniques for microbial community structure analysis), the Heath Excellence Fund Public Heath Effects of Hurricanes center (chemical transport following a major hurricane), LSU School of the Coast and the LSU Department of Geography &Anthropology with ConRuhr (Transatlantic Water Symposium), and the LSU Hurricane Center (Louisiana Levee School initiative with LA DNR &LA DOTD).

In addition, our organization is contacted regularly with various questions for the public and/or private sector concerning water issues; we try to connect these people with the proper experts within our organization and the broader academic community. We have built a comprehensive web portal LAWATER.com in conjunction with the LWRRI web site to help facilitate this effort.

LAWATER and electronic publication project. Two outreach projects that we would particularly like to highlight is the development of the LAWATER web portal for Louisiana water issues (www.lawater.lsu.edu) and the digital document library within LWRRI. The web portal LAWATER was designed as a comprehensive collection of web−based information on water issues within Louisiana. It captures information not only from the Institute but collects the rich content developed by USGS, EPA, DEQ, FEMA and others into one location. The portal is divided into several sections emphasizing 4 major issues: water quality, water supply, hazards and flooding and coastal restoration. While only in existence a little over two years, the web portal is being utilized in Louisiana's water community. In addition to LAWATER, we have been active archiving our past research products. LWRRI is one of the oldest research institutes on campus (founded in 1964). The collection of research products funded by the Institute date is in paper versions that are vulnerable to age and not accessible to the public. We have been scanning all of the documents produced by the institute into electronic archived versions for preservation and for any interested researchers to access (http://www.lwrri.lsu.edu/dwaterlibrary.htm).

Under the direction of our director, the Institute has developed a branding symbol for all of the information transfer activities and publications and is reconstituting the newsletter. Our annual report is housed at the Louisiana State Archives, Hill Memorial Library at LSU, and is available online at the Institute's web site.

In response to the focused RFP for the 2007−2008 solicitations, we received 7 new proposals and funded 3 of those after advisory board review. The theme, selected in consultation with faculty and advisory board members, is focused on resiliency of community water supplies in Louisiana's coastal zone, storm surge in the Louisiana coastal zone, adaptive management of Louisiana's water resources, total maximum daily load (TMDL) calculations in Louisiana water bodies, and scale−dependent behavior of hydrologic and water quality parameters. Also one has been continued until 2009 for the 104G program; which focuses on groundwater flow and transport.

NIWR−USGS Student Internship Program

The Louisiana Water Resources Research Institute did not have any students in the formal NIWR−USGS Intern Program during this reporting period. The Institute maintains both formal and informal relationships with the Baton Rouge office through part time employment of students not in the intern program, and the USGS District Chief serves on the Institute Advisory Board.

Information Transfer Symposia: Mitigation of Storm Surge using Vegetation (Spring, 2007) and Resilient Environmental Infrastructure for Coastal Communities (Fall, 2007)

Basic Information

Title:	Information Transfer Symposia: Mitigation of Storm Surge using Vegetation (Spring, 2007) and Resilient Environmental Infrastructure for Coastal Communities (Fall, 2007)
Project Number:	2007LA52B
Start Date:	3/1/2007
End Date:	2/29/2008
Funding Source:	104B
Congressional District:	06
Research Category:	Not Applicable
Focus Category:	Education, Management and Planning, Methods
Descriptors:	None
Principal Investigators:	John Pardue, Nedra Davis Korevec

Publication

Title. Information Transfer Symposia: *Mitigation of Storm Surge using Vegetation* (Spring, 2007) and *Resilient Environmental Infrastructure for Coastal Communities* (Fall, 2007).

Problem and Research Objectives

The Louisiana Water Resources Research Institute made a concerted effort in the 2007/2008 funding cycle to improve and expand outreach efforts to increase visibility in the Louisiana water/environmental community. In Louisiana, limited opportunities exist for exchange between university water scientists, state and federal agencies over water issues. A state “water” conference or summit has not been organized and only the state environmental agency, the Louisiana Department of Environmental Quality, sponsors a scientific/policy conference on environmental issues, some of which involve water. After discussions with the advisory board, the Institute thought this could best be accomplished by sponsoring 2, 1 –day symposia/workshops to focus on a specific science/engineering issue important to the state. The initial proposal included one symposium that would be conducted in the Spring and one in the Fall to different target audiences on different topics. The 2 topics selected for this funding cycles were: *Mitigation of Storm Surge using Vegetation* (Spring, 2007) and *Resilient Environmental Infrastructure for Coastal Communities* (Fall, 2007).

The Spring symposium held April 13, 2007 addressed an important issue to state and federal coastal planners. Following the Hurricane season of 2005, Louisiana’s coastal restoration focus was altered to consider the effect of wetlands on hurricane storm surge. This was modeled around a similar conference organized by the Maryland Water Resources Research Institute that the Louisiana director participated in during 2006. The Spring symposium addressed Louisiana’s coastal restoration and the effect of wetlands on hurricane storm surge. Wetland vegetation can help protect coastal communities by dampening waves and by the frictional resistance of the plants, themselves, reducing the energy and depth of the water. Hydraulic engineers have studied the flow through vegetation for many years, in the context of overbank flooding, but connecting these approaches with coastal restoration scientists is needed. Key scientific questions include: What are the appropriate quantitative procedures for frictional resistance and wave dampening of different wetland types? What types of wetlands provide ability to mitigate surge?

The Fall symposium was scheduled to address resilient water and wastewater infrastructure for coastal communities but a few key speakers were not available and it was decided to delay the symposium until they could be present. Instead, LWRRI had the opportunity to be a main sponsor for an international water meeting (*Transatlantic Water Symposium: Water, Friend or Foe*) between US scientists and those from the Ruhr area of Germany under the umbrella of an organization which pools University resources in the region, ConRuhr. A scientist group from this region traveled to LSU and a formal symposium was held in addition to wide ranging talks on water issues between the 2 countries. The Rhien-Ruhr region shares features with areas of our state in that water resources are developed and managed against a backdrop of a heavy industrialized corridor with competing needs for the water. Both areas also have extensive flooding issues and accompanying flood control issues.

Methodology

The format of each symposia was different. For the Spring vegetation symposia, nationally recognized experts to speak and interact with university, state agency and federal agency scientists. A round-table discussion was conducted. Because of lack of availability of on-campus conference venues, the Spring Symposium was held off-campus at a conference facility. Participants were asked to register via the LWRRI website. The URL was and is still available for viewing the tech transfer material http://www.lwrri.lsu.edu/MSSV07.htm. For the transatlantic symposium a group of invited German and US scientists gather at LSU for the conference.

Principal Findings and Significance

Conference 1 “Mitigating Storm Surge with Vegetation”. April, 2007.

LWRRI was the lead sponsor, "Mitigating Storm Surge with Vegetation Symposium" Hilton Baton Rouge Capitol Center Hotel, April 2007. LWRRI presented two keynote speakers, Heidi Nepf from MIT, and Robert Kadlec from the University of Michigan. The symposium was moderated by our Director, John Pardue. In addition, LWRRI provided administrative support for the coordination and production of the two-day symposium. The symposium was co-sponsored with URS, The LSU Department of Civil & Environmental Engineering, and the LSU Center for the Study of Public Health Impacts of Hurricanes. The symposium was attended by 125 people and generated discussion, post-conference feedback and generated substantial impetus to the science of understanding natural methods of mitigating storm surge. Details of the agenda and links to many of the presentations are presented below.

Invited Speakers:
Dr. Heidi Nepf, Professor, Department of Civil & Environmental Engineering, MIT
Dr. Robert Kadlec, Emeritus Professor, University of Michigan
Agenda: Mitigating Storm Surge with Vegetation Symposium Agenda [PDF].
Location: Hilton Baton Rouge Capitol Center Hotel, April 13, 2007, 8:00 AM-3:00 PM
Technical Transfer from Symposium: Download presentation files below.

Keynote Speaker, **Heidi Nepf**, MIT
Drag Associated with Emergent and Submerged Vegetation
Download full presentation: [PDF] 22MB

Keynote Speaker, **Robert Kadlec**, University of Michigan
Overland Flow in Treatment Wetlands

Ty Wamsley, USACE, ERDC
Modeling Storm Surge Propagation over Vegetated Landscape Features

Jim Chen, LSU
Wave Dampening by Vegetation

Bob Jacobsen, URS,
Incorporating friction resistance into diversion modeling
Download full presentation: [PPT] 104MB

Hassan Mashriqui, LSU
Incorporating vegetation effects into ADCIRC surge modeling

Joe Suhayda, LSU
Integrating science into Louisiana's Coastal
Download full presentation: [PPT] 4MB

Due to scheduling conflicts, the second symposium, **Resilient Environmental Infrastructure for Coastal Communities (Fall 2007)** is being rescheduled for the Fall 2008. LWRRI was subsequently co-sponsored another equally beneficial symposium with ConRuhr: March 31-April 1, 2008 at Louisiana State University, Baton Rouge after obtaining permission from USGS. The **TransAtlantic Water Symposium** was a 2-day Symposium organized by ConRuhr, the Center for Microscale Ecosystems, University of Duisburg-Essen, Germany, and Louisiana State University (LWRRI, LSU Department of Geography & Anthropology and the LSU School of the Coast). In addition, LWRRI provided administrative support for the coordination and production of the two-day symposium. It gathered leading thinkers from both sides of the Atlantic to exchange research and develop new initiatives.

On this website [http://www.uni-due.de/zmu/watersymposium/] you can download information and the talks which were presented at the conference. ConRuhr will add more to this site soon and extend it to an information platform for transatlantic research exchange.

Technical Transfer from TransAtlantic Water Symposium: Download presentation files below.

» Session 1

Fate of Organics during Soil Aquifer Treatment
David M. Quanrud, *Jianmin Zhang, Matt Tomanek,*
Robert G. Arnold, Wendell P. Ela, A. Eduardo Sáez
The University of Arizona
Download full presentation: presentation (pdf, 1.1mb)

Biological hydrogen production as a new source of energy for waste water treatment plants
T. Mietzel, *R. Widmann*
Universität Duisburg-Essen
Download full presentation: presentation (pdf, 750kb)

Wastewater treatment: Status and future in America, from environmental protection to resource recovery

Eberhard Morgenroth
Department of Civil and Environmental Engineering and Department of Animal Sciences

University of Illinois at Urbana-Champaign
Download full presentation: presentation (pdf, 3.6mb)

» Session 2

Chemical indicators of water quality
***Torsten C. Schmidt**1,2 and Ulrich Borchers2*
1 University Duisburg-Essen
2 IWW Water Centre, Moritzstr. 26, D-45476 Muelheim, Germany
Download full presentation: presentation (pdf, 450kb)

Investigations of occurrence and elimination of hazardous compounds in waste water treatment plants
***Michael Spiteller**, Sebastian Zuehlke1*
Christoph B. Hannich, Thomas Ries2
1 Technical University of Dortmund
2 Deutsche Projekt Union GmbH, Cologne, Germany
Download full presentation: presentation (pdf, 2.1mb)

Emerging Contaminants in the Environment
***Dana W. Kolpin**1, Edward T. Furlong2, Michael T. Meyer3, Larry, B. Barber4, Mark R. Burkhardt2, Steven D. Zaugg2, Vicki Blazer5*
1U.S. Geological Survey, Iowa City, IA 52244
2U.S. Geological Survey, National Water Quality Lab, Denver, CO 80225
3U.S. Geological Survey, Lawrence, KS 66049
4U.S. Geological Survey, Boulder, CO 80303
5U.S. Geological Survey, National Fish Health Research Lab, Kearneysville, WV 25430
. Download full presentation: presentation (pdf, 3.5mb)

Environmental Impacts of Chemicals in Urban Floods: Katrina's lessons for other coastal cities
John H Pardue
Louisiana State University, Baton Rouge Louisiana.
Download full presentation: presentation (pdf, 3.6mb)

» Session 3

Water and biofilms
Hans-Curt Flemming
University of Duisburg-Essen
Download full presentation: presentation (pdf, 2.5mb)

Challenges of Membrane Treatment Processes: Biofouling and Other Issues

Harry F. Ridgway
AquaMem Scientific Consultants, Rodeo, New Mexico, USA
Dept. of Civil & Environmental Engineering, Stanford University
Download full presentation: presentation (pdf, 6.1mb)

EPS: An Elusive Refuge for Bacteria in Water Systems
Alan W. Decho,
University of South Carolina
Download full presentation: presentation (pdf, 1.4mb)
» Session 4

Parasites as bioindicators in aquatic ecosystems
Bernd Sures
University of Duisburg-Essen
Download full presentation: (pdf, 1.7mb)

Effects of a hurricane on fish parasites
Robin M. Overstreet
The University of Southern Mississippi
Download full presentation: presentation (pdf, 4.6mb)

Challenges of Using Unconventional Water Resources in the Arid West
Tzahi Y. Cath and Jörg E. Drewes
Colorado School of Mines
Division of Environmental Science and Engineering
Download full presentation: presentation (pdf, 6.1mb)

» Keynote speeches

Opening remarks by *Dr. Rolf Kinne*,
Director of ConRuhr USA
Introduction (pdf, 85kb)

Europe's challenge; A transition towards an ecosystem based water management- learning how to enjoy the river ("Freude am Fluss").
Toine Smits
Radboud University of Nijmegen, NL
Download full presentation: presentation (pdf, 6.4mb)

America's Challenge: Two Hundred Years of River Management
Craig E. Colten
Louisiana State University
Download full presentation: presentation (pdf, 7mb)

USGS Summer Intern Program

None.

Notable Awards and Achievements

External Activities. LWRRI has been involved in several external activities directed at improving the Institute's presence.

- LWRRI has been active with NIWR in the yearly efforts to maintain the 104 funding within USGS's budget. Under the current administration, the President's budget has allocated no funding for the water institute's program. Every year, however, the Institutes' have been able to restore funding by working with their congressional delegations. We have been active informing the Louisiana delegation about the benefits of the program and we have obtained legislative support for our efforts. This culminated in the passage of the Water Resources Research Act Amendments of 2004 (S. 1017) in the Senate in Fall, 2005. The bill was cosponsored by Senator Vitter and it continues the state's institutes program for the next 5 years and plans to double the funds allocated to each institute. Both Sen. Vitter and Landrieu signed the recent “Dear Colleague” letter supporting restoration of funding to the program.

    ◊ The Director, Dr. John Pardue, was invited by the LSU Hurricane Center to participate and lead a breakout group in the preliminary program development for the Louisiana Levee School. In addition, LWRRI provided administrative support for the coordination and production of the two−day LA Levee School Planning meeting. LWRRI will continue to work with the LSU Hurricane Center on this important effort to establish a world class Center of Excellence for flood protection and coastal restoration. DNR and DOTD's support for the program showcased the State's dedication to coastal protection and restoration.

    ◊ LWRRI was the lead sponsor, "Mitigating Storm Surge with Vegetation Symposium" Hilton Baton Rouge Capitol Center Hotel, April 2007. LWRRI presented two keynote speakers, Heidi Nepf from MIT, and Robert Kadlec from the University of Michigan. The symposium was moderated by our Director, John Pardue. In addition, LWRRI provided administrative support for the coordination and production of the two−day symposium. The symposium was co−sponsored with URS, The LSU Department of Civil &Environmental Engineering, and the LSU Center for the Study of Public Health Impacts of Hurricanes. LWRRI will continue to work to integrate science into Louisiana's Coastal Plan.

    ◊ LWRRI was the co−sponsor for the "LSRC Training One Day Workshop" held in Baton Rouge, Metairie, Lake Charles, Houma, Covington, &Lafayette, March April 2007. LWRRI provided administrative support for the coordination and production of the six one−day workshops. The primary sponsor was the LSU Center for GeoInformatics.

    ◊ The Director, Dr. John Pardue, was invited by the ConRuhr, , the Center for Microscale Ecosystems, University of Duisburg−Essen, Germany, LSU Department of Geography &Anthropology and the LSU School of the Coast to co−sponsor and lead a session in the 2−day Symposium: TransAtlantic Water Symposium. In addition, LWRRI provided administrative support for the coordination and production of the two−day symposium. It has gathered leading thinkers from both sides of the Atlantic to exchange research and develop new initiatives at the LSU Lod Cook Alumni Center March 31− April 1, 2008.

◊ The Director, John Pardue led an effort as PI at LSU to develop a proposal for a Department of Homeland Security Center of Excellence in the area of natural hazards, coastal infrastructure and emergency management. This built upon LWRRI's leadership in storm surge modeling, hurricane response and the environmental impacts of hurricanes. The proposal was selected as a finalist and ultimately the public policy and evacuation projects within the LSU−led Center proposal were selected for funding in the new DHS Center co−lead by University of North Carolina and Jackson State. LSU will be a full partner in the Center and LWRRI's contribution to that funding was invaluable.

◊ The Director, John Pardue, has led the formation of a Coastal and Ecological Engineering degree program at LSU. The letter of intent was submitted this cycle and a proposal is in preparation.

◊ Dr. Pardue was named one of LSU's Distinguished Faculty members in 2006−2007 for his contributions in research, teaching and service.

◊ Project 2007LA51B – Dr. Sarah Fearnley reports that the most notable achievement accomplished through this work, besides the scientific contribution, is that Mr. Carl Bohling has decided to use the data collected and analyzed through this project as subject matter for his thesis to complete an MS degree in Geology from UNO.

◊ Follow−on funding for project 2006LA47B was garnered by Dr. Zhiqiang Deng. Title: Characterization of Nitrogen Retention in Louisiana Coastal Rivers (under review)

PI: Zhiqiang Deng

Agency: Louisiana Sea Grant

Program: Louisiana Sea Grant College Program

Duration: 02/2008 – 01/2010

Amount: $139,495

◊ Follow−on funding for project 2007LA50B was garnered by Dr. Zhiqiang Deng.

Title: Development of Ex−situ Sensor System for Water Quality Monitoring
PI: Zhi−Qiang Deng
Agency: Louisiana Board of Regents
Duration: 08/2008 – 07/2012
Amount: $100,000

Dr. Pardue's funded grants as a result of his work in the water resources area:

1. “Assessment &Remediation of public health impacts due to Hurricanes and major flooding events” Louisiana Millennium Health Excellence Fund; 2001−2007. I. Van Heerden, PI; Pardue and Reible, water modeling group, $120,000.
2. “Molecular methods in Environmental Engineering” Governor's Biotech Initiative.
3. “SGER: Hydrological, Chemical and Microbial Data Related to the Hurricane Katrina Flooding in New Orleans, LA”. National Science Foundation, SUGR , C.

Willson, J. Pardue, W. Moe and R. Dokka, 35K, 2005−2007.

4. “Phytoremediation of wetlands and CDFs” Hazardous Substance Research Center S/SW; 2001 – 2007. J. Pardue. $354,649.