Modeling the Big Black River: Evaluation of a Simplistic Water Quality Model

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The Mississippi Department of Environmental Quality (MDEQ) uses the Steady Riverine Environmental Assessment Model (STREAM) to establish permitted effluent limitations for industrial, commercial, and municipal facilities. While the U.S. Environmental Protection Agency (EPA) has approved of its use, questions arise regarding the model's simplicity. This research first evaluated STREAM using a statistical evaluation procedure based on sensitivity analyses, input probability distribution functions, and Monte Carlo simulation with site-specific data from a 46-mile reach of the Big Black River in central Mississippi. STREAM reasonably predicted dissolved oxygen (DO) based on a comparison of output probability distributions with observed DO. The observed DO was consistently within 80% confidence intervals of model predictions. This research also evaluated STREAM by comparing observed DO with predictions by both STREAM and the Enhanced Stream Water Quality Model (QUAL2E). One version of the QUAL2E and STREAM models utilized site-specific input data. A second version of each model involved additional calibration. A third version of STREAM was an uncalibrated model developed following MDEQ Regulations (1995) for cases where intensive input data are unavailable. All versions of the models were simulated at the 7Q10 flow for the Big Black River, the minimum flow expected for seven consecutive days during a period of ten years. STREAM over predicted while QUAL2E under predicted DO with the site-specific input data. Percent errors ranged between 4.8% and 11.2% for STREAM and 3.3% and 5.1% for QUAL2E. The uncalibrated STREAM model predicted the lowest DO for all scenarios and correspondingly provided the most conservative DO predictions.

Keywords. Dissolved Oxygen, Numerical Modeling, Rivers/Streams, Total Maximum Daily Load, Wastewater Discharge, Water Quality Modeling.

Introduction and Background

Water quality management attempts to protect of the uses of a water body while using the water as an economical means of waste disposal. The amount of waste a water body can assimilate depends on numerous factors (McBride, 2002; Mohamed et al., 2002; de Azevedo et al., 2000; Somlyódy et al., 1998). The water quality parameter of concern for waste load allocations (WLAs) and water quality based effluent limitations (WQBEL) is often the instream concentration of dissolved oxygen (DO). The Mississippi state standard for DO, as defined in the State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal Waters (2003), is a daily average concentration of at least 5.0 mg/L with an instantaneous minimum of no less than 4.0 mg/L. In order to sufficiently protect water quality, these standards must be attained at the low-flow, critical condition. Mississippi Department of Environmental Quality (MDEQ) regulations (1995) define the low-flow, critical condition as the 7Q10 flow: the minimum flow that occurs for seven consecutive days during a period of ten years.

The most commonly utilized model for predicting the impact of discharges on DO is the Enhanced Stream Water Quality Model (QUAL2E) (Bowen and Hieronymus, 2003; Chaudhury et al., 1998; Lung, 1998; Melching and Yoon, 1996; Walton and Webb, 1994). The QUAL2E model is a comprehensive and versatile water quality model widely used for WLAs, discharge permit determinations, and other conventional pollutant evaluations (Bowen and Hieronymus, 2003; Brown and Barnwell, 1987; Chaudhury et al., 1998; Lung, 1998; Melching and Yoon, 1996; Walton and Webb, 1994). It can simulate up to 15 water quality constituents in any combination desired by the user.

In lieu of the complexities of QUAL2E, MDEQ currently uses the Steady Riverine Environmental Assessment Model (STREAM) to establish permitted effluent limitations (MDEQ, 2004). STREAM is a simplistic, steady state, daily average, water quality model that utilizes a modified Streeter-Phelps (1923) DO sag equation. STREAM simulates DO, biochemical oxygen demand, and ammonia nitrogen concentrations. STREAM models DO as a function of the predicted dissolved oxygen saturation concentration (DOsat):

$$DO_{sat} = 14.652 + \left[-0.41022 + \left(0.007991 - 7.7774\times10^{-5}T\right)T\right]T \qquad (1)$$

where T is the temperature in degrees Celsius (Elmore and Hayes, 1987). The model solves for the steady state DO deficit (Di) concentration along a river reach using the following equation:

$$\begin{aligned} D_i = {} & D_{i-1}\exp\left(-k_a\frac{\Delta x}{U}\right) + \left[\frac{k_d}{k_a-k_r}\left\{\exp\left(-k_r\frac{\Delta x}{U}\right)-\exp\left(-k_a\frac{\Delta x}{U}\right)\right\}\right]L_{i-1} \\ & + \frac{4.57k_n}{k_a-k_n}\left[\exp\left(-k_n\frac{\Delta x}{U}\right)-\exp\left(-k_a\frac{\Delta x}{U}\right)\right]N_{i-1} - \left[1-\exp\left(-k_a\frac{\Delta x}{U}\right)\right]\frac{P}{k_a} \\ & + \left[1-\exp\left(-k_a\frac{\Delta x}{U}\right)\right]\frac{R}{k_a} + \left[1-\exp\left(-k_a\frac{\Delta x}{U}\right)\right]\frac{S}{k_a} \end{aligned} \qquad (2)$$

where D_{i-1} is the dissolved oxygen deficit concentration in the upstream stream reach (mg/L), k_a is the reaeration (McBride, 2002) rate (d^{-1}), Δx is the computational element distance (mile), U is the reach velocity (fps), k_d is the carbonaceous biochemical oxygen demand (CBOD) decay rate (d^{-1}), k_r is the overall CBOD removal rate (d^{-1}), L_{i-1} is the CBOD concentration in the upstream stream reach (mg/L), k_n is the nitrification rate (d^{-1}), N_{i-1} is the ammonia-nitrogen (NH_3-N) concentration in the upstream stream reach (mg/1), P is the photosynthesis rate (mg/L/d), R is the respiration rate (mg/L/d), and S is the sediment oxygen demand (Hatcher, 1986) rate (mg/L/d).

The major differences between QUAL2E model and STREAM are that QUAL2E simulates the complete nitrogen cycle, the complete phosphorus cycle, and growth cycle of algae. The growth cycle of algae is directly influenced by the concentrations of nitrogen and phosphorus. STREAM does not simulate phosphorus, and the only form of nitrogen simulated is ammonia nitrogen. Within STREAM, the user has the option of entering a value for the photosynthetic production of oxygen, oxygen utilized by aquatic plants through respiration, and community substrate oxygen demand. However, these values are constant within the model and do not respond to changes in the ammonia nitrogen concentrations.

Questions arise regarding the simplicity of STREAM in comparison to more commonly used models such as QUAL2E. Minimal analysis has been performed on STREAM to assess the level of confidence associated with model predictions, especially with respect to more commonly utilized water quality models. The objectives of this research were to evaluate STREAM using a statistical procedure that converts input parameter uncertainty into output prediction uncertainty and to compare STREAM predictions to predictions made with the more commonly utilized QUAL2E model. Evaluation of STREAM and other hydrologic and water quality models have been based on comparison of a model prediction with a single observation for a specific location (Sabbagh and Fox, 1999). However, modelers rarely know input parameters with exact certainty (Haan et al., 1995; Parker et al., 1995). An alternative evaluation strategy being increasingly used in hydrologic and water quality modeling involves uncertainty and probability analyses. The procedure is valid when input parameters are represented by singular values. Researchers have applied this statistical evaluation to a number of different models (Haan et al., 1995; Haan and Zhang, 1996; Prabhu, 1995; Zhang et al., 1995; Sabbagh and Fox, 1999; Haan and Skaggs, 2003) but not in-stream water quality models.

Big Black River Study Site

MDEQ received a request in 2001 to perform a WLA for a new National Pollutant Discharge Elimination System (NPDES) permitted facility in Madison County, Mississippi. This facility, known as the Canton Municipal Utilities Beattie's Bluff Wastewater Treatment Facility (CMU), planned to locate near the city of Canton. CMU was designed to treat wastewater from several local sources including a new Nissan facility that was under construction at that time. CMU proposed two discharge scenarios into the Big Black River: 4.0 and 8.0 million gallons per day (MGD). MDEQ's Office of Pollution Control, Water Quality Assessment Branch completed the WLA for the CMU project. The WLA established WQBELs for CMU to discharge treated wastewater into the Big Black River. MDEQ used an application of STREAM with very limited site-specific data to determine the discharge limitations for the proposed discharge scenarios. They assembled STREAM in accordance with MDEQ Regulations (1995). This application, like many WLA applications of STREAM, had no site-specific field data available for model input or calibration. In the absence of field data, MDEQ Regulations (1995) specified the methods and assumptions for the input data.

WQBELs were assigned to CMU for each discharge scenario. At the proposed flow of 4.0 MGD, MDEQ granted the facility permit limits of a monthly average of 22.0 mg/L 5-Day carbonaceous biochemical oxygen demand (CBOD5) and 2.0 mg/L ammonia nitrogen. At the proposed flow of 8.0 MGD, MDEQ granted the facility permit limits of a monthly average of 11.0 mg/L CBOD5 and 2.0 mg/L ammonia nitrogen. STREAM predicted no associated DO problems with the WQBELs set for each discharge scenario. However, MDEQ and U.S. Environmental Protection Agency (EPA) Region 4 proposed that an intensive WLA study be conducted within the Big Black River. The intensive study was conducted for one week in September 2002 during low flow conditions. A 46-mile segment of the Big Black River and its major tributaries were selected for intensive study. Water quality and hydraulic data were collected at multiple locations along the Big Black River and its major tributaries in order to develop a calibrated model of the system at low flow conditions.

Figure 1 shows the study area and all sampling locations including the main stem, tributaries, and wastewater treatment plants. The proposed CMU facility discharge location was at river mile 123. Seven monitoring stations were established within this segment of the Big Black River. Additional monitoring stations were also established within the major tributaries to the river including Pepper Creek, Bear Creek, Panther Creek, Cypress Creek, and Bogue Chitto Creek. The intensive study also sampled the effluent from five existing NPDES WWTPs in the area. These WWTPs discharge into the tributaries not the Big Black River itself. The samples taken from the wastewater treatment plants were analyzed for ultimate carbonaceous biochemical oxygen demand (CBODU), ammonia nitrogen, nitrate nitrogen, nitrite nitrogen, total kjeldahl nitrogen (TKN), total nitrogen, total dissolved phosphorus, total phosphorus, and total organic carbon (TOC). The data collected at the Big Black River and tributary water quality monitoring stations included DO, community oxygen metabolism, oxygen production and respiration, reaeration measurements, water quality, physiographic measurements, meteorologic measurements, time-of-travel and other hydraulic data.

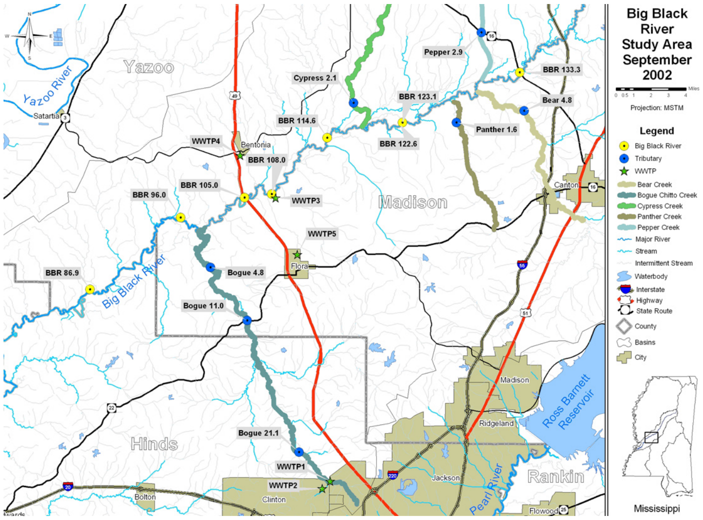

Figure 1. Big Black River Study Area – September 2002

METHODOLOGY

Statistical Evaluation

This research used a five-step statistical evaluation procedure based on Monte Carlo simulation. First, a sensitivity analysis was conducted on STREAM to determine the input parameters with the greatest impact on model predictions. The sensitivity of each parameter was determined by holding all other parameters constant while small (i.e., ±10%) variations were made to the parameter of interest. The second step developed a probability distribution function (PDF) for each parameter based on available data for the southeastern United States. A combination of chi-square goodness of fit and Kolmogorov-Smirnov tests (Haan, 1991) determined best-fit distributions. The third step generated unique PDFs for the sensitive input parameters based on observed data from the Big Black River intensive study. The intensive study collected six to seven measurements of sensitive model parameters over the 46-mile reach. This measured data allowed the derivation of a unique PDF for each parameter. The type of distribution was constrained to be that determined for the larger datasets (i.e., throughout the southeastern United States) mentioned above, but the parameters of the distribution were allowed to vary.

All available data regarding the hydraulics of the river as well as all discharges into the river were entered into the model. Model predictions were verified to ensure accurate flow predictions in the Big Black River before continuing with the water quality modeling. Output probability distributions of predicted DO were generated using Monte Carlo simulation (Cheney and Kincaid, 1994). Values for each of the sensitive parameters were derived by applying a random number to each unique probability distribution generated based on observed data from the study. As a conservative approach, each sensitive parameter was assumed constant along the entire reach. The Monte Carlo simulation included 1000 model runs generating 1000 output values for DO at each river mile. The final step used the output probability distributions to assess the model using 80% confidence intervals. Confidence intervals were assumed symmetric with respect to probability (Haan and Skaggs, 2003). Therefore, the 10% and 90% quantiles from an empirical probability plot of the output estimated the 80% confidence interval.

Comparison of Water Quality Models

This research then developed a more detailed, calibrated, model of the river segment using QUAL2E and data from the intensive study. The QUAL2E model of the Big Black River was developed as a steady-state simulation. The model was calibrated to simulate the conditions measured at the time of the study. The model simulated temperature, DO concentrations, BOD concentrations, the phosphorus cycle, the nitrogen cycle, and algae as chlorophyll a. Two versions of QUAL2E (QUALMOD1 and QUALMOD2) were assembled. One version used all input parameters exactly as measured from the study. The second version used all input parameters as measured with the exception of the community substrate oxygen demand. In-situ measurements of this parameter can be quite variable exhibiting standard deviations anywhere from 0.2% to 150% with an average standard deviation of 44% (Hatcher, 1986). The measured values of community substrate oxygen demand were reduced up to 35% within QUAL2E to provide a better calibration to the observed DO data.

In addition to the complex QUAL2E models, this research also developed three versions of STREAM (STREAM1, STREAM2, and STREAM3). Data collected from the intensive study was used to complete a steady state, calibrated STREAM model. STREAM1 utilized all input parameters exactly as measured from the study. STREAM2 used all input parameters as measured with the exception of the community substrate oxygen demand. The community substrate oxygen demand was increased up to 44% to provide a better calibration to the observed DO. This research assembled a third version of STREAM as if no site-specific data were available. This uncalibrated version used assumptions given in MDEQ regulations (1995) to determine model inputs. According to regulations, stream flow should be assumed the 7Q10 flow based on nearby USGS flow gages and drainage areas, and water temperature should be assumed based on flow: for streams with minimum low flow greater than 8.5 $m^3 s^{-1}$, the summer temperature should be assumed 30°C and the winter temperature should be assumed 20°C; for streams with minimum low flow greater than 1.4 $m^3 s^{-1}$ and less than 8.5 $m^3 s^{-1}$, the summer temperature should be assumed 28°C and winter temperature assumed 20°C; and for streams with minimum low flows less than 1.4 $m^3 s^{-1}$, the summer temperature should be 26°C and winter temperature should be 20°C. The regulations also provide guidance on estimating velocities, background conditions, and other parameters when site specific data are not available. The models predicted DO under the

7Q10 scenario, which is the low-flow critical condition according to MDEQ Regulations (1995). In all cases, the models analyzed the two discharge scenarios of 4.0 MGD and 8.0 MGD.

RESULTS AND DISCUSSION

Statistical Evaluation

Four parameters had the most significant influence on predicted DO concentrations: (1) the reaeration coefficient, (2) photosynthetic oxygen production, (3) oxygen utilized by aquatic plants through respiration, and (4) oxygen demand of bottom deposits, otherwise known as community substrate oxygen demand or sediment oxygen demand (SOD). Measured values of the reaeration coefficient were available for numerous studies occurring in the southeastern United States from 1991 to 1999 (Koenig, 2004). This data include over sixty measurements of the reaeration coefficients (d^{-1}) at the reference 20°C temperature for stream reaches in Alabama, Georgia, Tennessee, North Carolina, and South Carolina. Reaeration coefficients ranged between 0.02 and 19.29 d^{-1} with an average of 3.05 d^{-1}. Chi-square and Kolmogorov-Smirnov statistics indicated that the measured reaeration coefficients conformed to a Weibull distribution with a shape parameter (α) = 0.88 and a scale factor (β) = 3.44 (Devore, 1995).

The use of a Weibull distribution is uncommon in many uncertainty analyses that assume the distributions to be either normal or lognormal (Gibbons, 2003). Scientists commonly assume environmental data to be lognormally distributed. No theoretical justification exists for the use of the Weibull distribution in this research other than the fact that the Weibull distribution simply provided an improved fit to the observed data. Figure 2 illustrates the measured reaeration coefficient data along with the best-fit Weibull cumulative distribution function (CDF). The lognormal CDF is also shown for comparison.

A similar dataset was available for in-situ chamber measurements of the SOD. Measured values of SOD were available for numerous sites in the southeastern United States from 1977 to 2001 (Koenig, 2004). Available data included over 100 measurements in streams in Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, and Tennessee. SOD ranged between 0.11 and 7.90 g $O_2/m^2/d$ with an average of 1.81 g $O_2/m^2/d$. Measured SOD conformed to a lognormal distribution with a mean (μ) = 0.51 and a standard deviation (σ) = 0.94 (Devore, 1995).

Limited information was available for photosynthetic oxygen production and oxygen used through respiration. This research identified approximately 20 measurements of both variables in numerous case studies. Oxygen production rates at 20°C ranged between 0.64 and 18.65 g $O_2/m^2/d$ with an average of 7.89 g $O_2/m^2/d$. Respiration rates at 20°C ranged between 2.70 and

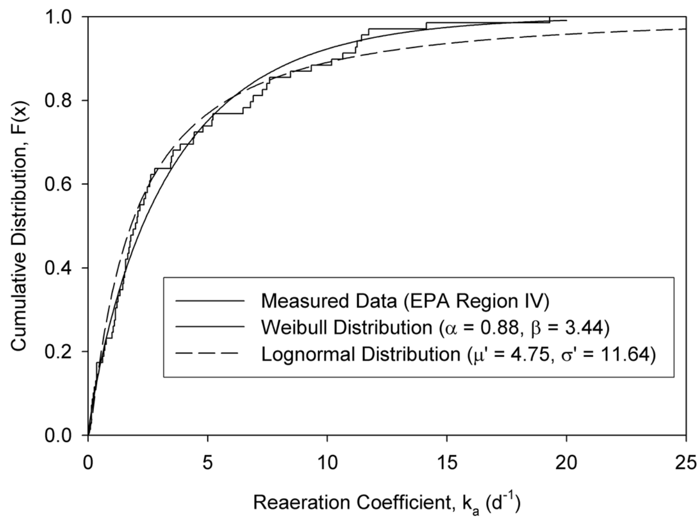

Figure 2. Measured reaeration coefficients from studies occurring in the southeastern United States from 1991 to 1999 and best-fit Weibull and Lognormal distributions.

30.70 g $O_2/m^2/d$ with an average of 10.36 g $O_2/m^2/d$. This limited information suggested a Weibull distribution with α = 1.47 and β = 8.72 for the photosynthetic oxygen production rate and a lognormal distribution with μ = 2.16 and σ = 0.78 for the oxygen utilized by aquatic plants through respiration.

The Big Black River intensive study included measurements of the four sensitive parameters. The intensive study included measured production and respiration rates at six locations along the 46-mile study reach with a range of 0.11 to 4.07 g $O_2/m^2/d$ and 0.04 to 2.72 g $O_2/m^2/d$, respectively. Reaeration coefficients measured at six locations ranged between 0.95 and 1.65 d^{-1}. SOD was measured at seven locations ranged between 0.80 and 1.2 g $O_2/m^2/d$. These measurements resulted in site-specific PDFs, assuming the representative distributions for each parameter as determined from the southeastern U.S. data. All distributions were representative of the range of values measured in the intensive study.

The DO concentrations measured at six locations (river miles 123, 115, 108, 105, 96, and 88) were used to evaluate STREAM. Figure 3 illustrates an example of the probability distribution results from the Monte Carlo simulations for river miles 108. Table 1 summarizes results from the statistical procedure for the rivers miles with measured DO concentrations. At each location the observed DO concentration fell within the 80% confidence intervals indicating that STREAM reasonably predicted DO at each river mile. Although the observed DO fell within the 80% confidence intervals at all river miles, STREAM over predicted DO. The observed DO at each river mile was generally less than the 25th percentile on the probability plot.

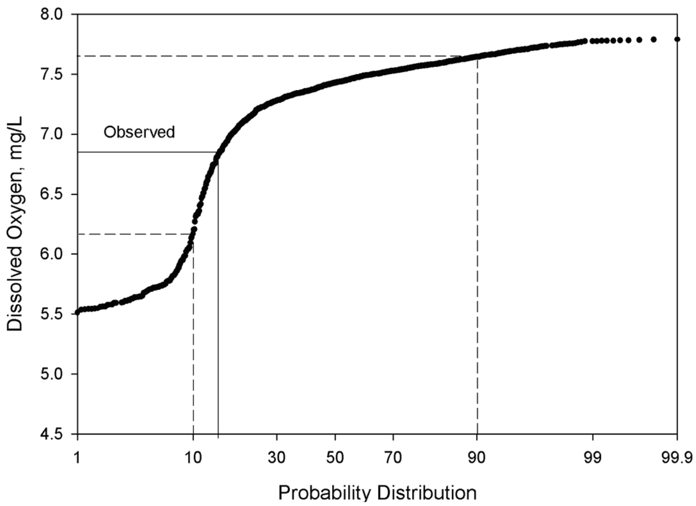

Figure 3. Comparison of observed DO concentration at river mile 108 versus the 80% confidence intervals on the distribution of predicted DO from the Monte Carlo simulations.

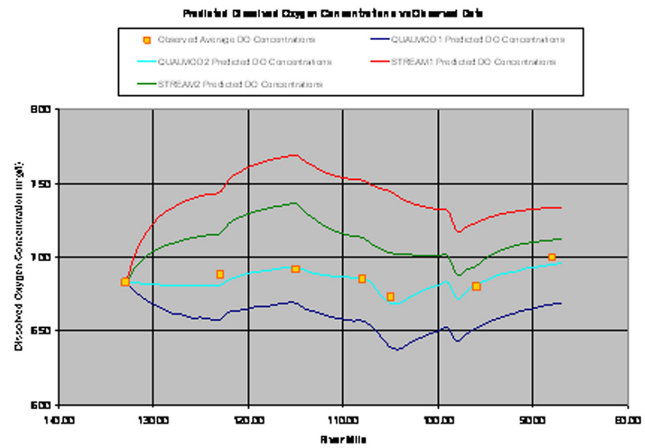

Figure 4. Observed versus predicted DO concentrations for river miles 132 to 88 along the Big Black River under study conditions.

Comparison of Water Quality Models

QUALMOD1, QUALMOD2, STREAM1, and STREAM2 simulated conditions along river miles 133 through 87. Verification of hydrologic predictions ensured that the models were properly simulating observed flows. Figure 4 compares observed DO to predicted DO using QUALMOD1, QUALMOD2, STREAM1, and STREAM2 at study conditions. Applying the models with detailed site-specific input data resulted in percent errors between predicted and observed DO concentrations ranging between 4.8% and 11.2% for STREAM and between 3.3% and 5.1% for QUAL2E. After calibration by adjusting the site-specific measured value of SOD within reported ranges, STREAM had percent errors in the range of 1.7% to 6.5% compared to percent errors of 0.1% to 1.0% for the calibrated QUAL2E model. QUALMOD1 and QUALMOD2 both predicted DO concentrations less than the concentrations measured in the field. STREAM1 and STREAM2 both predicted DO concentrations greater than the concentrations measured in the field. Modified QUALMOD1, QUALMOD2, STREAM1, and STREAM2 predicted DO under 7Q10 flow conditions with the addition of the CMU facility. The uncalibrated version of STREAM (STREAM3) also simulated this scenario. The 7Q10 flow was estimated to be 1.7 $m^3 s^{-1}$ based on historical flow data from United States Geological Survey (USGS) Station 07289730 near Bentonia, MS and USGS Station 07290000 near Bovina, MS. Equivalent predicted flow verified the hydrologic component of the models. Figures 5 and 6 along with Table 2 summarize the lowest simulated DO and DO sag concentrations for each model simulation. The DO concentrations predicted by the QUALMOD1 and QUALMOD2 applications were lower than the DO concentrations predicted by the STREAM1 and STREAM2 applications. The DO concentrations estimated by STREAM3 were the lowest of all simulations indicating that use of MDEQ regulations (1995) produced conservative

Table 1. Summary of statistical evaluation of STREAM for predicting DO concentrations at locations along the 46-mile Big Black River intensive study.

	River Mile 123	River Mile 115	River Mile 108	River Mile 105	River Mile 96	River Mile 88
Observed DO Concentration (mg/L)	6.88	6.92	6.85	6.73	6.80	7.00
Predicted DO - Average of 1000 Simulations (mg/L)	7.22	7.30	7.22	7.24	7.10	7.10
Predicted DO - Minimum (mg/L)	4.96	4.86	4.79	4.80	4.72	4.71
Predicted DO - Maximum (mg/L)	7.70	7.84	7.79	7.81	7.61	7.62
80% Confidence Level (mg/L)	6.20–7.60	6.24–7.70	6.17–7.64	6.18–7.66	6.08–7.48	6.08–7.49

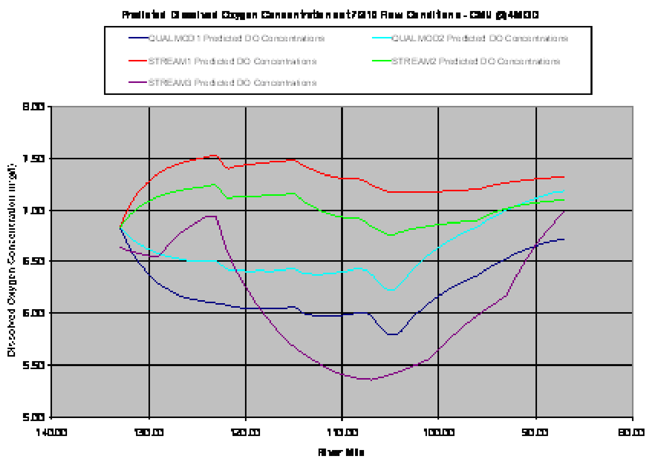

Figure 5. Predicted DO concentrations versus river mile-QUAL2E and STREAM simulations at 7Q10 flow and CMU facility at 4.0 MGD.

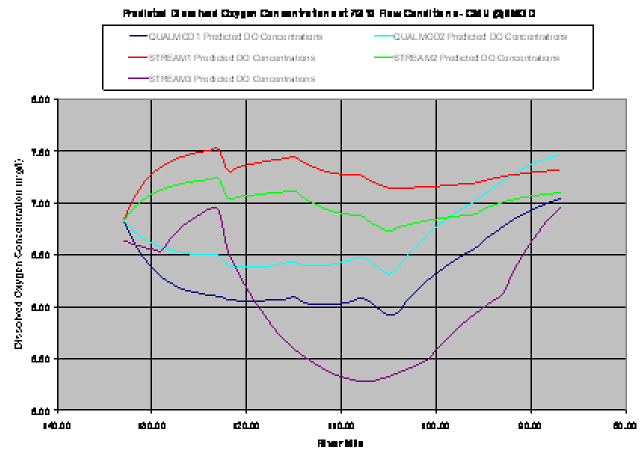

Figure 6. Predicted DO concentrations versus river mile-QUAL2E and STREAM simulations at 7Q10 flow and CMU facility at 8.0 MGD.

predictions for this segment of the Big Black River. All model applications of QUAL2E and STREAM confirmed the WQBELs assigned to the CMU facility. The models predicted no violations of the daily average DO standard of 5.0 mg/L.

SUMMARY AND CONCLUSIONS

MDEQ currently uses a simplistic water quality model for determining effluent limitations. This model, called STREAM, has been approved for MDEQ's use by EPA. However, concerns arise regarding the simplicity of the model and the lack of a detailed analysis of its predictive capability. STREAM was evaluated using a statistical evaluation technique based on sensitivity analysis, PDFs for input parameters, and Monte Carlo simulation using data from an intensive study along a 46-mile reach of the Big Black River in central Mississippi. The most sensitive input parameters in STREAM were the reaeration coefficient, photosynthesis and respiration rates, and SOD. Using datasets from the EPA's Region IV Science and Ecosystem Support Division and other studies, governing distributions (Weibull or lognormal) were developed for the sensitive STREAM parameters. Site-specific distributions were then generated for the sensitive parameters using data collected during an intensive study along the Big Black River. These distributions were then incorporated through Monte Carlo simulation. The Monte Carlo simulations allowed the development of output distributions for predicted DO at each river mile. Comparison of the observed DO concentrations with the confidence intervals on the model predicted distributions suggested that the model reasonably predicted DO. The model did tend to over estimate DO, which users of STREAM need to realize when using the model for defining effluent limitations. A second objective of this research was to evaluate the performance of STREAM in comparison to the more commonly utilized and complex water quality model, QUAL2E. Model evaluation

Table 2. Lowest predicted DO and DO sag concentrations for the 7Q10 flow.

Simulation	CMU Scenario	Lowest DO (River Mile)	DO Sag (River Mile)
QUALMOD1	4.0 MGD	5.79 mg/L (105)	5.79 mg/L (105)
QUALMOD1	8.0 MGD	5.92 mg/L (105)	5.92 mg/L (105)
QUALMOD2	4.0 MGD	6.22 mg/L (105)	6.22 mg/L (105)
QUALMOD2	8.0 MGD	6.32 mg/L (105)	6.32 mg/L (105)
STREAM1	4.0 MGD	6.83 mg/L (133)	7.17 mg/L (101-105)
STREAM1	8.0 MGD	6.83 mg/L (133)	7.15 mg/L (102-105)
STREAM2	4.0 MGD	6.76 mg/L (105)	6.76 mg/L (105)
STREAM2	8.0 MGD	6.73 mg/L (105)	6.73 mg/L (105)
STREAM3	4.0 MGD	5.76 mg/L (107)	5.76 mg/L (107)
STREAM3	8.0 MGD	5.28 mg/L (107-108)	5.28 mg/L (107-108)

involved comparing two versions of QUAL2E with three versions of STREAM for the Big Black River case study. The first versions of QUAL2E and STREAM utilized intensive field measurements collected on site. The second versions of QUAL2E and STREAM involved calibration beyond the intensive field collected data. A third version of STREAM involved parameters suggested by MDEQ regulations in cases where site-specific field data is unavailable. These models simulated the 7Q10 flow scenario with discharges of 4.0 MGD and 8.0 MGD from a wastewater treatment facility. Although the QUAL2E model is a much more sophisticated model that simulates more in stream processes than STREAM, comparison of the STREAM and QUAL2E models indicated that the models produced similar predictions for instream DO. The DO concentrations predicted by the calibrated STREAM simulations were consistently higher than those predicted by the calibrated QUAL2E simulations. The uncalibrated version of STREAM predicted the lowest DO concentrations of all the simulations; therefore, the uncalibrated model produced the most conservative estimates of waste load allocation.

ACKNOWLEDGEMENTS

The authors acknowledge the technical assistance and support of the Mississippi Department of Environmental Quality (MDEQ), especially the Water Quality Assessment Branch. The authors also acknowledge the technical assistance of Mark Koenig, Environmental Protection Agency Region 4 Science and Ecosystem Support Division, and Dr. James Martin, Mississippi State University, Department of Civil Engineering.

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