1. Title : Lake Houston Watershed Water Quality Prediction System

2. Focus Categories: Water Quality, Models, Management and Planning

3. Keywords : Hydrologic Models, Land Use, Watershed Protection

4. Duration: March 1, 2009 through February 28, 2010

5. Federal Funs Requested: $5,000

6. Non-Federal Funds Pledged:$10,000

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9.Congressional Districts: 2nd Congressional District

10. Abstract:

The increased degradation of influent to Lake Houston is causing increased water treatment cost for the City of Houston's Drinking Water Operations and has severe public and environmental health implications. The watersheds flowing into Lake Houston are impaired for bacteria and have concerns for nutrients. Therefore hydrologic models and water quality predictions concerning the influent from the watersheds to the lake are key to the operation of the City of Houston drinking water treatment plant. A water quality modeling system based on a distributed hydrologic model (*Vflo*™) that uses NEXRAD Radar rainfall input, is proposed. The system will be tested in Cypress Creek Watershed as part of a wider Basin effort. Cypress Creek is an urbanizing watershed with significant agricultural activity. As such historic water quality data will be analyzed for loading relationships in conjunction with a wider literature review of land use pollutant loading rates for determination of water quality parameters. These parameters will then be applied to hydrograph output from a *Vflo*™ model. This output will then be evaluated using water quality sampling during storm events, proposed for the Spring of 2009. The water quality model will then be launched for continuous real-time prediction of the water quality from Cypress Creek entering Lake Houston.

11. Statement of Critical Regional Water Problems:

Lake Houston is the primary source of drinking water for the city of Houston. Over 146 billion gallons are treated annually for 2 million customers (City of Houston, 2008). The lake is impaired for bacteria (TCEQ, 2008) and has concerns for nutrients and Chlorophyll-A (TCEQ, 2008). The watersheds flowing into the lake are also impaired for bacteria and have concerns for nutrients and depressed dissolved oxygen. With rising water treatment costs, the degraded influent has become a key concern for the City of Houston and thus protecting the watersheds is a chief priority. In order to efficiently manage the water quality an understanding of the watersheds and the relationship between pollutant loads and the influent flows is required.

12. Nature, Scope and Objectives of the Research:

The purpose of the proposed study is to improve the understanding of the relationship between pollutant loads into Lake Houston and rainfall events. By linking a hydrologic model to water quality applications, relationships between pollutant transport and water quality can be investigated. With greater understanding of the pollutant loading to the stream, the model can be used as a continuous, real time predictive model of water quality of the streams influent to Lake Houston and thus improve monitoring and management of water quality. Cypress Creek Watershed will be used as a test-bed for expansion of the predictive water quality model to other watersheds draining to Lake Houston. In future efforts the lessons learned from this project will be applied to develop a comprehensive water quality alert system that models the influent to Lake Houston and provides a management aid to water treatment operators.

The objectives of this study are to (1) Statistically analyze available water quality and stream flow data to characterize the spatial and temporal behaviors of the Cypress Creek Watershed and pollutant sources, (2) Develop a *Vflo*^{TM} hydrologic model using calibrated real-time NEXRAD Radar Rainfall input for improved prediction of stream flow, (3) Extend the hydrologic model to include water quality prediction capabilities by incorporating water quality-stream flow relationships, and (4) Conduct water quality sampling for evaluation of the proposed model (See Figure 2).

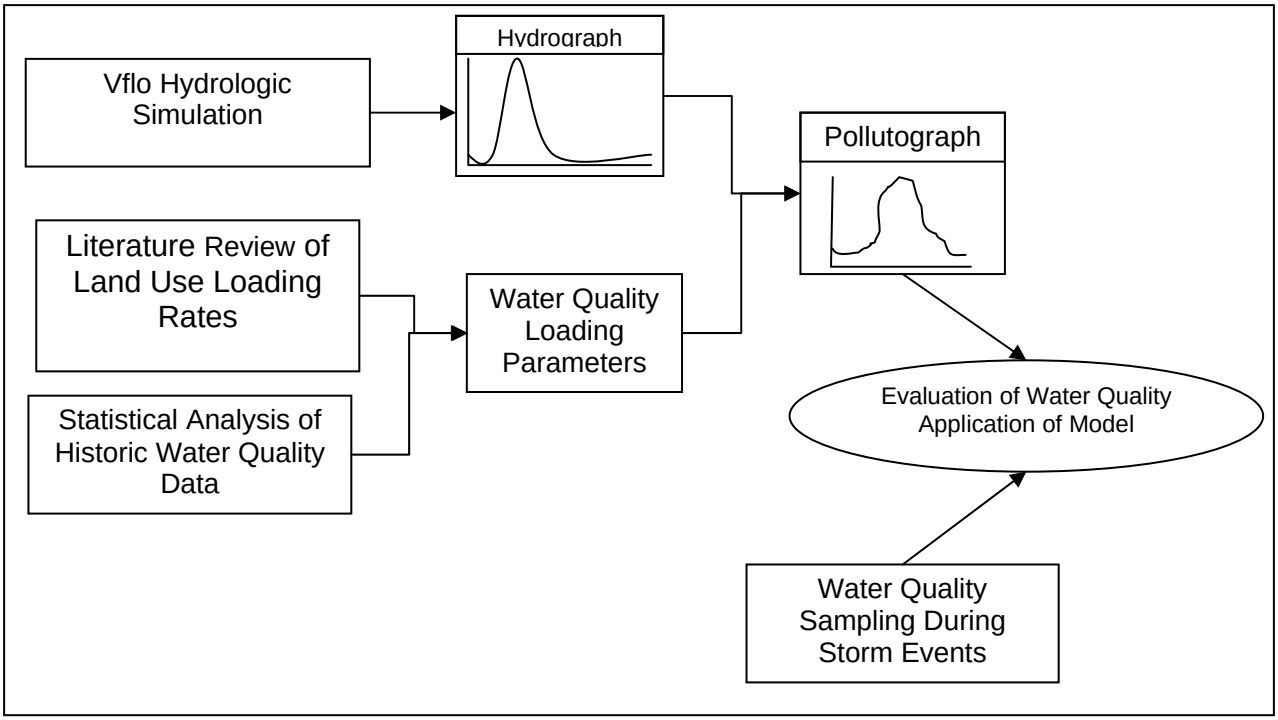

Figure 2: Proposed Research Activities

Current predictive models are based on a limited stream gage network, which limits the lead time for water treatment plant operators to adjust treatment processes to address changes in water quality due to the influent. Incorporation of Radar rainfall into hydrologic models has been shown to improve the accuracy and detail of the model (Fang, 2008), thus providing a more reliable prediction of influent flow. The Radar rainfall data is collected in 5 minute intervals at

1km resolution and calibrated to stream gauges and delivered in 15 minute intervals for continuous real time use in hydrologic models. *Vflo*™ is a distributed hydrologic model that uses finite element solutions of the kinematic wave equation for runoff routing. The model also uses finite elements to solve Green-Ampt infiltration and saturation excess equations for runoff generation (Bedient, 2003). Geospatial data representing elevation, soils, and land use are incorporated as parameters for the solution of these relationships. Radar data are used for precipitation inputs and the calculated runoff is routed overland or through channels. The model is used to simulate distributed runoff and other hydrologic quantities at any location within the study area, which supports the generation of hydrographs for the selected locations in real-time.

Analysis of water quality and stream flow shall provide appropriate relationships for loading of nitrogen, phosphorus, and bacteria (*E. coli*). Techniques including load duration curves and multivariate analysis will be used to characterize watershed behavior in response to flow (Shrestha, 2007 and Kim, 2005). These relationships and land use parameters will be combined with hydrologic simulation results from *Vflo*™ to model the transport and loading of pollutants into the stream (Vieux & Associates, Inc, 2006). In addition the continuous real-time *Vflo*™ model will be used to guide water sampling by predicting stream flow and thus improving storm event sampling.

In the spring of 2009, water quality sampling will be performed in conjunction with the USGS Water Science center office, located in Conroe, Texas. Efforts will be made to take multiple samples for multiple storm events, measuring *E. coli*, nitrogen, phosphorus, total suspended solids and other water quality parameters at a USGS monitoring station in Cypress Creek (08069000). The goal is to gather water quality data corresponding to multiple points on the hydrograph throughout the high flow event for the development of a pollutograph (Jin-liang, 2007). The collected data will then be used to evaluate the water quality output of the *Vflo*™ water quality application. In addition, improved sampling will be used to refine characterization of the watershed and analysis of pollutant loading relationships. Deployment of the continuous real-time predictive water quality model will improve the lead time for water treatment plants operators can adjust treatment processes to efficiently manage plant operations.

13. Results Expected from this Project:

The expected result from the proposed study is the development of a continuous real-time predictive model to be used by operators as a decision aid to manage the water quality of Lake Houston. At the same time the model will be employed to improve the current water quality sampling regime, so that data from a greater spectrum of flow conditions can be gathered. This in turn can be used to improve characterization of the watershed and pollutant source behaviors and thus refine future modeling efforts. The ultimate result is a utility for the protection of water quality and management of the watershed. It is also expected that the process can be exported and applied to other watersheds in a variety of locations.

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