DISSERTATION

CALIBRATED STOCHASTIC SIMULATION OF RIVER POLLUTION CONTROL STRATEGIES

Submitted by

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In partial fulfillment of the requirements

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ABSTRACT OF DISSERTATION

CALIBRATED STOCHASTIC SIMULATION OF RIVER POLLUTION CONTROL STRATEGIES

To account for both the major physical phenomena governing pollution transport in rivers and the uncertainty of parameters that influence that transport, a physically-based stochastic water quality model, supported by empirical stochastic models, is developed. Empirical stochastic models, linking a contemporaneous autoregressive moving average model (CARMA) with a modified general Monte Carlo simulation (GMCS) model, are derived from historical data to represent the statistical characteristics of selected river system parameters and state variables, including space-time correlation structure. These models are used to generate possible realizations of parameter values used as input to a modified version of the physically-based stochastic mass-transport model, QUAL2EU. The QUAL2EU model is applied using Monte-Carlo simulation to generate distributions of possible water quality concentrations at locations and times of interest along a river. The model is calibrated by using an optimization algorithm to adjust the statistics of selected stochastic parameters to minimize the difference between the statistics of water quality state variables predicted by the QUAL2EU model and the corresponding statistics generated by an empirical stochastic model based on historical measurements of the state variables at designated locations along the river. Model validation (testing) is conducted over a four-year period by comparing the statistics of measured water-quality constituents at several locations along the river generated by a stochastic empirical model, as well as the values as directly measured, to corresponding statistics of model predictions over the period.

The models are applied to a 190-km segment of the South Platte River in Colorado to simulate the diminished quality of river flows available for irrigation diversion due to return flows from economic activities. Distributions and statistics of flow rates, total dissolved solids (TDS), dissolved nitrogen (N) species, and fecal coliform concentrations are predicted along the river. To estimate the performance of alternative engineering interventions, eleven different pollution control strategies are considered, alone and in combination. Statistics of water quality constituent concentrations, and the associated probabilities of violation of recommended criteria, along with the spatial and temporal uniformity of these probabilities, are estimated. Over a 25-year horizon, for example, combined pollution control measures are predicted to achieve average reductions from 27 to 36% and from 31 to 39% in mean concentrations of TDS and N, respectively, for the 11 irrigation diversions located along the 53-km reach just downstream of Denver. Uncertainty in predicted concentrations, as indicated by the coefficients of variation, is found to be considerable. An average decrease of 18 percentage points in the probability of violation for TDS is predicted, while the estimated average decrease for N and fecal coliform are only 6 to 8 percentage points. Major conclusions are drawn and recommendations for further study are presented.

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CHAPTER 1

INTRODUCTION

1.1 Problem Overview

The pollution of streams and rivers, caused by the discharge of excessive amounts of municipal and industrial wastes as well as agriculture return flows, has been an increasing concern in recent years. One detriment of river pollution is the impact of the diminished quality of flows diverted to sustain the world's most productive food source, irrigated agriculture. Poor quality irrigation water can harm soils, reduce crop yields, threaten the health of farm workers, and further degrade agricultural return flows. This impact to valuable irrigated agricultural systems needs to be evaluated and a suitable remedy sought.

In the context of water pollution management in streams, water quality models often are applied to simulate surface water conditions along a river in response to alternative management interventions. Although a lot of research has been conducted and investments have been made in controlling water pollution, water quality in many streams has not substantially improved. This poor performance can be attributed in part to the use of deterministic models that fail to account for model prediction uncertainty. These uncertainties are associated with (1) the misspecification of the relations among the variables determining the dynamic behavior of the system (i.e. uncertainties about the model structure) and (2) the misspecification of values of the parameters (properties, boundary conditions, sinks, and sources) appearing in the identified structure of the dynamic model (Melching and Yoon 1996). In this study, the second type of uncertainty was considered and incorporated into an approach for river water quality management and planning. This ambiguity in parameter values originates from sparse data collection, data measurement and analysis errors, and from the inherent space-time heterogeneity of the natural environment.

In contrast to deterministic models, stochastic models are able to incorporate river system uncertainty and present the output of interest not simply as single values (deterministic results), but as values having related statistical characteristics. These statistics can be used to associate notions of probability and risk with pollution at times and locations of interest along the stream. Empirical stochastic models, based on the statistical properties of historical (observed) data, have been shown to have good capabilities to reproduce statistical characteristics under conditions similar to historic period of observation. However, they have been criticized for their lack of physical basis. Recently, several physically-based stochastic models, accounting for both the randomness of the river system and the governing physical phenomena, have been developed to solve water quality management and planning problems (Bobba et al. 2000, Duchesne et al. 2001, Giri et al. 2001, Han et al. 2001, Melching and Bauwens 2001, Portielje et al. 2000). However, these models have been restricted to using parameters with simple statistical characteristics (e.g. describing the model parameters using limited probability distributions or using means and standard deviations only) and have failed to account for the temporal and spatial correlations among the parameters.

The South Platte River in Colorado has been used for agricultural irrigation for well over 100 years. It currently helps Colorado's agriculture to produce an annual net farm income of about $1 billion and generates additional economic growth through many agriculture-related industries. The growing competition between different economic sectors (urban, industrial, and agricultural) for the limited water resource of the river has turned into a big issue for Colorado and poses a difficult challenge to the sustainability of productive irrigated agriculture. Waters are diverted, are partially consumed, and the remainder is returned, with increased dissolved constituent concentration, to be reused downstream. Agricultural users are concerned that, as urban areas grow, this degradation and recycling will continue, creating in-stream flows that are made up primarily of secondary-treated municipal wastewater effluent. Compounding the problem is the non-point source pollution from both urban and agricultural runoff and groundwater return flow that also accumulates along the river. To evaluate the likely impacts of diminished water quality on diversions to irrigation water use, and to assess alternative strategies for improvement, a multi-constituent river water quality model, incorporating parameter uncertainty, is developed in application to the South Platte River.

1.2 Main Purpose of the Work

The purpose of this study is to develop and apply a new methodology for simulating water quality and pollution control strategies along a river using a stochastic approach. The model accounts for both the system parameter uncertainty as well as the physical phenomena that govern the transport and reactions of water quality constituents in a stream. Empirical stochastic models, based on the historical measurements in the river basin are linked to an amended mass-transport model, QUAL2EU, to generate sets of spatially and temporally correlated, non-normal-restricted values for the mass-transport model parameters. The new physically-based stochastic river water quality model comprises two parts: (1) building and generating the parameters as correlated random variables and (2) predicting water-quality constituent concentrations, and associated performance measures, as random variables using mass transport and reaction via Monte Carlo simulation. The major contribution of the first part includes the specification of all major uncertainties in the watershed using defined statistical characteristics. Based on the analysis of historical (observed) data, a random field preserving the spatial-temporal persistence of the system is built. Multi-variate time series (CARMA) and multivariate marginal distribution generation (GMCS) models are used to reproduce the random features of the river system. Sets of random values are generated from these empirical models for the random parameter field. These sets preserve what is currently known about the river system studied, including statistical distributions and the correlation structure of available parameter data. These sets serve as part of the input parameters of the selected physically-based model. Because some model parameters are very sparsely sampled, appropriate statistical characteristics are derived from the literature. The assumptions made are confirmed through calibration and validation of the model using distributions of measured water-quality constituents at several locations along the river. Due to the complexity of relations among model parameters, a traditional try-and-error calibration procedure is not appropriate. Instead, a systematic algorithm incorporating the concepts of optimization and simulation is developed to fulfill this need. Using an appropriate uncertainty analysis (Monte Carlo simulation), the resulting physically-based stochastic model is used to predict the statistical characteristics of constituent concentrations, and probabilities of violation of water quality standards, in response to the uncertainty in the river system.

The proposed methodology is developed and implemented using data from a 190-km segment of the South Platte River in Colorado. To illustrate the possible hazards to irrigated agriculture, the probability distributions of flow rate, total dissolved solids (TDS) concentration, nitrogen species concentration (in four different forms: organic nitrogen, ammonia nitrogen, nitrite nitrogen and nitrate nitrogen) and fecal coliform concentration are predicted in response to various management alternatives.

1.3 Contributions

A multi-fold contribution to the body of knowledge pertaining to water resources/quality engineering is provided in this research. This contribution could be identified as theoretical and practical. On the theoretical side, a comprehensive framework has been created that describes the essential steps and the available techniques for integrating correlated data uncertainty with the governing physical phenomena of the river system. On the practical side, an algorithm has been developed to validate (test) and illustrate the methodology. Since the scales of analysis (both spatial scale and size of time steps) used in this study are relatively large, the level of detail of is most suitable to the feasibility-stage planning of river water quality management.

The incorporation of comprehensive random characteristics of model parameters in a river water quality model is a major contribution in this study. The physically-based stochastic model presented is able to predict the water quality conditions along the river and preserves well the following features:

(1) variability in time,

(2) variability in space,

(3) probability of occurrence,

(4) impact of the river system (physical variables) including the sources and sinks, hydraulic processes, and chemical reactions,

(5) spatial persistence with the other random variables in the watershed, and

(6) temporal persistence among random variables in the watershed.

Among these characteristics, a significant highlight is the prediction of the output of interest in response to model parameter uncertainty that is influenced by correlation structure both in space and time. As discussed by Adams (1998), "*Estimates of parameter uncertainty which fail to account for parameter correlations do not accurately represent modeler uncertainty*". Hence, building a random field model that explicitly accounts for parametric uncertainty in a framework that allows for space-time correlation structure is a significant improvement in random field generation.

Another key feature of the research is the calibration and validation (testing) of the stochastic model using distributions of measured water-quality constituents at several locations along the river. Hence, the assumptions (statistical characteristics) related to the knowledge uncertainty in the water system could be confirmed.

The systematic calibration of the model parameters was achieved by implementing optimization techniques to find the best values of the model parameters. This study presents a stochastic optimization-simulation model that can successfully solve large-scale stochastic nonlinear constrained problems. The resulting methodology yields a very robust tool in the field of flow and transport modeling.

The calibrated coefficients and correction factors offer useful information pertaining to the statistical characteristics of the river water quality model parameters, enhancing the general knowledge base regarding similar river systems.

1.4 Organization of the Dissertation

An outline and brief summaries of this document follow:

Chapter 1. Introduction. The general description of the problem is addressed. The main purpose of the work and associated contributions to the body of knowledge relative to water resources/quality management are also presented.

Chapter 2. Literature review. A general overview of the problem of river water quality and pollution control is presented. In reviewing the management of the river water quality, the major feasible pollution control strategies are discussed. To evaluate such strategies, the recommended water quality criteria for irrigation water use are proposed and different performance measures are discussed. Subsequently, modeling tools for addressing river water quality-water quality management are presented. The detailed governing processes and laws for river water quality are presented. The state-of-the-art models, established on these theories, are discussed and compared. Associated with the awareness of the uncertainty arising from complex river systems, stochasticapproached river water quality models are examined. The two categories of stochastic river water quality models, empirical and physically-based models, are outlined and contrasted. Finally, water quality models applied in the South Platte River are reviewed and presented.

Chapter 3. Methodology and Results. A copy of a journal paper, submitted on Sept 6, 2002, revised on 4 March 2003, and accepted for publication in the *Journal of Water Resource Planning and Management* of the American Society of Civil Engineers is presented to describe the methodology and results of this study. First, the methodology is presented along with the development of the empirical stochastic models, the equations of the physically-based model, and their interrelationships. Then comes a description of the study area, including the sampling periods, sizes and frequencies for the available model parameters. The procedures for stochastic model calibration and validation are outlined. Finally, the application of this model to predict the stochastic water quality conditions and probabilities of violation of proposed water quality standards along the lower South Platte River, in response to different pollution-control interventions, are presented. The relative performances of these strategies are summarized.

Chapter 4. Conclusions and Recommendations. This chapter reviews the salient points of this study. Problems encountered, characteristics of the key sources of the uncertainty in the river basin, techniques applied and model results are evaluated and discussed. Finally, recommendations for future efforts to extend the research are addressed.

References. A comprehensive list of consulted papers is presented. This list provides an excellent source of related studies and background information associated with this research.

Appendix A. Available Flow and Water Quality Records for Study Segment of South Platte River. This appendix presents the tables containing data on the available sources (wasteload facilities effluents, tributary inflows, nonpoint source recharges), sinks (irrigation diversions), and state variables (selected flow and water quality stations along the mainstem of the South Platte River) of the river system simulated. Statistical characteristics of these parameters as well as the correlation structures are presented.

Appendix B. Empirical Stochastic Modeling Procedures and Results. Appendix B displays tables containing information regarding the building of the empirical stochastic models, including the values of fitted coefficients, and their use in generating values of the random parameters. A list of different alternatives for determining the best method to cope with missing data present in the model is also provided.

Appendix C. Input Parameters for Physically-Based Stochastic River Water Quality Model. Tables containing the ranges of the values of the parameter set 2 (properties of the river system, including hydraulic geometry coefficients, hydraulic resistance, dispersion coefficient, and chemical rate coefficients; as well as the correction factors for the nonpoint sources) obtained through literature review are provided. The errors of the model predictions using the calibrated parameters in the calibration and validation periods are also described. Tables summarizing model results during the validation period are presented, including the simulation-related percentiles of the measured data. Figures illustrate the calibration and validation results associated with each of the predicted water quality constituents.

Appendix D. Simulated Performance of Alternative Pollution Control Strategies. This appendix summarizes the statistics of the predicted water quality constituents and performance measures for the proposed management strategies to reduce the pollution along the South Platte River. These performances are base on the compliance with recommended water quality criteria for agricultural water use. Due to the incomplete standards of Colorado for some of the water quality constituents simulated, the literature on the guidelines used in other states or countries are summarized.

Appendix E. Computer Program Code. Copies of the computer programs used in the study, along with brief descriptions, are provided.

CHAPTER 2

LITERATURE REVIEW

2.1 The General Problem of River Water Quality and Pollution Control

Many wastes produced by human activities (industrial, domestic and agricultural wastes) are disposed of in rivers due to the ability of rivers to rapidly mix, re-aerate and transport the wastewater away to the sea. However, the amount of wastes discharged into rivers and streams often exceeds their natural assimilative capacity. According to the Water Quality Inventory Report conducted by the U. S. Environmental Protection Agency (2002), 28 percent of the river miles in the U. S. are classified as "impaired" or "threatened" for their failure to meet established water quality standards. This pollution is caused mainly by industrial, domestic, and agricultural wastes; urban-related runoff/storm water; and resource extraction.

Urged by the growing public awareness and concern about controlling water pollution, the Federal Water Pollution Control Act Amendments were enacted in 1972. Amended in 1977, these laws became commonly known as the Clean Water Act. To fulfill its policy of zero discharge in 1985, the Act established the basic structure for regulating discharges of pollutants into the receiving watercourses of the United States. It gave the Environmental Protection Agency (EPA) the authority to implement pollution control programs by prohibiting any discharge into the public waterways unless authorized by permit. This permitting system is known as the National Pollutant

Discharge Elimination System (NPDES). The Clean Water Act also established requirements to set water quality standards for all contaminants in surface waters. In addition, it funded the construction of sewage treatment plants through a construction grants program. In 1987, the U. S. Congress amended the Clean Water Act to focus greater national efforts on nonpoint sources, seen as an increasingly major contributor to water pollution. The Act established a national program to control nonpoint sources of water pollution. It also authorized EPA to issue grants to States in order to assist them in implementing management programs (Vesilind and Peirce 1990, EPA 1998, EPA 2002).

Although these programs have been implemented for decades, the concentrations of pollutants in many streams still have not met the established standards for the following reasons: (1) some of the discharges frequently fail to comply with the permits, and (2) current water laws are not adequate to control the various types of pollutants coming into rivers. Moreover, complying with the current government regulations is not always enough to improve the pollution conditions in rivers. Therefore, decision-makers to further reduce the water pollution conditions in rivers and streams commonly use certain structural and management strategies. Examples include the improvement of current wastewater treatment levels, the control of nonpoint source pollution produced by agriculture, the increase in the sources of flow to dilute the pollution load in rivers, and the control of in-stream chemical and biological reactions of water bodies.

To plan for the management of water pollution in rivers, water quality models are often used to predict the impact of natural processes and human activities on the physical, chemical, and biological characteristics of a waterbody. By presenting the spatial and temporal changes of the substances along rivers and streams, a water quality model makes it possible to assess the water quality impairment, identify the sources of water standard violations, and develop and implement water quality control plans. Details of recent work in this area are summarized and discussed in the following sections, based on a broad review of the literature.

2.2 Management of River Water Quality

To improve the water quality concentrations in rivers and streams, the direct reduction of inputs of point and nonpoint source pollution has most commonly been applied. Besides these pollution source control strategies, the enhancement of the waste assimilative capacities of rivers has also been widely used in management and restorations of rivers and streams. The following sections summarize past studies related to river water quality management. Also, the literature provides very useful information to help determine the target pollution reduction levels which were proposed in this study, with respect to the current feasible technologies.

2.2.1 Improved Wastewater Treatment

The urban and industrial wastewaters in the South Platte River Basin in Colorado are most commonly treated with secondary processes before being discharged to the receiving waters. The plants are typically operated using biological processes, such as the activated-sludge or trickling-filter processes. In the past, biological oxygen demand (BOD) and suspended solids (SS) were the two major water quality constituents monitored in wastewater pollution. The current secondary treatment process is able to efficiently remove these two constituents. In order to meet higher standards for nitrogen, total dissolved solids, and fecal coliform concentrations of the wastewater, it is necessary to modify the current biological processes, by including chemical treatment, or advanced waste treatment operations and processes.

From the literature it appears that the modern techniques in wastewater treatment, some of which have been successfully applied, are able to take the effluent standards to a higher level. For instance, TDS loads can be reduced by using a reverse osmosis process (Kolarik and Priestley 1995). This advanced process has been widely accepted for desalination of brackish and seawater. Applied to wastewater treatment, the process is an advanced technology to further reduce the salinity of secondary treated wastewater. A plant constructed in Orange County was able to reduce the TDS loads of secondary treated effluent from 1200 mg/L down to 60 mg/L.

In Indiana, an advanced wastewater treatment (AWT) system was constructed to enlarge and upgrade the two existing secondary wastewater treatment plants (Crawford and Wangsness 1993). These plants used ozonation of the final effluent, rather than chlorination, and an oxygen-nitrification system to process up to 245 million gallons of effluent per day (368 cfs). After implementation of AWT, the ammonia concentrations dropped from 14.3 mg/L (median value) to <0.1 mg/L. However, the nitrate concentrations increased from <0.1 to 11.0 mg/L due to the ammonia nitrification occurring in the plants. The number of fecal coliform colonies also decreased in the effluents. The median number of colonies decreased from 50 to 32 colonies/100 ml and from 38 to 14 colonies/100 ml in two different plants.

Improved biological treatment processes can substantially reduce nitrogen pollution. In Bedimont, Australia, a biological nutrient removal plant achieved a treatment level of 1 mg/L to 2 mg/L organic nitrogen, 2 mg/L ammonia, and 6 mg/L total nitrogen in effluents (Kolarik and Priestley 1995). Compared to the current secondary treatment processes adopted by most of the waste facilities in the river system, this plant added anaerobic reactor and anoxic reactor tanks before the aeration basins. Bernet et al. (2000) investigated a similar biological process and the results showed that the performance of the process reached a total nitrogen removal of 85 to 91 %. Another biological process, known as a moving bed biofilm reactor, was studied through a pilot plant (Rusten et al. 2000). The pilot plant was fed primary treated municipal wastewater and the results showed that a 70 % annual average removal of total nitrogen could be achieved based on the influent concentration of 25 mg/L.

A pilot scale operation for reclamation of urban wastewater was studied by using an ultrafiltration membrane bioreactor (Cicek et al. 1998, Xing et al. 2000). This process is an improvement of the conventional activated sludge process, which is currently adopted by some of the waste facilities in the river system. It was observed that the performance of this modern process could achieve more than 96.2 % removal of the ammonia nitrogen and the resulting ammonia concentrations of the effluent ranged from less than 0.2 to 1.3 mg/L. Another improvement of the conventional activated sludge process, known as the membrane separation activated sludge process, was investigated using actual wastewater through a pilot plant in Japan (Murakami et al. 2000). Through this process, nitrogen presence was reduced by more than 80 % by additional nitrification and denitrification.

Reducing fecal coliform concentrations in effluent is usually done with the aid of advanced treatment processes. It had been shown that a post treatment level of 23 colonies/100ml fecal coliform can be achieved by disinfecting the secondary treated effluents using ultraviolet (UV) radiation (Kolarik and Priestley 1995). Another study using similar technology to meet the level required was presented by Jolis et al. (1999). The authors demonstrated that the process, UV disinfection following microfiltration, reliably met California Wastewater Reclamation Criteria by reducing the fecal coliform by 4.5 logs.

From the literature reviewed, it was concluded that modern technologies are available to bring wastewater effluent concentrations down to the level of 60 mg/L for total dissolved solids, 1 mg/L in organic nitrogen, 0.1 mg/L ammonia, 6 mg/L total nitrogen, and 14 colonies/100 ml for fecal coliform. However, each technology might only target specific water quality constituents instead of dealing with variable constituents as in the present study. On the other hand, some technologies go beyond simply improving the current secondary treatment processes and require constructing advanced (tertiary) treatment plants. From the viewpoint of cost-effectiveness and feasibility, it is impossible to achieve the above treatment levels in the next 25 years in the South Platte Basin. On the other hand, reducing 50 % of the current waste concentrations seems a reasonable target.

2.2.2 Reduction of Nonpoint Source Loads

According to the Colorado Nonpoint Assessment Report, the impact of nutrients, due to agricultural activities, is most severe in the South Platte River Basin (Water Quality Control Division 1989). In contrast to point source pollution (such as wastewater effluent outfalls), nonpoint source pollution is highly variable in quantity and character, and is affected by human alterations to the landscape and the watershed hydrology of relatively broad area. The mechanisms to control nonpoint source pollution include best management practices (BMPs) and management measures. BMPs are individual practices, while management measures are general groups of affordable management practices that are used together in a system to achieve more comprehensive goals. The best management practices can be structural interventions (to modify pollutant transport in water by reducing water use, re-routing water, or retaining water), cultural interventions (to manipulate the soil system to minimize pollutant losses in surface water or groundwater), and management controls (to regulate pesticide and fertilizer application rates). Each of these practices can achieve different levels of control on the pollution caused by sediment, phosphorus, nitrogen, pesticide, biological oxygen demand, salt, heavy metals and pathogenic organisms (Logan 1990). Several studies have estimated the effectiveness of BMP implementation. The results were either obtained from model simulation or measured after implementing field practices in a watershed. Model-simulated results presented by Mostaghimi et al. (1997) showed that the effectiveness of different practices applied to the Owl Run Watershed, Virginia varied from 0 % to 42.6 % in runoff reductions and 9.3 % to 65.6 % in total nitrogen reductions. The considered practices included no-till, strip cropping, grassed waterways, animal-waste storage structures, vegetative filter strips, nutrient management, fencing, and Conservation Reserve Program initiatives, which requires that highly erodible croplands be retired for a period of 10 years. Most of these practices did not achieve the long-term goal of 40 % reduction in pollutant loads. It was concluded that these procedures aimed at meeting the reduction goal were largely inefficient. In a field study by Dressing (1998), it was demonstrated that the effectiveness of sediment load reduction of individual practices in Idaho varied from 0 % to 95 %, although the total sediment loads were reduced by 75 %.

Due to the difficulties in implementing BMPs as well as in estimating the effectiveness of achieving the target results, it is believed that the achievable level of reduction of nonpoint source pollution loads in the South Platte River Basin is about 30 %, as suggested by results reported in the literature.

2.2.3 Flow Dilution

The idea of flow augmentation is to provide dilution flows to rivers in order to enhance the waste-assimilative capacities. The sources of dilution flows can be diversion from upstream reservoirs, pumping from an aquifer or nearby reservoir, transfer from another watershed, recycling (by back pumping) water from cleaner and more diluted downstream flows, or changing points of diversion and return (Novotny and Olem 1993). Some examples adopted in recent studies of river water quality management demonstrated that reservoir management (operational changes of the release rate and the release times of a single or multiple reservoirs) was effective in improving the downstream water quality condition of dissolved oxygen level and salinity (Azevedo et al. 2000, Campolo 2002, Hayes et al. 1998, Higgins and Brock 1999, Wurbs and Karama 1995). Such approaches, however, often are not cost effective.

2.2.4 Control of In-Stream Chemical and Biological Reactions

Another group of techniques to increase the waste-assimilative capabilities of rivers requires installation of structures or equipment to induce aeration to raise the dissolved oxygen level. To increase the reaeration capability of the streams, in-stream aeration is commonly accomplished by building cascades, rapids, weirs, or spillways; by installing floating or submerged aerators; or by turbine aeration in power plants. Among these, turbine and weir aeration usually are the cheapest alternatives. However, using the turbines of hydropower plants can decrease the overall efficiency of the plant (Novotney and Olem 1993). Besides these traditional technologies, Weiss (1998) proposed a method to aerate river flow with hollow-fiber membranes. This method has been shown to have the potential to aerate these watercourses more cost-effectively than current methods and may be able to provide aeration to locations where traditional technologies are not effective.

Since the oxygen related water quality constituents (dissolved oxygen, biochemical oxygen demand, etc.) are not a major concern to agricultural water use, these type of pollution control technologies were not considered in the present study.

2.2.5 Performance Measures for River Pollution Control

When examining different strategies to reduce the water quality pollution in rivers and streams, the responses of the river water quality to each strategy must be estimated. Performance measures are often defined in order to facilitate quantitative comparison among different water quality pollution control strategies. Through a single or set of multiple equations defined by analysts, performance measures are calculated as composite values that depend upon water quality model outputs of interest. In the literature reviewed, performance criteria used to assess water quality pollution conditions in rivers included the minimum DO concentration in the river, computed as a mean value over a period of time (Rauch and Harremoes 1998); the compliance with the water quality objectives (Smith-Evans and Dawes 1996); the reliability or probability of system failure (Han et al. 2001, Vasquez et al. 2000); and the magnitude of the calculated statistical moments for each alternative output. Besides these criteria, the performance measures developed by Azevedo et al. (2000), called spatial uniformity and temporal uniformity, provide estimates of the degree of spatial and temporal equity of good water quality throughout the river basin, based on a computed water quality index. These measures were adopted and amended for use in the present study, as described in chapter 3. The probability of violation, calculated from 250 realizations, of each river segment over a certain time step replaced the water quality index used in Azevedo's equations. Along with the temporally and spatially-averaged ensemble statistical moments, which include the minimum, 5th percentile, mean, 95th percentile, maximum, and CV (coefficient of variation) over the 250 realizations, the performance of each alternative could be summarized.

2.2.6 Decision Making with Uncertainty

Computational water quality models often are used to evaluate river water quality management options. Even when a good database and reliable models are adopted, decision-making about water quality management still will encounter several sources of uncertainty. These uncertainties arise from the spatial and temporal variability of model input data, the approximation of the mathematical model used to represent the real river system, and data sampling limitations and errors. In the past, to overcome failures in management due to ignoring the inherent uncertainty of the system, decision makers often relied on the use of safety factors, which were determined mainly through the experience and judgment. Safety factors are coefficients having magnitudes greater than one that are multiplied times selected results of an analysis to hedge against risk associated various sources of uncertainty in the system. Often, these coefficients are conservatively set high enough to encompass even the worst case (Ayyub 1997). In recent years, advances in probabilistic techniques and in computational power have enabled more direct methods for addressing situations of decision making with uncertainty. In the field of water management, uncertainty in parameters and in predicted variables has been represented in terms of probability of occurrence, confidence intervals, and statistical moments associated with variability and dispersion, such as standard deviation or coefficient of variation (Yen and Tung 1993, Duchesne et al. 2001, Melching and Bauwens 2001). Using such stochastic measures provides a systematic framework to quantify uncertainty in model output as a function of the uncertainties in the model itself and in the stochastic model input parameters. Unlike the deterministic approach, stochastic models provide decision makers with information about the likelihood of occurrence of river characteristics of varying magnitudes. From such information, engineers can associate notions of risk and reliability to alternative decisions about river management. The term "risk" often is used to characterize the probability of failure of a system component, leading to an operational failure or the violation of a prescribed performance standard. "Reliability", on the other hand, is the complement to risk, being the probability of successful performance, or one minus the probability of failure (Ayyub 1997; Yeh and Tung 1993).

2.3 Water Quality Criteria for River Diversions to Agriculture

Several water quality constituents have been identified as posing environmental hazards to irrigated agriculture (Wilox 1948). Among these, total dissolved solids (TDS), total nitrogen (in the form of organic nitrogen, ammonia nitrogen, nitrite nitrogen and nitrate nitrogen), and fecal coliform are the major concerns in the South Platte River basin (Gates et al. 1993). Applying water with high TDS to agricultural fields causes salt accumulation in the soil following water evaporation and crop transpiration. This in turn can cause a reduction in soil porosity, hydraulic permeability and infiltration rate, and destruction of the soil structure. High salinity (salt accumulation) in the soil suppresses root water uptake and the growth rate of crops, and can result in crop yield reduction (Tanji 1990, Feigin et al. 1991, National Research Council 1993).

Although nitrogen is an essential nutrient for crop growth, excess nitrogen applied to crops can cause adverse effects to crop yields and to the environment. Irrigation water containing measurable quantities of nitrite has been proven to be associated with a condition toxic to citrus and avocado trees. Excess nitrate promotes too much vegetative growth but not enough production of tubers or fruits (Sawyer and McCarty 1986). Experiments also have shown a significant reduction in the sucrose level in sugar beets due to the uptake of large quantities of nitrogen (Feigin et al. 1991). Since all nitrate salts are soluble and easily lost by leaching, the excess nitrogen following irrigation is delivered to underlying groundwater or to receiving surface water. Nitrogen can accelerate the eutrophication of streams and irrigation canals, resulting in algae blooms that pose maintenance problems to canal structures. Besides, water containing high nitrate concentration incurs health problems to human and livestock if ingested (Gates et al. 1993).

Fecal coliform bacteria are commonly found in wastewater and can pose health hazards to the agricultural environment. They may be associated with the transmission of disease to farm workers who are exposed to the contaminated water either by incidental physical contact or by inhalation of aerosols from spray-irrigated fields. Applying highly contaminated water to crops may cause accumulation of such organisms in plant tissues and increase the pathogens level in the food chain (Sawyer and McCarty 1986). Livestock can ingest disease-causing agents and consumers may catch diseases by eating produce irrigated with active fecal coliform (Gates et al. 1993).

The current Colorado standards for contaminants in agricultural waters are based on EPA's 1972 and 1976 water quality criteria standards (Gates et al. 1993). Colorado has no microbial guidelines (including fecal coliform standards) for agricultural uses. In addition, no standards currently exist for total dissolved solids. The only standards for agricultural water uses are nitrogen in nitrite and nitrate forms, and have been established mainly as a concern for watering livestock. They are 10 mg/L for nitrite as nitrogen and 100 mg/L for nitrate nitrogen.

Guidelines summarized and proposed by Gates et al. (1993) suggested that water with a TDS concentration range of 450 mg/L to 2000 mg/L is acceptable for irrigation. Canadian government proposed a 500 to 3500 mg/L standard of TDS for irrigation water uses and a 3000 mg/L standard for livestock watering (Canadian Council of Ministers of the Environment 1999). The Mauritius government regulates that a 1300-mg/L TDS concentraion is the highest permissible level for water used for irrigation (Mauritius Department of Environment 1999). Proposed by Thomas for the state of Mississippi

(2000), a range of TDS concentration of 0 mg/L to 1950 mg/L was acceptable for irrigation water quality for different levels of restricted use. Similarly, a TDS range of 487.5 mg/L to 1950 mg/L was proposed by Hergert et al (1977) for irrigation water uses in Nebraska and a 500 mg/L to 5000 mg/L range was recommended by Follet and Soltanpour (1999) for irrigation water use in Colorado.

The Mauritius government regulates that water for irrigation use should have ammonia concentration less than 5 mg/L and nitrate concentrations less than15 mg/L (Mauritius Department of Environment 1999). Gates el al. (1993) proposed these different levels of increasing restriction for nitrogen concentrations used to irrigate crop in Colorado, namely less than 5 mg/L, 5 - 30 mg/L, and greater than 30 mg/L.

Arizona has developed reclaimed water standards that recommend that a fecal coliform concentration of 1000 colonies/100ml (geometric mean of 5 samples) be the highest level permissible for any agricultural reuse. Guidelines presented by the Health Organization recommended a standard of 1000 colonies/100 ml for general irrigation of crops likely to be eaten raw (Gates et al. 1993). The Mauritius government also regulated the 1000 colonies/100 ml level as the fecal coliform standard for irrigation water (Mauritius Department of Environment 1999). However, the strictest fecal coliform standards were proposed by the Canadian government, which regulated that a fecal coliform level of 100 CFU/100 ml was the highest acceptable concentration for irrigation water (Canadian Council of Ministers of the Environment 1999).

Two sets of values were adopted to represent the low and high standards for irrigation water use in the present study. The low standards were set at 1000 mg/L for TDS, 10 mg/L for nitrite as nitrogen, 30 mg/L for total nitrogen in the off-irrigation season, 10 mg/L for total nitrogen in the irrigation season, and 1000 colonies/100 ml for fecal coliform. On the other hand, 500 mg/L of TDS, 10 mg/L of nitrite as nitrogen, 15 mg/L of total nitrogen in the off-irrigation season, 5 mg/L of total nitrogen in the irrigation season, and 500 colonies/100 ml of fecal coliform were adopted as the high, or more stringent, standards.

2.4 River Water Quality Models

2.4.1 Governing Processes and Laws for River Water Quality

To predict water quality conditions in rivers and to seek reliable remedies for river water pollution, mathematical models are often used. Most computational models developed to simulate the behavior of the hydrologic and water quality characteristics of a stream system are based on the theory of mass conservation. That is, the accumulation of mass within a finite control volume (often defined as an element within a river system), for a finite period of time, is the sum of the net loadings (external inputs, or sources, to the river minus withdrawals, or sinks, from the river), the net transport (the movement of the constituents into the river control volume from upstream minus the outflow to downstream), and the internal reactions (the gain or loss within the river system by transformation of the substances) of the mass (Chapra 1997). The sources to the river system usually come from wastewater discharges of municipal, industrial, and agricultural activities, as well as tributary and groundwater inflows. The sinks result from the withdrawals of the river flow for municipal, industrial and agricultural use, tributary outflow, and outflow to groundwater recharge. These loadings are in the form of point or nonpoint runoff along the river system. Within the mass transport in the river system, three processes are commonly addressed: transport by the principal water current (advection), transport due to mixing within the water body (dispersion), and transport of sediment particles within the water column and between the water and channel bed. The first two processes are associated with movement of the chemical or biological substances in dissolved form and the third process is associated with the movement of the substances in sorbed forms (Schnoor 1996).

The rate of transport of the constituents in the rivers depends on the hydrologic and hydrodynamic characteristics of the rivers, expressed by momentum and mass conservation equations. In their three-dimensional forms, these equations can be written as follows (McCutcheon 1989):

$$\frac{\partial \boldsymbol{u}}{\partial t} + \boldsymbol{u} \bullet \nabla \boldsymbol{u} = -\frac{1}{\rho}\nabla P + \nu\nabla^2 \boldsymbol{u} + g \qquad (2\text{-}1)$$

$$\frac{\partial \rho}{\partial t} + \nabla \bullet (\rho \boldsymbol{u}) = 0 \qquad (2\text{-}2)$$

where $\boldsymbol{u}$ is the instantaneous velocity vector with components u, v, and w along the respective three coordinate axes x, y and z, representing the longitudinal, vertical, and lateral directions within the river (LT^{-1}); P is the static pressure ($ML^{-1}T^{-2}$); ρ is the fluid density (ML^{-3}); ν is the kinematic viscosity of the fluid (L^2T^{-1}) and g is the gravitational acceleration (LT^{-2}). In equation (2-1), the partial derivatives of $\boldsymbol{u}$ with respect to time and space are expanded as follows:

$$\frac{\partial \boldsymbol{u}}{\partial t} = \frac{\partial u}{\partial t} + \frac{\partial v}{\partial t} + \frac{\partial w}{\partial t} \qquad (2\text{-}3)$$

$$\boldsymbol{u} \bullet \nabla \boldsymbol{u} = u\left(\frac{\partial u}{\partial x} + \frac{\partial v}{\partial x} + \frac{\partial w}{\partial x}\right) + v\left(\frac{\partial u}{\partial y} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial y}\right) + w\left(\frac{\partial u}{\partial z} + \frac{\partial v}{\partial z} + \frac{\partial w}{\partial z}\right) \qquad (2\text{-}4)$$

$$\nabla^2 \boldsymbol{u} = \left(\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} + \frac{\partial^2 u}{\partial z^2} \right) + \left(\frac{\partial^2 v}{\partial x^2} + \frac{\partial^2 v}{\partial y^2} + \frac{\partial^2 v}{\partial z^2} \right) + \left(\frac{\partial^2 w}{\partial x^2} + \frac{\partial^2 w}{\partial y^2} + \frac{\partial^2 w}{\partial z^2} \right) \qquad (2\text{-}5)$$

In contrast to solving these complex equations to obtain the hydraulic characteristics of the river system, some simplified methods have been used to solve the stream flow routine for water quality modeling (McCutcheon 1989). They are:

(1) Stage-discharge relationships for steady flow;

(2) Discharge-depth and discharge-velocity relationships that are often expressed by power forms and derived from field data;

(3) Solutions of the Manning equation, assuming steady uniform flow;

(4) Muskingum hydrologic routing (Smith 1978);

(5) Modified Puls hydrologic routing (Smith 1978);

(6) Solution of the kinematic wave approximation of the cross-section-averaged one-dimensional flow equations (French 1985);

(7) Solution of the diffusion analogy form of the cross-section-averaged one-dimensional flow equations (French 1985); and

(8) Solution of the full cross-section-averaged one-dimensional flow equations (French 1985).

Material transport in streams can be described using either Eulerian or Lagragrian reference frames. The Eulerian system assumes that an analyst stays at a fixed point on the stream bank and quantifies the water quality concentrations flowing by. By contrast, the Lagrangian system assumes that the analyst quantifies the water quality concentrations in a river by following the flow of the river. The Eulerian reference frame is used most extensively in river water quality modeling. Hence, in the following paragraphs, the mass transport equations are all presented using an Eulerian reference frame.

The advection of substances in rivers is described through the sum of the mass flux through a control volume and the storage change that it effects. This can occur in three directions (longitudinal, lateral, and vertical) and often is expressed in the following form (McCutcheon 1989):

$$\frac{DC_i}{Dt} = \frac{\partial C_i}{\partial t} + \frac{\partial (uC_i)}{\partial x} + \frac{\partial (vC_i)}{\partial y} + \frac{\partial (wC_i)}{\partial z} \qquad (2\text{-}6)$$

where C_i is the concentration of a water quality constituent i in the river (ML^{-3}). The term $\frac{\partial C_i}{\partial t}$ represents the change of the concentration of constituent i within a specific fixed control volume (holding x, y, and z constant) and the material derivative term $\frac{DC_i}{Dt}$ represents the change in concentration of that constituent in a specific fixed element of fluid moving with the flow.

Diffusion can be described using Fick's first law that states that the diffusive flux along any coordinate axis is proportional to the concentration gradient across the plane over that axis (McCutcheon 1989):

$$N_x = -D_m \frac{\partial C_i}{\partial x} \qquad (2\text{-}7)$$

$$N_y = -D_m \frac{\partial C_i}{\partial y} \qquad (2\text{-}8)$$

$$N_z = -D_m \frac{\partial C_i}{\partial z} \qquad (2\text{-}9)$$

where N_x, N_y, N_z are the diffusive fluxes along the x, y, and z axes ($ML^{-2}T^{-1}$); and D_m is the coefficient of molecular diffusivity with the unit length square per time (L^2T^{-1}). Hence, the total change in the water quality concentration in a river due to the effect of diffusion can be written as:

$$D_m(\frac{\partial^2 C_i}{\partial x^2}+\frac{\partial^2 C_i}{\partial y^2}+\frac{\partial^2 C_i}{\partial z^2}) \tag{2-10}$$

If the effects of advection and diffusion are combined the resulting mass balance equation is as follows (McCutcheon 1989):

$$\frac{\partial C_i}{\partial t}+\frac{\partial (uC_i)}{\partial x}+\frac{\partial (vC_i)}{\partial y}+\frac{\partial (wC_i)}{\partial z}=D_m(\frac{\partial^2 C_i}{\partial x^2}+\frac{\partial^2 C_i}{\partial y^2}+\frac{\partial^2 C_i}{\partial z^2}) \tag{2-11}$$

Some constituents become adsorbed to sediment particles. The sedimentation process describes these substances' movement in downstream direction with nearly the mean current velocity and in the vertical direction by their sedimentation velocity. The total transport of pollutants that adsorb, such as phosphorus, heavy metals and pesticides, must be considered as the sum of the adsorbed and dissolved phases. A term for the concentration change of an adsorbed form j is added in equation (2-11) to represent the total mass balance equation as follows (Krenkel and Novotny 1980):

$$\frac{\partial C_i}{\partial t}+\frac{\partial (uC_i)}{\partial x}+\frac{\partial (vC_i)}{\partial y}+\frac{\partial (wC_i)}{\partial z}=D_m(\frac{\partial^2 C_i}{\partial x^2}+\frac{\partial^2 C_i}{\partial y^2}+\frac{\partial^2 C_i}{\partial z^2})-\rho\frac{\partial s_j}{\partial t} \tag{2-12}$$

The rate of change of the adsorbed phase is written as:

$$\frac{\partial s_i}{\partial t}=K_s(s_{e_i}-s_i)-(K_{ss}s_i+M)/h \tag{2-13}$$

where s_j is the concentration of an adsorbed constituent i (MM^{-1}); K_s is the kinetic adsorption coefficient (T^{-1}); s_{e_i} is the adsorption equilibrium concentration of the pollution described by an isotherm (MM^{-1}); K_{ss} is the settling rate of the substance (MT^{-1}); M is the scour rate of the pollutant adsorbed on the sediment from the bottom deposits ($ML^{-2}T^{-1}$); and h is the depth of the flow (L).

The mass balance equation is often completed by adding two terms: $\frac{dC_i}{dt}$ that represents the growth and decay of the substances due to reactions within the control volume and S_i, the sum of the external sources and sinks of the substances (MT^{-1}):

$$\frac{\partial C_i}{\partial t}+\frac{\partial(uC_i)}{\partial x}+\frac{\partial(vC_i)}{\partial y}+\frac{\partial(wC_i)}{\partial z}=D_m\left(\frac{\partial^2 C_i}{\partial x^2}+\frac{\partial^2 C_i}{\partial y^2}+\frac{\partial^2 C_i}{\partial z^2}\right)-\rho\frac{\partial s_i}{\partial t}+\frac{dC_i}{dt}+\frac{S_i}{V} \quad (2\text{-}14)$$

The $\frac{dC_i}{dt}$ term refers to total internal constituent changes including the effects of uptake by phytoplankton, transformation into anther form, diffusion into or from benthal layers, and others. Such growth and decay should not be confused with the partial derivative $\frac{\partial C_i}{\partial t}$ and the material derivative $\frac{DC_i}{Dt}$ terms in equation (2-6). Transformations of substances in rivers are caused by complex interactions between chemical and biological reactions. The chemical processes are often characterized by zero (conservative), first, or second-order reactions. When the activities of microorganisms are considered in simulating water quality in rivers, biological models of growth, respiration, sedimentation, and predation are needed. For the nonconservative water quality constituents considered in this study, the transformations due to the chemical and biological processes can be written as (Brown and Barnwell 1987):

$$\frac{dC_{ON}}{dt}=\alpha\rho_A A-\beta_{ON}C_{ON}-\sigma_{ON}C_{ON} \quad (2\text{-}15)$$

$$\frac{dC_{NH_3}}{dt}=\beta_{ON}C_{ON}-\beta_{NH_3}C_{NH_3}+\sigma_{NH_3}/h-F\alpha\mu A \quad (2\text{-}16)$$

$$\frac{dC_{NO_2}}{dt} = \beta_{NH_3} C_{NH_3} - \beta_{NO_2} C_{NO_2} \tag{2-17}$$

$$\frac{dC_{NO_3}}{dt} = \beta_{NO_2} C_{NO_2} - (1-F)\alpha\mu_a A \tag{2-18}$$

$$\frac{dC_{FC}}{dt} = -k_{FC} C_{FC} \tag{2-19}$$

where C_{ON} = concentration of total organic nitrogen (ML^{-3}); C_{NH_3} = concentration of nitrogen as NH_3 (ML^{-3}); C_{NO_2} = concentration of nitrogen as NO_2 (ML^{-3}); C_{NO_3} = concentration of nitrogen as NO_3 (ML^{-3}); C_{FC} = concentration of fecal coliform (ML^{-3}); α is the fraction of algal biomass that is nitrogen (MM^{-1}); ρ_A = algal respiration rate (T^{-1}); A is the algal biomass concentration (ML^{-3}); β_{ON} = rate constant for hydrolysis of organic nitrogen to ammonia nitrogen (T^{-1}); σ_{ON} = rate coefficient for organic nitrogen settling (T^{-1}); β_{NH_3} = rate constant for the biological oxidation of ammonia nitrogen (T^{-1}); σ_{NH_3} = benthos source rate for ammonia nitrogen ($ML^{-2}T^{-1}$); F = fraction of algal nitrogen uptake from ammonia pool; μ_a = local specific growth rate of algae(T^{-1}); β_{NO_2} = rate constant for the oxidation of nitrite nitrogen (T^{-1}); and k_{FC} = fecal coliform die-off rate (T^{-1}).

For water quality studies in a river, whose length is much larger than the depth and width dimensions, the advection and diffusion processes along the longitudinal, or principal, direction of flow are more dominant than processes occurring in the other two directions. Therefore, the full three-dimensional processes are often integrated into one dimension. In other words, properties are averaged over the stream cross section, oriented perpendicular to the principal direction along the thalweg axis.

In the present study, a modified version of the widely used QUAL2E model

(Brown and Barnwell 1987) was used to approximate cross-section averaged one-dimensional river flow and mass transport under successive conditions of approximately steady-state flow. The model is used as a tool for feasibility-stage project planning, to understand the likely behavior of a river under broad long-term strategies for upgrading the quality of river flows. After identifying the most promising strategies, more detailed and focused analysis would be necessary in a later design phase. Since adsorbed substances are not considered as significant pollutants in the South Platte River basin, the material transported by sedimentation and erosion was not considered in the present study. Hence, for a given water quality constituent i, the resulting mass balance equation under steady state condition was expressed as follows (Brown and Barnwell 1987):

$$\frac{\partial(AD_{x_i}\frac{\partial C_i}{\partial x})}{A\partial x}-\frac{\partial(A\bar{u}C_i)}{A\partial x}+\frac{dC_i}{dt}+\frac{S_i}{V}=0 \tag{2-20}$$

where A = cross-sectional area of flow (L^2); D_{x_i} = longitudinal dispersion coefficient (L^2T^{-1}); $\bar{u}$ = cross-section averaged velocity (LT^{-1}); S_i = external sources or sinks (MT^{-1}); and $V = Adx$ = incremental volume along the river (L^3).

Following previous studies in the South Platte River Basin (Paschal and Mueller 1991), algal effects were assumed insignificant and were neglected. Hence, Eqs. (2-15), (2-16), and (2-18) could be simplified into the following forms for the present study:

$$\frac{dC_{ON}}{dt}=-\beta_{ON}C_{ON} \tag{2-21}$$

$$\frac{dC_{NH_3}}{dt}=\beta_{ON}C_{ON}-\beta_{NH_3}C_{NH_3} \tag{2-22}$$

$$\frac{dC_{NO_3}}{dt}=\beta_{NO_2}C_{NO_2} \tag{2-23}$$

2.4.2 Distributed-Parameter Models for River Quality Simulation

Water quality models have evolved from the Streeter and Phelps model in 1925, which solved for dissolved oxygen levels and bacteria concentrations in streams and estuaries, to current comprehensive models that simulate dissolved oxygen, nutrient and phosphorus cycling, suspended solids, several classes of algae, zooplankton invertebrates, plants, fish, and toxic pollution in streams, estuaries and lakes. In the years 1925 to 1960, model formulations were limited to simulating linear kinetics, simple flow geometry and steady-state systems in order to derive analytical solutions of the governing equations. After 1960, digital computers became widely available and the model solutions were not limited to analytical forms. With numerical solutions now accessible, models can describe more complicated geometries, kinetics, and unsteady-state simulations. In the 1970s, nonpoint source pollution began to be considered in water quality models, since point-source controls in many areas were insufficient (Chapra 1997)

While reviewing appropriate water quality models for this study of the South Platte River, preference was given to a model that would address advective transport, convective dispersion, and chemical and biological reactions affecting water quality in streams. Preferably, this model had to be widely used and documented. Additionally, due to the special specifications considered in this study, the model source code had to be available for possible modification.

The most widely documented available models predominately are those developed and supported by government agencies. Examples are QUAL2E, WASP5 (developed by US Environmental Protection Agency), CE-QUAL-ICM (developed by US Army Corps of Engineers Waterways Experiment Station), HEC5Q (developed by

US Army Corps of Engineers Hydrologic Engineering Center), MIKE11 (developed by the Danish Hydraulic Institute), the ATV model (developed by ATV, Germany), Salmon-Q (developed by HR Wallingford, UK), DUFLOW (developed by the University of Wageningen, the Netherlands), AQUASIM (developed by EAWAG, Switzerland), and DESERT (developed by IIASA). These models all include a hydrodynamic model, transport equation, and biochemical conversion process (chemical and biological reactions). In regard to the hydrodynamic part, only four out of the ten models allow the user to externally input the hydraulic characteristics of the river channel (QUAL2E, WASP5, MIKE11, and DESERT) and two of them cannot simulate control structures that are commonly present in river channels (QUAL2E and WASP5). In the transport equation part, four of them do not include sedimentation and erosion processes (QUAL2E, HEC5Q, Salmon-Q, and DUFLOW). In simulating the transformation of the constituents in rivers, all of them include organic matter, nitrogen and phosphorous cycling, and phytoplankton. Four offer options to simulate the transformation of silicon (CE-QUAL-ICM, MIKE11, ATV model, and Salmon-Q). For a detailed consideration of the growth and degradation of several classes of algae and zooplankton, six out of the ten models are available (CE-QUAL-ICM, MIKE11, ATV model, and Salmon-Q). Except WASP5 and DESERT models, all of these models contain submodels that calculate water temperature in addition to using temperature dependent rates. For calibration and validation of the model parameters, two of the ten models (AQUASIM and DESERT) have built-in procedures to automatically estimate the sets of optimal model parameters and three out of ten models include submodels to perform sensitivity and uncertainty analysis (QUAL2E, AQUASIM, and DESERT) (Rauch et al. 1998).

In recent years, even more comprehensive river water quality models have been developed that relax the assumptions used in models, like those mentioned above, that were developed primarily to solve regulatory water quality problems, such as relatively steady-streamflow and constant-emission conditions in rivers and streams. These new models provide a complete framework for river water quality modeling beyond simply regulatory purposes, by including more complete physical, chemical, and biological reactions among the substances in rivers, transient streamflow conditions, storm water events, varied nonpoint sources, and geographical information systems into the model formulations (Reichert et al. 2001, Reichert and Vanrolleghem 2001, Shanahan 2001, Vanrolleghem 2001, Wang et al 2000).

Among available models, QUAL2E has been widely applied to simulate the temporal and spatial changes of constituents of concern in many watersheds worldwide (e.g., Han et al. 2001, Azevedo et al. 2000, Paschal and Mueller 1991, Harton and McTernan 1990, Barnwell et al. 1989, Schoellhammer 1988, Brown 1987, Van Der Beken 1987), and has also served as the basis for more complex river water quality models (Vandenberghe 2001). It allows users to simulate several water quality constituents in a branching stream system under steady-streamflow and constant-emission conditions. The flow equations used in QUAL2E to derive velocity and turbulent diffusion coefficients are described for one-dimensional, steady, gradually varied flow. For the mass transport in the river system, QUAL2E addresses advection and dispersion along the longitudinal direction. In simulating the conversion processes for the constituents in rivers, the QUAL2E model includes degradation of organic material, growth and respiration of algae, nitrification, hydrolysis of organic nitrogen and phosphorus, re-aeration, sedimentation of algae, organic phosphorus and organic nitrogen, sediment uptake of oxygen, and sediment release of nitrogen and phosphorus. The above processes are integrated into a one-dimensional, advective-dispersive, mass transport equation, and are solved by a finite difference method. An advanced version of the model, QUAL2E-UNCAS, which incorporates uncertainty analysis techniques, is also widely used for estimation of the uncertainty in model predictions (Adams 1998, Cardwell and Ellis 1993, Larmie et al. 1989, Brown 1987). The QUAL2E-UNCAS model provides three optional approaches: sensitivity analysis, first order-error analysis, and Monte Carlo simulation. In the first approach, users can examine the magnitude of the change in values of each output variable resulting from perturbing the values of the input variables. The second approach, first order error analysis, allows users to alter the input variables to produces associated output changes in terms of normalized sensitivity coefficients (the percentage change in the output variables resulting from a one percent change in a respective input variable), and the components of variance for each output variable (the percentage of output variable variances attributable to each input variable variance). The third uncertainty approach, Monte Carlo simulation, allows users to describe each input variable using normal, lognormal or uniform marginal probability density distributions. Values of input variables are randomly and independently generated and input into the model to simulate the river system behavior. The uncertainty of the output variables are analyzed and presented in the form of probability distributions and summary statistics. The QUAL2E-UNCAS Monte-Carlo simulation option assumes that input random variables are uncorrelated normally, lognormally, or uniformly distributed, assumptions that are not sufficient to describe nature of parameter uncertainty in the

South Platte River Basin. Hence, this approach was revised and linked to a chosen empirical stochastic model to encompass the more extensive statistical structure, including trends and spatial/temporal correlation, in the South Platte River System.

2.4.3 Water Quality Model Calibration and Validation

Mathematical equations used in the water quality models require knowledge of a large number of coefficients and reaction rates for which only limited samples are available from rivers and streams. Although model user's manuals often provide guidelines for a rough estimate of these parameters, the ranges of values provided are commonly quite wide. Accurate values for these parameters remain to be well-estimated for most cases. Under these circumstances, the only way to obtain a set of coefficients adequately describing the watershed is to calibrate the model against measured system behavior. Model calibration is a procedure for adjusting model parameters until river behavior simulated by the model falls within acceptable margins, defined as the measured river behavior plus and minus an acceptable error. Following the calibration procedure, model validation is accomplished with the calibrated parameters by performing another event simulation independent from that used for calibration. The simulated results are then compared to available measured data associated with the validation set to determine if they are within an acceptable margin of error without additional parameter modification.

Of course, considerable field data are necessary to calibrate and validate river water quality models. The performance criteria for acceptance of model calibration and validation are often established on the basis of the comparison of paired data for model prediction and field observations at the same time and location. However, when the stochastic approach is adopted to simulate the water quality conditions in rivers and streams, these criteria are not sufficient since model output are in the form of distributions of possible flow and water quality constituent concentrations along the river. In this study, the criteria for model performance were defined by how closely the statistics of the simulated data matched the corresponding statistics derived from field data at the same times and locations.

Often, when a model contains a large number of parameters and complex inter-relationships among them, the manual calibration procedure, which basically is a trial-and-error parameter adjustment based on judgement, is not efficient and reliable. It is necessary in such cases to develop a more methodical approach to automatically calibrate the water quality model parameters. An optimization algorithm can be used to find the best combination of the statistics of the model parameters to achieve the most satisfactory fit of the statistics of the simulated output to those of the corresponding observed data.

Parameter estimation using optimization, sometimes referred to as the inverse problem, has been widely adopted to estimate model parameters in a deterministic setting (Khatibi et al. 2000, Madsen 2000, Gumrah et al. 2000, Guo and Zhang 2000, Nguyen et al. 2000, Ramesh et al. 2000, Schwartz et al. 2000, Simunek et al. 1999, Abdulla et al. 1999, Anagnostou and Krajewski 1999, Heidari and Ranjithan 1998, Lingireddy 1998, Mulligan and Brown 1998). By minimizing some function of the differences between simulated and observed data (e.g. the sum of the squares of the differences), the model parameters are identified using an optimization approach. Optimization algorithms can be classified as "local" and "global" methods (Madsen 2000). Local methods are efficient for locating the optimum of a uni-modal function, while global search algorithms are guaranteed to reach the global optimum eventually. The algorithms are further divided into "direct" and "gradient-based" methods. Direct search methods only use computed values of the objective function itself, whereas gradient-based methods also require the value of the gradients of the objective function with respect to the calibrated parameters in determining optimal solutions.

In the present study, the objective function is nonlinear and its gradients cannot be derived explicitly. Each decision variable in the objective function is constrained by minimum and maximum values (inequality constraints). Several decision variables (calibrated parameters) must be optimized in each objective function, which leads to a multidimensional problem. Besides, the objective function may have numerous local optima. These characteristics led the author to find a direct and global search method to optimize this nonlinear, constrained, multidimensional problem with as few evaluations of the objective function as possible.

The direct and global search methods commonly used for calibrating water management-related models are classified as simplex-method-based algorithms (Abdulla et al. 1999, Madsen 2000, Nguyen et al. 2000), and generic algorithms (Gumrah et al. 2000, Heidari and Ranjithan 1998, Lingireddy 1998, Mulligan and Brown 1998). Simplex-method-based algorithms adopt the concept of building a polyhedron (simplex) by expanding the decision variables (parameters to be calibrated) in an n-dimensional euclidean space. To search the minimum of the objective function (the differences between simulated and observed values of the output variables), the trial values of the decision variables can be selected at the vertices of the simplex. By estimating the objective function of each vertex, the point with the highest value of the objective function is replaced by a new point and a new simplex is formed. The same procedure is repeated until the size of the simplex is reduced to be less than a user-defined error tolerance. Genetic algorithms adopt the concept of evolution by natural selection and generic inheritance. The objective function plays the role of the environment and each decision variable is analogous to a biological gene of an individual. By evaluating each individual's "fitness" to the environment, the offspring are produced by stochastic crossover and mutation of individuals that have higher likelihood of "surviving". The population evolves to contain more and more high-performed individuals until the ending criteria are met.

In the above-cited studies, both types of algorithms proved to be robust in estimating the model parameters. However, in comparing these two types of algorithms, it has been shown that generic algorithms require relatively many computationally expensive function evaluations (Lingireddy 1998). Accordingly, it was decided that a simplex-method-based algorithm would be more appropriate for the present study. In the present study, the flexible tolerance method was adopted to solve a constrained multidimensional nonlinear problem (Himmelblua 1972) without estimating the gradient of the objective function. The flexible tolerance method is an algorithm to improve the value of the objective function by using information provided by feasible points (decision variables within defined constraints) as well as certain non-feasible points termed near-feasible points. The near-feasible limits are gradually made more restrictive until the user-defined tolerance limits are reached, yielding the solution to the problem.

2.4.4 Model and Parameter Uncertainty in Simulating River Water Quality

Uncertainties in environmental assessment and water management have drawn considerable attention in recent years. Some articles have shown that even modest uncertainty in input information can result in poor estimations in management plans. Uncertainty in the water quality planning and management can be categorized into two major types (Cardwell and Ellis 1993):

(a). Type I uncertainty (model uncertainty) - uncertainty inherent in the mathematical model of the physical processes (e.g., conservation of mass, conservation of momentum, chemical reactions) under consideration, resulting from misspecification and improper assumptions (simplifications) of terms and components of the processes.

(b). Type II uncertainty (parametric, or parameter value, uncertainty) - uncertainty associated with the parameters (boundary conditions, system properties, and sinks/sources) of the adopted mathematical models of the processes. This uncertainty is derived primarily from spatial and temporal variability, measurement error, and sparse sampling.

The objectives of the present study are associated with addressing the uncertainty in a model applied for river water quality planning and management purposes. Since EPA QUAL2EU model has been widely and successfully used in the past decades, a second more comprehensive (less simplified) water quality model was not considered to further identify Type I uncertainty. Instead, in this study, only Type II uncertainty was considered.

Stochastic approaches for addressing parametric uncertainty in river water quality simulation fall into two broad classes: empirical stochastic models and physical-based stochastic models. Empirical stochastic models are developed to describe historical measured values of variables without directly considering the physical laws of river water quality processes that govern those values. Measured data are simply analyzed to infer the statistical characteristics of the variables as observed along the river and over time. An empirical stochastic model can be used not only in a descriptive sense, but also in a predictive sense. That is, the model can be used to predict, or forecast, possible values of water quality concentrations at unobserved spatial locations and/or at future times of interest. Such predictions, however, are restricted by the assumption that unobserved and future concentrations in the river system will be influenced by conditions that are essentially the same as those that brought about the distribution of historical observations used to develop the model. If one desires to predict distributions of possible responses of constituent concentrations to changes in system boundary conditions, properties, and sinks or sources, it is necessary to employ a physically-based stochastic model.

In a physically-based (or mechanistic) model, the boundary conditions, properties, and sinks or sources are referred to collectively as parameters of the model. These parameters serve as independent variables in equations that approximate the governing physical laws. Since the model parameters themselves are subject to uncertainty, empirical stochastic models often represent them. A physically-based stochastic model is used to predict the stochastic characteristics of state, or output, variables of interest as functions of the stochastic characteristics of the parameters.

2.4.5 Empirical Stochastic River Quality Models

A river water quality system can be treated as a collection of spatial-temporal random fields (STRF), each random field defined as a family of random variables indexed by their positions in space and their positions in time, as well as dependent upon the events in probability. In general, these spatial-temporal random fields display underlying trends, or systematic patterns of variation, and are stochastically correlated to one another. The concentration of water quality constituent *i* in a one-dimensional cross-section averaged river system, modeled as one of the STRFs, has the following general form:

$$C_i(x,t;\omega) = \Re^{-1}[C_i(x,t;\omega)_{LST} + C_i(x,t)_{PT} + C_i'(x,t;\omega)] \qquad (2\text{-}24)$$

where $C_i(x,t;\omega)_{LST}$ is the large-scale stochastic trend component, reflecting the gradual low-order change in C_i with distance x, with time t, and with event in probability (ML^{-3}); $C_i(x,t)_{PT}$ is the deterministic periodic trend component reflecting the medium-scale cyclic variations with x, and/or with time, t (ML^{-3}); and $C_i'(x,t;\omega)$ is the statistically-homogeneous (i.e. statistics not varying with x and t; Christakos 1992) random component (ML^{-3}). The random component is auto correlated along x and t, as well as cross correlated with the random components of other water quality variables. The operator $\Re$ (usually a logarithmic or power function) can be used to transform the original concentration $C_i(x,\ t;\ \omega)$ to remove any large-scale trends that may exist in spatial or temporal variance in the river system. The process in Eq. (2-24) is a description of the probabilistic evolution of C_i in space and time, but does not contain a mathematical description of governing physical laws. Measured data are simply analyzed to infer the statistical characteristics of this process as observed along the river and over time; hence, Eq. (2-24) is referred to as an empirical stochastic model.

There are numerous approaches to developing and accounting for the components of the general model of Eq. (2-24) based on the historical statistic moments of interest. Often, these methods were developed based on reproducing and simulating the stationary (homogenous) random variables. That is, the statistical characteristics (including mean, standard deviation and correlation coefficients) of a certain random variable would not change over time or along the river (Brockwell and Davis 1996). Thus, before modeling random components of stochastic water quality variables C_t , the nonhomogeneous components, or trends, need to be detected and removed.

2.4.5.1 Detection and Modeling of Trends in Stochastic Water Quality Variables

To detect the nonhomogeneity of a stochastic water quality variable, that is, the possible changes in the mean and variance over time or along the river channel, several techniques have been proposed. The most often-used approach is to graphically plot the available series of values in order to detect any trends by visual judgment. However, for some series with small trends, visual judgment probably is not sufficient to identify the trends. Some authors have suggested examining autocorrelation plots to estimate whether a large-scale or periodic component in the mean was present (Brockwell and Davis 1996, Box et al. 1994). Other common technologies to detect changes in the mean and variance include the Mann-Whitney or Wilcoxon Rank Sum test, Sign test, Abbe test, T and F tests, Hotelling-Pabst test, Mann-Kendall test, Anderson's Correlogram test and

Baysesian analysis (Salas 1992). Often, regression analysis is also used to detect the presence of significant linear and nonlinear trends.

Detected trends in the variances of random variables can be removed by transformation functions, usually in the forms of a logarithmic or power function. Once the trend in the variances is removed, any detected nonhomogeneity in the mean can be further divided into large-scale trend and periodic trend components. The trend components can be quantified and removed by smoothing using moving average, simple differencing between data points at the different time (or spaces), seasonal decomposition method, Fourier Series or fitted multi-regression equations (Lehmann and Rode 2000, Brockwell and Davis 1996, Salas 1992). The seasonal decomposition method is also used to describe periodic trend components.

In this study, trends were detected using Anderson's Correlogram test, Bayesian test, and multi-regression analysis, that fitted a multi-regression model with independent variable (time) up to the poser of five to each of the random variable series to check if the fitted coefficients were significantly different (5% significance level) than zeroes. Once the trends were examined, simple differencing, seasonal decomposition, and multi-regression analyses were again applied to quantify and remove large-scale deterministic trends. These large-scale trends were predicted by exploiting the developed trend equations plus noise terms to generate a stochastic large-scale trend component to represent the non-homogeneity of the random variables into the future.

2.4.5.2 Modeling Random Components of Stochastic Water Quality Variables

Several approaches have been used in the literature to model the random components in space and/or in time of stochastic water quality variables, based on the nature and extent of the historical measurements and the statistical characteristics of the interest:

(a) Probability density function generation model - This method generates possible values of the statistically homogeneous random component of the considered stochastic variables based on fitted marginal probability distributions of measured data. For multidimensional problems, random variables are generated independently without considering the correlation structures among the variables both in time and space. This method is simple, but only preserves the marginal distributions of the variables (Bogardi and Milutin 1995; Cardwell and Ellis 1993; Frank and Teutsch 1992; Greiner and Parton 1995; Hession et al. 1996; Huwe and Totsche 1995; Mailhol et al. 1999; Nikolaidis et al. 1994; Quinodoz and Valocchi 1993; Kotsopoulos and Svehlik 1995; Reichard 1995; Wu and Workman 1999).

(b) Transition probability matrix method (e.g., Markov chain) - Given the theory that the probability of any particular future behavior of a process is only related to its current behavior, random components are generated by a one-step transition probability matrix derived from historical data. This method is simple and good for higher dimension problems. However, it only considers the lag-one serial correlation structure of the random field (Bogardi and Milutin 1995; Dudley and Scott 1993; Huang and Wu 1993; Karamouz and Vasiliadis 1992; Raman and Chandramouli 1996).

(c) Matrix composition method - This methodology is based on the theory that the correlation structure, which describes the degree of spatial persistence among different random components, is the most important statistical property to be considered. The resulting covariance matrix is decomposed into upper and lower triangular matrices. A vector of independent random numbers then multiplies the lower triangular matrix in order to produce a random field that preserves the imposed covariance structure. This method is simple, exact, and good for higher dimension problems. However, it is very computationally intensive and has usually been applied to generate only normally-distributed random variables (Chan 1993; Clifton and Neumann 1982; Davis 1987; Dietrich and Newsam 1993).

(d) Correlated variables with different marginal distributions method - This algorithm combines the matrix composition and probability density function methods to generate correlated random components with differing marginal distributions (including non-normal distributions). Instead of decomposing the correlation matrix into upper and lower triangular matrices, the eigen systems are calculated to reproduce the random field. This method preserves both the persistence relationships among the stochastic parameters and the associated joint distributions. It is good for higher dimension problems but only spatial correlation of the field is considered (Chang et al.1994, Gates and Al-Zahrani 1996[a,b], Mahendrarajah et al. 1996).

(e) Auto-regressive moving average (ARMA), Auto-regressive integrated moving average (ARIMA), periodic ARMA (PARMA), and approximate multivariate autoregressive moving average (CARMA) models - Based on the shape of the total and partial autocorrelation functions of the considered random components, this group of models can be built as a linear combination of the components at different times (or different locations) and preserves the temporal and even spatial structure of the random field. They are capable of solving higher-dimension problems but are computationally intensive. For generating multidimensional problems, the most commonly-used models are AR models (Ellis et al. 1993) since the full multivariate ARMA models often lead to complex and difficult estimation of model coefficients. An approximate multivariate auto-regressive moving average (CARMA) model has been developed to overcome this difficulty by incorporating the one-dimensional ARMA(p, q) model and lag-zero cross-correlation functions among variables. Thereby, the model can preserve the historical means, standard deviations, and lag-zero cross correlation, as well as individual serial correlation structures (Ahmad et al. 2001; Claps et al. 1993; Matalas 1961; Lehmann and Rode 2000; Mohan and Arumugam 1995; Nikolaidis et al. 1994; O'Connell 1974; Powell and Matsumto 1994; Salas et al. 1990; Samani and Yakhkeshi 1995; Worrall and Burt 1998; Zhao and Mays 1995).

Lehmann and Rode (2000) used a seasonal ARIMA (periodic auto-regressive integrated moving average, as referred to in this study) model to detect the possible trends in the 13-year metabolism and water quality data in the river Elbe at Magdeburg, Germany due to the reduction of wastewater emissions. In this study, weekly average values of discharge, dissolved oxygen, biochemical and chemical oxygen demand, ammonium, ortho-phosphate, total lead, and chlorophyll-a were treated as stochastic variables. Applying curve fitting and the linear combination of the sine and cosine functions, the large-scale trend and periodic components, as defined in Eq.(2-24), were removed. The authors further estimated the cross correlation coefficients of the random components and proved that this process was much more efficient than the traditional time-consuming pre-whitening approach.

Worrall and Burt (1998) used a univariate SARMA model to predict the monthly nitrate levels in three catchments in the North and South of England. The authors first used linear regression and Fourier series to simulate the linear trend and periodic components of the series. The simple AR model and SARMA models were fitted to each of the detrended series. Model predictions were tested against historical data held back the period of construction of the time series model for 13 months to test that this empirical modeling could provide a simple, efficient method to support water management.

Different forms of ARMA models were tested and discussed by Ellis et al (1993). In their study, three ARMA-based approaches were applied to daily influent BOD mass-loading, ammonia concentration, and total organic nitrogen, as well as effluent BOD concentrations for use in evaluating the reliability of designing the wastewater treatment plants. Each data series were fit using the univariate, uncorrelated model (the random variable represented by the sum of a constant and a white noise component), the univariate ARMA model, and the multi-variate

ARMA model. The authors concluded that the multi-variate ARMA model was more effective for modeling the complete statistical structure (including correlation structure) of the available historical data.

(f) Spectral methods (Discrete Fourier transform, Direct Fourier transform, and Fast Fourier transform) - Applications based on the spectral method are usually made by summing a finite cosine series where coefficients have uniformly-distributed random phases and amplitudes proportional to the spectral density function of the process. The advantage of the method is that it requires only a modest computational effort even for higher dimension problems. However, the method is only asymptotically exact. That is, the correlation structure of the ensemble of realizations is close to the structure required, only if enough harmonics are used. Furthermore, the method also requires the explicit knowledge of the Fourier transform of the correlation function from equal sampling points (Dietrich and Newsam 1993, Gutjahr 1989, Jinno et al. 1993, Kawamura et al. 1996, Latinopoulos et al. 1997, Mejia and Rodriguez-Iturbe 1974, Robin et al. 1993).

(g) Turning bands method - The turning bands method produces values of random components by generating one-dimensional line processes over discrete bands specified by the power spectral density function. The line processes are then projected to the desired locations of the spatial domain and are combined. Similar to the spectral method, the turning bands method is computationally efficient but only asymptotically exact. The accuracy of results depends on several parameters. These parameters include the discretization and truncation of the line spectra, and the number and orientation of the bands used to generate the random field. Furthermore, it can only be applied to processes with stationary and radically symmetric correlation functions, and requires the knowledge of the line structure for generation of the line realizations (Brannan and Haselow 1993, Delhomme 1979, Franke and Teutsch 1994, Mantogolou and Wilson 1982, Mantogolou 1987, Thompson et al. 1989).

(h) Hybrid method - By combining the spectral method and the matrix decomposition method, some authors have presented a fast and exact method for multidimensional Gaussian stochastic simulations of random components. The assumptions of stationarity and equispacing ensure that the realization of the random process correlation matrix has Toeplitz structure. A block circulant matrix can be produced by embedding a sample correlation matrix. By standard eigen-decomposition of a block circulant matrix in terms of fast Fourier transform, the square root of the block circulant matrix can be efficiently calculated. The multiplication of a white noise vector by the square root of the circulant matrix yields a random vector whose subvector has the exact correlation structure required. However, this approach is only valid when the following three conditions are satisfied: the mesh of the sampling grid is rectangular, the random field is stationary (that is, the correlation function is invariant under translation), and the embedded matrix is nonnegative definite (Dietrich and Newsam 1993).

As described in Chapter 3, a multivariate CARMA time series model [class (e) above] was used to generate random components of parameters and variables derived from long and regular sample period data in the present study. For the other uncertain variables of the water quality model, derived from short or irregular historical data, Chang's Monte Carlo simulation model [class (d) above] was adopted.

2.4.6 Physically-Based Stochastic River Water Quality Models

Besides using empirical stochastic models, which lack physical basis, several researchers have incorporated the stochastic approach into physically-based river water quality models. The governing equations operate on the stochastic parameters to predict the stochastic water quality state variables of interest. Hence, in a physically-based formulation, a constituent concentration C_i in a river would be represented in general as

$$C_i(x,t;\omega) = \mathbf{f}[\mathbf{P}(x,t;\omega)] + E_{f_i} \tag{2-25}$$

where **f** is a set of functions (include the mass conservation, momentum conservation equations, and biochemical reaction equations presented in section 2.4.1) that approximate governing physical laws of solute transport and reaction, and **P** is a set of stochastic parameters that represent boundary conditions (including initial conditions) on the concentration, river properties (e.g. hydraulic geometry, hydraulic resistance, chemical and biological reaction coefficients), sinks (e.g. diversions from the river, seepage to groundwater, evaporation), and sources (e.g. tributary inflows, inflows from wastewater treatment plants, seepage from groundwater, nonpoint source inflows). Sometimes, a term E_{f_i} is used to represent the random error associated with misspecification of the model form itself.

Some attempts have been made to analytically solve the stochastic equations represented by (2-25). For instance, uncertain parameters can be expressed as random space functions, each being a compromised of an expected value and a random fluctuation, and can be imported into the deterministic form of the governing physical equations (Cheng et al. 1993, Deng et al. 1993, Or 1995, Sun and Yeh 1992). Another approach is to embed the randomness of the model parameters into the governing equations using simple marginal distributions (Quinodoz and Valocchi 1993). Even under these simplifying assumptions, due to the complexity of the physical governing equations and/or the number of the random variables incorporated, explicit solutions to the stochastic equations are difficult, if not impossible, to derive.

To solve physically-based stochastic river water quality models using numerical methods, the First-Order Reliability method (FORM) (Han et al. 2001, Maier et al. 2000, Melching and Bauwens 2001, Portielje et al. 2000) and Monte Carlo Simulation (MCS) (Duchesne et al. 2001, Giri et al. 2001) have been adopted. The FORM utilizes a first-order Taylor series, expanded about the mean values of the uncertain model input variables, to approximate the physical governing equations. The MCS technique predicts uncertain water system behavior by first generating values of the random model input variables from predetermined probability distributions. Numerous possible sets of generated input values (realizations) are sequentially entered into the physically-based model to predict possible realizations of model output that correspond to the respective randomly generated input (Brown and Barnwell 1987, Han et al. 2001, Maier et al. 2000). Over numerous realizations, the statistical characteristics of the output, as dependent on the statistical characteristics of the input, can be estimated.

Han et al. (2001) presented a model, called QUAL2E-RA, by applying the FORM to the QUAL2E model (which includes governing equations for flow, mass transport, and biological reaction) to estimate the violation probabilities of DO and BOD concentrations to the existing water quality standards at several locations along the Han River in Korea. In this study, an optimization algorithm was first applied to calibrate and validate the model reaction coefficients (BOD deoxygenation rates, settling rates, and sediment oxygen demand rates) in a deterministic setting. These calibrated deterministic coefficients were later used as the base values in the stochastic analysis. The stochastic water quality analysis was performed by treating the flow rate, water quality variables (DO and BOD) of headwater and pollutant loads from tributaries, as well as aforementioned reaction coefficients as independent random variables.

Also using the QUAL2E model, Maier et al (2000) concluded that the FORM could achieve a similar performance as MCS does in estimating reliability, vulnerability, and resilience of a river system with less computer time. The methodology was applied to the William River watershed in Oregon to estimate the failure of the river system in meeting prescribed dissolved oxygen (DO) standards in response to different levels of wastewater treatment. In this study, headwater flows, four tributary flows, and temperature of one gaging station in the river were considered as random variables. The mean, standard deviation, marginal distribution and lower bound of each random variable, derived from up to 17-years of daily records, were preserved in the model generation. The cross correlation and lag-one auto correlation coefficients were considered significant when their absolute values were greater than 0.7. Re-aeration coefficients for each of four river reaches as well as the sediment oxygen demand (SOD) at two stations were treated as spatial uncorrelated, normally-distributed random parameters, where the four re-aeration coefficients were presented with the same statistics and probability distributions.

By applying the FORM to the unsteady state river water quality model, Melching and Bauwens (2001) used the Salmon-Q model (derived from a unsteady state mass transport equation) to determine the random model parameters contributing the most to the variance of the output of interest. The methodology was applied to a 21.75-km river reach of the Zenne River in Brussels to simulate the annual mean DO concentration at a point in that reach by linking a nonpoint pollution load model, a constant treatment efficiency model, and a river water quality model. In the river water quality model, 34 parameters were considered as random variables including the dry weather flow rate, the concentrations of 5-day biological oxygen demand (BOD_5), total organic nitrogen, ammonia, nitrate, suspended solids, DO, temperature at the upstream and downstream boundaries, model parameters for mud erosion, stream dispersion, and decay rates for all the water quality constituents simulated in this study. The mean values, coefficients of variation, and distribution types of each random variable were considered as input to the water quality model. The cross and auto correlation among or within random variables were not addressed in the paper.

The FORM was also adopted in a mass transport equation to simulate river DO concentrations by Portielje et al. (2000). By applying the Dissolved Oxygen Stream Model (developed from a mass transport equation) in the Klausholm A River in Northern Jutland, Denmark, the frequencies of occurrence of extremely low DO concentrations along an 11-km river reach were simulated. Within this study, 8 system parameters, including the re-aeration rate, decay rate for soluble COD, decay and sedimentation rate of particulate COD, as well as three event-related parameters, which were the COD concentration and effluents from three combined sewer overflows and two storm water outlets were treated as random variables. Again, the cross-correlation and auto correlation coefficients among and within the random variables were not addressed. Similar to Maier et al. (2000), the authors demonstrated that FORM was more computationally efficient than MCS in evaluating the risk of failure in the river system.

The advantage of FORM is its simplicity, because it only requires the first two statistical moments of the uncertain model parameters and forcing functions, along with the associated sensitivity of the model output to the parameters. However, the assumption that the single linearization of the model output function (derived by expanding the Taylor series at a failure point) at the central values of the uncertain model parameters (or forcing functions) can represent the system performance over the complete range of the model parameters (or forcing functions) is a primary weakness. Besides, the results cannot approximate the probability density function of the output, but only few simple statistics. In contrast to the above methods, the Monte Carlo simulation technique consists in generating numerous possible values (realizations) of random parameters from their estimated probability distributions as input to a physically-based model and solving the model to yield numerous possible values of the outputs of interest. By using a large number of realizations in the above procedure, the statistical characteristics of the output variables can be analyzed.

Among the studies in which MCS is applied to water management, the random variable generators that provide the possible input realizations to the physical model are quite different. In some studies, the random parameters have been generated from uncorrelated multivariate marginal distributions (Duchesne et al. 2001, Giri et al. 2001, Hession et al. 1996). This approach has been adopted to describe a spatially correlated random field by either separating the overall random field into several homogeneous, spatially independent components (Wu and Workman 1999) or combining with regression analysis (Mailhol et al. 1999). To model spatially persistent random parameter fields using actual spatial correlation functions, the turning bands method (Latinopoulos et al. 1997; Mahendrarajah et al. 1996), and the matrix decomposition method (Clifton and Neuman 1982) have been used.

In addition to the spatially-correlated properties of parameters considered in the water management problem, the issue of spatial-temporal variability was addressed by Nikolaidis et al. (1994). A stochastic model that simulated collective statistical properties of time series was developed to generate input data for a physically-based model.

Duchesne et al. (2001) presented a MCS methodology to simulate the ammonia and DO concentrations along a 10-km stretch of the River Cam in England. In this study, a continuously-stirred-tank-reactor model which included hydraulic, water quality transport and mixing, and biochemical submodels was used and 26 model parameters related to growth and decay of the DO, BOD, ammonium, nitrate and chlorophyll-a concentrations were defined as random variables. With parameters selected randomly from proposed ranges, assuming uncorrelated, uniform distributions, the methodology was able to rank the wastewater treatment plant control strategies based on their probable impacts on river water quality.

Giri et al. (2001) applied MCS in a one-dimensional water quality model to assess the long-term impacts of 2,3,7,8-tetrachlor-odibenzo-*p*-dioxin (TCDD) to three compartments (water, sediment, fish) of an assumed small, shallow river. In this study, four parameters, including TCDD partition coefficients in suspended particulates and sorption to suspended particulates, fish feeding and depuration rates of the transport and biochemical model were defined as random variables. Each uncertain parameter was assumed uncorrelated with uniform, normal or lognormal distribution. The authors concluded that the effects of parameter uncertainty to the model predictions were quite substantial. A comparison was made between stochastic and deterministic results and a substantial difference was observed.

As summarized above, several studies in recent years have explored the combination of stochastic and physically-based (mechanistic) approaches to solving river water quality management problems. While accounting for parametric uncertainty in predicting mass transport and biochemical reactions in rivers, one or more simplifying assumptions have been commonly employed:

(1) Only a limited number of random parameters are considered in order to make the stochastic water quality model convenient to solve;

(2) Selected terms in equations used to model the governing physical principles are eliminated to make them easier to solve in a stochastic setting;

(3) The statistical characteristics of the random parameters and state variables are limited to the following:

   a. Random variables are statistically homogeneous (large-scale and periodic trends are ignored or considered negligible), and/or

   b. Auto correlation and cross correlation structure in space and time are simplified or ignored, and/or

c. Marginal probability distributions are normal or symmetric, and/or

d. Coefficients of variation are relatively small (less than about 25%);

(4) Systematic model calibration and validation (testing) are not performed or, if performed, are not conducted in a stochastic setting;

(5) Stochastic features of parameters and state variables based upon irregularly-measured data are not addressed;

(6) Spatial and temporal structure of the river water quality system is decomposed and studied separately; and

(7) Physically-based stochastic models are applied in evaluating a limited range of engineering interventions to the considered river system.

It is the aim of the present study to relax the above assumptions in developing and implementing a more comprehensive approach to addressing parametric uncertainty in simulating pollution control strategies in a complex river system.

2.5 Water Quality Modeling of the South Platte River

A few studies have been reported in recent years related to water quality modeling in the South Platte River in Colorado. Spahr and Blackely (1985) first used the USGS-QW model to simulate the effects of effluents in the South Platte River in 1985. Their simulation covered a 14.5-mile reach of the river extending from the gauging station at Littleton, Colorado to the gauging station at 50th Avenue in Denver (Segment 14). Flow, DO, 5-day carbonaceous biochemical oxygen demand ($CBOD_5$), TDS, nitrogen species, and fecal coliform were constituents predicted in this study. Model calibration and validation were based on data collected on October 7, 1982, September 22, 1983, and

January 26, 1984. These three data sets were then used to calibrate and validate the QUAL2E model used by Paschal and Mueller (1991). By adding another 4.5-mile river reach upstream to the outflow from Chatfield Reservoir, the data sampled on the above dates were used to represent the summer chronic, summer acute, and winter chronic cases.

Segment 15 of the South Platte River, extending from the Burlington Ditch headgate to the confluence with Big Dry Creek, has suffered from depression of DO in the low flow season due to high concentrations of ammonia discharging to the stream from municipal wastewater treatment plants. In 1986, EPA Region VIII developed total maximum daily loads (TMDLs) for the segment after assuming authority to issue the NPDES permit for the Denver Metro Wastewater Reclamation District's Central Facility. At the same time, the staff of EPA Region VIII adapted the stream water quality model QUAL2 and developed a steady state, one-dimensional spreadsheet-based water quality model, called STREAMDO. STREAMDO was applied to Segment 15 of the South Platte River to model DO and un-ionized ammonia (Zander and Love 1990).

Based upon the STREAMDO model, the Segment 15 Water Quality Model was developed by incorporating the Colorado Ammonia model. In view of the fact that in-stream DO standards were not being met in the river segment below Denver in summer, even with ammonia removal technologies being applied by wastewater facilities, the Segment 15 Water Quality Model was adopted to investigate alternatives to traditional in-plant treatment (Houck et al. 1997). Based on the model prediction, six preferred alternatives, including the combinations of stream re-aeration, channel modification, effluent diversion and wastewater treatment improvements, were predicted to lower the stream DO in the segment 15 to meet both the acute and chronic DO standards for July through October. In 1999, Metro Wastewater Reclamation District and Camp Dresser & McKee Company (Neal and Johnson 1999) updated and recalibrated the Segment 15 Water Quality Model to reestablish baseline DO predictions of regulatory interest. The calibrated model was also used to predict impacts on DO for a variety of alternative in-stream improvements.

In 2000, the Segment 15 Water Quality Model and a Segment 14 Water Quality Model were used to predict DO and nitrate concentrations under low flow conditions (Colorado Department of Public Health and Environment 2000). The project goal was to evaluate the need for controls of effluents from the dischargers to protect the municipal supplies of Thornton, Brighton and Fort Lupton, which withdraw water from groundwater affected by the river.

To date, no stochastic models of river water quality have been applied in study of the South Platte River.

2.6 Conclusions from the Literature Review

To overcome failures in river water quality management due to ignoring the inherent uncertainty in river system characteristics, stochastic water quality models have been developed in recent years. These models, both empirical and physically-based, have been used to simulate probabilistic features of constituent concentrations and standards compliance. Methods used to date, however, have discarded important statistical features of river systems or have simplified the governing equations, due to lack of data and/or based on a desire to simplify the solution process. The present study develops a methodology that coordinates the use of both empirical and physically-based models to more comprehensively account for the uncertain nature of river water quality. In contrast to past studies, a large number of random parameters and variables are addressed, using both regularly and irregularly measured data, including statistical nonhomogeneity and spatial and temporal correlation structures. Moreover, unlike previous studies, the models are calibrated and tested in a stochastic setting. Application to a 190-km segment of the South Platte River in Colorado allows evaluation of the effectiveness of a wide variety of strategies to control pollution from constituents that threaten diversions to irrigated agriculture. Methodology and results are presented in Chapter 3.

CHAPTER 3

METHODOLOGY AND RESULTS

The methodology and results of this study are given in a refereed paper, entitled "Strategic river water quality planning using calibrated stochastic simulation", presented on the following pages, and accepted for publication in the *Journal of Water Resources Planning and Management* of the American Society of Civil Engineers (ASCE). The ready-to-copyedit version of the paper is presented here, and likely will receive editorial modifications prior to scheduled publication in 2004. This paper is copyrighted by the ASCE.

Supporting details of input data, computed results, and computer program code are provided in Appendices A through E.

Strategic River Water Quality Planning

Using Calibrated Stochastic Simulation

Pei-chih Chiang[1] and Timothy K. Gates, Member, ASCE[2]

ABSTRACT: Coordinated application of empirical and physically-based stochastic models, based upon diverse and variable field data, creates a method for river water quality planning that is calibrated to account for parameter uncertainty. The models are applied to assess interventions for improving the quality of river flows diverted for irrigation along a 190-km segment of the South Platte River in Colorado. Eleven different pollution control strategies are considered, alone and in combination. Statistics of total dissolved solids (TDS), dissolved nitrogen (N) species, and fecal coliform concentrations are modeled, along with associated probabilities of violation of recommended criteria, and the spatial and temporal uniformity of these probabilities. Over a 25 year horizon, for example, combined pollution control measures are predicted to achieve average reductions from 27 to 36% and from 31 to 39% in mean concentrations of TDS and N, respectively, for the 11 irrigation diversions located along the 53-km stretch just downstream of Denver. Uncertainty in predicted concentrations, as measured by the coefficient of variation, is considerable. An average decrease of 18 percentage points in the probability of violation for TDS is predicted, while the estimated average decrease for N and fecal coliform are a modest 6 to 8 percentage points.

CE Database Keywords: River water quality; Stochastic simulation; Strategic planning; Uncertainty analysis; South Platte River; Colorado.

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Introduction and Background

In the semiarid Western United States, it is increasingly important to improve the quality of river flows through engineering intervention. Numerous and varied water quality criteria must now be met in the face of multiple water use objectives (water supply, recreation, in-stream ecology, etc.), increasing competition between economic sectors (agricultural, urban, industrial) for limited water resources, and strict water rights laws. Structural and management changes are needed to redistribute available river flows, to upgrade wastewater treatment facilities, to reduce nonpoint sources of pollution, and to alter in-stream mixing and reactions of pollutants. Decisions about such changes must be supported by sound data and modeling tools. Even when a good database and reliable models are available, however, the description and prediction of concentrations of water quality constituents in rivers remains an exercise burdened by considerable uncertainty.

Dissolved chemical constituents often vary to a large extent from point to point along a river and over time. Furthermore, concentrations cannot be measured without error, and the frequency of measurement often is quite limited due to financial and other constraints. As a result, ambiguity clouds the ability to characterize constituent concentrations at times and locations of concern in a river system. The values of river properties and boundary conditions that together control the concentrations are also unclear.

This paper describes strategic planning to meet recommended water quality criteria for diversions to irrigated agriculture along the highly appropriated South Platte River in Colorado. Following the lead of previous researchers (e.g. Melching and Yoon

1996, Han et al 2001, and Melching and Bauwens 2001), the current study treats water quality constituent concentrations as random variables having estimated probabilities of occurrence. It builds upon this approach with a new tack that uses a simulation model adjusted by field observations in a stochastic setting. Extensive field data are used to develop, calibrate, and validate a physically-based stochastic model for predicting distributions of possible concentrations under alternative pollution-control strategies. Empirical stochastic models are used to characterize correlated model parameters and to assist in calibrating the physically-based model. The comparative performance of alternative strategies for reducing the probability of violation of proposed water quality criteria is described.

Stochastic River Water Quality Modeling

Attempts to estimate uncertainty in either the concentrations of chemical and biological constituents of direct interest (referred to in this paper as state variables) or in the characteristics that influence those concentrations (referred to in this paper as parameters) fall into two broad classes: empirical stochastic models and physically-based (mechanistic) stochastic models. In the present study, these two approaches were integrated.

Empirical Stochastic Models of Water Quality Parameters and Variables

The concentration of a water quality constituent *i*, in a one-dimensional cross-section averaged river system can be represented as a stochastic process having the following general form:

$$C_i(x,t;\omega) = \Re^{-1}[C_i(x,t;\omega)_{LST} + C_i(x,t)_{PT} + C_i'(x,t;\omega)] \quad (1)$$

where $C_i(x,t;\omega)_{LST}$ = a large-scale stochastic trend component, reflecting gradual low-order change in C_i with distance, x, from a reference datum along the longitudinal axis of the river and/or gradual change with time, t, dependent on an event in probability ω (with associated probability density function) (ML^{-3}); $C_i(x,t)_{PT}$ = a deterministic periodic trend component reflecting medium-scale cyclic variations with x, and/or with time, t (ML^{-3}); and $C_i'(x,t;\omega)$ = a statistically-homogeneous (i.e. statistics not varying with x and t; Christakos 1992) random component (ML^{-3}). The random component may be autocorrelated along x and t, as well as crosscorrelated with random components of other water quality variables. An operator $\Re$ (usually a logarithmic or power function) can be used to transform the original concentration $C_i(x, t; \omega)$ to remove any large-scale trends that may exist in spatial or temporal variance in the river system. Eq. (1) describes the probabilistic evolution of C_i in space and time, without recourse to a mathematical description of governing physical laws. Measured data are simply analyzed to infer the statistical characteristics of this process as observed along the river and over time; hence, Eq. (1) is referred to as an *empirical* stochastic model.

There are numerous approaches to developing and accounting for the components of the general model of Eq. (1) (Brockwell and Davis 1996, Box et al. 1994, Salas 1993, Salas et al. 1980), including the seasonal autoregressive moving average (SARMA) and contemporaneous autoregressive moving average (CARMA) models used herein. Several researchers have applied such approaches in describing various river water quality constituents (e.g., Tsirkunov et al. 1992, Ellis et al. 1993, Worrall and Burt 1999, Lehmann and Rode 2001, Ahmad et al. 2001). None, however, have included a comprehensive multivariate analysis of different variables spread over different locations along a river, as was done in the present study.

An empirical stochastic model can be used not only in a descriptive sense, but also in a predictive sense. That is, the model can be used to predict, or forecast, possible values of C_i at unobserved spatial locations and/or at future times of interest. Such predictions, however, are restricted by the assumption that unobserved and future concentrations in the river system will be influenced by conditions that are essentially the same as those that brought about the distribution of historical observations used to develop the model. If one desires to predict distributions of possible responses of constituent concentrations to changes in system boundary conditions, properties, and sinks or sources, it is necessary to employ a physically-based stochastic model.

Physically-based Stochastic Water Quality Simulation

In a physically-based model, the boundary conditions, properties, and sinks or sources are referred to collectively as parameters of the model. These parameters serve as independent variables in equations that approximate the governing physical laws. Since the model parameters themselves are subject to uncertainty, they often are represented by empirical stochastic models similar to Eq. (1). The governing equations operate on the stochastic parameters to predict the stochastic water quality state variables of interest. Hence, in a physically-based formulation, a constituent concentration C_i in a river would be represented in general as

$$C_i(x,t;\omega) = \mathbf{f}[\mathbf{P}(x,t;\omega)] + E_{f_i} \tag{2}$$

where **f** is a set of functions that approximate governing physical laws of solute transport and reaction, and **P** is a set of stochastic parameters that represent boundary conditions (including initial conditions) on the concentration, river properties (e.g. hydraulic geometry, hydraulic resistance, chemical and biological reaction coefficients), sinks (e.g. diversions from the river, seepage to groundwater, evaporation), and sources (e.g. tributary inflows, inflows from wastewater treatment plants, seepage from groundwater, nonpoint source inflows). Sometimes, a term E_{f_i} is used to represent the random error associated with misspecification of the model form itself.

Numerous approaches can be taken to approximate the functions, **f**, in Eq. (2). A complete formulation would include dynamic equations of mass conservation, momentum and/or energy conservation, thermodynamic state relationships, chemical reactions, and biological reactions (Chapra 1997, Martin and McCutcheon 1999). In most instances, however, assumptions are made that eliminate or simplify some of these equations for use in a given river system. The level of detail needed for decision-making, the expected rate of system change with time, the availability of data, and the scale of analysis are some of the issues that affect the assumptions that are made. In the present study, a modified version of the widely used QUAL2E model (Brown and Barnwell 1987) was used to approximate cross-section averaged one-dimensional river flow and mass transport under successive conditions of approximately steady-state flow. The model is used as a tool for feasibility-stage project planning, to understand the likely behavior of a river under broad long-term strategies for upgrading the quality of river flows. After identifying the most promising strategies, more detailed and focused analysis would be necessary in a later design phase.

For water quality constituent *i*, the one-dimensional mass transport equation under a steady-state flow condition in a river within a given time period can be written as:

$$\frac{\partial(AD_{x_i}\frac{\partial C_i}{\partial x})}{A\partial x} - \frac{\partial(A\bar{u}C_i)}{A\partial x} + \frac{dC_i}{dt} + \frac{S_i}{V} = 0 \tag{3}$$

where A = cross-sectional area of flow (L^2); D_{x_i} = longitudinal dispersion coefficient (L^2T^{-1}); $\bar{u}$ = cross-section averaged velocity (LT^{-1}); S_i = external sources or sinks (MT^{-1}); and $V = Adx$ = incremental volume along the river (L^3). The terms on the left-hand side of Eq. (3) represent, respectively, dispersion, advection, constituent changes over time, and external sources/sinks and dilutions. The following empirical relationship is used by QUAL2E to compute longitudinal dispersion along the river as a function of channel properties:

$$D_{x_i} = 3.82\, k_D n \bar{u} h^{\frac{5}{6}} \tag{4}$$

where k_D = dimensionless dispersion coefficient, n = Manning hydraulic resistance ($T/L^{1/3}$), and h = flow depth (vertical distance from the water surface to the thalweg axis) (L).

The QUAL2E model is essentially a hydrologic routing model. Within a time period where the flow can be considered steady, the flow rate, Q, can be calculated from

$$\frac{\partial Q}{\partial x} = q_x \tag{5}$$

where $A = Q/\bar{u}$ and q_x = the sum of the external inflows (flow sources) and diversions (flow sinks) per unit length along the river [$(L^3/T)/L$]. Values of $\bar{u}$ and h, in each element along the river are treated as power functions of the flow rate:

$$\bar{u} = aQ^b \tag{6}$$

and
$$h = cQ^d \tag{7}$$

where a, b, c, and d = empirically-derived coefficients that are influenced by hydraulic geometry, energy dissipation, and hydraulic controls in the channel. In QUAL2E, the governing Eqs. (3) through (7) are solved using a finite-difference approximation applied to one-dimensional river elements (Stone and Brian 1963).

The third term in Eq. (3), dC_i/dt, represents the change in concentration of a constituent i due to physical, chemical, and biological reactions and interactions that occur in the stream. In the present study, the QUAL2E model was used to compute total dissolved solids concentration, C_{TDS}; organic-N concentration, C_{ON}; ammonia-N concentration, C_{NH_3}; nitrite-N concentration, C_{NO_2}; nitrate-N concentration, C_{NO_3}; and fecal coliform concentration, C_{FC}, as well as Q. Total dissolved solids were assumed to be conservative and nonreacting. For the four nitrogen constituent concentrations and for fecal coliform, the within-reach reactions were computed as

$$\frac{dC_{ON}}{dt} = -\beta_{ON} C_{ON} \tag{8}$$

$$\frac{dC_{NH_3}}{dt} = \beta_{ON} C_{ON} - \beta_{NH_3} C_{NH_3} \tag{9}$$

$$\frac{dC_{NO_2}}{dt} = \beta_{NH_3} C_{NH_3} - \beta_{NO_2} C_{NO_2} \tag{10}$$

$$\frac{dC_{NO_3}}{dt} = \beta_{NO_2} C_{NO_2} \tag{11}$$

$$\frac{dC_{FC}}{dt} = -k_{FC} C_{FC} \tag{12}$$

where β_{ON} = rate constant for hydrolysis of organic nitrogen to ammonia nitrogen (T^{-1}); β_{NH_3} = rate constant for the biological oxidation of ammonia nitrogen (T^{-1}); β_{NO_2} = rate constant for the oxidation of nitrite nitrogen (T^{-1}); and k_{FC} = fecal coliform die-off rate (T^{-1}). Eq's (8) – (12) neglect the effects of settling and entrainment interactions with the river bed. Also, effects of algal uptake, including periphyton, were assumed insignificant (Paschal and Mueller 1991) and were not explicitly accounted for.

Managing Quality of Irrigation Diversions in the South Platte River

A previously neglected water-pollution issue has drawn increasing attention in Colorado in recent years: the extent to which return flows and wastewater effluent from municipal and industrial sources impair the quality of water for downstream use by irrigated agriculture. State water laws, modified in the 1970s to allow upstream users to divert flows under augmentation and exchange plans, permit portions of a stream to be diverted out of priority as long as flows are returned in a manner that does not impair the diversion rights of senior appropriators downstream (Vranesh 1987). Over the past twenty years, water rights decrees have been predominated by urban augmentation and exchange plans. Downstream agricultural users are concerned that, as urban areas grow, this trend will continue, creating in-stream flows that are made up primarily of secondary-treated municipal wastewater effluent. Compounding the problem is the non-point source pollution from urban and agricultural runoff and groundwater return flow that also accumulates along the river.

The present study develops a combination of empirical and physically-based stochastic modeling in application to managing the quality of agricultural diversions from the South Platte River (Figure 1). The river basin has a total drainage area of about 63,000 km^2. About 90% of Colorado's population lies along the front-range (meeting of the mountains with the eastern plains) urban corridor within the South Platte River Basin. Hence, the river is intensively used, providing water for multiple demands, including municipal supply, industrial supply, recreation, and agriculture. About 445,000 ha of productive irrigated land lie within the basin, including about 295,000 ha within Colorado. This land is supplied by direct flow rights from the South Platte River and by flows conveyed to the river from west of the continental divide via the Colorado Big Thompson project.

A number of water quality constituents pose environmental hazards to irrigated agriculture (Ayres and Westcot 1985). In the South Platte River Basin the constituents of primary concern are total dissolved solids (TDS), total dissolved nitrogen (N), and microbial pathogens, as indicated by the presence of fecal coliform bacteria. Significant levels of TDS promote long-term salinization on irrigated lands having poor drainage. Above threshold levels, elevated salinity concentrations cause linear reductions in crop yield and may degrade soil structure and permeability (Tanji 1990). High levels of N (in the form of nitrite, nitrate, ammonia, and organic nitrogen) can adversely affect the quality of certain crops like sugar beets, vegetables, and potatoes (Task Force for Water Reuse 1989, Bouwer and Idelovitch 1987), and can pollute shallow aquifers underlying croplands. Also, high concentrations of N in the form of nitrite (NO_2) pose a threat to the health of livestock. The presence of pathogenic organisms may cause illness in agricultural workers exposed to direct contact, and can taint vegetable crops that are grown for raw consumption by humans.

Comprehensive in-stream water quality standards for agricultural water use have not yet been adopted in Colorado. However, standards of this type have been enacted in California and Arizona, and have been recommended for Colorado (Gates et al 1993). These guidelines were used in developing the low and high criteria for TDS, total N, fecal coliform, and NO_2 considered in the present study. Low criteria were: 1000 mg/L for TDS, 10 mg/L for N in the irrigation season and 30 mg/L in the off season, and 1000 colonies per 100 mL for fecal coliform. The high criteria were: 500 mg/L for TDS, 5 mg/L for N in the irrigation season and 15 mg/L in the off season, and 500 colonies per 100 mL for fecal coliform. The limit for NO_2 was set at 10 mg/L for both the low and high criteria.

Strategies were considered for meeting recommended criteria along a 190-km segment of the South Platte River that extends from Chatfield Reservoir to Weldona (Figure 1). This reach contains 9 tributaries and 14 major waste facilities along the main stem. There are 28 diversions from the main stem, 27 of which are to irrigation canals. The mean annual streamflow along this reach ranged from 11 to 35 m^3/s over the period 1976-1995. This is the most intensely monitored stretch of the South Platte River and, as such, provides a database adequate for modeling. There are 7 gaging stations along the main stem, and 13 located on the tributaries, that are regularly monitored for flow. About four of these stations also are regularly monitored for TDS. Numerous other locations are monitored at regular and irregular intervals for several other water quality constituents, including nitrogen species and fecal coliform. This reach also includes sampling sites applied in a recently-completed USGS National Water-Quality Assessment Program study (Dennehy et al 2000, Litke and Kimbrough 1998). More details on water quality monitoring in the reach are summarized in the following sections and elaborated in Chiang (2003).

Development and Testing of Stochastic Models

Several interrelated models were developed and used in this study, and their relationships are illustrated in Figure 2. Univariate SARMA time series models were constructed for each regularly-measured parameter and water quality state variable and these models were combined into a multivariate CARMA model. Irregularly-measured parameters and state variables were represented by a general Monte Carlo simulation (GMCS) model. The CARMA and GMCS models were then coupled into a CARMA-GMCS model. When used to generate correlated values of a set of regularly- and irregularly-measured parameters (parameter set 1) for input into the physically-based QUAL2E simulation model, the CARMA-GMCS model is referred to as empirical stochastic model A. When used to generate values of the state variables for use in calibration of the QUAL2E model, it is referred to as empirical stochastic model B.

An optimization model was then used to calibrate the statistics of a parameter set 2 so as to cause the statistics of the state variables predicted by QUAL2E to best match the corresponding statistics of the state variables generated by the CARMA-GMCS model. Realizations of parameter set 2 were generated by a probability distribution function (PDF) model, referred to as empirical stochastic model C, for input into the QUAL2E simulation model. The QUAL2E simulation model was validated using data from a period not used in the calibration process.

Development of Empirical Stochastic Models for Parameters and State Variables

SARMA and CARMA Models of Regularly-Measured Parameters and State Variables

The autoregressive moving average (ARMA) model is an empirical stochastic model that preserves the spatial and/or temporal persistence (long-term correlation) of a stochastic variable that is measured at fairly regular discrete intervals in time (Salas 1993). A multivariate form of ARMA model is further able to preserve the cross-correlation among several stochastic variables in a system. However, the use of full multivariate ARMA models often leads to complex and difficult estimation of model coefficients. Hence, in the present study an approximate multivariate contemporaneous autoregressive moving average model, or CARMA model, was used to overcome this difficulty. The CARMA model incorporates seasonal ARMA, or SARMA, models along with lag-zero cross-correlation functions (Salas 1993). The SARMA model was chosen as the basis for the CARMA model in view of the periodic behavior of variables often observed in the South Platte River system. Data were segregated into six consecutive seasons, each season containing eight "weeks", for purpose of analysis. The fourth "week" interval at the end of each month contained seven to ten days, depending upon the number of days in the month. Thus, in the developed SARMA models (of each stochastic variable inside the CARMA model) each season actually represented eight to nine calendar weeks.

Data for every stochastic variable within a given season and at a given location within the river system were analyzed to determine the presence of gradual trends. Any detected trends were removed and the resulting residuals were transformed, if necessary, to fit an approximately normally-distributed or symmetrically-distributed probability distribution form. Based on the autoregressive and partial regressive functions of the transformed residuals, a SARMA[$(p_i, r_i)(p_i', r_i')$] model with periodic lag l was fitted to a stochastic variable for a given season at a position x_m (m = 1, … M) along the river as:

$$\left[\left(1-\pi_{i_1}H....-\pi_{i_{p_i}}H^{p_i}\right)\left(1-\Pi_{i_1}H^{l}..-\Pi_{i_{p'_i}}H^{lp'_i}\right)\right]Z_i(x_m,t;\omega)=$$

$$\left[\left(1-\theta_{i_1}H...-\theta_{i_{r_i}}H^{r_i}\right)\left(1-\Theta_{i_1}H^{l}...-\Theta_{i_{r'_i}}H^{lr'_i}\right)\right]\varepsilon_i(x_m,t;\omega) \quad (13)$$

where Z_i = normally-distributed and standardized stochastic water quality variable [state variable or parameter; in the case of a constituent concentration, Z_i is a normalized form of the residual C_i' in Eq. (1)]; i = 1, 2, …, N is the index of each stochastic variable in the river system; N = total number of stochastic variables simulated in the CARMA model; H^j = a backward shift operator where $H^j[Z_i(t)]$ = $Z_i(t-j)$; π_{i_k} = fitted k^{th} order autoregressive coefficient of the stochastic variable i; Π_{i_k} = fitted k^{th} order periodic autoregressive coefficient for the stochastic variable i; p_i = the highest order of fitted autoregressive coefficient for the stochastic variable i; p'_i = the highest order of fitted periodic autoregressive coefficient for the stochastic variable i; θ_{i_k} = fitted k^{th} order moving-average coefficient of the stochastic variable i; Θ_{i_k} = fitted k^{th} order periodic moving-average coefficient of the stochastic variable i; r_i = the highest order of fitted moving-average coefficient for the stochastic variable i; r'_i = the highest order of fitted periodic moving-average coefficient for the stochastic variable i; and ε_i = time independent but space dependent normally-distributed noise variable with zero mean and variance $\sigma_{s_i}^2$. The values of p_i, p'_i, r_i, r'_i are determined from the autocorrelation and partial correlation function of each detrended series Z_i. The noise term ε_i for each stochastic variable in the CARMA model can be divided by its standard deviation to form a standardized noise series that is time independent but correlated among variables in different seasons and at different locations along the river:

$$\boldsymbol{\varepsilon} = \hat{\boldsymbol{L}}\boldsymbol{\xi} \tag{14}$$

where $\boldsymbol{\varepsilon}$ = column matrix with 6*NM* (6 seasons with *N* stochastic variables at *M* locations within the river system) elements of the standardized noise series $\varepsilon_i^1 = \varepsilon_i / \sigma_{s_i}$, $i = 1, \ldots, 6NM$; σ_{s_i} = standard deviation of the noise term, ε_i; $\boldsymbol{\xi}$ = column matrix with standardized elements ξ_i that are normally distributed white noise random variables, independent in time and space and season; and $\hat{\boldsymbol{L}}$ = 6*NM*x6*NM* matrix parameter. The matrix $\hat{\boldsymbol{L}}$ can be determined by solving

$$\hat{\boldsymbol{L}}\hat{\boldsymbol{L}}^T = \hat{\boldsymbol{C}}_0 \tag{15}$$

where $\hat{\boldsymbol{C}}_0$ = historical lag-zero crosscorrelation matrix derived from the standardized, spatially and seasonally correlated noise series $\boldsymbol{\varepsilon}$.

SARMA models in the general form of Eq. (13) were fit to historic data on several regularly-measured (routinely sampled on a periodic basis) water quality parameters and state variables of constituent concentration at selected locations along the study reach of the South Platte River and were incorporated into the CARMA model.

GMCS Model of Irregularly-Measured Parameters and State Variables

Measurement of water quality variables often is irregular, or aperiodic, due to the difficulty and expense of sampling and analysis. Also, in rivers across the United States systematic measurements of water quality variables have been conducted only for relatively short and intermittent periods of time. The CARMA approach, described above, cannot easily be applied to develop empirical stochastic models for variables that are measured with irregular or partial intervals. Fortunately, in many cases where irregular measurements are taken, they are taken at locations where flow rate is measured at regular intervals. Hence, the correlation of the irregularly-measured water quality variables with the regularly-measured flow rates often can be estimated. This allows a link to be established, via the correlation with flow rate, between the irregulary-measured water quality variables and the regularly-measured water quality variables that may be accounted for in a CARMA model. In the present study, the statistical characteristics of irregularly-measured water quality variables, including correlation to flow rate and other variables, were empirically modeled using a modification of the GMCS model, originally developed by Chang et al (1994). In this model, the correlation coefficient of each pair of nonnormal stochastic variables is transformed to an equivalent correlation coefficient for a bivariate standard normal distribution using semiempirical formulae based on the Nataf model. Multivariate values can be generated in a correlated standard normal space and then mapped back to the original space using inverse transformations. A number of irregularly-measured parameters and state variables in the studied segment of the South Platte River were modeled using the modified GMCS approach. In cases where concentration values were missing from the sampling record, they were estimated through analysis of linear regression relationships with sampled variables (Hirsch 1982, Vogel and Stedinger 1985). In some cases, constituent concentrations in tributary inflows were derived from data at gaging stations in the respective tributaries that were located upstream of the confluence with the South Platte River. Initial estimates of nonpoint source loads of the various constituents to the South Platte River were obtained from mass balance calculations between in-stream gaging stations and samples from storm sewers. These loads also were modeled using GMCS and later were adjusted using correction factors derived from calibration of the physically-based model.

Historical data were analyzed to infer trends and statistical characteristics (marginal probability distributions and correlation) of the residuals for both the regularly- and irregularly-measured variables described above, and the coefficients of the appropriate CARMA models were estimated. Trends were estimated using regression analysis and, if found significant (a 5% significance level was used for all statistical significance tests in this study), were removed by subtracting the fitted regression equation or by differencing. No significant variance trends were detected in the historical data for any of the variables. Significant trends in the mean were found in only about 5% of the cases. Table 1 summarizes the parameters and variables modeled by the CARMA and GMCS components of the CARMA-GMCS model, along with their types of measurement and available periods of record.

The fitted univariate SARMA models of the residuals for each of the six seasons of the year resulted in autoregressive coefficients up to order p_i = 3 and periodic autoregressive coefficients up to order p_i' = 2. The moving average coefficients were significant up to order r_i = 1 and r_i'= 2, and their values ranged from –0.96 to 0.98. The lag-zero cross correlation matrix $\hat{\boldsymbol{C}}_0$ (and the corresponding matrix $\hat{\boldsymbol{L}}$) was estimated from data sampled over the period 1988 – 1995 with mixwise deletion (Switzer et al. 1998) of missing data. About 45% of the more than 100,000 computed correlation coefficients, making up the symmetric elements of $\hat{\boldsymbol{C}}_0$, were found to be statistically significant. Their absolute values ranged from 0.11 to 0.97. Lag zero cross correlations between variables sharing a common river location were computed and used in the GMCS model. However, cross correlations between variables at different locations along the river were not considered due to inadequate contemporaneous sample data. About 69% of the 389 lag-zero correlation coefficients were statistically significant and their absolute values ranged from 0.15 to 0.97.

Coupling of CARMA and GMCS Models

A combined CARMA-GMCS stochastic model was used to generate correlated realizations of both regularly- and irregularly-measured water quality variables (state variables and parameters) along the studied segment of the South Platte River. Generation of the possible values of these stochastic variables was accomplished by first generating correlated realizations of the regularly-measured variables using the CARMA model. The flow rate values generated by the CARMA model were then entered into the GMCS model to find corresponding random numbers in the standard normal space. Next, the GMCS model was used to generate correlated values of irregularly-measured variables that corresponded to these flow rates. Hence, stochastic realizations were modeled that preserved the statistical characteristics (including correlation structure) inferred from the analysis of both the regularly- and irregularly-measured data. A total of 465 parameters and 89 state variables at different locations along the river within the six seasons were generated using the CARMA-GMCS model. The CARMA-GMCS model generated multivariate series with correlation coefficients that significantly differed from those inferred from the historical data in only about 6 % of the cases. Significant differences between the estimated mean and standard deviation of the generated and historical series occurred in less than 1 % and in about 17 % of the cases, respectively.

Examples of parameters and state variables generated by the CARMA-GMCS model, using Monte Carlo 250 realizations, are provided in Figure 3 for a few regularly and irregularly-measured variables. Both the available historic observed series and the distributions of modeled time series are shown. For regularly-measured series, stochastic predictions beyond the period used to develop the time series models (after 1996) reveal greater variability due to the presence of stochastic trends. The water quality parameters that were modeled using the CARMA-GMCS method are referred to as parameter set 1. Parameter set 2 consisted of those parameters that were determined through calibration of the physically-based model, as described below.

Calibration and Validation of Stochastic Simulation Model

Within the studied segment of the South Platte River, data are very limited or are not available on the hydraulic geometry coefficients, *a*, *b*, *c*, and *d*; hydraulic resistance, *n*; the dispersion coefficient, k_D; chemical rate coefficients, β_{ON} , β_{NH_3} , and β_{NO_2} ; and biological rate coefficient, k_{FC}. As a result, the statistics of these parameters were estimated by calibration of the modified physically-based QUAL2E model. In addition, deterministic source correction factors for nonpoint source loading, for wasteload concentrations, and for tributary flow concentrations were computed for each season for all river reaches. These factors were needed to account for ungaged nonpoint sources of water quality constituents, like urban storm runoff and agricultural return flows, and sparse data on effluents from wastewater treatment plants and tributary inflows, and on concentrations in diverted flows. The source correction factors were multiplied by the associated generated random values of non-point source load, wastewater concentration, and tributary concentration. Together, the hydraulic geometry coefficients, hydraulic resistance, rate coefficients, and correction factors made up parameter set 2 for the physically-based model. An optimization procedure determined the values of correction factors and marginal distributions, mean values, and coefficients of variation of the stochastic parameters that would cause the statistics of the state variables predicted by the QUAL2E model to most closely match the corresponding statistics of the state variables predicted by the empirical CARMA-GMCS model derived from historic data.

The physically-based QUAL2E simulation model was calibrated for the statistics of parameter set 2 using the following optimization criterion, applied separately to each of the six seasons of the year:

$$\text{Minimize } O(x) = \frac{1}{2}\left(\sqrt{\frac{1}{N_V}\sum_{i=1}^{N_V}\left(\frac{\mu_i^{\text{sim}} - \mu_i^{\text{C-G}}}{\mu_i^{\text{C-G}}}\right)^2} + \sqrt{\frac{1}{N_V}\sum_{i=1}^{N_V}\left(\frac{\sigma_i^{\text{sim}} - \sigma_i^{\text{C-G}}}{\sigma_i^{\text{C-G}}}\right)^2}\right) \quad (16)$$

where μ_i^{sim} = ensemble mean of the values of a water quality state variable simulated by QUAL2E at a designated river location and week within the given season; $\mu_i^{\text{C-G}}$ = ensemble mean of the CARMA-GMCS generated values of a water quality state variable at a designated river location and week within the given season; σ_i^{sim} = ensemble standard deviation of the values of a water quality state variable simulated by QUAL2E at a designated output location and week within the given season; $\sigma_i^{\text{C-G}}$ = ensemble standard deviation of the CARMA-GMCS generated values of a water quality state variable at a designated river location and week within the given season; and N_V = total number of considered space-time values of all water quality state variables within the given season. For computational efficiency, fifty realizations were employed in both the physically-based stochastic model (QUAL2E) and the empirical stochastic model (CARMA-GMCS) for calibration. The first and second radical terms in Eq. (16) represent the respective mean square errors of the mean and standard deviation between simulated and empirically-generated values of the water quality state variables. Hence, the overall criterion represents a minimization of the average mean square error in the mean and standard deviation. The criterion was achieved using a systematic application of the flexible tolerance optimization algorithm (Himmelblua 1972), along with repetitive simulation. In the first stage of the optimization procedure, the flexible tolerance method was used to determine mean values of β_{ON} , β_{NH_3} , β_{NO_2} , k_{FC}, and the source correction factors for each season sequentially for each of twelve reaches from upstream to downstream along the river. In the second stage, the mean values of *a*, *b*, *c*, and *d* were determined by flexible tolerance optimization for each season sequentially for each of twelve reaches from upstream to downstream along the river. Mean values of k_D and *n* were estimated from existing field data. Finally, the marginal distributions (normal or lognormal) and CVs of β_{ON} , β_{NH_3} , β_{NO_2} , k_{FC}, *a*, *b*, *c*, *d*, k_D, and *n* along the entire studied segment for each season were estimated by repetitive simulation to achieve the minimization in Eq. (16). The optimization procedure assumed no gradual or periodic trends in the stochastic parameters of parameter set 2. Table 2 summarizes the range of statistics for parameter set 2 determined from the calibration procedure. Optimal values of the parameter statistics were constrained to be consistent with ranges of parameter values reported in the literature. Such ranges, based upon limited studies previously conducted in the South Platte River and upon studies conducted in other rivers, also are summarized in Table 2.

The CARMA-GMCS model was used to generate 250 realizations of parameter sets 1 and 2 for each of the six seasons. Each realization represented a possible space-time distribution of parameter values in the studied segment of the river under current baseline conditions. Each realization was entered as input into the QUAL2E model to simulate an associated possible realization of the water quality constituents along the river. All simulations were constrained to be in compliance with Colorado's water rights and with the South Platte Compact, which governs minimum flows to Nebraska. The CARMA-GMCS model also was used to generate 250 stochastic realizations of the water quality constituents at available gaged locations along the river based on historical observations. The plots in Figures 4 and 5 present a representative comparison of the statistics of selected variables predicted by the calibrated physically-based stochastic model to the statistics of corresponding variables generated by the empirical stochastic model for a representative week in the low flow season (second week of January 1994) and a week in the high flow season (second week in May 1994), respectively. The average mean square error in the mean and standard deviation of the constituent values predicted by the physically-based and empirical models over all constituents, all gaged sites, and all weeks was 9% and 14%, respectively.

The calibrated simulation model was validated by applying it to predict distributions of the water quality constituent concentrations over the years 1997 – 2000, a period outside the period used for calibration. Figures 6 and 7 show representative plots of the statistics simulated by the QUAL2E model for the fourth week of March 1997 and the third week of July 2000, respectively. For comparison, the corresponding means of values generated by the CARMA-GMCS model as well as available measured values at gaging locations during the validation period are also shown. The average mean square error in the mean of the constituent values predicted by the physically-based model compared to the empirical model over all constituents, all gaged sites, and all weeks was about 9 % in 1997, 1998, 1999, and in 2000. The largest average errors in the mean over all of the validation years were in the N species, ranging from 8 % to 12 %. The average mean square error in the standard deviation of the constituent values predicted by the physically-based and empirical models over all constituents, all gaged sites, and all weeks was about 14 % in 1997 and 1998, and about 15 % in 1999 and 2000. The largest average errors in the standard deviation over all of the validation years were in the N species, ranging from 12 % to 20 %. In all but 8 % of the cases, values measured within the validation period fell within the 90% confidence interval (between the 5^{th} and 95^{th} percentile) of the simulated values.

Assessing Strategies for Water Quality Improvement

The calibrated stochastic simulation model was used to explore several alternatives for improving water quality in the studied segment of the South Platte River relative to recommended criteria for agricultural diversions. Summary descriptions of the considered alternative strategies are:

- *Strategy 1: Base-line conditions.* This alternative assumed no significant changes in boundary conditions (flow and water quality), diversions, wastewater treatment levels for municipal and industrial plants, or nonpoint source loading to the river segment over the next 25 years. Projected increases in wastewater flow rates were accounted for, however. The output of this strategy was used to evaluate the comparative effects of changes under the other modeled strategies.

- *Strategies 2A – 2E: Improved wastewater treatment levels to reduce pollutant loading.* These strategies considered the effect over the next 25 years of respective reductions in all pollutant constituent concentrations by 10%, 20%, 30%, 40%, and 50%, achieved by implementation of modern refined treatment processes in each of the wastewater treatment plants along the South Platte river.

- *Strategy 3: Increased reservoir release at the upstream boundary.* This strategy considered the effect of an upstream storage development and a rehabilitation of the Chatfield Reservoir to allow a 20% increase in flow releases, contributing to dilution of downstream pollution.

- *Strategies 4A – 4C: Reduction in nonpoint source pollution.* These strategies considered the effect of respective reductions of 10%, 20%, and 30% in nonpoint source loading of all pollutant constituents along the river, brought about by implementation of best management practices for agricultural return flows and urban runoff. Current loading rates were estimated to vary from 10 - 99,000 (kg/day)/km for TDS, 0.1 – 327 (kg/day)/km for organic N, 0.1 – 197 (kg/day)/km for N as NH_3, 0.1 – 352 (kg/day)/km for N as NO_2, and 0.3 – 2700 (kg/day)/km for N as NO_3.

- *Strategy 5: Relocation of the Burlington Ditch diversion (D3).* The Burlington Ditch diversion currently is located upstream from the outfall of the Metro Wastewater Treatment plant facility (W5), the largest plant along the South Platte River. The ditch can potentially divert all of the flow in the South Platte River during certain times of the year, essentially leaving only wastewater effluent from Metro in the downstream reach of the river. Hence, relocating the Burlington ditch to the downstream side of the Metro plant, to achieve dilution, was proposed and simulated.

Numerous combinations of the above strategies also were considered. Three of the most promising combinations are described in this paper:

- *Strategy 6: Combination of strategies 2E and 4C.*
- *Strategy 7: Combination of strategies 2E, 4C, and 5.*
- *Strategy 8: Combination of strategies 2E, 3, 4C, and 5.*

It was assumed that each strategy could be planned and implemented over a 5-year period. In the case of nonpoint source loads, it was assumed that another 5 years of transition would be required to reach the final target level of pollution control. Within this transition period, pollutant loading rates were evenly decreased until final target rates were achieved at the end of the periods. Thereafter, loading rates remained constant at the target rate until the end of the 25-year planning period.

In simulating future water quality conditions, the effects of urban growth were taken into account. Increases in wastewater treatment plant discharge rates ranging from about 20% to 50% and increases in tributary constituent concentrations ranging from 1% to 35% were used in the model, based on current projections over the next 25 years and on probabilistic estimates of the fraction of wastewater flows contributing to flow at the mouth of each tributary (Chiang 2003).

The physically-based model was run for 250 possible realizations under each considered alternative. Simulated output for each strategy consisted of predictions of 250 possible realizations of each of the water quality constituent concentrations in all 91 river elements for every week over the 25-year period. Table 3 provides a summary of the mean and CV of predicted concentrations, averaged over all river locations and all weeks in the season, for each of the six seasons for strategy 1 and strategy 8. Figure 8 illustrates with box and whisker plots the probability distribution of computed concentrations C_{TDS}, C_{NO_2}, C_N (total concentration of N as organic N, NO_2, NO_3, and NH_3) and C_{FC}, averaged over all irrigation diversion points and downstream at Weldona and over all weeks within the irrigation period (March – October) over the 25-year simulation, for strategies 1, 2E, 3, 4C, 5, 6, 7, and 8. For comparison, the recommended low and high criteria are shown on each plot. The results in Table 3 and Figure 8 reveal considerable variability in predicted concentrations. The relative variability was moderate for C_{TDS} and C_N (average CV ranging from about 0.10 to about 0.60), and was considerably larger for C_{NO_2} and C_{FC} (average CV ranging from about 0.50 to about 1.00). The 90% confidence intervals of average predicted concentrations were 467 to 1074 mg/L for C_{TDS}, 0.03 to 0.25 mg/L for C_{NO_2}, 3.7 to 9.0 mg/L for C_N, and 71 to 729 colonies/100 mL for C_{FC} under strategy 1; and were 363 to 869 mg/L for C_{TDS}, 0.02 to 0.19 mg/L for C_{NO_2}, 2.9 to 6.5 mg/L for C_N, and 59 to 566 colonies/100 mL for C_{FC} under strategy 8. On the average, strategies 6, 7, and 8 were most effective in lowering the space-time averaged expected values (means) of C_{TDS} and C_N. However, the average expected value of C_{TDS} did not comply with the recommended high criteria under any of the considered strategies, and in the case of C_N the average expected value was only slightly below the high criteria. Positive impacts were much more marked for specific diversions along the river, as seen in Figures 9 and 10.

The probability distribution of computed concentrations C_{TDS} ,C_{NO_2},C_N and C_{FC} , averaged over all weeks within the irrigation period (March – October) over the 25-year simulation at the diversion points along the river and downstream at Weldona, are illustrated by box and whisker plots in Figures 9 and 10 for strategies 1 and 8, respectively. For comparison, the recommended low and high criteria are shown on each plot. In comparing strategy 8 with strategy 1, reductions of 27 % to 36 % in mean values of C_{TDS} over the irrigation season were predicted for diversions D2 through D15, along the 53-km reach downstream of Denver. Corresponding reductions of 31 % to 39 % were predicted for mean values of C_N , and 17 % to 39 % for mean values of C_{FC} along this reach. Further downstream, reductions in C_{TDS} and C_N were more modest. This disparity is thought to be due primarily to proximate effects of the reduction in wasteloads from wastewater treatment plants in the Denver area. These measures are less effective further downstream, where the relative influence of tributary and nonpoint source loads is greater. Nonpoint source load reduction had a more uniform impact in reducing mean concentrations along the river. The uncertainty in the predicted values, as indicated by the spread in the distributions plotted in Figures 9 and 10, is considerable in the case of each of the constituents. It varies along the river, depending on differences from location to location in the inherent variability in the available data and on the local effects of the flow and transport equations.

Three performance measures were computed for use in evaluating each strategy with respect to compliance with recommended water quality criteria. The first measure was the temporal and spatial average of the probability of violation of the recommended water quality criteria for constituent i over a given time period and a considered number of locations:

$$\bar{p}_{V_i} = \frac{1}{N_w}\sum_{j=1}^{N_w}\frac{1}{M_l}\sum_{m=1}^{M_l}(p_{V_i})_{m,j} \tag{17}$$

where N_w = the total number of weeks within the considered time period over the 25 simulated years, M_l = the total number of considered locations along the river segment, and $(p_{V_i})_{m,j}$ = the probability of violation of the water quality criteria for constituent i computed over all realizations at location m and week j. The measure $\bar{p}_{V_i}$ provided an indication of the system-wide likelihood that water quality criteria for irrigation diversion would be violated under implementation of the considered strategy. The second performance measure was the spatial uniformity of the probability of violation for constituent i over a considered number of river locations and for a given time period (Azevedo et al. 2000):

$$U_{s_i} = 1 - \{\frac{1}{N_w}\sum_{j=1}^{N_w}\mathrm{CV}_s[(p_{V_i})_{m,j}]\}, \text{if } \{\frac{1}{N_w}\sum_{i=1}^{N_w}\mathrm{CV}_s[(p_{V_i})_{m,j}]\} < 1$$

$$U_{s_i} = 0, \text{ otherwise} \tag{18}$$

where CV_s = the spatial coefficient of variation of $(p_{V_i})_{m,j}$ computed over all considered locations. The higher the value of U_{s_i} is, the greater is the equity in the degree to which compliance with water quality criteria is achieved among locations along the river. The third measure was the temporal uniformity of the probability of violation for constituent i

over a given time period and for a considered number of river locations (Azevedo et al. 2000):

$$U_{t_i} = 1 - \{\frac{1}{M_l}\sum_{m=1}^{M_l} \mathrm{CV}_t[(p_{V_i})_{m,j}]\}, \text{if } \{\frac{1}{M_l}\sum_{m=1}^{M_l} \mathrm{CV}_t[(p_{V_i})_{m,j}]\} < 1$$

$$U_{t_i} = 0, \text{ otherwise} \qquad (19)$$

where CV_t = the temporal coefficient of variation of $(p_{V_i})_{m,j}$ computed over all considered weeks within the time period of interest over the 25 simulated years. Higher values of U_{t_i} indicate a lower degree of temporal fluctuation in the probability of violation of water quality criteria.

Values of $\bar{p}_{V_i}$, U_{s_i}, and U_{t_i} were computed for each water quality constituent under each considered strategy for both the recommended high criteria and the recommended low criteria. Table 4 summarizes the values computed under the high criteria over all irrigation diversion points and the downstream station at Weldona and over all weeks within the irrigation period (March – October) through the 25-year simulation period for strategies 1 and 8. Values for C_{NO_2} are not shown since the probability of violation for C_{NO_2} was computed as zero for all considered strategies. These results indicate that implementation of strategy 8 could be expected to reduce the average probability of violation by about 18 percentage points for C_{TDS}, about 8 percentage points for C_N , and about 6 percentage points for C_{FC}. The degree of spatial and temporal variability in the probability of violation did not change much between strategy 1 and strategy 8, except in the case of C_{TDS} where spatial uniformity was significantly reduced ($U_{s_{TDS}}$ was lowered by 0.29). This was due to the fact that under strategy 8 the mean values of C_{TDS} were reduced below the recommended criteria for diversions D5 to D7, while the downstream diversions remained in violation in the mean. Values of $\overline{p}_{V_i}$ computed as time averages over the irrigation period at all irrigation diversion points and downstream at Weldona for strategy 1 varied from 0.14 at Farmer's and Gardner's Ditch (D2) to 0.94 at Lower Latham Ditch (D18) for C_{TDS} , 0 at Farmer's and Gardner's Ditch (D2) to 0.34 at Corona Ranch Ditch (D25) for C_N , and from 0.03 at Lower Latham Ditch (D18) to 0.51 at Gardener's Ditches (D4) for C_{FC} . For strategy 8, the values ranged from 0.03 at Farmer's and Gardner's Ditch (D2) to 0.91 at Lower Latham (D18) for C_{TDS} , from 0 at Farmer's and Gardner's Ditch (D2) to 0.28 at Corona Ranch Ditch (D25) for C_N , and from 0.01 at Lower Latham Ditch (D18) to 0.37 at Farmer's and Gardener's Ditch (D2) for C_{FC} .

Summary and Conclusions

This study evaluates plans for improving river water quality while directly acknowledging the uncertainty that arises from variable and, in some cases, sparse field data. This was done by treating the parameters of a widely used physically-based model as random variables. Some parameters were represented directly, using empirical stochastic models with statistics inferred from observed field measurements. The remaining parameters were represented using statistics derived from a calibration process performed with an optimization algorithm. The calibration process yielded parameter statistics that caused the mean and standard deviation of water quality concentrations (state variables) predicted by the physically-based model to most closely match the corresponding statistics of empirical stochastic models derived from field data. The methodology incorporated space-time correlation structure among parameters and state variables. It produced a modeling device for predicting distributions of possible constituent concentrations that would arise from alternative pollution control strategies to be implemented along a river – distributions that can be used to associate notions of probability, risk, and confidence with the outcome of planning decisions.

The developed models were applied to assess alternative strategies for improving the quality of flows diverted for irrigation from the South Platte River in Colorado. Extensive data analysis, through empirical modeling and calibration, enriched the body of knowledge regarding the statistical characteristics of water quality parameters and variables along the river. The calibrated planning model was applied to consider eleven different pollution control strategies, alone and in combination, over a 25-year horizon. Results indicated that, in an overall average sense, significant though not substantial improvements could likely be achieved through a combination of pollution control measures. Some specific locations along the river, however, were predicted to benefit markedly. Reducing nonpoint source loading was most effective in uniformly lowering the probability of violation of recommended criteria along the river. Higher degrees of wastewater treatment were most successful in the upper and middle portion of the considered river segment. Increased reservoir releases and the relocation of a major point of diversion were predicted to have the least impact on river water quality. The level of uncertainty associated with model predictions was moderate to high, suggesting the need for caution in forming expectations about the potential impact that considered interventions might have. The model did not consider socioeconomic constraints, which would be needed for a final ranking of pollution control strategies, especially in light of variable impacts among irrigation diversions along the river.

In interpreting these results and the applicability of this methodology to similar problems, readers should be aware of potential limitations. The model forms that were used in this study have been found by others to perform well in application to similar problems, and the model parameters were quantified to insure a sufficient match to the statistics inferred from the available field data. However, a systematic evaluation of the uncertainty associated with the selected model forms themselves was not conducted [i.e. the error term E_{f_i} in Eq. (2) was not explicitly considered]; hence, other types of empirical and physically-based models might better represent the water quality processes in this or other rivers. Moreover, for some variables, available data were sparse; and, it is believed that model prediction uncertainty could be reduced, particularly along the downstream reaches of the river, by implementing data obtained from new monitoring stations and from a more regular sampling regime at existing stations. Additional data on constituent loading from nonpoint sources are especially needed. Lastly, this study made an assumption that is common to this type of predictive stochastic modeling, namely, that the statistical characteristics of the model parameters derived from analysis of historic conditions will not be substantially affected by any alteration of the model forcing functions that would be associated with planned system interventions (i.e. changes in upstream flow as affected by reservoir release, in concentrations of wastewater treatment plant effluents, and in nonpoint source loads). The degrees of change considered in this study (up to as high as 50%) were deemed small enough to warrant this assumption. However, after an initial ranking of solution strategies, sensitivity analysis of predicted system performance to the assumed statistical characteristics of the parameters might be fitting before selecting a final course of action.

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Table 1. Summary of Parameters and State Variables Modeled using CARMA and GMCS Components of the CARMA-GMCS Model.

Parameter or State Variable	Locations in River System	Type of Measurement	Period of Record: Range	Period of Record: Average
Modeled Using CARMA Component of CARMA-GMCS Model				
Q	Upstream river boundary at Littleton	Daily average	57 years	
	Seven river gaging stations	Daily average	11 – 105 years	54 years
q_x	Nine tributaries	Daily average	21 – 73 years	33 years
	Twenty-seven irrigation canals	Monthly average	48 years	
	Fourteen municipal and industrial Wastewater treatment plants	Monthly average	10 years	
C_{NH_3}	Fourteen municipal and industrial Wastewater treatment plants	Monthly average	10 years	
C_{NO_2}	One municipal and industrial Wastewater treatment plants	Monthly average	10 years	
C_{NO_3}	Three municipal and industrial Wastewater treatment plants	Monthly average	10 years	
C_{FC}	Fourteen municipal and industrial Wastewater treatment plants	Monthly average	10 years	
C_{TDS}	Englewood river gaging station	Daily average	11 years	
Modeled Using GMCS Component of CARMA-GMCS Model				
C_{ON}	Upstream river boundary at Littleton	47 instantaneous	36 years	
	Seven tributaries	10 - 51 instantaneous	10 – 47 years	26 years
	Five river gaging stations	9 - 84 instantaneous	11 – 51 years	37 years
C_{NH_3}	Upstream river boundary at Littleton	47 instantaneous	36 years	
	Seven tributaries	10 - 248 instantaneous	10 – 47 years	26 years
	Five river gaging stations	9 - 114 instantaneous	11 – 51 years	37 years
C_{NO_2}	Upstream river boundary at Littleton	47 instantaneous	36 years	
	Seven tributaries	10 - 203 instantaneous	10 – 47 years	26 years
	Five river gaging stations	9 - 93 instantaneous	11 – 51 years	37 years
C_{NO_3}	Upstream river boundary at Littleton	47 instantaneous	36 years	
	Seven tributaries	10 - 203 instantaneous	10 – 47 years	26 years
	Five river gaging stations	9 - 84 instantaneous	11 – 51 years	37 years
C_{FC}	Upstream river boundary at Littleton	45 instantaneous	36 years	
	One tributary	183 instantaneous	15 years	
	Two river gaging stations	29 - 43 instantaneous	42 – 46 years	44 years
C_{TDS}	Upstream river boundary at Littleton	88 instantaneous	36 years	
	One wastewater treatment plant	Daily instantaneous	1 year	
	Five river gaging stations	63 - 329 instantaneous	11 – 51 years	37 years
	Seven tributaries	10 - 218 instantaneous	10 – 47 years	26 years

Table 2. Calibrated Range of Statistics of Parameter Set 2 and Range of Values from Literature

Name	Mean		CV		Probability Distribution		Range Reported
	Calibrated	Literature	Calibrated	Literature	Calibrated	Literature	in Literature[1]
k_D	60-510	-	0.05-0.50	0.05-0.50	NM, LN	-	8.6-7500
n	0.025-0.040	0.016-1.5	0.05	0.01-0.69	NM, LN	-	0.01 - >3.0
a	0.05-1.22	-	0.05-0.33	0.05-0.50	NM, LN	-	0.05-1.22
b	0.14-0.77	-	0.01-0.08	0.01-0.50	NM, LN	-	0.14-0.64
c	0.08-0.93	-	0.10-0.50	0.05-0.50	NM, LN	-	0.08-0.93
d	0.22-0.69	-	0.01-0.33	0.01-0.50	NM, LN	-	0.27-0.58
β_{ON}	0.02-0.90	0.5	0.05-0.25	0.05-1.00	NM, LN	NM	0.00-3.00
β_{NH_3}	0.02-3.16	0.2	0.13-0.25	0.05-1.00	NM, LN	NM	0.003-3.16
β_{NO_2}	0.05-45.00	-	0.05-0.20	0.05-1.00	NM, LN	-	0.05-49.8
k_{FC}	0.05-2.63	-	0.05-0.63	0.05-1.00	NM, LN	-	0.05-29.1

NM : Normal Distribution
LN: Lognormal Distribution

[1] See detailed references in Chiang (2003).

TABLE 3. Spatial and Temporal Average of the Mean and CV of Predicted River Concentrations for Strategies 1 and 8

Season	Strategy	C_{TDS} (mg/L)		C_{NO_2} (mg/L)		C_N (mg/L)		C_{FC} (colonies/100 mL)	
		Mean	CV	Mean	CV	Mean	CV	Mean	CV
Jan-Feb	1	911	0.09	0.30	0.56	8.0	0.18	248	0.57
	8	697	0.11	0.19	0.54	5.1	0.18	207	0.54
Mar-Apr	1	942	0.20	0.09	0.50	6.5	0.22	207	0.76
	8	721	0.22	0.06	0.47	4.2	0.19	169	0.73
May-Jun	1	619	0.58	0.17	0.67	4.1	0.46	371	1.01
	8	504	0.61	0.13	0.67	3.3	0.44	296	0.97
Jul-Aug	1	704	0.32	0.09	0.60	6.3	0.28	571	0.50
	8	582	0.33	0.07	0.56	5.0	0.28	444	0.47
Sep-Oct	1	742	0.52	0.10	0.52	5.9	0.16	235	0.82
	8	567	0.55	0.08	0.51	4.1	0.15	189	0.80
Nov-Dec	1	758	0.19	0.12	0.62	6.8	0.33	445	0.86
	8	577	0.22	0.07	0.65	4.7	0.37	402	0.84

TABLE 4. Performance Measures of Strategies 1 and 8 Related to Violation of the Recommended High Criteria During the Irrigation Period.

Strategy	C_{TDS} (500 mg/L criteria)			C_N (5 and 15 mg/L criteria)			C_{FC} (500 colonies/100 mL criteria)		
	$\bar{p}_V$	U_s	U_t	$\bar{p}_V$	U_s	U_t	$\bar{p}_V$	U_s	U_t
1	0.79	0.72	0.97	0.26	0.61	0.88	0.20	0.08	0.78
8	0.61	0.43	0.90	0.18	0.69	0.92	0.14	0.06	0.71

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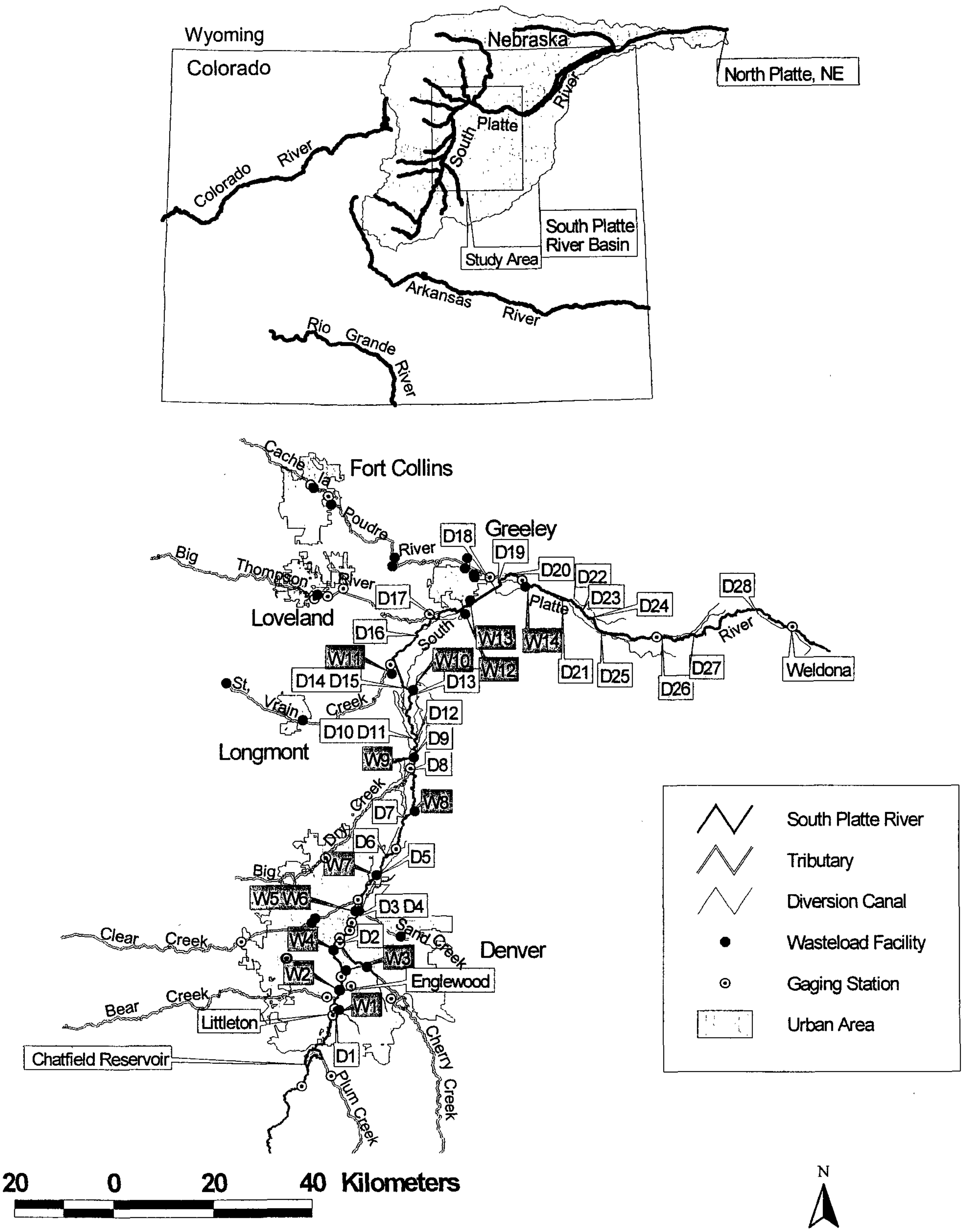

Wyoming
Colorado
Nebraska
North Platte, NE
Colorado River
South Platte River
South Platte River Basin
Study Area
Arkansas River
Rio Grande River
Fort Collins
Cache la Poudre River
Greeley
Big Thompson River
Loveland
St. Vrain Creek
Longmont
Dry Creek
Big Dry Creek
Clear Creek
Bear Creek
Sand Creek
Cherry Creek
Plum Creek
Denver
Englewood
Littleton
Chatfield Reservoir
Weldona
D1
D2
D3 D4
D5
D6
D7
D8
D9
D10 D11
D12
D13
D14 D15
D16
D17
D18
D19
D20
D21
D22
D23
D24
D25
D26
D27
D28
W1
W2
W3
W4
W5 W6
W7
W8
W9
W10
W11
W12
W13
W14
South Platte River
Tributary
Diversion Canal
Wasteload Facility
Gaging Station
Urban Area
20 0 20 40 Kilometers
N

FIG. 1.

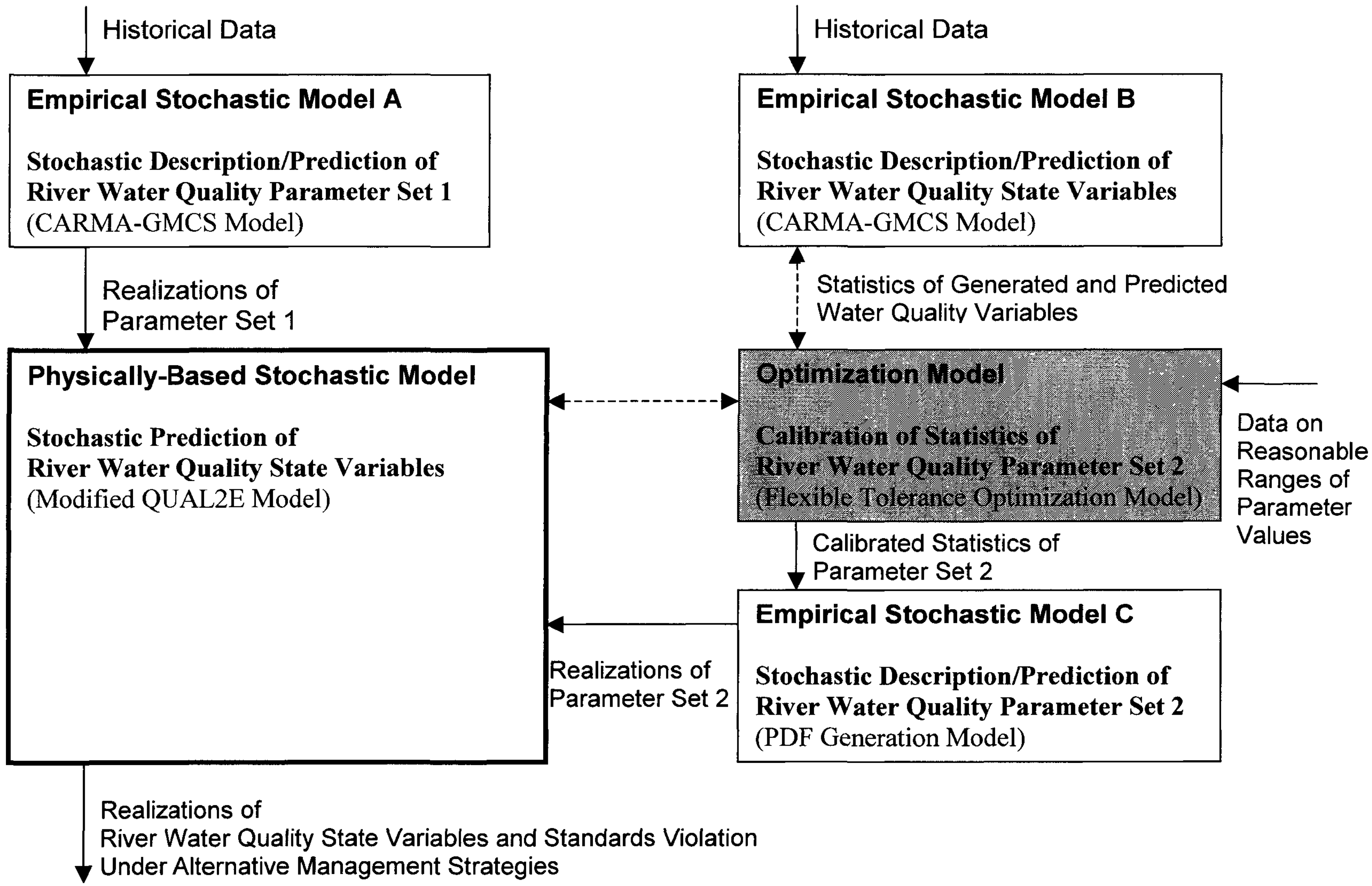
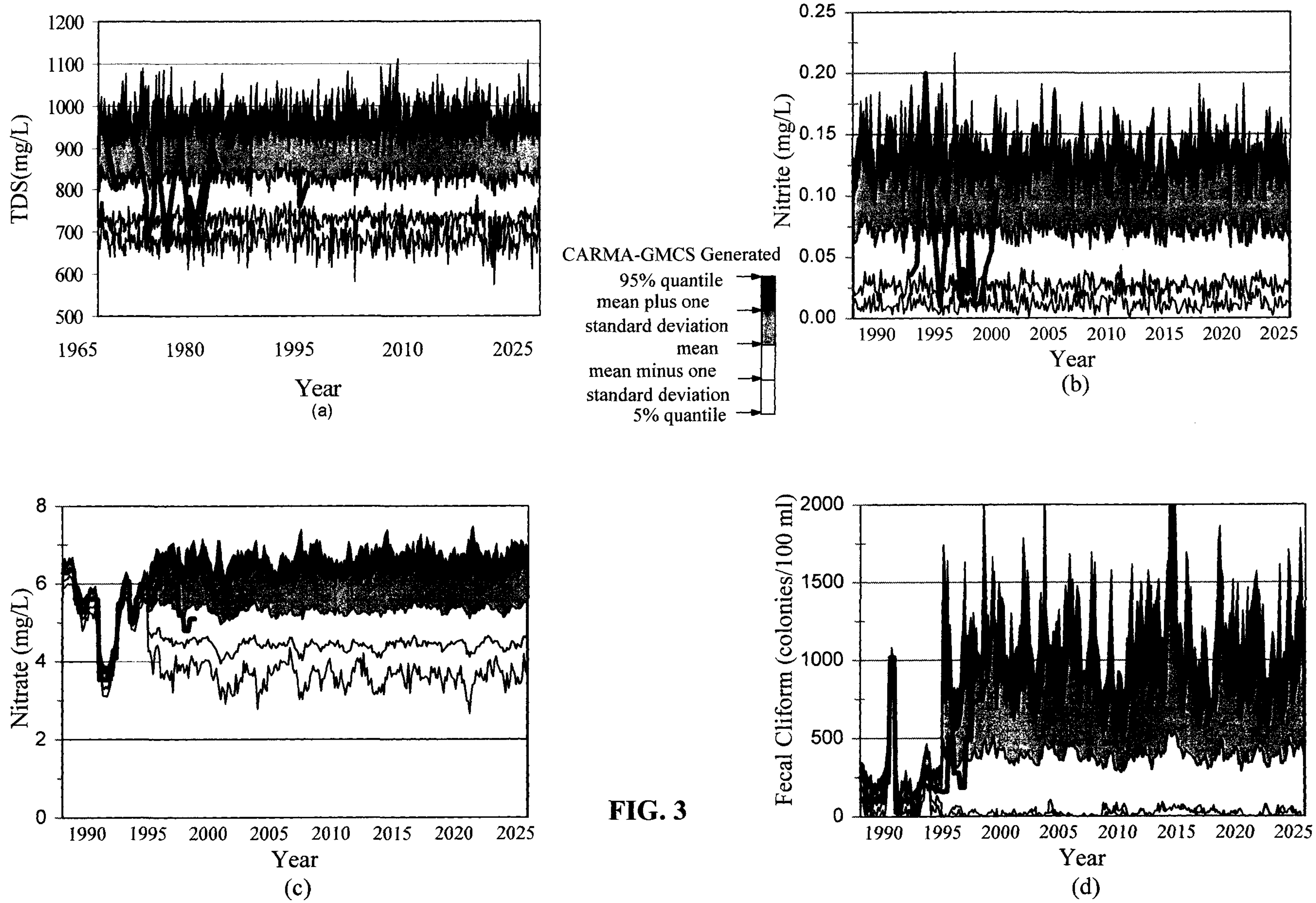
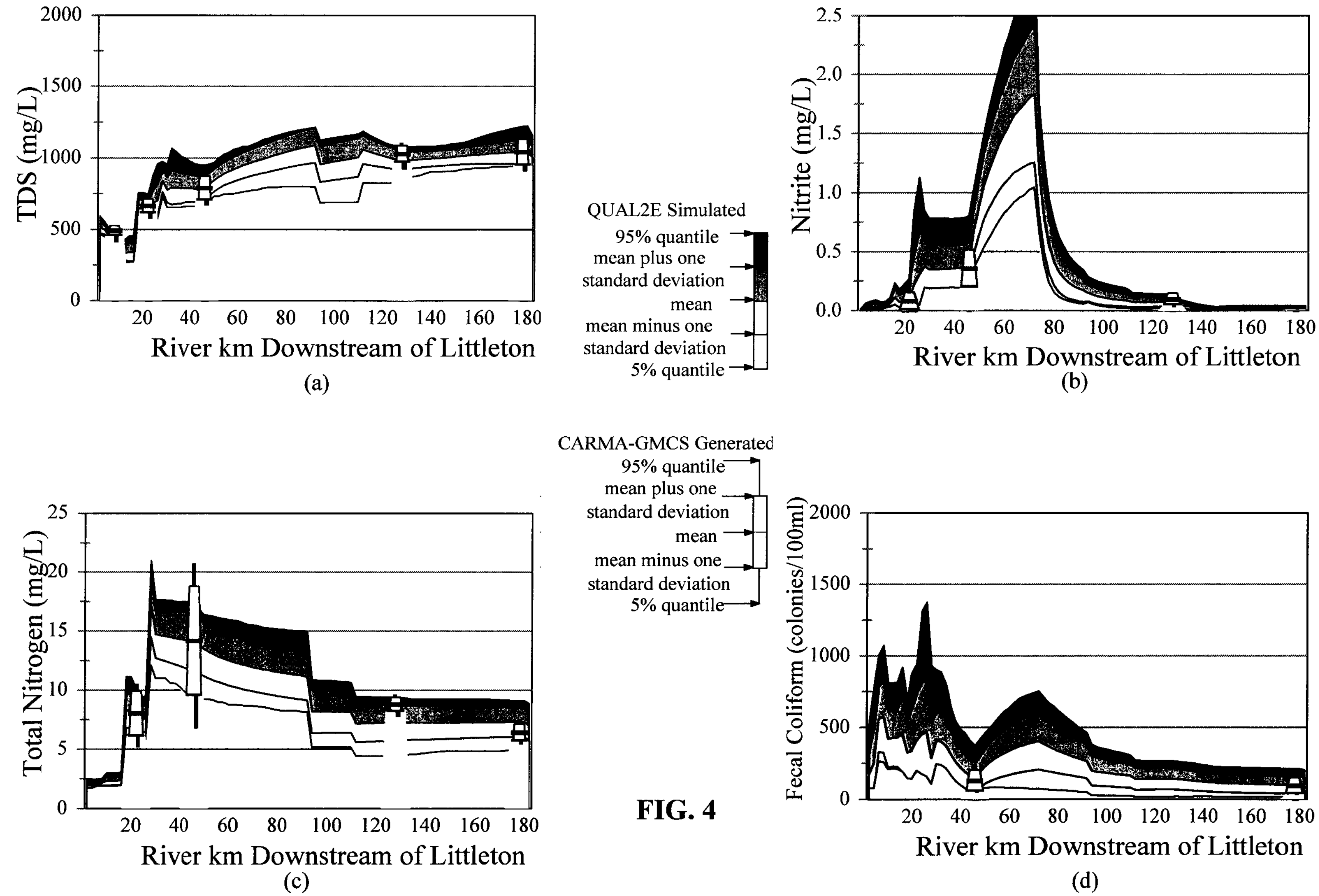

Historical Data
Historical Data
Empirical Stochastic Model A
Stochastic Description/Prediction of
River Water Quality Parameter Set 1
(CARMA-GMCS Model)
Empirical Stochastic Model B
Stochastic Description/Prediction of
River Water Quality State Variables
(CARMA-GMCS Model)
Realizations of
Parameter Set 1
Statistics of Generated and Predicted
Water Quality Variables
Physically-Based Stochastic Model
Stochastic Prediction of
River Water Quality State Variables
(Modified QUAL2E Model)
Optimization Model
Calibration of Statistics of
River Water Quality Parameter Set 2
(Flexible Tolerance Optimization Model)
Data on
Reasonable
Ranges of
Parameter
Values
Calibrated Statistics of
Parameter Set 2
Empirical Stochastic Model C
Stochastic Description/Prediction of
River Water Quality Parameter Set 2
(PDF Generation Model)
Realizations of
Parameter Set 2
Realizations of
River Water Quality State Variables and Standards Violation
Under Alternative Management Strategies

FIG. 2



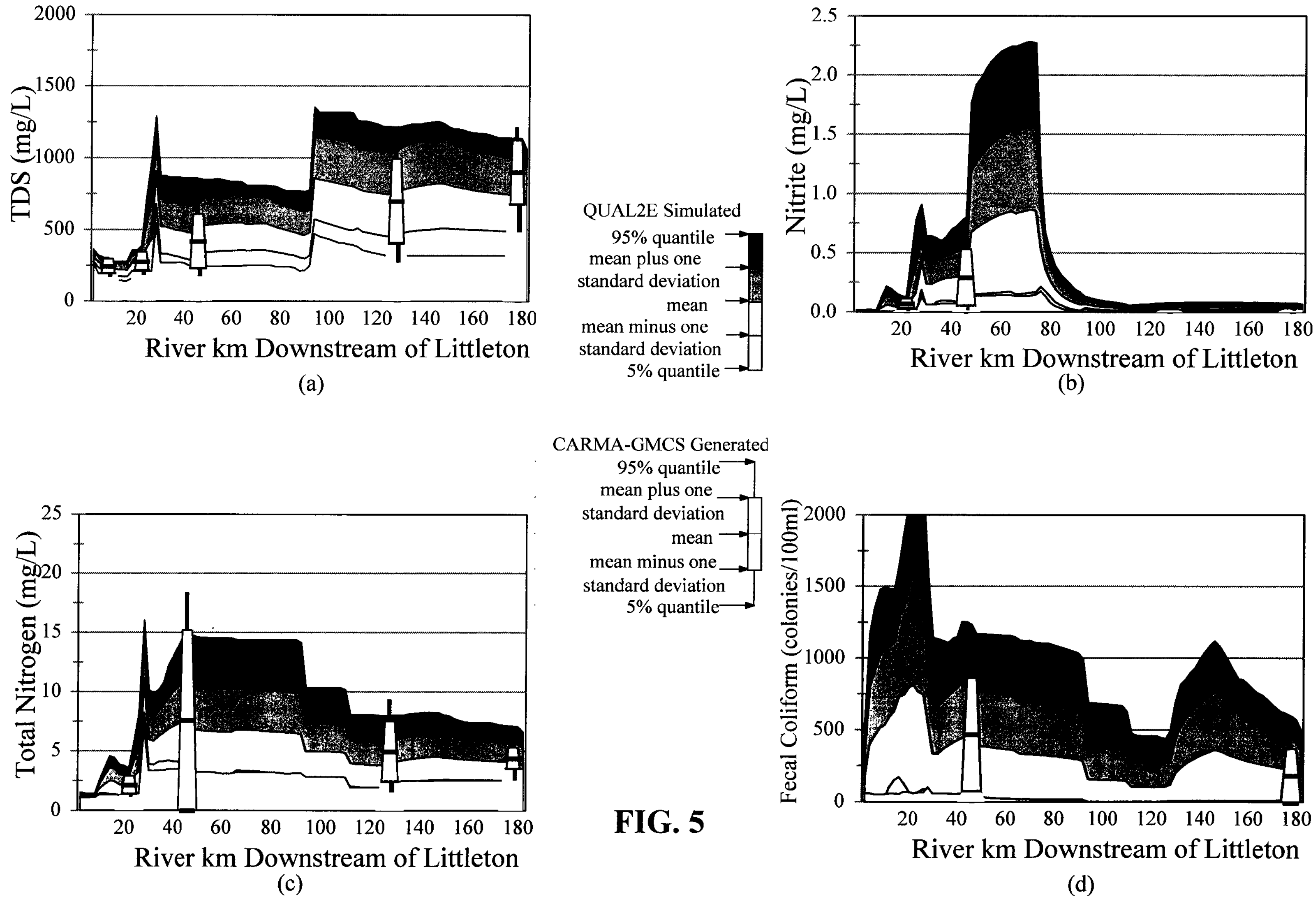
TDS(mg/L)
1200
1100
1000
900
800
700
600
500
1965
1980
1995
2010
2025
Year
(a)
CARMA-GMCS Generated
95% quantile
mean plus one standard deviation
mean
mean minus one standard deviation
5% quantile
Nitrite (mg/L)
0.25
0.20
0.15
0.10
0.05
0.00
1990
1995
2000
2005
2010
2015
2020
2025
Year
(b)
Nitrate (mg/L)
8
6
4
2
0
1990
1995
2000
2005
2010
2015
2020
2025
Year
(c)
Fecal Cliform (colonies/100 ml)
2000
1500
1000
500
0
1990
1995
2000
2005
2010
2015
2020
2025
Year
(d)

FIG. 3



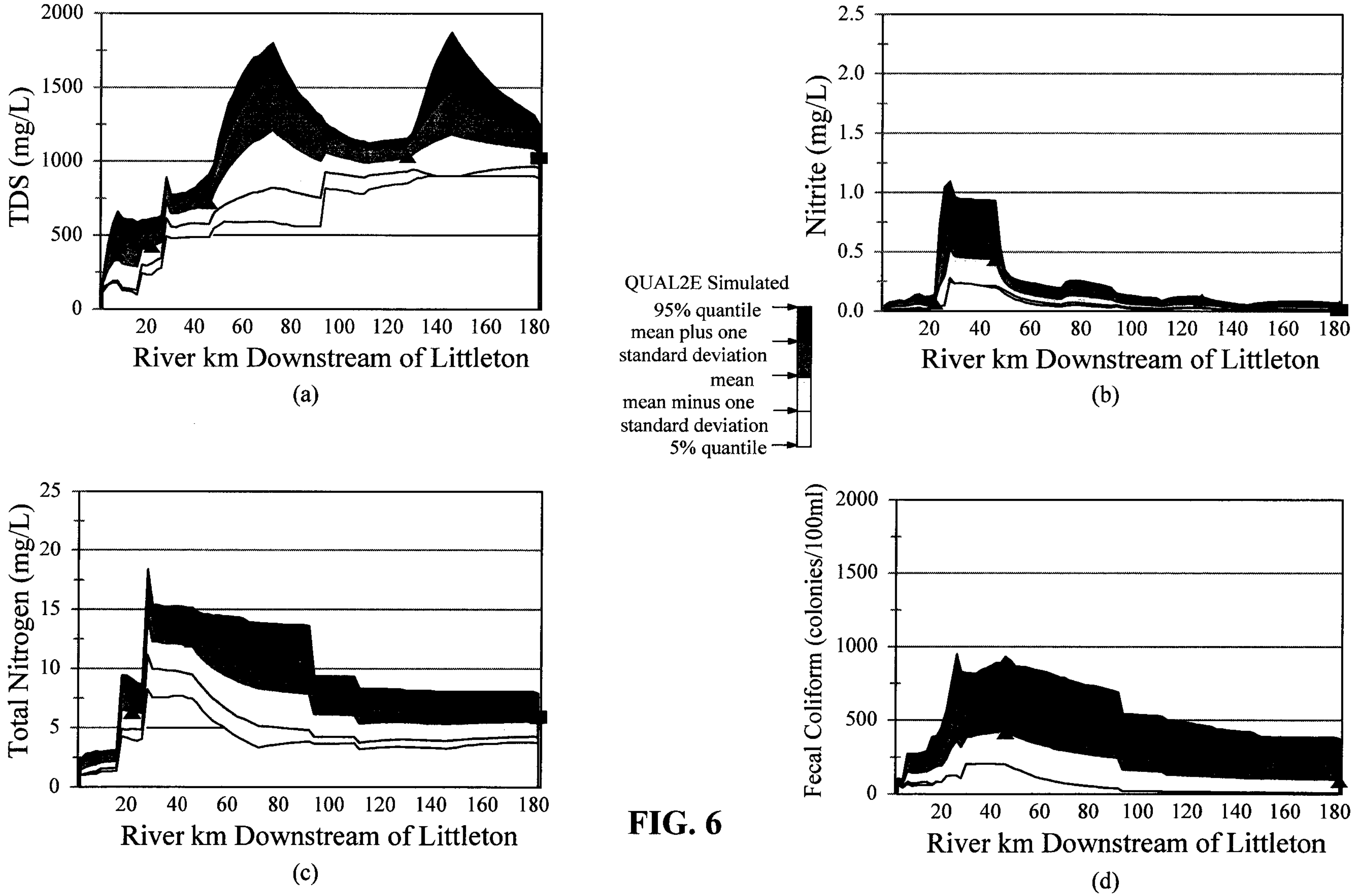
TDS (mg/L)
River km Downstream of Littleton
(a)
Nitrite (mg/L)
River km Downstream of Littleton
(b)
QUAL2E Simulated
95% quantile
mean plus one standard deviation
mean
mean minus one standard deviation
5% quantile
CARMA-GMCS Generated
95% quantile
mean plus one standard deviation
mean
mean minus one standard deviation
5% quantile
Total Nitrogen (mg/L)
River km Downstream of Littleton
(c)
Fecal Coliform (colonies/100ml)
River km Downstream of Littleton
(d)

FIG. 4



TDS (mg/L)
2000
1500
1000
500
0
20 40 60 80 100 120 140 160 180
River km Downstream of Littleton
(a)
QUAL2E Simulated
95% quantile
mean plus one standard deviation
mean
mean minus one standard deviation
5% quantile
Nitrite (mg/L)
2.5
2.0
1.5
1.0
0.5
0.0
20 40 60 80 100 120 140 160 180
River km Downstream of Littleton
(b)
CARMA-GMCS Generated
95% quantile
mean plus one standard deviation
mean
mean minus one standard deviation
5% quantile
Total Nitrogen (mg/L)
25
20
15
10
5
0
20 40 60 80 100 120 140 160 180
River km Downstream of Littleton
(c)
Fecal Coliform (colonies/100ml)
2000
1500
1000
500
0
20 40 60 80 100 120 140 160 180
River km Downstream of Littleton
(d)

FIG. 5



2000
1500
1000
500
0
TDS (mg/L)
20 40 60 80 100 120 140 160 180
River km Downstream of Littleton
(a)
2.5
2.0
1.5
1.0
0.5
0.0
Nitrite (mg/L)
20 40 60 80 100 120 140 160 180
River km Downstream of Littleton
(b)
QUAL2E Simulated
95% quantile
mean plus one standard deviation
mean
mean minus one standard deviation
5% quantile
25
20
15
10
5
0
Total Nitrogen (mg/L)
20 40 60 80 100 120 140 160 180
River km Downstream of Littleton
(c)
2000
1500
1000
500
0
Fecal Coliform (colonies/100ml)
20 40 60 80 100 120 140 160 180
River km Downstream of Littleton
(d)

FIG. 6

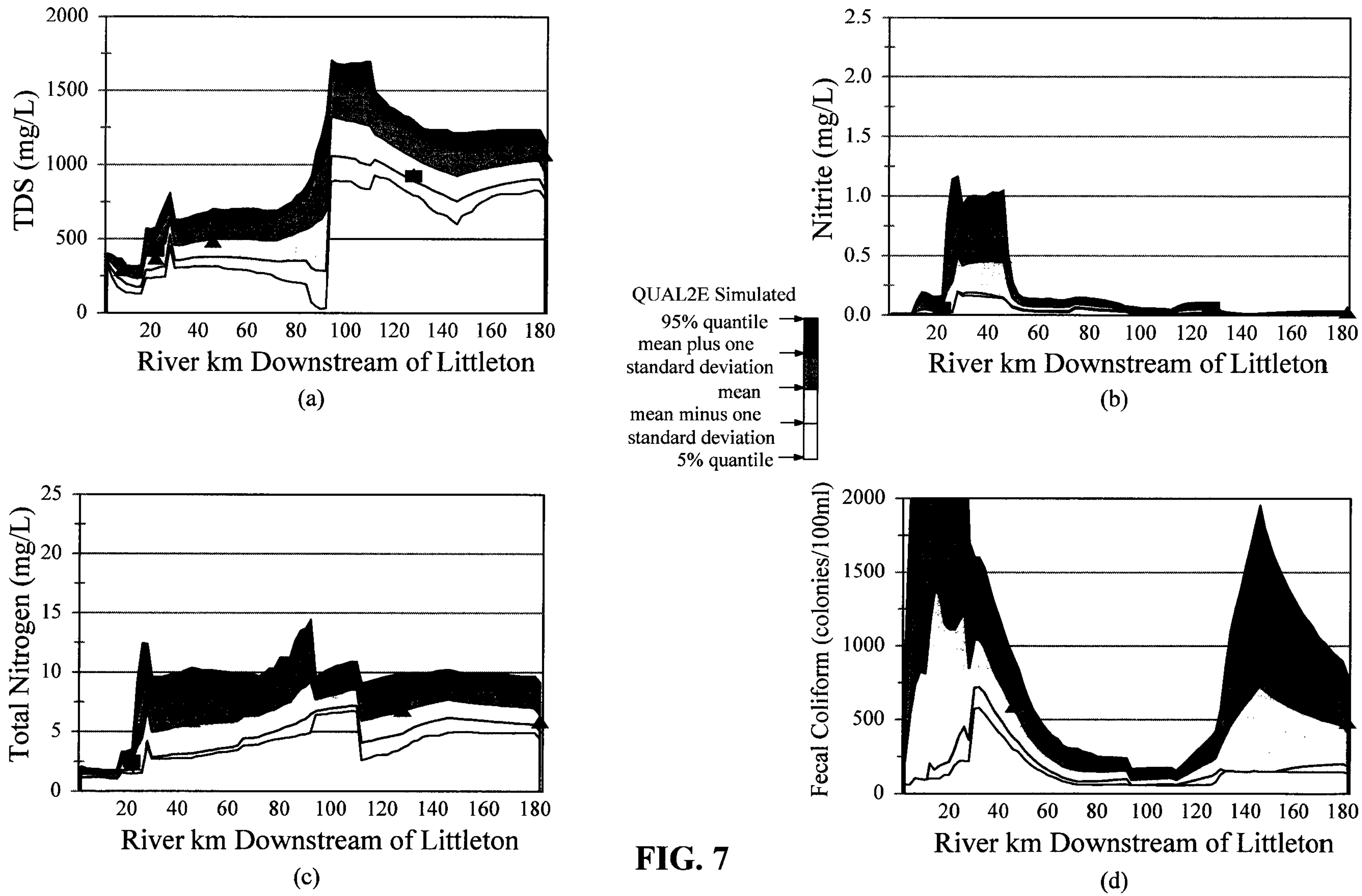

TDS (mg/L)
River km Downstream of Littleton
(a)
Nitrite (mg/L)
River km Downstream of Littleton
(b)
QUAL2E Simulated
95% quantile
mean plus one standard deviation
mean
mean minus one standard deviation
5% quantile
Total Nitrogen (mg/L)
River km Downstream of Littleton
(c)
Fecal Coliform (colonies/100ml)
River km Downstream of Littleton
(d)

FIG. 7

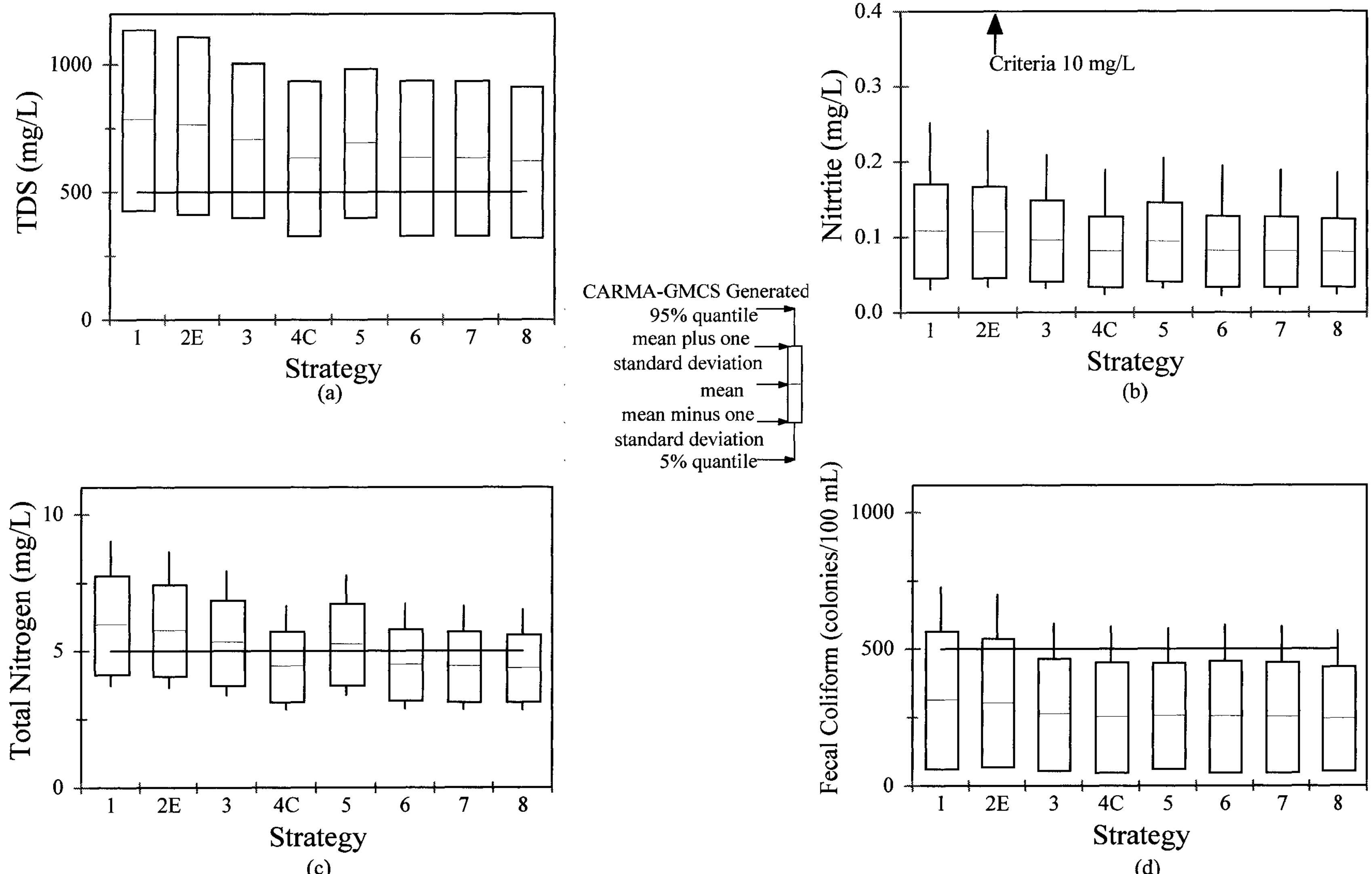

TDS (mg/L)
1000
500
0
1
2E
3
4C
5
6
7
8
Strategy
(a)
0.4
0.3
0.2
0.1
0.0
Criteria 10 mg/L
Nitrite (mg/L)
Strategy
(b)
CARMA-GMCS Generated
95% quantile
mean plus one
standard deviation
mean
mean minus one
standard deviation
5% quantile
Total Nitrogen (mg/L)
10
5
0
Strategy
(c)
Fecal Coliform (colonies/100 mL)
1000
500
0
Strategy
(d)

FIG. 8

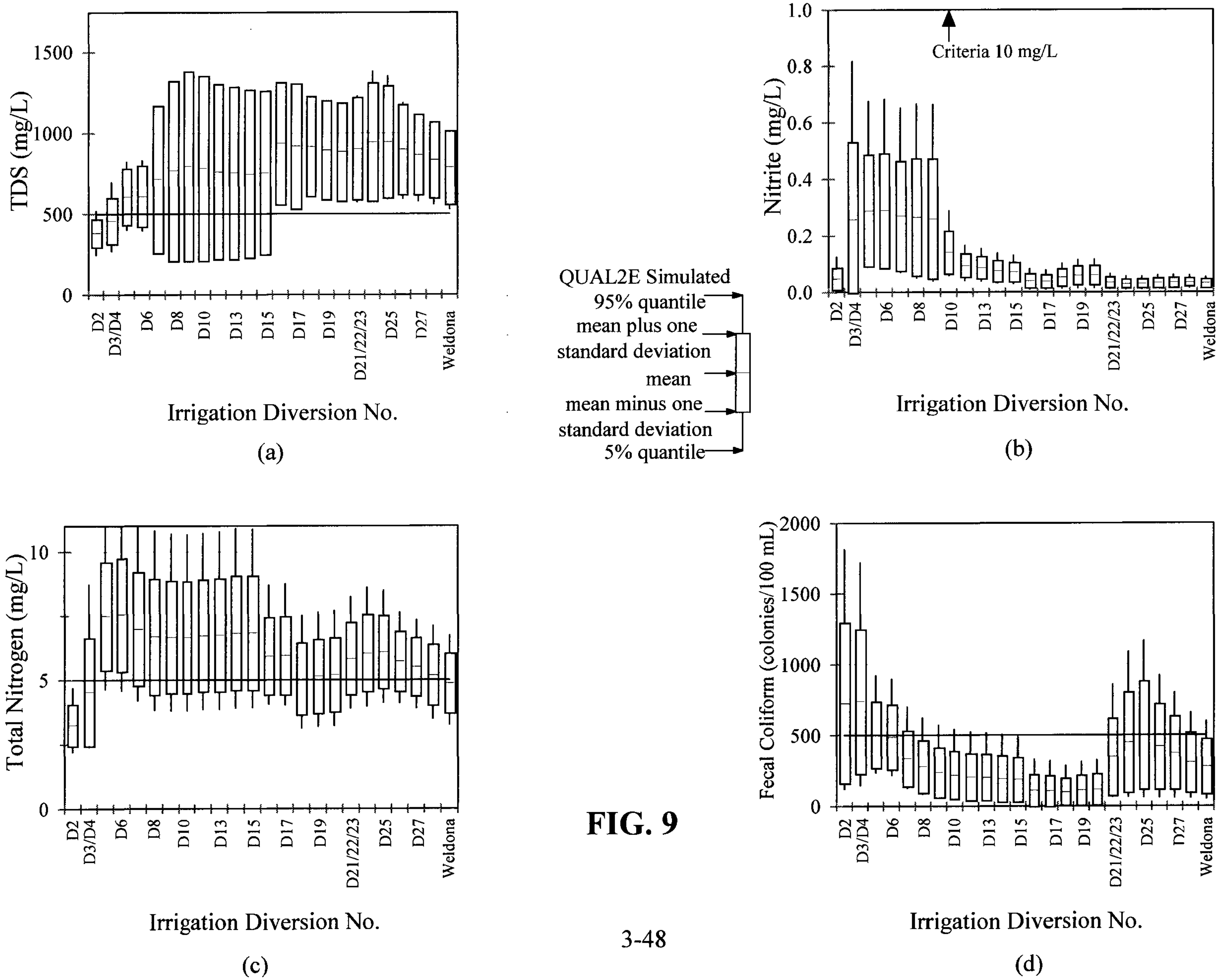

TDS (mg/L)
Irrigation Diversion No.
(a)
1.0
0.8
0.6
0.4
0.2
0.0
Criteria 10 mg/L
Nitrite (mg/L)
Irrigation Diversion No.
(b)
QUAL2E Simulated
95% quantile
mean plus one standard deviation
mean
mean minus one standard deviation
5% quantile
Total Nitrogen (mg/L)
Irrigation Diversion No.
(c)
Fecal Coliform (colonies/100 mL)
Irrigation Diversion No.
(d)
D2
D3/D4
D6
D8
D10
D13
D15
D17
D19
D21/22/23
D25
D27
Weldona

FIG. 9

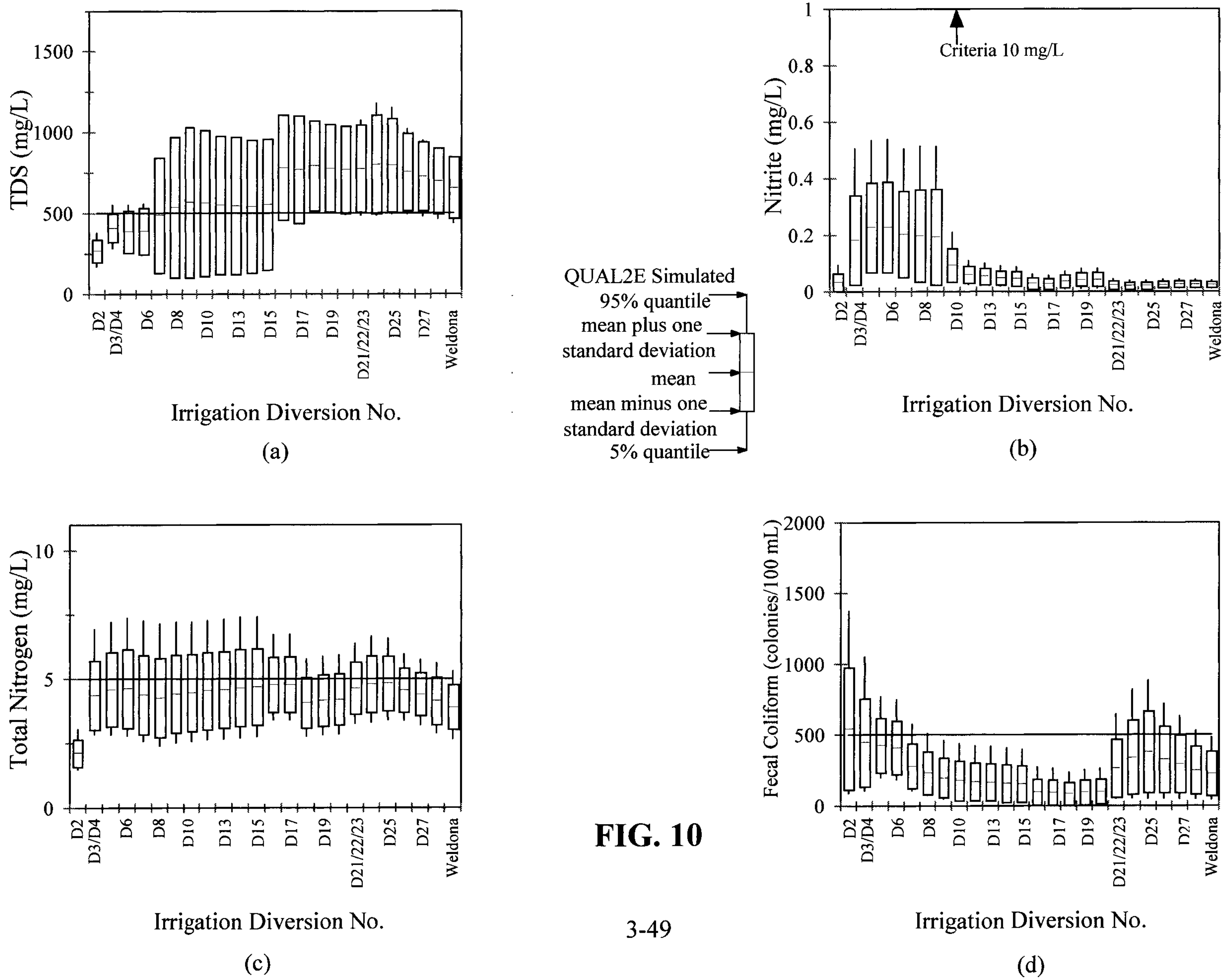

TDS (mg/L)
1500
1000
500
0
D2
D3/D4
D6
D8
D10
D13
D15
D17
D19
D21/22/23
D25
D27
Weldona
Irrigation Diversion No.
(a)
QUAL2E Simulated
95% quantile
mean plus one standard deviation
mean
mean minus one standard deviation
5% quantile
Nitrite (mg/L)
1
0.8
0.6
0.4
0.2
0
Criteria 10 mg/L
Irrigation Diversion No.
(b)
Total Nitrogen (mg/L)
10
5
0
Irrigation Diversion No.
(c)
Fecal Coliform (colonies/100 mL)
2000
1500
1000
500
0
Irrigation Diversion No.
(d)

FIG. 10

CHAPTER 4

CONCLUSIONS AND RECOMMENDATIONS

To account for both the major physical phenomena governing pollution transport in rivers and the uncertainty of parameters that influence that transport, a physically-based stochastic water quality model, supported by empirical stochastic models, was developed for feasibility-stage project planning. This study provides a robust method for predicting water quality conditions in a stream by accounting for uncertainty coming from knowledge limitations, in a large part due to inherent data variations in time and space, measurement error, and sparse sampling of boundary conditions, system properties, and forcing functions. It presents the space-time output of interest not as single-valued (deterministic), but as distributions of possible values having statistical characteristics. These statistics can be used to associate notions of probability and risk to pollution at times and locations of interest along the stream. As such, water quality managers can implement pollution control strategies with an idea of "how likely" certain water quality conditions will prove to be. The application of this approach to the lower South Platte River in Colorado provides an important contribution to the understanding of this river basin as well as to the science in general. First of all, the parameter description and calibration results provide useful information to enrich the body of knowledge pertaining to the statistical characteristics of water quality parameters and variables along the river and over time, including statistical trends and correlation structure. They also exhibit the effects that irregular sampling can have on model predictions and the need for further enhancement of the river monitoring network. Second, the combined use of empirical and physically-based stochastic models in conjunction with an optimization algorithm, yields an effective means to calibrate and validate (test) river water quality simulation in a stochastic context. Third, the statistical features of the predicted results afford useful information to indicate the level of ambiguity derived from model parameter uncertainty associated with a realistic, and moderately data-rich, river system. Fourth, the performance measures associated with each water quality constituent reveal the versatile responses of the river segments to different types of water quality pollution control strategies. Based on these responses, water-quality managers can better understand what magnitude and level of uncertainty of impacts can be expected from implementing alternative strategies. Overall, the proposed methodology offers a wide variety of potential applications not only in the water quality simulation in particular but also in the water-management field in general.

Several summary findings were presented in Chapter 3. Given below are some additional general conclusions, including limitations, that were derived from this study:

(1) The empirical stochastic models of parameters and state variables closely reproduced the historical means of the random variables but were unable in 17% of the cases to reproduce the standard deviations of the historical data with statistical significance. Part of this error can be attributed to the characteristics of the marginal distributions of the random variables in the river system; namely, data were transformed

into symmetric probability distributions rather than into normal probability distributions. The effects of these limitations also can be revealed in estimating the model simulation-related percentiles of the measured data over the validation (test) periods. It was concluded that the empirical stochastic models were limited in their ability to reproduce the extreme values of the historical data, that is, values that exceeded the 95 percent interval estimated from historical measurements or close to the historic outliers.

(2) The development of the SARMA models revealed that the flow rate data tended to be fit with pure AR(1) models except in the March-April season, when moving average coefficients were significant. The characteristics of these orders agree well with the orders of time series model generally derived from hydrologic phenomena (Salas 1990). The water quality data were fitted with more complex forms of SARMA models. The residuals of the SARMA models fitted to the irrigation diversions were less adequate in passing the normality test. This could be explained by the fact that the original data in this group contained numerous zeroe values associated with few or no diversions occurring in some years.

(3) Due to a lack of data, mass balance was used to obtain preliminary estimates of flow rate and TDS concentrations for nonpoint source pollution along the river. However, the mass balance equations included the unknown concentration of the TDS of water diverted to the irrigation canals. A complex dynamic optimization program would be required to solve this problem and was beyond the scope of this study. Instead, correction factors (similar to the correction factors assigned to the preliminary estimates of N species and fecal coliform that were sampled from storm sewers) were assigned and calibrated to reduce model prediction errors. However, it was observed that the

errors, in the lower segment of the river where a lot of the irrigation canals are located, would increase as the numbers of realizations increased. This was caused partly from the effect of sparse sampling along the river. The calibrated values of the nonpoint source correction factors also revealed considerable variability, reflecting in part the sparse data available. If more monitoring stations could be set up downstream of Henderson, these errors and variability likely could be reduced.

(4) Calibrated parameters were also applied to model randomly-selected weeks within the period from which the statistics of the observed water quality state variables were derived. The results showed that the mean square errors between simulated and observed statistics grew, but within the reasonable ranges. The augmentation of the errors was observed coming from the water quality constituents at critical river locations that were previously noticed to have less prediction ability.

(5) The validation (test) results show that the model was effective in simulating a four-year period, by comparing the predicted distributions of the water quality constituents to those of values generated by empirical models at selected locations along the river during the period. Evaluating the simulated-related percentiles of the measured data also supported the validation of the model. The model predictions were very satisfactory, with average percentiles of the measured data falling roughly within the 70% confidence band (range between the mean plus one standard deviation and the mean minus one standard deviation) of the model generated data.

Some observations and conclusions derived from the specific application to the South Platte River in Colorado are:

(1) The level of uncertainty in predicted performance of pollution control strategies in amending constituent concentrations along the South Platte River was substantial. The relative variability was moderate for C_{TDS} and C_N (average CV ranging from about 0.10 to about 0.60), and was considerably larger for C_{NO_2} and C_{FC} (average CV ranging from about 0.50 to about 1.0).

(2) The projected wastewater increase along the considered reach of the river (derived from assumed pollution growth in the future) was significant only in terms of Q. Due to the high variability of the river water quality concentrations, the locations of the wastewater treatment plants (all congregated in the upper portion of the river), and the assumption of their compliance to the permit system (NPDES), the increase of the wastewater loads over the 25-year planning period had no notable effect on the considered water quality constituents over the different seasons. The only exception was C_N, which revealed a decrease over the 25-year planning period in the Nov-Dec season. The C_N of the Metro Denver Reclamation District (MDWD) was lower than that of the river water at this time of the year. Given the fact that the effluents from the MDWD are the major contributor to the river flow in this season, the effect of wastewater increase due to the population growth over the 25-year period (equivalent to a flow dilution in this season) could be acutely felt.

(3) Nonpoint source reduction appears to be the most effective strategy in improving water quality for irrigation diversions. Impacts from increasing the level of wastewater treatment were more pronounced in the upper and middle portions of the considered river reach. However, in the non-irrigation seasons, when the flow in the

river is low, the effects of the wasteload reductions would be acutely felt. Increased reservoir releases and relocation of the Burlington Ditch were predicted to achieve only limited reduction in water quality pollution along the river.

(4) Although the improved management strategies considered in this study did not achieve a dramatic improvement in water quality over the river system as a whole, the pollution in some critical segments of the river was greatly diminished. Standard deviations in predicted water quality concentrations along the river were also reduced (by 16% to 31%), most markedly in the lower segment of the river from Henderson to Kersey. This was the longest river reach stretching between two adjacent control stations and contained most of the diversions to irrigation canals. It was believed that the considered strategies would help lower the extreme values of the water quality constituent concentrations associated with ill estimation of the nonpoint source pollution, caused by sparse sampling along the river, and would decrease the chances of model-simulated outliers.

(5) As described in Appendix D, a deterministic simulation of baseline conditions was conducted using the mean values of the model parameters, as derived from the analysis of field data and from the stochastic calibration procedure. A comparison of spatial and temporal averages of deterministic predictions with spatial and temporal averages of the means of stochastic predictions showed similarity for many, though not all, constituent concentrations. However, the distinct advantage of the stochastic approach, especially in cases like the South Platte River where the level of prediction uncertainty is substantial (as indicated by moderate to high CV values), is the ability to address confidence intervals, probabilities of occurrence, and notions of the

risk/reliability associated with the predicted performance of alternative pollution control strategies.

The developed model provides a useful tool in describing the uncertainty associated with implementing alternative river pollution control strategies. However, the following recommendations for improvement are offered:

(1) Given the sparse sampling of most of the water quality constituents in the South Platte River Basin, the tradeoff between preserving the seasonality of the system and deriving more reliable statistical moments from historical data to better represent reality can be critical. Sensitivity analysis should be used to help uncover the best combination of the model dimensions (for example, the numbers of seasons per year used to represent the seasonal behavior of the river system, the length of the river reaches and elements, etc.) and the sample sizes needed to reproduce the historical statistical moments.

(2) The uncertainties associated with the model output can be further quantified and reduced by collecting more data in the river system over time and space.

(3) Nonpoint source pollution was one of the most highly uncertain variables in the South Platte River system, especially downstream of Henderson. To reduce model prediction uncertainty due to the lack of information about the nonpoint source pollution, the knowledge associated with this pollution should be enhanced. Measuring the quantity and quality of groundwater interaction and surface return flows along the river corridor can do this, and/or a model developed for predicting nonpoint source loads supported by a GIS database could be used.

(4). Although the model proved effective over a four-year validation (test) period, both the empirical stochastic models and the calibrated parameters should be updated (recalibrated) from time to time to insure more reliable predictions. In the meantime, sensitivity analysis of predicted system performance to the assumed statistical characteristics of model parameters should be conducted before developing detailed designs of selected pollution control alternatives.

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APPENDICES

APPENDIX A:

Available Flow and Water Quality Records for Study Segment of South Platte River

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Introduction to Appendix A

This appendix presents tables that summarize the characteristics of the available flow and water quality records for the study segment of the South Platte River Basin, stretching from Littleton to Weldona. Table A-1 lists and locates the records according to four major categories: the tributaries along the study segment, the major waste facilities (with effluents greater than 1 million gallon per day) along the segment, the diversions along the segment, and the long-term in-stream gauging stations along of the main stem and at the mouth of the tributaries. The tributaries were assigned codes starting with "T", the waste facilities were assigned codes starting with "W", the diversions were assigned codes starting with "D", and gauging stations were assigned codes starting with "G". All the code numbers were ordered from upstream to downstream. The location of each site was defined using the kilometers downstream of the gauging station at Littleton. There are eight gauging stations along the study segment, nine tributaries (with a total of 14 stations representing the water quality conditions of the tributary inflows), 28 diversion canals (27 of which are irrigation ditches), and 14 major domestic and industrial waste facilities.

Tables A-2 to A-5 list the sample period, sample size, and basic statistical characteristics (mean, standard deviation, minimum, and maximum) of sites in each of the four categories. The period of record for tributary inflows ranges from 21 to 73 years with 9 to 3341samples. The flow rates of these inflows, averaged over the entire period of record, varied from 0.06 to 6.73 m^3/s. The average over the period of record ranged from 134.0 to 1244.7 mg/L for C_{TDS}; 0.19 to 2.95 mg/L for C_{ON}; 0.06 to 0.99 mg/L for C_{NH_3}; 0.01 to 0.17 mg/L for C_{NO_2}; 0.22 to 6.79 mg/L for C_{NO_3}; and 807 colonies/100 ml for C_{FC}. The average waste flow rates ranged from 0.005 to 5.77 m^3/s. The average waste effluent concentrations ranged from 540.4 mg/L for C_{TDS}; from 0.16 to 11.29 mg/L for C_{NH_3}; from 0.01 to 0.17 mg/L for C_{NO_2}; from 4.19 to 11.50 mg/L for C_{NO_3}; and from 7.68 to 547.16 colonies/100 ml for C_{FC}. The average river diversions over the entire period of record varied from 0.04 to 2.53 m^3/s. Along the main stem of the river, the average flow rates ranged from 4.24 to 25.88 m^3/s; average C_{TDS} ranged from 258.79

to 1330.09 mg/L; average C_{ON} ranged from 0.58 to 1.66 mg/L; average C_{NH_3}, ranged from 0.07 to 4.99 mg/L; average C_{NO_2}, ranged from 0.01 to 0.35 mg/L; average C_{NO_3}, ranged from 0.32 to 6.39 mg/L; and average C_{FC} ranged from 305.93 to 420.87 colonies/100 ml.

Computed cross correlation among the flow and different water quality constituents at the same sites is summarized in Tables A-6 to A-8. For the tributary inflows, the percentages of non-significant cross correlation coefficients ranged from 23.8 to 77.8% and the values of the significant correlation coefficients ranged from 0.14 to 0.90. For variables at gauging stations along the main stem, the percentages of non-significant cross correlation coefficients ranged from 17.9 to 67.9%. The values of significant correlation coefficients at these stations ranged from 0.17 to 0.93. To test if the computed Pearson coefficient differs from zero at the 5% level, the significant bounds of $\pm\frac{1.96}{\sqrt{N}}$ were used, where 1.96 is the 97.5% quantile of the standard normal distribution, and N is the sample size of the paired series (Brockwell and Davis 1996).

Since seasonal variations were observed in the regularly-sampled flow rates along the South Platte River, the decision was made to further segregate all regularly-sampled data series into six seasonal sub-series. The cross correlations among different stations as well as among different seasons were calculated according to variable categories. The percentages of non-significance coefficients and the range of values for significant correlation among variables within the different categories are summarized in Table A-9. The percentages of non-significant coefficient between combinations of variables in the four categories ranged from 23 to 70%. The variables among gauging stations along the South Platte River main stem in the months of May and June showed the most significant correlation. On the contrary, the waste effluent variables and tributary inflow variables in the months of May and June revealed the lowest percentage of significant correlation.

TABLE A-1. Tributaries, Wasteload Facilities, Diversions, and Gauging Stations Along the Study Segment of the South Platte River

Code	River km	Government Specified ID	Name
G1	0.0	06710000	South Platte River at Littleton
G2	1.9	06710245	South Platte River at Union Ave, at Englewood
D1	1.9	1013	Englewood Intake
T1	4.3	06711500	Bear Creek at Mouth, at Sheridan
G3	6.5	06711565	South Platte River at Englewood
W1	7.0	0032999	Littleton/Englewood Wastewater Treatment Plant
W2	7.5	0001091	Public Service Company-Arapahoe
T2	8.0	06711570	Havard Gulch at Colorado Boulevard
T3	8.0	06711575	Havard Gulch at Havard Park at Denver
W3	10.0	0001236	Gates Rubber Company
T4		06711635	NA Storm Drain at DFC at Lakewood
T5		06711637	NA Strom Drain at DFC N. Ave at Lakewood
W4	15.7	0001139	Public Service Company-Zuni
D2	17.5	800	Farmers and Gardeners Ditch
T6	18.3	06713500	Cherry Creek at Denver
T7		06713010	Cherry Knoll Storm Sewer at Denver
G4	19.0	06714000	South Platte River at Denver
T8	21.6	06714100	36th Storm Sewer at Denver
D3	24.1	802	Burlington Ditch
D4	24.6	806	Gardeners Ditch
G5	25.1	06714215	South Platte River at 64th Ave, at Commerce City
W5	25.3	0026638	Metro Denver Reclamation District
T9	27.3	06719505	Clear Creek at Golden
W6	28.6	0001104	Public Service Company-Cherokee
W7	34.7	0026662	South Adams Wastewater and Sanitary District
D5	38.1	808	Fulton Ditch
D6	40.5	809	Branter Ditch
G6	43.2	06720500	South Platte River at Henderson
D7	52.9	810	Brighton Ditch
W8	53.5	0021547	Brighton Wastewater Treatment Plant
D8	60.9	812	Lupton Bottom Ditch
T10	64.6	06720820	Big Dry Creek at Westermister
W9	65.2	0021440	Fort Lupton Wastewater Treatment Plant
D9	67.0	813	Platteville Ditch
D10	76.2	817	Evans No. 2
D11	76.2	821	Meadow Island 1 Ditch
D12	81.1	822	Meadow Island Ditch
D13	85.5	824	Farmer's Independent Ditch
W10	85.5	0040355	Platteville Wastewater Treatment Plant
D14	88.7	825	Hewes Cook Ditch
D15	91.5	826	Jay Thomas Ditch
W11	93.4	0001121	Public Service Company-Fort Saint Vrain
T11	93.5	06731000	St. Vrain Creek at Mouth, near Platteville
D16	102.4	828	Union Ditch
D17	108.0	830	Section No. 3 Ditch
T12	109.2	06744000	Big Thompson River at Mouth, near La Salle, CO
D18	113.6	834	Lower Latham Ditch
W12	115.8	0021644	La Salle Wastewater Treatment Plant
W13	118.3	0020508	Evans Wastewater Treatment Plant
D19	118.5	836	Patterson Ditch
D20	121.7	837	Highland Ditch
T13	122.5	06752270	Cache la Poudre River above Box Elder Creek, near Timnath
T14	122.5	06752500	Cache la Poudre River near Greeley
G7	126.5	06754000	South Platte River near Kersey
W14	127.8	0021954	Kersey Sanitary District
D21	134.2	503	Riverside Inlet Canal
D22	134.2	501	Empire Inlet Canal
D23	135.0	504	Illinois Ditch
D24	141.4	507	Bijou Canal
D25	145.4	509	Corona Ranch Ditch
D26	154.7	513	Jackson Lake Inlet Canal
D27	162.7	511	Weldon Valley Ditch
D28	176.4	514	Fort Morgan Canal
G8	181.2	06758500	South Platte River near Weldona

TABLE A-2. Statistical Characteristics of Tributary Inflows Along the Study Segment of the South Platte River

Variables		Date Period (mm/yy)	No.	Mean	STD	Min.	Max.		Date Period (mm/yy)	No.	Mean	STD	Min.	Max.
T1 Bear Creek at Mouth at Sheridan								T8 36th Storm Sewer at Denver						
q (m^3/s)		10/26-09/00	3340	1.25	2.63	0.01	39.24	*	05/75-01/84	36	0.41	0.39	0.00	1.28
C_{TDS}(mg/L)	*	04/72-04/94	48	273.07	88.34	0.00	432.50	*	05/75-01/84	36	367.64	661.76	29.41	3823.53
C_{ON}(mg/L)	*	04/72-04/94	48	1.52	1.78	0.15	8.79	*	05/75-01/84	36	2.83	1.90	0.15	9.40
C_{NH_3}(mg/L)	*	04/72-04/94	48	0.13	0.08	0.03	0.38	*	05/75-01/84	36	0.59	0.60	0.01	2.40
C_{NO_2}(mg/L)	*	04/72-04/94	10	0.02	0.00	0.02	0.02	*	05/75-01/84	36	0.11	0.10	0.01	0.50
C_{NO_3}(mg/L)	*	04/72-04/94	48	0.73	0.38	0.16	1.74	*	05/75-01/84	36	0.71	0.70	0.02	3.60
C_{FC}(colonies/100ml)	*	04/72-04/94	1	26080	NA	26080	26080	*	05/75-01/84	36	93046	131197	2620.53	692220
EC (microsiemens/cm)	*	04/72-04/94	48	446.32	124.92	239.40	721.20	*	05/75-01/84	36	575.68	1073.60	50.00	6081.80
T2 Harvard Gulch at Colorado Boulevard								T9 Clear Creek at Golden						
q (m^3/s)		04/80-09/90	193	0.22	0.11	0.00	0.38		10/74-09/97	1052	5.38	7.59	0.68	59.03
C_{TDS}(mg/L)		NA						*	04/81-06/97	107	134.06	80.07	0.00	352.60
C_{ON}(mg/L)		NA						*	04/81-06/97	107	0.19	0.04	0.08	0.33
C_{NH_3}(mg/L)		NA						*	04/81-06/97	97	0.06	0.05	0.00	0.19
C_{NO_2}(mg/L)		NA						*	04/81-06/97	106	0.01	0.00	0.00	0.02
C_{NO_3}(mg/L)		NA						*	04/81-06/97	105	0.22	0.15	0.03	0.64
C_{FC}(colonies/100ml)		NA							NA					
EC (microsiemens/cm)		NA							03/81-09/97	812	219.23	84.65	3.31	508.00
T3 Harvard Gulch at Harvard Park at Denver								T10 Big Dry Creek at Westminster						
q (m^3/s)		04/83-09/94	206	0.07	0.04	0.00	0.38		07/87-09/97	479	0.43	0.63	0.01	6.67
C_{TDS}(mg/L)		NA							NA					
C_{ON}(mg/L)		NA						*	07/87-10/97	1	0.85	NA	0.85	0.85
C_{NH_3}(mg/L)		NA						*	07/87-10/97	1	0.05	NA	0.05	0.05
C_{NO_2}(mg/L)		NA						*	07/87-10/97	1	0.03	NA	0.03	0.03
C_{NO_3}(mg/L)		NA						*	07/87-10/97	1	1.27	NA	1.27	1.27
C_{FC}(colonies/100ml)		NA							NA					
EC (microsiemens/cm)		NA						*	07/87-10/97	89	972.94	633.73	150.00	2750.00
T4 NA Storm Sewer Drain at DFC at Lakewood								T11 St. Vrain Creek at Mouth Near Platteville						
q (m^3/s)	*	07/75-09/81	59	0.06	0.06	0.00	0.26		02/27-09/00	3341	6.18	9.40	0.46	104.46
C_{TDS}(mg/L)	*	07/75-09/81	59	220.59	183.82	36.76	941.18	*	01/50-07/95	218	963.85	268.24	158.00	1610.00
C_{ON}(mg/L)	*	07/75-09/81	59	2.95	3.05	0.00	14.00	*	01/50-07/95	221	0.53	0.17	0.18	1.19
C_{NH_3}(mg/L)	*	07/75-09/81	59	0.75	0.91	0.01	4.81	*	01/50-07/95	210	0.57	0.65	0.00	5.35
C_{NO_2}(mg/L)	*	07/75-09/81	59	0.17	0.34	0.03	2.60	*	01/50-07/95	218	0.11	0.06	0.00	0.35
C_{NO_3}(mg/L)	*	07/75-09/81	59	0.69	0.53	2.72	11.00	*	01/50-07/95	211	3.84	1.28	0.18	7.25
C_{FC}(colonies/100ml)	*	07/75-09/81	59	2288.00	1668.00	175.00	6900.00		NA					
EC (microsiemens/cm)	*	07/75-09/81	59	304.66	351.21	11.00	1775.00	*	01/50-07/95	232	1354.89	301.00	315.00	2080.00
T5 NA Storm Drain at DFC N. Ave at Lakewood								T12 Big Thompson River at Loveland						
q (m^3/s)	*	07/80-08/81	21	0.03	0.03	0.00	0.14		07/79-09/00	876	2.26	6.53	0.03	70.68
C_{TDS}(mg/L)		NA						*	06/79-08/97	183	661.76	308.82	51.47	1492.65
C_{ON}(mg/L)	*	07/80-08/81	21	2.21	2.09	0.32	10.02	*	06/79-08/97	183	0.62	0.27	0.04	2.48
C_{NH_3}(mg/L)	*	07/80-08/81	21	0.99	0.97	0.01	4.56	*	06/79-08/97	183	0.12	0.43	0.01	4.60
C_{NO_2}(mg/L)	*	07/80-08/81	21	0.10	0.07	0.01	0.21	*	06/79-08/97	183	0.01	0.01	0.01	0.10
C_{NO_3}(mg/L)	*	07/80-08/81	21	1.39	0.92	0.33	3.50	*	06/79-08/97	183	0.68	0.35	0.15	2.19
C_{FC}(colonies/100ml)	*	07/80-08/81	21	5898.33	4325.95	200.00	22500	*	06/79-08/97	183	807.55	1341.99	55.00	11651
EC (microsiemens/cm)	*	07/80-08/81	21	306.91	210.40	62.50	985.00	*	06/79-08/97	183	909.21	519.29	60.00	1950.00
T6 Cherry Creek at Denver								T13 Cache la Poudre River above Box Elder Creek						
q (m^3/s)		10/41-09/96	2640	0.62	1.26	0.03	39.56		10/80-09/00	812	4.55	14.16	0.06	132.70
C_{TDS}(mg/L)	*	02/58-08/97	197	665.46	164.40	17.90	1198.00	*	10/79-08/97	199	1123.39	628.33	61.00	2618.00
C_{ON}(mg/L)	*	02/58-08/97	199	0.61	0.83	0.03	9.70	*	10/79-08/97	204	1.00	0.64	0.20	4.40
C_{NH_3}(mg/L)	*	02/58-08/97	180	0.24	0.37	0.00	3.76	*	10/79-08/97	248	0.27	0.63	0.01	6.60
C_{NO_2}(mg/L)		02/58-08/97	183	0.06	0.09	0.00	1.08	*	10/79-08/97	203	0.04	0.06	0.01	0.68
C_{NO_3}(mg/L)		02/58-08/97	199	2.63	1.25	0.00	10.77	*	10/79-08/97	203	1.47	1.29	0.01	9.20
C_{FC}(colonies/100ml)		NA							NA					
EC (microsiemens/cm)	*	02/58-08/97	199	1002.63	314.34	100.00	2800.00	*	10/79-08/97	248	1359.85	759.92	80.00	2800.00
T7 Cherry Knoll Storm Sewer at Denver								T14 Cache la Poudre River near Greeley						
q (m^3/s)	*	08/80-09/81	23	0.06	0.06	0.00	0.26		10/40-09/92	720	6.73	14.99	0.04	145.40
C_{TDS}(mg/L)		NA						*	01/50-01/97	194	1244.73	303.40	169.12	1838.24
C_{ON}(mg/L)	*	08/80-09/81	23	0.85	0.45	0.50	2.35	*	01/50-01/97	5	1.00	0.45	0.60	1.83
C_{NH_3}(mg/L)	*	08/80-09/81	23	0.60	0.43	0.01	1.49	*	01/50-01/97	5	0.66	0.34	0.24	1.20
C_{NO_2}(mg/L)	*	08/80-09/81	23	0.03	0.04	0.01	0.22	*	01/50-01/97	5	0.17	0.04	0.11	0.24
C_{NO_3}(mg/L)	*	08/80-09/81	23	0.52	0.33	0.01	1.22	*	01/50-01/97	5	6.79	0.95	5.75	8.31
C_{FC}(colonies/100ml)	*	08/80-09/81	23	6378.67	2043.38	825.00	13725		NA					
EC (microsiemens/cm)	*	08/80-09/81	23	59.36	39.13	8.00	144.00	*	01/50-01/97	202	1676.26	348.53	277.00	2350.00

Notes: No.-Number of observations
NA-Not available
*-Irregularly sampled data

TABLE A-3. Statistical Characteristics of Major Waste Facilities Effluents Along the Study Segment of the South Platte River

Variables	Date Period (mm/yy)	No.	Mean	STD	Min.	Max.	Date Period (mm/yy)	No.	Mean	STD	Min.	Max
W1 Littleton/Englewood Wastewater Treatment Plant							W8 Brighton Wastewater Treatment Plant					
q (m^3/s)	01/88-12/98	131	1.05	0.10	0.81	1.32	01/88-12/98	132	0.08	0.01	0.06	0.11
C_{TDS} (mg/L)	NA						NA					
C_{NH_3} (mg/L)	01/88-12/98	131	11.29	9.45	0.50	28.90	01/88-12/98	132	3.63	3.77	0.17	18.82
C_{NO_2} (mg/L)	NA						NA					
C_{NO_3} (mg/L)	NA						01/88-12/98	132	4.67	2.74	0.00	12.21
C_{FC} (colonies/100ml)	01/88-12/98	130	166.11	199.31	10.00	1900.00	01/88-12/98	132	125.99	205.18	1.72	1628.80
W2 Public Service Company-Arapahoe							W9 Fort Lupton Wastewater Treatment Plant					
q (m^3/s)	01/88-12/98	132	0.011	0.005	0.001	0.031	01/88-12/98	132	0.04	0.01	0.01	0.07
C_{TDS} (mg/L)	NA						NA					
C_{NH_3} (mg/L)	01/88-12/98	132	0.16	0.32	0.00	2.14	01/88-12/98	132	3.24	4.22	0.00	16.70
C_{NO_2} (mg/L)	NA						NA					
C_{NO_3} (mg/L)	NA						NA					
C_{FC} (colonies/100ml)	NA						01/88-12/98	132	545.42	1118.61	1.40	8511.00
W3 Gates Rubber Company							W10 Platteville Wastewater Treatment Plant					
q (m^3/s)	01/88-09/94	80	0.011	0.014	0.000	0.035	01/89-12/98	132	0.005	0.004	0.002	0.041
C_{TDS} (mg/L)	NA						NA					
C_{NH_3} (mg/L)	NA						NA					
C_{NO_2} (mg/L)	NA						NA					
C_{NO_3} (mg/L)	NA						NA					
C_{FC} (colonies/100ml)	NA						01/89-12/98	132	547.16	910.03	0.00	6007.52
W4 Public Service Co.-Zuni							W11 Public Service Company-Fort St. Vrain					
q (m^3/s)	04/88-12/98	132	2.06	1.85	0.18	21.17	07/88-12/98	30	0.09	0.03	0.02	0.16
C_{TDS} (mg/L)	NA						NA					
C_{NH_3} (mg/L)	NA						07/88-12/98	30	1.46	2.82	0.00	24.23
C_{NO_2} (mg/L)	NA						NA					
C_{NO_3} (mg/L)	NA						NA					
C_{FC} (colonies/100ml)	NA						NA					
W5 Metro Denver Reclamation District							W12 Evans Wastewater Treatment Plant					
q (m^3/s)	01/88-12/98	132	5.77	0.98	2.04	7.89	11/88-09/94	55	0.021	0.008	0.012	0.031
C_{TDS} (mg/L)	01/92-12/92	365	540.04	121.13	121.00	1190.00	NA					
C_{NH_3} (mg/L)	01/88-12/98	132	8.45	7.15	3.36	80.16	NA					
C_{NO_2} (mg/L)	01/88-12/98	132	0.17	0.21	0.05	2.26	NA					
C_{NO_3} (mg/L)	01/88-12/98	132	4.19	1.44	0.00	6.60	NA					
C_{FC} (colonies/100ml)	01/88-12/98	132	273.64	218.06	39.00	1520.00	NA					
W6 Public Service Company-Cherokee							W13 La Salle Wastewater Treatment Plant					
q (m^3/s)	01/88-12/98	132	0.09	0.02	0.04	0.16	01/88-09/94	55	0.007	0.003	0.004	0.011
C_{TDS} (mg/L)	NA						NA					
C_{NH_3} (mg/L)	01/89-12/98	132	0.20	0.17	0.00	1.47	NA					
C_{NO_2} (mg/L)	NA						NA					
C_{NO_3} (mg/L)	01/89-12/98	132	11.50	4.99	0.50	27.12	NA					
C_{FC} (colonies/100ml)	NA						NA					
W7 South Adams Wastewater and Sanitary District							W14 Kersey Sanitary District					
q (m^3/s)	01/88-12/98	132	0.12	0.01	0.09	0.15	01/88-09/94	55	0.005	0.004	0.002	0.042
C_{TDS} (mg/L)	NA						NA					
C_{NH_3} (mg/L)	01/88-12/98	132	7.46	3.76	1.70	20.00	NA					
C_{NO_2} (mg/L)	NA						NA					
C_{NO_3} (mg/L)	NA						NA					
C_{FC} (colonies/100ml)	01/88-12/98	132	71.68	115.31	1.00	796.00	NA					

Notes: No.-Number of observations
NA-Not available

TABLE A-4. Statistical Characteristics of Flow Diversions Along the Study Segment of the South Platte River

Name	Date Period (mm/yy)	No.	Mean (m^3/s)	STD (m^3/s)	Min. (m^3/s)	Max. (m^3/s)
D1 Englewood Intake	11/49-10/98	576	0.30	0.17	0	0.77
D2 Farmers and Gardeners Ditch	11/49-10/98	576	0.26	0.18	0	0.86
D3 Burlington Ditch	11/49-10/98	576	2.53	2.95	0	17.37
D4 Gardeners Ditch	11/49-10/98	576	0.04	0.04	0	0.11
D5 Fulton Ditch	11/49-10/98	576	0.91	1.17	0	4.57
D6 Branter Ditch	11/49-10/98	576	0.51	0.62	0	2.32
D7 Brighton Ditch	11/49-10/98	576	0.36	0.40	0	1.42
D8 Lupton Bottom Ditch	11/49-10/98	576	0.61	0.79	0	3.14
D9 Platteville Ditch	11/49-10/98	576	0.72	0.83	0	3.40
D10 Evans No. 2	11/49-10/98	576	1.56	1.75	0	6.66
D11 Meadow Island 1 Ditch	11/49-10/98	576	0.22	0.26	0	1.20
D12 Meadow Island Ditch	11/49-10/98	576	0.41	0.50	0	1.67
D13 Farmer's Independent Ditch	11/49-10/98	576	0.64	0.78	0	3.28
D14 Hewes Cook Ditch	11/49-10/98	576	0.76	1.00	0	3.35
D15 Jay Thomas Ditch	11/49-10/98	576	0.11	0.13	0	0.51
D16 Union Ditch	11/49-10/98	576	1.13	1.26	0	3.84
D17 Section No. 3 Ditch	11/49-10/98	576	0.33	0.43	0	1.65
D18 Lower Latham Ditch	11/49-10/98	576	1.51	1.86	0	7.11
D19 Patterson Ditch	11/49-10/98	576	0.19	0.22	0	0.66
D20 Highland Ditch	11/49-10/98	576	0.15	0.21	0	0.70
D21 Riverside Inlet Canal	11/49-10/98	576	1.46	2.52	0	13.07
D22 Empire Inlet Canal	11/49-10/98	576	1.27	1.88	0	8.55
D23 Illinois Ditch	11/49-10/98	576	0.19	0.23	0	0.73
D24 Bijou Canal	11/49-10/98	576	1.78	2.10	0	9.86
D25 Corona Ranch Ditch	11/49-10/98	576	0.08	0.10	0	0.56
D26 Jackson Lake Inlet Canal	11/49-10/98	576	1.26	1.78	0	8.46
D27 Weldon Valley Ditch	11/49-10/98	576	1.11	1.37	0	4.75
D28 Fort Morgan Canal	11/49-10/98	576	1.64	1.89	0	8.47

Note: No.-Number of observations

TABLE A-5. Statistical Characteristics of Flow and Water Quality Monitoring Records at Gauging Stations Along the South Platte River

Variables		Date Period (mm/yy)	No.	Mean	STD	Min.	Max.		Date Period (mm/yy)	No.	Mean	STD	Min.	Max.
G1 South Platte River at Littleton								G5 South Platte River at 64th Ave, at Commerce City						
Q (m^3/s)		10/42-09/96	2640	7.09	12.96	0.21	156.12		10/82-09/96	705	7.93	15.65	0.15	109.23
C_{TDS} (mg/L)	*	10/50-09/86	93	258.79	76.35	108.00	417.00		NA					
C_{ON} (mg/L)	*	10/50-09/86	93	0.66	0.30	0.08	1.70	*	02/82-08/97	3	0.58	0.08	0.51	0.69
C_{NH_3} (mg/L)	*	10/50-09/86	87	0.07	0.05	0.00	0.18	*	02/82-08/97	3	0.32	0.28	0.09	0.71
C_{NO_2} (mg/L)	*	10/50-09/86	93	0.01	0.00	0.00	0.02	*	02/82-08/97	3	0.11	0.05	0.08	0.18
C_{NO_3} (mg/L)	*	10/50-09/86	92	0.32	0.26	0.00	1.05	*	02/82-08/97	3	6.39	2.44	4.32	9.82
C_{FC} (colonies/100ml)		NA							NA					
EC (microsiemens/cm)		10/79-09/94	384	383.79	55.89	53.72	569.49	*	02/82-08/97	160	970.76	438.39	200.00	2050.00
G2 South Platte River at Union Ave, at Englewood								G6 South Platte River at Henderson						
Q (m^3/s)		08/89-09/00	384	4.24	8.27	0.29	72.70		05/26-09/00	3380	12.10	18.10	0.21	220.37
C_{TDS} (mg/L)		NA						*	10/54-09/95	317	588.42	187.04	147.00	980.00
C_{ON} (mg/L)		NA						*	10/54-09/95	319	1.86	1.23	0.00	10.00
C_{NH_3} (mg/L)		NA						*	10/54-09/95	319	4.99	4.66	0.00	21.69
C_{NO_2} (mg/L)		NA						*	10/54-09/95	319	0.35	0.23	0.00	1.10
C_{NO_3} (mg/L)		NA						*	10/54-09/95	319	6.28	7.51	0.07	50.00
C_{FC} (colonies/100ml)		NA						*	10/54-09/95	316	420.87	471.48	0.00	2570.00
EC (microsiemens/cm)	*	04/89-11/95	68	596.43	229.77	104.00	1410.00	*	10/54-09/95	316	949.64	296.49	0.00	1470.00
G3 South Platte River at Englewood								G7 South Platte River near Kersey						
Q (m^3/s)		02/83-09/00	704	9.43	14.89	0.78	97.26		01/14-09/00	3912	25.88	44.06	1.10	720.54
C_{TDS} (mg/L)	*	01/81-08/97	63	384.17	136.10	10.63	656.50	*	10/49-08/00	344	1074.85	303.55	202.00	1846.00
C_{ON} (mg/L)	*	01/81-08/97	70	0.62	0.22	0.16	1.25	*	10/49-08/00	353	0.73	0.43	0.26	5.48
C_{NH_3} (mg/L)	*	01/81-08/97	70	0.14	0.06	0.06	0.32	*	10/49-08/00	331	0.66	1.12	0.00	15.61
C_{NO_2} (mg/L)	*	01/81-08/97	7	0.02	0.00	0.02	0.02	*	10/49-08/00	351	0.09	0.05	0.00	0.42
C_{NO_3} (mg/L)	*	01/81-08/97	70	1.09	0.37	0.38	2.19	*	10/49-08/00	352	5.72	2.34	0.00	13.41
C_{FC} (colonies/100ml)		NA						*	10/49-08/00	1	40.00	NA		
EC (microsiemens/cm)		10/85-09/96	576	586.36	163.09	45.00	974.70	*	10/49-08/00	348	1434.59	382.02	173.50	2520.00
G4 South Platte River at Denver								G8 South Platte River near Weldona						
Q (m^3/s)		07/1895-09/00	4860	9.94	15.12	0.40	188.13		10/52-09/00	2108	20.56	37.55	1.25	394.86
C_{TDS} (mg/L)	*	04/72-08/00	114	424.98	155.12	82.26	858.10	*	10/52-07/97	341	1330.09	332.52	373.07	2887.27
C_{ON} (mg/L)	*	04/72-08/00	114	0.74	0.61	0.04	4.40	*	10/52-07/97	344	0.88	0.58	0.15	6.01
C_{NH_3} (mg/L)	*	04/72-08/00	106	0.77	1.03	0.00	5.60	*	10/52-07/97	300	0.20	0.32	0.00	2.90
C_{NO_2} (mg/L)	*	04/72-08/00	111	0.10	0.08	0.00	0.44	*	10/52-07/97	331	0.04	0.02	0.00	0.12
C_{NO_3} (mg/L)	*	04/72-08/00	113	3.81	3.30	0.06	24.50	*	10/52-07/97	340	5.06	1.23	0.43	8.63
C_{FC} (colonies/100ml)		NA						*	10/52-07/97	342	305.93	1192.25	0.64	15570.00
EC (microsiemens/cm)	*	04/72-08/00	118	691.95	341.36	154.00	2590.00	*	10/52-07/97	340	1608.86	351.78	406.00	2870.00

Notes: No.-Number of observations
NA-Not available
*-Irregularly sampled data

TABLE A-6. Cross Correlation Coefficients between Flow and Water Quality Variables of the Tributaries Inflows Along the Study Segment of the South Platte River

Variables	q	C_{TDS}	C_{ON}	C_{NH_3}	C_{NO_2}	C_{NO_3}	C_{FC}	EC	q	C_{TDS}	C_{ON}	C_{NH_3}	C_{NO_2}	C_{NO_3}	C_{FC}	EC
T1 Bear Creek at Mouth at Sheridan									T9 Clear Creek at Golden							
q	1	-0.706	---	0.884	---	---	NA	-0.699	1	-0.819	--	-0.480	--	-0.586	NA	-0.609
C_{TDS}		1	---	---	---	---	NA	0.833		1	--	0.729	--	0.879	NA	0.995
C_{ON}			1	---	---	---	NA	---			1	--	--	--	NA	--
C_{NH_3}				1	---	---	NA	---				1	0.450	0.904	NA	0.716
C_{NO_2}					1	---	NA	---					1	--	NA	--
C_{NO_3}						1	NA	0.882						1	NA	0.853
C_{FC}							1	NA							1	NA
EC								1								1
T4 NA Storm Sewer Drain at DFC at Lakewood									T10 Big Dry Creek at Westminster							
q	1	-0.329	--	--	--	--	--	--	1	NA	NA	NA	NA	NA	NA	-0.501
C_{TDS}		1	-0.326	--	--	0.917	0.537	--		1	NA	NA	NA	NA	NA	NA
C_{ON}			1	0.417	--	-0.435	-0.959	--			1	NA	NA	NA	NA	NA
C_{NH_3}				1	--	--	--	--				1	NA	NA	NA	NA
C_{NO_2}					1	--	NA	--					1	NA	NA	NA
C_{NO_3}						1	--	--						1	NA	NA
C_{FC}							1	--							1	NA
EC								1								1
T5 NA Storm Drain at DFC N. Ave at Lakewood									T11 St. Vrain Creek at Mouth Near Platteville							
q	1	NA	--	--	-0.542	--	--	--	1	-0.412	--	--	-0.414	-0.779	NA	-0.707
C_{TDS}		1	NA	NA	NA	NA	NA	NA		1	0.853	0.636	0.824	0.893	NA	0.969
C_{ON}			1	--	--	0.454	--	--			1	--	0.483	0.424	NA	0.444
C_{NH_3}				1	0.692	0.685	0.832	--				1	--	0.434	NA	--
C_{NO_2}					1	0.881	--	--					1	0.616	NA	0.420
C_{NO_3}						1	--	--						1	NA	0.858
C_{FC}							1	--							1	NA
EC								1								1
T6 Cherry Creek at Denver									T12 Big Thompson River at Loveland							
q	1	-0.516	--	--	--	--	NA	-0.397	1	--	--	--	--	0.313	--	-0.383
C_{TDS}		1	-0.416	-0.477	--	--	NA	0.975		1	--	--	--	0.693	--	-0.284
C_{ON}			1	0.878	-0.706	-0.399	NA	--			1	0.359	0.333	0.169	0.157	--
C_{NH_3}				1	0.843	--	NA	-0.524				1	0.355	--	0.144	--
C_{NO_2}					1	-0.309	NA	--					1	--	--	0.158
C_{NO_3}						1	NA	--						1	--	-0.471
C_{FC}							1	NA							1	-0.269
EC								1								1
T7 Cherry Knoll Storm Sewer at Denver									T13 Cache la Poudre River above Box Elder Creek near Timnatl							
q	1	NA	0.619	--	--	--	--	--	1	-0.439	--	--	--	--	NA	-0.443
C_{TDS}		1	NA	NA	NA	NA	NA	NA		1	--	--	--	--	NA	0.981
C_{ON}			1	0.620	0.757	0.639	--	--			1	0.450	0.245	--	NA	--
C_{NH_3}				1	0.578	0.776	0.639	--				1	0.354	--	NA	-0.145
C_{NO_2}					1	0.658	--	--					1	0.509	NA	--
C_{NO_3}						1	0.626	0.622						1	NA	0.364
C_{FC}							1	--								NA
EC								1								1
T8 36th Storm Sewer at Denver									T14 Cache la Poudre River near Greeley							
q	1	--	--	--	-0.330	-0.525	--	--	1	-0.778	--	---	--	--	NA	-0.42*
C_{TDS}		1	0.896	--	--	0.655	0.584	0.945		1	NA	NA	NA	NA	NA	0.943
C_{ON}			1	---	--	0.725	--	--			1	--	0.923	--	NA	--
C_{NH_3}				1	0.725	--	--	--				1	--	--	NA	--
C_{NO_2}					1	--	---	--					1	--	NA	--
C_{NO_3}						1	0.623	--						1	NA	--
C_{FC}							1	0.598							NA	NA
EC								1								1

Notes: -- - Not significant
*- Calculated from continuous samples

TABLE A-7. Cross Correlation Coefficients between Flow and Water Quality Constituent in the Wasteload Effluents Along the Study Segment of the South Platte River

Variables	q	C_{NH_3}	C_{NO_2}	C_{NO_3}	C_{FC}	q	C_{NH_3}	C_{NO_2}	C_{NO_3}	C_{FC}
W1 Littleton/Englewood WWTP						W7 South Adams W&SD				
q	1	-0.441	NA	NA	0.158	1	-0.243	NA	NA	0.147
C_{NH_3}		1	NA	NA	--		1	NA	NA	--
C_{NO_2}			1	NA	NA			1	NA	NA
C_{NO_3}				1	NA				1	NA
C_{FC}					1					1
W5 Metro Denver Reclamation District						W8 Brighton WWTP				
q	1	0.254	0.385	0.144	0.144	1	--	NA	0.714	--
C_{NH_3}		1	0.876	-0.184	0.412		1	NA	--	0.340
C_{NO_2}			1	--	0.463			1	NA	NA
C_{NO_3}				1	-0.484				1	--
C_{FC}					1					1
W6 Public Service Company-Cherokee						W9 Fort Lupton WWTP				
q	1	--	NA	--	NA	1	-0.541	NA	NA	-0.115
C_{NH_3}		1	1	--	NA		1	NA	NA	0.101
C_{NO_2}				NA	NA			1	NA	NA
C_{NO_3}				1	NA				1	NA
C_{FC}					1					1

Note: -- Not significant
NA-Calculations were not made due to inadequate or missing data

TABLE A-8. Cross Correlation Coefficients between Flow and Water Quality Variables of the Monitoring Records at Gauging Stations Along the Study Segment of the South Platte River

Variables	Q	C_{TDS}	C_{ON}	C_{NH_3}	C_{NO_2}	C_{NO_3}	C_{FC}	EC	Q	C_{TDS}	C_{ON}	C_{NH_3}	C_{NO_2}	C_{NO_3}	C_{FC}	EC
G1 South Platte River at Littleton									G5 South Platte River at 64th Ave, at Commerce City							
Q	1	-0.414	--	--	--	--	--	-0.646*	1	NA	NA	NA	NA	NA	NA	-0.520
C_{TDS}		1	-0.281	--	--	--	--	0.746		1	NA	NA	NA	NA	NA	NA
C_{ON}			1	--	--	--	--	--			1	NA	NA	NA	NA	NA
C_{NH_3}				1	0.901	--	--	--				1	NA	NA	NA	NA
C_{NO_2}					1	--	-0.325	--					1	NA	NA	NA
C_{NO_3}						1	0.407	--						1	NA	NA
C_{FC}							1	0.348							1	NA
EC								1								1
G2 South Platte River at Union Ave, at Englewood									G6 South Platte River at Henderson							
Q	1	NA	NA	NA	NA	NA	NA	-0.375	1	-0.623	-0.445	-0.295	-0.412	-0.170	0.391	-0.631
C_{TDS}		1	NA	NA	NA	NA	NA	NA		1	0.520	0.450	0.252	0.389	-0.325	0.985
C_{ON}			1	NA	NA	NA	NA	NA			1	--	--	--	--	0.505
C_{NH_3}				1	NA	NA	NA	NA				1	0.246	-0.186	-0.202	0.569
C_{NO_2}					1	NA	NA	NA					1	0.382	--	0.271
C_{NO_3}						1	NA	NA						1	-0.283	0.322
C_{FC}							1	NA							1	-0.335
EC								1								1
G3 South Platte River at Englewood									G7 South Platte River near Kersey							
Q	1	--	--	-0.889	NA	-0.945	NA	-0.350*	1	-0.720	--	-0.325	-0.590	-0.819	NA	-0.409
C_{TDS}		1	--	--	--	--	NA	--		1	--	--	--	--	NA	0.978
C_{ON}			1	--	--	--	NA	--			1	0.773	0.651	0.442	NA	--
C_{NH_3}				1	-0.933	0.743	NA	--				1	0.585	0.531	NA	0.377
C_{NO_2}					1	0.839	NA	--					1	0.694	NA	0.681
C_{NO_3}						1	NA	--						1	NA	0.900
C_{FC}							1	NA							1	NA
EC								1								1
G4 South Platte River at Denver									G8 South Platte River near Weldona							
Q	1	-0.701	--	--	-0.357	0.467	NA	-0.650	1	-0.584	0.374	0.353	--	--	0.386	-0.647
C_{TDS}		1	0.379	0.433	0.682	NA	NA	0.955		1	--	--	--	--	--	0.922
C_{ON}			1	0.689	--	--	NA	0.644			1	0.663	--	--	--	--
C_{NH_3}				1	0.372	--	NA	0.672				1	--	0.457	--	--
C_{NO_2}					1	0.675	NA	0.624					1	--	--	--
C_{NO_3}						1	NA	0.662						1	--	0.454
C_{FC}							1	NA							1	--
EC								1								1

Notes: - -Not significant
*-Calculate from continuous samples
NA-Calculations were not made due to inadequate or missing data

TABLE A-9. Strength and Percentage of Non-Significance in the Cross Correlation among Continuously Sampled Water Quality Variables Along tl Study Segment of the South Platte River

Variable Groups	Avg. % of Non-Sign. Correlation	Ranges of Significant Correlation Coefficients		Min. % of Non-Sign. Correlation	Months When Minimum Occurred	Max. % of Non-Sign. Correlation	Months When Maximum Occurred
		Max.	Min.				
All	54.6	0.97	0.11	49.1	May-Jun	62.6	Nov-Dec
G vs G	23.0	0.98	0.24	13.3	May-Jun	42.2	Nov-Dec
D vs D	35.0	0.85	0.12	18.8	Sep-Oct	64.4	Jan-Feb
W vs W	48.0	0.91	0.21	45.7	Jan-Feb	51.1	May-Jun
T vs T	45.6	0.76	0.17	31.1	Jul-Aug	66.7	Jan-Feb
G vs D	50.1	0.72	0.11	29.3	May-Jun	79.4	Nov-Dec
G vs W	66.8	0.63	0.23	51.9	May-Jun	82.2	Nov-Dec
G vs T	33.5	0.87	0.18	24.0	Mar-Feb	51.0	Jan-Feb
D vs W	62.9	0.81	0.23	58.9	Jan-Feb	66.5	May-Jun
D vs T	52.7	0.63	0.10	38.2	May-Jun	68.1	Nov-Dec
W vs T	70.0	0.72	0.20	61.1	May-Jun	72.5	Mar-Apr

Notes: G-Variables at gaging stations along the South Platte River
D-Variables at irrigation diversion flows
W-Variables at wasteload effluents
T-Variables at tributary inflows

APPENDIX B:

Empirical Stochastic Modeling Procedures and Results

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Introduction to Appendix B

This appendix summarizes the empirical stochastic model building procedures and results. Because missing values of variables were commonly observed in the river system, an augmentation procedure (filling in the missing data of a short data record) was used before building the empirical stochastic model. Based on the different sampling frequencies and sources of the variables (parameters and state variables) monitored in the watershed, the available data were divided into four categories: Group I, Group II, Group III, and Group IV. Data in Group I were collected by the USGS multiple times each day and were transformed into weekly average values. They include the flow rates at the upstream boundary condition, tributary inflows (part of the parameter set 1), and the state variables Q and C_{TDS} (usually measured as electrical conductivity, EC, and converted to equivalent C_{TDS}) gaging stations along the South Platte River main stem. Group II data, reported by the Colorado Department of Public Health and Environment, includes both the flow rates and water quality concentrations of waste facility effluents (part of the parameter set 1). The data in Group III, gathered by the Colorado Division of Water Resources, were the measured diversion flows along the South Platte River main stem (referred to as part of the parameter set 1). Group IV data also were collected by USGS but on an irregular schedule. These data included various water quality concentrations along the South Platte River (at the upstream boundary and along the main stem) as well as of the tributary inflows (part of parameter set 1).

The variables having the longest available records at a given gauging station were usually Q or C_{TDS}. Values of variables with short records were filled in using regression analysis. First, each of the long and short record variables at a given station was transformed into a normally distributed values and the cross correlation between each transformed pair was calculated before performing linear regression analysis. In the case of short records for Q at a given station, correlation and regression analyses with long records of Q at a nearby station were conducted. The fitted linear coefficients (referred to as a_1 and a_2 in Tables B-1 to B-4) were tested if they were significantly greater than zero. If this was not the case, another base series (series with longer or more complete sample data that were sampled at a nearby site or the series of the other water quality constituent records of the same site) was searched until stronger correlation (significantly different from zero, as defined in Appendix A) was found. Tables B-1 to B-4 list the coefficients of a linear regression equation of the form $y_i = a_1 + a_2 (v_i - v_2)$ that was used to fill in missing values of short record variables. In this equation, y_i is the missing normalized value of the short record series at time i, v_i is the corresponding normalized value of the long record series at that time, and v_2 is the mean of the detrended and normalized values of the long record series computed over all times where short record values were also available (Hirsch 1982, Vogel and Stedinger 1985).

After the missing data for short records were filled in, the possible trend of each series was examined by visually inspecting time series or autocorrelation plots, or calculating the associated statistics of Anderson's correlogram test or the Sign test to determine if the hypothesis of stationarity in the series should be rejected (Salas 1993). If the test results indicated that a statistically significant trend was present, the trend component was removed by differencing of lag one or two, by fitting and removing a multi-regression equation, or by the seasonal decomposition method (Brockwell and Davis 1996, Salas 1980). The residuals of the detrended data series were transformed into normally or symmetrically distributed forms using logarithm or power functions (as summarized in Tables B-5 to B-7). The flow rate data tended to be positively skewed and could be easily transformed using a logarithm. Negatively skewed series were commonly observed for water quality constituent data and were transformed using power functions.

The transformed, standard normally-distributed residuals of the regularly sampled data were fitted with univariate SARMA models as summarized in Tables B-8 to B-10, representing Groups I, II, and III, respectively. In Group I, most of the series were fitted with pure auto-regressive models of order up to $p_i = 1$ and $p'_i = 2$. The exceptions were series sampled from season two (March-April). Due to the complexity of the shapes of the autocorrelation and partial correlation plots, moving average components were needed to simulate the data collected during these two months. More complex modeling was required to fit the data in the Groups II and III, especially for water quality concentrations. The calculated values of π_{i_k} for these groups were around

0.9 since data in these groups were segregated from monthly average or monthly total data (that is, the weekly average values for each month were formed by repeating the same monthly average four times, and π_{i_k} was related to the correlation coefficient of lag one).

The goodness of fit of the CARMA model was evaluated by comparing the generated and historical statistical moments (lag-zero cross correlation coefficient, mean, and standard deviation) for each variable. Due to the inconsistency of the sample size of each random variable predicted, pairwise deletion, casewise deletion and mixwise deletion of missing values were conducted (Switzer et al. 1998). The results are summarized in Tables B-11 and B-12. It was found that the mixwise deletion of missing values, combined with purging 13 series that had small sample sizes or were closely nonstationary in time, was the best method for successfully reproducing the cross correlation coefficients, means, and standard deviations of the historical series.

TABLE B-1. Summary of Statistics and Coefficients Associated with Augmentation Missing Values of Variables in Group I

Short Series (Site-Variable)	Long Series (Site-Variable)	Month	N_1+N_2	N_1	N_2	Correlation Coefficient	a_1	a_2	Variable Efficiency
G1-*Q*	G4-*Q*	Jan-Feb	440	360	80	0.567	4.023	1.763	0.942
		Mar-Apr	440	360	80	0.677	4.707	1.288	0.917
		May-Jun	440	360	80	0.765	6.031	1.066	0.894
		Jul-Aug	440	360	80	0.772	5.908	0.789	0.892
		Sep-Oct	440	360	80	0.700	4.544	1.669	0.911
		Nov-Dec	440	360	80	0.570	4.123	2.318	0.941
G2-*Q*	G3-*Q*	Jan-Feb	64	53	11	0.900	3.591	0.874	0.861
		Mar-Apr	64	51	13	0.944	4.588	0.875	0.819
		May-Jun	64	56	8	0.894	4.738	1.217	0.901
		Jul-Aug	64	54	10	0.960	4.800	1.177	0.856
		Sep-Oct	64	56	8	0.804	3.884	1.669	0.920
		Nov-Dec	64	56	8	0.910	3.500	0.950	0.897
G3-*EC*	G3-*Q*	Jan-Feb	96	59	37	-0.774	5.46E+08	1.22E+08	0.772
		Mar-Apr	96	78	18	-0.815	6.777	0.165	0.876
		May-Jun	96	78	18	-0.866	6.744	0.120	0.860
		Jul-Aug	96	82	14	-0.856	6.860	0.123	0.894
		Sep-Oct	96	72	24	-0.714	1.19E+08	4.08E+07	0.874
		Nov-Dec	96	72	24	-0.626	7.41E+07	3.19E+07	0.904
T6-*q*	G4-Q	Jan-Feb	440	322	118	0.633	2.163	2.098	0.893
		Mar-Apr	440	333	107	0.612	2.498	1.337	0.909
		May-Jun	440	336	104	0.521	3.074	0.893	0.936
		Jul-Aug	440	339	101	0.488	2.669	1.733	0.946
		Sep-Oct	440	333	107	0.464	2.336	1.319	0.948
		Nov-Dec	440	320	120	0.558	1.880	1.428	0.916
T9-C_{TDS}	T9-*q*	Jan-Feb	136	80	56	-0.616	1.64E+06	1.78E+06	0.847
		Mar-Apr	136	89	47	-0.574	5.31E+06	2.43E+06	0.889
		May-Jun	136	82	54	-0.829	4.036	1.358	0.729
		Jul-Aug	136	75	61	-0.655	4.87E+05	3.22E+05	0.811
		Sep-Oct	136	82	54	-0.417	4.245	0.891	0.935
		Nov-Dec	136	81	55	-0.739	5.397	0.354	0.781
T10-*q*	G6-*Q*	Jan-Feb	80	64	16	0.147	0.217	4.323	0.998
		Mar-Apr	80	64	16	0.414	1.113	2.920	0.968
		May-Jun	80	64	16	0.571	4.005	0.495	0.937
		Jul-Aug	80	69	11	0.415	3.484	0.854	0.978
		Sep-Oct	80	68	12	0.451	1.896	4.850	0.971
		Nov-Dec	80	64	16	0.223	0.372	2.246	0.992
T12-*q*	T11-*q*	Oct-Mar	384	48	336	0.653	4.525	1.078	0.638
		Apr-Sep	384	31	353	0.692	3.614	0.561	0.577
T13-*EC*	T13-*q*	Jan-Feb	80	68	12	-0.505	7.539	0.038	0.963
		Mar-Apr	80	64	16	-0.832	1.39E+09	1.71E+08	0.863
		May-Jun	80	64	16	-0.837	3.938	1.276	0.861
		Jul-Aug	80	72	8	-0.859	5.338	0.363	0.927
		Sep-Oct	80	64	16	-0.626	3.35E+07	1.47E+07	0.924
		Nov-Dec	80	47	33	-0.159	3.45E+07	1.80E+07	0.995
T14-*q*	T13-*q*	Jan-Feb	664	624	40	0.743	4.448	1.336	0.967
		Mar-Apr	664	624	40	0.746	4.583	1.002	0.966
		May-Jun	664	628	36	0.776	4.451	1.190	0.967
		Jul-Aug	664	632	32	0.739	3.745	0.842	0.974
		Sep-Oct	660	628	32	0.817	4.343	1.064	0.968
		Nov-Dec	656	624	32	0.795	5.215	0.739	0.969

Notes: N_1+N_2-the length of total series
N_1-the length of short series
N_2-the length of missing values
Correlation coefficient-Pearson correlation coefficient before augmentation for actual data
Variable efficiency-MSE(simulated mean)/MSE(sample mean), where MSE equals mean square error

TABLE B-2. Summary of Statistics and Coefficients Associated with Augmentation of Missing Values of Variables in Group II

Short Series (Site-Variable)	Long Series (Site-Variable)	Month	N_1+N_2	N_1	N_2	Correlation Coefficient	a_1	a_2	Variable Efficiency
W1-q	W8-q	Nov-Dec	88	84	4	-0.253	1.457	4.51E+04	1.000
W1-C_{NH_3}	W8-C_{NH_3}	Nov-Dec	88	84	4	-0.626	1.828	6.88E+03	0.983
W1-C_{FC}	W8-C_{FC}	Nov-Dec	88	84	4	0.607	3.264	1.45E+03	0.984
W2-q	W6-q	Jan-Dec	324	308	16	0.101	1.000	0.234	0.168
W2-C_{NH_3}	W11-C_{NH_3}	Jan-Feb	80	24	56	0.533	-1.289	0.281	0.822
		Mar-Apr	80	24	56	-0.415	-0.713	0.764	1.000
		May-Jun	80	24	56	-0.328	-1.460	0.314	0.946
		Jul-Aug	84	28	56	-0.619	-1.471	0.646	0.760
		Sep-Oct	80	24	56	0.752	-1.423	0.758	0.618
		Nov-Dec	80	28	52	-0.707	-1.357	0.574	0.687
W4-q	W6-q	Jan-Dec	324	172	152	0.176	3.607	1.076	0.988
W6-C_{NH_3}	W11-C_{NH_3}	Jan-Feb	72	24	48	0.500	0.300	0.168	0.854
		Mar-Apr	72	24	48	0.370	-0.987	0.275	0.930
		May-Jun	72	24	48	0.189	-1.177	0.291	0.990
		Jul-Aug	68	28	40	0.273	-1.356	0.754	0.971
		Sep-Oct	68	28	40	0.409	-1.285	0.836	0.918
		Nov-Dec	72	32	40	-0.360	0.029	0.053	0.942
W6-C_{NO_3}	W11-C_{NH_3}	Jan-Feb	72	24	48	0.866	2.59E+04	1.64E+04	0.508
		Mar-Apr	72	28	44	0.142	4.231	0.095	0.996
		May-Jun	72	24	48	-0.358	1.755	0.623	0.936
		Jul-Aug	68	28	40	0.104	2.201	0.758	1.000
		Sep-Oct	68	28	40	-0.104	4.402	0.142	0.999
		Nov-Dec	72	32	40	0.265	2.974	0.264	1.000
W8-C_{NO_3}	W8-C_{NH_3}	Jan-Dec	528	36	492	-0.326	2301.000	919.300	0.921
W9-C_{NH_3}	W9-q	Jan-Dec	324	4	320	-0.373	1.238	3.70E+07	0.998
W10-q	W8-q	Jan-Feb	88	76	12	0.331	-1.449	1.946	1.000
		Mar-Apr	88	80	8	-0.356	-1.266	21.310	0.989
		May-Jun	88	64	24	-0.453	0.103	0.079	0.947
		Jul-Aug	88	60	28	0.348	-1.401	0.360	0.966
		Sep-Oct	88	72	16	0.101	-0.844	0.171	0.999
		Nov-Dec	88	80	8	-0.567	0.043	0.161	0.972
W10-C_{FC}	W8-C_{FC}	Jan-Feb	88	76	12	0.296	6.512	0.749	0.990
		Mar-Apr	88	80	8	-0.253	5.525	0.605	0.995
		May-Jun	88	64	24	0.190	4.939	1.231	0.999
		Jul-Aug	88	60	28	-0.173	5.317	0.917	0.994
		Sep-Oct	88	72	16	0.198	5.253	3.028	0.995
		Nov-Dec	88	80	8	-0.269	5.030	16.510	1.000
W11-q	W6-q	Jan-Feb	88	60	28	0.457	2.59E+02	1.92E+02	0.938
		Mar-Apr	88	60	28	0.704	1.61E+03	1.93E+03	0.845
		May-Jun	88	56	32	0.424	10.070	1.277	0.940
		Jul-Aug	88	68	20	0.541	1.75E+03	6.06E+03	0.936
		Sep-Oct	88	64	24	0.332	12.170	28.560	1.000
		Nov-Dec	88	72	16	-0.231	1.543	0.580	0.992
W11-C_{NH_3}	W6-C_{NH_3}	Jan-Feb	40	24	16	0.477	1.078	1.998	0.922
		Mar-Apr	40	24	16	0.370	-0.925	1.696	0.958
		May-Jun	40	24	16	0.189	-0.668	2.068	0.994
		Jul-Aug	48	28	20	0.273	-0.686	0.941	0.979
		Sep-Oct	48	28	20	0.410	-0.278	1.252	0.941
		Nov-Dec	48	32	16	-0.360	-1.189	24.490	0.965

Notes: N_1+N_2-the length of total series
N_1-the length of short series
N_2-the length of missing values
Correlation coefficient-Pearson correlation coefficient before augmentation for actual data
Variable efficiency-MSE(simulated mean)/MSE(sample mean), where MSE equals mean square error

TABLE B-3. Summary of Statistics and Coefficients Associated with Augmentation of Missing Values of Variables in Group III

Short Series (Site-Variable)	Long Series (Site-Variable)	Month	N_1+N_2	N_1	N_2	Correlation Coefficient	a_1	a_2	Variable Efficiency
D2	G4	Jan-Feb	376	352	24	0.453	2.916	1.595	0.987
		Mar-Apr	376	352	24	0.296	3.096	0.510	0.995
		May-Jun	376	352	24	0.140	2.967	0.442	0.999
		Jul-Aug	376	352	24	0.147	3.865	0.165	0.999
		Sep-Oct	376	352	24	0.253	3.949	0.170	0.996
		Nov-Dec	376	352	24	0.369	4.100	0.324	0.991
D4	G4	Jan-Feb	376	328	48	0.283	0.013	0.015	0.999
		Mar-Apr	376	328	48	0.176	-0.979	1.013	1.000
		May-Jun	376	328	48	-0.349	92.480	36.940	0.985
		Jul-Aug	376	328	48	-0.321	25.670	18.050	0.987
		Sep-Oct	376	328	48	-0.413	1.620	0.301	0.979
		Nov-Dec	376	328	48	0.106	0.013	0.000	1.000
D21	G7	Jan-Feb	376	360	16	0.237	-0.598	12.780	0.998
		Mar-Apr	376	360	16	0.109	-0.277	6.685	1.000
		May-Jun	376	360	16	0.525	3.921	0.766	0.988
		Jul-Aug	376	360	16	0.518	-0.514	3.156	0.989
		Sep-Oct	376	360	16	0.159	2.651	4.022	1.000
		Nov-Dec	376	360	16	0.155	0.133	12.140	1.000
D22	G7	Jan-Feb	224	136	88	-0.142	0.980	7.876	0.994
		Mar-Apr	224	136	88	-0.154	3.062	2.532	1.000
		May-Jun	224	136	88	0.118	3.222	1.073	0.996
		Jul-Aug	224	136	88	0.357	0.510	2.395	0.952
		Sep-Oct	224	136	88	-0.153	0.429	4.025	0.993
		Nov-Dec	224	136	88	-0.165	3.638	2.530	0.992

Notes: N_1+N_2-the length of total series
N_1-the length of short series
N_2-the length of missing values
Correlation coefficient-Pearson correlation coefficient before augmentation for actual data
Variable efficiency-MSE(simulated mean)/MSE(sample mean), where MSE equals mean square error

TABLE B-4. Summary of Statistics and Coefficients Associated with Augmentation of Missing Values of Variables in Group IV

Short Series (Site-Variable)	Long Series (Site-Variable)	N_1+N_2	N_1	N_2	Correlation Coefficient	a_1	a_2	Variable Efficiency
G1-Q	G1-EC	88	70	18	-0.889	5.200	1.80E-09	0.839
G1-C_{TDS}	G1-EC	88	71	17	0.956	7.500	4.10E-11	0.824
G1-C_{ON}	G1-EC	88	47	41	-0.145	-0.052	3.00E-10	1.000
G1-C_{NH_3}	G1-EC	88	47	41	0.152	-1.300	1.80E-10	1.000
G1-C_{NO_2}	G1-EC	88	47	41	0.625	0.013	8.30E-13	0.712
G1-C_{NO_3}	G1-EC	88	47	41	0.893	-1.100	6.40E-10	0.345
G2-EC	G2-Q	68	63	5	-0.730	6.800	0.510	0.961
T1-q	T1-C_{NH_3}	48	41	7	0.931	3.700	5.000	0.874
T1-C_{TDS}	T1-C_{NH_3}	50	10	40	0.108	5.20E+06	1.50E+07	0.999
T1-C_{ON}	T1-q	46	10	36	0.385	0.290	0.810	0.966
T1-C_{NH_3}	T1-q	46	10	36	0.893	-1.300	0.270	0.379
T1-C_{NO_3}	T1-C_{NH_3}	49	10	39	0.663	1.200	0.410	0.705
T1-EC	T1-C_{NH_3}	48	10	38	-0.150	1.80E+08	2.30E+08	0.998
G3-Q	G3-EC	70	57	13	-0.581	4.500	0.000	0.940
G3-C_{TDS}	G3-EC	72	9	63	0.979	4.70E+06	0.150	0.146
G3-C_{ON}	G3-EC	71	9	62	0.391	0.640	0.000	0.936
G3-C_{NH_3}	G3-EC	72	9	63	0.553	0.035	0.000	0.824
G3-C_{NO_3}	G3-EC	72	9	63	0.306	2.900	0.000	0.975
T4-q	T4-C_{NH_3}+C_{ON}	59	33	26	0.187	0.400	1.600	1.000
T4-C_{TDS}	T4-C_{NH_3}+C_{ON}	59	36	23	-0.107	0.390	0.810	0.999
T4-C_{ON}	T4-C_{NH_3}+C_{ON}	59	34	25	0.918	1.100	1.600	0.645
T4-C_{NH_3}	T4-C_{NH_3}+C_{ON}	59	34	25	0.459	-0.250	1.500	0.920
T4-C_{NO_2}	T4-C_{NH_3}+C_{ON}	59	26	33	0.311	-0.790	1.500	0.962
T4-C_{NO_3}	T4-C_{NH_3}+C_{ON}	59	36	23	-0.152	1.900	1.100	0.996
T4-C_{FC}	T4-C_{NH_3}+C_{ON}	59	11	48	0.487	7.500	1.800	0.862
T4-EC	T4-C_{NH_3}+C_{ON}	59	43	16	0.339	5.400	1.600	0.974
T5-C_{FC}	T5-C_{NH_3}+C_{ON}	21	17	4	0.397	5.200	2.100	0.978
T6-q	T6-EC	192	152	40	-0.699	2.800	19.000	0.899
T6-C_{TDS}	T6-EC	192	40	152	0.948	1.90E+08	1.00E+09	0.291
T6-C_{ON}	T6-EC	192	46	146	-0.213	-0.730	8.500	0.977
T6-C_{NH_3}	T6-EC	192	46	146	-0.486	-1.100	9.700	0.833
T6-C_{NO_2}	T6-EC	192	44	148	-0.209	-1.500	2.500	0.978
T6-C_{NO_3}	T6-EC	192	40	152	0.036	2.600	1.500	1.000
T7-q	T7-EC	18	11	7	-0.105	1.200	17.000	1.000
T7-C_{ON}	T7-EC	18	11	7	0.158	-0.590	17.000	0.998
T7-C_{NH_3}	T7-EC	18	11	7	0.301	-0.070	7.600	0.984
T7-C_{NO_2}	T7-EC	18	11	7	0.360	-1.600	4.700	0.973
T7-C_{NO_3}	T7-EC	18	11	7	0.639	1.100	1.600	0.866
T7-C_{FC}	T7-EC	18	10	8	-0.275	12.000	0.680	0.988
G4-C_{TDS}	G4-Q	101	22	79	-0.879	6.80E+08	1.30E+08	0.405
G4-C_{ON}	G4-Q	101	32	69	-0.496	-0.530	0.430	0.848
G4-C_{NH_3}	G4-Q	101	32	69	-0.320	-0.730	0.830	0.946
G4-C_{NO_2}	G4-Q	101	32	69	-0.597	-1.300	0.220	0.771
G4-C_{NO_3}	G4-Q	101	32	69	-0.810	1.300	0.510	0.560
G4-EC	G4-Q	101	51	50	-0.919	6.600	0.260	0.584
G5-Q	G5-EC	155	124	31	-0.766	3.900	23.000	0.883

Notes: N_1+N_2-the length of total series
N_1-the length of short series
N_2-the length of missing values
Correlation coefficient-Pearson correlation coefficient before augmentation for actual data
Variable efficiency-MSE(simulated mean)/MSE(sample mean), where MSE equals mean square error

TABLE B-4. Summary of Statistics and Coefficients Associated with Augmentation of Missing Values of Variables in Group IV (Cont.)

Short Series (Site-Variable)	Long Series (Site-Variable)	N_1+N_2	N_1	N_2	Correlation Coefficient	a_1	a_2	Variable Efficiency
G8-*q*	G8-*EC*	36	32	4	-0.389	2.300	0.580	0.986
G8-C_{TDS}	G8-*EC*	36	34	2	0.979	3.900	0.920	0.947
G8-C_{ON}	G8-*EC*	36	33	3	0.256	0.850	1.200	0.996
G8-C_{NH_3}	G8-*EC*	36	33	3	0.133	-0.540	1.000	0.999
G8-C_{NO_2}	G8-*EC*	33	33	3	0.480	-1.400	0.370	0.983
G8-C_{NO_3}	G8-*EC*	36	33	3	0.417	-0.470	1.200	0.987
G8-C_{FC}	G8-*EC*	36	19	17	0.731	13.000	0.900	0.761
T9-C_{TDS}	T9-*q*	138	17	86	-0.960	5.400	0.260	0.235
T9-C_{ON}	T9-*q*	138	17	86	-0.122	-1.400	0.110	0.998
T9-C_{NH_3}	T9-*q*	138	17	86	-0.666	-1.400	0.170	0.660
T9-C_{NO_2}	T9-*q*	138	17	86	-0.252	-1.600	0.017	0.974
T9-C_{NO_3}	T9-*q*	138	17	86	-0.807	-1.100	0.310	0.476
T9-*EC*	T9-*q*	138	95	8	-0.865	6.500	0.120	0.942
G6-*Q*	G6-*EC*	288	155	133	-0.791	4.900	5.40E-09	0.712
G6-C_{TDS}	G6-*EC*	288	246	42	0.976	5.20E+08	0.650	0.861
G6-C_{ON}	G6-*EC*	288	74	214	0.238	0.580	2.30E-09	0.966
G6-C_{NH_3}	G6-*EC*	288	110	178	0.582	1.800	2.70E-09	0.795
G6-C_{NO_2}	G6-*EC*	288	89	199	0.244	-0.069	9.90E-10	0.965
G6-C_{NO_3}	G6-*EC*	219	84	135	0.359	1.500	3.70E-09	0.942
G6-C_{FC}	G6-*EC*	288	42	246	-0.523	5.500	4.40E-09	0.782
T11-*q*	T11-*EC*	218	136	82	-0.559	4.500	2.80E-09	0.884
T11-C_{TDS}	T11-*EC*	218	200	18	0.959	1.50E+09	1.300	0.924
T11-C_{ON}	T11-*EC*	218	29	189	0.452	0.002	4.10E-10	0.846
T11-C_{NH_3}	T11-*EC*	218	29	189	0.207	-0.670	1.90E-09	0.980
T11-C_{NO_2}	T11-*EC*	218	29	189	0.460	-1.300	5.10E-10	0.839
T11-C_{NO_3}	T11-*EC*	218	29	189	0.790	440.0000	4.60E-07	0.472
T12-C_{TDS}	T12-*q*	68	12	56	-0.951	7.100	0.310	0.264
T12-C_{NH_3}	T12-*q*	68	60	8	-0.229	-1.000	0.770	0.995
T12-C_{NO_2}	T12-*q*	68	60	8	-0.171	-1.300	0.420	0.998
T12-C_{NO_3}	T12-*q*	68	57	11	-0.284	1.400	0.620	0.989
T12-*EC*	T12-*q*	68	64	4	-0.685	1.30E+10	2.30E+09	0.973
T13-C_{TDS}	T13-*q*	204	61	143	-0.824	1.60E+10	2.30E+09	0.528
T13-C_{ON}	T13-*q*	204	91	113	-0.247	-0.021	0.240	0.971
T13-C_{NH_3}	T13-*q*	204	199	5	0.124	-1.000	0.190	1.000
T13-C_{NO_2}	T13-*q*	204	199	5	-0.165	-1.500	0.064	1.000
T13-C_{NO_3}	T13-*q*	204	147	57	-0.460	0.390	0.280	0.942
T13-*EC*	T13-*q*	204	194	10	-0.837	7.50E+09	1.50E+09	0.966
T14-C_{TDS}	T14-*q*	208	194	14	-0.491	2.507	0.200	0.984
T14-$C_{NO_2}+C_{NO_3}$	T14-*q*	208	150	58	-0.344	4.783	0.829	0.969
T14-*EC*	T14-*q*	208	201	7	-0.434	1.68E+06	378621.5	0.994
G7-*Q*	G7-*EC*	298	194	104	-0.654	6.300	3.00E-09	0.852
G7-C_{TDS}	G7-*EC*	298	241	57	0.943	2.20E+08	0.2600	0.830
G7-C_{ON}	G7-*EC*	298	43	255	0.108	-0.530	1.00E-09	0.997
G7-C_{NH_3}	G7-*EC*	298	43	255	0.493	-0.480	1.50E-09	0.807
G7-C_{NO_2}	G7-*EC*	298	43	255	0.729	-1.300	3.70E-10	0.555
G7-C_{NO_3}	G7-*EC*	298	44	254	0.843	2800.000	2.00E-06	0.401
G8-*Q*	G8-*EC*	254	213	41	-0.735	5.700	1.60E-10	0.913
G8-C_{TDS}	G8-*EC*	254	166	88	0.925	1.700	1.20E-11	0.705
G8-C_{ON}	G8-*EC*	254	33	221	-0.225	-0.570	7.80E-11	0.973
G8-C_{NH_3}	G8-*EC*	254	33	221	-0.158	-1.200	7.70E-11	0.991
G8-C_{NO_2}	G8-*EC*	254	33	221	0.192	-1.500	1.10E-11	0.983
G8-C_{NO_3}	G8-*EC*	254	33	221	0.386	530.000	2.20E-08	0.887
G8-C_{FC}	G8-*EC*	254	28	226	-0.175	4.500	1.70E-10	1.000

Notes: N_1+N_2-the length of total series
N_1-the length of short series
N_2-the length of missing values
Correlation coefficient-Pearson correlation coefficient before augmentation for actual data
Variable efficiency-MSE(simulated mean)/MSE(sample mean), where MSE equals mean square error

TABLE B-5. Summary Statistics, Method of Transformation to Normal or Symmetric Distribution, and Method of Detrending Variables in Group I

Site-Variable	Month	Mean	STD	Min.	Max.	Dt.	c_0	c_1	c_2	c_3	c_4	c_5	Type	Tran. Coe.
G1-*Q*	Jan-Feb	56.25	33.31	11.14	263.60								L	23.45
	Mar-Apr	191.50	405.61	11.57	5513.00								L	3.13
	May-Jun	663.34	816.20	19.71	4303.00								L	-4.52
	Jul-Aug	386.73	354.60	19.29	2661.00								L	98.78
	Sep-Oct	120.48	133.69	7.54	1264.00								L	0.61
	Nov-Dec	84.82	85.21	12.57	908.10								L	3.35
G2-*Q*	Jan-Feb	40.00	23.55	10.26	98.29								L	-1.58
	Mar-Apr	101.14	68.68	12.43	381.00	D(1)							L	18.62
	May-Jun	322.30	406.73	73.86	2161.00								L	751.00
	Jul-Aug	308.76	501.49	42.29	2567.00								L	50.16
	Sep-Oct	64.20	49.31	17.29	290.40								L	-7.58
	Nov-Dec	62.48	46.70	10.29	195.40								L	-0.30
T1-*q*	Jan-Feb	19.30	10.39	2.69	53.00								L	-0.10
	Mar-Apr	34.63	57.89	0.84	681.43								L	-0.01
	May-Jun	128.23	187.20	0.34	1385.71								L	3.11
	Jul-Aug	37.01	54.29	0.51	481.14								L	1.68
	Sep-Oct	23.08	33.30	0.91	379.00								L	3.22
	Nov-Dec	22.05	15.25	2.00	143.86								L	1.59
G3-*Q*	Jan-Feb	82.80	48.72	32.71	303.71								L	-25.70
	Mar-Apr	244.81	301.00	33.86	2104.29								L	-2.09
	May-Jun	830.89	837.80	83.86	3434.29								L	-63.39
	Jul-Aug	510.65	588.64	41.29	3242.86								L	81.74
	Sep-Oct	162.87	226.19	27.57	1326.00								L	7.13
	Nov-Dec	139.95	149.76	32.00	1175.71								L	-15.89
G3-*EC*	Jan-Feb	724.77	126.34	379.50	974.70	SD							E	974.90
	Mar-Apr	583.68	104.37	372.60	865.00								L	534.60
	May-Jun	425.97	89.61	201.10	761.10								E	1192.00
	Jul-Aug	452.03	79.30	226.00	716.70								L	-0.81
	Sep-Oct	638.90	141.01	45.00	892.00								E	1784.00
	Nov-Dec	692.80	146.63	254.70	944.30								E	52.06
T2-*q*	Jan-Feb													
	Mar-Apr	6.36	5.74	2.20	53.05								L	-1.34
	May-Jun	9.15	4.31	2.01	20.29								L	3.77
	Jul-Aug	8.28	3.71	0.10	19.43								L	17.24
	Sep-Oct	6.86	3.45	-1.73	16.70								L	5.72
	Nov-Dec													
T3-*q*	Jan-Feb													
	Mar-Apr	2.86	1.78	-3.57	7.23								L	29.12
	May-Jun	3.52	2.31	0.00	13.50								L	6.92
	Jul-Aug	3.42	1.62	0.34	8.29								E	10.14
	Sep-Oct	3.34	1.61	0.00	7.24								L	29.14
	Nov-Dec													
T6-*q*	Jan-Feb	11.96	15.28	1.34	229.30								L	-0.74
	Mar-Apr	28.69	80.85	2.77	1397.00								L	-1.90
	May-Jun	33.67	37.17	0.96	249.70								L	-0.40
	Jul-Aug	30.23	54.41	1.90	546.00								L	1.08
	Sep-Oct	15.40	14.66	2.61	202.30								L	1.09
	Nov-Dec	10.71	10.47	2.40	103.20								L	-1.43
G4-*Q*	Jan-Feb	117.75	67.32	28.14	598.86								L	25.17
	Mar-Apr	272.02	420.36	19.14	6642.86								L	-0.39
	May-Jun	841.47	934.08	29.00	6614.29								L	24.18
	Jul-Aug	494.08	463.65	27.00	5164.29								L	184.60
	Sep-Oct	222.85	233.56	14.29	2637.00								L	33.99
	Nov-Dec	157.20	115.78	21.57	1410.00								L	21.22
G5-*Q*	Jan-Feb	79.18	89.29	5.16	412.00								L	-3.74
	Mar-Apr	211.59	387.00	5.33	2807.14								L	13.64
	May-Jun	691.21	937.62	6.04	3857.14								L	-1.51
	Jul-Aug	456.27	589.84	20.23	3368.57								L	196.90
	Sep-Oct	131.54	274.20	6.77	1400.29								L	-5.77
	Nov-Dec	86.74	199.93	5.29	1564.29								L	-5.09

Notes: SD-Seasonal decomposition
Dt.-Method of detrending
D(N)-Differencing with lag *N*
MR-Multiple Regression
c_0, c_1, c_2, c_3, c_4, c_5 -MR coefficients in
$y = c_0 + c_1 t + c_2 t^2 + c_3 t^3 + c_4 t^4 + c_5 t^5 + x$
Type-Transformation Type

L-Natural log transform, and the transformation function equals $\log(x-c)$ where c is the transformation coefficient
E-Power of e transform, and the transformation function equals $(x-c)^e$ where c is the transformation coefficient
N-No transformation needed
Tran. Coe.-Transformation Coefficient

TABLE B-5. Summary Statistics, Method of Transformation to Normal or Symmetric Distribution, and Method of Detrending Variables in Group I (Cont.)

Site-Variable	Month	Mean	STD	Min.	Max.	Dr.	c_0	c_1	c_2	c_3	c_4	c_5	Type	Tran. Coe.
T9-*q*	Jan-Feb	42.04	12.04	24.00	115.57								L	-7.19
	Mar-Apr	55.47	26.30	24.57	180.29								L	-17.13
	May-Jun	545.67	394.68	62.43	2084.29								L	237.20
	Jul-Aug	355.08	272.89	95.29	1571.43								L	-51.79
	Sep-Oct	105.99	45.35	48.00	365.14								L	-18.46
	Nov-Dec	54.95	17.45	29.57	146.00								L	-0.37
T9-*EC*	Jan-Feb	294.76	59.77	-23.04	365.60								E	-128.80
	Mar-Apr	298.85	41.11	102.40	380.60								E	761.40
	May-Jun	139.42	58.66	66.47	285.80								L	-44.25
	Jul-Aug	118.66	41.77	-103.10	171.10								E	120.50
	Sep-Oct	190.33	44.73	124.40	508.00								L	-63.42
	Nov-Dec	264.94	36.62	185.80	398.10								E	0.20
G6-*Q*	Jan-Feb	199.71	143.67	17.43	798.43								L	38.41
	Mar-Apr	317.09	482.73	7.43	7308.57								L	17.67
	May-Jun	1029.09	1141.14	54.71	7781.43								L	21.80
	Jul-Aug	563.84	510.07	71.71	4467.14								L	396.50
	Sep-Oct	246.14	240.09	13.09	2010.00								L	68.21
	Nov-Dec	198.16	180.21	12.91	1802.86								L	21.53
T10-*q*	Jan-Feb	1.63	0.92	0.38	5.39								L	0.14
	Mar-Apr	5.97	7.54	0.71	53.68								L	-0.51
	May-Jun	34.52	25.70	-0.23	96.86								L	23.21
	Jul-Aug	33.46	17.49	6.00	91.14								L	13.70
	Sep-Oct	13.72	28.02	1.00	235.60								L	-0.80
	Nov-Dec	2.07	1.50	0.63	10.84								L	0.33
T11-*q*	Jan-Feb	115.35	51.56	23.14	367.14								L	233.50
	Mar-Apr	146.80	173.70	16.29	2818.57								L	40.97
	May-Jun	531.66	652.68	18.71	3688.57								L	4.54
	Jul-Aug	238.11	227.45	31.00	2042.29								L	104.30
	Sep-Oct	150.13	128.67	18.29	2275.14								L	90.98
	Nov-Dec	124.76	58.27	24.43	350.86								L	123.70
T12-*q*	Jan-Feb	78.19	26.70	48.75	158.20								L	-45.77
	Mar-Apr	74.85	112.22	8.02	913.70								L	65.54
	May-Jun	475.61	765.74	11.91	4498.00								L	20.60
	Jul-Aug	205.01	258.73	37.41	1938.00								L	11.47
	Sep-Oct	91.94	51.03	19.10	324.00								L	301.00
	Nov-Dec	88.05	44.26	51.39	377.00								L	-35.26
T14-*q*	Jan-Feb	4.25	0.55	2.71	5.79								E	0.20
	Mar-Apr	4.49	0.67	2.27	7.57								E	6.23
	May-Jun	4.32	1.85	-1.61	8.54								L	8.74
	Jul-Aug	3.59	1.05	-1.61	8.01								L	1.33
	Sep-Oct	4.19	0.71	2.76	6.22								E	0.20
	Nov-Dec	4.99	0.32	3.90	6.07								E	0.20
G7-*Q*	Jan-Feb	662.31	275.33	168.00	2645.7								L	92.45
	Mar-Apr	770.18	871.39	39.00	13447.1								L	254.90
	May-Jun	2170.13	3227.92	42.57	25442.9								L	32.39
	Jul-Aug	596.82	955.48	53.14	10421.4								L	-31.92
	Sep-Oct	572.46	518.01	68.86	6087.0								L	227.20
	Nov-Dec	706.58	356.07	74.43	3458.6								L	1310.00
G8-*Q*	Jan-Feb	544.53	358.86	56.29	1895.7								L	264.10
	Mar-Apr	553.61	608.09	66.14	5427.1								L	-41.25
	May-Jun	1740.42	2743.58	44.14	13942.9								L	-42.79
	Jul-Aug	559.53	919.93	103.00	9111.4								L	-18.55
	Sep-Oct	525.27	504.75	59.00	3554.3								L	60.99
	Nov-Dec	430.56	398.74	63.14	3095.7								L	-19.09

Notes: SD-Seasonal decomposition
Dt.-Method of detrending
D(N)-Differencing with lag *N*
MR-Multiple Regression
c_0, c_1, c_2, c_3, c_4, c_5 -MR coefficients in
$y = c_0+c_1t+c_2t^2+c_3t^3+c_4t^4+c_5t^5+x$
Type-Transformation Type

L-Natural log transform, and the transformation function equals log(x-c) where c is the transformation coefficient
E-Power of e transform, and the transformation function equals $(x-c)^e$ where c is the transformation coefficient
N-No transformation needed
Tran. Coe.-Transformation Coefficient

TABLE B-6. Summary Statistics, Method of Transformation to Normal or Symmetric Distribution, and Method of Detrending Variables in Group II

Site-Variable	Month	Mean	STD	Min.	Max.	Dt.	c_0	c_1	c_2	c_3	c_4	c_5	Type	Tran. Coe.
W1-q	Jan-Feb	22.17	1.74	18.50	26.50								E	-16.99
	Mar-Apr	22.99	2.34	19.40	29.40								E	-17.83
	May-Jun	25.18	2.32	21.80	30.10								L	-15.22
	Jul-Aug	25.26	2.16	22.00	29.00								L	-15.43
	Sep-Oct	24.24	1.85	21.50	27.20								L	3.05
	Nov-Dec	23.30	1.92	20.70	27.70	MR	1.10E+00	-7.37E-02	6.60E-03	-1.93E-04	2.41E-06	-1.08E-08	L	-18.61
W1-C_{NH_3}	Jan-Feb	13.62	10.10	2.00	28.90								L	-1.80
	Mar-Apr	12.46	10.76	0.90	26.70								L	3.30
	May-Jun	11.20	9.93	1.00	27.10								E	0.40
	Jul-Aug	10.17	8.45	1.10	22.50								L	-0.90
	Sep-Oct	9.87	7.75	0.50	20.80								L	8.00
	Nov-Dec	10.19	8.56	1.00	25.40								L	3.70
W1-C_{FC}	Jan-Feb	113.18	87.40	10.00	368.00								L	40.20
	Mar-Apr	171.50	127.65	20.00	531.00								L	31.86
	May-Jun	184.00	146.89	20.00	514.00								L	22.39
	Jul-Aug	261.95	382.31	30.00	1900.00								L	86.45
	Sep-Oct	142.50	102.24	20.00	390.00								L	57.08
	Nov-Dec	114.60	132.56	20.00	606.00								L	-4.18
W2-q	Jan-Feb	0.30	0.10	0.15	0.48								L	0.05
	Mar-Apr	0.23	0.09	0.02	0.39								E	0.59
	May-Jun	0.18	0.08	0.08	0.35								L	0.12
	Jul-Aug	0.19	0.07	0.08	0.36								L	0.23
	Sep-Oct	0.24	0.07	0.11	0.40								L	0.34
	Nov-Dec	0.32	0.14	0.13	0.71								L	0.07
W2-C_{NH_3}	Jan-Feb	0.21	0.16	0.10	0.89								L	0.10
	Mar-Apr	0.47	0.55	0.00	2.14								L	0.20
	May-Jun	0.08	0.11	0.00	0.42								L	0.20
	Jul-Aug	0.09	0.07	0.00	0.29								L	0.29
	Sep-Oct	0.05	0.05	0.00	0.15								L	0.20
	Nov-Dec	0.10	0.12	0.00	0.45	SD							L	0.20
W3-q	Jan-Feb	0.26	0.11	0.09	0.54								L	4.33
	Mar-Apr	0.19	0.05	0.09	0.24								E	-1.43
	May-Jun	0.17	0.05	0.09	0.30								L	0.45
	Jul-Aug	0.21	0.06	0.12	0.33								L	3.70
	Sep-Oct	0.29	0.11	0.12	0.51								L	6.70
	Nov-Dec	0.33	0.11	0.15	0.54								L	6.70
W4-q	Jan-Feb	42.22	9.07	20.90	64.63								L	-3.04
	Mar-Apr	40.79	12.80	4.18	69.84								L	-3.62
	May-Jun	37.68	17.00	5.80	97.29								L	-2.01
	Jul-Aug	43.14	13.21	23.80	96.14								L	-1.16
	Sep-Oct	38.72	10.23	17.54	71.44								L	-2.05
	Nov-Dec	41.90	11.17	4.20	77.94	MR	3.05E+00	-7.97E-04	2.66E-05	-3.22E-07	1.31E-09		L	8.38
W5-q	Jan-Feb	119.80	16.93	79.00	143.00								L	143.20
	Mar-Apr	128.95	19.82	81.00	165.00								E	165.20
	May-Jun	151.17	13.12	129.00	181.80								E	163.20
	Jul-Aug	155.50	9.88	139.00	174.40								L	-109.40
	Sep-Oct	137.53	17.69	88.00	158.30								E	-88.44
	Nov-Dec	114.48	28.71	77.00	180.40								L	-44.63
W5-C_{NH_3}	Jan-Feb	8.83	3.85	5.00	19.80								L	6.53
	Mar-Apr	8.42	3.56	5.00	16.70								L	-2.14
	May-Jun	6.98	2.61	5.20	15.90								L	-5.00
	Jul-Aug	6.70	2.85	4.20	15.80								L	-1.69
	Sep-Oct	7.40	3.74	4.90	19.10								E	0.20
	Nov-Dec	8.24	5.13	4.50	22.00								L	-3.25
W5-C_{NO_3}	Jan-Feb	0.16	0.03	0.10	0.21								E	0.41
	Mar-Apr	0.16	0.05	0.09	0.30								L	0.11
	May-Jun	0.14	0.09	0.05	0.49								L	0.15
	Jul-Aug	0.16	0.13	-0.01	0.57								L	0.15
	Sep-Oct	0.18	0.18	0.02	0.84								L	0.18
	Nov-Dec	0.13	0.05	0.06	0.23								L	0.14

Notes: SD-Seasonal decomposition
Dt.-Method of detrending
D(N)-Differencing with lag N
MR-Multiple Regression
$c_0, c_1, c_2, c_3, c_4, c_5$ -MR coefficients in $y = c_0+c_1 t+c_2 t^2+c_3 t^3+c_4 t^4+c_5 t^5+x$
Type-Transformation Type

L-Natural log transform, and the transformation function equals $\log(x-c)$ where c is the transformation coefficient
E-Power of e transform, and the transformation function equals $(x-c)^e$ where c is the transformation coefficient
N-No transformation needed
Tran. Coe.-Transformation Coefficient

TABLE B-6. Summary Statistics, Method of Transformation to Normal or Symmetric Distribution, and Method of Detrending Variables in Group II (Cont.)

Site-Variable	Month	Mean	STD	Min.	Max.	Dt.	c_0	c_1	c_2	c_3	c_4	c_5	Type	Tran. Coe.
W5-C_{NO_3}	Jan-Feb	4.36	1.39	0.07	5.75								E	1.32
	Mar-Apr	3.59	1.65	0.00	5.39	MR	2.67E+01	-1.09E+01	9.82E-01	-2.58E-02	2.66E-04	-9.45E-07	E	0.20
	May-Jun	3.63	1.20	0.04	4.92								E	0.16
	Jul-Aug	4.06	1.45	0.37	6.00								E	0.63
	Sep-Oct	4.98	1.58	0.67	6.60								E	-2.38
	Nov-Dec	4.78	1.40	0.66	5.93								E	-3.57
W5-C_{FC}	Jan-Feb	138.44	54.31	63.00	244.20								L	52.40
	Mar-Apr	210.51	110.57	52.55	495.00								L	185.20
	May-Jun	335.90	326.64	39.00	1520.00								L	170.30
	Jul-Aug	309.32	196.90	130.00	831.00								L	-114.80
	Sep-Oct	380.34	317.31	160.00	1409.00								L	-111.90
	Nov-Dec	205.95	139.21	51.00	712.00								L	113.80
W6-q	Jan-Feb	2.28	0.55	1.36	3.62								L	-0.54
	Mar-Apr	2.04	0.47	1.28	2.85								L	3.05
	May-Jun	1.88	0.63	0.80	3.10								E	0.20
	Jul-Aug	2.13	0.48	1.37	3.09								L	6.38
	Sep-Oct	1.88	0.38	1.25	2.82								L	-0.29
	Nov-Dec	1.95	0.46	1.20	3.04								L	0.06
W6-C_{NH_3}	Jan-Feb	0.41	0.14	0.10	0.75								E	4.70
	Mar-Apr	0.16	0.11	0.00	0.35								L	0.55
	May-Jun	0.15	0.13	0.00	0.54								L	0.20
	Jul-Aug	0.10	0.09	0.00	0.28								L	0.20
	Sep-Oct	0.10	0.09	0.00	0.27	MR	6.69E+00	-8.92E-01	3.56E-02	-6.31E-04	5.03E-06	-1.46E-08	L	0.20
	Nov-Dec	0.12	0.08	0.00	0.24								E	0.32
W6-C_{NO_3}	Jan-Feb	20.28	6.49	6.29	32.61								E	90.29
	Mar-Apr	17.26	6.34	6.90	27.16								E	54.52
	May-Jun	6.61	7.54	1.09	36.11								L	-0.02
	Jul-Aug	5.41	2.95	1.00	13.35								L	6.37
	Sep-Oct	8.92	4.56	0.50	18.14								E	0.20
	Nov-Dec	12.95	3.90	5.95	22.55								L	3.16
W7-q	Jan-Feb	2.59	0.21	2.19	2.84								E	-1.99
	Mar-Apr	2.56	0.19	2.11	2.82								E	-1.91
	May-Jun	2.66	0.24	2.21	3.09								E	-1.01
	Jul-Aug	2.89	0.37	2.11	3.36								E	-1.23
	Sep-Oct	2.79	0.28	2.34	3.28								E	3.48
	Nov-Dec	2.67	0.22	2.22	2.96								E	-1.69
W7-C_{NH_3}	Jan-Feb	9.99	3.83	4.50	16.00								E	0.20
	Mar-Apr	8.86	4.30	3.50	20.00								L	2.58
	May-Jun	7.10	3.13	2.20	14.00								L	6.10
	Jul-Aug	5.82	2.41	2.30	11.00	MR	3.41E+00	-1.47E-02	1.67E-03	-5.87E-05	7.83E-07	-3.57E-09	L	22.20
	Sep-Oct	5.54	2.56	1.80	10.00								E	0.20
	Nov-Dec	7.47	3.80	1.70	15.00								L	15.20
W7-C_{FC}	Jan-Feb	61.26	75.61	1.00	298.00	MR	4.21E+00	-1.31E-01	1.93E-02	-7.25E-04	9.89E-06	-4.57E-08	L	2.65
	Mar-Apr	51.55	88.34	1.00	347.00								L	1.39
	May-Jun	80.14	83.34	1.00	334.00								L	13.20
	Jul-Aug	131.86	211.86	1.00	796.00								L	173.20
	Sep-Oct	60.23	77.15	1.00	356.00								L	7.40
	Nov-Dec	45.05	57.27	1.00	227.00								L	1.25
W8-q	Jan-Feb	1.58	0.16	1.31	1.87								L	2.07
	Mar-Apr	1.69	0.20	1.35	2.07								L	2.27
	May-Jun	1.80	0.16	1.51	2.11								L	-1.09
	Jul-Aug	1.90	0.21	1.67	2.46								L	-1.47
	Sep-Oct	1.79	0.20	1.50	2.33								L	-1.18
	Nov-Dec	1.61	0.15	1.35	1.90								L	-0.74
W8-C_{NH_3}	Jan-Feb	4.03	3.31	0.35	14.40								L	2.26
	Mar-Apr	5.17	5.20	0.21	18.82								L	0.66
	May-Jun	4.98	4.80	0.45	17.80								L	0.32
	Jul-Aug	2.28	2.25	0.40	9.14								L	-0.20
	Sep-Oct	2.18	1.94	0.17	8.26								L	0.23
	Nov-Dec	3.08	2.66	0.53	11.67								L	0.13
W8-C_{NO_3}	Jan-Feb	8.88	2.61	2.37	12.46								E	1.88
	Mar-Apr	8.53	3.71	-0.84	12.93								E	6.86
	May-Jun	8.61	3.09	3.52	12.83								E	4.85
	Jul-Aug	6.40	2.57	2.37	10.98								L	22.16
	Sep-Oct	7.29	2.97	-3.13	11.43								L	45.92
	Nov-Dec	8.44	2.11	4.19	12.08								E	8.21

Notes: SD-Seasonal decomposition
Dt -Method of detrending
D(N)-Differencing with lag N
MR-Multiple Regression
$c_0, c_1, c_2, c_3, c_4, c_5$ -MR coefficients in
$y = c_0+c_1t+c_2t^2+c_3t^3+c_4t^4+c_5t^5+x$
Type-Transformation Type

L-Natural log transform, and the transformation function equals $\log(x-c)$ where c is the transformation coefficient
E-Power of e transform, and the transformation function equals $(x-c)^e$ where c is the transformation coefficient
N-No transformation needed
Tran. Coe.-Transformation Coefficient

TABLE B-6. Summary Statistics, Method of Transformation to Normal or Symmetric Distribution, and Method of Detrending Variables in Group II (Cont. 1)

Site-Variable	Month	Mean	STD	Min.	Max.	Dt.	c_0	c_1	c_2	c_3	c_4	c_5	Type	Tran. Coe.
W8-C_{FC}	Jan-Feb	67.39	96.94	1.72	440.40								L	12.19
	Mar-Apr	69.40	71.32	4.56	347.93								L	55.96
	May-Jun	232.00	393.41	9.32	1628.80								L	8.23
	Jul-Aug	127.73	142.78	9.42	578.36								L	-3.53
	Sep-Oct	145.80	153.39	4.96	639.00								L	27.55
	Nov-Dec	119.04	148.00	7.08	572.50								L	29.45
W9-q	Jan-Feb	0.80	0.32	0.21	1.64								L	1.38
	Mar-Apr	0.88	0.23	0.43	1.41								L	1.61
	May-Jun	0.98	0.24	0.68	1.57								L	-0.48
	Jul-Aug	1.03	0.35	0.29	1.65								E	3.50
	Sep-Oct	0.86	0.35	0.18	1.52								E	4.76
	Nov-Dec	0.85	0.31	0.14	1.64								L	2.66
W9-C_{NH_3}	Jan-Feb	6.49	6.21	0.00	16.70								L	0.09
	Mar-Apr	3.25	3.69	0.26	14.10	MR	1.51E+00	-7.36E-02	1.16E-02	-4.60E-04	6.33E-06	-2.90E-08	L	-0.06
	May-Jun	2.03	1.90	0.11	6.45								L	0.30
	Jul-Aug	1.60	1.92	0.11	7.20								L	0.09
	Sep-Oct	2.12	3.23	0.08	13.00								L	0.53
	Nov-Dec	3.96	4.50	0.06	14.80								L	0.23
W9-C_{FC}	Jan-Feb	318.86	316.77	1.40	1264.00								L	206.60
	Mar-Apr	455.86	795.31	12.30	3981.00								L	349.00
	May-Jun	512.62	664.89	16.78	2875.00	SD							L	48.22
	Jul-Aug	408.64	342.94	2.26	1223.90								L	189.50
	Sep-Oct	941.98	1786.18	22.90	8511.00								L	185.00
	Nov-Dec	634.57	1663.20	15.30	8136.00								L	33.86
W10-q	Jan-Feb	0.13	0.02	0.10	0.18								L	0.10
	Mar-Apr	0.15	0.17	0.06	0.93								L	0.14
	May-Jun	0.09	0.03	0.05	0.14								E	0.20
	Jul-Aug	0.10	0.04	0.04	0.16								E	0.20
	Sep-Oct	0.09	0.03	0.04	0.14								E	0.20
	Nov-Dec	0.11	0.03	0.06	0.17								E	0.20
W10-C_{FC}	Jan-Feb	1049.48	1249.99	9.00	5000.00								L	69.61
	Mar-Apr	247.86	238.14	10.00	1100.00								E	900.20
	May-Jun	409.01	644.03	1.00	2000.00								L	8.61
	Jul-Aug	589.03	1295.93	7.50	6007.52								L	49.16
	Sep-Oct	482.97	616.21	2.00	2000.00								L	9.93
	Nov-Dec	519.13	750.19	0.00	3000.00								L	23.96
W11-q	Jan-Feb	1.94	0.62	0.87	3.02								E	0.20
	Mar-Apr	2.23	0.59	1.06	3.14								E	3.34
	May-Jun	2.04	0.54	1.10	3.02								E	0.20
	Jul-Aug	2.05	0.60	0.81	3.36								E	6.91
	Sep-Oct	2.04	0.94	-0.81	3.32								E	13.47
	Nov-Dec	1.65	0.65	0.53	2.81								L	1.34
W11-C_{NH_3}	Jan-Feb	0.82	1.10	0.05	5.00								L	0.15
	Mar-Apr	0.41	0.34	0.00	1.00								L	0.45
	May-Jun	0.32	0.23	-0.00	0.77								L	0.24
	Jul-Aug	0.59	0.55	0.00	2.40								L	1.06
	Sep-Oct	1.66	1.96	0.23	7.00								L	-0.03
	Nov-Dec	3.31	3.15	0.03	12.00	MR	2.43E+00	-5.07E-02	9.01E-04	-7.67E-06			L	0.92
W12-q	Jan-Feb	0.56	0.33	0.23	1.62								L	38.74
	Mar-Apr	0.49	0.24	0.13	1.24								L	39.20
	May-Jun	0.57	0.35	0.22	1.84								L	-5.91
	Jul-Aug	0.44	0.19	0.07	0.79								L	148.20
	Sep-Oct	0.39	0.19	0.03	0.71								E	33.40
	Nov-Dec	0.43	0.18	0.04	0.75								E	70.20
W13-q	Jan-Feb	0.16	0.11	0.03	0.35								L	-1.65
	Mar-Apr	0.21	0.15	0.03	0.43								E	2.51
	May-Jun	0.19	0.15	0.03	0.50								L	-1.94
	Jul-Aug	0.18	0.14	0.03	0.44								L	-2.20
	Sep-Oct	0.15	0.11	0.02	0.33								L	-0.96
	Nov-Dec	0.13	0.11	0.02	0.33								L	-1.32
W14-q	Jan-Feb	0.13	0.03	0.08	0.21								L	-0.22
	Mar-Apr	0.10	0.03	0.05	0.16								L	11.20
	May-Jun	0.09	0.03	0.06	0.16								L	-3.09
	Jul-Aug	0.14	0.05	0.07	0.26								L	-1.75
	Sep-Oct	0.14	0.03	0.08	0.20								L	27.78
	Nov-Dec	0.12	0.03	0.08	0.20								L	8.88

Notes: SD-Seasonal decomposition
Dt.-Method of detrending
D(N)-Differencing with lag N
MR-Multiple Regression
c_0, c_1, c_2, c_3, c_4, c_5 -MR coefficients in
$y = c_0+c_1 t+c_2 t^2+c_3 t^3+c_4 t^4+c_5 t^5+x$
Type-Transformation Type

L-Natural log transform, and the transformation function equals log(x-c) where c is the transformation coefficient
E-Power of e transform, and the transformation function equals $(x-c)^e$ where c is the transformation coefficient
N-No transformation needed
Tran. Coe.-Transformation Coefficient

TABLE B-7. Summary Statistics, Method of Transformation to Normal or Symmetric Distribution, and Method of Detrending Variables in Group III

Site-Variable	Month	Mean	STD	Min.	Max.	Dt.	c_0	c_1	c_2	c_3	c_4	c_5	C_5	Type	Tran. Coe.
D1-*q*	Jan-Feb	6.34	1.45	0.46	9.45									E	2.16
	Mar-Apr	7.85	2.88	0.00	18.37									E	58.01
	May-Jun	14.99	5.36	3.47	27.07									E	108.50
	Jul-Aug	18.07	4.91	2.90	25.68									E	6.79
	Sep-Oct	11.15	4.10	0.61	20.17									L	80.87
	Nov-Dec	6.43	1.28	1.39	8.30									E	-1.58
D2-*q*	Jan-Feb	13.92	6.50	0.00	36.29									L	38.83
	Mar-Apr	13.15	5.75	0.00	30.00									L	52.34
	May-Jun	9.58	4.45	0.67	21.81									L	10.77
	Jul-Aug	10.46	3.78	2.43	18.65									L	37.50
	Sep-Oct	9.38	4.70	0.00	21.19									L	42.58
	Nov-Dec	12.23	4.48	0.00	26.39									E	169.70
D3-*q*	Jan-Feb	111.46	57.85	0.00	214.20									E	321.50
	Mar-Apr	87.90	85.12	0.00	350.97									L	44.07
	May-Jun	167.24	140.54	2.26	582.48									L	58.10
	Jul-Aug	109.36	107.07	19.61	613.27									L	-11.15
	Sep-Oct	96.78	78.69	1.29	374.04									L	25.98
	Nov-Dec	148.63	97.06	0.00	453.54									E	444.80
D4-*q*	Jan-Feb	NA													
	Mar-Apr	0.41	0.66	0.00	3.14									L	0.20
	May-Jun	2.68	1.07	0.00	4.82									E	2.61
	Jul-Aug	3.00	0.95	0.81	4.49									E	0.06
	Sep-Oct	1.93	1.34	0.00	5.27									L	2.83
	Nov-Dec	NA													
D5-*q*	Jan-Feb	NA													
	Mar-Apr	14.37	20.46	0.00	86.53									L	0.20
	May-Jun	72.47	33.33	4.43	156.54									E	1252.00
	Jul-Aug	97.85	27.19	37.36	161.52									L	323.20
	Sep-Oct	40.08	24.25	0.00	88.47									E	708.00
	Nov-Dec	NA													
D6-*q*	Jan-Feb	NA													
	Mar-Apr	9.96	13.46	0.00	52.88									L	0.20
	May-Jun	43.06	15.92	6.94	82.05									E	656.60
	Jul-Aug	47.52	11.95	24.32	79.43									L	-14.40
	Sep-Oct	26.45	12.06	0.00	46.44									E	11.81
	Nov-Dec	0.53	2.11	0.00	14.00									L	0.20
D7-*q*	Jan-Feb	NA													
	Mar-Apr	4.76	7.57	0.00	30.65									L	0.20
	May-Jun	25.78	9.12	4.39	44.13									E	44.33
	Jul-Aug	31.71	7.90	19.42	50.13									L	-1.83
	Sep-Oct	14.16	7.85	0.00	29.93									E	45.10
	Nov-Dec	NA													
D8-*q*	Jan-Feb	NA													
	Mar-Apr	7.03	10.56	0.00	35.90									L	0.20
	May-Jun	50.92	20.46	4.03	110.83									E	367.30
	Jul-Aug	67.31	14.21	35.45	98.13									L	31.54
	Sep-Oct	27.55	16.47	0.00	51.60									E	38.90
	Nov-Dec	0.42	1.96	0.00	13.10									L	0.20
D9-*q*	Jan-Feb														
	Mar-Apr	7.38	11.71	0.00	48.51									L	0.20
	May-Jun	47.99	20.06	4.77	99.40									E	0.20
	Jul-Aug	68.14	19.91	32.00	120.03									L	-3.29
	Sep-Oct	28.59	16.74	0.00	60.10									E	481.00
	Nov-Dec	0.36	1.62	0.00	10.90									L	0.20
D10-*q*	Jan-Feb	5.50	19.42	0.00	98.68									L	0.20
	Mar-Apr	20.49	28.54	0.00	119.54									L	0.20
	May-Jun	88.37	49.32	0.00	208.00									L	208.20
	Jul-Aug	134.91	51.59	0.00	235.16									E	147.20
	Sep-Oct	64.26	49.55	0.00	182.70									L	68.71
	Nov-Dec	NA													
D11-*q*	Jan-Feb	NA													
	Mar-Apr	1.66	3.39	0.00	15.30									L	0.20
	May-Jun	14.35	6.38	0.00	27.02									E	216.40
	Jul-Aug	21.63	6.37	0.00	42.36									E	44.96
	Sep-Oct	8.71	6.00	0.00	21.53									L	43.27
	Nov-Dec	16.64	39.42	0.00	191.92									L	0.20
D12-*q*	Jan-Feb	NA													
	Mar-Apr	3.11	6.22	0.00	30.80									L	0.20
	May-Jun	29.24	13.18	0.00	59.00									E	928.20
	Jul-Aug	39.45	12.40	0.00	58.71									L	-7.62
	Sep-Oct	13.90	10.28	0.00	36.47									L	18.43
	Nov-Dec	NA													
D13-*q*	Jan-Feb	NA													
	Mar-Apr	4.84	8.13	0.00	31.67									L	0.20
	May-Jun	41.41	22.75	2.90	115.84									L	92.10
	Jul-Aug	64.51	12.91	26.29	114.90									L	89.39
	Sep-Oct	24.96	18.70	0.00	63.73									L	48.00
	Nov-Dec	0.30	1.54	0.00	11.83									L	0.20
D14-*q*	Jan-Feb	NA													
	Mar-Apr	4.06	8.35	0.00	40.93									L	0.20
	May-Jun	52.14	25.59	0.00	118.17									L	472.90
	Jul-Aug	79.79	27.88	0.32	108.26									E	-38.51
	Sep-Oct	25.23	23.76	0.00	96.00									L	9.20
	Nov-Dec	0.40	2.77	0.00	25.70									L	0.20

Notes: SD-Seasonal decomposition
Dt.-Method of detrending
D(N)-Differencing with lag N
MR-Multiple Regression
c_0, c_1, c_2, c_3, c_4, c_5 -MR coefficients in
$y = c_0+c_1t+c_2t^2+c_3t^3+c_4t^4+c_5t^5+x$
Type-Transformation Type

L-Natural log transform, and the transformation function equals $\log(x-c)$ where c is the transformation coefficient
E-Power of e transform, and the transformation function equals $(x-c)^e$ where c is the transformation coefficient
N-No transformation needed
Tran. Coe.-Transformation Coefficient

TABLE B-7. Summary Statistics, Method of Transformation to Normal or Symmetric Distribution, and Method of Detrending Variables in Group III (Cont.)

Site-Variable	Month	Mean	STD	Min.	Max.	Dt.	c_0	c_1	c_2	c_3	c_4	c_5	Type	Tran. Coe.
D15-*q*	Jan-Feb	NA												
	Mar-Apr	0.94	2.10	0.00	9.58								L	0.20
	May-Jun	5.92	3.92	0.00	16.58								L	6.42
	Jul-Aug	8.80	3.95	1.23	17.97								L	36.14
	Sep-Oct	5.19	4.21	0.00	17.70								L	9.05
	Nov-Dec	NA												
D16-*q*	Jan-Feb	NA												
	Mar-Apr	9.56	15.97	0.00	69.97								L	0.20
	May-Jun	71.43	24.53	0.00	125.67								E	502.90
	Jul-Aug	108.59	16.50	59.19	135.61								E	-14.94
	Sep-Oct	47.39	30.71	0.00	101.53								E	0.20
	Nov-Dec	NA												
D17-*q*	Jan-Feb													
	Mar-Apr	1.76	3.89	0 00	20.30								L	0.20
	May-Jun	18.95	10.80	0.00	45.87								L	91.93
	Jul-Aug	36.60	9 53	15.16	58.39								E	0.20
	Sep-Oct	12.05	9.46	0.00	40.13								L	20.27
	Nov-Dec													
D18-*q*	Jan-Feb													
	Mar-Apr	15.14	24.37	0.00	89.63								L	0.20
	May-Jun	89.13	41.13	4.84	178.17								L	712.90
	Jul-Aug	162.91	46.00	45.61	250.91								E	376.60
	Sep-Oct	52 58	33.13	0 00	120.60								L	241.40
	Nov-Dec													
D19-*q*	Jan-Feb													
	Mar-Apr	0.96	2.47	0.00	11.40								L	0.20
	May-Jun	11.84	4.93	0.00	18.87								E	7.28
	Jul-Aug	18 52	2.55	7 00	23.39								E	-3 12
	Sep-Oct	8.79	5 71	0.00	21.08								L	42.35
	Nov-Dec													
D20-*q*	Jan-Feb													
	Mar-Apr	0 62	1.85	0.00	10.23								L	0.20
	May-Jun	9.09	5.92	0.00	21.70								E	0.20
	Jul-Aug	17.28	4.56	0.00	24.55								E	49.30
	Sep-Oct	5.14	5.01	0.00	18.00								L	2.45
	Nov-Dec													
D21-*q*	Jan-Feb	179.13	89.59	60.16	377.26								L	17.25
	Mar-Apr	171.82	88.25	41.40	461.59								L	560.10
	May-Jun	95.22	105.14	0.00	401.01								L	19.00
	Jul-Aug	25.19	44.04	0.00	204.45								L	0.20
	Sep-Oct	69.94	106.64	0.00	1286.00								L	0.20
	Nov-Dec	52 57	103.99	0 00	402.67								L	0.2
D22-*q*	Jan-Feb	42.88	106.48	0.00	1082.00								L	0.2
	Mar-Apr	68.29	211.71	0 00	2861.00								L	3.26
	May-Jun	51.34	65 33	0.00	301.80								L	9.18
	Jul-Aug	17.93	53.41	0.00	626.00								L	0.20
	Sep-Oct	71.96	341.53	0.00	3446.00								L	0.20
	Nov-Dec	113.77	334.48	0.00	3980.00								L	10.58
D23-*q*	Jan-Feb	0.00	0.00	0.00	0.00								L	0.2
	Mar-Apr	1.73	4.29	0.00	18.80								L	0.20
	May-Jun	12.89	7 61	0 00	24.80								E	18.80
	Jul-Aug	16.33	5 04	0.00	25.61								E	3.40
	Sep-Oct	8.41	7.58	0.00	22.00								L	11.20
	Nov-Dec													
D24-*q*	Jan-Feb	9.68	17.53	0.00	51.57								E	0.2
	Mar-Apr	32 47	49 54	0.00	184 54								L	0.20
	May-Jun	115.73	67.54	0 00	297.70								L	93.23
	Jul-Aug	136.91	57 55	52.97	348.07								L	65.82
	Sep-Oct	88.67	70 81	0.00	313.47								L	49.87
	Nov-Dec	0.76	4.20	0.00	28.97								L	0.2
D25-*q*	Jan-Feb	0.37	0.98	0.00	4.08								L	0.2
	Mar-Apr	2.91	4.33	0.00	19.94								L	0.68
	May-Jun	4.89	2.57	0.00	11.38								L	18.62
	Jul-Aug	2.88	2.03	0.13	9.00								E	0 20
	Sep-Oct	6.07	4.32	0.00	16.80								L	6.50
	Nov-Dec													
D26-*q*	Jan-Feb	45.35	56.01	0.00	232.75								E	-17.22
	Mar-Apr	72 59	54.90	10.27	202.52								L	23.18
	May-Jun	29.55	31.32	0.00	113.03								L	10.22
	Jul-Aug	3.86	6.48	0.00	19.00								L	0.20
	Sep-Oct	15.00	29.67	0.00	115.90								L	0.20
	Nov-Dec	115.95	78.69	0.00	265.81								L	266
D27-*q*	Jan-Feb													
	Mar-Apr	17.08	27.47	0.00	98.73								L	0.20
	May-Jun	80.67	33.79	0.00	157.55								E	315 30
	Jul-Aug	125.98	32.92	22.10	167 81								E	-37.65
	Sep-Oct	58.15	34.19	0.00	148.60								L	148.80
	Nov-Dec	0.62	2.61	0.00	15.67								L	0.2
D28-*q*	Jan-Feb	40.72	29.15	0.00	106.00								L	424.2
	Mar-Apr	22.90	30.19	0.00	96.57								L	0.20
	May-Jun	91.08	51.97	0.00	215.34								L	430.90
	Jul-Aug	166.15	54.29	0.00	299.11								E	0.20
	Sep-Oct	76.78	53.02	0.00	212.50								L	319.00
	Nov-Dec	59.69	23.52	0.00	120.17								L	191

Notes: SD-Seasonal decomposition
Dt.-Method of detrending
D(N)-Differencing with lag N
MR-Multiple Regression
c_0, c_1, c_2, c_3, c_4, c_5 -MR coefficients in
$y = c_0+c_1 t+c_2 t^2+c_3 t^3+c_4 t^4+c_5 t^5+x$
Type-Transformation Type

L-Natural log transform, and the transformation function equals $\log(x-c)$ where c is the transformation coefficient
E-Power of e transform, and the transformation function equals $(x-c)^e$ where c is the transformation coefficient
N-No transformation needed
Tran. Coe.-Transformation Coefficient

TABLE B-8. Summary of Coefficients for Fitted Univariate SARMA Models for the Variables in Group I

Site-Variable	Month	π_1	π_2	π_3	Π_1	Π_2	Π_3	θ_1	θ_2	θ_3	Θ_1	Θ_2	σ_5^2
G1-*Q*	Jan-Feb	0.829											0.314
	Mar-Apr	0.705			-0.037	0.314							0.450
	May-Jun	0.773											0.403
	Jul-Aug	0.723											0.478
	Sep-Oct	0.712											0.495
	Nov-Dec	0.710											0.496
G2-*Q*	Jan-Feb	0.679											0.530
	Mar-Apr				0.001	0.483		0.479	0.520				0.731
	May-Jun	0.412											0.830
	Jul-Aug	0.564											0.682
	Sep-Oct	0.535											0.712
	Nov-Dec	0.443						-0.312					0.595
T1-*q*	Jan-Feb	0.861											0.258
	Mar-Apr	0.760											0.422
	May-Jun	0.837											0.299
	Jul-Aug	0.728											0.471
	Sep-Oct	0.784											0.385
	Nov-Dec	0.823											0.321
G3-*Q*	Jan-Feb	0.759											0.425
	Mar-Apr	0.552			-0.059	0.457							0.529
	May-Jun	0.745											0.449
	Jul-Aug	0.670											0.565
	Sep-Oct	0.677											0.548
	Nov-Dec	0.720											0.479
G3-*EC*	Jan-Feb	0.988											0.652
	Mar-Apr	0.574			-0.054	0.426							0.605
	May-Jun	0.644											0.585
	Jul-Aug	0.401											0.838
	Sep-Oct	0.480											0.776
	Nov-Dec	0.510											0.752
T2-*q*	Jan-Feb	NA											
	Mar-Apr	0.635			-0.020	0.260							0.539
	May-Jun	0.492	0.286										0.480
	Jul-Aug	0.685											0.530
	Sep-Oct	0.735			-0.297								0.514
	Nov-Dec	NA											
T3-*q*	Jan-Feb	NA											
	Mar-Apr	0.607											0.636
	May-Jun	0.725											0.470
	Jul-Aug	0.575											0.674
	Sep-Oct	0.687											0.530
	Nov-Dec	NA											
T6-*q*	Jan-Feb	0.638			0.118	0.158							0.492
	Mar-Apr	0.650			0.062	0.159							0.497
	May-Jun	0.548	0.148										0.575
	Jul-Aug	0.574											0.671
	Sep-Oct	0.606			0.140	0.163							0.514
	Nov-Dec	0.741			0.068	0.191							0.362
G4-*Q*	Jan-Feb	0.841											0.292
	Mar-Apr	0.683			0.038	0.242							0.472
	May-Jun	0.793											0.371
	Jul-Aug	0.706											0.502
	Sep-Oct	0.751											0.437
	Nov-Dec	0.757											0.427

TABLE B-8. Summary of Coefficients for Fitted Univariate SARMA Models for the Variables in Group I (Cont.)

Site-Variable	Month	π_1	π_2	π_3	Π_1	Π_2	Π_3	θ_1	θ_2	θ_3	Θ_1	Θ_2	σ_ε^2
G5-*Q*	Jan-Feb	0.765											0.422
	Mar-Apr	0.729											0.469
	May-Jun	0.481	0.277										0.525
	Jul-Aug	0.550											0.698
	Sep-Oct	0.511			0.120	0.234							0.700
	Nov-Dec	0.781											0.392
T9-*q*	Jan-Feb	0.783											0.386
	Mar-Apr	0.516			-0.675	0.324					-0.962		0.482
	May-Jun	0.559			-0.423	0.577					-0.956		0.238
	Jul-Aug	0.676			-0.556	0.441					-0.783		0.340
	Sep-Oct	0.658			-0.072	0.581							0.426
	Nov-Dec	0.719			-0.026	0.442							0.414
T9-*EC*	Jan-Feb	0.818											0.328
	Mar-Apr	0.736	-0.211										0.613
	May-Jun	0.758	-0.204		-0.263								0.517
	Jul-Aug	0.643			-0.184								0.587
	Sep-Oct	0.583			-0.184	0.220							0.638
	Nov-Dec	0.674			-0.051	0.272							0.531
G6-*Q*	Jan-Feb	0.565											0.639
	Mar-Apr	0.662			0.963						0.899		0.415
	May-Jun	0.775			0.072			0.117					0.425
	Jul-Aug	0.875											0.234
	Sep-Oct	0.853											0.263
	Nov-Dec	0.710			0.033	0.204							0.413
T10-*q*	Jan-Feb	0.561											0.685
	Mar-Apr	0.498											0.755
	May-Jun	0.374			0.160	0.318							0.781
	Jul-Aug	0.623											0.614
	Sep-Oct				-0.062	0.624							0.643
	Nov-Dec	0.329											0.897
T11-*q*	Jan-Feb	0.852											0.274
	Mar-Apr	0.756			0.021	0.144							0.397
	May-Jun	0.760											0.423
	Jul-Aug	0.673			0.044	0.162							0.487
	Sep-Oct	0.827											0.316
	Nov-Dec	0.912			0.004	-0.180							0.198
T12-*q*	Jan-Feb	0.862											0.248
	Mar-Apr	0.585			-0.204	0.372							0.528
	May-Jun	0.624											0.619
	Jul-Aug	0.503											0.758
	Sep-Oct	0.378			-0.017	0.249							0.793
	Nov-Dec	0.640											0.588
T14-*q*	Jan-Feb	0.899	-0.041		0.061								0.237
	Mar-Apr	0.700			0.048	0.156							0.462
	May-Jun	0.736			-0.093	0.153							0.448
	Jul-Aug	0.519	0.040	0.142									0.614
	Sep-Oct	0.691			-0.008	0.410							0.365
	Nov-Dec	0.869	-0.027										0.285
G7-*Q*	Jan-Feb	0.874											0.237
	Mar-Apr	0.733											0.465
	May-Jun	0.795											0.369
	Jul-Aug	0.661											0.563
	Sep-Oct	0.746			-0.007	0.200							0.401
	Nov-Dec	0.893			-0.069	-0.253							0.262
G8-*Q*	Jan-Feb	0.853											0.274
	Mar-Apr	0.739											0.454
	May-Jun	0.748											0.441
	Jul-Aug	0.592											0.649
	Sep-Oct	0.798											0.368
	Nov-Dec	0.850											0.279

TABLE B-9. Summary of Coefficients for Fitted Univariate SARMA Models for the Variables in Group II

Site-Variable	Month	π_1	π_2	π_3	Π_1	Π_2	Π_3	θ_1	θ_2	θ_3	Θ_1	Θ_2	σ_ε^2
W1-q	Jan-Feb	0.996			-0.353	-0.161	-0.339						0.129
	Mar-Apr	0.970			-0.089	-0.409							0.155
	May-Jun	0.946			-0.159	-0.082	-0.344						0.174
	Jul-Aug	0.973			-0.108	-0.074	-0.288						0.123
	Sep-Oct	0.987			-0.476								0.093
	Nov-Dec	0.697			-0.601								0.419
W1-C_{NH_3}	Jan-Feb	0.917			-0.583								0.320
	Mar-Apr	0.974			-0.508	-0.438	-0.742						0.193
	May-Jun	0.824											0.343
	Jul-Aug	0.974			-0.759	-0.251							0.226
	Sep-Oct	0.940			-0.520								0.217
	Nov-Dec	0.874			-0.401								0.356
W1-C_{FC}	Jan-Feb	0.920			-0.801	-0.663	-0.452						0.289
	Mar-Apr	0.879			-0.469	-0.388	-0.255						0.319
	May-Jun	0.900											0.212
	Jul-Aug	0.896			-0.394	0.058	-0.384						0.216
	Sep-Oct	0.917			-0.583	-0.428	-0.335						0.294
	Nov-Dec	0.923			-0.307								0.212
W2-q	Jan-Feb	0.870			-0.325								0.320
	Mar-Apr	0.913			-0.454	-0.193	-0.424						0.265
	May-Jun	0.904			-0.556								0.274
	Jul-Aug	0.847			-0.571								0.345
	Sep-Oct	0.906			-0.713	-0.618	-0.587						0.253
	Nov-Dec	0.894			-0.240	-0.385							0.280
W2-C_{NH_3}	Jan-Feb	0.917			-0.637	-0.607	-0.718						0.279
	Mar-Apr	0.943			-0.792	-0.627	-0.412						0.274
	May-Jun	0.903			-0.747	-0.331							0.310
	Jul-Aug	0.837			-0.724	-0.511							0.342
	Sep-Oct	0.944			-0.860	-0.409							0.263
	Nov-Dec	0.896			-0.256	-0.389							0.293
W3-q	Jan-Feb	0.698			-0.324								0.496
	Mar-Apr	0.961			-0.611								0.182
	May-Jun	0.933			-0.501								0.260
	Jul-Aug	0.950			-0.535								0.229
	Sep-Oct	0.953			-0.798	-0.425							0.242
	Nov-Dec	0.936			-0.420	-0.247							0.239
W4-q	Jan-Feb	0.941			-1.078	-0.439							0.217
	Mar-Apr	0.897			-0.959	-0.600							0.252
	May-Jun	0.889			-0.615	-0.333	-0.196						0.329
	Jul-Aug	0.900			-0.598	-0.366							0.307
	Sep-Oct	0.857			-0.512	-0.639	-0.282						0.281
	Nov-Dec	0.894			-0.588	-0.293							0.317
W5-q	Jan-Feb	0.924			-0.401								0.257
	Mar-Apr	0.908			-0.257								0.262
	May-Jun	0.866			-0.075	-0.423							0.263
	Jul-Aug	0.889			-0.086	-0.290							0.258
	Sep-Oct	0.959			-0.512	-0.338	-0.297						0.236
	Nov-Dec	0.902											0.196
W5-C_{NH_3}	Jan-Feb	0.916			-0.059	-0.302							0.206
	Mar-Apr	0.948			-0.257	-0.423	-0.308						0.205
	May-Jun	0.958			-0.578	-0.734	-0.453						0.203
	Jul-Aug	0.888			-0.560	-0.472	-0.249						0.318
	Sep-Oct	0.941			-0.736	-0.421	-0.325						0.269
	Nov-Dec	0.835											0.307
W5-C_{NO_2}	Jan-Feb	0.946			-0.588								0.193
	Mar-Apr	0.950			0.122	-0.404	0.429						0.099
	May-Jun	0.933			-0.642	-0.755	-0.537						0.206
	Jul-Aug	0.965			-0.629								0.103
	Sep-Oct	0.930			-0.515	-0.236	-0.623						0.214
	Nov-Dec	0.868			-0.368	-0.307							0.330

TABLE B-9. Summary of Coefficients for Fitted Univariate SARMA Models for the Variables in Group II (Cont.)

Site-Variable	Month	π_1	π_2	π_3	Π_1	Π_2	Π_3	θ_1	θ_2	θ_3	Θ_1	Θ_2	σ_s^2
W5-C_{NO_3}	Jan-Feb	0.866											0.247
	Mar-Apr	0.923											0.138
	May-Jun	0.927			-0.396								0.218
	Jul-Aug	0.927			-0.072	-0.123	-0.613						0.149
	Sep-Oct	0.688											0.534
	Nov-Dec	0.901			-0.269								0.237
W5-C_{FC}	Jan-Feb	0.897			-0.373	-0.132	-0.421						0.275
	Mar-Apr	0.902			-0.463	-0.510							0.298
	May-Jun	0.892			-0.154	-0.589							0.242
	Jul-Aug	0.926			-0.013	-0.702							0.173
	Sep-Oct	0.937			-0.419								0.228
	Nov-Dec	0.955			-0.396	-0.346	-0.478						0.215
W6-q	Jan-Feb	0.969			-0.571	-0.416							0.207
	Mar-Apr	0.940			-0.146	-0.296	-0.236						0.206
	May-Jun	0.966			-0.347	-0.437	-0.334						0.201
	Jul-Aug	0.984			-0.676	-0.170							0.157
	Sep-Oct	0.950			-0.467	-0.554	-0.152						0.231
	Nov-Dec	0.930			-0.436	-0.512							0.247
W6-C_{NH_3}	Jan-Feb	0.929			-0.726								0.237
	Mar-Apr	0.945			-0.757	-0.115							0.233
	May-Jun	0.931			-0.565	-0.564	-0.685						0.232
	Jul-Aug	0.945			-0.539	0.057	0.381						0.172
	Sep-Oct	0.923											0.163
	Nov-Dec	0.925			-0.619	-0.588							0.263
W6-C_{NO_3}	Jan-Feb	0.882											0.260
	Mar-Apr	0.911			-0.753	-0.329							0.298
	May-Jun	0.934			-0.693	-0.351	-0.523						0.215
	Jul-Aug	0.889			-0.611	-0.311	-0.259						0.323
	Sep-Oct	0.865			-0.611								0.316
	Nov-Dec	0.872											0.248
W7-q	Jan-Feb	0.894											0.205
	Mar-Apr	0.937			-0.531	-0.410							0.249
	May-Jun	0.958			-0.551								0.166
	Jul-Aug	0.981			-0.269								0.095
	Sep-Oct	0.968			-0.349	-0.105	-0.311						0.157
	Nov-Dec	0.972			-0.677	-0.301							0.176
W7-C_{NH_3}	Jan-Feb	0.954			-0.268								0.142
	Mar-Apr	0.946			-0.341	-0.237							0.194
	May-Jun	0.962			-0.536								0.145
	Jul-Aug	0.574			-0.543	-0.255							0.486
	Sep-Oct	0.959			-0.204	0.295							0.089
	Nov-Dec	0.949											0.107
W7-C_{FC}	Jan-Feb	0.768											0.418
	Mar-Apr	0.949											0.134
	May-Jun	0.954			-0.574								0.220
	Jul-Aug	0.929			0.087	-0.386							0.171
	Sep-Oct	0.921			-0.383	-0.444							0.262
	Nov-Dec	0.971			-0.385								0.115
W8-q	Jan-Feb	0.922											0.172
	Mar-Apr	0.869											0.245
	May-Jun	0.879											0.227
	Jul-Aug	0.901			-0.128	-0.335							0.246
	Sep-Oct	0.901			-0.544	-0.312	-0.358						0.301
	Nov-Dec	0.910			-0.311	-0.387							0.264
W8-C_{NH_3}	Jan-Feb	0.923			-0.282								0.207
	Mar-Apr	0.963			0.017	-0.498	-0.271						0.130
	May-Jun	0.875			-0.067	-0.615							0.223
	Jul-Aug	0.862			-0.552	-0.435							0.330
	Sep-Oct	0.920			0.050	-0.433							0.183
	Nov-Dec	0.964			-0.694	-0.441							0.199
W8-C_{NO_3}	Jan-Feb	0.882											0.222
	Mar-Apr	0.924			-0.238	-0.549							0.224
	May-Jun	0.875			-0.068	-0.612							0.224
	Jul-Aug	0.934			-0.641	-0.519							0.258
	Sep-Oct	0.920			-0.022	-0.432							0.198
	Nov-Dec	0.959			-0.700	-0.397							0.212

TABLE B-9. Summary of Coefficients for Fitted Univariate SARMA Models for the Variables in Group II (Cont. 1)

Site-Variable	Month	π_1	π_2	π_3	Π_1	Π_2	Π_3	θ_1	θ_2	θ_3	Θ_1	Θ_2	σ_ε^2
W8-C_{FC}	Jan-Feb	0.907			-0.859	-0.374							0.294
	Mar-Apr	0.905			-0.731	-0.620	-0.594						0.269
	May-Jun	0.906			-0.405	-0.454	-0.389						0.273
	Jul-Aug	0.917			-0.157	-0.299							0.225
	Sep-Oct	0.926			-0.289	-0.352							0.254
	Nov-Dec	0.891			-0.328	-0.589							0.255
W9-q	Jan-Feb	0.970			-0.404	-0.436	-0.325						0.181
	Mar-Apr	0.963			-0.312	-0.201	-0.566						0.167
	May-Jun	0.941			-0.297								0.170
	Jul-Aug	0.944			-0.127	-0.285							0.168
	Sep-Oct	0.944			-0.594	-0.457							0.239
	Nov-Dec	0.962			-0.544	-0.439	-0.270						0.213
W9-C_{NH_3}	Jan-Feb	0.938			-0.504	-0.422	-0.877						0.173
	Mar-Apr	0.654			-0.487	-0.409							0.425
	May-Jun	0.982			-0.565								0.113
	Jul-Aug	0.972			-0.174	-0.500							0.144
	Sep-Oct	0.921			-0.347	-0.383							0.253
	Nov-Dec	0.939											0.120
W9-C_{FC}	Jan-Feb	0.912			-0.475	-0.304	-0.341						0.284
	Mar-Apr	0.914			-0.401								0.254
	May-Jun	0.939			-0.899	-0.553							0.251
	Jul-Aug	0.928			-0.460	0.125							0.209
	Sep-Oct	0.903			-0.433	-0.269	-0.501						0.258
	Nov-Dec	0.940			-0.267	-0.154	-0.301						0.210
W10-q	Jan-Feb	0.888			-0.682	-0.704	-0.502						0.260
	Mar-Apr	0.901			-0.738	-0.383							0.305
	May-Jun	0.928			-0.811	-0.430							0.273
	Jul-Aug	0.924			-0.285	-0.596							0.228
	Sep-Oct	0.941			-0.283	-0.443							0.218
	Nov-Dec	0.837			-0.350	-0.119	-0.292						0.322
W10-C_{FC}	Jan-Feb	0.866											0.263
	Mar-Apr	0.976			-0.766						0.707		0.134
	May-Jun	0.880			-0.326	-0.232							0.308
	Jul-Aug	0.902			-0.482	-0.298	-0.434						0.276
	Sep-Oct				-0.468	-0.261							0.298
	Nov-Dec	0.874			-0.560	-0.537	-0.263						0.319
W11-q	Jan-Feb	0.970			-0.458	-0.354							0.198
	Mar-Apr	0.925			-0.434								0.254
	May-Jun	0.974			-0.251	-0.427							0.152
	Jul-Aug	0.947			-0.327	-0.302							0.199
	Sep-Oct	0.953			-0.624	-0.533							0.230
	Nov-Dec	0.944			-0.517	-0.531							0.232
W11-C_{NH_3}	Jan-Feb	0.844			-0.531	-0.435							0.343
	Mar-Apr	0.975			-0.893	-0.233							0.172
	May-Jun	0.958			-0.799	-0.686	-0.568						0.240
	Jul-Aug	0.927			-0.411	-0.442							0.251
	Sep-Oct	0.897			-0.431								0.281
	Nov-Dec	0.954			-0.341								0.161
W12-q	Jan-Feb	0.956			-0.494								0.160
	Mar-Apr	0.963			-0.511								0.158
	May-Jun	0.959			-0.516	-0.338							0.193
	Jul-Aug	0.985			-0.529	-0.434	-0.556						0.139
	Sep-Oct	0.976			-0.348								0.097
	Nov-Dec	0.982			-0.376	-0.339							0.116
W13-q	Jan-Feb	0.917			-0.509	-0.235							0.281
	Mar-Apr	0.914			-0.318								0.232
	May-Jun	0.926			-0.365								0.214
	Jul-Aug	0.951			-0.364	-0.286	-0.433						0.208
	Sep-Oct	0.936			-0.196	-0.018	-0.441						0.187
	Nov-Dec	0.911			-0.292								0.238
W14-q	Jan-Feb	0.909			-0.382	-0.500	-0.591						0.200
	Mar-Apr	0.866			-0.275	-0.490							0.288
	May-Jun	0.925			-0.037	-0.420							0.194
	Jul-Aug	0.925			-0.034	-0.420							0.194
	Sep-Oct	0.886			-0.246	-0.447							0.276
	Nov-Dec	0.927			-0.320	-0.363							0.255

TABLE B-10. Summary of Coefficients for Fitted Univariate SARMA Models for the Variables in Group III

Site-Variable	Month	π_1	π_2	π_3	Π_1	Π_2	Π_3	θ_1	θ_2	θ_3	Θ_1	Θ_2	σ_ε^2
D1-*q*	Jan-Feb	0.976			-0.491	-0.280							0.122
	Mar-Apr	0.954			-0.598	-0.118	-0.345						0.180
	May-Jun	0.960			-0.800	-0.466	-0.454						0.214
	Jul-Aug	0.964			-0.564	-0.406	-0.270						0.203
	Sep-Oct	0.939			-0.628	-0.109	-0.315						0.200
	Nov-Dec	0.974			-0.527	-0.077	-0.185						0.126
D2-*q*	Jan-Feb	0.878			-0.151	0.092	0.331						0.194
	Mar-Apr	0.800			0.529	0.221					0.597		0.271
	May-Jun	0.983			-0.555	-0.261	-0.159						0.111
	Jul-Aug	0.945											0.108
	Sep-Oct	0.928			-0.278	0.048	0.215						0.147
	Nov-Dec	0.869			-0.195	0.205							0.260
D3-*q*	Jan-Feb	0.911			-0.440	-0.419	-0.218						0.283
	Mar-Apr	0.939			-0.754	-0.503	-0.481						0.251
	May-Jun	0.964			-0.560								0.146
	Jul-Aug	0.962			-0.319	-0.234	-0.315						0.170
	Sep-Oct	0.961			-0.361	-0.369							0.169
	Nov-Dec	0.970			-0.802	-0.427	-0.201						0.204
D4-*q*	Jan-Feb												
	Mar-Apr	0.851			-0.579	-0.117	-0.332						0.294
	May-Jun	0.943			-0.437								0.191
	Jul-Aug	0.941			-0.200								0.152
	Sep-Oct	0.972			-0.717	-0.362	-0.315						0.188
	Nov-Dec												
D5-*q*	Jan-Feb												
	Mar-Apr	0.969			-0.752	-0.196	-0.317						0.153
	May-Jun	0.957			-0.833	-0.515	-0.481						0.215
	Jul-Aug	0.957			-0.625	-0.369	-0.296						0.229
	Sep-Oct	0.948			-0.917	-0.445	-0.435						0.162
	Nov-Dec												
D6-*q*	Jan-Feb												
	Mar-Apr	0.944			-0.793	-0.293	-0.360						0.196
	May-Jun	0.958			-0.816	-0.506	-0.406						0.229
	Jul-Aug	0.941			-0.588	-0.286	-0.195						0.252
	Sep-Oct	0.953			-0.894	-0.462	-0.455						0.197
	Nov-Dec	0.914			-0.791	-0.383	-0.220						0.291
D7-*q*	Jan-Feb												
	Mar-Apr	0.945			-0.706	-0.153	-0.339						0.171
	May-Jun	0.966			-0.760	-0.416	-0.486						0.185
	Jul-Aug	0.954			-0.515	-0.159	-0.289						0.200
	Sep-Oct	0.969			-0.879	-0.496	-0.532						0.150
	Nov-Dec												
D8-*q*	Jan-Feb												
	Mar-Apr	0.930			-0.872	-0.348	-0.386						0.166
	May-Jun	0.955			-0.856	-0.532	-0.444						0.226
	Jul-Aug	0.942			-0.684	-0.293	-0.202						0.253
	Sep-Oct	0.974			-0.833	-0.375	-0.488						0.111
	Nov-Dec	0.922			-0.811	-0.502	-0.332						0.291
D9-*q*	Jan-Feb												
	Mar-Apr	0.942			-0.781	-0.258	-0.333						0.199
	May-Jun	0.956			-0.774	-0.449	-0.507						0.201
	Jul-Aug	0.955			-0.521	-0.143	-0.215						0.195
	Sep-Oct	0.943			-0.857	-0.283	-0.318						0.174
	Nov-Dec	0.892			-0.717	-0.465	-0.230						0.317
D10-*q*	Jan-Feb	0.933			-0.269								0.196
	Mar-Apr	0.939			-0.593	-0.204	-0.301						0.241
	May-Jun	0.935			-0.824	-0.533	-0.545						0.218
	Jul-Aug	0.953			-0.485	-0.152	-0.283						0.200
	Sep-Oct	0.966			-0.713	-0.319	-0.230						0.197
	Nov-Dec	0.984			-0.294						0.685		0.215
D11-*q*	Jan-Feb												
	Mar-Apr	0.947			-0.890	-0.275	-0.260						0.182
	May-Jun	0.995			-0.454	-0.186	-0.410				0.808		0.182
	Jul-Aug	0.958			-0.557	-0.411	-0.359						0.226
	Sep-Oct	0.923			-0.939	-0.527	-0.479						0.195
	Nov-Dec												
D12-*q*	Jan-Feb												
	Mar-Apr	0.963			-0.950	-0.354	-0.305						0.153
	May-Jun	0.907			-0.672	-0.348	-0.410						0.272
	Jul-Aug	0.940			-0.614	-0.381	-0.310						0.259
	Sep-Oct	0.943			-0.844	-0.491	-0.500						0.211
	Nov-Dec												
D13-*q*	Jan-Feb												
	Mar-Apr	0.936			-0.965	-0.487	-0.421						0.181
	May-Jun	0.974			-0.820	-0.466	-0.513						0.160
	Jul-Aug	0.922			-0.532	-0.327	-0.263						0.279
	Sep-Oct	0.982			-1.291	-0.837	-0.528				-0.392		0.087
	Nov-Dec	0.940			-0.841	-0.460	-0.328						0.258
D14-*q*	Jan-Feb												
	Mar-Apr	0.950			-0.966	-0.299	-0.253						0.144
	May-Jun	0.931			-0.710	-0.344	-0.494						0.207
	Jul-Aug	0.964			-0.534	-0.294	-0.330						0.193
	Sep-Oct	0.967			-0.920	-0.502	-0.503						0.143
	Nov-Dec	0.934			-0.815	-0.642	-0.480						0.271

TABLE B-10. Summary of Coefficients for Fitted Univariate SARMA Models for the Variables in Group III (Cont.)

Site-Variable	Month	π_1	π_2	π_3	Π_1	Π_2	Π_3	θ_1	θ_2	θ_3	Θ_1	Θ_2	σ_ε^2
D15-*q*	Jan-Feb												
	Mar-Apr	0.948			-0.704	-0.205							0.223
	May-Jun	0.931			-0.635	-0.334	-0.278						0.271
	Jul-Aug	0.962			-0.442	-0.460							0.176
	Sep-Oct	0.965			-0.652	-0.218	-0.320						0.182
	Nov-Dec												
D16-*q*	Jan-Feb												
	Mar-Apr	0.926			-0.927	-0.322	-0.295						0.176
	May-Jun	0.911			-0.801	-0.436	-0.430						0.252
	Jul-Aug	0.950			-0.617	-0.292	-0.182						0.233
	Sep-Oct	0.962			-0.817	-0.341	-0.451						0.137
	Nov-Dec												
D17-*q*	Jan-Feb												
	Mar-Apr	0.904			-0.874	-0.357	-0.261						0.258
	May-Jun	0.922			-0.735	-0.404	-0.470						0.244
	Jul-Aug	0.956			-0.529	-0.279	-0.223						0.211
	Sep-Oct	0.948			-0.625	-0.342	-0.601						0.182
	Nov-Dec												
D18-*q*	Jan-Feb												
	Mar-Apr	0.931			-0.958	-0.198	-0.159						0.136
	May-Jun	0.953			-0.809	-0.525	-0.453						0.235
	Jul-Aug	0.963			-0.659	-0.304	-0.295						0.202
	Sep-Oct	0.939			-0.905	-0.364	-0.393						0.128
	Nov-Dec												
D19-*q*	Jan-Feb												
	Mar-Apr	0.908			-0.840	-0.341	-0.221						0.273
	May-Jun	0.936			-0.784	-0.471	-0.398						0.260
	Jul-Aug	0.989									0.924		0.256
	Sep-Oct	0.956			-0.864	-0.230	-0.299						0.131
	Nov-Dec												
D20-*q*	Jan-Feb												
	Mar-Apr	0.935			-0.876	-0.440	-0.337						0.247
	May-Jun	0.945			-0.641	-0.504	-0.588						0.228
	Jul-Aug	0.957			-0.681	-0.480	-0.414						0.236
	Sep-Oct	0.983			-0.865	-0.451	-0.550						0.092
	Nov-Dec												
D21-*q*	Jan-Feb	0.866			-0.173	-0.659							0.219
	Mar-Apr	0.951			-0.836	-0.392	-0.452						0.207
	May-Jun	0.952			-0.480	-0.140	-0.292						0.204
	Jul-Aug	0.937			-0.566	-0.372	-0.317						0.266
	Sep-Oct	0.917			-0.651	-0.367	-0.208						0.306
	Nov-Dec	0.979			-0.494	-0.108							0.106
D22-*q*	Jan-Feb	0.838											0.300
	Mar-Apr	0.675	0.202										0.275
	May-Jun	0.865			-0.371	0.093	-0.220						0.300
	Jul-Aug	0.741											0.452
	Sep-Oct	0.803			-0.364	0.057	-0.240						0.371
	Nov-Dec	0.919			-0.055	-0.264							0.209
D23-*q*	Jan-Feb												
	Mar-Apr	0.929			-0.707	-0.244	-0.148						0.270
	May-Jun	0.962			-0.535	-0.214	-0.470						0.179
	Jul-Aug	0.970			-0.649	-0.298							0.175
	Sep-Oct	0.964			-0.876	-0.324	-0.263						0.184
	Nov-Dec	0.926			-0.792	-0.416	-0.252						0.281
D24-*q*	Jan-Feb	0.958			-0.761								0.194
	Mar-Apr	0.969			-0.794	-0.269	-0.350						0.157
	May-Jun	0.950			-0.711	-0.314	-0.268						0.235
	Jul-Aug	0.944			-0.626	-0.495	-0.170						0.255
	Sep-Oct	0.964			-0.906	-0.436	-0.457						0.143
	Nov-Dec	0.914			-0.757	-0.538	-0.338						0.294
D25-*q*	Jan-Feb	0.917			-0.694	-0.400	-0.386						0.284
	Mar-Apr	0.933			-0.562								0.245
	May-Jun	0.906			-0.807	-0.464	-0.450						0.301
	Jul-Aug	0.922			-0.654	-0.554							0.264
	Sep-Oct	0.893			-0.800	-0.555	-0.480						0.294
	Nov-Dec												
D26-*q*	Jan-Feb	0.892			-0.329	-0.566							0.271
	Mar-Apr	0.883			-0.824	-0.502	-0.335						0.321
	May-Jun	0.889			-1.476	-1.048	-0.401						0.163
	Jul-Aug	0.931			-0.341	-0.354							0.230
	Sep-Oct	0.946			-0.903	-0.859	-0.590						0.250
	Nov-Dec	0.891			-0.918	-0.579	-0.405						0.292
D27-*q*	Jan-Feb												
	Mar-Apr	0.933			-0.953	-0.376	-0.364						0.124
	May-Jun	0.958			-0.679	-0.301	-0.330						0.213
	Jul-Aug	0.964			-0.550	-0.403	-0.126						0.199
	Sep-Oct	0.971			-0.939	-0.399	-0.354						0.139
	Nov-Dec	0.923			-0.803	-0.625	-0.460						0.269
D28-*q*	Jan-Feb	0.940			-0.602	-0.222	-0.229						0.246
	Mar-Apr	0.975			-0.965	-0.633	-0.516						0.174
	May-Jun	0.958			-0.791	-0.364	-0.307						0.223
	Jul-Aug	0.963			-0.399	-0.243							0.173
	Sep-Oct	0.966			-0.954	-0.279	-0.192						0.149
	Nov-Dec	0.955			-0.109	-0.340	-0.153						0.148

TABLE B-11. Evaluation of the Goodness of Fit of CARMA Models, Associated with Alternative Methods for Deletion of Missing Data (Due to Inconsistency in Number of Observations in Paired Series), by Comparison of Historical and Generated Correlation Coefficients

			No Purging		Purging 13 Series		Purging 19 Series	
Alternative	***L*** Matrix	***Cor₀*** Matrix	No. of Sign.	Percentage	No. of Sign.	Percentage	No. of Sign.	Percentage
1	PWD	PWD	16612	15.465	16612	15.465	19171	17.847
2	PWD	MWD1	21328	19.856	21323	19.851	24551	22.856
3	MWD1	PWD	37491	34.903	6504	6.055	7926	7.379
4	MWD1	MWD1	40125	37.355	7887	7.342	9121	8.491
5	MWD2	PWD	37477	34.890	7441	6.927	7740	7.206
6	MWD2	MWD2	41486	38.622	10520	9.794	9448	8.796
7	CWD	PWD	37330	34.753	16156	15.041	18422	17.150
8	CWD	CWD	58900	54.834	47096	43.844	52141	48.541

Notes: CWD-Casewise deletion of missing data, sample size = 24, data sampled from year 1994 to 1996
MWD1-Mixwise deletion of missing data, sample size = 72, data sampled from year 1988 to 1996
MWD2-Mixwise deletion of missing data, sample size = 64, data sampled from year 1988 to 1995
PWD-Pairwise deletion of missing data, sample size = 24 through 832, data sampled from year 1895 to 1996
L Matrix-the decomposed matrix of correlation matrix C_0 and $C_0 = L^T L$
C_0 Matrix-lag zero correlation matrix calculated from univariate SARMA model residuals
Cor_0 Matrix-historical correlation matrix of series at lag zero before fitting the SARMA model
No. of Sign.-Total number of correlation coefficients which are significant different from the historical coefficients

TABLE B-12. Evaluation of the Goodness of Fit of CARMA Models, Associated with Alternative Methods for Deletion of Missing Data (Due to Inconsistency in Number of Observations in Paired Series), by Comparison of Historical and Generated Means and Standard Deviations

Alternative	*L* Matrix	Mean		Standard Deviation	
		No. of Series Failed	%	No. of Series Failed	%
1	PWD	6	0.013	453	97.629
2	MWD1	4	0.009	454	97.845
3	MWD2	6	0.013	454	97.845
4	CWD	6	0.013	454	97.845
5*	PWD	4	0.009	95	18.849
6*	MWD1	3	0.006	96	19.048
7*	MWD2	5	0.011	96	19.048
8*	CWD	3	0.006	95	18.849
9*	PWD	1	0.002	99	19.643
10*	MWD1	0	0.000	106	21.032
11*	MWD2	0	0.000	103	20.437
12*	CWD	1	0.002	103	20.437

Notes: CWD-Casewise deletion of missing data, sample size = 24, data sampled from year 1994 to 1996
MWD1-Mixwise deletion of missing data, sample size = 72, data sampled from year 1988 to 1996
MWD2-Mixwise deletion of missing data, sample size = 64, data sampled from year 1988 to 1995
PWD-Pairwise deletion of missing data, sample size = 24 through 832, data sampled from year 1895 to 1996
L Matrix-the decomposed matrix of correlation matrix C_0 and $C_0 = L^T L$
C_0 Matrix-lag zero correlation matrix calculated from univariate SARMA model residuals
Cor_0 Matrix-historical correlation matrix of series at lag zero before fitting the SARMA model
No. of Series Failed.-Total number of means or standard deviations which are significant different from the historical coefficients

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Input Parameters for Physically-Based Stochastic River Water Quality Model

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FIG. C-2. Values simulated by the QUAL2E model along the river and generated by the CARMA-GMCS model at gaging locations for (a) *Q*, (b) C_{TDS}, (c) C_{ON}, (d) C_{NH_3} (e) C_{NO_2}, (f) C_{NO_3}, (g) C_N, and (h) C_{FC} during a second week in the early spring season (Week 2, March 1994). See note in Figure C-1 label.

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FIG. C-8. Values simulated by the QUAL2E model along the river, mean values generated by CARMA models at gaging locations, and measured values at gaging stations for (a) Q, (b) C_{TDS}, (c) C_{ON}, (d) C_{NH_3} (e) C_{NO_2}, (f) C_{NO_3}, (g) C_N, and (h) C_{FC} during a week in the validation period (Week 1, May 1998). See note in Figure C-7 label.

FIG. C-9. Values simulated by the QUAL2E model along the river, mean values generated by CARMA models at gaging locations, and measured values at gaging stations for (a) Q, (b) C_{TDS}, (c) C_{ON}, (d) C_{NH_3} (e) C_{NO_2}, (f) C_{NO_3}, (g) C_N, and (h) C_{FC} during a week in the early winter season during the validation period (Week 2, December 1999). See note in Figure C-7 label.

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Introduction to Appendix C

This appendix summarizes the characteristics of parameters used in the QUAL2E physically-based stochastic water quality model applied to the study segment of the South Platte River. Mean square errors associated with calibration and validation of the model are also presented. Tables C-1 through C-6 summarize values from the literature that were used as the basis for preliminary estimation of the values of the parameters in parameter set 2 used for the South Platte River in the present study. These tables include characteristics of parameter values used in previous studies in the South Platte River, as well as values used in other rivers. Table C-7 lists the levels of variability in model parameters recommended in the QUAL2E users manual (Brown and Barnwell 1987). Based upon data presented in previous tables, the ranges and levels of variability (as CV) adopted for calibrating the stochastic model in the present study are listed in Table C-8.

The model was calibrated using values generated over all 8 weeks in a season for all six seasons in the year 1994. Since the model contained a large number of parameters and complex inter-relationships among them, the calibration was performed using a flexible tolerance optimization algorithm (Himmelblua 1972), to find the combination of the statistics of the model parameters to achieve the most satisfactory fit of the statistics of the simulated output to those generated by the empirical stochastic models. The acceptability of the calibration results was tested by considering the mean square errors of calibration, not only for the selected calibration year of 1994, but for all of the weeks of the years 1993, 1995 and 1996, that were within the period from which the statistics of the observed water quality variables were derived. The mean square errors between the empirical model-generated statistics and the QUAL2E model-simulated statistics for each of the state variables are summarized for each of the calibration weeks in Table C-9. The model was calibrated using 50 realizations for computer efficiency. In addition, 100 and 250 realizations were performed using the calibrated parameters to calculate the associated mean square errors. Except for Q, the higher the number of realizations for each state variable, the higher were the mean square errors in the statistics, though all were still within an acceptable range. (All of the water quality concentrations along the river are related to the hydraulic coefficients and reaction rates that were calibrated based on 50 realizations. However, Q was generated from a stochastic empirical model that was developed using historical measurements with sample sizes typically much larger than 50.) A total of 250 realizations was chosen to simulate the water quality state variables along the river for the considered improvement strategies, because this number would probably better represent the population distributions of the random variables. The plots in Figures C-1 to C-6 show representative comparisons between the statistics of selected state variables predicted by the calibrated physically-based stochastic model and the statistics of corresponding variables generated by the empirical stochastic model for each calibration week. The calibrated model parameters were also applied in simulating conditions all weeks of each of the six seasons within each of the years 1993, 1995 and 1996. This was done to examine the assumption that the parameters calibrated, based upon the data within year 1994, would yield comparable model performance for other years within the period used for inferring the statistics of the empirical model used in the calibration process. Table C-10 summarizes the mean square errors associated with model performance within all weeks inside 1993, 1995, and 1996. The errors remain the same for the mean and increased by 1 percentage point of standard deviation compared to the calibration dates but stayed within an acceptable range. The increased errors were associated with C_{NH_3} and C_{NO_3} concentrations at Henderson and Weldona stations in low flow seasons and are thought to be due primarily to the effect of sparse sampling.

The parameter statistics derived from the calibration process were further validated using data generated in years 1997 to 2000, outside of the period used for calibration. The average, minimum, and maximum values, of the mean square errors between empirical model-generated statistics and simulated statistics of the state variables, calculated over all weeks within the season and over all gauging locations within the river, are presented in Tables C-11 to C-14 for each season within 1997, 1998, 1999, and 2000, respectively. Some examples also are plotted in Figures C-7 to C-10. The statistics of the simulation-related percentiles associated with each of the measured values of the state variables for each of the years in the validation period are summarized in Table C-15. The average simulation-related percentiles for Q were greater than 50% since most of the Q data were positively skewed. The average percentiles for the other water quality variables were around 50%. The ranges of the percentiles for each of the water quality constituents simulated were roughly from 4% to 96%. The statistics of the simulation-related percentiles associated with each of the mean values generated with the empirical stochastic model (CARMA-GMCS) for each of the years of the validation period are also summarized in Table C-16. A similar pattern of the distribution of the percentiles associated with measuremed data can be observed. The average percentiles were greater than 50% for Q and were distributed around the 50% for the other water quality constituents.

The calibrated statistical characteristics of the random parameters are listed in Tables C-17 and C-18. Compared with values reported in the literature (Table C-8), the calibrated parameters seem quite reasonable. The calibrated deterministic correction factors are also reported in Tables C-19 and C-20. Their values illustrate the effects of sparse sampling within the river segment and the variable characteristics of the nonpoint source pollution among seasons as well as along the river segments. For example, larger values of the correction factors were calculated for organic and ammonia nitrogen in the upstream portion of the study segment and for nitrate in the downstream portion of the study segment in the summer seasons. This is thought to be due to the fact that the major contributor of nonpoint source pollution along the river is urban runoff in the upstream portion of the river and agricultural return flow in the downstream portion. The interpretation of the values of the correction factors for nonpoint source TDS concentration and for tributary inflows reveals the effect of sparse sampling both in time and space. It was observed that more sampling sites probably were necessary downstream of the Denver station. The calibrated correction factors for the missing values of the point sources also well comply with the monitoring records sampled by USGS. The small factors were estimated for the TDS concentrations of the Littleton/Englewood plant in summer and for the nitrate concentration in winter when the less stringent discharge ammonia limit (NPDES) is applied and the wastewater bypasses the nitrifying trickle filter.

TABLE C-1. Values of QUAL2E Hydraulic Parameters for the South Platte River Reported in the Literature

Reach No.	k_D	*n*	*a*	*b*	*c*	*d*
1	60(b),510(c)	0.045(a),0.025(b)	0.1(b),0.31(d)	0.48(b)0.37(d)	0.14(b),0.19(d)	0.45(b),0.40(d)
2	60(b),510(c)	0.045(a),0.025(b)	0.1(b)	0.48(b)	0.14(b)	0.45(b)
3	60(b),510(c)	0.045(a),0.025(b)	0.1(b),0.06(d)	0.48(b),0.60(d)	0.14(b),0.14(d)	0.45(b),0.40(d)
4	130-200(b),510(c)	0.040(a),0.025(b)	0.1(b)	0.48(b)	0.14(b)	0.45(b)
5	130-200(b),510(c)	0.040(a),0.030(b)	0.39(b)	0.29(b)	0.044(b)	0.58(b)
6	130-200(b),510(c)	0.040(a),0.030(b)	0.39(b)	0.29(b)	0.044(b)	0.58(b)
7	130-200(b),510(c)	0.040(a),0.030(b)	0.39(b),0.12(d)	0.29(b),0.48(d)	0.044(b),0.08(d)	0.58(b)0.52(d)
8	510(c)	0.040(a)				
9	510(c)	0.040(a)				
10	510(c)	0.040(a)	0.72(d)	0.17(d)	0.008(d)	0.83(d)
11	510(c)	0.040(a)				
12	510(c)	0.040(a)				

Notes: (a) Lockhead (1991)
(b) Denver Regional Council of Governments (1990)
(c) Brown and Barnwell (1987)
(d) Regression analysis results from data collected by the Colorado Division of Water Resources (1992)

TABLE C-2. Values of QUAL2E Hydraulic Parameters Reported in the Literature for Rivers Outside the South Platte Basin

Locations	Coefficient for Velocity *a*	Exponent for Velocity *b*	Coefficient for Depth *c*	Exponent for Depth *d*	References
	NA	0.167	NA	NA	Lacey (1946)*
Rivers in India	NA	0.17	NA	NA	Inglis (1949)*
	NA	0.156	NA	NA	White (1939)*
	NA	0.167	NA	NA	Blench (1957)*
American Canal Systems	NA	0.14	0.52-0.34	0.36	Henderson (1966)*
	NA	0.177	NA	NA	Wilson(rough)*
	NA	0.174	NA	NA	Wilson(smooth)*
Miami River, FL	0.8	0.2	NA	NA	Pettis (1937)*
Nontidal Rivers in England and Wales	1.22	0.167	0.545	0.33	Nixon (1959)*
Nontidal Rivers in England and Wales	0.61	0.24	0.93	0.27	Nash (1959)*
American Rivers	NA	0.34	NA	0.4	Leopold and Maddock (1953)*
	NA	0.167	NA	0.33	Kennedy (1895)
	NA	0.167	NA	0.33	Lacey (1929)
	NA	0.167	NA	0.33	Blench (1957,1961)
	NA	0.167	NA	0.33	Simons and Albertson (1960)
Benford Ouse River, England	0.046	0.64	NA	NA	Whitehead et al. (1986)
White Oak Run, VA					

Note: *- Summaries from *Khalil* (1975)

TABLE C-3. Statistical Characteristics of Field-Measured Values of Manning's Roughness Coefficient, *n*, Reported in the Literature

Locations	Sample Statistics			References
	Sample Size	Mean	CV	
Rio Grande Canal-Flat Bedform (Space-Time)	19	0.017	0.17	Culbertson et al. (1992)
Rio Grande Canal-Dune Bedform (Space-Time)	20	0.028	0.10	Culbertson et al. (1992)
Rio Grande Canal-Flat Bedform (Space-Time)	5	0.023	0.13	Culbertson et al. (1992)
28 Canals with Ditchbank Vegetation (Space-Time)	280	0.032	0.40	Bakry, Gates, and Khattab (1992)
9 Canals with Submerged Vegetation (Space-Time)	156	0.051	0.40	Bakry, Gates, and Khattab (1992)
68 Alluvial River (Space)	68	0.047	0.51	Higginson and Johnston (1992)
Superglacial River (Space)	10	0.016	0.20	Kostrzewski and Zwolinski (1992)
Gezira Canal (Space)	21	0.036	0.27	Ahmed (1992)
Menoufi Canal (Space)	30	0.029	0.24	Ahmed (1992)
Tawfiky Canal (Time)	30	0.016	0.12	Ahmed and Saad (1992)
Menoufi Canal (Time)	12	0.031	0.14	Ahmed and Saad (1992)
Behery Canal (Time)	19	0.029	0.06	Ahmed and Saad (1992)
Payne Creek, Florida (Time)	10	0.067	0.23	Gillen (1996)
Peace River, Florida (Time)	9	0.029	0.06	Gillen (1996)
Horse Creek, Florida (Time)	7	0.055	0.19	Gillen (1996)
South Creek, Florida (Time)	8	0.051	0.33	Gillen (1996)
Walker Creek, Florida (Time)	14	0.096	0.69	Gillen (1996)
Bullfrog Creek, Florida (Time)	7	0.055	0.12	Gillen (1996)
Delaney Creek, Florida (Time)	14	0.048	0.53	Gillen (1996)
Baker Creek, Florida (Time)	7	0.083	0.31	Gillen (1996)
Anclote River, Florida (Time)	17	0.076	0.19	Gillen (1996)
Withlacoochee River, Florida (Time)	11	0.127	0.20	Gillen (1996)
Ptarmigan Valley, Alaska (Space)	15	0.111	0.33	Marcus et al. (1992)
Upper Delaware River Estuary, NJ (High Flow, Space-Time)		0.030 0.313	0.0276 0.0298	Davidson, Vichnevetsky, and Wang (1978)
Upper Delaware River Estuary, NJ (Intermdian Flow, Space-Time)		0.035 0.035	0.0217 0.0216	Davidson, Vichnevetsky, and Wang (1978)
Upper Delaware River Estuary, NJ (Low Flow, Space-Time)		0.042 0.041	0.0109 0.0070	Davidson, Vichnevetsky, and Wang (1978)

TABLE C-4. Reaction Rate Constants Used for the South Platte River Along Reaches 1 through 8, as Reported in the Literature

River km		Element	Reach	Water Quality Reaction Coefficients			
From	To	No.	No.	β_{ON}	β_{NH_3}	β_{NO_2}	k_{FC}
0.00	2.01	1	1	0.5(a),0.1-0.9(c)	1.0(a),0.5-1.0(c)	8.0(a),8.0-45.0(c)	1.5(a)
2.01	4.02	2	2	0.5(a),0.1-0.9(c)	1.0(a),0.5-1.0(c)	8.0(a),8.0-45.0(c)	1.5(a)
4.02	6.03	3	2	0.5(a),0.1-0.9(c)	1.0(a),0.5-1.0(c)	8.0(a),8.0-45.0(c)	1.5(a)
6.03	8.05	4	2	0.5(a),0.1-0.9(c)	1.0(a),0.5-1.0(c)	8.0(a),8.0-45.0(c)	1.5(a)
8.05	10.06	5	2	0.0-0.3(a),0.1-0.9(c)	1.0(a),0.5-1.0(c)	45(a),8.0-45.0(c)	1.5(a)
10.06	12.07	6	3	0.0(a),0.1-0.9(c)	1.0(a),0.5-1.0(c)	45(a),8.0-45.0(c)	1.5(a)
12.07	14.08	7	3	0.0(a),0.1-0.9(c)	1.0(a),0.5-1.0(c)	25(a),8.0-45.0(c)	1.5(a)
14.08	16.09	8	4	0.2(a),0.1-0.9(c)	0.5(a),0.5-1.0(c)	15(a),8.0-45.0(c)	1.5(a)
16.09	18.10	9	4	0.2-0.9(a),0.1-0.9(c)	0.5(a),0.5-1.0(c)	10-8(a),8.0-45.0(c)	1.5(a)
18.10	20.11	10	4	0.9(a),0.1-0.9(c)	1.0(a),0.5-1.0(c)	8.0(a),8.0-45.0(c)	1.5(a)
20.11	22.12	11	4	0.9(a),0.1-0.9(c)	1.0(a),0.5-1.0(c)	8.0(a),8.0-45.0(c)	1.5(a)
22.12	24.14	12	5	0.9(a),0.1-0.9(c)	1.0(a),0.5-1.0(c)	8.0(a),8.0-45.0(c)	
24.14	26.15	13	5	0.9(a),0.1-0.9(c)	1.0(a),0.5-1.0(c)	8.0(a),8.0-45.0(c)	
26.15	28.16	14	5	3.0(b)	3.0(b),0.3-0.7(c)	3.0(b),3.0(c)	
28.16	30.17	15	6	3.0(b)	3.0(b),0.3-0.7(c)	3.0(b),3.0(c)	
30.17	32.18	16	6	3.0(b)	3.0(b),0.3-0.7(c)	3.0(b),3.0(c)	
32.18	34.19	17	7	2.2(b)	2.2(b),0.3-0.7(c)	2.2(b),3.0(c)	
34.19	36.20	18	7	2.2(b)	2.2(b),0.3-0.7(c)	2.2(b),3.0(c)	
36.20	38.21	19	7	2.2(b)	2.2(b),0.3-0.7(c)	2.2(b),3.0(c)	
38.21	40.23	20	7	2.2(b)	2.2(b),0.3-0.7(c)	2.2(b),3.0(c)	
40.23	42.24	21	7	2.6(b)	2.6(b),0.3-0.7(c)	2.6(b),3.0(c)	
42.24	44.25	22	7	2.6(b)	2.6(b),0.3-0.7(c)	2.6(b),3.0(c)	
44.25	46.26	23	7	2.6(b)	2.6(b),0.3-0.7(c)	2.6(b),3.0(c)	
46.26	48.27	24	8	2.6(b)	2.6(b),0.3-0.7(c)	2.6(b),3.0(c)	
48.27	50.28	25	8	2.6(b)	2.6(b),0.3-0.7(c)	2.6(b),3.0(c)	
50.28	52.29	26	8	2.6(b)	2.6(b),0.3-0.7(c)	2.6(b),3.0(c)	
52.29	54.30	27	8	2.6(b)	2.6(b),0.3-0.7(c)	2.6(b),3.0(c)	
54.30	56.32	28	8	2.6(b)	2.6(b),0.3-0.7(c)	2.6(b),3.0(c)	
56.32	58.33	29	8	2.6(b)	2.6(b),0.3-0.7(c)	2.6(b),3.0(c)	
58.33	60.34	30	8	2.6(b)	2.6(b),0.3-0.7(c)	2.6(b),3.0(c)	
60.34	62.35	31	8	2.6(b)	2.6(b),0.3-0.7(c)	2.6(b),3.0(c)	
62.35	64.36	32	8				
64.36	66.37	33	8				
66.37	68.38	34	8				
68.38	70.39	35	8				
70.39	72.41	36	8				

Notes: (a) Spahr and Blakely (1985)
(b) Environmental Protection Agency (1972)
(c) Denver Regional Council of Governments (1990)
(d) Brown and Barnwell (1987)
(e) Lockhead (1991)

TABLE C-5. Statistical Summary of Nitrogen Transformation Rates Reported in the Literature

Locations or Sources	β_{ON}	β_{NH_3}	β_{NO_2}	References
Potomac Estuary, MD	0.035			Thomann et al. (1974)
Potomac Estuary, MD	0.03			Thomann et al. (1974)
Chesapeake Bay	0.14			Salas & Thomann (1978)
Lake Koocanusa, MT	0.001	0.003-0.03	0.09	Chen & Orlob (1973)
Greate Lakes	0.02			Scavia et al. (1976)
Lake Ontario	0.02			Scavia (1980)
	0.003	0.02	0.25	Zison (1978)
	0.1	0.02	0.25	Porcella (1983)
Shallow Lakes	0.01			Nyholm (1978)
Greate Lakes	0.005			Bierman et al. (1980)
	0.1, 0.2			Jorgensen (1977)
Chattahoochee River, TX		0.25-0.52		McCutcheon (1987)
West Fork Trinity River, TX		0.50		
EXPLORE-I Model Manual	0.1-0.4	0.1-0.5	5.0-10.0	Baca et al. (1973)
	0.02-0.04	0.1-0.5	3.0-10.0	Baca and Arnett (1976)
South Africa	0.005-0.05	0.05-0.2	0.2-0.5	Smith (1978)
	0.001-0.02	0.05-0.2	0.05-0.2	Brandes and Masch (1971)
QUAL2E Model Manual	0.02-0.4	0.1-1.0	0.2-2.0	Brown and Barnwell (1987)
Ouachita River, AK and LA		0.1	0.5	NCASI (1982)
Lake Ontario		1.0-3.16		Lean and Knowles (1987)
Phone River (NW Miditerreanea Sea)		0.25-0.36	0.32-3.67	Feliatra and Bianchi (1993)
Toujiang River (China)		0.12		Xie (1991)
River Waal (Netherlands)		0.13-1.10		Botermans and Admiraal (1988)
River Ijssel (Netherlands)		0.27-0.03		Botermans and Admiraal (1988)
River Lek (Netherlands)		0.37-0.03		Botermans and Admiraal (1988)
Rawlett Creek, TX		1.25	6.98	Warwick and Shetty (1988)
San Antonio River, TX		0.36	5.30	Warwick and Shetty (1988)
East Fork Trinity River, TX		0.25-0.85	0.22	Warwick and Shetty (1988)
Arkansas River, TX		2.07	11.30	Warwick and Shetty (1988)
Trinity River, TX		1.43-2.81	47.83	Warwick and Shetty (1988)
Sims Bayou, TX		0.75-1.72	12.29	Warwick and Shetty (1988)
Halls Bayou, TX		1.08		Warwick and Shetty (1988)
Scheldt Estuary		0.17-0.49		Somville (1978)

TABLE C-6. Summary of Coliform Die-Off Rate Values Reported in the Literature

Locations	Season and Temperature (T)	k_{FC}	References
Ohio River	Summer (20 °C)	1.18	Colo. Dept. of Public Health and Environment (undated)
	Winter (5 °C)	1.08	
Upper Illinois River	June-September	2.04	Colo. Dept. of Public Health and Environment (undated)
	October and May	2.52	
	December-March	0.58	
	April and November	1.03	
Lower Illinois River	June-September	2.04	Colo. Dept. of Public Health and Environment (undated)
	October and May	0.89	
	December-March	0.62	
	April and November	0.70	
"Shallow Turbulent Stream"		15.12	Colo. Dept. of Public Health and Environment (undated)
Missouri River	Winter	0.48	Colo. Dept. of Public Health and Environment (undated)
Tennessee River (Knoxville)	Summer	1.03	Colo. Dept. of Public Health and Environment (undated)
Tennessee River (Chattanooga)	Summer	0.12	Colo. Dept. of Public Health and Environment (undated)
Sacramento River	Summer	1.73	Colo. Dept. of Public Health and Environment (undated)
Cumberland River	Summer	5.52	Colo. Dept. of Public Health and Environment (undated)
Glatt River		26.40	Colo. Dept. of Public Health and Environment (undated)
Groundwater Stream	10 °C	0.50	Colo. Dept. of Public Health and Environment (undated)
Leaf River (Mississippi)		0.41	Colo. Dept. of Public Health and Environment (undated)
Wastewater Lagoon	7.9-25.5 °C	0.20-0.70	Colo. Dept. of Public Health and Environment (undated)
Maturation Ponds		1.99	Colo. Dept. of Public Health and Environment (undated)
	19 °C	1.68	Colo. Dept. of Public Health and Environment (undated)
Oxidation Ponds		$0.108(1.19)^{(T-20)}$	Colo. Dept. of Public Health and Environment (undated)
Lake Michigan	10-17 °C	8.640	Colo. Dept. of Public Health and Environment (undated)
	June-December	8.720	Zanoni et al. (1978)
Ford Lake (Ypsilenti, Michigan)	August	9.600	Colo. Dept. of Public Health and Environment (undated)
DeGray Reservoir (Arkansas)	October 1976 (15 °C)	1.248	Colo. Dept. of Public Health and Environment (undated)
	March 1977 (10 °C)	2.62 and 0.38	Colo. Dept. of Public Health and Environment (undated)
	June 1977 (20 °C)	3.31 and 2.74	Colo. Dept. of Public Health and Environment (undated)
Al-Samra Stabilization Ponds (Jordan)	December-March	0.68-0.11	Pescod and Saqqar (1991)
Eutrophic Lake		0.77	Bulson et al. (1984)
Balmoral Beach (Sydney)	February, 1976	1.38-29.09	Bellair et al. (1977)
High Rate Algal Pond		0.35-2.34	Fallowfield et al. (1996)
Grand Traverse Bay (Michigan)		$0.2 + 0.0223\ T$	Canale et al. (1973)
Stabilization Ponds (Kenya)		0.25-7.50	Mills et al. (1992)

TABLE C-7. Levels of Variability for Model Parameters Presented in Brown and Barnwell (1987)

Parameters Name	Coefficient of Variation (%)		
	Low	Typical	High
k_D	1.00	20.00	50.00
n	1.00	10.00	15.00
a	1.00	5.00	15.00
b	0.10	5.00	15.00
c	1.00	5.00	15.00
d	0.10	5.00	15.00
β_{ON}	5.00	25.00	100.00
β_{NH_3}	5.00	20.00	100.00
β_{NO_2}	5.00	20.00	100.00
k_{FC}	5.00	25.00	100.00

TABLE C-8. Ranages and Level of Variability for Model Parameters Used in the QUAL2E Simulation Model of the South Platte River Study Segment

Parameters	Range of Values		Coefficient of Variation (%)				
Name	Minimum	Maximum	Low	Moderately Low	Average	Moderately High	High
k_D	NA	NA	5.00	12.50	20.00	35.00	50.00
n	NA	NA	5.00	15.00	25.00	37.50	50.00
a	0.046	1.22	5.00	10.00	15.00	32.50	50.00
b	0.140	0.77	1.00	8.00	15.00	32.50	50.00
c	0.080	0.93	5.00	10.00	15.00	32.50	50.00
d	0.217	0.69	1.00	8.00	15.00	32.50	50.00
β_{ON}	0.02	0.90	5.00	15.00	25.00	62.50	100.00
β_{NH_3}	0.003	3.16	5.00	12.50	20.00	60.00	100.00
β_{NO_2}	0.05	45.00	5.00	12.50	20.00	60.00	100.00
k_{FC}	0.05	4.00	5.00	15.00	25.00	62.50	100.00

TABLE C-9. Mean Square Errors Between Empirical Model-Generated and QUAL2EU Model-Simulated Statistics of Water Quality State Variables Along the Study Reach of the South Platte River for Weeks Used for Model Calibration

Date	No. of Monte Carlo Simulations	Mean-Square Error (%)	*Q*	C_{TDS}	C_{ON}	C_{NH_3}	C_{NO_2}	C_{NO_3}	C_{FC}	Average
Jan-Feb/1994	50	Mean	4.6	3.5	2.3	9.5	10.8	9.6	7.1	6.8
		STD	8.4	10.8	12.8	12.2	13.7	23.4	11.9	13.3
	100	Mean	4.8	4.0	5.1	9.4	16.0	10.7	6.4	8.1
		STD	10.3	9.9	14.1	12.8	15.4	23.8	20.3	15.2
	250	Mean	4.4	4.1	4.9	9.9	15.5	10.3	7.2	8.0
		STD	10.3	10.4	12.3	12.5	16.6	24.0	25.2	15.9
Mar-Apr/1994	50	Mean	3.7	3.4	10.3	12.0	16.0	9.0	4.0	8.3
		STD	9.3	7.9	11.8	17.0	14.8	13.6	7.9	11.7
	100	Mean	3.7	2.4	11.4	11.8	16.6	8.7	7.0	8.8
		STD	8.0	8.1	10.7	12.7	15.1	14.9	13.8	11.9
	250	Mean	3.7	3.2	11.8	12.2	16.4	8.5	6.2	8.8
		STD	7.9	6.2	8.7	12.1	16.3	12.9	11.3	10.8
May-Jun/1994	50	Mean	9.4	8.9	18.8	9.9	5.6	7.0	10.3	10.0
		STD	11.6	5.7	10.6	17.7	7.6	15.4	6.4	10.7
	100	Mean	7.6	10.1	17.7	9.9	14.7	5.7	8.0	10.5
		STD	11.5	17.2	9.9	21.8	8.2	8.9	7.7	12.2
	250	Mean	7.1	11.3	18.3	8.5	14.3	5.3	6.8	10.2
		STD	10.9	12.4	8.4	19.9	6.9	9.6	5.7	10.5
Jul-Aug/1994	50	Mean	8.4	6.8	16.5	6.4	13.1	9.0	10.2	10.1
		STD	18.8	12.8	15.1	32.2	10.0	11.6	8.5	15.6
	100	Mean	7.9	7.2	18.7	9.4	12.4	9.8	9.7	10.7
		STD	16.6	12.1	17.3	30.7	8.9	12.2	6.2	14.8
	250	Mean	8.5	7.0	17.3	7.4	11.9	8.9	9.1	10.0
		STD	18.9	12.4	16.8	31.1	10.0	12.1	7.7	15.6
Sep-Oct/1994	50	Mean	5.9	13.2	12.7	5.6	5.0	8.0	8.1	8.4
		STD	9.7	12.8	11.3	23.3	14.3	19.4	12.4	14.7
	100	Mean	7.2	13.0	11.7	5.8	5.7	8.3	6.5	8.3
		STD	8.5	17.1	14.4	21.5	10.1	16.9	27.0	16.5
	250	Mean	6.1	18.0	10.7	5.0	5.1	7.3	3.8	8.0
		STD	9.2	19.0	13.7	21.9	8.9	16.4	22.7	16.0
Nov-Dec/1994	50	Mean	7.5	5.9	4.8	5.3	4.9	8.2	9.2	6.5
		STD	10.8	7.2	24.1	12.1	17.3	21.7	16.0	15.6
	100	Mean	7.9	5.5	5.4	5.3	3.6	7.8	11.5	6.7
		STD	11.1	6.2	22.1	14.3	21.4	26.8	16.5	16.9
	250	Mean	7.7	5.1	5.1	5.4	3.6	7.3	12.4	6.7
		STD	11.2	4.8	22.7	12.2	19.7	24.5	14.8	15.7
Average	50	Mean	6.6	6.9	10.9	8.1	9.2	8.5	8.2	8.3
		STD	11.4	9.6	14.3	19.1	12.9	17.5	10.5	13.6
	100	Mean	6.5	7.0	11.7	8.6	11.5	8.5	8.2	8.9
		STD	11.0	11.7	14.7	19.0	13.2	17.2	15.3	14.6
	250	Mean	6.2	8.1	11.3	8.1	11.1	7.9	7.6	8.6
		STD	11.4	10.9	13.7	18.3	13.1	16.6	14.6	14.1

TABLE C-10. Mean Square Errors Between Empirical Model-Generated and QUAL2E Model-Simulated Statistics of Water Quality State Variables Along the Study Reach of the South Platte River for Weeks Used for Model Calibration

Season	Year	Mean-Square Error (%)	Q	C_{TDS}	C_{ON}	C_{NH_3}	C_{NO_2}	C_{NO_3}	C_{FC}	Average
Jan-Feb	1993	Mean	4.6	3.8	5.4	9.3	13.3	10.7	4.6	7.4
		STD	10.3	9.7	11.7	14.2	12.7	25.7	20.1	14.9
	1995	Mean	4.3	4.0	5.6	8.2	16.4	10.4	5.7	7.8
		STD	10.5	9.1	10.9	11.0	15.7	27.5	22.5	15.3
	1996	Mean	4.7	4.2	4.2	10.2	12.7	10.1	4.0	7.2
		STD	8.9	12.0	13.3	14.1	12.6	24.4	20.4	15.1
Mar-Apr	1993	Mean	3.4	2.5	10.9	11.4	16.5	9.8	8.2	9.0
		STD	7.3	6.8	8.7	12.7	13.1	11.8	12.9	10.5
	1995	Mean	3.8	2.9	10.8	12.3	15.0	9.6	5.5	8.6
		STD	8.2	5.2	8.0	12.7	15.3	11.8	9.3	10.1
	1996	Mean	3.6	2.4	10.6	11.3	16.3	8.6	7.8	8.7
		STD	8.3	6.1	7.3	12.8	16.3	13.9	17.5	11.7
May-Jun	1993	Mean	7.8	10.6	18.9	9.3	13.6	4.1	4.1	9.8
		STD	10.7	5.3	9.8	21.3	8.0	7.7	7.0	10.0
	1995	Mean	8.6	10.0	17.6	8.4	13.4	4.8	7.9	10.1
		STD	10.9	4.4	9.1	18.9	8.2	9.8	7.6	9.8
	1996	Mean	8.1	10.2	19.2	8.7	12.7	4.3	6.4	9.9
		STD	11.3	5.7	9.5	18.9	8.0	7.7	8.0	9.9
Jul-Aug	1993	Mean	7.7	7.3	15.6	6.5	14.1	9.1	11.4	10.3
		STD	16.1	11.2	16.1	34.2	7.1	13.7	6.3	15.0
	1995	Mean	9.2	6.7	15.5	7.2	13.5	8.9	11.1	10.3
		STD	17.1	13.8	16.1	34.0	5.2	13.5	7.7	15.4
	1996	Mean	7.3	7.4	15.9	6.0	12.7	8.6	11.1	9.9
		STD	16.8	13.3	15.2	35.4	8.8	14.7	6.4	15.8
Sep-Oct	1993	Mean	5.4	12.7	10.9	4.8	6.2	7.0	5.8	7.5
		STD	7.9	28.3	12.4	22.5	9.5	17.3	20.0	16.8
	1995	Mean	5.4	12.8	11.0	5.0	6.7	7.3	3.2	7.3
		STD	8.4	20.9	12.9	20.8	10.5	17.5	14.4	15.1
	1996	Mean	5.7	13.1	11.2	5.0	5.3	7.0	4.7	7.4
		STD	9.8	16.4	14.4	21.8	10.5	15.5	22.6	15.8
Nov-Dec	1993	Mean	7.5	5.8	6.3	7.2	4.6	7.3	18.8	8.2
		STD	11.0	4.4	20.7	12.4	18.8	23.3	22.0	16.1
	1995	Mean	7.4	6.1	6.3	6.7	3.9	7.1	13.7	7.3
		STD	11.1	6.2	21.1	13.1	19.3	24.0	19.4	16.3
	1996	Mean	7.4	5.1	6.3	8.5	6.4	7.2	18.3	8.5
		STD	11.5	5.9	20.2	14.1	16.9	28.7	25.8	17.6
Average	1993	Mean	6.1	7.1	11.3	8.1	11.4	8.0	8.8	8.7
		STD	10.5	10.9	13.2	19.6	11.5	16.6	14.7	13.9
	1995	Mean	6.4	7.1	11.1	8.0	11.5	8.0	7.8	8.6
		STD	11.0	9.9	13.0	18.4	12.4	17.4	13.5	13.7
	1996	Mean	6.1	7.1	11.2	8.3	11.0	7.6	8.7	8.6
		STD	11.1	9.9	13.3	19.5	12.2	17.5	16.8	14.3

TABLE C-11. Mean Square Errors (MSE) Between Empirical Model-Generated and QUAL2EU Model-Simulated Statistics of Water Quality State Variables Along the Study Reach of the South Platte River During the Validation Year 1997

Season	Space-Time Statistic	MSE in Mean (%)								MSE in Standard Deviation (%)							
		Q	C_{TDS}	C_{ON}	C_{NH_3}	C_{NO_2}	C_{NO_3}	C_{FC}	Average	Q	C_{TDS}	C_{ON}	C_{NH_3}	C_{NO_2}	C_{NO_3}	C_{FC}	Average
Jan-Feb	Avg.	4.7	4.5	3.0	10.6	10.9	10.7	3.6	6.8	7.4	14.3	13.4	15.2	13.7	21.4	24.1	15.6
	Min.	4.5	4.4	2.1	9.4	8.6	10.4	1.4	1.4	6.8	11.9	10.0	12.3	11.9	17.5	10.4	6.8
	Max.	4.9	4.8	4.5	12.1	12.3	11.1	6.1	12.3	8.0	17.8	17.4	21.5	16.7	26.7	32.9	32.9
Mar-Apr	Avg.	3.6	2.4	12.1	11.3	18.3	8.2	6.2	8.9	9.7	6.5	9.7	14.3	12.1	13.7	16.1	11.7
	Min.	2.7	1.6	11.1	12.8	15.6	7.8	1.3	1.3	6.3	3.0	8.3	10.4	8.3	11.5	7.6	3.0
	Max.	4.5	4.2	13.8	12.8	19.3	8.8	8.7	19.3	11.5	9.0	12.5	18.0	16.4	15.4	27.7	27.7
May-Jun	Avg.	8.2	10.2	19.1	8.2	14.0	4.2	10.4	10.6	9.2	4.2	8.4	16.3	9.2	13.1	10.2	10.1
	Min.	6.7	8.7	18.2	7.0	13.0	3.0	7.6	3.0	6.8	3.1	7.0	10.9	5.9	10.4	6.5	3.1
	Max.	8.9	11.1	20.8	10.3	15.1	5.5	14.8	20.8	12.5	5.3	9.5	21.8	12.4	17.5	15.9	21.8
Jul-Aug	Avg.	6.9	7.5	18.1	6.8	11.5	8.8	8.4	9.7	16.6	11.4	15.4	34.1	8.2	14.6	6.3	15.2
	Min.	6.2	7.0	16.8	6.3	9.4	7.8	5.4	5.4	14.0	8.4	11.9	32.1	5.7	10.3	1.9	1.9
	Max.	7.9	8.0	19.9	7.8	12.9	9.4	10.0	19.9	20.1	15.1	16.8	36.2	11.0	18.1	10.2	36.2
Sep-Oct	Avg.	5.3	12.0	10.6	6.0	5.4	6.7	6.4	7.5	11.0	12.7	15.3	21.0	11.6	14.5	26.6	16.1
	Min.	4.5	5.2	10.2	3.0	3.1	6.2	1.7	1.7	9.4	5.3	10.7	19.0	7.9	9.1	22.4	5.3
	Max.	5.9	13.8	11.4	7.8	7.3	7.7	11.0	13.8	12.8	16.0	18.9	23.3	15.7	16.9	33.6	33.6
Nov-Dec	Avg.	7.7	6.0	6.2	7.4	4.2	7.5	14.5	7.6	12.1	5.6	20.9	13.5	19.2	25.9	20.3	16.8
	Min.	7.5	5.3	5.7	5.7	3.0	6.9	8.1	3.0	11.6	3.5	17.2	10.5	16.5	20.8	6.9	3.5
	Max.	7.9	6.5	7.2	8.6	4.9	7.9	18.5	18.5	12.8	6.8	23.9	17.0	22.1	30.5	31.8	31.8
Year Round	Avg.	6.0	7.1	11.5	8.4	10.7	7.7	8.3	8.5	11.0	9.1	13.9	19.1	12.3	17.2	17.3	14.3
	Min.	2.7	1.6	2.1	3.0	3.0	3.0	1.3	1.3	6.3	3.0	7.0	10.4	5.7	9.1	1.9	1.9
	Max.	8.9	13.8	20.8	12.8	19.3	11.1	18.5	20.8	20.1	17.8	23.9	36.2	22.1	30.5	33.6	36.2

TABLE C-12. Mean Square Errors (MSE) Between Empirical Model-Generated and QUAL2EU Model-Simulated Statistics of Water Quality State Variables Along the Study Reach of the South Platte River During the Validation Year 1998

Season	Space-Time Statistic	MSE in Mean (%)								MSE in Standard Deviation (%)							
		Q	C_{TDS}	C_{ON}	C_{NH_3}	C_{NO_2}	C_{NO_3}	C_{FC}	Average	Q	C_{TDS}	C_{ON}	C_{NH_3}	C_{NO_2}	C_{NO_3}	C_{FC}	Average
Jan-Feb	Avg.	4.8	4.4	2.5	10.6	10.8	10.5	5.1	7.0	7.1	13.2	12.3	15.3	14.6	20.8	25.0	15.5
	Min.	4.5	4.0	1.6	10.6	9.1	10.3	3.5	1.6	6.0	9.3	9.7	13.6	13.5	18.1	18.5	6.0
	Max.	5.1	4.8	4.0	11.6	12.0	10.7	8.6	12.0	9.1	19.5	15.5	19.1	16.3	24.7	33.3	33.3
Mar-Apr	Avg.	4.1	3.2	12.3	11.0	18.7	8.9	5.0	9.0	10.2	6.6	10.2	13.2	15.2	14.3	9.9	11.4
	Min.	3.8	1.6	11.4	10.0	16.5	7.9	0.7	0.7	8.4	5.7	9.1	10.7	10.1	14.6	6.6	5.7
	Max.	4.7	4.3	12.8	11.7	20.9	9.8	9.0	20.9	11.3	8.9	12.5	16.9	20.3	15.8	13.5	20.3
May-Jun	Avg.	7.1	11.0	19.2	7.8	14.7	5.0	8.9	10.5	8.3	5.1	9.2	17.1	9.2	10.3	12.8	10.3
	Min.	5.9	10.2	18.3	7.1	11.6	3.0	1.7	1.7	6.6	3.2	8.7	14.3	6.0	6.8	7.5	3.2
	Max.	8.6	11.9	21.1	9.1	16.2	8.0	16.3	21.1	10.5	7.9	11.9	23.5	14.1	15.5	16.2	23.5
Jul-Aug	Avg.	6.5	7.1	19.3	6.6	12.4	9.1	8.2	9.9	16.5	12.3	15.5	33.3	6.7	13.6	5.3	14.7
	Min.	6.5	6.8	17.4	5.3	10.0	8.4	5.9	5.3	16.4	10.4	11.9	31.5	5.2	11.4	2.4	2.4
	Max.	7.2	7.5	21.2	7.8	13.7	9.9	9.8	21.2	18.0	14.2	18.6	36.8	9.6	15.9	7.2	36.8
Sep-Oct	Avg.	5.2	13.5	11.4	5.2	5.6	6.8	3.3	7.3	11.7	11.4	16.2	23.2	11.2	12.4	24.7	15.8
	Min.	4.5	12.9	11.1	3.8	4.3	6.2	1.8	1.8	10.0	8.6	13.5	19.1	4.9	8.4	18.5	4.9
	Max.	5.9	13.8	11.9	7.3	6.9	7.6	8.9	13.8	13.0	18.2	18.3	28.6	19.1	17.1	35.0	35.0
Nov-Dec	Avg.	7.6	6.0	6.3	7.5	4.9	7.6	17.7	8.2	12.2	6.1	19.6	12.3	17.7	27.0	29.4	17.7
	Min.	7.5	5.4	5.2	6.1	3.8	7.3	9.3	3.8	11.8	3.2	17.6	8.5	15.0	24.0	16.9	3.2
	Max.	7.8	6.9	7.7	9.2	6.2	7.8	22.4	22.4	12.4	8.1	23.0	14.5	20.6	28.8	35.9	35.9
Year Round	Avg.	5.9	7.5	11.8	8.1	11.2	8.0	8.0	8.7	11.0	9.1	13.8	19.0	12.4	16.4	17.8	14.2
	Min.	3.8	1.6	1.6	3.8	3.8	3.0	0.7	0.7	6.0	3.2	8.7	8.5	4.9	6.8	2.4	2.4
	Max.	8.6	13.8	21.2	11.7	20.9	10.7	22.4	22.4	18.0	19.5	23.0	36.8	20.6	28.8	35.9	36.8

TABLE C-13. Mean Square Errors (MSE) Between Empirical Model-Generated and QUAL2EU Model-Simulated Statistics of Water Quality State Variables Along the Study Reach of the South Platte River During the Validation Year 1999

Season	Space-Time Statistic	MSE in Mean (%)								MSE in Standard Deviation (%)							
		Q	C_{TDS}	C_{ON}	C_{NH_3}	C_{NO_2}	C_{NO_3}	C_{FC}	Average	Q	C_{TDS}	C_{ON}	C_{NH_3}	C_{NO_2}	C_{NO_3}	C_{FC}	Average
Jan-Feb	Avg.	4.7	4.4	3.3	9.6	11.1	10.0	3.4	6.6	7.2	11.0	12.6	14.6	14.1	19.9	18.6	14.0
	Min.	4.4	4.2	2.3	8.5	8.4	9.6	1.2	1.2	5.8	7.6	11.6	11.6	8.8	18.1	9.1	5.8
	Max.	5.0	4.9	4.2	11.0	13.5	10.4	5.3	13.5	8.3	13.8	15.8	20.0	17.4	21.0	24.5	24.5
Mar-Apr	Avg.	3.8	2.8	11.9	11.2	18.3	9.0	4.4	8.8	9.3	6.0	9.5	14.4	13.6	13.9	11.5	11.2
	Min.	3.4	2.3	11.5	10.3	16.4	7.9	1.3	1.3	8.5	4.3	7.1	12.8	5.9	12.0	4.6	4.3
	Max.	4.3	3.8	12.4	12.5	20.0	9.7	9.1	20.0	11.0	7.2	11.7	15.6	23.9	15.5	15.7	23.9
May-Jun	Avg.	7.9	10.2	18.5	8.0	14.8	5.2	9.2	10.5	9.0	5.9	9.1	17.9	8.7	12.7	10.4	10.5
	Min.	6.9	9.8	17.6	6.4	12.0	2.8	1.9	1.9	8.0	4.1	7.7	14.7	5.8	7.5	3.5	3.5
	Max.	9.3	10.6	19.1	9.7	17.1	6.5	14.5	19.1	10.5	7.9	10.0	21.0	11.8	17.3	16.1	21.0
Jul-Aug	Avg.	6.1	7.4	18.6	7.0	11.3	9.3	8.2	9.7	15.5	13.5	14.0	34.1	5.6	13.4	7.9	14.9
	Min.	5.5	6.3	17.3	5.9	9.4	8.4	6.4	5.5	14.7	11.2	12.6	31.5	3.2	9.4	4.5	3.2
	Max.	6.8	8.1	20.3	8.5	13.2	10.1	10.7	20.3	16.4	17.2	16.1	35.9	7.4	15.9	11.2	35.9
Sep-Oct	Avg.	5.2	13.2	11.3	5.3	5.3	6.6	5.4	7.5	11.0	16.8	15.9	24.2	12.8	13.3	25.5	17.1
	Min.	4.8	12.5	10.6	2.9	3.1	6.1	3.1	2.9	8.7	8.7	13.3	17.6	10.0	11.8	17.1	8.7
	Max.	5.8	14.0	13.1	7.2	6.3	7.2	7.5	14.0	13.3	39.0	18.1	28.9	16.1	15.6	33.6	39.0
Nov-Dec	Avg.	7.6	5.7	6.9	9.7	5.9	7.0	30.1	10.4	12.1	5.3	19.7	16.4	18.2	27.5	41.8	20.1
	Min.	7.2	5.2	6.3	8.6	4.5	6.6	21.8	4.5	11.9	4.1	19.2	12.8	15.1	23.9	34.0	4.1
	Max.	7.7	6.9	7.3	11.9	7.1	7.6	40.5	40.5	12.4	8.4	20.9	21.2	22.8	32.1	53.7	53.7
Year Round	Avg.	5.9	7.3	11.7	8.5	11.1	7.8	10.1	8.9	10.7	9.7	13.5	20.3	12.2	16.8	19.3	14.6
	Min.	3.4	2.3	2.3	2.9	3.1	2.8	1.2	1.2	5.8	4.1	7.1	11.6	3.2	7.5	3.5	3.2
	Max.	9.3	14.0	20.3	12.5	20.0	10.4	40.5	40.5	16.4	39.0	20.9	35.9	23.9	32.1	53.7	53.7

TABLE C-14. Mean Square Errors (MSE) Between Empirical Model-Generated and QUAL2EU Model-Simulated Statistics of Water Quality State Variables Along the Study Reach of the South Platte River During the Validation Year 2000

Season	Space-Time Statistic	MSE in Mean (%)								MSE in Standard Deviation (%)							
		Q	C_{TDS}	C_{ON}	C_{NH_3}	C_{NO_2}	C_{NO_3}	C_{FC}	Average	Q	C_{TDS}	C_{ON}	C_{NH_3}	C_{NO_2}	C_{NO_3}	C_{FC}	Average
Jan-Feb	Avg.	4.6	4.5	2.8	9.8	11.4	10.2	3.7	6.7	7.2	11.1	13.1	15.0	15.1	23.2	20.1	14.9
	Min.	4.4	4.3	2.0	8.3	9.5	10.0	1.5	1.5	6.3	8.9	11.8	10.4	12.5	21.9	14.2	6.3
	Max.	5.0	5.0	3.3	11.9	14.2	10.5	6.1	14.2	8.2	13.6	14.8	21.0	21.2	24.9	27.8	27.8
Mar-Apr	Avg.	3.5	2.1	11.1	11.5	16.5	9.1	14.1	9.7	10.2	5.9	9.4	12.7	19.6	13.1	28.3	14.2
	Min.	2.9	2.0	10.4	10.4	14.7	8.5	5.0	2.0	9.3	4.4	6.1	10.5	14.4	10.2	18.0	4.4
	Max.	4.3	2.4	12.0	12.8	17.6	9.8	20.2	20.2	11.0	7.9	13.8	15.6	24.9	15.2	40.9	40.9
May-Jun	Avg.	8.1	10.0	17.9	7.7	15.3	5.9	9.7	10.7	8.7	6.7	8.4	17.9	8.3	13.6	10.8	10.6
	Min.	6.9	9.3	16.6	5.1	11.8	4.3	5.5	4.3	7.8	4.3	6.6	16.6	5.9	7.7	4.5	4.3
	Max.	8.8	10.8	18.7	9.3	17.4	7.9	15.7	18.7	10.4	15.6	10.6	19.5	11.3	25.0	14.0	25.0
Jul-Aug	Avg.	7.3	7.4	17.6	6.9	11.2	8.6	9.5	9.8	16.1	11.9	14.1	35.3	6.9	14.2	6.3	15.0
	Min.	6.5	6.6	15.0	5.9	9.2	7.8	7.9	5.9	13.6	9.6	12.7	32.3	3.5	11.3	0.8	0.8
	Max.	7.9	8.3	19.3	8.8	14.5	10.6	12.4	19.3	17.8	13.1	16.2	39.6	10.2	17.1	10.8	39.6
Sep-Oct	Avg.	5.6	13.2	11.5	5.3	5.0	7.2	4.0	7.4	12.2	19.4	16.7	22.5	11.2	15.2	24.6	17.4
	Min.	4.8	12.8	10.4	3.9	3.0	6.4	1.0	1.0	9.5	9.3	13.5	20.0	6.9	11.1	20.3	6.9
	Max.	6.7	13.6	12.7	7.1	7.6	7.9	8.1	13.6	14.4	39.1	21.1	25.3	14.5	21.9	34.8	39.1
Nov-Dec	Avg.	7.6	5.4	6.2	7.1	5.5	7.3	18.5	8.2	12.1	5.8	20.9	12.5	19.2	25.7	29.3	17.9
	Min.	7.4	5.1	5.4	6.5	4.2	6.7	12.3	4.2	11.8	3.5	19.7	9.7	16.9	21.5	6.6	3.5
	Max.	7.9	5.6	7.5	7.7	6.3	8.2	24.4	24.4	12.5	7.1	22.8	15.1	21.3	29.5	40.7	40.7
Year Round	Avg.	6.1	7.1	11.2	8.1	10.8	8.0	9.9	8.7	11.1	10.1	13.8	19.3	13.4	17.5	19.9	15.0
	Min.	2.9	2.0	2.0	3.9	3.0	4.3	1.0	1.0	6.3	3.5	6.1	9.7	3.5	7.7	0.8	0.8
	Max.	8.8	13.6	19.3	12.8	17.6	10.6	24.4	24.4	17.8	39.1	22.8	39.6	24.9	29.5	40.9	40.9

TABLE C-15. Average and Extreme Simulation-Related Percentiles of Values of Water Quality State Variables Measured Along the Study Segment of the South Platte River During the Validation Period (1997-2000)

Series	Year	Q				C_{TDS}				C_{ON}				C_{NH_3}				C_{NO_2}				C_{NO_3}				C_{FC}			
		No.*	Min.	Max.	Mean	No.*	Min.	Max.	Mean	No.*	Min.	Max.	Mean	No.*	Min.	Max.	Mean	No.*	Min.	Max.	Mean	No.*	Min.	Max.	Mean	No.*	Min.	Max.	Mean
Jan-Feb	1997	40	33.2	94.0	70.0	2	96.0	97.6	96.8	0	NA	NA	NA	0	NA	NA	NA	0	NA	NA	NA	0	NA	NA	NA	0	NA	NA	NA
	1998	40	68.8	96.0	73.7	7	2.0	72.0	24.9	5	35.6	87.2	65.4	5	22.8	94.8	59.0	5	83.6	96.0	90.8	5	0.4	88.0	57.7	1	14.0	14.0	14.0
	1999	40	26.0	96.0	73.4	4	5.2	51.6	30.4	4	72.4	96.0	89.7	3	68.4	76.0	72.2	2	36.0	98.4	68.3	3	65.2	97.2	82.2	0	NA	NA	NA
	2000	40	74.8	96.0	87.8	4	0.8	4.0	2.7	4	24.8	93.6	62.7	4	45.2	76.0	66.4	4	26.8	83.2	71.0	4	21.2	61.6	52.7	0	NA	NA	NA
Mar-Apr	1997	40	6.0	96.4	53.5	2	34.4	72.0	53.2	1	35.6	35.6	35.6	1	4.0	4.0	4.0	1	1.6	1.6	1.6	1	69.2	69.2	69.2	1	3.2	3.2	3.2
	1998	40	30.0	94.0	87.6	6	0.8	80.0	18.3	5	5.6	91.2	56.2	5	1.2	33.2	14.6	5	10.0	96.0	49.0	5	2.0	96.0	54.5	1	18.4	18.4	18.4
	1999	40	2.0	96.0	50.9	5	2.8	92.0	38.8	5	32.4	93.2	64.9	5	47.6	89.2	43.7	5	25.2	96.4	65.5	5	34.8	96.0	72.8	1	14.4	14.4	14.4
	2000	40	3.6	95.6	67.6	6	1.2	82.0	35.6	5	3.6	3.6	67.7	5	0.4	0.4	24.0	5	26.8	83.2	71.0	5	6.4	6.4	67.4	1	19.6	19.6	19.6
May-Jun	1997	40	6.0	98.0	68.2	7	0.8	94.0	43.8	3	4.8	32.0	22.1	3	55.2	55.2	18.8	4	6.4	50.4	32.9	4	6.4	83.2	53.6	0	NA	NA	NA
	1998	40	19.2	98.0	75.5	7	12.0	66.8	42.7	6	3.2	36.4	24.5	6	1.2	93.6	39.1	6	8.0	94.0	50.0	6	24.4	92.4	63.3	1	77.2	77.2	77.2
	1999	40	40.0	98.0	90.1	5	14.0	54.0	25.6	5	3.2	92.4	31.0	5	0.4	94.4	36.2	5	2.4	89.2	43.4	5	3.6	80.4	31.8	1	38.4	38.4	38.4
	2000	40	7.2	74.4	40.1	7	32.4	91.2	73.1	5	7.2	32.4	41.8	5	1.6	52.8	31.2	5	26.8	83.2	71.0	5	58.0	76.4	73.6	1	62.4	62.4	62.4
Jul-Aug	1997	40	12.8	93.0	70.4	7	4.4	68.4	25.8	6	20.8	86.0	47.1	6	0.4	68.0	28.1	6	6.0	98.4	51.7	6	0.4	59.2	28.5	1	2.0	2.0	2.0
	1998	40	43.6	97.0	83.8	5	1.2	52.0	20.2	4	12.0	76.8	41.8	4	72.8	94.8	87.0	3	54.8	94.8	77.9	4	8.8	73.2	32.3	0	NA	NA	NA
	1999	40	47.2	95.0	88.7	5	0.8	15.6	6.7	5	16.4	78.0	33.2	5	6.4	98.4	25.9	5	26.4	88.8	50.5	5	8.4	83.6	34.1	1	53.6	53.6	53.6
	2000	40	2.0	96.8	36.0	6	18.8	76.0	46.7	4	34.0	47.6	53.6	4	14.0	14.0	25.6	4	26.8	83.2	71.0	4	63.2	68.8	74.0	0	NA	NA	NA
Sep-Oct	1997	40	62.0	96.6	90.0	7	5.2	96.4	41.5	5	2.4	96.0	52.4	5	0.8	72.0	29.5	5	0.8	28.4	15.3	5	14.4	60.8	40.4	1	53.2	53.2	53.2
	1998	40	55.2	95.0	87.0	5	2.4	77.2	49.5	4	8.8	76.8	39.5	4	1.6	96.4	47.2	4	23.6	84.0	51.6	4	14.4	95.2	47.6	0	NA	NA	NA
	1999	40	30.0	97.0	84.8	4	17.6	39.2	27.3	4	21.2	91.6	54.3	4	4.0	73.2	40.7	4	32.0	96.4	54.7	4	25.6	94.8	62.6	0	NA	NA	NA
	2000	40	4.0	86.0	53.2	1	81.2	96.0	88.6	2	37.2	94.0	65.6	2	1.6	60.0	30.8	2	26.8	83.2	71.0	2	83.2	91.6	87.4	0	NA	NA	NA
Nov-Dec	1997	40	77.6	94.0	92.1	4	37.6	95.2	58.3	4	2.8	48.0	27.8	4	54.4	70.4	64.5	4	6.4	58.8	32.6	5	1.2	44.8	18.0	0	NA	NA	NA
	1998	40	22.0	96.0	77.6	5	47.6	94.0	71.1	4	8.8	97.2	71.4	4	12.0	73.2	39.3	5	26.0	66.0	38.2	5	13.6	90.8	53.3	1	60.4	60.4	60.4
	1999	40	60.8	92.0	82.9	5	29.6	84.8	55.8	5	47.6	80.4	60.2	5	0.8	68.4	30.5	5	1.2	55.6	22.0	5	17.6	80.4	55.5	1	88.4	88.4	88.4
	2000	40	3.6	90.8	55.9	0	NA	NA	NA	0	NA	NA	NA	0	NA	NA	NA	0	NA	NA	NA	0	NA	NA	NA	0	NA	NA	NA
Total	1997	240	6.0	95.3	74.0	29	0.8	97.6	53.2	19	2.0	96.0	37.0	19	4.0	92.0	29.0	20	6.0	98.4	26.8	21	4.0	83.2	41.9	3	14.0	53.2	19.5
	1998	240	19.2	96.0	80.9	35	0.8	94.0	37.8	28	3.2	97.2	49.8	28	1.2	96.4	47.7	28	8.0	96.0	59.6	29	0.4	96.0	51.4	4	64.4	70.4	42.5
	1999	240	2.0	95.7	78.5	28	0.8	92.0	30.8	28	3.2	96.0	55.5	27	0.4	98.4	41.5	26	1.2	98.4	50.7	27	3.6	97.2	56.5	4	34.8	91.6	48.7
	2000	240	2.0	89.9	56.8	24	6.4	96.0	49.3	20	5.2	94.0	58.3	20	4.0	72.0	35.6	20	14.0	92.0	71.0	20	6.0	74.0	71.0	2	53.6	53.6	41.0

Note: No.*-Total number of measurements

TABLE C-16. Average and Extreme Simulation-Related Percentiles of Empirical Model (CARMA-GMCS)-Generated Mean Values of Water Quality State Variables Measured Along the Study Segment of the South Platte River During the Validation Period (1997-2000)

Series	Year	No.*	Q			C_{TDS}			C_{ON}			C_{NH_3}			C_{NO_2}			C_{NO_3}			C_{FC}		
			Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.	Mean
Jan-Feb	1997	40	50.0	78.0	62.2	48.4	93.6	63.1	29.2	65.2	62.9	43.2	77.2	61.6	65.6	76.8	60.8	18.8	94.0	61.2	48.8	69.6	63.6
	1998	40	52.0	78.0	60.9	50.8	92.4	61.8	30.8	62.8	61.2	39.6	79.6	62.9	66.0	79.2	61.2	20.8	96.0	61.0	51.6	67.2	64.4
	1999	40	48.0	82.0	61.6	54.8	94.4	61.2	25.2	61.2	61.5	40.4	81.6	63.6	67.2	78.8	62.9	18.8	96.0	61.8	52.8	69.6	57.8
	2000	40	46.0	74.0	61.9	53.6	92.4	61.3	28.0	54.0	62.3	47.6	72.8	62.9	26.8	83.2	71.0	22.0	90.4	62.6	54.4	71.6	60.0
Mar-Apr	1997	40	46.0	82.0	64.5	36.0	62.4	63.5	40.4	66.8	63.8	37.2	78.4	61.3	33.6	88.4	64.1	38.4	93.6	64.7	61.2	70.8	66.0
	1998	40	52.0	78.0	63.8	30.4	61.2	62.7	38.4	68.0	63.7	40.8	77.6	64.1	34.0	88.0	63.4	34.8	94.4	63.4	63.6	74.4	64.4
	1999	40	46.0	76.0	64.2	34.4	59.2	63.4	34.4	66.4	64.5	38.8	76.4	64.6	34.0	88.4	65.6	38.4	94.4	65.5	58.8	72.8	65.8
	2000	40	50.0	76.0	63.9	30.8	59.6	63.7	42.8	60.8	63.6	38.8	74.8	63.5	26.8	83.2	71.0	35.6	88.0	63.6	56.8	68.8	64.2
May-Jun	1997	40	54.0	90.0	70.2	38.0	88.0	68.1	30.4	84.0	70.2	51.2	82.4	66.4	49.2	84.4	69.0	37.2	74.0	68.4	51.2	64.4	59.2
	1998	40	54.0	88.0	69.9	36.8	86.8	71.4	25.2	96.0	67.6	48.0	82.0	66.6	49.6	84.4	67.7	36.4	75.2	68.3	49.6	62.8	53.0
	1999	40	50.0	82.0	68.4	39.2	85.6	66.8	26.8	92.0	67.1	50.4	79.6	67.4	49.6	84.0	66.8	40.4	74.8	68.8	51.6	63.2	55.2
	2000	40	48.0	88.0	68.2	38.8	84.4	70.3	24.4	88.0	68.6	51.6	74.4	69.4	26.8	83.2	71.0	41.2	68.8	69.6	49.2	62.8	58.2
Jul-Aug	1997	40	42.0	74.0	61.9	11.6	86.0	55.1	33.2	92.0	56.7	32.0	73.6	56.9	53.2	78.4	57.2	22.8	68.0	57.2	53.6	66.8	61.8
	1998	40	48.0	72.0	61.2	14.8	88.4	57.7	29.2	98.0	55.8	32.4	74.8	55.2	51.6	84.8	55.2	18.8	68.0	57.8	48.0	66.8	60.0
	1999	40	46.0	74.0	60.7	14.8	88.8	55.8	29.2	72.0	57.7	32.4	75.6	56.3	55.2	81.2	57.4	19.2	69.2	56.4	50.8	64.8	57.6
	2000	40	48.0	78.0	61.8	16.8	89.2	57.2	29.6	80.0	55.4	35.6	69.6	57.7	26.8	83.2	71.0	21.2	59.6	55.7	51.2	68.8	59.4
Sep-Oct	1997	40	42.0	78.0	59.9	32.4	96.2	59.9	34.8	76.6	58.7	43.2	62.8	59.8	38.4	64.4	59.3	40.4	89.6	58.2	53.2	69.2	64.8
	1998	40	38.0	74.0	59.9	36.8	92.8	60.4	37.2	83.0	58.5	41.6	61.6	58.2	41.2	69.2	58.2	38.4	90.0	58.1	50.8	67.2	61.6
	1999	40	46.0	78.0	60.6	34.8	96.0	60.0	35.2	86.0	59.4	42.8	60.8	59.1	42.8	67.6	57.9	37.6	88.4	58.3	56.0	68.0	62.0
	2000	40	44.0	78.0	61.2	32.4	95.6	59.4	32.4	92.0	59.5	41.2	52.8	60.2	26.8	83.2	71.0	37.2	84.0	59.0	54.4	67.6	58.8
Nov-Dec	1997	40	48.0	80.0	64.3	46.4	88.8	64.5	24.4	92.4	65.4	48.0	68.0	65.5	45.2	67.2	63.1	8.0	78.8	64.0	66.8	77.2	69.6
	1998	40	50.0	86.0	65.4	48.0	90.4	66.6	26.8	93.6	65.4	45.6	70.4	65.1	44.8	63.6	63.8	10.4	77.6	66.4	68.4	77.2	70.4
	1999	40	44.0	90.0	64.7	49.2	89.6	65.3	26.4	94.8	65.5	44.0	68.0	65.5	45.2	64.8	64.0	10.0	77.2	63.3	60.4	74.4	69.2
	2000	40	46.0	84.0	65.0	46.0	88.8	65.0	30.0	89.2	65.4	46.8	58.8	66.4	26.8	83.2	71.0	10.0	68.4	65.3	67.2	76.8	71.4
Total	1997	240	42.0	90.0	63.8	11.6	96.2	62.4	24.4	92.4	62.9	32.0	82.4	61.9	33.6	88.4	62.2	8.0	94.0	62.3	48.8	77.2	64.2
	1998	240	38.0	72.0	63.5	14.8	61.2	63.4	25.2	62.8	62.0	32.4	61.6	62.0	34.0	63.6	61.6	10.4	68.0	62.5	48.0	62.8	62.3
	1999	240	44.0	74.0	63.3	14.8	59.2	62.1	25.2	61.2	62.6	32.4	60.8	62.8	34.0	64.8	62.4	10.0	69.2	62.4	50.8	63.2	61.3
	2000	240	44.0	74.0	63.7	16.8	59.6	62.8	24.4	54.0	62.5	35.6	52.8	63.4	26.8	83.2	71.0	10.0	59.6	62.6	49.2	62.8	62.0

Note: No.*-Total number of CARMA-GMCS generated mean values

TABLE C-17. Calibrated Mean Values of Selected QUAL2E Model Parameters Along the Study Segment of the South Platte River

Series	Reach No.	*a*	*b*	*c*	*d*	β_{ON}	β_{NH_3}	β_{NO_2}	k_{FC}
	1	0.306	0.373	0.191	0.398	0.022	0.627	0.406	0.500
	2	0.306	0.373	0.191	0.398	0.480	0.087	1.748	0.500
J	3	0.047	0.722	0.898	0.227	0.020	3.160	18.833	0.500
A	4	0.047	0.666	0.090	0.579	0.020	3.160	7.781	1.500
N	5	0.722	0.151	0.429	0.675	0.205	1.285	0.090	3.956
	6	0.723	0.462	0.555	0.365	0.274	0.021	0.120	3.466
F	7	0.384	0.140	0.714	0.539	0.021	0.023	0.090	3.965
E	8	0.121	0.478	0.083	0.522	0.222	1.272	0.437	0.427
B	9	0.028	0.701	0.677	0.221	0.048	1.036	13.359	0.458
	10	0.719	0.173	0.008	0.692	0.020	0.284	3.743	0.332
	11	0.488	0.149	0.383	0.217	0.020	3.160	45.000	0.383
	12	0.498	0.380	0.459	0.379	0.020	3.150	19.770	0.545
	1	0.306	0.373	0.191	0.398	0.126	1.281	0.762	0.786
	2	0.306	0.373	0.191	0.398	0.158	1.202	1.074	0.708
M	3	0.306	0.373	0.191	0.398	0.020	0.618	0.785	0.262
A	4	0.059	0.597	0.143	0.403	0.026	1.272	0.682	0.726
R	5	0.059	0.597	0.143	0.403	0.082	0.295	0.091	0.192
	6	0.059	0.597	0.143	0.403	0.055	0.030	1.174	0.134
A	7	0.121	0.478	0.083	0.522	0.134	0.020	0.091	0.057
P	8	0.493	0.143	0.504	0.217	0.685	1.071	19.921	0.069
R	9	0.511	0.218	0.528	0.217	0.891	1.294	20.000	0.061
	10	0.636	0.182	0.415	0.217	0.891	1.253	10.664	0.095
	11	0.719	0.173	0.008	0.692	0.020	3.141	29.997	0.125
	12	0.621	0.216	0.015	0.584	0.020	2.959	8.628	0.062
	1	0.221	0.190	0.733	0.501	0.032	0.399	0.324	0.500
	2	0.948	0.320	0.917	0.299	0.058	0.577	0.754	0.500
M	3	0.306	0.373	0.191	0.398	0.170	0.366	0.550	0.500
A	4	0.059	0.597	0.143	0.403	0.025	0.078	6.084	1.500
Y	5	0.540	0.738	0.269	0.217	0.023	0.783	9.379	0.884
	6	0.564	0.277	0.372	0.235	0.041	0.028	0.136	0.576
J	7	0.637	0.212	0.444	0.217	0.033	0.209	4.811	0.615
U	8	1.213	0.738	0.912	0.692	0.117	3.122	19.353	0.060
N	9	0.087	0.363	0.591	0.555	0.895	3.160	19.390	0.058
	10	1.203	0.316	0.574	0.692	0.055	3.160	19.762	0.074
	11	1.220	0.768	0.227	0.690	0.450	3.157	30.000	0.071
	12	0.086	0.569	0.927	0.377	0.878	3.160	8.913	0.058
	1	0.549	0.352	0.422	0.224	0.885	1.039	0.695	3.960
	2	1.000	0.140	0.507	0.221	0.900	0.239	1.015	3.863
J	3	1.072	0.685	0.918	0.583	0.021	0.346	0.806	3.838
U	4	1.017	0.286	0.637	0.518	0.020	0.220	0.397	3.767
L	5	1.220	0.722	0.422	0.295	0.164	0.022	1.093	3.089
	6	0.656	0.508	0.506	0.233	0.151	0.023	1.302	1.206
A	7	0.678	0.139	0.191	0.238	0.021	0.020	0.844	3.039
U	8	0.055	0.290	0.902	0.626	0.883	0.606	12.585	1.148
G	9	0.046	0.660	0.930	0.347	0.846	2.831	19.466	0.181
	10	0.054	0.605	0.569	0.689	0.629	3.077	19.901	0.063
	11	0.533	0.140	0.776	0.288	0.021	3.160	29.945	0.377
	12	1.064	0.181	0.217	0.692	0.020	3.160	3.742	0.058
	1	0.046	0.602	0.570	0.283	0.148	0.024	0.423	0.500
	2	0.216	0.575	0.920	0.344	0.438	0.020	0.718	0.500
S	3	0.055	0.719	0.179	0.585	0.134	1.288	0.100	0.500
E	4	1.193	0.753	0.120	0.227	0.102	0.117	0.090	1.500
P	5	0.107	0.140	0.207	0.300	0.296	1.286	0.118	3.425
	6	0.612	0.660	0.291	0.386	0.032	0.022	0.103	0.052
O	7	0.476	0.243	0.487	0.230	0.022	0.022	0.091	3.198
C	8	0.121	0.478	0.083	0.522	0.900	0.048	7.040	3.896
T	9	0.028	0.701	0.677	0.220	0.639	0.574	19.032	2.244
	10	0.719	0.173	0.008	0.692	0.050	3.160	19.956	1.560
	11	0.457	0.253	0.401	0.305	0.020	3.105	20.000	0.643
	12	0.339	0.341	0.081	0.219	0.022	0.274	1.326	0.934
	1	0.619	0.333	0.416	0.242	0.892	0.621	0.384	0.500
	2	0.692	0.141	0.439	0.283	0.812	1.269	1.081	0.500
N	3	0.274	0.238	0.179	0.296	0.021	1.018	0.054	0.500
O	4	0.151	0.140	0.315	0.230	0.020	1.290	0.055	1.500
V	5	0.059	0.597	0.143	0.403	0.330	1.300	4.109	0.513
	6	0.059	0.597	0.143	0.403	0.629	1.300	1.034	0.432
D	7	0.121	0.478	0.083	0.522	0.900	1.301	11.020	0.060
E	8	0.651	0.140	0.927	0.495	0.701	0.688	14.246	0.053
C	9	0.103	0.464	0.191	0.692	0.401	0.261	19.997	0.102
	10	0.741	0.210	0.894	0.533	0.020	1.299	15.998	0.057
	11	0.556	0.182	0.766	0.219	0.023	3.160	20.000	0.051
	12	0.658	0.255	0.082	0.232	0.022	1.982	7.566	0.128

TABLE C-18. Calibrated Coefficients of Variation and Probability Distributions of Selected QUAL2E Model Parameters for Each Season for the Study Segment of the South Platte River

Parameter	Jan-Feb		Mar-Apr		May-Jun		Jul-Aug		Sep-Oct		Nov-Dec	
Name	CV	Dist.	CV	Dist.	CV	Dist.	CV	Dist.	CV	Dist.	CV	Dist.
k_D	0.20	NM	0.20	NM	0.20	NM	0.35	NM	0.50	LN	0.20	NM
a	0.15	LN	0.10	LN	0.33	NM	0.05	NM	0.10	NM	0.05	NM
b	0.01	LN	0.01	NM	0.01	NM	0.08	NM	0.01	LN	0.01	LN
c	0.50	NM	0.33	NM	0.15	LN	0.10	NM	0.50	NM	0.50	LN
d	0.08	NM	0.01	LN	0.01	LN	0.01	LN	0.33	NM	0.15	LN
n	0.05	NM	0.05	NM	0.05	LN	0.05	NM	0.05	NM	0.05	NM
β_{ON}	0.25	LN	0.15	LN	0.05	NM	0.05	LN	0.25	LN	0.25	LN
β_{NH_3}	0.20	LN	0.13	LN	0.13	NM	0.13	NM	0.20	LN	0.13	NM
β_{NO_2}	0.20	NM	0.20	LN	0.05	LN	0.05	NM	0.20	LN	0.20	NM
k_{FC}	0.25	LN	0.63	NM	0.63	LN	0.05	LN	0.25	LN	0.15	NM

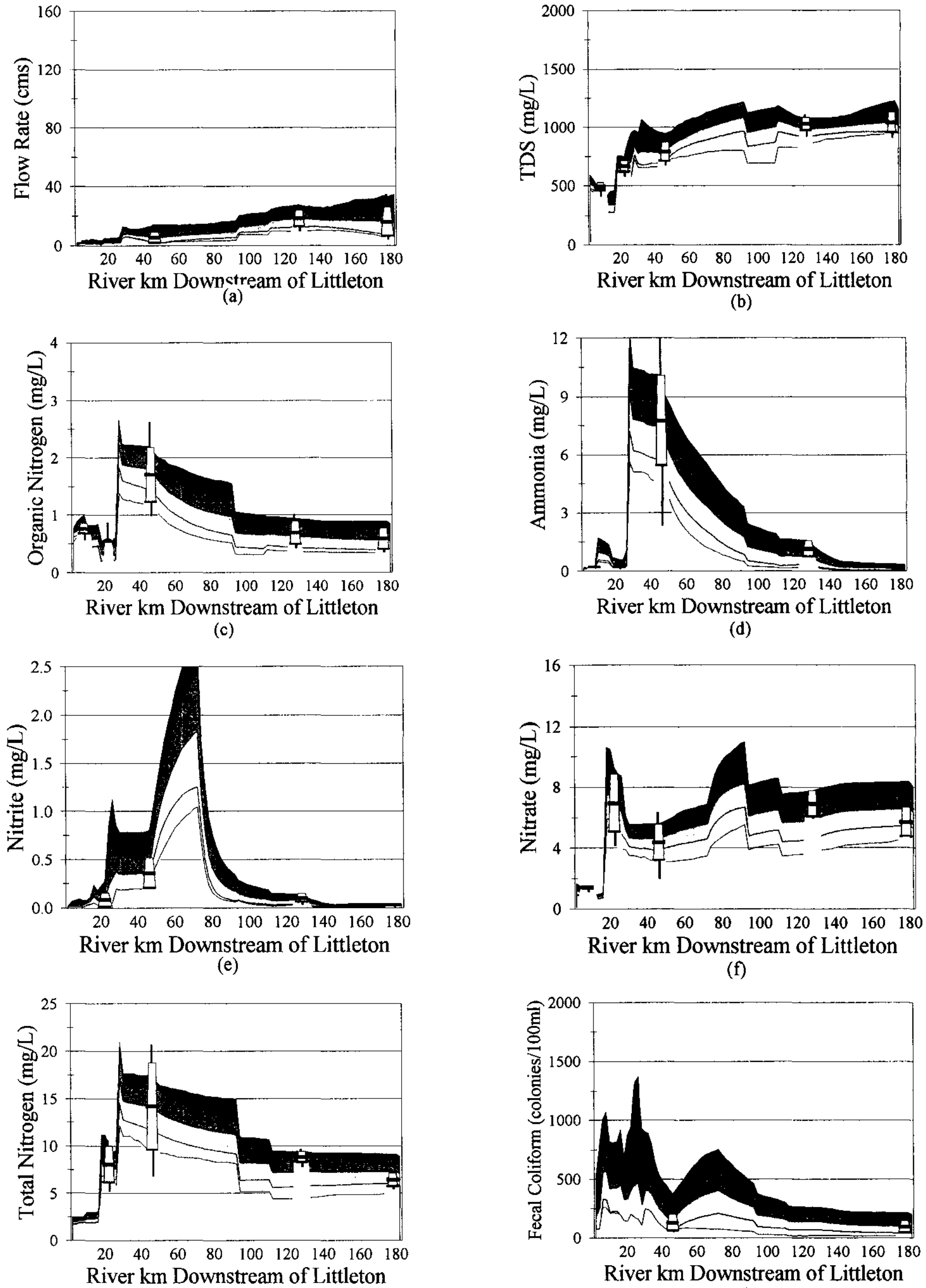
Notes: CV-Coefficient of Variation
Dist.-Distribution
NM-Normal distribution
LN-Lognormal distribution

TABLE C-19. Calibrated Deterministic Values of Nonpoint Source Correction Factors Along the Study Segment of the South Platte River Basin

Series	Reach No.	Factor for Nonpoint Source (C_{TDS}) fctts$_i$	Factor for Nonpoint Source ($C_{O\text{-}N}$) fcton$_i$	Factor for Nonpoint Source (C_{NH_3}) fctam$_i$	Factor for Nonpoint Source (C_{NO_2}) fctni$_i$	Factor for Nonpoint Source (C_{NO_3}) fctna$_i$	Factor for Nonpoint Source (C_{FC}) fct$_i$
	1	1.2611	0.0073	0.6225	0.0592	0.3088	0.5000
	2	0.5440	0.6710	0.0520	1.8745	0.1901	0.5000
J	3	2.1664	0.2957	3.0000	0.0002	0.0006	0.5000
A	4	1.2517	0.9026	3.0000	2.1700	0.0011	0.5000
N	5	2.0451	0.0002	0.0122	2.7980	0.0001	0.7282
	6	2.1217	0.0004	0.4279	0.3194	0.0001	0.2505
F	7	0.3538	0.0003	0.0477	2.3738	0.0000	0.5579
E	8	1.1973	0.3241	0.0104	1.9839	2.6740	0.3100
B	9	1.3015	0.2944	0.1717	0.5864	2.0002	0.0274
	10	0.0002	0.0821	2.9999	0.5724	2.0002	0.0996
	11	1.1611	0.2486	0.1738	2.5605	1.1054	0.0084
	12	1.4417	0.1882	0.0433	3.0001	1.3344	0.0039
	1	0.0023	0.2385	0.8800	0.8427	0.3822	0.0123
	2	2.3927	0.4297	0.4175	1.2419	0.3474	0.0008
M	3	0.0374	0.8436	2.5082	3.7837	0.0000	0.1345
A	4	0 0004	0.0003	2.0998	1.2494	0.0012	0.0724
R	5	0.8712	0.0001	0.0109	3.9634	0.3875	0.4291
	6	0.2703	0.1692	0.0008	0.7430	2.7102	0.1885
A	7	1.5120	0.0001	0.0001	0.2423	2.6815	0.4385
P	8	2.1892	0.0702	0.0053	2.8101	0.0733	0.0009
R	9	0.3707	0.0203	0.1694	1.8757	2.6624	0.0001
	10	1.2416	2.9944	0.2609	1.0945	2.4996	0.0001
	11	3.0000	0.1069	0.1758	0.6142	0.4434	0.0000
	12	0.5486	0.0825	0.1819	3.0002	1.2859	0.0001
	1	1.4308	0.0754	0.2577	0.7151	0.2343	0.5000
	2	0.5136	0.3360	0.1395	0.0420	1.1767	0.5000
M	3	1.7920	0.0003	2.5834	1.7935	1.4806	0.5000
A	4	0.0017	0.0045	0.7915	1.5650	0.8044	0.5000
Y	5	3.0001	0.0001	0.2286	3.4511	2.7943	0.1555
	6	0.9331	0 0043	0.2035	0.0058	0.2147	0.0882
J	7	0.0371	1.6331	1.9100	3.3959	3.0000	0.5894
U	8	1.1709	0.0000	0.3701	2.9958	0.0002	0.0007
N	9	0.0065	0.0330	0.3700	0.0006	0.6176	0.0043
	10	0.0024	0.0001	0.2821	2.1830	0.8507	0.0001
	11	1.3519	0.0028	0.4268	2.9942	1.4478	0.4323
	12	0.5788	0.9374	0.0006	2.9956	0.4025	0.0001
	1	0.8361	0.7497	0.0151	1.3883	2.6729	0.7732
	2	0.3369	0.7306	0.2888	1.2428	1.2370	1.0790
J	3	0.0000	0.0011	0.0005	2.1551	0.0001	2.9417
U	4	0.0019	0.0008	0.0003	2.7910	0.0197	0.0631
L	5	1.7582	2.8103	0.0028	2.2765	3.0001	0.6685
	6	0.3370	0.2087	0.0071	3.5112	1.3902	0.3816
A	7	1.9009	0.3130	0.0001	2.5410	2.6051	0.0014
U	8	0.6261	0.5194	2.9742	2.5673	0.0010	0.3344
G	9	1.6186	0.1231	1.7281	0.0198	2.3301	0.0591
	10	0.0002	0.6903	0.3314	2.8303	1.7877	0.3620
	11	0.2313	0.5793	0.0025	2.1886	2.2095	1.1788
	12	1.1593	0.0229	0.1158	3.3037	3.0001	0.0043
	1	0.0681	0.0001	0.0002	0.1213	0.0755	0.5000
	2	0.9254	0.6690	0.6258	0.0317	2.2025	0.5000
S	3	0.0000	0.4038	1.1783	4.0307	0.0216	0.5000
E	4	1.8042	0.0008	0.6218	0.0120	0.0121	0.5000
P	5	0.4331	0.0017	0.0157	1.4493	0.0004	0 0045
	6	0.0005	0.0104	0.0013	2.8230	0.0001	0.7882
O	7	0.0003	0.0011	0.0005	0.0535	0.0001	0.0662
C	8	1.4020	0.0070	0.8834	0.9404	0.4020	0.0889
T	9	0.6814	0.3341	2.3592	2.2248	0.1777	0.0074
	10	0.0004	0.0633	0.0003	1.3242	1.7270	0.0008
	11	1.0807	0.0001	0.0001	2.5143	1.9784	0.4028
	12	0.0001	0.0000	0.0001	2.9487	0.0017	0.3634
	1	2.1329	1.1352	0.7668	1.6845	0.0076	0.5000
	2	1.6754	0.7052	0 5799	0.0018	3.6328	0.5000
N	3	0.0003	0.3084	2.9135	2.9799	0.1858	0.5000
O	4	0.0993	0.0044	0.6510	2.9999	2.9956	0.5000
V	5	0.0840	1.4443	0.3005	3.4239	0.6202	2.5146
	6	1.5562	0.0010	0.0000	0.0069	0.0006	1.9859
D	7	0.4623	0.0053	0.0037	0.0004	0.0063	0.0012
E	8	1.1819	0.0027	0.0412	2.9502	0.0407	0.0001
C	9	0.0002	0.0066	0.4343	0.7372	1.0061	0.0000
	10	0.1166	0.9560	0.0123	2.8284	2.3758	0.0000
	11	0.0001	0.0005	0.0001	0.0031	0.0001	0.2215
	12	0.8795	0.0025	2.9938	0.0002	0.2231	0.5272

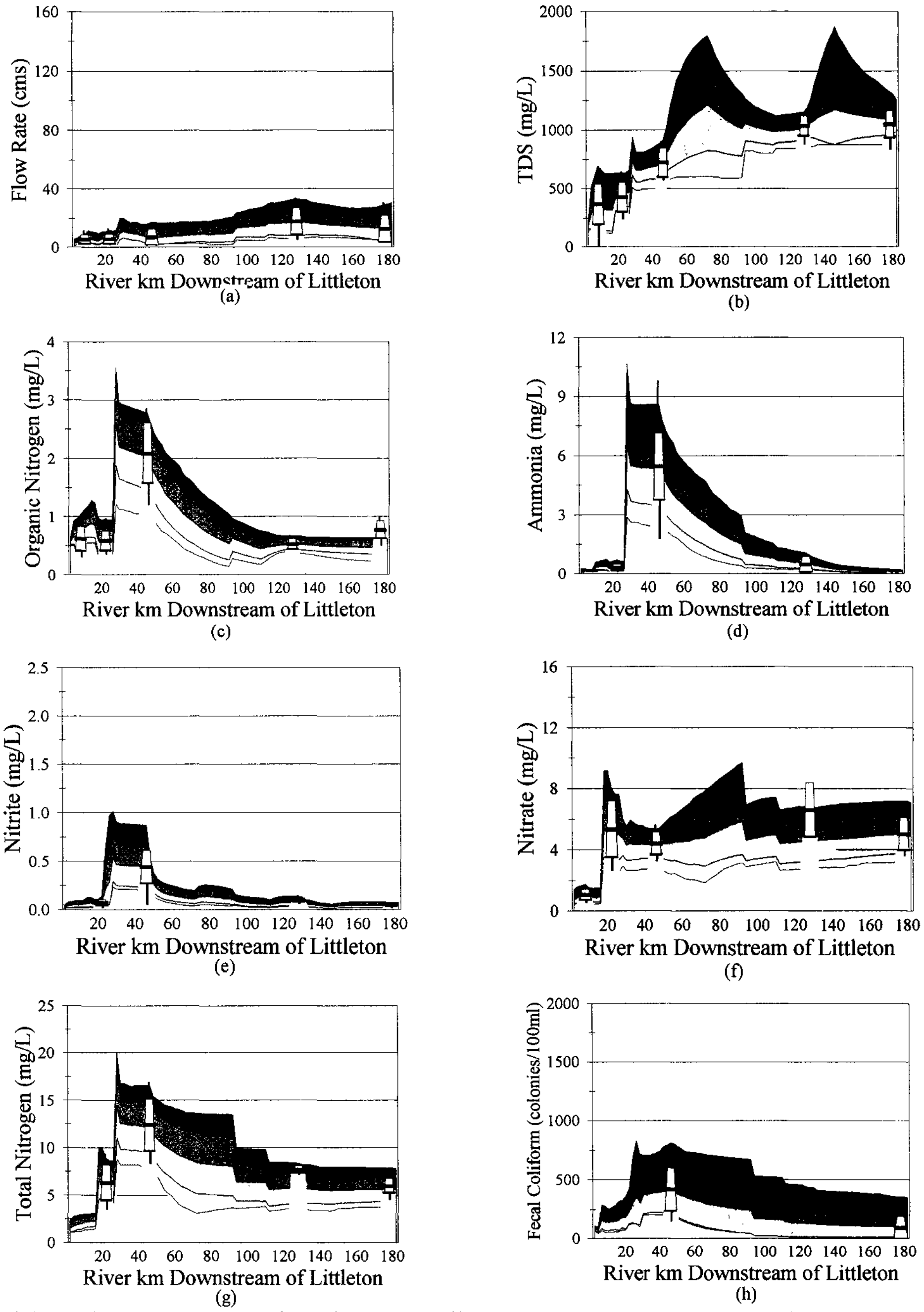
TABLE C-20. Calibrated Deterministic Values of Point Source Correction Factors Along the Study Segment of the South Platte River

Name (Site-Variable)	Jan-Feb	Mar-Apr	May-Jun	Jul-Aug	Sep-Oct	Nov-Dec
T1-C_{TDS}	1.000	1.000	1.000	1.000	2.774	2.444
T1-C_{ON}	0.102	0.053	0.062	0.372	0.159	0.094
T1-C_{NH_3}	1.178	1.000	0.896	0.499	0.386	0.377
T1-C_{NO_3}	2.548	0.379	2.026	2.025	2.458	2.856
W1-C_{TDS}	0.363	0.004	0.276	0.583	1.000	1.000
W1-C_{ON}	0.130	0.647	1.771	0.242	0.382	0.678
W1-C_{NO_2}	0.033	1.197	1.000	0.781	0.731	2.759
W1-C_{NO_3}	1.000	1.449	1.000	0.800	0.007	0.443
W4-C_{TDS}	0.975	0.655	0.470	0.518	0.617	0.650
W4-C_{ON}	1.000	1.000	1.000	0.082	0.174	0.133
W4-C_{NH_3}	0.197	1.000	1.000	1.000	0.004	1.000
W4-C_{NO_2}	1.000	0.988	0.233	0.034	0.213	1.139
W4-C_{NO_3}	2.817	2.438	0.488	1.568	0.341	2.240
T6-C_{NO_2}	2.152	2.326	1.000	2.369	2.503	3.000
T6-C_{NO_3}	0.001	1.000	0.258	1.000	2.987	1.000
W5-C_{TDS}	1.771	1.947	2.186	1.968	2.087	1.835
T9-C_{NH_3}	1.000	1.000	1.000	0.065	1.000	0.036
T9-C_{NO_2}	1.000	1.000	1.000	4.945	1.000	4.052
T9-C_{NO_3}	1.000	1.000	1.000	1.000	1.000	1.081
W6-C_{NO_2}	1.000	1.000	1.000	0.024	1.000	4.457
W6-C_{NO_3}	1.000	1.000	1.000	1.000	1.000	0.036
T11-C_{TDS}	1.172	0.896	2.656	1.378	0.982	2.034
T11-C_{ON}	0.177	0.951	3.845	1.003	0.564	1.213
T11-C_{NH_3}	0.960	0.094	1.019	0.005	1.000	0.186
T11-C_{NO_2}	2.337	1.000	2.991	1.000	0.365	0.297
T11-C_{NO_3}	1.186	2.738	0.048	4.030	2.109	1.796
T12-C_{TDS}	1.000	1.320	1.000	1.000	1.000	1.000
T12-C_{NH_3}	2.959	0.504	0.441	0.886	1.000	0.243
T12-C_{NO_2}	1.689	2.003	1.000	1.000	0.320	2.644
T12-C_{NO_3}	0.000	2.689	1.000	1.000	1.000	1.000
T14-C_{NO_2}	1.000	1.000	2.539	2.050	1.000	1.000



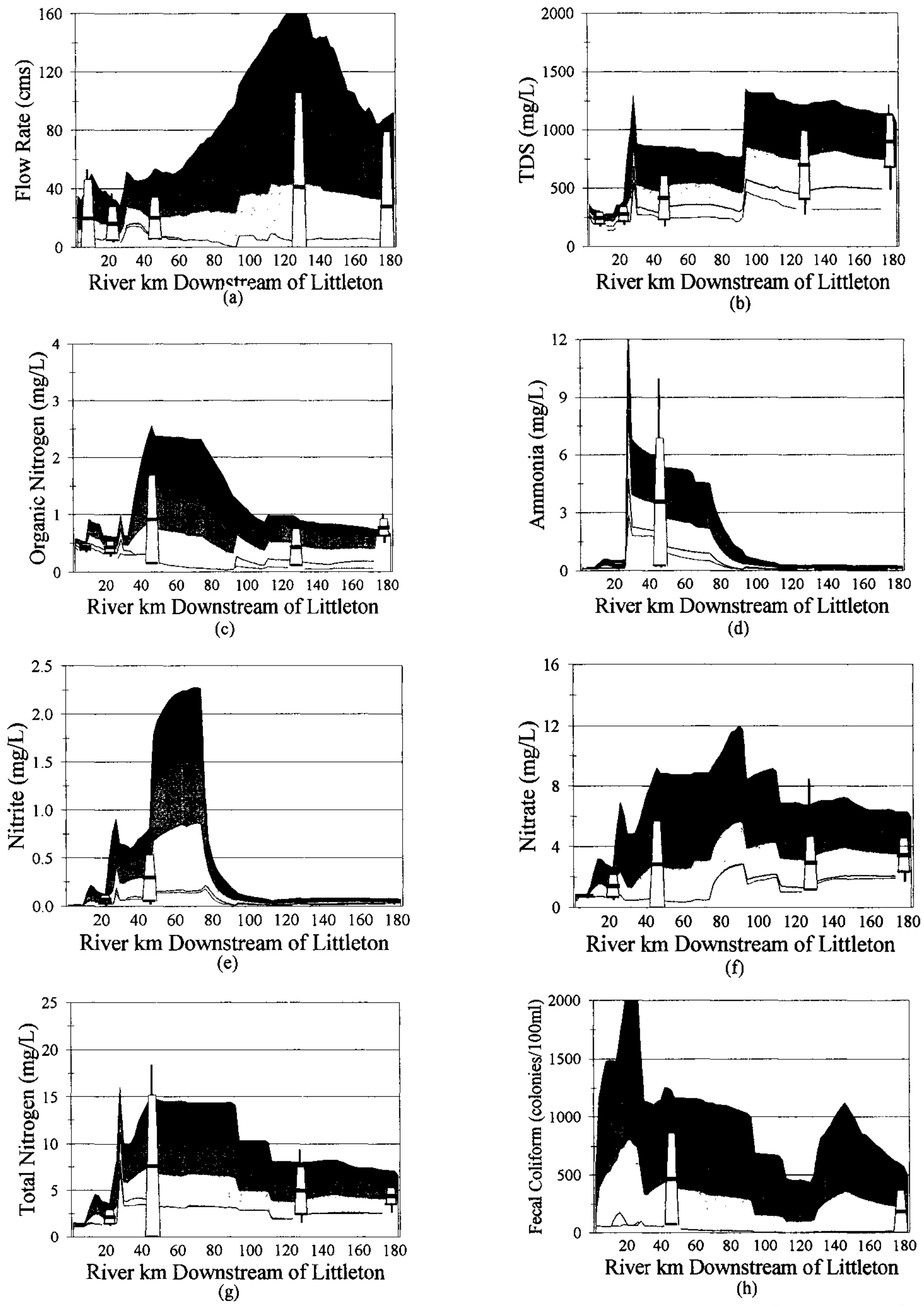
Note: The lightest shaded area extends from the 5% quantile simulated by the QUAL2E model to mean minus one standard deviation. The next darker shaded area extends from the mean minus one standard deviation to the mean, the next darker area from the mean to the mean plus one standard deviation, and the darkest from the mean plus one standard deviation to the 95% quantile simulated by the QUAL2E model. The upper and lower whiskers on the Box and Whisker plots represent CARMA-GMCS generated 95% and 5% quantiles, respectively; the upper and lower sides of the box represent the mean plus one standard deviation and mean minus one standard deviation; and the mark in the middle of the box represents the mean.

FIG. C-1. Values Simulated by the QUAL2E Model Along the River And Generated by the CARMA-GMCS Model at Guaging Locations for (a) Q, (b) C_{TDS}, (c) $C_{O\text{-}N}$, (d) C_{NH_3}, (e) C_{NO_2}, (f) C_{NO_3}, (g) C_N, and (h) C_{FC} during a Second Week in the Low-Flow Season (Week 2, January 1994)



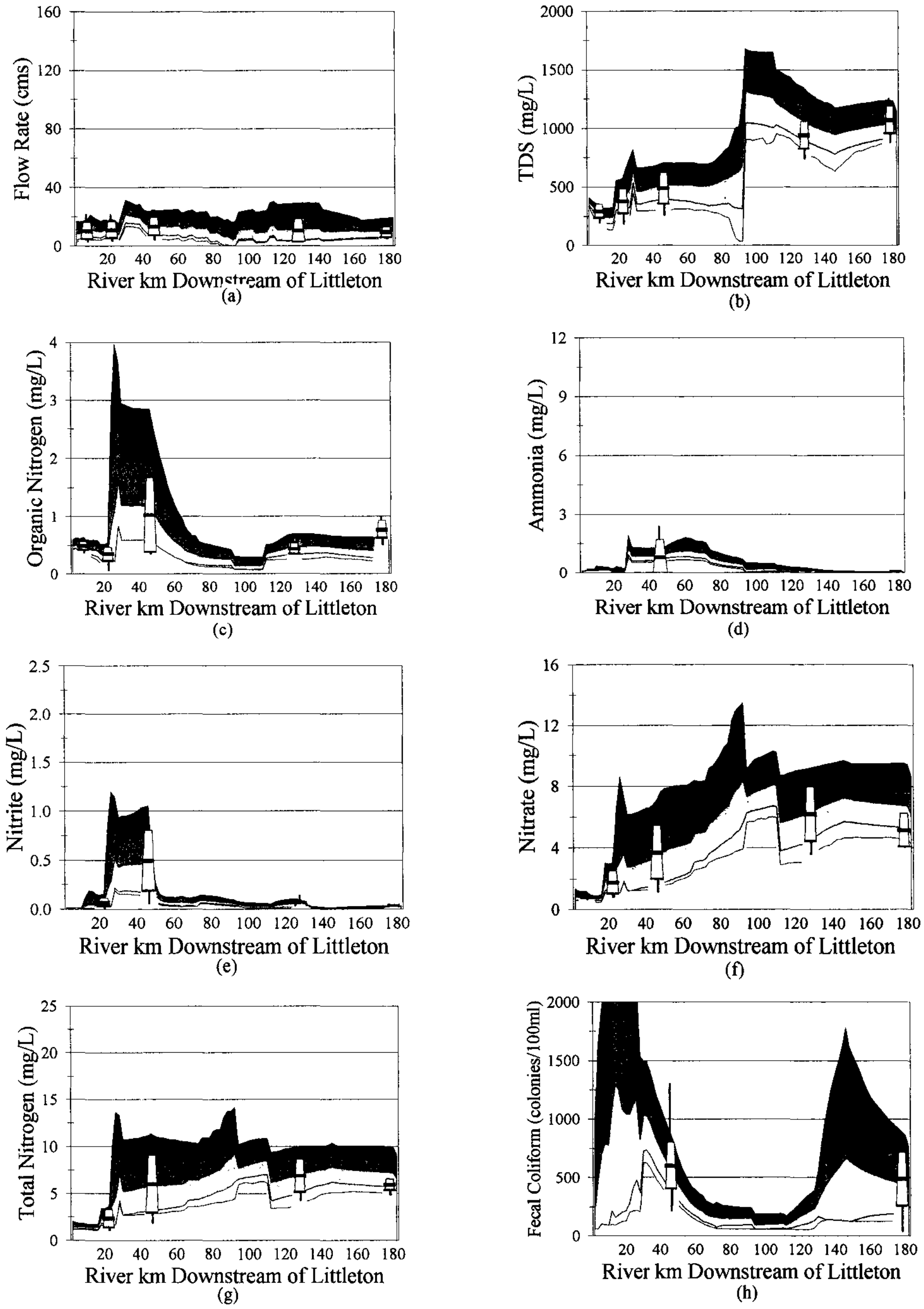
Note: The lightest shaded area extends from the 5% quantile simulated by the QUAL2E model to mean minus one standard deviation. The next darker shaded area extends from the mean minus one standard deviation to the mean, the next darker area from the mean to the mean plus one standard deviation, and the darkest from the mean plus one standard deviation to the 95% quantile simulated by the QUAL2E model. The upper and lower whiskers on the Box and Whisker plots represent CARMA-GMCS generated 95% and 5% quantiles, respectively; the upper and lower sides of the box represent the mean plus one standard deviation and mean minus one standard deviation; and the mark in the middle of the box represents the mean.

FIG. C-2. Values Simulated by the QUAL2E Model Along the River And Generated by the CARMA-GMCS Model at Guaging Locations for (a) Q, (b) C_{TDS}, (c) $C_{O\text{-}N}$, (d) C_{NH_3}, (e) C_{NO_2}, (f) C_{NO_3}, (g) C_N, and (h) C_{FC} during a Second Week in the Early-Spring Season (Week 2, March 1994)



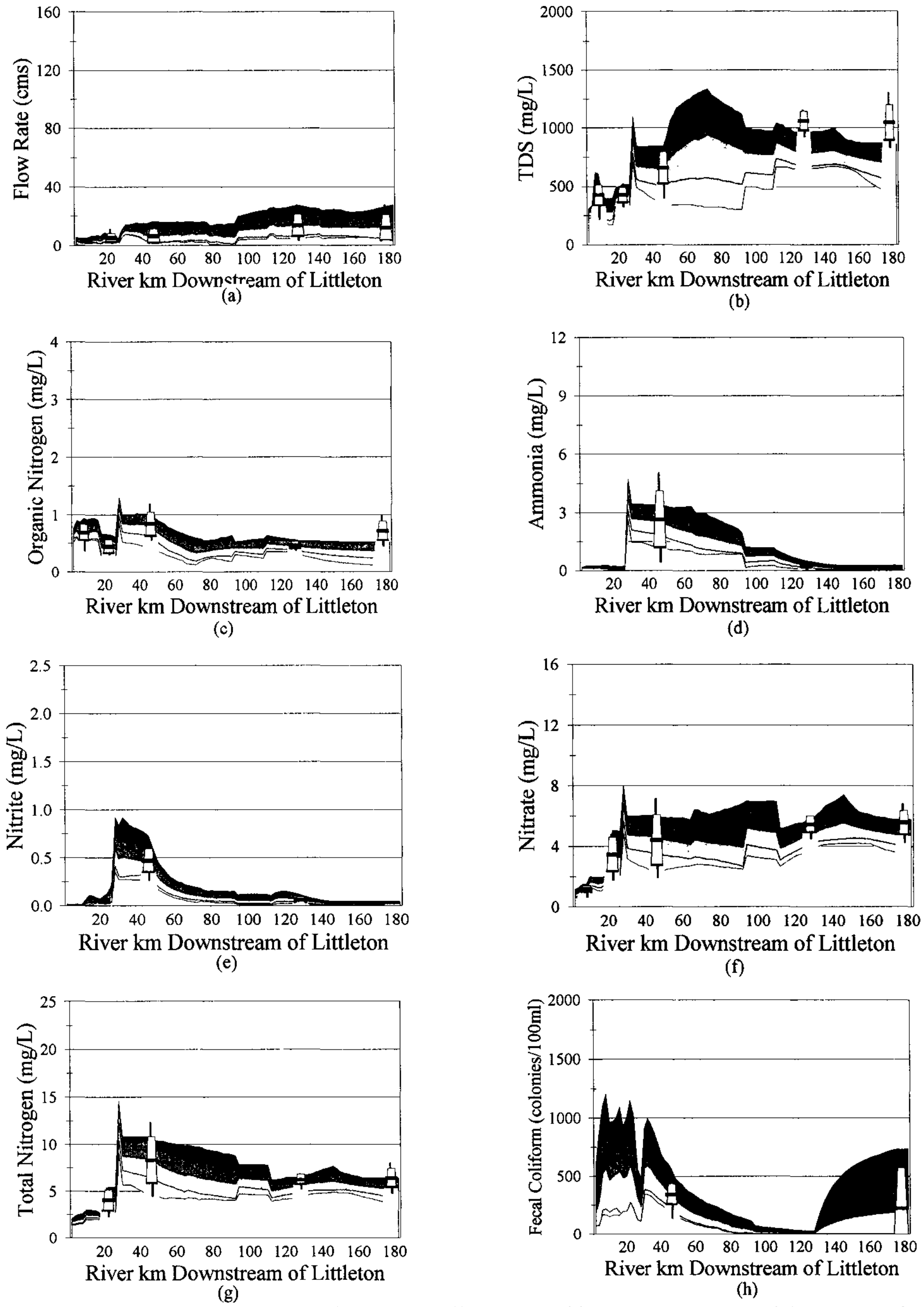
Note: The lightest shaded area extends from the 5% quantile simulated by the QUAL2E model to mean minus one standard deviation. The next darker shaded area extends from the mean minus one standard deviation to the mean, the next darker area from the mean to the mean plus one standard deviation, and the darkest from the mean plus one standard deviation to the 95% quantile simulated by the QUAL2E model. The upper and lower whiskers on the Box and Whisker plots represent CARMA-GMCS generated 95% and 5% quantiles, respectively; the upper and lower sides of the box represent the mean plus one standard deviation and mean minus one standard deviation; and the mark in the middle of the box represents the mean.

FIG. C-3. Values Simulated by the QUAL2E Model Along the River And Generated by the CARMA-GMCS Model at Guaging Locations for (a) Q, (b) C_{TDS}, (c) $C_{O\text{-}N}$, (d) C_{NH_3}, (e) C_{NO_2}, (f) C_{NO_3}, (g) C_N, and (h) C_{FC} during a Second Week in the High-Flow Season (Week 2, May 1994)



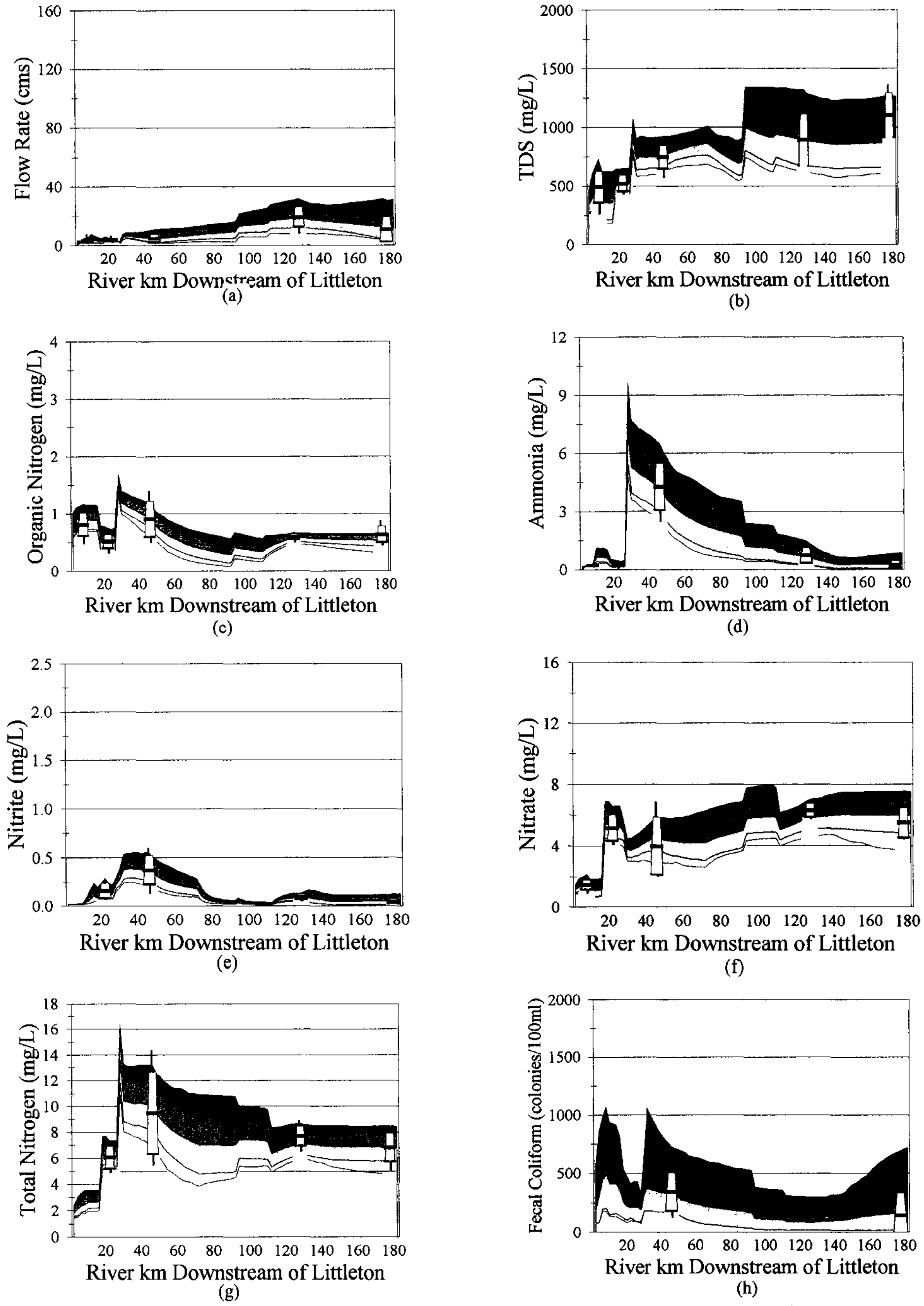
Note: The lightest shaded area extends from the 5% quantile simulated by the QUAL2E model to mean minus one standard deviation. The next darker shaded area extends from the mean minus one standard deviation to the mean, the next darker area from the mean to the mean plus one standard deviation, and the darkest from the mean plus one standard deviation to the 95% quantile simulated by the QUAL2E model. The upper and lower whiskers on the Box and Whisker plots represent CARMA-GMCS generated 95% and 5% quantiles, respectively; the upper and lower sides of the box represent the mean plus one standard deviation and mean minus one standard deviation; and the mark in the middle of the box represents the mean.

FIG. C-4. Values Simulated by the QUAL2E Model Along the River And Generated by the CARMA-GMCS Model at Guaging Locations for (a) Q, (b) C_{TDS}, (c) $C_{O\text{-}N}$, (d) C_{NH_3}, (e) C_{NO_2}, (f) C_{NO_3}, (g) C_N, and (h) C_{FC} during a Second Week in the Summer Season (Week 2, July 1994)



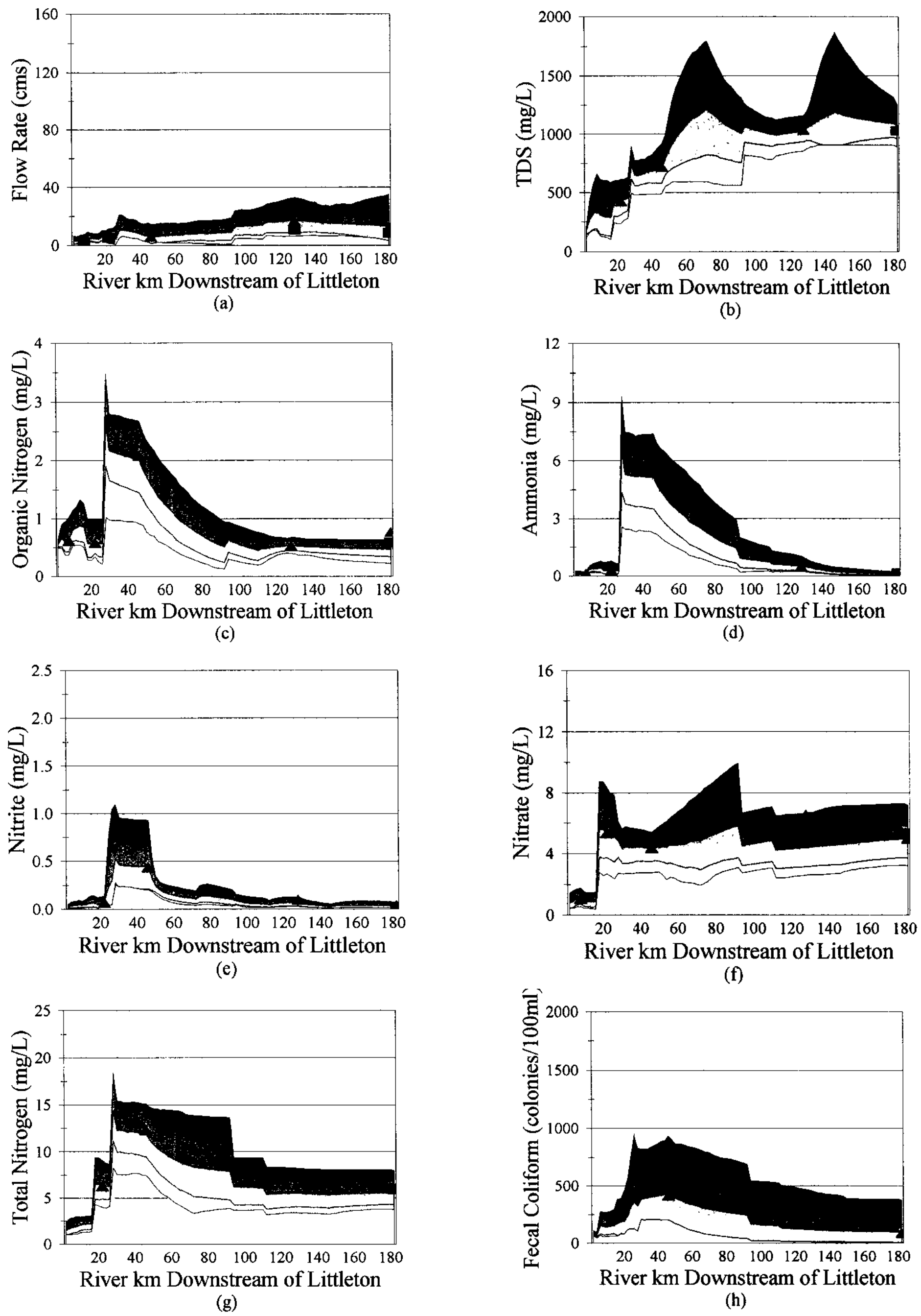
Note: The lightest shaded area extends from the 5% quantile simulated by the QUAL2E model to mean minus one standard deviation. The next darker shaded area extends from the mean minus one standard deviation to the mean, the next darker area from the mean to the mean plus one standard deviation, and the darkest from the mean plus one standard deviation to the 95% quantile simulated by the QUAL2E model. The upper and lower whiskers on the Box and Whisker plots represent CARMA-GMCS generated 95% and 5% quantiles, respectively; the upper and lower sides of the box represent the mean plus one standard deviation and mean minus one standard deviation; and the mark in the middle of the box represents the mean.

FIG. C-5. Values Simulated by the QUAL2E Model Along the River And Generated by the CARMA-GMCS Model at Guaging Locations for (a) Q, (b) C_{TDS}, (c) $C_{O\text{-}N}$, (d) C_{NH_3}, (e) C_{NO_2}, (f) C_{NO_3}, (g) C_N, and (h) C_{FC} during a Second Week in the Fall Season (Week 2, September 1994)



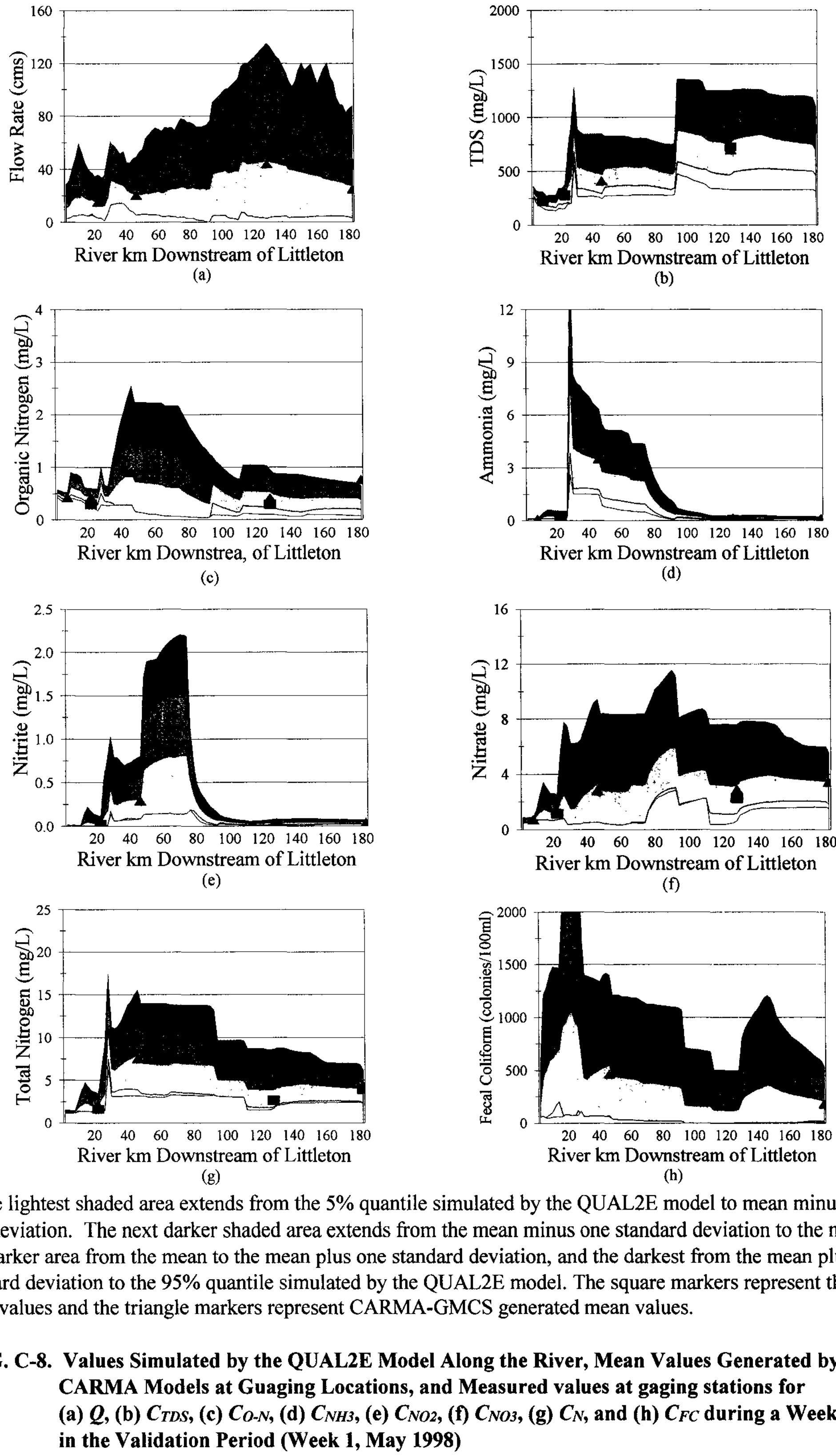
Note: The lightest shaded area extends from the 5% quantile simulated by the QUAL2E model to mean minus one standard deviation. The next darker shaded area extends from the mean minus one standard deviation to the mean, the next darker area from the mean to the mean plus one standard deviation, and the darkest from the mean plus one standard deviation to the 95% quantile simulated by the QUAL2E model. The upper and lower whiskers on the Box and Whisker plots represent CARMA-GMCS generated 95% and 5% quantiles, respectively; the upper and lower sides of the box represent the mean plus one standard deviation and mean minus one standard deviation; and the mark in the middle of the box represents the mean.

FIG. C-6. Values Simulated by the QUAL2E Model Along the River And Generated by the CARMA-GMCS Model at Guaging Locations for (a) Q, (b) C_{TDS}, (c) $C_{O\text{-}N}$, (d) C_{NH_3}, (e) C_{NO_2}, (f) C_{NO_3}, (g) C_N, and (h) C_{FC} during a Second Week in the Early Winter Season (Week 2, November 1994)



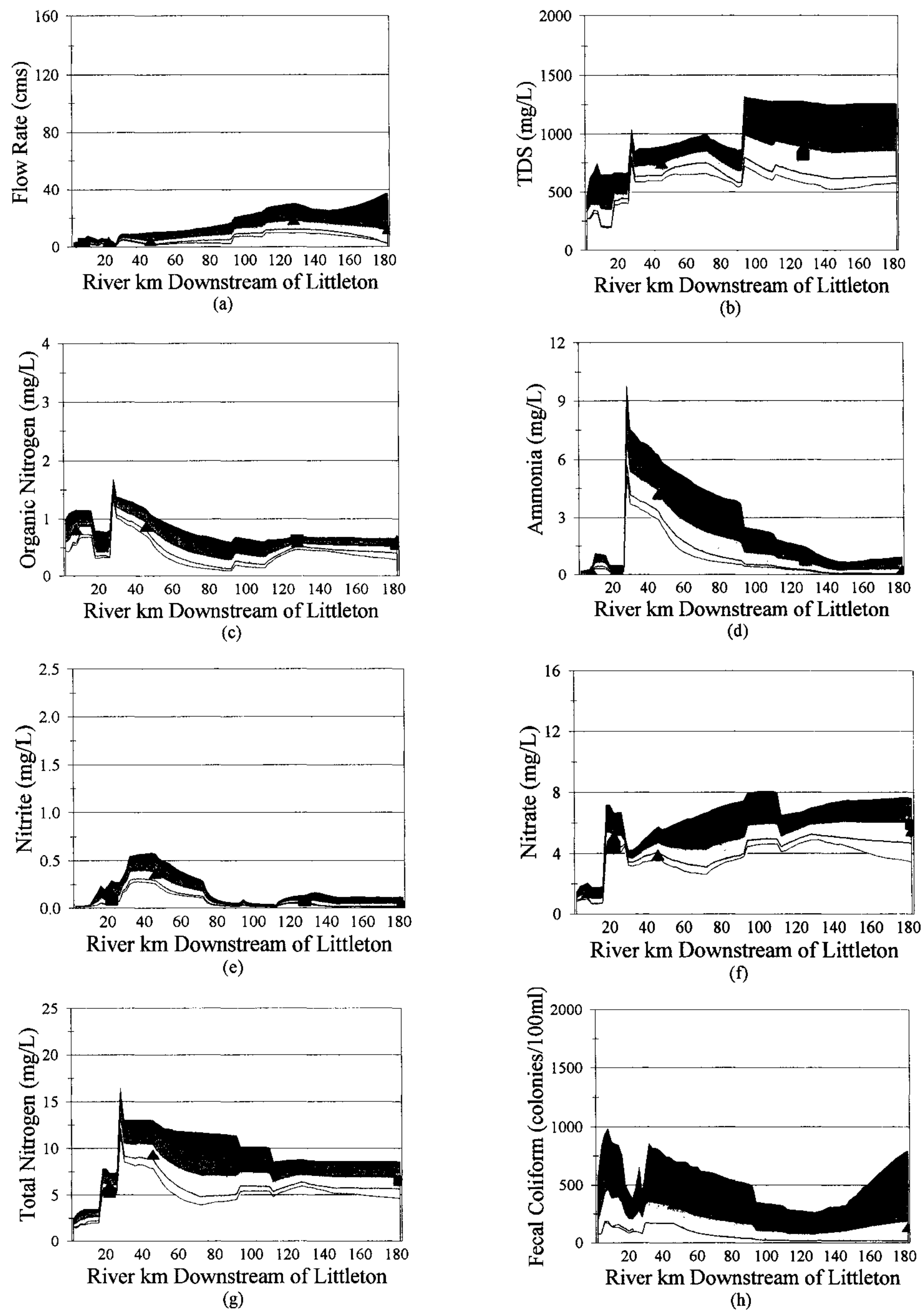
Note: The lightest shaded area extends from the 5% quantile simulated by the QUAL2E model to mean minus one standard deviation. The next darker shaded area extends from the mean minus one standard deviation to the mean, the next darker area from the mean to the mean plus one standard deviation, and the darkest from the mean plus one standard deviation to the 95% quantile simulated by the QUAL2E model. The square markers represent the measured values and the triangle markers represent CARMA-GMCS generated mean values.

FIG. C-7. Values Simulated by the QUAL2E Model Along the River, Mean Values Generated by CARMA Models at Guaging Locations, and Measured values at gaging stations for (a) Q, (b) C_{TDS}, (c) $C_{O\text{-}N}$, (d) C_{NH3}, (e) C_{NO2}, (f) C_{NO3}, (g) C_N, and (h) C_{FC} during a Week in the Validation Period (Week 4, March 1997)



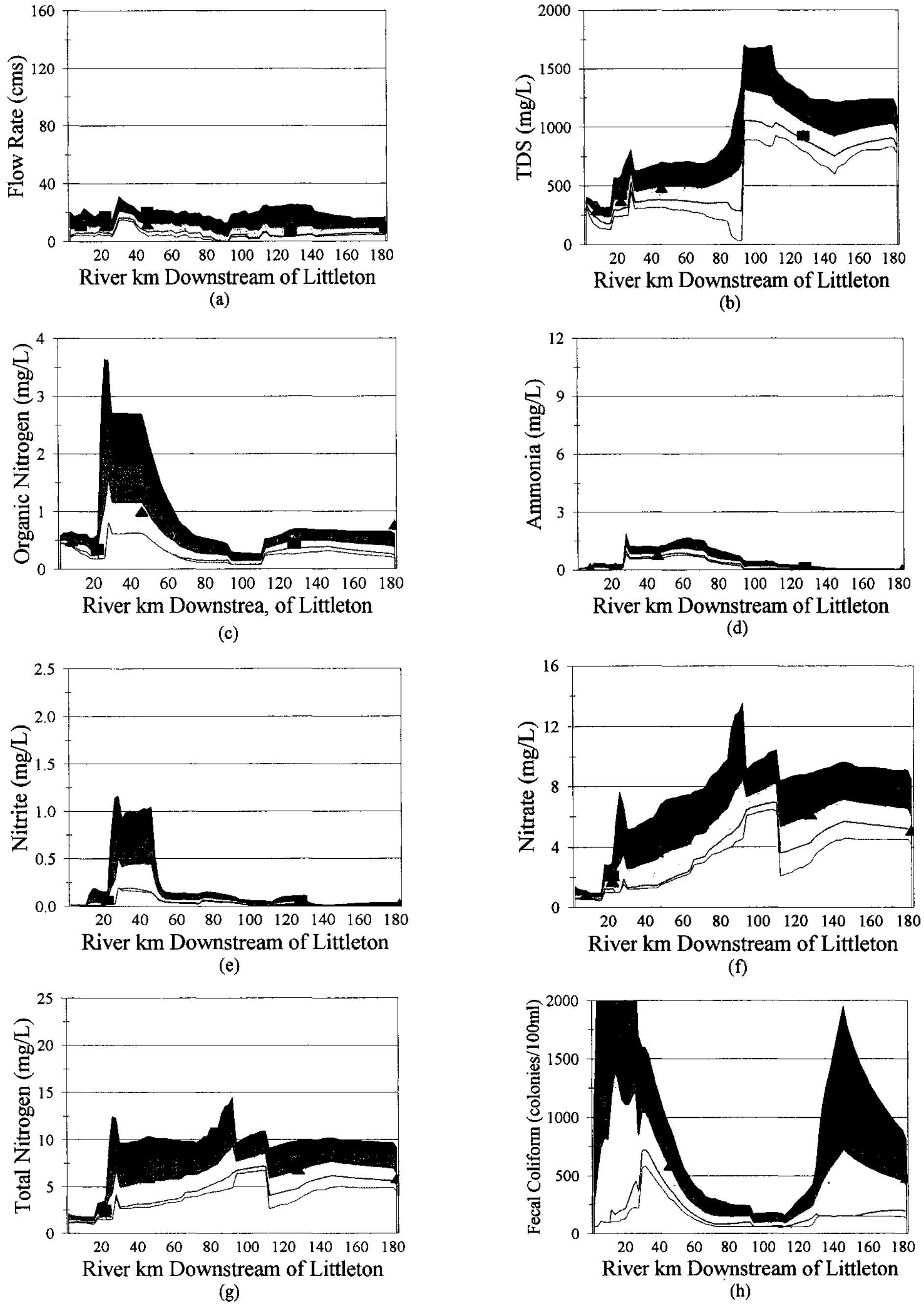
Note: The lightest shaded area extends from the 5% quantile simulated by the QUAL2E model to mean minus one standard deviation. The next darker shaded area extends from the mean minus one standard deviation to the mean, the next darker area from the mean to the mean plus one standard deviation, and the darkest from the mean plus one standard deviation to the 95% quantile simulated by the QUAL2E model. The square markers represent the measured values and the triangle markers represent CARMA-GMCS generated mean values.

FIG. C-8. Values Simulated by the QUAL2E Model Along the River, Mean Values Generated by CARMA Models at Guaging Locations, and Measured values at gaging stations for (a) Q, (b) C_{TDS}, (c) $C_{O\text{-}N}$, (d) C_{NH3}, (e) C_{NO2}, (f) C_{NO3}, (g) C_N, and (h) C_{FC} during a Week in the Validation Period (Week 1, May 1998)



Note: The lightest shaded area extends from the 5% quantile simulated by the QUAL2E model to mean minus one standard deviation. The next darker shaded area extends from the mean minus one standard deviation to the mean, the next darker area from the mean to the mean plus one standard deviation, and the darkest from the mean plus one standard deviation to the 95% quantile simulated by the QUAL2E model. The square markers represent the measured values and the triangle markers represent CARMA-GMCS generated mean values.

FIG. C-9. Values Simulated by the QUAL2E Model Along the River, Mean Values Generated by CARMA Models at Guaging Locations, and Measured values at gaging stations for (a) Q, (b) C_{TDS}, (c) $C_{O\text{-}N}$, (d) C_{NH3}, (e) C_{NO2}, (f) C_{NO3}, (g) C_{N}, and (h) C_{FC} during a Week in the Validation Period (Week 2, December 1999)



Note: The lightest shaded area extends from the 5% quantile simulated by the QUAL2E model to mean minus one standard deviation. The next darker shaded area extends from the mean minus one standard deviation to the mean, the next darker area from the mean to the mean plus one standard deviation, and the darkest from the mean plus one standard deviation to the 95% quantile simulated by the QUAL2E model. The square markers represent the measured values and the triangle markers represent CARMA-GMCS generated mean values.

FIG. C-10. Values Simulated by the QUAL2E Model Along the River, Mean Values Generated by CARMA Models at Guaging Locations, and Measured values at gaging stations for (a) Q, (b) C_{TDS}, (c) $C_{O\text{-}N}$, (d) C_{NH3}, (e) C_{NO2}, (f) C_{NO3}, (g) C_N, and (h) C_{FC} during a Week in the Validation Period (Week 3, July 2000)

APPENDIX D:

Simulated Performance of Alternative Pollution Control Strategies

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TABLE D-48. Space-Time Average and Standard Deviation of Ensemble Statistical Moments of Computed Water Quality Concentrations for Each Combined Management Alternative Applied during the Sep-Oct Season (Computed over All Diversion Points and Downstream Station at Weldona)

TABLE D-49. Space-Time Average and Standard Deviation of Ensemble Statistical Moments of Computed Water Quality Concentrations for Each Combined Management Alternative Applied during the Nov-Dec Season (Computed over All Diversion Points and Downstream Station at Weldona)

TABLE D-50. Space-Time Average Ensemble Statistical Moments of Computed Water Quality Concentrations for Each Individual Management Alternative Applied during the Jan-Feb Season (Computed on the Major Diversion Canals)

TABLE D-51. Space-Time Average Ensemble Statistical Moments of Computed Water Quality Concentrations for Each Individual Management Alternative Applied during the Mar-Apr Season (Computed on the Major Diversion Canals)

TABLE D-52. Space-Time Average Ensemble Statistical Moments of Computed Water Quality Concentrations for Each Individual Management Alternative Applied during the May-Jun Season (Computed on the Major Diversion Canals)

TABLE D-53. Space-Time Average Ensemble Statistical Moments of Computed Water Quality Concentrations for Each Individual Management Alternative Applied during the Jul-Aug Season (Computed on the Major Diversion Canals)

TABLE D-54. Space-Time Average Ensemble Statistical Moments of Computed Water Quality Concentrations for Each Individual Management Alternative Applied during the Sep-Oct Season (Computed on the Major Diversion Canals)

TABLE D-55. Space-Time Average Ensemble Statistical Moments of Computed Water Quality Concentrations for Each Individual Management Alternative Applied during the Nov-Dec Season (Computed on the Major Diversion Canals)

TABLE D-56. Space-Time Average Ensemble Statistical Moments of Computed Water Quality Concentrations for Each Combined Management Alternative Applied during the Jan-Feb Season (Computed on the Major Diversion Canals)

TABLE D-57. Space-Time Average Ensemble Statistical Moments of Computed Water Quality Concentrations for Each Combined Management Alternative Applied during the Jan-Feb Season (Computed on the Major Diversion Canals)

TABLE D-58. Space-Time Average Ensemble Statistical Moments of Computed Water Quality Concentrations for Each Combined Management Alternative Applied during the Jan-Feb Season (Computed on the Major Diversion Canals)

TABLE D-59. Space-Time Average Ensemble Statistical Moments of Computed Water Quality Concentrations for Each Combined Management Alternative Applied during the Jan-Feb Season (Computed on the Major Diversion Canals)

TABLE D-60. Space-Time Average Ensemble Statistical Moments of Computed Water Quality Concentrations for Each Combined Management Alternative Applied during the Jan-Feb Season (Computed on the Major Diversion Canals)

TABLE D-61. Space-Time Average Ensemble Statistical Moments of Computed Water Quality Concentrations for Each Combined Management Alternative Applied during the Jan-Feb Season (Computed on the Major Diversion Canals)

TABLE D-62. Spatial and Temporal Average of River Concentrations for Strategies 1 and 8 Predicted by the Deterministic Model Using Mean Values of the Parameters Compared to the Spatial and Temporal Average of the Mean of River Water Quality Concentrations Predicted by Stochastic Model for Strategies 1 and 8

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FIG. D-1. Space Average of Ensemble Statistical Moments of Q for Strategy 1 over the 25-year Planning Period (Computed over All Diversion Points and Downstream Station at Weldona). *Note:* The upper and lower whiskers on the Box and Whisker plots represent QUAL2E simulated 95% and 5% quantiles, respectively; the upper and lower sides of the box represent the mean plus one standard deviation and mean minus one standard deviation; and the mark in the middle of the box represents the mean.

FIG. D-2. Space Average of Ensemble Statistical Moments of C_{TDS} for Strategy 1 over the 25-year Planning Period (Computed over All Diversion Points and Downstream Station at Weldona). See note in Figure D-1 label.

FIG. D-3. Space Average of Ensemble Statistical Moments of C_{NO2} for Strategy 1 over the 25-year Planning Period (Computed over All Diversion Points and Downstream Station at Weldona). See note in Figure D-1 label.

FIG. D-4. Space Average of Ensemble Statistical Moments of C_N for Strategy 1 over the 25-year Planning Period (Computed over All Diversion Points and Downstream Station at Weldona). See note in Figure D-1 label.

FIG. D-5. Space Average of Ensemble Statistical Moments of C_{FC} for Strategy 1 over the 25-year Planning Period (Computed over All Diversion Points and Downstream Station at Weldona). See note in Figure D-1 label.

FIG. D-6. Space Average of Ensemble Statistical Moments of Q for Strategy 8 over the 25-year Planning Period (Computed over All Diversion Points and Downstream Station at Weldona). See note in Figure D-1 label.

FIG. D-7. Space Average of Ensemble Statistical Moments of C_{TDS} for Strategy 8 over the 25-year Planning Period (Computed over All Diversion Points and Downstream Station at Weldona). See note in Figure D-1 label.

FIG. D-8. Space Average of Ensemble Statistical Moments of C_{NO2} for Strategy 8 over the 25-year Planning Period (Computed over All Diversion Points and Downstream Station at Weldona). See note in Figure D-1 label.

FIG. D-9. Space Average of Ensemble Statistical Moments of C_N for Strategy 8 over the 25-year Planning Period (Computed over All Diversion Points and Downstream Station at Weldona). See note in Figure D-1 label.

FIG. D-10. Space Average of Ensemble Statistical Moments of C_{FC} for Strategy 8 over the 25-year Planning Period (Computed over All Diversion Points and Downstream Station at Weldona). See note in Figure D-1 label.

Introduction to Appendix D

This chapter mainly describes the responses of proposed pollution control interventions predicted by the stochastic model. The performance of each alternative was measured based on the violation of the recommended water quality standard for agricultural water use. Current Colorado standards for contaminants in agriculture waters are based on EPA's 1972 and 1976 water quality criteria standards [*Gates, et al.*, 1993]. Except nitrite (10 mg/L) and nitrate (100 mg/L), Colorado has no standards for the rest of the water quality constituents simulated in this study. Adopted from other states' or countries' standards or recommended criteria (as shown in Table D-1), two sets of standard were proposed. They are a low standard: TDS 1000 mg/L, nitrite 10 mg/L, total nitrogen 30 mg/L, and fecal coliform 1000 colonies/100 ml; and a high standard: TDS 500 mg/L, nitrite 10 mg/L, total nitrogen 15 mg/L, and fecal coliform 500 colonies/100 ml. For the summer months of May through August, the criteria for total nitrogen are restricted to 5 and 10 mg/L for the high and low standards, respectively. Based on the above standards, Table D-2 to D-7 list the temporal uniformity, spatial uniformity and probability of violation, averaged over all river elements and over all weeks in the 25-year period for each season for individual alternatives. Table D-8 to D-13 list the temporal uniformity, spatial uniformity and probability of violation, averaged over all the irrigation diversion points and over all weeks in the 25-year period for each season for individual alternatives. The corresponding average statistical moments are listed in Tables D-14 to D-25. From these results, it was found that a 30% nonpoint source cut was superior in the high flow seasons in reducing the TDS pollution along the river and a 50% wasteload cut was only of benefit in the low-flow seasons when the municipal effect is most acutely felt. Similar behavior can be found in the total nitrogen reductions. To reduce the fecal coliform concentrations along the river, control of the nonpoint source pollution is always the most effective. The current water quality standards for nitrite are much higher than the nitrite concentrations predicted to occur along the river.

All the individual alternatives were randomly combined to create the combined alternatives. Tables D-26 to D-31 present the performance measures of each combined alternative, averaged over all river elements and over all weeks in a season over the 25-year period. The performance measures estimated only at irrigation diversion points and downstream at Weldon are listed in Tables D-32 to D-37. The statistical moments in response to the combined alternatives, averaged over the whole river system as well as at the irrigation diversion points and downstream at Weldon are shown in Table D-38 to D-43 and D-44 to D-49 for the different seasons. The combination of wasteload reduction and nonpoint source pollution cut was always the most efficient alternative and the combined-two alternative already achieved a sound performance. To determine the response of different river segments to the strategies, the statistical moments of the water quality concentrations at the major diversion points are also presented in Tables D-50 to D-55 and D-56 to D-61 for different seasons, different individual or combined strategies. From these results, it appears that increasing the wasteload treatment level was more helpful to the irrigation water diverted in the upper segment of the river. This is also obvious in the low flow seasons when domestic wastewater effects are more pronounced. On the contrary, the achievements of the nonpoint source control were significant in the lower segment of the river where extensive agricultural lands are located. When irrigation activities are active, the effects of such alternatives were especially notable. As for the remaining two individual strategies, i.e. relocation of the Burlington Ditch and increased reservoir release, the effects were limited to the upper segment of the river.

The spatial averaged (average over all irrigation diversion locations and downstream at Weldona) ensemble statistical moments time series plots for strategy 1 and 8 over the 25-year planning period are presented in Figures D-1 through D-10. The effect of wastewater increase due to population growth in the watershed is not observed to be significant in these plots. The only gradual increase (or decrease for some of the water quality constituent concentrations where the wastewater was less polluted than the receiving river water) over the 25-year period can only be observed in the winter season when the wastewater contribution is acutely felt. The locations of the wastewater treatment plants are a factor in yielding this insignificant trend over the 25-year planning period. The two largest wastewater treatment plants are located in the 28-km upstream river segment. Considering the total study reach of 190 km, the effect of the wastewater increase in this upstream segment was considerably dissipated.

Sometimes, decision-making is focused on comparison of average performance between competing strategies. In such cases, deterministic models may prove adequate tools to support feasibility planning. To explore such an approach in the current problem, the deterministic QUAL2E model was applied to the analysis of strategies 1 and 8 for the South Platte River, and the results were then compared with stochastic model results. This was done by using the mean values of all model parameters, as estimated from historical data and as determined from calibration, as deterministic input to the QUAL2E model. Deterministic and stochastic model results are summarized in Table D-62.

Strategy 8 was predicted by the deterministic model to reduce overall average (averaged over all weeks within the 25-year period and over all river locations) C_{TDS} by 22%, C_{NO_2} by 30%, C_N by 31%, and C_{FC} by 16%. These results were very similar to the spatial-temporal averaged mean values predicted by the stochastic model: a reduction in C_{TDS} by 22%, C_{NO_2} by 31%, C_N by 30%, and C_{FC} by 18%. In comparing strategy 8 with strategy 1 using deterministic model results, reductions of 29 % to 38 % in C_{TDS} over the irrigation season were predicted for diversions D2 through D15, along the 53-km reach downstream of Denver. Corresponding reductions of 35 % to 42 % were predicted for C_N , and 14 % to 34 % for C_{FC} along this reach. Using the stochastic model, similar reductions of 27 % to 36 % in time-averaged mean values of C_{TDS} over the irrigation season were predicted, along with reductions of 31 % to 39 % for time-averaged mean values of C_N , and 17 % to 39 % for time-averaged mean values of C_{FC} along this reach. At specific locations along the river, differences between time-averaged values of river concentrations predicted by the deterministic model for a given strategy and the respective time-averaged mean values predicted by the stochastic model were more substantial. For strategy 1, these differences ranged from 0.4 % to 20 % for C_{TDS} along the river, from 0 % to 150 % for C_{NO_2} , 1 % to 44 % for C_N , and 4.3 % to 85

% for C_{FC}. For strategy 8, the differences in the temporal averages varied from 0.7 % to 20 % for C_{TDS}, from 0 % to 171 % for C_{NO_2}, from 0 % to 45 % for C_N, and from 0 % to 85 % for C_{FC}.

In consideration of average comparative performance between strategies, differences between results obtained from the deterministic and stochastic modeling approaches were found to be very similar. However, the values of constituent concentrations predicted within each strategy were often substantially different. This is due in part to the nonlinearity of the physically-based model and the complex correlation structures of the random parameters. Also, though comparative average results were similar, the deterministic model was not able to predict the considerable uncertainty present in predicted system performance, as indicated by the relatively high coefficients of variation yielded by the stochastic model, nor could the deterministic model estimate the probability of violation associated with each water quality constituent.

TABLE D-1. Summary of Current Available or Recommended Water Quality Criteria for Irrigation Use

C_{TDS} (mg/L)					C_N (mg/L)			C_{ON} (mg/L)	C_{NH_3} (mg/L)	C_{NO_2} (mg/L)	C_{NO_3} (mg/L)	C_{FC} (colonies/ 100 mL)	Reference
Degree of Restriction of Use				Standards	Degree of Restriction of Use								
None	Low	Median	High		None	Median	High						
				1300					5		15	1000	Mauritius Department of Environmen (1999)
				500-3500								100	Canadian Council of Ministers of the Environment (1999)
	0.00-487.5	487.5-1,950	>1,950										Thomas (2001), Recommended for Mississippi
<487.5	487.5	1,950											Hergert and Knudsen (1977), Recommended for Nebraska
500	500-1,000	1,000-2,000	2,000-5,000										Follet and Soltanpour (1999), Recommended for Colorado
<450		450-2,000	>2,000		<5	5-30	>30					1000*	Gates, et al. (1993), Recommended for Colorado

TABLE D-2. Space-Time Average and Standard Deviation of Performance Measures for Each Individual Management Strategy Applied during the Jan-Feb Season (Computed over All River Locations)

Strategy		High Criteria												Low Criteria											
		C_{TDS} (500 mg/L)			C_{NO_3} (10 mg/L)			C_N (15 mg/L)			C_{FC} (500 colonies/100 ml)			C_{TDS} (1000 mg/L)			C_{NO_3} (10 mg/L)			C_N (30 mg/L)			C_{FC} (1000 colonies/100 ml)		
		U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v
1	Average	0.73	0.97	0.93	1.00	1.00	0.00	0.00	0.75	0.01	0.00	0.73	0.10	0.28	0.92	0.39	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.74	0.02
	STD	0.00	0.01	0.25	0.00	0.00	0.00	0.00	0.07	0.04	0.00	0.13	0.16	0.03	0.02	0.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.04
2A	Average	0.73	0.97	0.93	1.00	1.00	0.00	0.00	0.78	0.00	0.00	0.73	0.10	0.18	0.85	0.32	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.74	0.01
	STD	0.00	0.01	0.25	0.00	0.00	0.00	0.00	0.16	0.02	0.00	0.13	0.16	0.08	0.05	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.04
2B	Average	0.73	0.96	0.92	1.00	1.00	0.00	0.04	0.94	0.00	0.00	0.73	0.10	0.09	0.76	0.26	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.74	0.01
	STD	0.00	0.01	0.25	0.00	0.00	0.00	0.20	0.10	0.01	0.00	0.13	0.16	0.12	0.11	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.04
2C	Average	0.72	0.96	0.91	1.00	1.00	0.00	0.80	0.95	0.00	0.00	0.73	0.10	0.06	0.72	0.22	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.74	0.01
	STD	0.01	0.01	0.25	0.00	0.00	0.00	0.41	0.10	0.01	0.00	0.12	0.15	0.13	0.16	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.04
2D	Average	0.67	0.95	0.87	1.00	1.00	0.00	0.80	0.95	0.00	0.00	0.73	0.10	0.06	0.70	0.19	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.74	0.01
	STD	0.03	0.01	0.27	0.00	0.00	0.00	0.41	0.10	0.01	0.00	0.12	0.15	0.13	0.19	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.04
2E	Average	0.64	0.95	0.84	1.00	1.00	0.00	0.80	0.95	0.00	0.00	0.73	0.10	0.06	0.74	0.17	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.74	0.01
	STD	0.05	0.01	0.29	0.00	0.00	0.00	0.41	0.10	0.01	0.00	0.12	0.15	0.13	0.15	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.04
3	Average	0.71	0.95	0.92	1.00	1.00	0.00	0.00	0.71	0.01	0.00	0.73	0.10	0.26	0.91	0.37	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.74	0.01
	STD	0.01	0.02	0.27	0.00	0.00	0.00	0.00	0.11	0.03	0.00	0.13	0.15	0.03	0.02	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.04
4A	Average	0.73	0.95	0.92	1.00	1.00	0.00	0.00	0.75	0.01	0.00	0.77	0.09	0.11	0.86	0.25	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.75	0.01
	STD	0.00	0.01	0.25	0.00	0.00	0.00	0.00	0.07	0.04	0.00	0.12	0.15	0.13	0.05	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.04
4B	Average	0.72	0.95	0.92	1.00	1.00	0.00	0.00	0.74	0.01	0.00	0.80	0.08	0.09	0.65	0.16	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.76	0.01
	STD	0.00	0.02	0.26	0.00	0.00	0.00	0.00	0.08	0.04	0.00	0.08	0.14	0.13	0.21	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.03
4C	Average	0.72	0.95	0.92	1.00	1.00	0.00	0.00	0.73	0.01	0.00	0.75	0.07	0.08	0.46	0.13	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.79	0.01
	STD	0.00	0.02	0.26	0.00	0.00	0.00	0.00	0.08	0.04	0.00	0.08	0.13	0.13	0.34	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.03
5	Average	0.73	0.97	0.93	1.00	1.00	0.00	0.00	0.67	0.00	0.00	0.72	0.11	0.25	0.90	0.36	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.72	0.01
	STD	0.00	0.01	0.25	0.00	0.00	0.00	0.00	0.28	0.01	0.00	0.18	0.16	0.04	0.02	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.04

Notes: Average-U_s, U_t, and P_v values averaged over all river locations and over all seasons within the 25-year planning period
STD-Standard deviation of U_s, U_t, and P_v values over all river locations and over all seasons within the 25-year planning period

TABLE D-3. Space-Time Average and Standard Deviation of Performance Measures for Each Individual Management Strategy Applied during the Mar-Apr Season (Computed over All River Locations)

Strategy		High Criteria												Low Criteria											
		C_{TDS} (500 mg/L)			C_{NO_2} (10 mg/L)			C_N (15 mg/L)			C_{FC} (500 colonies/100 ml)			C_{TDS} (1000 mg/L)			C_{NO_2} (10 mg/L)			C_N (30 mg/L)			C_{FC} (1000 colonies/100 ml)		
		U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v
1	Average	0.70	0.98	0.89	1.00	1.00	0.00	0.00	0.72	0.00	0.00	0.65	0.08	0.31	0.87	0.47	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.50	0.00
	STD	0.00	0.00	0.27	0.00	0.00	0.00	0.00	0.20	0.01	0.00	0.06	0.09	0.02	0.06	0.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00
2A	Average	0.69	0.98	0.88	1.00	1.00	0.00	0.00	0.92	0.00	0.00	0.65	0.08	0.27	0.90	0.43	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.49	0.00
	STD	0.01	0.00	0.27	0.00	0.00	0.00	0.00	0.18	0.00	0.00	0.07	0.08	0.04	0.06	0.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00
2B	Average	0.68	0.98	0.87	1.00	1.00	0.00	0.80	0.92	0.00	0.00	0.64	0.08	0.24	0.90	0.40	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.48	0.00
	STD	0.01	0.00	0.28	0.00	0.00	0.00	0.41	0.19	0.00	0.00	0.07	0.08	0.06	0.05	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00
2C	Average	0.66	0.98	0.84	1.00	1.00	0.00	0.80	0.92	0.00	0.00	0.63	0.07	0.20	0.90	0.37	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.48	0.00
	STD	0.02	0.01	0.28	0.00	0.00	0.00	0.41	0.19	0.00	0.00	0.07	0.08	0.08	0.06	0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00
2D	Average	0.59	0.97	0.79	1.00	1.00	0.00	0.80	0.92	0.00	0.00	0.62	0.07	0.16	0.89	0.34	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.49	0.00
	STD	0.05	0.01	0.31	0.00	0.00	0.00	0.41	0.19	0.00	0.00	0.07	0.07	0.10	0.06	0.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.00
2E	Average	0.54	0.96	0.76	1.00	1.00	0.00	0.80	0.92	0.00	0.00	0.61	0.07	0.12	0.88	0.32	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.50	0.00
	STD	0.08	0.02	0.33	0.00	0.00	0.00	0.41	0.19	0.00	0.00	0.08	0.07	0.12	0.05	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.00
3	Average	0.68	0.98	0.88	1.00	1.00	0.00	0.00	0.76	0.00	0.00	0.65	0.08	0.28	0.87	0.43	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.47	0.00
	STD	0.01	0.00	0.28	0.00	0.00	0.00	0.00	0.19	0.01	0.00	0.06	0.08	0.04	0.06	0.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00
4A	Average	0.68	0.98	0.88	1.00	1.00	0.00	0.00	0.72	0.00	0.00	0.59	0.07	0.25	0.89	0.38	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.57	0.00
	STD	0.01	0.00	0.28	0.00	0.00	0.00	0.00	0.20	0.01	0.00	0.10	0.08	0.06	0.03	0.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00
4B	Average	0.66	0.98	0.87	1.00	1.00	0.00	0.00	0.72	0.00	0.00	0.48	0.06	0.14	0.88	0.31	1.00	1.00	0.00	1.00	1.00	0.00	0.08	0.74	0.00
	STD	0.02	0.01	0.29	0.00	0.00	0.00	0.00	0.20	0.01	0.00	0.19	0.07	0.14	0.04	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.28	0.27	0.00
4C	Average	0.65	0.97	0.87	1.00	1.00	0.00	0.00	0.72	0.00	0.00	0.39	0.05	0.11	0.84	0.25	1.00	1.00	0.00	1.00	1.00	0.00	0.44	0.77	0.00
	STD	0.03	0.01	0.30	0.00	0.00	0.00	0.00	0.19	0.01	0.00	0.27	0.06	0.15	0.06	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.51	0.30	0.00
5	Average	0.70	0.98	0.89	1.00	1.00	0.00	0.00	0.85	0.00	0.00	0.67	0.09	0.28	0.87	0.44	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.53	0.00
	STD	0.01	0.00	0.26	0.00	0.00	0.00	0.00	0.19	0.00	0.00	0.06	0.09	0.04	0.07	0.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.00

Notes: Average-U_s, U_t, and P_v values averaged over all river locations and over all seasons within the 25-year planning period
STD-Standard deviation of U_s, U_t, and P_v values over all river locations and over all seasons within the 25-year planning period

TABLE D-4. Space-Time Average and Standard Deviation of Performance Measures for Each Individual Management Strategy Applied during the May-Jun Season (Computed over All River Locations)

Strategy		High Criteria												Low Criteria											
		C_{TDS} (500 mg/L)			C_{NO_3} (10 mg/L)			C_N (15 mg/L)			C_{FC} (500 colonies/100 ml)			C_{TDS} (1000 mg/L)			C_{NO_3} (10 mg/L)			C_N (30 mg/L)			C_{FC} (1000 colonies/100 ml)		
		U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v
1	Average	0.56	0.95	0.61	1.00	1.00	0.00	0.41	0.87	0.25	0.36	0.89	0.27	0.00	0.72	0.11	1.00	1.00	0.00	0.00	0.57	0.04	0.00	0.53	0.08
	STD	0.01	0.02	0.27	0.00	0.00	0.00	0.01	0.02	0.15	0.02	0.01	0.17	0.00	0.05	0.12	0.00	0.00	0.00	0.00	0.12	0.04	0.00	0.11	0.10
2A	Average	0.55	0.95	0.60	1.00	1.00	0.00	0.43	0.86	0.24	0.36	0.88	0.27	0.00	0.70	0.10	1.00	1.00	0.00	0.00	0.56	0.04	0.00	0.53	0.08
	STD	0.01	0.02	0.27	0.00	0.00	0.00	0.01	0.02	0.14	0.02	0.01	0.17	0.00	0.05	0.12	0.00	0.00	0.00	0.00	0.11	0.04	0.00	0.11	0.10
2B	Average	0.53	0.95	0.58	1.00	1.00	0.00	0.44	0.86	0.24	0.36	0.88	0.27	0.00	0.67	0.10	1.00	1.00	0.00	0.00	0.56	0.03	0.00	0.53	0.08
	STD	0.02	0.02	0.27	0.00	0.00	0.00	0.01	0.02	0.13	0.02	0.01	0.17	0.00	0.06	0.12	0.00	0.00	0.00	0.00	0.12	0.04	0.00	0.11	0.10
2C	Average	0.51	0.95	0.57	1.00	1.00	0.00	0.44	0.86	0.23	0.36	0.88	0.27	0.00	0.63	0.10	1.00	1.00	0.00	0.00	0.55	0.03	0.00	0.53	0.08
	STD	0.03	0.01	0.27	0.00	0.00	0.00	0.01	0.02	0.13	0.02	0.01	0.17	0.00	0.08	0.12	0.00	0.00	0.00	0.00	0.12	0.04	0.00	0.11	0.10
2D	Average	0.49	0.96	0.55	1.00	1.00	0.00	0.44	0.86	0.22	0.36	0.88	0.27	0.00	0.60	0.10	1.00	1.00	0.00	0.00	0.54	0.03	0.00	0.53	0.08
	STD	0.04	0.01	0.28	0.00	0.00	0.00	0.01	0.02	0.12	0.02	0.01	0.17	0.00	0.10	0.11	0.00	0.00	0.00	0.00	0.12	0.04	0.00	0.11	0.10
2E	Average	0.47	0.95	0.54	1.00	1.00	0.00	0.44	0.85	0.22	0.35	0.88	0.27	0.00	0.58	0.09	1.00	1.00	0.00	0.00	0.53	0.03	0.00	0.53	0.08
	STD	0.05	0.01	0.28	0.00	0.00	0.00	0.01	0.02	0.12	0.02	0.01	0.17	0.00	0.11	0.11	0.00	0.00	0.00	0.00	0.15	0.04	0.00	0.11	0.10
3	Average	0.55	0.95	0.60	1.00	1.00	0.00	0.44	0.86	0.24	0.39	0.88	0.27	0.00	0.66	0.09	1.00	1.00	0.00	0.00	0.55	0.03	0.00	0.53	0.08
	STD	0.01	0.02	0.27	0.00	0.00	0.00	0.02	0.02	0.13	0.03	0.02	0.16	0.00	0.07	0.10	0.00	0.00	0.00	0.00	0.13	0.04	0.00	0.11	0.09
4A	Average	0.56	0.94	0.60	1.00	1.00	0.00	0.36	0.85	0.23	0.32	0.87	0.25	0.00	0.66	0.10	1.00	1.00	0.00	0.00	0.48	0.03	0.00	0.44	0.07
	STD	0.01	0.02	0.26	0.00	0.00	0.00	0.04	0.03	0.14	0.04	0.02	0.17	0.00	0.06	0.11	0.00	0.00	0.00	0.00	0.15	0.04	0.00	0.18	0.09
4B	Average	0.54	0.94	0.57	1.00	1.00	0.00	0.30	0.86	0.20	0.27	0.86	0.23	0.00	0.57	0.09	1.00	1.00	0.00	0.00	0.30	0.02	0.00	0.42	0.06
	STD	0.02	0.02	0.26	0.00	0.00	0.00	0.08	0.02	0.14	0.07	0.03	0.17	0.00	0.13	0.10	0.00	0.00	0.00	0.00	0.24	0.03	0.00	0.21	0.08
4C	Average	0.52	0.94	0.54	1.00	1.00	0.00	0.23	0.85	0.18	0.21	0.83	0.21	0.00	0.52	0.08	1.00	1.00	0.00	0.00	0.44	0.02	0.00	0.45	0.05
	STD	0.03	0.02	0.26	0.00	0.00	0.00	0.13	0.03	0.13	0.11	0.05	0.16	0.00	0.17	0.10	0.00	0.00	0.00	0.00	0.25	0.02	0.00	0.16	0.07
5	Average	0.54	0.94	0.59	1.00	1.00	0.00	0.43	0.86	0.24	0.38	0.89	0.28	0.00	0.71	0.10	1.00	1.00	0.00	0.00	0.56	0.04	0.00	0.55	0.09
	STD	0.01	0.02	0.27	0.00	0.00	0.00	0.01	0.02	0.14	0.02	0.01	0.17	0.00	0.05	0.12	0.00	0.00	0.00	0.00	0.12	0.04	0.00	0.09	0.10

Notes: Average-U_s, U_t, and P_v values averaged over all river locations and over all seasons within the 25-year planning period
STD-Standard deviation of U_s, U_t, and P_v values over all river locations and over all seasons within the 25-year planning period

TABLE D-5. Space-Time Average and Standard Deviation of Performance Measures for Each Individual Management Strategy Applied during the Jul-Aug Season (Computed over All River Locations)

Strategy		High Criteria												Low Criteria											
		C_{TDS} (500 mg/L)			C_{NO_2} (10 mg/L)			C_N (15 mg/L)			C_{FC} (500 colonies/100 ml)			C_{TDS} (1000 mg/L)			C_{NO_2} (10 mg/L)			C_N (30 mg/L)			C_{FC} (1000 colonies/100 ml)		
		U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v
1	Average	0.54	0.97	0.68	1.00	1.00	0.00	0.54	0.94	0.70	0.11	0.78	0.41	0.00	0.68	0.20	1.00	1.00	0.00	0.24	0.82	0.08	0.00	0.83	0.18
	STD	0.01	0.00	0.31	0.00	0.00	0.00	0.01	0.01	0.32	0.01	0.08	0.36	0.00	0.07	0.25	0.00	0.00	0.00	0.04	0.03	0.06	0.00	0.04	0.22
2A	Average	0.51	0.97	0.66	1.00	1.00	0.00	0.53	0.93	0.69	0.11	0.78	0.41	0.00	0.68	0.19	1.00	1.00	0.00	0.22	0.81	0.07	0.00	0.83	0.18
	STD	0.02	0.00	0.32	0.00	0.00	0.00	0.01	0.02	0.32	0.01	0.08	0.36	0.00	0.07	0.24	0.00	0.00	0.00	0.04	0.03	0.05	0.00	0.04	0.22
2B	Average	0.47	0.96	0.64	1.00	1.00	0.00	0.52	0.93	0.67	0.11	0.78	0.41	0.00	0.69	0.19	1.00	1.00	0.00	0.19	0.81	0.07	0.00	0.83	0.17
	STD	0.03	0.01	0.34	0.00	0.00	0.00	0.02	0.03	0.33	0.01	0.08	0.36	0.00	0.07	0.24	0.00	0.00	0.00	0.05	0.03	0.05	0.00	0.03	0.22
2C	Average	0.42	0.96	0.62	1.00	1.00	0.00	0.50	0.95	0.66	0.11	0.78	0.41	0.00	0.68	0.18	1.00	1.00	0.00	0.16	0.80	0.07	0.00	0.83	0.17
	STD	0.06	0.01	0.35	0.00	0.00	0.00	0.02	0.03	0.33	0.01	0.08	0.36	0.00	0.07	0.23	0.00	0.00	0.00	0.06	0.03	0.05	0.00	0.04	0.22
2D	Average	0.37	0.93	0.59	1.00	1.00	0.00	0.49	0.96	0.65	0.11	0.78	0.40	0.00	0.67	0.18	1.00	1.00	0.00	0.13	0.80	0.06	0.00	0.83	0.17
	STD	0.08	0.02	0.37	0.00	0.00	0.00	0.03	0.02	0.33	0.01	0.08	0.36	0.00	0.07	0.23	0.00	0.00	0.00	0.07	0.04	0.05	0.00	0.04	0.22
2E	Average	0.32	0.93	0.58	1.00	1.00	0.00	0.47	0.96	0.64	0.11	0.78	0.40	0.00	0.67	0.17	1.00	1.00	0.00	0.10	0.79	0.06	0.00	0.83	0.17
	STD	0.11	0.03	0.38	0.00	0.00	0.00	0.04	0.02	0.34	0.01	0.08	0.36	0.00	0.07	0.22	0.00	0.00	0.00	0.07	0.04	0.05	0.00	0.04	0.22
3	Average	0.51	0.95	0.66	1.00	1.00	0.00	0.53	0.92	0.68	0.10	0.76	0.39	0.00	0.65	0.17	1.00	1.00	0.00	0.26	0.78	0.06	0.00	0.81	0.15
	STD	0.02	0.02	0.32	0.00	0.00	0.00	0.01	0.03	0.32	0.01	0.09	0.35	0.00	0.07	0.21	0.00	0.00	0.00	0.05	0.06	0.04	0.00	0.05	0.20
4A	Average	0.53	0.97	0.67	1.00	1.00	0.00	0.54	0.94	0.68	0.09	0.79	0.39	0.00	0.67	0.17	1.00	1.00	0.00	0.14	0.74	0.05	0.00	0.83	0.16
	STD	0.01	0.00	0.31	0.00	0.00	0.00	0.01	0.01	0.31	0.02	0.08	0.36	0.00	0.07	0.23	0.00	0.00	0.00	0.08	0.08	0.04	0.00	0.04	0.21
4B	Average	0.52	0.97	0.66	1.00	1.00	0.00	0.53	0.94	0.65	0.07	0.82	0.37	0.00	0.64	0.15	1.00	1.00	0.00	0.07	0.52	0.04	0.00	0.82	0.14
	STD	0.01	0.00	0.32	0.00	0.00	0.00	0.01	0.01	0.30	0.04	0.07	0.35	0.00	0.08	0.22	0.00	0.00	0.00	0.09	0.26	0.03	0.00	0.03	0.19
4C	Average	0.50	0.97	0.64	1.00	1.00	0.00	0.52	0.93	0.61	0.04	0.83	0.35	0.00	0.60	0.14	1.00	1.00	0.00	0.06	0.59	0.03	0.00	0.81	0.12
	STD	0.02	0.01	0.32	0.00	0.00	0.00	0.02	0.01	0.29	0.05	0.07	0.34	0.00	0.09	0.21	0.00	0.00	0.00	0.09	0.21	0.02	0.00	0.04	0.17
5	Average	0.54	0.97	0.68	1.00	1.00	0.00	0.54	0.94	0.69	0.12	0.78	0.41	0.00	0.69	0.19	1.00	1.00	0.00	0.24	0.82	0.07	0.00	0.84	0.18
	STD	0.01	0.00	0.31	0.00	0.00	0.00	0.01	0.02	0.32	0.01	0.08	0.36	0.00	0.07	0.24	0.00	0.00	0.00	0.04	0.03	0.05	0.00	0.04	0.22

Notes: Average-U_s, U_t, and P_v values averaged over all river locations and over all seasons within the 25-year planning period
STD-Standard deviation of U_s, U_t, and P_v values over all river locations and over all seasons within the 25-year planning period

TABLE D-6. Space-Time Average and Standard Deviation of Performance Measures for Each Individual Management Strategy Applied during the Sep-Oct Season (Computed over All River Locations)

Strategy		High Criteria												Low Criteria											
		C_{TDS} (500 mg/L)			C_{NO_2} (10 mg/L)			C_N (15 mg/L)			C_{FC} (500 colonies/100 ml)			C_{TDS} (1000 mg/L)			C_{NO_2} (10 mg/L)			C_N (30 mg/L)			C_{FC} (1000 colonies/100 ml)		
		U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v
1	Average	0.60	0.93	0.80	1.00	1.00	0.00	0.08	0.99	0.00	0.00	0.77	0.15	0.00	0.65	0.08	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.76	0.02
	STD	0.00	0.01	0.32	0.00	0.00	0.00	0.28	0.01	0.00	0.00	0.07	0.19	0.00	0.10	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.04
2A	Average	0.59	0.92	0.79	1.00	1.00	0.00	0.80	1.00	0.00	0.00	0.77	0.15	0.00	0.72	0.07	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.76	0.02
	STD	0.00	0.02	0.32	0.00	0.00	0.00	0.41	0.00	0.00	0.00	0.07	0.18	0.00	0.07	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.04
2B	Average	0.59	0.89	0.78	1.00	1.00	0.00	0.80	1.00	0.00	0.00	0.77	0.15	0.00	0.71	0.06	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.76	0.02
	STD	0.00	0.03	0.32	0.00	0.00	0.00	0.41	0.00	0.00	0.00	0.08	0.18	0.00	0.07	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.04
2C	Average	0.57	0.86	0.74	1.00	1.00	0.00	0.80	1.00	0.00	0.00	0.76	0.15	0.00	0.71	0.05	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.76	0.02
	STD	0.01	0.06	0.32	0.00	0.00	0.00	0.41	0.00	0.00	0.00	0.07	0.18	0.00	0.07	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.04
2D	Average	0.49	0.89	0.69	1.00	1.00	0.00	0.80	1.00	0.00	0.00	0.76	0.15	0.00	0.70	0.05	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.76	0.02
	STD	0.05	0.06	0.33	0.00	0.00	0.00	0.41	0.00	0.00	0.00	0.07	0.18	0.00	0.07	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.04
2E	Average	0.43	0.86	0.65	1.00	1.00	0.00	0.80	1.00	0.00	0.00	0.76	0.14	0.00	0.70	0.04	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.76	0.02
	STD	0.08	0.05	0.35	0.00	0.00	0.00	0.41	0.00	0.00	0.00	0.07	0.18	0.00	0.07	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.04
3	Average	0.59	0.87	0.80	1.00	1.00	0.00	0.56	0.99	0.00	0.00	0.75	0.14	0.00	0.69	0.07	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.73	0.02
	STD	0.00	0.05	0.33	0.00	0.00	0.00	0.51	0.01	0.00	0.00	0.07	0.17	0.00	0.09	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.03
4A	Average	0.59	0.93	0.80	1.00	1.00	0.00	0.12	0.99	0.00	0.00	0.77	0.14	0.00	0.62	0.06	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.74	0.02
	STD	0.00	0.01	0.32	0.00	0.00	0.00	0.33	0.01	0.00	0.00	0.07	0.18	0.00	0.11	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.03
4B	Average	0.59	0.92	0.79	1.00	1.00	0.00	0.12	0.99	0.00	0.00	0.77	0.13	0.00	0.59	0.05	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.70	0.01
	STD	0.00	0.02	0.32	0.00	0.00	0.00	0.33	0.01	0.00	0.00	0.07	0.17	0.00	0.12	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.03
4C	Average	0.58	0.92	0.78	1.00	1.00	0.00	0.12	0.99	0.00	0.00	0.78	0.12	0.00	0.55	0.04	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.64	0.01
	STD	0.01	0.02	0.32	0.00	0.00	0.00	0.33	0.01	0.00	0.00	0.06	0.15	0.00	0.13	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.02
5	Average	0.61	0.93	0.80	1.00	1.00	0.00	0.80	1.00	0.00	0.00	0.78	0.15	0.00	0.71	0.06	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.75	0.02
	STD	0.01	0.01	0.31	0.00	0.00	0.00	0.41	0.00	0.00	0.00	0.08	0.18	0.00	0.07	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.04

Notes: Average-U_s, U_t, and P_v values averaged over all river locations and over all seasons within the 25-year planning period
STD-Standard deviation of U_s, U_t, and P_v values over all river locations and over all seasons within the 25-year planning period

TABLE D-7. Space-Time Average and Standard Deviation of Performance Measures for Each Individual Management Strategy Applied during the Nov-Dec Season (Computed over All River Locations)

Strategy		High Criteria												Low Criteria											
		C_{TDS} (500 mg/L)			C_{NO_2} (10 mg/L)			C_N (15 mg/L)			C_{FC} (500 colonies/100 ml)			C_{TDS} (1000 mg/L)			C_{NO_2} (10 mg/L)			C_N (30 mg/L)			C_{FC} (1000 colonies/100 ml)		
		U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v
1	Average	0.73	0.98	0.90	1.00	1.00	0.00	0.00	0.30	0.01	0.46	0.91	0.32	0.00	0.59	0.11	1.00	1.00	0.00	0.07	0.55	0.00	0.00	0.70	0.11
	STD	0.01	0.00	0.24	0.00	0.00	0.00	0.00	0.20	0.02	0.02	0.01	0.17	0.00	0.12	0.11	0.00	0.00	0.00	0.16	0.29	0.00	0.00	0.07	0.13
2A	Average	0.72	0.98	0.89	1.00	1.00	0.00	0.00	0.62	0.01	0.46	0.91	0.31	0.00	0.78	0.09	1.00	1.00	0.00	0.07	0.55	0.00	0.00	0.70	0.11
	STD	0.01	0.00	0.25	0.00	0.00	0.00	0.00	0.24	0.01	0.03	0.01	0.17	0.00	0.09	0.10	0.00	0.00	0.00	0.16	0.29	0.00	0.00	0.07	0.12
2B	Average	0.70	0.98	0.88	1.00	1.00	0.00	0.00	0.69	0.01	0.46	0.91	0.31	0.00	0.86	0.08	1.00	1.00	0.00	0.07	0.53	0.00	0.00	0.70	0.11
	STD	0.01	0.00	0.26	0.00	0.00	0.00	0.00	0.20	0.01	0.03	0.01	0.17	0.00	0.10	0.09	0.00	0.00	0.00	0.17	0.29	0.00	0.00	0.07	0.12
2C	Average	0.68	0.97	0.84	1.00	1.00	0.00	0.00	0.70	0.01	0.46	0.91	0.31	0.00	0.87	0.07	1.00	1.00	0.00	0.05	0.49	0.00	0.00	0.70	0.11
	STD	0.03	0.01	0.27	0.00	0.00	0.00	0.00	0.21	0.01	0.03	0.01	0.17	0.00	0.11	0.08	0.00	0.00	0.00	0.15	0.30	0.00	0.00	0.07	0.12
2D	Average	0.61	0.97	0.78	1.00	1.00	0.00	0.00	0.70	0.01	0.47	0.91	0.31	0.00	0.87	0.06	1.00	1.00	0.00	0.03	0.48	0.00	0.00	0.69	0.11
	STD	0.06	0.01	0.29	0.00	0.00	0.00	0.00	0.21	0.01	0.03	0.01	0.16	0.00	0.11	0.07	0.00	0.00	0.00	0.10	0.29	0.00	0.00	0.07	0.12
2E	Average	0.54	0.96	0.73	1.00	1.00	0.00	0.00	0.70	0.01	0.47	0.91	0.31	0.00	0.87	0.06	1.00	1.00	0.00	0.03	0.49	0.00	0.00	0.69	0.10
	STD	0.10	0.02	0.31	0.00	0.00	0.00	0.00	0.21	0.01	0.03	0.01	0.16	0.00	0.11	0.06	0.00	0.00	0.00	0.10	0.28	0.00	0.00	0.07	0.12
3	Average	0.70	0.98	0.89	1.00	1.00	0.00	0.00	0.29	0.01	0.47	0.91	0.32	0.00	0.60	0.10	1.00	1.00	0.00	0.11	0.55	0.00	0.00	0.71	0.11
	STD	0.02	0.01	0.27	0.00	0.00	0.00	0.00	0.24	0.02	0.03	0.01	0.17	0.00	0.16	0.11	0.00	0.00	0.00	0.21	0.31	0.00	0.00	0.07	0.13
4A	Average	0.71	0.98	0.89	1.00	1.00	0.00	0.00	0.31	0.01	0.42	0.91	0.30	0.00	0.57	0.10	1.00	1.00	0.00	0.07	0.55	0.00	0.00	0.62	0.10
	STD	0.01	0.00	0.25	0.00	0.00	0.00	0.00	0.22	0.02	0.03	0.01	0.17	0.00	0.18	0.11	0.00	0.00	0.00	0.16	0.28	0.00	0.00	0.12	0.12
4B	Average	0.70	0.97	0.88	1.00	1.00	0.00	0.00	0.32	0.01	0.37	0.90	0.28	0.00	0.59	0.09	1.00	1.00	0.00	0.07	0.55	0.00	0.00	0.51	0.08
	STD	0.02	0.01	0.27	0.00	0.00	0.00	0.00	0.22	0.02	0.05	0.02	0.17	0.00	0.26	0.10	0.00	0.00	0.00	0.16	0.29	0.00	0.00	0.20	0.11
4C	Average	0.68	0.97	0.87	1.00	1.00	0.00	0.00	0.34	0.01	0.31	0.88	0.26	0.00	0.65	0.09	1.00	1.00	0.00	0.07	0.55	0.00	0.00	0.40	0.07
	STD	0.03	0.01	0.28	0.00	0.00	0.00	0.00	0.22	0.02	0.10	0.03	0.17	0.00	0.28	0.10	0.00	0.00	0.00	0.16	0.28	0.00	0.00	0.26	0.10
5	Average	0.74	0.98	0.89	1.00	1.00	0.00	0.00	0.65	0.01	0.53	0.92	0.36	0.00	0.72	0.09	1.00	1.00	0.00	0.07	0.55	0.00	0.02	0.77	0.14
	STD	0.01	0.00	0.23	0.00	0.00	0.00	0.00	0.24	0.01	0.05	0.01	0.16	0.00	0.10	0.09	0.00	0.00	0.00	0.16	0.29	0.00	0.03	0.05	0.14

Notes: Average-U_s, U_t, and P_v values averaged over all river locations and over all seasons within the 25-year planning period
STD-Standard deviation of U_s, U_t, and P_v values over all river locations and over all seasons within the 25-year planning period

TABLE D-8. Space-Time Average and Standard Deviation of Performance Measures for Each Individual Management Strategy Applied during the Jan-Feb Season (Computed over All Irrigation Diversion Points and Downstream Station at Weldona)

Strategy		High Criteria												Low Criteria											
		C_{TDS} (500 mg/L)			C_{NO_2} (10 mg/L)			C_N (15 mg/L)			C_{FC} (500 colonies/100 ml)			C_{TDS} (1000 mg/L)			C_{NO_2} (10 mg/L)			C_N (30 mg/L)			C_{FC} (1000 colonies/100 ml)		
		U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v
1	Average	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.89	0.00	0.00	0.90	0.11	0.40	0.94	0.46	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.83	0.04
	STD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.16	0.21	0.02	0.01	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.09
2A	Average	1.00	1.00	1.00	1.00	1.00	0.00	0.79	0.96	0.00	0.00	0.90	0.11	0.34	0.93	0.39	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.83	0.04
	STD	0.00	0.00	0.00	0.00	0.00	0.00	0.41	0.08	0.00	0.00	0.16	0.21	0.06	0.02	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.09
2B	Average	0.98	1.00	0.99	1.00	1.00	0.00	0.80	0.98	0.00	0.00	0.90	0.11	0.22	0.89	0.33	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.83	0.04
	STD	0.01	0.00	0.02	0.00	0.00	0.00	0.41	0.05	0.00	0.00	0.16	0.21	0.12	0.05	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.09
2C	Average	0.88	0.99	0.95	1.00	1.00	0.00	0.80	0.98	0.00	0.00	0.90	0.11	0.12	0.82	0.28	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.83	0.04
	STD	0.07	0.00	0.12	0.00	0.00	0.00	0.41	0.05	0.00	0.00	0.16	0.21	0.16	0.12	0.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.09
2D	Average	0.71	0.98	0.89	1.00	1.00	0.00	0.80	0.98	0.00	0.00	0.90	0.11	0.09	0.77	0.25	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.83	0.04
	STD	0.15	0.01	0.25	0.00	0.00	0.00	0.41	0.05	0.00	0.00	0.16	0.21	0.17	0.14	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.09
2E	Average	0.69	0.96	0.88	1.00	1.00	0.00	0.80	0.98	0.00	0.00	0.90	0.11	0.08	0.75	0.23	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.83	0.04
	STD	0.16	0.02	0.26	0.00	0.00	0.00	0.41	0.05	0.00	0.00	0.16	0.21	0.17	0.16	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.09
3	Average	1.00	1.00	1.00	1.00	1.00	0.00	0.11	0.88	0.00	0.00	0.89	0.11	0.38	0.93	0.44	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.84	0.04
	STD	0.00	0.00	0.00	0.00	0.00	0.00	0.28	0.06	0.00	0.00	0.21	0.21	0.03	0.02	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.09
4A	Average	1.00	1.00	1.00	1.00	1.00	0.00	0.03	0.87	0.00	0.00	0.95	0.11	0.19	0.89	0.30	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.87	0.04
	STD	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.06	0.00	0.00	0.09	0.21	0.17	0.05	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.08
4B	Average	1.00	1.00	1.00	1.00	1.00	0.00	0.03	0.87	0.00	0.00	0.94	0.10	0.12	0.68	0.20	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.88	0.03
	STD	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.06	0.00	0.00	0.08	0.20	0.18	0.22	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.07
4C	Average	1.00	1.00	1.00	1.00	1.00	0.00	0.03	0.87	0.00	0.00	0.92	0.09	0.11	0.44	0.15	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.85	0.03
	STD	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.05	0.00	0.00	0.08	0.19	0.18	0.37	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.06
5	Average	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.90	0.01	0.00	0.88	0.09	0.37	0.92	0.43	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.82	0.03
	STD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.02	0.00	0.22	0.14	0.03	0.03	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.05

Notes: Average-U_s, U_t, and P_v values averaged over all river locations and over all seasons within the 25-year planning period
STD-Standard deviation of U_s, U_t, and P_v values over all river locations and over all seasons within the 25-year planning period

TABLE D-9. Space-Time Average and Standard Deviation of Performance Measures for Each Individual Management Strategy Applied during the Mar-Apr Season (Computed over All Irrigation Diversion Points and Downstream Station at Weldona)

Strategy		High Criteria												Low Criteria											
		C_{TDS} (500 mg/L)			C_{NO_2} (10 mg/L)			C_N (15 mg/L)			C_{FC} (500 colonies/100 ml)			C_{TDS} (1000 mg/L)			C_{NO_2} (10 mg/L)			C_N (30 mg/L)			C_{FC} (1000 colonies/100 ml)		
		U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v
1	Average	0.81	0.99	0.94	1.00	1.00	0.00	0.26	0.73	0.00	0.02	0.69	0.09	0.44	0.86	0.51	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.41	0.00
	STD	0.01	0.00	0.18	0.00	0.00	0.00	0.33	0.23	0.00	0.03	0.06	0.09	0.03	0.08	0.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00
2A	Average	0.79	0.99	0.93	1.00	1.00	0.00	0.81	0.92	0.00	0.02	0.68	0.09	0.40	0.93	0.47	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.40	0.00
	STD	0.01	0.00	0.19	0.00	0.00	0.00	0.38	0.21	0.00	0.03	0.06	0.09	0.05	0.06	0.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.00
2B	Average	0.77	0.99	0.92	1.00	1.00	0.00	0.81	0.92	0.00	0.02	0.67	0.09	0.36	0.93	0.44	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.40	0.00
	STD	0.02	0.00	0.21	0.00	0.00	0.00	0.38	0.21	0.00	0.03	0.07	0.09	0.07	0.06	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22	0.00
2C	Average	0.75	0.98	0.89	1.00	1.00	0.00	0.81	0.92	0.00	0.02	0.67	0.08	0.31	0.92	0.40	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.39	0.00
	STD	0.03	0.01	0.22	0.00	0.00	0.00	0.38	0.21	0.00	0.03	0.07	0.08	0.09	0.06	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.00
2D	Average	0.69	0.98	0.85	1.00	1.00	0.00	0.81	0.92	0.00	0.02	0.66	0.08	0.27	0.92	0.37	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.41	0.00
	STD	0.06	0.01	0.25	0.00	0.00	0.00	0.38	0.21	0.00	0.03	0.07	0.08	0.12	0.06	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.00
2E	Average	0.65	0.97	0.83	1.00	1.00	0.00	0.81	0.92	0.00	0.02	0.65	0.08	0.22	0.90	0.34	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.43	0.00
	STD	0.08	0.01	0.27	0.00	0.00	0.00	0.38	0.21	0.00	0.03	0.08	0.08	0.14	0.05	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22	0.00
3	Average	0.79	0.99	0.94	1.00	1.00	0.00	0.35	0.78	0.00	0.03	0.69	0.09	0.41	0.88	0.48	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.39	0.00
	STD	0.01	0.00	0.19	0.00	0.00	0.00	0.38	0.23	0.00	0.03	0.06	0.09	0.04	0.08	0.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.00
4A	Average	0.80	0.99	0.94	1.00	1.00	0.00	0.26	0.73	0.00	0.01	0.63	0.08	0.36	0.88	0.41	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.55	0.00
	STD	0.01	0.00	0.19	0.00	0.00	0.00	0.33	0.23	0.00	0.02	0.10	0.08	0.08	0.08	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.26	0.00
4B	Average	0.78	0.99	0.93	1.00	1.00	0.00	0.26	0.73	0.00	0.01	0.50	0.07	0.21	0.86	0.33	1.00	1.00	0.00	1.00	1.00	0.00	0.13	0.66	0.00
	STD	0.02	0.00	0.20	0.00	0.00	0.00	0.33	0.23	0.00	0.01	0.20	0.07	0.19	0.07	0.22	0.00	0.00	0.00	0.00	0.00	0.00	0.29	0.32	0.00
4C	Average	0.76	0.99	0.93	1.00	1.00	0.00	0.26	0.74	0.00	0.00	0.39	0.06	0.16	0.80	0.27	1.00	1.00	0.00	1.00	1.00	0.00	0.50	0.71	0.00
	STD	0.03	0.00	0.22	0.00	0.00	0.00	0.32	0.23	0.00	0.01	0.28	0.06	0.21	0.07	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.47	0.38	0.00
5	Average	0.85	0.99	0.96	1.00	1.00	0.00	0.01	0.85	0.00	0.04	0.71	0.10	0.41	0.90	0.48	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.43	0.00
	STD	0.02	0.00	0.14	0.00	0.00	0.00	0.04	0.21	0.00	0.04	0.06	0.09	0.04	0.08	0.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.00

Notes: Average-U_s, U_t, and P_v values averaged over all river locations and over all seasons within the 25-year planning period
STD-Standard deviation of U_s, U_t, and P_v values over all river locations and over all seasons within the 25-year planning period

TABLE D-10. Space-Time Average and Standard Deviation of Performance Measures for Each Individual Management Strategy Applied during the May-Jun Season (Computed over All Irrigation Diversion Points and Downstream Station at Weldona)

Strategy		High Criteria												Low Criteria											
		C_{TDS} (500 mg/L)			C_{NO_2} (10 mg/L)			C_N (15 mg/L)			C_{FC} (500 colonies/100 ml)			C_{TDS} (1000 mg/L)			C_{NO_2} (10 mg/L)			C_N (30 mg/L)			C_{FC} (1000 colonies/100 ml)		
		U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v
1	Average	0.68	0.96	0.64	1.00	1.00	0.00	0.52	0.87	0.27	0.31	0.87	0.26	0.00	0.65	0.11	1.00	1.00	0.00	0.03	0.56	0.05	0.00	0.52	0.08
	STD	0.01	0.02	0.20	0.00	0.00	0.00	0.01	0.02	0.13	0.02	0.02	0.18	0.00	0.06	0.12	0.00	0.00	0.00	0.03	0.11	0.04	0.00	0.12	0.10
2A	Average	0.66	0.96	0.62	1.00	1.00	0.00	0.52	0.86	0.27	0.31	0.87	0.26	0.00	0.63	0.10	1.00	1.00	0.00	0.03	0.56	0.04	0.00	0.52	0.08
	STD	0.02	0.01	0.21	0.00	0.00	0.00	0.01	0.03	0.13	0.02	0.02	0.18	0.00	0.06	0.12	0.00	0.00	0.00	0.03	0.11	0.04	0.00	0.12	0.10
2B	Average	0.64	0.96	0.60	1.00	1.00	0.00	0.53	0.86	0.26	0.31	0.87	0.26	0.00	0.59	0.10	1.00	1.00	0.00	0.03	0.55	0.04	0.00	0.52	0.08
	STD	0.03	0.01	0.22	0.00	0.00	0.00	0.01	0.03	0.12	0.02	0.02	0.17	0.00	0.07	0.12	0.00	0.00	0.00	0.03	0.11	0.04	0.00	0.12	0.10
2C	Average	0.61	0.96	0.58	1.00	1.00	0.00	0.53	0.86	0.26	0.31	0.87	0.25	0.00	0.55	0.10	1.00	1.00	0.00	0.03	0.54	0.04	0.00	0.52	0.08
	STD	0.04	0.01	0.22	0.00	0.00	0.00	0.01	0.03	0.12	0.02	0.02	0.17	0.00	0.09	0.12	0.00	0.00	0.00	0.03	0.11	0.04	0.00	0.12	0.10
2D	Average	0.59	0.95	0.57	1.00	1.00	0.00	0.53	0.86	0.25	0.31	0.87	0.25	0.00	0.52	0.10	1.00	1.00	0.00	0.03	0.53	0.04	0.00	0.51	0.08
	STD	0.05	0.01	0.23	0.00	0.00	0.00	0.01	0.02	0.12	0.02	0.02	0.17	0.00	0.11	0.12	0.00	0.00	0.00	0.04	0.12	0.04	0.00	0.12	0.10
2E	Average	0.56	0.95	0.55	1.00	1.00	0.00	0.53	0.85	0.25	0.31	0.87	0.25	0.00	0.51	0.09	1.00	1.00	0.00	0.03	0.52	0.04	0.00	0.51	0.08
	STD	0.06	0.01	0.24	0.00	0.00	0.00	0.01	0.03	0.11	0.02	0.02	0.17	0.00	0.11	0.11	0.00	0.00	0.00	0.04	0.14	0.04	0.00	0.12	0.10
3	Average	0.67	0.96	0.63	1.00	1.00	0.00	0.54	0.85	0.26	0.34	0.87	0.26	0.00	0.58	0.09	1.00	1.00	0.00	0.03	0.52	0.04	0.00	0.52	0.07
	STD	0.02	0.01	0.21	0.00	0.00	0.00	0.02	0.04	0.12	0.04	0.02	0.17	0.00	0.08	0.10	0.00	0.00	0.00	0.03	0.13	0.04	0.00	0.12	0.09
4A	Average	0.67	0.95	0.61	1.00	1.00	0.00	0.48	0.85	0.25	0.27	0.86	0.24	0.00	0.56	0.09	1.00	1.00	0.00	0.02	0.46	0.04	0.00	0.43	0.07
	STD	0.02	0.02	0.20	0.00	0.00	0.00	0.04	0.05	0.13	0.04	0.02	0.17	0.00	0.09	0.11	0.00	0.00	0.00	0.03	0.15	0.04	0.00	0.18	0.09
4B	Average	0.64	0.95	0.58	1.00	1.00	0.00	0.43	0.86	0.23	0.23	0.84	0.22	0.00	0.46	0.08	1.00	1.00	0.00	0.01	0.29	0.03	0.00	0.42	0.05
	STD	0.03	0.03	0.21	0.00	0.00	0.00	0.07	0.04	0.13	0.06	0.03	0.17	0.00	0.16	0.10	0.00	0.00	0.00	0.03	0.24	0.03	0.00	0.21	0.08
4C	Average	0.60	0.95	0.55	1.00	1.00	0.00	0.37	0.85	0.21	0.17	0.80	0.20	0.00	0.43	0.08	1.00	1.00	0.00	0.01	0.40	0.02	0.00	0.45	0.04
	STD	0.06	0.03	0.21	0.00	0.00	0.00	0.11	0.04	0.12	0.10	0.06	0.16	0.00	0.19	0.10	0.00	0.00	0.00	0.03	0.24	0.02	0.00	0.19	0.07
5	Average	0.66	0.95	0.63	1.00	1.00	0.00	0.52	0.87	0.27	0.35	0.88	0.26	0.00	0.65	0.11	1.00	1.00	0.00	0.03	0.55	0.04	0.00	0.54	0.08
	STD	0.02	0.02	0.21	0.00	0.00	0.00	0.01	0.02	0.13	0.03	0.02	0.17	0.00	0.06	0.12	0.00	0.00	0.00	0.03	0.11	0.04	0.00	0.10	0.09

Notes: Average-U_s, U_t, and P_v values averaged over all river locations and over all seasons within the 25-year planning period
STD-Standard deviation of U_s, U_t, and P_v values over all river locations and over all seasons within the 25-year planning period

TABLE D-11. Space-Time Average and Standard Deviation of Performance Measures for Each Individual Management Strategy Applied during the Jul-Aug Season (Computed over All Irrigation Diversion Points and Downstream Station at Weldona)

Strategy		High Criteria											
		C_{TDS} (500 mg/L)			C_{NO_2} (10 mg/L)			C_N (15 mg/L)			C_{FC} (500 colonies/100 ml)		
		U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v
1	Average	0.69	0.97	0.74	1.00	1.00	0.00	0.68	0.93	0.77	0.00	0.72	0.34
	STD	0.02	0.00	0.23	0.00	0.00	0.00	0.01	0.02	0.25	0.00	0.16	0.37
2A	Average	0.65	0.96	0.72	1.00	1.00	0.00	0.67	0.92	0.76	0.00	0.72	0.34
	STD	0.02	0.01	0.25	0.00	0.00	0.00	0.01	0.03	0.25	0.00	0.16	0.37
2B	Average	0.60	0.96	0.70	1.00	1.00	0.00	0.65	0.92	0.75	0.00	0.72	0.34
	STD	0.04	0.01	0.27	0.00	0.00	0.00	0.01	0.04	0.26	0.00	0.16	0.37
2C	Average	0.56	0.95	0.67	1.00	1.00	0.00	0.64	0.94	0.74	0.00	0.73	0.34
	STD	0.06	0.01	0.30	0.00	0.00	0.00	0.02	0.05	0.26	0.00	0.17	0.37
2D	Average	0.51	0.92	0.65	1.00	1.00	0.00	0.63	0.96	0.73	0.00	0.73	0.34
	STD	0.08	0.03	0.32	0.00	0.00	0.00	0.03	0.03	0.27	0.00	0.17	0.37
2E	Average	0.46	0.94	0.63	1.00	1.00	0.00	0.61	0.96	0.72	0.00	0.73	0.34
	STD	0.11	0.04	0.34	0.00	0.00	0.00	0.03	0.02	0.27	0.00	0.17	0.37
3	Average	0.64	0.95	0.72	1.00	1.00	0.00	0.67	0.90	0.76	0.00	0.70	0.33
	STD	0.02	0.02	0.25	0.00	0.00	0.00	0.01	0.04	0.25	0.00	0.17	0.37
4A	Average	0.67	0.97	0.73	1.00	1.00	0.00	0.67	0.93	0.75	0.00	0.76	0.33
	STD	0.01	0.00	0.24	0.00	0.00	0.00	0.01	0.02	0.24	0.00	0.13	0.37
4B	Average	0.66	0.96	0.71	1.00	1.00	0.00	0.66	0.93	0.72	0.00	0.76	0.31
	STD	0.01	0.01	0.24	0.00	0.00	0.00	0.02	0.02	0.24	0.00	0.10	0.36
4C	Average	0.63	0.96	0.69	1.00	1.00	0.00	0.63	0.92	0.67	0.00	0.79	0.29
	STD	0.03	0.01	0.25	0.00	0.00	0.00	0.03	0.02	0.24	0.00	0.10	0.34
5	Average	0.69	0.97	0.75	1.00	1.00	0.00	0.69	0.93	0.78	0.00	0.73	0.34
	STD	0.02	0.01	0.23	0.00	0.00	0.00	0.01	0.02	0.24	0.00	0.16	0.37

Strategy		Low Criteria											
		C_{TDS} (1000 mg/L)			C_{NO_2} (10 mg/L)			C_N (30 mg/L)			C_{FC} (1000 colonies/100 ml)		
		U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v
1	Average	0.00	0.65	0.20	1.00	1.00	0.00	0.33	0.81	0.09	0.00	0.83	0.14
	STD	0.00	0.10	0.24	0.00	0.00	0.00	0.04	0.03	0.06	0.00	0.07	0.22
2A	Average	0.00	0.65	0.19	1.00	1.00	0.00	0.32	0.81	0.09	0.00	0.83	0.14
	STD	0.00	0.08	0.24	0.00	0.00	0.00	0.04	0.03	0.06	0.00	0.07	0.22
2B	Average	0.00	0.66	0.19	1.00	1.00	0.00	0.30	0.80	0.09	0.00	0.84	0.14
	STD	0.00	0.09	0.24	0.00	0.00	0.00	0.04	0.03	0.06	0.00	0.07	0.22
2C	Average	0.00	0.65	0.19	1.00	1.00	0.00	0.28	0.79	0.08	0.00	0.84	0.14
	STD	0.00	0.09	0.23	0.00	0.00	0.00	0.05	0.03	0.06	0.00	0.07	0.22
2D	Average	0.00	0.65	0.18	1.00	1.00	0.00	0.25	0.79	0.08	0.00	0.84	0.14
	STD	0.00	0.08	0.23	0.00	0.00	0.00	0.05	0.04	0.06	0.00	0.07	0.22
2E	Average	0.00	0.64	0.18	1.00	1.00	0.00	0.23	0.78	0.08	0.00	0.84	0.14
	STD	0.00	0.08	0.22	0.00	0.00	0.00	0.06	0.04	0.06	0.00	0.07	0.22
3	Average	0.00	0.62	0.17	1.00	1.00	0.00	0.38	0.76	0.08	0.00	0.83	0.12
	STD	0.00	0.08	0.21	0.00	0.00	0.00	0.06	0.06	0.05	0.00	0.07	0.19
4A	Average	0.00	0.63	0.17	1.00	1.00	0.00	0.24	0.72	0.06	0.00	0.85	0.13
	STD	0.00	0.09	0.23	0.00	0.00	0.00	0.06	0.09	0.04	0.00	0.08	0.20
4B	Average	0.00	0.60	0.16	1.00	1.00	0.00	0.11	0.49	0.05	0.00	0.87	0.11
	STD	0.00	0.09	0.21	0.00	0.00	0.00	0.14	0.26	0.03	0.00	0.06	0.18
4C	Average	0.00	0.56	0.14	1.00	1.00	0.00	0.09	0.55	0.04	0.00	0.87	0.09
	STD	0.00	0.11	0.20	0.00	0.00	0.00	0.13	0.23	0.03	0.00	0.07	0.16
5	Average	0.00	0.68	0.20	1.00	1.00	0.00	0.34	0.81	0.09	0.00	0.85	0.13
	STD	0.00	0.08	0.24	0.00	0.00	0.00	0.04	0.03	0.06	0.00	0.07	0.20

Notes: Average-U_s, U_t, and P_v values averaged over all river locations and over all seasons within the 25-year planning period
STD-Standard deviation of U_s, U_t, and P_v values over all river locations and over all seasons within the 25-year planning period

TABLE D-12. Space-Time Average and Standard Deviation of Performance Measures for Each Individual Management Strategy Applied during the Sep-Oct Season (Computed over All Irrigation Diversion Points and Downstream Station at Weldona)

Strategy		High Criteria												Low Criteria											
		C_{TDS} (500 mg/L)			C_{NO_2} (10 mg/L)			C_N (15 mg/L)			C_{FC} (500 colonies/100 ml)			C_{TDS} (1000 mg/L)			C_{NO_2} (10 mg/L)			C_N (30 mg/L)			C_{FC} (1000 colonies/100 ml)		
		U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v
1	Average	0.69	0.96	0.85	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.81	0.11	0.00	0.68	0.10	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.75	0.02
	STD	0.00	0.00	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.15	0.00	0.09	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.03
2A	Average	0.68	0.94	0.84	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.81	0.10	0.00	0.74	0.08	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.75	0.02
	STD	0.00	0.01	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.14	0.00	0.06	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.03
2B	Average	0.68	0.90	0.82	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.81	0.10	0.00	0.73	0.07	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.74	0.01
	STD	0.01	0.04	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.14	0.00	0.06	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.03
2C	Average	0.66	0.86	0.79	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.81	0.10	0.00	0.72	0.06	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.74	0.01
	STD	0.01	0.09	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.14	0.00	0.06	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.03
2D	Average	0.59	0.91	0.74	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.81	0.10	0.01	0.71	0.06	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.75	0.01
	STD	0.05	0.09	0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.14	0.02	0.06	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.03
2E	Average	0.54	0.91	0.72	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.81	0.10	0.03	0.70	0.05	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.75	0.01
	STD	0.07	0.05	0.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.14	0.04	0.06	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.03
3	Average	0.68	0.93	0.85	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.79	0.10	0.00	0.71	0.09	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.75	0.01
	STD	0.00	0.03	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.14	0.00	0.08	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.03
4A	Average	0.68	0.96	0.84	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.81	0.10	0.00	0.64	0.07	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.74	0.01
	STD	0.00	0.01	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.13	0.00	0.11	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.02
4B	Average	0.68	0.96	0.84	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.82	0.09	0.00	0.60	0.05	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.72	0.01
	STD	0.00	0.01	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.12	0.01	0.12	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.02
4C	Average	0.67	0.96	0.83	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.82	0.07	0.12	0.55	0.04	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.68	0.01
	STD	0.01	0.00	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.10	0.12	0.13	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.02
5	Average	0.75	0.97	0.86	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.81	0.10	0.00	0.72	0.08	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.72	0.01
	STD	0.04	0.01	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.14	0.00	0.06	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.03

Notes: Average-U_s, U_t, and P_v values averaged over all river locations and over all seasons within the 25-year planning period
STD-Standard deviation of U_s, U_t, and P_v values over all river locations and over all seasons within the 25-year planning period

TABLE D-13. Space-Time Average and Standard Deviation of Performance Measures for Each Individual Management Strategy Applied during the Nov-Dec Season (Computed over All Irrigation Diversion Points and Downstream Station at Weldona)

Strategy		High Criteria												Low Criteria											
		C_{TDS} (500 mg/L)			C_{NO_3} (10 mg/L)			C_N (15 mg/L)			C_{FC} (500 colonies/100 ml)			C_{TDS} (1000 mg/L)			C_{NO_3} (10 mg/L)			C_N (30 mg/L)			C_{FC} (1000 colonies/100 ml)		
		U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v
1	Average	0.77	0.99	0.91	1.00	1.00	0.00	0.01	0.21	0.01	0.52	0.92	0.34	0.00	0.49	0.07	1.00	1.00	0.00	0.78	0.72	0.00	0.00	0.76	0.13
	STD	0.02	0.00	0.21	0.00	0.00	0.00	0.02	0.26	0.01	0.02	0.01	0.16	0.00	0.12	0.08	0.00	0.00	0.00	0.32	0.39	0.00	0.00	0.05	0.15
2A	Average	0.73	0.98	0.90	1.00	1.00	0.00	0.00	0.62	0.01	0.52	0.92	0.34	0.00	0.72	0.06	1.00	1.00	0.00	0.78	0.72	0.00	0.00	0.76	0.13
	STD	0.01	0.00	0.24	0.00	0.00	0.00	0.00	0.29	0.01	0.02	0.01	0.16	0.00	0.17	0.07	0.00	0.00	0.00	0.32	0.39	0.00	0.00	0.05	0.14
2B	Average	0.70	0.98	0.87	1.00	1.00	0.00	0.00	0.68	0.01	0.52	0.92	0.34	0.00	0.84	0.06	1.00	1.00	0.00	0.77	0.70	0.00	0.00	0.76	0.13
	STD	0.03	0.01	0.26	0.00	0.00	0.00	0.00	0.26	0.01	0.02	0.01	0.16	0.00	0.13	0.06	0.00	0.00	0.00	0.31	0.39	0.00	0.00	0.05	0.14
2C	Average	0.66	0.97	0.84	1.00	1.00	0.00	0.00	0.68	0.01	0.52	0.92	0.33	0.00	0.85	0.05	1.00	1.00	0.00	0.79	0.67	0.00	0.00	0.76	0.13
	STD	0.05	0.01	0.28	0.00	0.00	0.00	0.00	0.26	0.01	0.02	0.01	0.16	0.00	0.13	0.06	0.00	0.00	0.00	0.31	0.42	0.00	0.00	0.05	0.14
2D	Average	0.60	0.96	0.78	1.00	1.00	0.00	0.00	0.68	0.01	0.52	0.92	0.33	0.00	0.86	0.04	1.00	1.00	0.00	0.77	0.67	0.00	0.00	0.76	0.13
	STD	0.08	0.01	0.30	0.00	0.00	0.00	0.00	0.26	0.01	0.02	0.01	0.16	0.00	0.13	0.05	0.00	0.00	0.00	0.30	0.42	0.00	0.00	0.05	0.14
2E	Average	0.55	0.95	0.73	1.00	1.00	0.00	0.00	0.68	0.01	0.52	0.92	0.33	0.00	0.86	0.04	1.00	1.00	0.00	0.78	0.67	0.00	0.00	0.76	0.13
	STD	0.10	0.02	0.31	0.00	0.00	0.00	0.00	0.26	0.01	0.02	0.01	0.16	0.00	0.13	0.04	0.00	0.00	0.00	0.29	0.41	0.00	0.00	0.05	0.14
3	Average	0.74	0.99	0.90	1.00	1.00	0.00	0.00	0.25	0.01	0.54	0.92	0.35	0.00	0.51	0.07	1.00	1.00	0.00	0.81	0.71	0.00	0.00	0.77	0.14
	STD	0.02	0.00	0.24	0.00	0.00	0.00	0.01	0.31	0.01	0.02	0.01	0.16	0.00	0.18	0.08	0.00	0.00	0.00	0.29	0.42	0.00	0.01	0.06	0.14
4A	Average	0.76	0.99	0.91	1.00	1.00	0.00	0.00	0.24	0.01	0.49	0.92	0.32	0.00	0.45	0.07	1.00	1.00	0.00	0.78	0.72	0.00	0.00	0.70	0.12
	STD	0.01	0.00	0.22	0.00	0.00	0.00	0.02	0.28	0.01	0.03	0.01	0.16	0.00	0.26	0.08	0.00	0.00	0.00	0.32	0.39	0.00	0.00	0.09	0.14
4B	Average	0.75	0.99	0.90	1.00	1.00	0.00	0.00	0.26	0.01	0.45	0.91	0.30	0.00	0.51	0.06	1.00	1.00	0.00	0.78	0.72	0.00	0.00	0.61	0.10
	STD	0.01	0.00	0.23	0.00	0.00	0.00	0.01	0.28	0.01	0.05	0.02	0.17	0.00	0.31	0.07	0.00	0.00	0.00	0.32	0.39	0.00	0.00	0.16	0.14
4C	Average	0.73	0.98	0.88	1.00	1.00	0.00	0.00	0.30	0.01	0.39	0.89	0.28	0.00	0.62	0.06	1.00	1.00	0.00	0.78	0.72	0.00	0.00	0.53	0.09
	STD	0.02	0.00	0.23	0.00	0.00	0.00	0.01	0.29	0.01	0.09	0.02	0.17	0.00	0.33	0.07	0.00	0.00	0.00	0.32	0.39	0.00	0.00	0.24	0.13
5	Average	0.85	0.99	0.94	1.00	1.00	0.00	0.00	0.60	0.01	0.59	0.93	0.38	0.00	0.57	0.06	1.00	1.00	0.00	0.79	0.73	0.00	0.15	0.81	0.16
	STD	0.05	0.00	0.12	0.00	0.00	0.00	0.00	0.27	0.01	0.04	0.01	0.15	0.00	0.20	0.07	0.00	0.00	0.00	0.32	0.38	0.00	0.08	0.04	0.13

Notes: Average-U_s, U_t, and P_v values averaged over all river locations and over all seasons within the 25-year planning period
STD-Standard deviation of U_s, U_t, and P_v values over all river locations and over all seasons within the 25-year planning period

TABLE D-14. Space-Time Average and Standard Deviation of Ensemble Statistical Moments of Computed Water Quality Concentrations for Each Individual Management Strategy Applied during the Jan-Feb Season (Computed over All River Locations)

Strategy		C_{TDS}				C_{NO_2}				C_N				C_{FC}			
		5%	Mean	95%	CV	5%	Mean	95%	CV	5%	Mean	95%	CV	5%	Mean	95%	CV
1	Avg.	770.3	911.4	1037.0	0.09	0.16	0.30	0.50	0.56	5.60	7.97	10.13	0.18	77.8	248.0	510.3	0.57
	STD_s	169.1	189.9	202.5	0.03	0.27	0.43	0.62	0.18	2.20	2.90	3.43	0.04	73.6	159.4	372.2	0.11
	STD_t	7.5	6.3	8.6	0.00	0.01	0.01	0.02	0.03	0.13	0.07	0.11	0.01	5.8	9.9	24.5	0.02
2A	Avg.	742.1	887.0	1014.0	0.10	0.15	0.28	0.48	0.55	5.31	7.54	9.54	0.18	76.8	246.8	509.2	0.57
	STD_s	167.9	189.1	202.2	0.03	0.25	0.40	0.59	0.19	2.01	2.63	3.09	0.04	72.2	158.0	371.1	0.11
	STD_t	17.9	17.4	18.1	0.00	0.01	0.01	0.03	0.03	0.24	0.25	0.34	0.01	6.0	10.3	24.9	0.02
2B	Avg.	713.1	862.6	993.0	0.10	0.14	0.27	0.46	0.55	4.99	7.11	8.98	0.18	75.7	245.6	508.1	0.57
	STD_s	167.8	189.4	203.0	0.03	0.23	0.38	0.55	0.19	1.82	2.36	2.75	0.04	70.9	156.7	369.9	0.12
	STD_t	31.8	29.4	28.2	0.01	0.01	0.02	0.04	0.02	0.39	0.46	0.61	0.01	6.3	10.7	25.2	0.02
2C	Avg.	683.6	838.2	973.3	0.11	0.13	0.25	0.44	0.55	4.66	6.68	8.43	0.18	74.7	244.4	507.0	0.57
	STD_s	168.9	190.8	205.0	0.04	0.22	0.36	0.53	0.19	1.63	2.10	2.43	0.04	69.5	155.3	368.7	0.12
	STD_t	46.4	41.6	38.0	0.01	0.02	0.03	0.05	0.02	0.55	0.68	0.88	0.01	6.5	11.1	25.6	0.02
2D	Avg.	653.6	813.8	954.6	0.12	0.12	0.24	0.41	0.55	4.31	6.25	7.92	0.18	73.6	243.2	505.9	0.57
	STD_s	171.3	193.4	207.8	0.04	0.20	0.33	0.50	0.20	1.43	1.84	2.13	0.05	68.1	154.0	367.5	0.12
	STD_t	61.3	53.8	47.4	0.01	0.02	0.04	0.06	0.02	0.72	0.89	1.14	0.01	6.8	11.5	25.9	0.02
2E	Avg.	623.0	789.4	936.8	0.13	0.11	0.22	0.39	0.55	3.94	5.82	7.45	0.19	72.5	242.0	504.8	0.58
	STD_s	174.9	196.9	211.0	0.04	0.19	0.31	0.47	0.20	1.24	1.60	1.87	0.05	66.8	152.7	366.3	0.12
	STD_t	76.6	66.1	56.3	0.02	0.03	0.04	0.07	0.02	0.90	1.11	1.37	0.01	7.2	12.0	26.3	0.02
3	Avg.	762.8	904.0	1029.0	0.09	0.16	0.30	0.50	0.55	5.58	7.90	10.03	0.18	76.6	243.7	500.6	0.56
	STD_s	176.4	195.7	207.7	0.03	0.26	0.42	0.61	0.18	2.19	2.88	3.40	0.03	70.2	153.0	359.9	0.11
	STD_t	9.3	9.5	11.4	0.00	0.01	0.01	0.02	0.03	0.14	0.09	0.14	0.01	6.1	11.3	27.2	0.02
4A	Avg.	755.8	882.1	997.1	0.09	0.15	0.29	0.49	0.56	5.50	7.82	9.98	0.18	76.3	236.0	480.9	0.56
	STD_s	162.2	177.7	187.7	0.03	0.26	0.42	0.61	0.18	2.19	2.92	3.47	0.04	73.6	154.1	352.0	0.11
	STD_t	12.3	23.6	31.8	0.01	0.01	0.01	0.02	0.03	0.16	0.14	0.17	0.01	6.1	16.1	38.6	0.02
4B	Avg.	738.8	852.9	960.1	0.08	0.15	0.29	0.48	0.56	5.39	7.68	9.85	0.18	74.7	224.1	451.5	0.55
	STD_s	154.5	165.9	174.1	0.03	0.26	0.41	0.59	0.18	2.19	2.94	3.52	0.04	73.6	148.8	331.8	0.11
	STD_t	22.3	41.9	54.7	0.01	0.01	0.01	0.03	0.03	0.22	0.22	0.24	0.01	6.6	23.0	55.4	0.02
4C	Avg.	718.4	823.6	926.0	0.08	0.15	0.28	0.46	0.56	5.26	7.54	9.73	0.19	73.2	212.1	422.1	0.55
	STD_s	145.9	154.4	162.0	0.02	0.25	0.40	0.58	0.18	2.19	2.96	3.56	0.04	73.6	143.6	311.8	0.11
	STD_t	35.5	60.3	75.6	0.01	0.01	0.02	0.04	0.03	0.29	0.31	0.31	0.01	7.3	30.3	73.0	0.02
5	Avg.	760.9	903.5	1031.0	0.10	0.15	0.28	0.47	0.56	5.17	7.39	9.46	0.18	80.7	252.8	516.4	0.56
	STD_s	167.1	188.3	201.3	0.03	0.24	0.39	0.57	0.19	2.00	2.52	2.99	0.04	74.1	156.1	361.2	0.11
	STD_t	10.2	9.3	10.8	0.00	0.01	0.02	0.03	0.03	0.31	0.33	0.38	0.01	5.7	9.0	23.4	0.02

Notes: Avg.-Spatial and temporal-averaged ensemble statistical moments over all river locations and over all weeks in the season
STD_s-Standard deviation over all river locations of the values of the temporal-averaged ensemble statistical moments (averaged over all weeks in the seas
STD_t-Standard deviation over all years in the 25-year period of the values of the spatial-averaged ensemble statistical moments (averaged over all river lo

TABLE D-15. Space-Time Average and Standard Deviation of Ensemble Statistical Moments of Computed Water Quality Concentrations for Each Individual Management Strategy Applied during the Mar-Apr Season (Computed over All River Locations)

Strategy		C_{TDS}				C_{NO_2}				C_N				C_{FC}			
		5%	Mean	95%	CV	5%	Mean	95%	CV	5%	Mean	95%	CV	5%	Mean	95%	CV
1	Avg.	682.7	942.4	1246.0	0.20	0.04	0.09	0.19	0.50	4.29	6.47	8.84	0.22	65.5	206.5	479.3	0.76
	STD_s	250.0	288.2	439.3	0.11	0.03	0.08	0.21	0.14	1.58	2.29	2.99	0.05	59.8	110.7	184.1	0.27
	STD_t	9.1	13.3	29.3	0.04	0.00	0.00	0.01	0.02	0.18	0.12	0.11	0.01	4.3	8.3	24.7	0.04
2A	Avg.	662.6	922.5	1229.0	0.21	0.04	0.09	0.19	0.50	4.10	6.11	8.28	0.22	63.5	202.1	474.7	0.77
	STD_s	250.1	289.0	443.5	0.11	0.02	0.08	0.21	0.15	1.45	2.07	2.68	0.05	57.9	108.0	182.6	0.27
	STD_t	14.7	21.4	36.3	0.04	0.00	0.00	0.01	0.02	0.13	0.14	0.28	0.01	3.7	7.4	24.4	0.04
2B	Avg.	641.7	902.6	1213.0	0.22	0.03	0.08	0.18	0.49	3.92	5.76	7.73	0.21	61.4	197.8	470.1	0.78
	STD_s	250.6	290.3	447.8	0.11	0.02	0.07	0.21	0.15	1.33	1.85	2.38	0.05	56.1	105.3	181.1	0.27
	STD_t	23.9	30.7	43.5	0.04	0.00	0.00	0.01	0.02	0.14	0.30	0.55	0.02	3.2	7.2	24.3	0.04
2C	Avg.	620.2	882.7	1197.0	0.22	0.03	0.08	0.17	0.49	3.73	5.40	7.19	0.20	59.3	193.4	465.6	0.80
	STD_s	251.6	292.1	452.1	0.11	0.02	0.07	0.21	0.16	1.21	1.63	2.08	0.06	54.1	102.6	179.6	0.27
	STD_t	34.2	40.3	50.8	0.04	0.00	0.01	0.01	0.02	0.20	0.47	0.82	0.02	3.0	7.7	24.5	0.04
2D	Avg.	598.0	862.8	1182.0	0.23	0.03	0.08	0.17	0.48	3.53	5.05	6.65	0.19	57.0	189.0	461.2	0.81
	STD_s	253.2	294.5	456.5	0.12	0.02	0.07	0.21	0.17	1.10	1.42	1.78	0.06	52.1	99.9	178.2	0.27
	STD_t	45.1	50.1	57.9	0.04	0.00	0.01	0.01	0.02	0.28	0.64	1.09	0.02	3.2	8.6	24.8	0.04
2E	Avg.	574.9	842.9	1168.0	0.24	0.03	0.07	0.16	0.48	3.33	4.69	6.13	0.19	54.7	184.7	456.8	0.82
	STD_s	255.4	297.5	460.9	0.12	0.02	0.07	0.21	0.18	0.99	1.21	1.50	0.06	50.0	97.2	176.7	0.27
	STD_t	56.5	59.9	64.9	0.05	0.00	0.01	0.02	0.02	0.38	0.82	1.34	0.03	3.8	10.0	25.4	0.04
3	Avg.	664.3	923.0	1226.0	0.21	0.04	0.09	0.19	0.50	4.28	6.39	8.71	0.22	65.6	205.4	473.9	0.74
	STD_s	252.2	288.7	429.4	0.11	0.02	0.07	0.21	0.15	1.55	2.23	2.92	0.05	57.8	107.8	180.4	0.24
	STD_t	14.4	20.5	36.2	0.04	0.00	0.00	0.01	0.02	0.17	0.10	0.12	0.01	4.3	7.9	24.1	0.05
4A	Avg.	666.8	908.4	1189.0	0.20	0.04	0.09	0.19	0.50	4.19	6.38	8.77	0.23	65.2	200.2	455.7	0.74
	STD_s	239.4	272.4	409.4	0.11	0.03	0.07	0.20	0.13	1.57	2.31	3.03	0.05	59.6	107.4	173.2	0.26
	STD_t	14.6	33.0	62.2	0.04	0.00	0.00	0.01	0.02	0.14	0.09	0.11	0.01	4.2	7.0	26.4	0.05
4B	Avg.	648.0	874.4	1134.0	0.19	0.04	0.09	0.18	0.50	4.09	6.29	8.71	0.23	64.9	193.8	432.2	0.72
	STD_s	227.1	256.9	379.4	0.10	0.02	0.07	0.18	0.13	1.56	2.33	3.07	0.05	59.5	104.1	162.4	0.26
	STD_t	25.3	54.1	95.8	0.04	0.00	0.00	0.01	0.02	0.11	0.08	0.13	0.01	4.0	7.9	35.0	0.06
4C	Avg.	626.0	840.4	1082.0	0.18	0.04	0.08	0.17	0.49	3.98	6.19	8.64	0.23	64.5	187.5	409.0	0.70
	STD_s	213.0	241.6	349.9	0.09	0.02	0.07	0.17	0.12	1.55	2.36	3.11	0.05	59.3	100.9	151.7	0.26
	STD_t	39.3	75.4	127.4	0.04	0.00	0.00	0.01	0.02	0.13	0.11	0.15	0.01	3.8	10.5	46.8	0.07
5	Avg.	665.1	927.0	1234.0	0.21	0.04	0.09	0.18	0.49	4.10	6.12	8.39	0.22	66.8	211.0	487.1	0.76
	STD_s	248.3	285.3	438.7	0.11	0.03	0.08	0.21	0.13	1.46	2.05	2.74	0.05	61.2	113.0	186.7	0.26
	STD_t	13.7	19.2	33.8	0.04	0.00	0.00	0.01	0.02	0.13	0.15	0.24	0.01	4.7	9.5	25.4	0.04

Notes: Avg.-Spatial and temporal-averaged ensemble statistical moments over all river locations and over all weeks in the season
STD_s-Standard deviation over all river locations of the values of the temporal-averaged ensemble statistical moments (averaged over all weeks in the seasc
STD_t-Standard deviation over all years in the 25-year period of the values of the spatial-averaged ensemble statistical moments (averaged over all river loc

TABLE D-16. Space-Time Average and Standard Deviation of Ensemble Statistical Moments of Computed Water Quality Concentrations for Each Individual Management Strategy Applied during the May-Jun Season (Computed over All River Locations)

Strategy		C_{TDS}				C_{NO_2}				C_N				C_{FC}			
		5%	Mean	95%	CV	5%	Mean	95%	CV	5%	Mean	95%	CV	5%	Mean	95%	CV
1	Avg.	297.7	619.3	948.4	0.58	0.02	0.17	0.48	0.67	2.08	4.14	8.07	0.46	28.2	370.9	1031.0	1.01
	STD_s	77.5	176.2	276.2	0.27	0.02	0.24	0.71	0.31	0.46	1.10	2.84	0.12	28.5	203.1	490.6	0.23
	STD_t	7.7	13.6	13.1	2.57	0.00	0.01	0.02	0.01	0.07	0.10	0.32	0.02	1.8	13.4	41.2	0.03
2A	Avg.	291.7	609.6	938.2	0.59	0.02	0.17	0.48	0.68	2.05	4.09	8.00	0.46	27.5	369.2	1029.0	1.02
	STD_s	77.9	176.9	277.5	0.28	0.02	0.24	0.71	0.31	0.45	1.07	2.81	0.13	27.4	202.5	490.3	0.23
	STD_t	7.1	13.9	14.4	2.64	0.00	0.01	0.02	0.01	0.07	0.11	0.32	0.02	1.7	13.6	41.4	0.03
2B	Avg.	285.6	599.9	928.8	0.60	0.02	0.17	0.48	0.68	2.02	4.03	7.94	0.47	26.7	367.5	1028.0	1.02
	STD_s	78.8	178.2	279.1	0.30	0.01	0.24	0.71	0.32	0.44	1.04	2.77	0.13	26.2	201.8	490.0	0.23
	STD_t	7.7	15.9	16.9	2.72	0.00	0.01	0.02	0.01	0.08	0.12	0.33	0.02	1.7	13.8	41.7	0.03
2C	Avg.	279.4	590.2	919.9	0.62	0.02	0.17	0.48	0.68	1.98	3.98	7.87	0.47	25.9	365.8	1026.0	1.03
	STD_s	80.1	179.8	281.0	0.31	0.01	0.24	0.71	0.32	0.44	1.01	2.74	0.14	25.0	201.2	489.7	0.23
	STD_t	9.4	18.9	20.1	2.80	0.00	0.01	0.02	0.01	0.09	0.14	0.34	0.02	1.8	14.0	42.0	0.03
2D	Avg.	273.1	580.5	911.7	0.63	0.02	0.17	0.48	0.69	1.95	3.92	7.81	0.48	25.1	364.1	1025.0	1.03
	STD_s	81.8	181.9	282.9	0.33	0.01	0.24	0.71	0.33	0.44	0.98	2.70	0.14	23.8	200.5	489.4	0.23
	STD_t	11.7	22.5	23.3	2.89	0.00	0.01	0.02	0.02	0.11	0.16	0.35	0.02	2.0	14.3	42.2	0.03
2E	Avg.	266.6	570.9	904.1	0.65	0.02	0.17	0.48	0.70	1.91	3.87	7.74	0.48	24.2	362.4	1023.0	1.04
	STD_s	84.0	184.4	284.8	0.35	0.01	0.24	0.71	0.33	0.44	0.96	2.67	0.15	22.6	199.9	489.2	0.23
	STD_t	14.5	26.5	26.6	2.99	0.00	0.01	0.02	0.02	0.13	0.18	0.36	0.02	2.2	14.7	42.5	0.04
3	Avg.	296.6	602.8	917.7	0.57	0.02	0.17	0.47	0.68	2.07	4.05	7.85	0.45	29.7	366.2	1004.0	0.97
	STD_s	81.1	175.7	267.2	0.26	0.02	0.23	0.70	0.31	0.48	1.08	2.71	0.11	26.6	182.9	449.8	0.18
	STD_t	7.3	17.6	30.0	2.59	0.00	0.01	0.02	0.01	0.07	0.13	0.36	0.02	2.4	14.3	47.6	0.05
4A	Avg.	288.4	603.7	927.6	0.57	0.02	0.16	0.45	0.66	2.03	3.97	7.64	0.45	27.7	348.6	964.9	1.01
	STD_s	73.1	172.8	276.7	0.26	0.02	0.23	0.66	0.31	0.44	1.05	2.67	0.12	28.4	190.8	458.8	0.23
	STD_t	8.1	17.0	20.2	2.45	0.00	0.01	0.03	0.01	0.09	0.17	0.44	0.02	1.7	20.7	65.8	0.04
4B	Avg.	278.8	587.9	908.5	0.56	0.02	0.15	0.42	0.65	1.98	3.80	7.21	0.43	27.2	326.2	898.9	1.00
	STD_s	68.9	169.5	278.3	0.24	0.02	0.21	0.61	0.30	0.43	1.00	2.50	0.11	28.2	178.5	427.0	0.22
	STD_t	12.1	23.8	30.3	2.28	0.00	0.02	0.04	0.01	0.11	0.27	0.66	0.02	1.6	32.8	102.2	0.04
4C	Avg.	269.0	572.1	891.2	0.54	0.02	0.14	0.39	0.64	1.92	3.63	6.79	0.42	26.7	303.9	833.0	0.99
	STD_s	65.0	166.3	280.6	0.22	0.02	0.20	0.57	0.30	0.41	0.95	2.34	0.11	28.1	166.2	395.1	0.22
	STD_t	17.5	32.2	40.3	2.08	0.00	0.02	0.06	0.02	0.15	0.37	0.91	0.02	1.6	46.2	141.7	0.04
5	Avg.	287.4	607.1	939.7	0.60	0.02	0.17	0.48	0.68	2.03	4.08	7.98	0.46	29.1	377.5	1043.0	1.00
	STD_s	79.5	175.9	275.9	0.29	0.01	0.24	0.71	0.31	0.44	1.05	2.78	0.13	29.6	199.4	480.5	0.22
	STD_t	7.5	14.3	14.2	2.69	0.00	0.01	0.02	0.01	0.08	0.11	0.33	0.02	2.0	13.8	41.3	0.04

Notes: Avg.-Spatial and temporal-averaged ensemble statistical moments over all river locations and over all weeks in the season
STD_s-Standard deviation over all river locations of the values of the temporal-averaged ensemble statistical moments (averaged over all weeks in the seasc
STD_t-Standard deviation over all years in the 25-year period of the values of the spatial-averaged ensemble statistical moments (averaged over all river loc

TABLE D-17. Space-Time Average and Standard Deviation of Ensemble Statistical Moments of Computed Water Quality Concentrations for Each Individual Management Strategy Applied during the Jul-Aug Season (Computed over All River Locations)

Strategy		C_{TDS}				C_{NO_2}				C_N				C_{FC}			
		5%	Mean	95%	CV	5%	Mean	95%	CV	5%	Mean	95%	CV	5%	Mean	95%	CV
1	Avg.	392.0	703.5	970.9	0.32	0.03	0.09	0.20	0.60	3.82	6.31	9.46	0.28	169.6	570.8	1107.0	0.50
	STD_s	179.1	259.6	347.3	0.14	0.03	0.10	0.28	0.29	1.43	1.94	2.75	0.11	131.6	396.1	892.9	0.19
	STD_t	12.8	13.2	30.3	0.17	0.00	0.00	0.01	0.03	0.13	0.13	0.20	0.01	7.4	16.0	36.0	0.01
2A	Avg.	385.0	693.2	960.3	0.32	0.02	0.09	0.20	0.59	3.76	6.23	9.37	0.29	168.8	569.8	1106.0	0.50
	STD_s	181.9	264.2	352.5	0.15	0.03	0.10	0.28	0.29	1.45	1.95	2.74	0.12	129.8	395.1	892.4	0.18
	STD_t	12.4	15.1	31.7	0.17	0.00	0.00	0.01	0.03	0.15	0.16	0.22	0.01	7.4	16.2	36.3	0.01
2B	Avg.	378.0	682.8	949.8	0.33	0.02	0.09	0.20	0.59	3.70	6.15	9.29	0.29	168.0	568.9	1105.0	0.50
	STD_s	184.9	269.0	357.8	0.15	0.03	0.10	0.28	0.28	1.48	1.97	2.73	0.13	128.1	394.1	891.9	0.18
	STD_t	13.0	18.3	33.9	0.18	0.00	0.00	0.01	0.03	0.17	0.19	0.25	0.01	7.5	16.4	36.5	0.01
2C	Avg.	370.9	672.5	939.6	0.33	0.02	0.08	0.20	0.59	3.64	6.07	9.21	0.30	167.2	567.9	1104.0	0.50
	STD_s	188.1	274.1	363.2	0.16	0.03	0.10	0.28	0.28	1.51	2.00	2.72	0.13	126.2	393.1	891.3	0.18
	STD_t	14.5	22.2	36.6	0.18	0.00	0.00	0.01	0.03	0.20	0.22	0.28	0.01	7.6	16.7	36.8	0.01
2D	Avg.	363.8	662.1	929.7	0.34	0.02	0.08	0.20	0.59	3.57	5.99	9.13	0.30	166.3	567.0	1103.0	0.50
	STD_s	191.6	279.4	368.7	0.17	0.02	0.10	0.28	0.27	1.55	2.03	2.72	0.14	124.4	392.2	890.8	0.18
	STD_t	16.7	26.6	39.6	0.18	0.00	0.00	0.01	0.03	0.22	0.26	0.31	0.01	7.7	16.9	37.1	0.01
2E	Avg.	356.6	651.8	919.9	0.35	0.02	0.08	0.20	0.59	3.50	5.92	9.05	0.31	165.4	566.0	1102.0	0.50
	STD_s	195.3	285.0	374.2	0.17	0.02	0.10	0.28	0.27	1.59	2.06	2.72	0.15	122.5	391.2	890.3	0.18
	STD_t	19.3	31.3	43.0	0.19	0.00	0.01	0.01	0.02	0.25	0.29	0.34	0.02	7.9	17.2	37.3	0.01
3	Avg.	384.4	681.0	936.8	0.31	0.03	0.08	0.19	0.58	3.73	6.13	9.19	0.28	164.0	536.5	1033.0	0.49
	STD_s	169.3	253.1	337.2	0.13	0.03	0.10	0.27	0.28	1.42	1.95	2.72	0.11	124.6	360.4	807.8	0.18
	STD_t	12.2	22.2	40.1	0.17	0.00	0.01	0.01	0.03	0.17	0.22	0.32	0.01	8.9	33.3	72.8	0.01
4A	Avg.	385.5	687.1	947.4	0.31	0.03	0.08	0.19	0.59	3.73	6.04	8.96	0.27	164.1	539.6	1040.0	0.50
	STD_s	173.7	253.2	341.4	0.14	0.03	0.10	0.27	0.29	1.36	1.82	2.59	0.11	129.0	373.3	835.8	0.18
	STD_t	11.4	17.5	33.0	0.17	0.00	0.01	0.01	0.03	0.18	0.28	0.45	0.01	9.3	33.7	71.9	0.01
4B	Avg.	378.6	670.7	925.0	0.31	0.02	0.08	0.18	0.59	3.63	5.77	8.47	0.26	158.4	508.5	973.5	0.49
	STD_s	168.1	247.1	336.3	0.13	0.03	0.10	0.25	0.29	1.30	1.71	2.42	0.11	126.3	350.7	778.9	0.18
	STD_t	11.4	25.5	41.2	0.16	0.00	0.01	0.02	0.03	0.23	0.44	0.74	0.01	12.2	52.8	112.2	0.01
4C	Avg.	371.0	654.3	903.6	0.30	0.02	0.07	0.17	0.58	3.53	5.51	7.98	0.25	152.6	477.4	907.1	0.48
	STD_s	162.0	241.3	332.6	0.12	0.03	0.09	0.23	0.30	1.23	1.60	2.26	0.10	123.4	328.3	722.1	0.18
	STD_t	13.4	34.8	51.6	0.16	0.00	0.01	0.03	0.03	0.29	0.61	1.05	0.02	15.4	72.2	153.3	0.01
5	Avg.	390.7	701.9	969.4	0.32	0.03	0.09	0.20	0.60	3.80	6.28	9.41	0.28	170.3	568.8	1102.0	0.50
	STD_s	179.7	259.9	347.5	0.14	0.03	0.10	0.27	0.29	1.42	1.93	2.72	0.10	132.3	390.8	880.8	0.19
	STD_t	12.8	13.4	30.2	0.17	0.00	0.00	0.01	0.03	0.14	0.14	0.21	0.01	7.4	16.6	37.4	0.01

Notes: Avg.-Spatial and temporal-averaged ensemble statistical moments over all river locations and over all weeks in the season
STD_s-Standard deviation over all river locations of the values of the temporal-averaged ensemble statistical moments (averaged over all weeks in the seasc
STD_t-Standard deviation over all years in the 25-year period of the values of the spatial-averaged ensemble statistical moments (averaged over all river loc

TABLE D-18. Space-Time Average and Standard Deviation of Ensemble Statistical Moments of Computed Water Quality Concentrations for Each Individual Management Strategy Applied during the Sep-Oct Season (Computed over All River Locations)

		C_{TDS}				C_{NO_3}				C_N				C_{FC}			
Strategy		5%	Mean	95%	CV	5%	Mean	95%	CV	5%	Mean	95%	CV	5%	Mean	95%	CV
1	Avg.	463.7	741.8	913.7	0.52	0.05	0.10	0.17	0.52	4.33	5.85	7.42	0.16	66.6	235.1	532.9	0.82
	STD_s	133.4	194.4	235.4	0.27	0.07	0.10	0.16	0.22	1.43	1.91	2.38	0.04	93.7	189.6	429.3	0.35
	STD_t	19.9	30.9	23.1	0.38	0.00	0.00	0.00	0.02	0.06	0.04	0.10	0.01	1.6	8.1	19.6	0.03
2A	Avg.	448.4	722.5	894.0	0.53	0.04	0.09	0.16	0.52	4.19	5.61	7.08	0.16	65.3	233.3	530.8	0.82
	STD_s	131.2	189.5	233.1	0.28	0.06	0.10	0.15	0.22	1.31	1.72	2.13	0.04	91.7	187.9	428.8	0.34
	STD_t	18.0	32.9	28.7	0.39	0.00	0.00	0.01	0.02	0.08	0.14	0.25	0.01	1.9	8.6	20.2	0.03
2B	Avg.	432.7	703.1	874.9	0.54	0.04	0.09	0.16	0.52	4.04	5.37	6.74	0.16	64.0	231.5	528.8	0.81
	STD_s	130.3	186.0	232.6	0.29	0.06	0.09	0.14	0.21	1.20	1.54	1.90	0.03	89.7	186.3	428.2	0.34
	STD_t	19.4	37.5	35.9	0.40	0.00	0.00	0.01	0.02	0.14	0.26	0.41	0.01	2.4	9.2	20.8	0.03
2C	Avg.	416.8	683.7	856.6	0.55	0.04	0.08	0.15	0.53	3.88	5.13	6.41	0.15	62.7	229.7	526.8	0.81
	STD_s	130.7	183.9	233.8	0.31	0.05	0.08	0.14	0.21	1.09	1.38	1.69	0.03	87.7	184.7	427.7	0.33
	STD_t	23.5	43.8	43.7	0.41	0.00	0.01	0.01	0.02	0.22	0.38	0.57	0.01	3.0	9.8	21.5	0.03
2D	Avg.	400.4	664.4	838.8	0.57	0.04	0.08	0.15	0.54	3.71	4.89	6.10	0.15	61.3	228.0	524.9	0.81
	STD_s	132.3	183.3	236.7	0.33	0.05	0.08	0.13	0.21	1.00	1.24	1.51	0.03	85.7	183.2	427.1	0.33
	STD_t	29.5	51.1	51.6	0.42	0.01	0.01	0.01	0.02	0.30	0.50	0.73	0.01	3.6	10.4	22.1	0.03
2E	Avg.	383.6	645.1	821.6	0.59	0.03	0.08	0.14	0.55	3.53	4.65	5.79	0.15	59.9	226.2	523.1	0.81
	STD_s	135.0	184.2	241.1	0.35	0.04	0.07	0.13	0.20	0.93	1.13	1.39	0.03	83.6	181.7	426.6	0.32
	STD_t	36.7	59.4	59.6	0.44	0.01	0.01	0.01	0.03	0.39	0.62	0.88	0.01	4.3	11.1	22.8	0.03
3	Avg.	460.8	731.3	898.1	0.51	0.05	0.10	0.16	0.51	4.33	5.79	7.28	0.16	64.7	226.2	512.1	0.81
	STD_s	136.5	197.6	237.8	0.26	0.07	0.10	0.16	0.22	1.42	1.89	2.35	0.03	90.4	178.3	405.5	0.34
	STD_t	19.2	31.6	28.2	0.38	0.00	0.00	0.01	0.02	0.06	0.09	0.19	0.01	2.6	12.7	29.7	0.03
4A	Avg.	454.6	721.6	885.2	0.50	0.05	0.09	0.16	0.51	4.23	5.74	7.31	0.17	66.2	225.2	504.4	0.82
	STD_s	130.5	186.1	219.3	0.25	0.07	0.10	0.15	0.22	1.43	1.92	2.42	0.04	93.4	182.4	403.0	0.36
	STD_t	18.6	32.5	33.4	0.37	0.00	0.00	0.01	0.02	0.08	0.10	0.16	0.01	1.7	13.2	33.4	0.03
4B	Avg.	444.8	701.4	859.1	0.49	0.05	0.09	0.15	0.51	4.13	5.64	7.20	0.17	65.7	215.4	476.0	0.81
	STD_s	127.6	178.1	204.6	0.24	0.07	0.10	0.15	0.21	1.43	1.94	2.45	0.04	93.2	175.5	376.8	0.36
	STD_t	19.1	38.6	46.9	0.36	0.00	0.00	0.01	0.02	0.13	0.17	0.23	0.01	1.9	19.0	49.8	0.03
4C	Avg.	434.1	681.4	835.5	0.48	0.04	0.09	0.15	0.50	4.02	5.53	7.11	0.17	65.2	205.6	448.0	0.81
	STD_s	124.8	170.7	192.0	0.23	0.07	0.10	0.14	0.21	1.43	1.96	2.49	0.05	92.8	168.8	351.0	0.37
	STD_t	21.9	47.7	60.1	0.35	0.00	0.01	0.01	0.02	0.20	0.23	0.28	0.01	2.1	24.9	66.8	0.03
5	Avg.	445.4	719.0	892.8	0.54	0.06	0.12	0.19	0.51	4.06	5.46	6.95	0.16	64.3	233.0	532.5	0.83
	STD_s	128.5	182.5	224.9	0.28	0.10	0.15	0.22	0.23	1.16	1.56	2.02	0.04	90.2	188.5	426.9	0.34
	STD_t	18.0	33.7	28.8	0.39	0.01	0.01	0.01	0.02	0.14	0.22	0.30	0.01	2.3	8.8	20.1	0.03

Notes: Avg.-Spatial and temporal-averaged ensemble statistical moments over all river locations and over all weeks in the season
STD_s-Standard deviation over all river locations of the values of the temporal-averaged ensemble statistical moments (averaged over all weeks in the seasc
STD_t-Standard deviation over all years in the 25-year period of the values of the spatial-averaged ensemble statistical moments (averaged over all river loc

TABLE D-19. Space-Time Average and Standard Deviation of Ensemble Statistical Moments of Computed Water Quality Concentrations for Each Individual Management Strategy Applied during the Nov-Dec Season (Computed over All River Locations)

Strategy		C_{TDS}				C_{NO_2}				C_N				C_{FC}			
		5%	Mean	95%	CV	5%	Mean	95%	CV	5%	Mean	95%	CV	5%	Mean	95%	CV
1	Avg.	557.4	757.8	1005.0	0.19	0.06	0.12	0.20	0.62	4.43	6.81	9.77	0.33	73.5	444.8	1139.0	0.86
	STD_s	129.2	150.5	211.4	0.08	0.08	0.14	0.20	0.36	1.84	2.22	2.66	0.14	67.5	231.1	513.6	0.13
	STD_t	6.4	5.5	18.0	0.01	0.00	0.01	0.01	0.12	0.23	0.36	0.75	0.03	4.1	18.9	52.0	0.03
2A	Avg.	537.5	733.9	976.5	0.19	0.05	0.11	0.19	0.61	4.25	6.52	9.37	0.33	72.0	441.7	1135.0	0.86
	STD_s	122.4	148.0	212.9	0.08	0.08	0.13	0.20	0.35	1.64	1.96	2.37	0.14	65.3	228.5	511.7	0.13
	STD_t	9.0	15.0	29.1	0.01	0.01	0.01	0.01	0.12	0.30	0.47	0.89	0.03	4.4	18.6	52.0	0.03
2B	Avg.	516.6	709.9	948.8	0.20	0.05	0.11	0.18	0.61	4.06	6.22	8.99	0.33	70.4	438.6	1132.0	0.87
	STD_s	117.0	147.1	215.0	0.07	0.07	0.12	0.19	0.34	1.44	1.72	2.12	0.15	63.0	226.0	509.8	0.13
	STD_t	18.4	26.6	41.8	0.01	0.01	0.01	0.02	0.11	0.37	0.60	1.03	0.04	4.7	18.5	52.0	0.03
2C	Avg.	495.0	686.0	922.3	0.20	0.05	0.10	0.18	0.60	3.87	5.92	8.62	0.33	68.9	435.5	1129.0	0.87
	STD_s	113.6	147.8	217.6	0.07	0.06	0.11	0.18	0.33	1.25	1.49	1.94	0.15	60.6	223.5	507.9	0.12
	STD_t	28.9	38.5	54.6	0.01	0.01	0.02	0.02	0.11	0.46	0.74	1.18	0.04	5.2	18.5	52.1	0.03
2D	Avg.	472.5	662.1	897.2	0.20	0.04	0.09	0.17	0.60	3.67	5.63	8.27	0.34	67.2	432.4	1126.0	0.88
	STD_s	112.6	150.1	220.5	0.07	0.06	0.10	0.17	0.32	1.07	1.29	1.83	0.16	58.3	221.0	506.1	0.12
	STD_t	40.1	50.4	66.9	0.01	0.01	0.02	0.03	0.10	0.55	0.88	1.34	0.04	5.8	18.7	52.2	0.03
2E	Avg.	449.2	638.2	873.2	0.21	0.04	0.09	0.16	0.60	3.45	5.33	7.93	0.34	65.5	429.3	1123.0	0.88
	STD_s	114.5	153.9	223.7	0.06	0.05	0.10	0.16	0.30	0.89	1.12	1.83	0.16	55.9	218.5	504.3	0.12
	STD_t	51.7	62.4	78.8	0.01	0.01	0.02	0.03	0.10	0.66	1.02	1.49	0.04	6.5	18.9	52.3	0.03
3	Avg.	549.8	746.5	989.0	0.19	0.06	0.11	0.20	0.61	4.42	6.75	9.65	0.32	73.7	449.9	1150.0	0.85
	STD_s	134.1	156.6	213.6	0.08	0.08	0.13	0.20	0.35	1.81	2.20	2.65	0.13	65.0	227.4	507.9	0.12
	STD_t	6.0	9.7	24.3	0.01	0.00	0.01	0.01	0.12	0.24	0.38	0.79	0.03	4.3	20.2	53.9	0.03
4A	Avg.	545.8	744.7	992.1	0.19	0.06	0.11	0.19	0.62	4.35	6.71	9.67	0.33	73.0	421.5	1069.0	0.85
	STD_s	125.4	149.4	218.4	0.08	0.08	0.13	0.20	0.37	1.85	2.24	2.69	0.14	67.3	219.5	482.4	0.13
	STD_t	7.0	11.0	23.9	0.01	0.00	0.01	0.01	0.12	0.27	0.42	0.81	0.04	4.3	22.3	62.3	0.03
4B	Avg.	533.3	731.7	979.9	0.19	0.06	0.11	0.19	0.62	4.27	6.60	9.58	0.34	72.5	398.2	999.4	0.84
	STD_s	121.5	148.6	225.2	0.08	0.08	0.13	0.19	0.38	1.86	2.26	2.72	0.15	67.1	207.9	451.1	0.14
	STD_t	13.4	18.6	30.3	0.01	0.00	0.01	0.02	0.13	0.31	0.48	0.86	0.04	4.5	32.9	95.0	0.03
4C	Avg.	519.9	718.6	968.6	0.20	0.06	0.11	0.18	0.63	4.18	6.49	9.49	0.35	72.0	375.0	930.0	0.82
	STD_s	117.5	147.9	231.8	0.07	0.08	0.13	0.19	0.38	1.87	2.28	2.74	0.16	66.8	196.4	419.9	0.14
	STD_t	21.5	26.5	36.6	0.01	0.00	0.01	0.02	0.13	0.36	0.55	0.91	0.04	4.7	45.9	134.5	0.04
5	Avg.	520.4	721.4	968.4	0.20	0.05	0.10	0.18	0.68	4.10	6.27	9.03	0.34	75.4	501.9	1295.0	0.87
	STD_s	111.8	140.8	205.6	0.07	0.07	0.12	0.19	0.45	1.60	1.82	2.14	0.15	69.1	246.0	544.6	0.12
	STD_t	17.1	21.1	32.3	0.01	0.01	0.01	0.02	0.15	0.35	0.57	1.00	0.04	3.8	40.0	105.2	0.03

Notes: Avg.-Spatial and temporal-averaged ensemble statistical moments over all river locations and over all weeks in the season
STD_s-Standard deviation over all river locations of the values of the temporal-averaged ensemble statistical moments (averaged over all weeks in the seasc
STD_t-Standard deviation over all years in the 25-year period of the values of the spatial-averaged ensemble statistical moments (averaged over all river loc

TABLE D-20. Space-Time Average and Standard Deviation of Ensemble Statistical Moments of Computed Water Quality Concentrations for Each Individual Management Strategy Applied during the Jan-Feb Season (Computed over All Irrigation Diversion Points and Downstream Station at Weldona)

Strategy		C_{TDS}				C_{NO_3}				C_N				C_{FC}			
		5%	Mean	95%	CV	5%	Mean	95%	CV	5%	Mean	95%	CV	5%	Mean	95%	CV
1	Avg.	833.7	960.3	1088.0	0.09	0.04	0.14	0.30	0.67	5.11	7.13	9.12	0.18	60.1	242.6	571.3	0.64
	STD_s	139.5	141.0	151.2	0.03	0.08	0.22	0.47	0.18	1.20	1.39	1.62	0.02	67.4	239.9	622.2	0.15
	STD_t	6.1	4.9	8.3	0.00	0.00	0.00	0.01	0.04	0.13	0.05	0.12	0.01	4.6	13.1	41.6	0.02
2A	Avg.	705.7	850.8	990.1	0.11	0.03	0.11	0.26	0.64	3.75	5.48	7.06	0.19	54.0	233.2	556.6	0.65
	STD_s	186.8	195.3	215.3	0.06	0.05	0.19	0.43	0.26	0.61	0.82	1.05	0.04	55.5	224.1	598.2	0.17
	STD_t	66.6	58.5	54.8	0.01	0.01	0.02	0.03	0.03	0.75	0.83	1.01	0.01	6.5	16.3	44.5	0.02
2B	Avg.	653.4	753.3	852.7	0.09	0.03	0.10	0.23	0.65	3.54	4.97	6.31	0.17	50.3	197.9	462.4	0.64
	STD_s	154.8	149.2	158.0	0.05	0.05	0.16	0.36	0.22	0.65	0.77	0.87	0.03	56.1	196.5	504.2	0.15
	STD_t	96.0	116.1	137.7	0.01	0.01	0.02	0.05	0.03	0.86	1.11	1.42	0.01	8.2	37.1	94.8	0.02
2C	Avg.	716.8	853.6	984.0	0.10	0.03	0.10	0.22	0.65	3.74	5.57	7.27	0.20	50.0	210.9	514.3	0.66
	STD_s	184.2	203.7	229.1	0.04	0.05	0.15	0.33	0.25	0.82	0.71	0.73	0.05	44.8	166.4	505.0	0.18
	STD_t	61.2	57.0	57.5	0.01	0.00	0.03	0.05	0.04	0.76	0.78	0.91	0.02	8.2	25.7	59.1	0.02
2D	Avg.	752.4	850.5	954.7	0.08	0.04	0.12	0.26	0.68	4.67	6.54	8.49	0.18	56.2	201.4	461.3	0.62
	STD_s	111.1	104.0	101.8	0.03	0.07	0.20	0.39	0.15	1.19	1.45	1.77	0.02	66.1	200.9	500.7	0.12
	STD_t	52.7	71.3	87.6	0.01	0.00	0.01	0.04	0.04	0.36	0.37	0.37	0.01	6.0	35.4	94.4	0.02
2E	Avg.	831.5	952.8	1072.0	0.08	0.05	0.12	0.25	0.65	5.16	7.21	9.21	0.18	57.2	216.7	514.2	0.64
	STD_s	126.2	138.7	157.8	0.02	0.08	0.19	0.37	0.18	1.69	1.86	2.09	0.03	58.0	177.4	504.7	0.15
	STD_t	6.7	8.0	13.9	0.00	0.00	0.01	0.04	0.05	0.13	0.07	0.14	0.01	5.4	22.9	58.4	0.02
3	Avg.	763.0	857.5	957.7	0.07	0.04	0.11	0.22	0.67	4.82	6.72	8.68	0.18	53.0	185.6	430.7	0.63
	STD_s	87.1	86.8	90.7	0.02	0.07	0.17	0.33	0.16	1.82	2.15	2.51	0.03	57.9	160.6	433.8	0.13
	STD_t	48.7	68.2	85.4	0.01	0.00	0.02	0.05	0.06	0.28	0.30	0.31	0.01	7.1	40.8	104.3	0.02
4A	Avg.	648.6	748.3	847.4	0.09	0.03	0.10	0.22	0.65	3.53	4.94	6.26	0.17	50.4	195.4	455.7	0.63
	STD_s	157.2	151.9	159.9	0.05	0.05	0.16	0.36	0.22	0.64	0.77	0.88	0.03	55.4	191.6	492.5	0.15
	STD_t	98.4	118.4	139.8	0.01	0.01	0.02	0.05	0.03	0.87	1.13	1.44	0.01	8.2	37.9	96.8	0.02
4B	Avg.	710.6	847.5	978.0	0.10	0.03	0.10	0.22	0.64	3.73	5.54	7.22	0.20	50.4	209.1	507.6	0.65
	STD_s	184.8	204.7	230.2	0.04	0.05	0.15	0.33	0.25	0.79	0.70	0.74	0.05	45.0	163.8	493.2	0.18
	STD_t	64.2	60.0	60.4	0.01	0.00	0.03	0.05	0.03	0.77	0.80	0.93	0.02	8.0	26.5	61.2	0.02
4C	Avg.	656.9	751.2	844.4	0.08	0.03	0.09	0.19	0.65	3.54	5.03	6.43	0.18	46.2	177.9	423.8	0.64
	STD_s	152.4	155.1	168.1	0.03	0.05	0.14	0.28	0.22	0.85	0.83	0.84	0.04	44.6	146.5	421.9	0.15
	STD_t	94.8	116.9	140.3	0.01	0.00	0.03	0.07	0.04	0.86	1.08	1.37	0.01	10.0	44.2	107.4	0.02
5	Avg.	757.7	851.6	950.6	0.07	0.04	0.11	0.22	0.66	4.80	6.68	8.60	0.18	53.1	184.1	425.6	0.62
	STD_s	92.6	92.1	96.0	0.02	0.08	0.17	0.32	0.16	1.76	2.08	2.42	0.03	57.7	158.2	424.6	0.13
	STD_t	50.5	70.6	88.4	0.01	0.00	0.02	0.05	0.05	0.29	0.32	0.34	0.01	7.1	41.4	106.0	0.02

Notes: Avg.-Spatial and temporal-averaged ensemble statistical moments over all diversion points and downstream at Weldona and over all weeks in the season

STD_s-Standard deviation over all irrigation diversion points and downstream at Weldona of the values of the temporal-averaged ensemble statistical moments (averaged over all weeks in the season)

STD_t-Standard deviation over all years in the 25-year period of the values of the spatial-averaged ensemble statistical moments (average over all irrigation diversion points and downstream at Weldona)

TABLE D-21. Space-Time Average and Standard Deviation of Ensemble Statistical Moments of Computed Water Quality Concentrations for Each Individual Management Strategy Applied during the Mar-Apr Season (Computed over All Irrigation Diversion Points and Downstream Station at Weldona)

Strategy		C_{TDS}				C_{NO_3}				C_N				C_{FC}			
		5%	Mean	95%	CV	5%	Mean	95%	CV	5%	Mean	95%	CV	5%	Mean	95%	CV
1	Avg.	718.0	997.6	1307.0	0.19	0.04	0.09	0.20	0.50	4.36	6.73	9.37	0.23	61.1	213.7	512.9	0.80
	STD_s	199.5	228.4	408.6	0.08	0.02	0.08	0.23	0.15	1.11	1.66	2.33	0.06	56.5	110.6	182.0	0.24
	STD_t	10.4	14.4	30.6	0.05	0.00	0.00	0.01	0.02	0.21	0.15	0.13	0.01	5.0	9.4	28.0	0.05
2A	Avg.	582.9	874.5	1211.0	0.24	0.03	0.07	0.16	0.46	3.39	4.81	6.33	0.18	51.3	191.0	484.1	0.85
	STD_s	226.8	252.2	417.8	0.10	0.02	0.08	0.23	0.19	0.62	0.74	1.05	0.05	45.5	95.5	170.4	0.22
	STD_t	69.5	72.2	73.8	0.06	0.00	0.01	0.02	0.03	0.37	0.88	1.50	0.03	3.4	10.5	28.8	0.04
2B	Avg.	553.2	781.3	1045.0	0.21	0.03	0.07	0.14	0.47	3.11	4.57	6.15	0.20	49.6	169.9	409.2	0.80
	STD_s	196.4	209.6	346.4	0.09	0.02	0.07	0.19	0.16	0.64	0.83	1.19	0.06	46.9	88.7	145.8	0.24
	STD_t	86.9	129.3	176.5	0.05	0.00	0.01	0.03	0.02	0.51	1.00	1.60	0.02	3.9	20.4	62.0	0.07
2C	Avg.	594.6	890.1	1228.0	0.23	0.03	0.07	0.15	0.46	3.35	4.76	6.28	0.19	51.3	195.0	493.1	0.86
	STD_s	229.5	253.6	434.6	0.10	0.02	0.07	0.21	0.18	0.65	0.70	0.98	0.06	48.0	97.7	168.6	0.23
	STD_t	63.7	64.9	66.4	0.06	0.00	0.01	0.03	0.03	0.39	0.90	1.53	0.03	3.6	9.5	27.5	0.04
2D	Avg.	644.6	870.8	1115.0	0.17	0.03	0.09	0.18	0.49	4.05	6.39	9.06	0.24	61.2	192.2	429.4	0.72
	STD_s	166.3	184.5	310.2	0.06	0.02	0.07	0.18	0.14	1.08	1.69	2.36	0.05	53.9	96.9	147.1	0.22
	STD_t	45.3	87.3	140.9	0.05	0.00	0.00	0.01	0.02	0.13	0.13	0.19	0.01	4.7	11.9	53.5	0.08
2E	Avg.	687.1	968.1	1281.0	0.20	0.03	0.08	0.17	0.48	4.28	6.43	8.90	0.22	63.0	215.1	508.4	0.77
	STD_s	193.3	214.7	386.9	0.08	0.02	0.07	0.20	0.14	1.07	1.50	2.12	0.05	55.0	105.5	169.9	0.22
	STD_t	19.7	26.1	39.7	0.05	0.00	0.00	0.01	0.02	0.16	0.13	0.26	0.02	5.5	9.5	26.7	0.05
3	Avg.	644.8	874.9	1124.0	0.17	0.03	0.08	0.16	0.49	3.93	6.20	8.84	0.25	60.9	194.1	435.1	0.73
	STD_s	156.0	169.0	307.2	0.07	0.02	0.07	0.17	0.11	1.18	1.69	2.33	0.06	56.9	99.6	146.9	0.23
	STD_t	45.7	87.0	139.0	0.05	0.00	0.01	0.02	0.02	0.15	0.20	0.28	0.01	4.6	11.6	52.1	0.08
4A	Avg.	540.0	766.7	1028.0	0.21	0.03	0.06	0.14	0.46	3.11	4.53	6.08	0.20	50.5	169.8	405.0	0.78
	STD_s	194.1	207.8	336.3	0.09	0.01	0.06	0.19	0.17	0.60	0.80	1.16	0.05	45.2	85.7	141.3	0.22
	STD_t	93.0	135.1	182.2	0.06	0.00	0.01	0.03	0.03	0.51	1.02	1.63	0.03	3.5	20.5	63.3	0.07
4B	Avg.	578.9	872.0	1208.0	0.24	0.03	0.07	0.14	0.45	3.35	4.71	6.21	0.18	52.1	194.0	486.7	0.84
	STD_s	224.5	250.1	419.6	0.10	0.02	0.07	0.21	0.18	0.61	0.67	0.95	0.05	46.1	94.3	163.8	0.21
	STD_t	71.5	73.5	75.1	0.06	0.00	0.01	0.03	0.03	0.39	0.93	1.56	0.03	3.2	9.6	27.9	0.04
4C	Avg.	548.1	778.0	1042.0	0.21	0.02	0.06	0.13	0.46	3.06	4.47	6.01	0.20	50.5	172.9	412.2	0.79
	STD_s	194.8	206.6	346.0	0.09	0.02	0.06	0.17	0.15	0.64	0.77	1.10	0.06	47.7	87.8	140.2	0.23
	STD_t	89.5	131.0	177.5	0.05	0.01	0.02	0.04	0.03	0.54	1.05	1.67	0.02	3.6	19.3	60.9	0.07
5	Avg.	632.3	859.5	1108.0	0.18	0.03	0.08	0.16	0.48	3.95	6.15	8.71	0.24	62.0	193.2	429.7	0.71
	STD_s	158.3	169.5	299.0	0.07	0.02	0.06	0.16	0.11	1.10	1.60	2.24	0.05	54.5	96.1	142.6	0.22
	STD_t	50.3	92.3	143.9	0.05	0.00	0.01	0.02	0.02	0.15	0.23	0.34	0.01	5.0	11.8	53.4	0.09

Notes: Avg.-Spatial and temporal-averaged ensemble statistical moments over all diversion points and downstream at Weldona and over all weeks in the season

STD_s-Standard deviation over all irrigation diversion points and downstream at Weldona of the values of the temporal-averaged ensemble statistical moments (averaged over all weeks in the season)

STD_t-Standard deviation over all years in the 25-year period of the values of the spatial-averaged ensemble statistical moments (average over all irrigation diversion points and downstream at Weldona)

TABLE D-22. Space-Time Average and Standard Deviation of Ensemble Statistical Moments of Computed Water Quality Concentrations for Each Individual Management Strategy Applied during the May-Jun Season (Computed over All Irrigation Diversion Points and Downstream Station at Weldona)

Strategy		C_{TDS}				C_{NO_2}				C_N				C_{FC}			
		5%	Mean	95%	CV	5%	Mean	95%	CV	5%	Mean	95%	CV	5%	Mean	95%	CV
1	Avg.	296.7	630.0	979.2	0.65	0.02	0.16	0.44	0.65	2.14	4.40	8.78	0.49	24.0	358.3	1023.0	1.05
	STD_s	56.3	141.8	214.2	0.26	0.02	0.23	0.67	0.24	0.39	0.88	2.50	0.10	26.4	216.3	543.4	0.24
	STD_t	8.4	15.8	15.1	3.05	0.00	0.01	0.01	0.01	0.07	0.12	0.37	0.02	1.9	14.9	45.9	0.04
2A	Avg.	265.3	567.1	904.5	0.72	0.02	0.15	0.42	0.68	1.94	4.04	8.22	0.51	21.9	348.9	993.5	1.02
	STD_s	76.5	159.1	225.5	0.34	0.01	0.22	0.67	0.27	0.39	0.69	2.15	0.12	19.2	193.6	496.0	0.20
	STD_t	14.2	34.1	45.3	3.61	0.00	0.01	0.02	0.02	0.14	0.23	0.49	0.02	2.2	16.1	51.8	0.05
2B	Avg.	237.2	529.9	858.1	0.67	0.02	0.13	0.35	0.65	1.82	3.56	7.01	0.48	18.8	284.6	818.6	1.05
	STD_s	57.3	160.1	267.9	0.28	0.01	0.18	0.54	0.26	0.32	0.61	1.89	0.11	20.4	173.1	436.4	0.24
	STD_t	29.5	55.0	71.2	2.99	0.00	0.02	0.06	0.02	0.21	0.51	1.15	0.02	2.6	48.5	145.5	0.04
2C	Avg.	262.4	577.8	926.3	0.74	0.02	0.15	0.42	0.69	1.95	4.10	8.37	0.51	21.6	351.8	1015.0	1.05
	STD_s	78.2	165.5	243.1	0.37	0.01	0.22	0.67	0.27	0.37	0.70	2.29	0.12	22.3	195.1	500.4	0.23
	STD_t	15.6	28.8	30.9	3.66	0.00	0.01	0.02	0.02	0.14	0.20	0.43	0.02	1.8	15.8	48.2	0.04
2D	Avg.	271.1	566.8	883.3	0.58	0.02	0.13	0.35	0.61	1.98	3.77	7.17	0.45	24.1	292.6	810.7	0.98
	STD_s	43.1	134.2	222.4	0.20	0.02	0.18	0.53	0.24	0.31	0.73	1.93	0.08	24.5	161.5	402.7	0.19
	STD_t	16.3	39.2	60.7	2.49	0.00	0.02	0.06	0.02	0.15	0.43	1.07	0.03	2.3	45.4	147.0	0.06
2E	Avg.	295.8	613.1	945.6	0.65	0.02	0.15	0.42	0.65	2.15	4.29	8.46	0.48	27.7	358.8	1002.0	0.99
	STD_s	64.4	138.3	206.8	0.29	0.02	0.22	0.66	0.24	0.35	0.77	2.28	0.10	28.6	184.3	462.9	0.19
	STD_t	8.0	17.4	30.6	3.21	0.00	0.01	0.02	0.01	0.07	0.14	0.43	0.02	3.4	15.1	50.1	0.05
3	Avg.	264.5	575.4	910.7	0.61	0.02	0.13	0.35	0.62	1.97	3.81	7.27	0.45	24.1	294.6	826.8	1.02
	STD_s	52.9	140.9	238.0	0.23	0.01	0.18	0.54	0.24	0.33	0.73	2.02	0.09	30.0	166.7	408.3	0.24
	STD_t	18.0	35.7	46.4	2.62	0.00	0.02	0.06	0.02	0.15	0.42	1.04	0.03	1.9	44.9	143.2	0.05
4A	Avg.	238.4	517.5	830.0	0.66	0.02	0.12	0.34	0.64	1.81	3.49	6.84	0.47	20.3	284.0	802.4	1.01
	STD_s	58.4	153.4	249.5	0.28	0.01	0.18	0.53	0.27	0.32	0.58	1.76	0.11	19.2	158.4	401.5	0.20
	STD_t	29.0	60.5	85.0	3.00	0.00	0.02	0.06	0.02	0.21	0.54	1.20	0.02	2.4	48.8	150.4	0.05
4B	Avg.	264.3	564.8	899.4	0.73	0.02	0.15	0.42	0.69	1.93	4.02	8.15	0.51	22.9	350.3	994.0	1.01
	STD_s	77.7	158.5	227.2	0.36	0.01	0.22	0.66	0.27	0.36	0.67	2.13	0.12	20.9	178.7	460.2	0.19
	STD_t	14.7	35.0	47.3	3.69	0.00	0.01	0.02	0.02	0.14	0.24	0.51	0.02	2.1	16.0	52.2	0.05
4C	Avg.	235.7	527.5	854.1	0.68	0.02	0.13	0.34	0.65	1.82	3.55	6.95	0.47	20.0	286.2	818.9	1.04
	STD_s	60.1	160.5	269.8	0.31	0.01	0.18	0.54	0.27	0.30	0.58	1.87	0.11	22.1	160.2	405.2	0.23
	STD_t	30.1	55.9	72.5	3.08	0.00	0.02	0.06	0.02	0.21	0.52	1.17	0.03	2.2	48.2	146.3	0.04
5	Avg.	267.9	564.1	880.5	0.60	0.02	0.13	0.34	0.62	1.99	3.75	7.10	0.44	25.5	293.7	810.8	0.97
	STD_s	49.8	133.7	224.3	0.23	0.01	0.18	0.53	0.24	0.30	0.67	1.89	0.09	27.9	153.4	377.5	0.19
	STD_t	17.2	39.9	61.4	2.62	0.00	0.02	0.06	0.02	0.15	0.44	1.09	0.03	2.6	45.2	147.6	0.06

Notes: Avg.-Spatial and temporal-averaged ensemble statistical moments over all diversion points and downstream at Weldona and over all weeks in the season

STD_s-Standard deviation over all irrigation diversion points and downstream at Weldona of the values of the temporal-averaged ensemble statistical moments (averaged over all weeks in the season)

STD_t-Standard deviation over all years in the 25-year period of the values of the spatial-averaged ensemble statistical moments (average over all irrigation diversion points and downstream at Weldona)

TABLE D-23. Space-Time Average and Standard Deviation of Ensemble Statistical Moments of Computed Water Quality Concentrations for Each Individual Management Strategy Applied during the Jul-Aug Season (Computed over All Irrigation Diversion Points and Downstream Station at Weldona)

Strategy		C_{TDS}				C_{NO_2}				C_N				C_{FC}			
		5%	Mean	95%	CV	5%	Mean	95%	CV	5%	Mean	95%	CV	5%	Mean	95%	CV
1	Avg.	378.7	729.1	1044.0	0.36	0.02	0.09	0.21	0.59	4.06	6.86	10.32	0.30	151.7	500.8	928.9	0.46
	STD_s	185.0	225.7	289.7	0.17	0.03	0.10	0.31	0.29	1.22	1.36	1.69	0.13	110.5	391.0	822.2	0.11
	STD_t	13.9	17.0	47.2	0.22	0.00	0.00	0.01	0.03	0.15	0.15	0.23	0.01	7.0	13.7	30.9	0.01
2A	Avg.	338.8	652.8	950.0	0.39	0.02	0.08	0.19	0.58	3.59	6.24	9.58	0.33	144.5	470.6	872.2	0.45
	STD_s	189.7	251.3	314.3	0.19	0.02	0.09	0.28	0.25	1.39	1.58	1.73	0.16	98.1	352.6	748.9	0.11
	STD_t	19.7	45.8	72.4	0.24	0.00	0.01	0.01	0.02	0.34	0.43	0.55	0.02	8.5	28.5	58.1	0.01
2B	Avg.	324.4	618.4	900.5	0.38	0.02	0.07	0.17	0.58	3.37	5.54	8.25	0.30	132.1	413.2	756.6	0.44
	STD_s	184.7	248.1	323.9	0.18	0.02	0.08	0.25	0.26	1.21	1.29	1.44	0.15	94.3	316.8	662.6	0.11
	STD_t	25.5	64.5	94.9	0.22	0.00	0.01	0.03	0.02	0.46	0.86	1.37	0.02	15.1	65.8	131.8	0.02
2C	Avg.	345.5	673.9	986.5	0.40	0.02	0.08	0.19	0.58	3.70	6.43	9.78	0.32	147.8	483.6	898.4	0.46
	STD_s	202.8	262.2	332.8	0.21	0.02	0.09	0.26	0.24	1.39	1.61	1.73	0.13	103.6	361.6	767.7	0.11
	STD_t	17.4	34.9	59.1	0.24	0.00	0.01	0.01	0.02	0.28	0.33	0.43	0.01	7.4	19.7	41.0	0.01
2D	Avg.	359.0	655.2	921.2	0.33	0.02	0.07	0.16	0.57	3.67	5.81	8.45	0.27	131.6	396.4	720.1	0.44
	STD_s	153.4	205.5	271.8	0.13	0.03	0.08	0.23	0.28	1.02	1.08	1.28	0.11	95.8	295.2	611.9	0.11
	STD_t	11.9	48.2	84.5	0.21	0.00	0.01	0.03	0.03	0.34	0.75	1.27	0.02	15.8	72.3	144.9	0.02
2E	Avg.	380.9	710.7	1004.0	0.35	0.03	0.08	0.19	0.56	4.01	6.68	9.93	0.29	148.0	463.3	852.7	0.45
	STD_s	168.9	215.5	278.0	0.16	0.03	0.10	0.26	0.25	1.11	1.30	1.56	0.09	104.2	336.2	706.4	0.11
	STD_t	13.5	23.2	54.6	0.22	0.00	0.01	0.02	0.03	0.17	0.24	0.40	0.01	7.8	31.2	65.4	0.01
3	Avg.	362.0	675.0	958.5	0.34	0.02	0.07	0.16	0.57	3.76	5.97	8.63	0.26	135.1	407.9	741.7	0.44
	STD_s	167.1	211.4	279.6	0.15	0.03	0.09	0.23	0.27	0.96	1.04	1.28	0.08	101.5	303.8	628.2	0.11
	STD_t	11.6	39.3	69.2	0.21	0.00	0.01	0.03	0.03	0.30	0.68	1.19	0.02	14.6	67.3	136.3	0.01
4A	Avg.	321.0	600.0	864.8	0.37	0.02	0.07	0.16	0.56	3.29	5.38	8.01	0.30	128.6	392.9	716.6	0.43
	STD_s	172.3	237.1	308.6	0.16	0.02	0.08	0.23	0.25	1.18	1.28	1.37	0.15	89.3	291.0	609.3	0.11
	STD_t	27.1	73.4	110.3	0.23	0.00	0.01	0.03	0.02	0.50	0.93	1.46	0.02	16.5	73.6	146.4	0.02
4B	Avg.	340.5	652.6	947.1	0.39	0.02	0.08	0.18	0.57	3.60	6.23	9.47	0.32	143.9	458.6	848.1	0.45
	STD_s	188.5	251.1	317.2	0.19	0.02	0.09	0.25	0.24	1.35	1.57	1.68	0.13	97.8	330.8	702.3	0.11
	STD_t	19.0	45.9	73.3	0.24	0.00	0.01	0.02	0.02	0.33	0.44	0.60	0.01	8.7	33.2	67.3	0.01
4C	Avg.	326.2	618.2	898.3	0.37	0.02	0.07	0.16	0.57	3.38	5.53	8.17	0.29	131.3	403.0	736.8	0.44
	STD_s	183.8	248.0	326.0	0.18	0.02	0.08	0.22	0.24	1.18	1.29	1.36	0.11	93.9	297.5	623.5	0.11
	STD_t	24.7	64.5	95.6	0.22	0.00	0.01	0.03	0.02	0.45	0.86	1.40	0.02	15.5	69.1	138.3	0.02
5	Avg.	362.6	658.4	923.4	0.33	0.02	0.07	0.16	0.55	3.71	5.84	8.41	0.26	131.7	388.6	703.5	0.43
	STD_s	152.5	202.2	268.6	0.14	0.03	0.08	0.22	0.26	0.93	1.03	1.27	0.08	95.8	280.3	578.7	0.11
	STD_t	11.2	46.7	83.1	0.21	0.00	0.01	0.03	0.03	0.32	0.73	1.28	0.02	15.8	74.8	150.8	0.02

Notes: Avg.-Spatial and temporal-averaged ensemble statistical moments over all diversion points and downstream at Weldona and over all weeks in the season

STD_s-Standard deviation over all irrigation diversion points and downstream at Weldona of the values of the temporal-averaged ensemble statistical moments (averaged over all weeks in the season)

STD_t-Standard deviation over all years in the 25-year period of the values of the spatial-averaged ensemble statistical moments (average over all irrigation diversion points and downstream at Weldona)

TABLE D-24. Space-Time Average and Standard Deviation of Ensemble Statistical Moments of Computed Water Quality Concentrations for Each Individual Management Strategy Applied during the Sep-Oct Season (Computed over All Irrigation Diversion Points and Downstream Station at Weldona)

Strategy		C_{TDS}				C_{NO_3}				C_N				C_{FC}			
		5%	Mean	95%	CV	5%	Mean	95%	CV	5%	Mean	95%	CV	5%	Mean	95%	CV
1	Avg.	472.6	787.1	964.9	0.59	0.04	0.09	0.16	0.53	4.34	5.93	7.65	0.17	45.5	187.6	451.3	0.86
	STD_s	113.6	156.0	200.3	0.29	0.06	0.09	0.13	0.21	1.13	1.48	1.93	0.04	76.0	164.5	416.6	0.33
	STD_t	24.2	37.6	28.6	0.45	0.00	0.00	0.00	0.02	0.07	0.04	0.10	0.01	1.1	7.4	19.6	0.04
2A	Avg.	385.0	678.5	864.4	0.67	0.03	0.07	0.14	0.56	3.56	4.68	5.84	0.15	39.7	176.7	432.7	0.84
	STD_s	134.0	160.9	219.6	0.37	0.04	0.06	0.11	0.18	0.78	0.89	1.11	0.04	64.6	151.0	397.7	0.30
	STD_t	39.7	67.9	66.4	0.52	0.01	0.01	0.01	0.03	0.37	0.63	0.96	0.02	3.5	11.6	26.8	0.04
2B	Avg.	361.3	617.0	776.4	0.63	0.03	0.07	0.12	0.53	3.28	4.38	5.56	0.16	38.8	155.1	369.3	0.84
	STD_s	119.1	134.1	168.9	0.33	0.04	0.06	0.10	0.18	0.74	0.83	1.01	0.04	65.3	134.4	334.5	0.32
	STD_t	51.5	97.7	115.7	0.50	0.01	0.01	0.02	0.02	0.53	0.80	1.12	0.01	3.9	24.6	62.9	0.04
2C	Avg.	382.3	682.8	875.6	0.69	0.04	0.08	0.15	0.55	3.49	4.63	5.83	0.16	38.9	177.3	434.6	0.85
	STD_s	135.7	153.4	216.1	0.39	0.05	0.08	0.13	0.20	0.68	0.78	1.04	0.03	64.5	153.2	400.5	0.30
	STD_t	40.9	66.5	61.5	0.54	0.00	0.00	0.01	0.02	0.41	0.66	0.97	0.01	3.8	11.0	24.8	0.04
2D	Avg.	442.7	709.6	861.7	0.53	0.04	0.08	0.14	0.50	4.02	5.55	7.24	0.18	43.5	159.3	369.8	0.84
	STD_s	101.2	131.8	153.0	0.24	0.06	0.08	0.12	0.19	1.12	1.51	1.98	0.05	73.1	139.1	326.8	0.34
	STD_t	24.1	58.1	74.8	0.42	0.00	0.01	0.01	0.02	0.21	0.25	0.33	0.01	1.8	22.8	62.4	0.04
2E	Avg.	461.7	765.3	944.2	0.60	0.05	0.11	0.18	0.51	4.23	5.67	7.25	0.17	43.3	180.3	431.4	0.85
	STD_s	109.5	128.1	170.4	0.30	0.08	0.13	0.18	0.21	0.94	1.20	1.59	0.04	70.9	155.9	390.5	0.32
	STD_t	21.2	39.5	33.8	0.47	0.01	0.01	0.01	0.02	0.07	0.14	0.28	0.01	1.8	10.1	26.7	0.04
3	Avg.	431.9	703.3	862.8	0.56	0.05	0.10	0.16	0.51	3.88	5.35	7.01	0.18	42.5	159.0	369.3	0.86
	STD_s	101.0	105.3	122.9	0.26	0.08	0.13	0.18	0.20	1.02	1.34	1.80	0.05	72.0	140.6	329.9	0.35
	STD_t	25.5	60.5	75.0	0.44	0.01	0.01	0.01	0.02	0.26	0.33	0.41	0.01	2.2	22.8	62.3	0.04
4A	Avg.	360.7	609.5	764.6	0.62	0.03	0.07	0.12	0.53	3.28	4.34	5.48	0.16	38.4	152.2	361.4	0.83
	STD_s	117.2	133.4	166.3	0.32	0.04	0.06	0.09	0.17	0.73	0.82	1.01	0.04	63.9	130.3	322.9	0.31
	STD_t	51.7	100.9	121.0	0.49	0.01	0.01	0.02	0.02	0.53	0.82	1.16	0.01	4.1	25.7	66.1	0.04
4B	Avg.	380.8	673.8	861.5	0.69	0.04	0.08	0.15	0.54	3.48	4.59	5.75	0.15	38.5	173.9	424.9	0.84
	STD_s	132.9	151.7	210.9	0.38	0.05	0.08	0.13	0.20	0.67	0.77	1.03	0.03	63.0	148.6	386.5	0.29
	STD_t	41.4	70.4	67.7	0.54	0.00	0.01	0.01	0.02	0.41	0.68	1.01	0.02	4.0	12.6	29.3	0.04
4C	Avg.	357.4	612.0	773.6	0.64	0.04	0.07	0.13	0.52	3.22	4.28	5.44	0.16	37.6	152.4	362.2	0.85
	STD_s	118.5	124.8	160.1	0.35	0.05	0.08	0.12	0.19	0.65	0.71	0.93	0.04	63.6	132.0	325.0	0.32
	STD_t	53.1	100.1	117.2	0.51	0.00	0.01	0.02	0.02	0.56	0.85	1.18	0.01	4.5	25.6	65.5	0.04
5	Avg.	432.4	696.4	851.3	0.55	0.05	0.10	0.16	0.50	3.90	5.33	6.93	0.18	42.0	156.1	361.8	0.85
	STD_s	97.8	104.7	122.2	0.26	0.08	0.12	0.17	0.19	0.98	1.28	1.72	0.05	70.1	136.2	318.8	0.34
	STD_t	25.0	62.8	79.7	0.43	0.01	0.01	0.01	0.03	0.25	0.34	0.46	0.01	2.4	23.9	65.3	0.04

Notes: Avg.-Spatial and temporal-averaged ensemble statistical moments over all diversion points and downstream at Weldona and over all weeks in the season
STD_S-Standard deviation over all irrigation diversion points and downstream at Weldona of the values of the temporal-averaged ensemble statistical moments (averaged over all weeks in the season)
STD_t-Standard deviation over all years in the 25-year period of the values of the spatial-averaged ensemble statistical moments (average over all irrigation diversion points and downstream at Weldona)

TABLE D-25. Space-Time Average and Standard Deviation of Ensemble Statistical Moments of Computed Water Quality Concentrations for Each Individual Management Strategy Applied during the Nov-Dec Season (Computed over All Irrigation Diversion Points and Downstream Station at Weldona)

Strategy		C_{TDS}				C_{NO_2}				C_N				C_{FC}			
		5%	Mean	95%	CV	5%	Mean	95%	CV	5%	Mean	95%	CV	5%	Mean	95%	CV
1	Avg.	557.2	743.1	968.4	0.17	0.05	0.12	0.22	0.71	4.51	7.03	10.00	0.30	67.3	504.2	1310.0	0.86
	STD_s	100.4	120.4	188.8	0.05	0.07	0.13	0.23	0.39	1.31	1.45	1.74	0.12	56.3	318.2	778.4	0.08
	STD_t	7.3	5.0	16.5	0.01	0.00	0.01	0.01	0.14	0.12	0.23	0.58	0.03	3.6	23.4	58.4	0.03
2A	Avg.	433.5	612.4	822.5	0.20	0.03	0.09	0.18	0.68	3.46	5.35	7.71	0.30	59.0	491.3	1299.0	0.88
	STD_s	102.3	143.1	208.0	0.04	0.04	0.10	0.21	0.31	0.49	0.53	1.07	0.14	44.1	296.3	736.2	0.06
	STD_t	58.5	66.7	83.4	0.01	0.01	0.02	0.03	0.11	0.60	1.02	1.56	0.03	5.6	23.9	60.0	0.03
2B	Avg.	410.7	575.3	776.6	0.19	0.03	0.08	0.16	0.69	3.24	5.02	7.44	0.33	56.6	404.8	1051.0	0.85
	STD_s	83.3	136.6	232.0	0.06	0.04	0.09	0.18	0.34	0.55	0.52	1.01	0.17	44.6	256.6	627.9	0.07
	STD_t	70.7	87.3	109.1	0.01	0.01	0.03	0.04	0.12	0.71	1.19	1.71	0.04	6.6	62.4	170.0	0.03
2C	Avg.	428.7	613.6	826.5	0.20	0.03	0.08	0.16	0.76	3.42	5.26	7.55	0.30	59.8	513.8	1365.0	0.88
	STD_s	91.1	134.3	207.9	0.03	0.04	0.08	0.16	0.37	0.65	0.53	1.08	0.16	46.2	219.4	527.5	0.05
	STD_t	60.9	66.0	81.3	0.01	0.01	0.03	0.04	0.15	0.61	1.06	1.63	0.03	5.4	27.0	72.2	0.03
2D	Avg.	511.5	690.6	914.1	0.18	0.05	0.11	0.20	0.70	4.23	6.61	9.58	0.32	67.1	424.5	1071.0	0.82
	STD_s	90.8	116.0	200.5	0.06	0.07	0.12	0.20	0.40	1.32	1.54	1.82	0.13	54.1	250.1	601.6	0.09
	STD_t	24.3	31.6	42.5	0.01	0.00	0.02	0.03	0.14	0.27	0.46	0.79	0.03	3.7	56.3	163.1	0.04
2E	Avg.	529.3	714.3	934.0	0.17	0.05	0.10	0.18	0.77	4.40	6.66	9.36	0.30	70.5	526.1	1365.0	0.85
	STD_s	55.6	90.4	166.1	0.04	0.06	0.11	0.18	0.47	1.51	1.41	1.32	0.13	56.2	225.9	525.3	0.07
	STD_t	12.3	16.3	29.3	0.01	0.00	0.02	0.03	0.17	0.15	0.37	0.79	0.03	3.9	29.5	71.2	0.03
3	Avg.	497.0	676.9	899.9	0.18	0.04	0.09	0.17	0.81	4.12	6.34	9.18	0.34	67.2	439.5	1119.0	0.83
	STD_s	42.6	83.0	180.4	0.06	0.06	0.10	0.16	0.54	1.63	1.60	1.45	0.15	56.8	199.3	447.4	0.08
	STD_t	29.5	37.5	48.3	0.01	0.01	0.02	0.04	0.20	0.30	0.56	0.91	0.04	3.8	55.4	157.3	0.04
4A	Avg.	407.4	568.9	766.1	0.19	0.03	0.08	0.16	0.68	3.23	4.99	7.36	0.33	57.7	407.8	1055.0	0.85
	STD_s	84.9	137.1	228.9	0.05	0.04	0.09	0.17	0.33	0.53	0.54	1.04	0.16	43.5	244.2	598.2	0.07
	STD_t	72.3	90.4	114.2	0.01	0.01	0.03	0.04	0.11	0.72	1.21	1.75	0.04	6.1	62.0	169.4	0.03
4B	Avg.	425.1	606.3	815.4	0.20	0.03	0.08	0.16	0.75	3.41	5.22	7.48	0.30	60.8	511.6	1352.0	0.88
	STD_s	92.6	134.5	205.4	0.03	0.04	0.08	0.15	0.36	0.61	0.53	1.08	0.15	45.1	214.0	516.1	0.05
	STD_t	62.7	69.7	86.9	0.01	0.01	0.03	0.04	0.14	0.62	1.08	1.66	0.03	4.9	26.9	69.3	0.03
4C	Avg.	401.4	568.1	769.0	0.20	0.03	0.07	0.14	0.76	3.19	4.89	7.21	0.33	58.2	424.9	1105.0	0.85
	STD_s	70.9	128.5	227.4	0.05	0.04	0.08	0.14	0.42	0.70	0.54	0.99	0.18	45.6	186.7	437.9	0.06
	STD_t	75.2	90.8	112.7	0.01	0.01	0.03	0.05	0.15	0.74	1.26	1.82	0.04	6.0	59.5	161.9	0.03
5	Avg.	493.0	669.9	888.8	0.18	0.04	0.09	0.16	0.79	4.12	6.30	9.07	0.33	68.3	437.7	1109.0	0.82
	STD_s	45.4	85.8	179.7	0.06	0.06	0.10	0.16	0.52	1.55	1.54	1.40	0.15	55.2	194.5	438.3	0.08
	STD_t	31.2	40.7	53.5	0.01	0.01	0.02	0.04	0.19	0.30	0.58	0.95	0.04	3.9	56.0	160.2	0.04

Notes: Avg.-Spatial and temporal-averaged ensemble statistical moments over all diversion points and downstream at Weldona and over all weeks in the season

STD_s-Standard deviation over all irrigation diversion points and downstream at Weldona of the values of the temporal-averaged ensemble statistical moments (averaged over all weeks in the season)

STD_t-Standard deviation over all years in the 25-year period of the values of the spatial-averaged ensemble statistical moments (average over all irrigation diversion points and downstream at Weldona)

TABLE D-26. Space-Time Average and Standard Deviation of Performance Measures for Each Combined Management Strategy Applied during the Jan-Feb Season (Computed over All River Locations)

Strategy		High Criteria												Low Criteria											
		C_{TDS} (500 mg/L)			C_{NO_2} (10 mg/L)			C_N (15 mg/L)			C_{FC} (500 colonies/100 ml)			C_{TDS} (1000 mg/L)			C_{NO_2} (10 mg/L)			C_N (30 mg/L)			C_{FC} (1000 colonies/100 ml)		
		U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v
1	Average	0.73	0.97	0.93	1.00	1.00	0.00	0.00	0.75	0.01	0.00	0.73	0.10	0.28	0.92	0.39	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.74	0.02
	STD	0.00	0.01	0.25	0.00	0.00	0.00	0.00	0.07	0.04	0.00	0.13	0.16	0.03	0.02	0.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.04
2E+3	Average	0.62	0.93	0.83	1.00	1.00	0.00	0.80	0.95	0.00	0.00	0.73	0.09	0.06	0.75	0.16	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.74	0.01
	STD	0.06	0.03	0.30	0.00	0.00	0.00	0.41	0.10	0.01	0.00	0.13	0.14	0.13	0.13	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.04
6	Average	0.60	0.92	0.80	1.00	1.00	0.00	0.80	0.95	0.00	0.00	0.74	0.07	0.34	0.80	0.10	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.80	0.01
	STD	0.07	0.03	0.30	0.00	0.00	0.00	0.41	0.10	0.01	0.00	0.08	0.13	0.36	0.21	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.03
2E+5	Average	0.64	0.95	0.84	1.00	1.00	0.00	0.80	0.95	0.00	0.00	0.72	0.10	0.06	0.71	0.18	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.72	0.01
	STD	0.04	0.01	0.29	0.00	0.00	0.00	0.41	0.10	0.01	0.00	0.18	0.15	0.13	0.18	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.04
3+4C	Average	0.70	0.95	0.92	1.00	1.00	0.00	0.00	0.69	0.01	0.00	0.74	0.07	0.08	0.46	0.12	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.81	0.01
	STD	0.01	0.02	0.27	0.00	0.00	0.00	0.00	0.14	0.03	0.00	0.08	0.12	0.13	0.34	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.03
3+5	Average	0.71	0.95	0.92	1.00	1.00	0.00	0.00	0.73	0.00	0.00	0.72	0.10	0.22	0.89	0.34	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.72	0.01
	STD	0.01	0.02	0.27	0.00	0.00	0.00	0.00	0.26	0.01	0.00	0.18	0.15	0.05	0.03	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.03
4C+5	Average	0.72	0.95	0.92	1.00	1.00	0.00	0.00	0.68	0.00	0.00	0.75	0.08	0.07	0.43	0.12	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.79	0.01
	STD	0.00	0.02	0.26	0.00	0.00	0.00	0.00	0.29	0.01	0.00	0.09	0.13	0.13	0.34	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.02
2E+3+	Average	0.58	0.91	0.79	1.00	1.00	0.00	0.80	0.95	0.00	0.00	0.73	0.06	0.39	0.83	0.09	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.81	0.01
4C	STD	0.08	0.04	0.31	0.00	0.00	0.00	0.41	0.10	0.01	0.00	0.09	0.12	0.40	0.22	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.03
2E+3+	Average	0.62	0.93	0.83	1.00	1.00	0.00	0.80	0.95	0.00	0.00	0.72	0.10	0.06	0.72	0.17	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.73	0.01
5	STD	0.05	0.03	0.30	0.00	0.00	0.00	0.41	0.10	0.01	0.00	0.18	0.14	0.13	0.16	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.03
7	Average	0.60	0.92	0.81	1.00	1.00	0.00	0.80	0.95	0.00	0.00	0.74	0.07	0.31	0.80	0.10	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.79	0.01
	STD	0.07	0.03	0.30	0.00	0.00	0.00	0.41	0.10	0.01	0.00	0.09	0.13	0.34	0.20	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.02
3+4C+	Average	0.70	0.95	0.92	1.00	1.00	0.00	0.00	0.74	0.00	0.00	0.74	0.07	0.07	0.45	0.12	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.81	0.01
5	STD	0.01	0.02	0.27	0.00	0.00	0.00	0.00	0.26	0.01	0.00	0.09	0.12	0.13	0.32	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.02
8	Average	0.58	0.91	0.80	1.00	1.00	0.00	0.80	0.95	0.00	0.00	0.73	0.07	0.39	0.83	0.09	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.81	0.01
	STD	0.08	0.04	0.31	0.00	0.00	0.00	0.41	0.10	0.01	0.00	0.09	0.11	0.40	0.21	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.02

Notes: Average-U_s, U_t, and P_v values averaged over all river locations and over all seasons within the 25-year planning period
STD-Standard deviation of U_s, U_t, and P_v values over all river locations and over all seasons within the 25-year planning period

TABLE D-27. Space-Time Average and Standard Deviation of Performance Measures for Each Combined Management Strategy Applied during the Mar-Apr Season (Computed over All River Locations)

Strategy		High Criteria												Low Criteria											
		C_{TDS} (500 mg/L)			C_{NO_2} (10 mg/L)			C_N (15 mg/L)			C_{FC} (500 colonies/100 ml)			C_{TDS} (1000 mg/L)			C_{NO_2} (10 mg/L)			C_N (30 mg/L)			C_{FC} (1000 colonies/100 ml)		
		U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v
1	Average	0.70	0.98	0.89	1.00	1.00	0.00	0.00	0.72	0.00	0.00	0.65	0.08	0.31	0.87	0.47	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.50	0.00
	STD	0.00	0.00	0.27	0.00	0.00	0.00	0.00	0.20	0.01	0.00	0.06	0.09	0.02	0.06	0.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00
2E+3	Average	0.53	0.95	0.75	1.00	1.00	0.00	0.80	0.92	0.00	0.00	0.61	0.06	0.09	0.87	0.30	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.51	0.00
	STD	0.09	0.02	0.34	0.00	0.00	0.00	0.41	0.19	0.00	0.00	0.08	0.07	0.13	0.06	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.00
6	Average	0.49	0.90	0.73	1.00	1.00	0.00	0.80	0.92	0.00	0.00	0.39	0.04	0.07	0.70	0.18	1.00	1.00	0.00	1.00	1.00	0.00	0.56	0.79	0.00
	STD	0.11	0.06	0.35	0.00	0.00	0.00	0.41	0.19	0.00	0.00	0.25	0.04	0.14	0.18	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.51	0.31	0.00
2E+5	Average	0.54	0.96	0.76	1.00	1.00	0.00	0.80	0.92	0.00	0.00	0.64	0.07	0.11	0.88	0.32	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.49	0.00
	STD	0.08	0.02	0.33	0.00	0.00	0.00	0.41	0.19	0.00	0.00	0.07	0.08	0.12	0.06	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.00
3+4C	Average	0.64	0.96	0.86	1.00	1.00	0.00	0.00	0.77	0.00	0.00	0.39	0.05	0.10	0.81	0.23	1.00	1.00	0.00	1.00	1.00	0.00	0.56	0.79	0.00
	STD	0.04	0.02	0.31	0.00	0.00	0.00	0.00	0.20	0.01	0.00	0.27	0.05	0.15	0.07	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.51	0.29	0.00
3+5	Average	0.69	0.98	0.88	1.00	1.00	0.00	0.00	0.88	0.00	0.00	0.66	0.08	0.25	0.88	0.41	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.50	0.00
	STD	0.01	0.00	0.27	0.00	0.00	0.00	0.00	0.19	0.00	0.00	0.05	0.09	0.05	0.07	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.00
4C+5	Average	0.66	0.97	0.87	1.00	1.00	0.00	0.00	0.86	0.00	0.00	0.41	0.05	0.10	0.82	0.23	1.00	1.00	0.00	1.00	1.00	0.00	0.56	0.79	0.00
	STD	0.03	0.01	0.29	0.00	0.00	0.00	0.00	0.19	0.00	0.00	0.27	0.06	0.15	0.07	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.51	0.29	0.00
2E+3+	Average	0.48	0.89	0.73	1.00	1.00	0.00	0.80	0.92	0.00	0.00	0.38	0.04	0.07	0.64	0.17	1.00	1.00	0.00	1.00	1.00	0.00	0.56	0.80	0.00
4C	STD	0.12	0.07	0.36	0.00	0.00	0.00	0.41	0.19	0.00	0.00	0.26	0.04	0.14	0.24	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.51	0.29	0.00
2E+3+	Average	0.52	0.95	0.75	1.00	1.00	0.00	0.80	0.92	0.00	0.00	0.63	0.07	0.09	0.87	0.29	1.00	1.00	0.00	1.00	1.00	0.00	0.01	0.46	0.00
5	STD	0.09	0.02	0.34	0.00	0.00	0.00	0.41	0.19	0.00	0.00	0.07	0.07	0.13	0.06	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.15	0.00
7	Average	0.48	0.90	0.73	1.00	1.00	0.00	0.80	0.92	0.00	0.00	0.41	0.04	0.07	0.69	0.18	1.00	1.00	0.00	1.00	1.00	0.00	0.64	0.79	0.00
	STD	0.11	0.06	0.35	0.00	0.00	0.00	0.41	0.19	0.00	0.00	0.26	0.05	0.14	0.19	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.49	0.31	0.00
3+4C+	Average	0.65	0.96	0.86	1.00	1.00	0.00	0.00	0.89	0.00	0.00	0.40	0.05	0.09	0.80	0.22	1.00	1.00	0.00	1.00	1.00	0.00	0.61	0.80	0.00
5	STD	0.03	0.02	0.30	0.00	0.00	0.00	0.00	0.19	0.00	0.00	0.26	0.06	0.14	0.09	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.49	0.29	0.00
8	Average	0.47	0.88	0.72	1.00	1.00	0.00	0.80	0.92	0.00	0.00	0.39	0.04	0.07	0.63	0.17	1.00	1.00	0.00	1.00	1.00	0.00	0.64	0.80	0.00
	STD	0.12	0.07	0.36	0.00	0.00	0.00	0.41	0.19	0.00	0.00	0.26	0.04	0.14	0.24	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.49	0.28	0.00

Notes: Average-U_s, U_t, and P_v values averaged over all river locations and over all seasons within the 25-year planning period
STD-Standard deviation of U_s, U_t, and P_v values over all river locations and over all seasons within the 25-year planning period

TABLE D-28. Space-Time Average and Standard Deviation of Performance Measures for Each Combined Management Strategy Applied during the May-Jun Season (Computed over All River Locations)

Strategy		High Criteria												Low Criteria											
		C_{TDS} (500 mg/L)			C_{NO_2} (10 mg/L)			C_N (15 mg/L)			C_{FC} (500 colonies/100 ml)			C_{TDS} (1000 mg/L)			C_{NO_2} (10 mg/L)			C_N (30 mg/L)			C_{FC} (1000 colonies/100 ml)		
		U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v
1	Average	0.56	0.95	0.61	1.00	1.00	0.00	0.41	0.87	0.25	0.36	0.89	0.27	0.00	0.72	0.11	1.00	1.00	0.00	0.00	0.57	0.04	0.00	0.53	0.08
	STD	0.01	0.02	0.27	0.00	0.00	0.00	0.01	0.02	0.15	0.02	0.01	0.17	0.00	0.05	0.12	0.00	0.00	0.00	0.00	0.12	0.04	0.00	0.11	0.10
2E+3	Average	0.46	0.95	0.53	1.00	1.00	0.00	0.45	0.85	0.21	0.38	0.88	0.26	0.00	0.54	0.08	1.00	1.00	0.00	0.00	0.51	0.03	0.00	0.52	0.07
	STD	0.05	0.01	0.28	0.00	0.00	0.00	0.02	0.02	0.11	0.03	0.02	0.16	0.00	0.14	0.09	0.00	0.00	0.00	0.00	0.15	0.03	0.00	0.12	0.09
6	Average	0.35	0.93	0.45	1.00	1.00	0.00	0.28	0.84	0.15	0.19	0.82	0.20	0.00	0.56	0.07	1.00	1.00	0.00	0.00	0.49	0.01	0.00	0.45	0.05
	STD	0.13	0.01	0.28	0.00	0.00	0.00	0.10	0.04	0.10	0.12	0.05	0.16	0.00	0.13	0.09	0.00	0.00	0.00	0.00	0.24	0.02	0.00	0.16	0.07
2E+5	Average	0.46	0.95	0.53	1.00	1.00	0.00	0.44	0.85	0.22	0.38	0.89	0.27	0.00	0.58	0.09	1.00	1.00	0.00	0.00	0.52	0.03	0.00	0.56	0.08
	STD	0.05	0.01	0.28	0.00	0.00	0.00	0.01	0.02	0.12	0.02	0.01	0.17	0.00	0.11	0.11	0.00	0.00	0.00	0.00	0.15	0.03	0.00	0.10	0.10
3+4C	Average	0.50	0.94	0.53	1.00	1.00	0.00	0.27	0.84	0.17	0.24	0.82	0.20	0.00	0.50	0.07	1.00	1.00	0.00	0.00	0.40	0.01	0.00	0.42	0.04
	STD	0.04	0.02	0.26	0.00	0.00	0.00	0.12	0.04	0.12	0.10	0.05	0.15	0.00	0.17	0.08	0.00	0.00	0.00	0.00	0.25	0.02	0.00	0.19	0.06
3+5	Average	0.53	0.95	0.59	1.00	1.00	0.00	0.45	0.86	0.23	0.41	0.88	0.27	0.00	0.64	0.09	1.00	1.00	0.00	0.00	0.54	0.03	0.00	0.55	0.08
	STD	0.02	0.02	0.27	0.00	0.00	0.00	0.02	0.02	0.13	0.04	0.02	0.16	0.00	0.09	0.10	0.00	0.00	0.00	0.00	0.12	0.04	0.00	0.09	0.09
4C+5	Average	0.48	0.93	0.52	1.00	1.00	0.00	0.26	0.84	0.17	0.23	0.83	0.21	0.00	0.55	0.08	1.00	1.00	0.00	0.00	0.43	0.02	0.00	0.44	0.05
	STD	0.06	0.02	0.26	0.00	0.00	0.00	0.12	0.03	0.12	0.10	0.04	0.16	0.00	0.15	0.09	0.00	0.00	0.00	0.00	0.24	0.02	0.00	0.17	0.06
2E+3+	Average	0.33	0.92	0.45	1.00	1.00	0.00	0.30	0.83	0.14	0.22	0.82	0.19	0.00	0.54	0.06	1.00	1.00	0.00	0.00	0.48	0.01	0.00	0.43	0.04
4C	STD	0.14	0.02	0.28	0.00	0.00	0.00	0.10	0.04	0.09	0.11	0.05	0.14	0.00	0.15	0.07	0.00	0.00	0.00	0.00	0.25	0.01	0.00	0.17	0.06
2E+3+	Average	0.45	0.95	0.52	1.00	1.00	0.00	0.45	0.85	0.21	0.40	0.88	0.27	0.00	0.54	0.07	1.00	1.00	0.00	0.00	0.50	0.03	0.00	0.55	0.08
5	STD	0.06	0.01	0.28	0.00	0.00	0.00	0.02	0.02	0.11	0.04	0.02	0.16	0.00	0.15	0.09	0.00	0.00	0.00	0.00	0.15	0.03	0.00	0.09	0.08
7	Average	0.33	0.93	0.45	1.00	1.00	0.00	0.28	0.83	0.15	0.23	0.83	0.21	0.00	0.57	0.07	1.00	1.00	0.00	0.00	0.49	0.01	0.00	0.43	0.05
	STD	0.14	0.01	0.28	0.00	0.00	0.00	0.10	0.04	0.10	0.10	0.05	0.15	0.00	0.12	0.09	0.00	0.00	0.00	0.00	0.24	0.02	0.00	0.18	0.06
3+4C+	Average	0.46	0.94	0.51	1.00	1.00	0.00	0.28	0.84	0.17	0.26	0.83	0.20	0.00	0.53	0.06	1.00	1.00	0.00	0.00	0.41	0.01	0.00	0.43	0.04
5	STD	0.06	0.02	0.26	0.00	0.00	0.00	0.11	0.04	0.11	0.09	0.05	0.15	0.00	0.14	0.08	0.00	0.00	0.00	0.00	0.25	0.02	0.00	0.18	0.06
8	Average	0.32	0.92	0.44	1.00	1.00	0.00	0.30	0.83	0.14	0.25	0.82	0.20	0.00	0.54	0.06	1.00	1.00	0.00	0.00	0.48	0.01	0.00	0.41	0.04
	STD	0.15	0.02	0.28	0.00	0.00	0.00	0.10	0.04	0.09	0.10	0.05	0.14	0.00	0.16	0.07	0.00	0.00	0.00	0.00	0.24	0.01	0.00	0.18	0.06

Notes: Average-U_s, U_t, and P_v values averaged over all river locations and over all seasons within the 25-year planning period
STD-Standard deviation of U_s, U_t, and P_v values over all river locations and over all seasons within the 25-year planning period

TABLE D-29. Space-Time Average and Standard Deviation of Performance Measures for Each Combined Management Strategy Applied during the Jul-Aug Season (Computed over All River Locations)

Strategy		High Criteria												Low Criteria											
		C_{TDS} (500 mg/L)			C_{NO_2} (10 mg/L)			C_N (15 mg/L)			C_{FC} (500 colonies/100 ml)			C_{TDS} (1000 mg/L)			C_{NO_2} (10 mg/L)			C_N (30 mg/L)			C_{FC} (1000 colonies/100 ml)		
		U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v
1	Average	0.54	0.97	0.68	1.00	1.00	0.00	0.54	0.94	0.70	0.11	0.78	0.41	0.00	0.68	0.20	1.00	1.00	0.00	0.24	0.82	0.08	0.00	0.83	0.18
	STD	0.01	0.00	0.31	0.00	0.00	0.00	0.01	0.01	0.32	0.01	0.08	0.36	0.00	0.07	0.25	0.00	0.00	0.00	0.04	0.03	0.06	0.00	0.04	0.22
2E+3	Average	0.29	0.91	0.56	1.00	1.00	0.00	0.46	0.95	0.63	0.10	0.76	0.39	0.00	0.62	0.14	1.00	1.00	0.00	0.11	0.74	0.05	0.00	0.82	0.15
	STD	0.13	0.04	0.39	0.00	0.00	0.00	0.04	0.02	0.34	0.02	0.10	0.35	0.00	0.08	0.18	0.00	0.00	0.00	0.07	0.07	0.04	0.00	0.05	0.19
6	Average	0.19	0.83	0.52	1.00	1.00	0.00	0.41	0.95	0.54	0.04	0.83	0.35	0.00	0.56	0.13	1.00	1.00	0.00	0.04	0.39	0.02	0.00	0.81	0.12
	STD	0.18	0.10	0.40	0.00	0.00	0.00	0.08	0.01	0.31	0.05	0.06	0.33	0.00	0.12	0.19	0.00	0.00	0.00	0.08	0.36	0.02	0.00	0.04	0.16
2E+5	Average	0.31	0.93	0.57	1.00	1.00	0.00	0.47	0.96	0.64	0.12	0.78	0.40	0.00	0.67	0.17	1.00	1.00	0.00	0.09	0.79	0.06	0.00	0.83	0.17
	STD	0.11	0.03	0.38	0.00	0.00	0.00	0.04	0.02	0.34	0.01	0.08	0.36	0.00	0.07	0.22	0.00	0.00	0.00	0.07	0.04	0.05	0.00	0.04	0.21
3+4C	Average	0.45	0.94	0.62	1.00	1.00	0.00	0.51	0.91	0.59	0.04	0.82	0.33	0.00	0.55	0.12	1.00	1.00	0.00	0.06	0.54	0.03	0.00	0.78	0.10
	STD	0.05	0.03	0.34	0.00	0.00	0.00	0.02	0.03	0.28	0.05	0.06	0.32	0.00	0.12	0.17	0.00	0.00	0.00	0.09	0.27	0.02	0.00	0.05	0.14
3+5	Average	0.51	0.95	0.66	1.00	1.00	0.00	0.53	0.92	0.68	0.10	0.76	0.39	0.00	0.66	0.17	1.00	1.00	0.00	0.26	0.78	0.06	0.00	0.82	0.15
	STD	0.02	0.02	0.32	0.00	0.00	0.00	0.01	0.03	0.32	0.01	0.10	0.35	0.00	0.07	0.21	0.00	0.00	0.00	0.05	0.06	0.04	0.00	0.05	0.19
4C+5	Average	0.49	0.97	0.64	1.00	1.00	0.00	0.51	0.93	0.60	0.04	0.83	0.35	0.00	0.60	0.14	1.00	1.00	0.00	0.06	0.58	0.03	0.00	0.81	0.12
	STD	0.03	0.01	0.32	0.00	0.00	0.00	0.02	0.01	0.29	0.05	0.06	0.34	0.00	0.09	0.20	0.00	0.00	0.00	0.09	0.22	0.02	0.00	0.04	0.16
2E+3+	Average	0.17	0.81	0.51	1.00	1.00	0.00	0.39	0.93	0.52	0.04	0.82	0.33	0.00	0.49	0.11	1.00	1.00	0.00	0.04	0.45	0.02	0.00	0.78	0.10
4C	STD	0.19	0.10	0.40	0.00	0.00	0.00	0.08	0.02	0.30	0.05	0.06	0.32	0.00	0.15	0.15	0.00	0.00	0.00	0.08	0.37	0.02	0.00	0.05	0.14
2E+3+	Average	0.28	0.91	0.56	1.00	1.00	0.00	0.45	0.95	0.63	0.10	0.76	0.39	0.00	0.62	0.14	1.00	1.00	0.00	0.09	0.73	0.05	0.00	0.82	0.15
5	STD	0.13	0.04	0.39	0.00	0.00	0.00	0.05	0.02	0.34	0.01	0.10	0.35	0.00	0.08	0.18	0.00	0.00	0.00	0.08	0.08	0.04	0.00	0.05	0.19
7	Average	0.18	0.82	0.52	1.00	1.00	0.00	0.40	0.95	0.54	0.04	0.83	0.35	0.00	0.56	0.13	1.00	1.00	0.00	0.04	0.42	0.02	0.00	0.82	0.12
	STD	0.19	0.10	0.40	0.00	0.00	0.00	0.08	0.01	0.31	0.05	0.06	0.33	0.00	0.12	0.19	0.00	0.00	0.00	0.08	0.38	0.02	0.00	0.04	0.16
3+4C+	Average	0.45	0.94	0.62	1.00	1.00	0.00	0.51	0.91	0.58	0.04	0.82	0.33	0.00	0.55	0.12	1.00	1.00	0.00	0.06	0.52	0.03	0.00	0.78	0.10
5	STD	0.05	0.02	0.34	0.00	0.00	0.00	0.02	0.03	0.28	0.05	0.06	0.32	0.00	0.12	0.17	0.00	0.00	0.00	0.09	0.28	0.02	0.00	0.05	0.14
8	Average	0.17	0.81	0.51	1.00	1.00	0.00	0.39	0.93	0.52	0.04	0.81	0.33	0.00	0.49	0.11	1.00	1.00	0.00	0.04	0.49	0.02	0.00	0.78	0.10
	STD	0.19	0.10	0.41	0.00	0.00	0.00	0.09	0.02	0.30	0.05	0.06	0.32	0.00	0.15	0.15	0.00	0.00	0.00	0.08	0.36	0.02	0.00	0.05	0.13

Notes: Average-U_s, U_t, and P_v values averaged over all river locations and over all seasons within the 25-year planning period
STD-Standard deviation of U_s, U_t, and P_v values over all river locations and over all seasons within the 25-year planning period

TABLE D-30. Space-Time Average and Standard Deviation of Performance Measures for Each Combined Management Strategy Applied during the Sep-Oct Season (Computed over All River Locations)

Strategy		High Criteria												Low Criteria											
		C_{TDS} (500 mg/L)			C_{NO_2} (10 mg/L)			C_N (15 mg/L)			C_{FC} (500 colonies/100 ml)			C_{TDS} (1000 mg/L)			C_{NO_2} (10 mg/L)			C_N (30 mg/L)			C_{FC} (1000 colonies/100 ml)		
		U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v
1	Average	0.60	0.93	0.80	1.00	1.00	0.00	0.08	0.99	0.00	0.00	0.77	0.15	0.00	0.65	0.08	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.76	0.02
	STD	0.00	0.01	0.32	0.00	0.00	0.00	0.28	0.01	0.00	0.00	0.07	0.19	0.00	0.10	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.04
2E+3	Average	0.42	0.79	0.65	1.00	1.00	0.00	0.80	1.00	0.00	0.00	0.75	0.13	0.00	0.69	0.04	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.73	0.02
	STD	0.09	0.09	0.35	0.00	0.00	0.00	0.41	0.00	0.00	0.00	0.07	0.16	0.01	0.06	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.03
6	Average	0.40	0.85	0.61	1.00	1.00	0.00	0.80	1.00	0.00	0.00	0.76	0.11	0.09	0.60	0.03	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.64	0.01
	STD	0.10	0.06	0.34	0.00	0.00	0.00	0.41	0.00	0.00	0.00	0.06	0.14	0.09	0.08	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.02
2E+5	Average	0.41	0.88	0.64	1.00	1.00	0.00	0.80	1.00	0.00	0.00	0.78	0.15	0.00	0.69	0.04	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.75	0.02
	STD	0.09	0.09	0.35	0.00	0.00	0.00	0.41	0.00	0.00	0.00	0.08	0.18	0.00	0.07	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.04
3+4C	Average	0.58	0.87	0.78	1.00	1.00	0.00	0.56	0.99	0.00	0.00	0.75	0.11	0.01	0.60	0.04	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.61	0.01
	STD	0.01	0.05	0.33	0.00	0.00	0.00	0.51	0.01	0.00	0.00	0.06	0.14	0.03	0.10	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.02
3+5	Average	0.60	0.88	0.79	1.00	1.00	0.00	0.80	1.00	0.00	0.00	0.76	0.14	0.00	0.70	0.06	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.71	0.02
	STD	0.01	0.05	0.31	0.00	0.00	0.00	0.41	0.00	0.00	0.00	0.09	0.17	0.00	0.06	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.03
4C+5	Average	0.60	0.92	0.77	1.00	1.00	0.00	0.80	1.00	0.00	0.00	0.77	0.11	0.07	0.61	0.03	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.63	0.01
	STD	0.00	0.02	0.31	0.00	0.00	0.00	0.41	0.00	0.00	0.00	0.07	0.15	0.08	0.07	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.02
2E+3+4C	Average	0.38	0.77	0.60	1.00	1.00	0.00	0.80	1.00	0.00	0.00	0.73	0.10	0.10	0.60	0.03	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.61	0.01
	STD	0.11	0.11	0.34	0.00	0.00	0.00	0.41	0.00	0.00	0.00	0.06	0.12	0.09	0.07	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.02
2E+3+5	Average	0.40	0.87	0.64	1.00	1.00	0.00	0.80	1.00	0.00	0.00	0.76	0.13	0.00	0.69	0.04	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.71	0.02
	STD	0.10	0.07	0.35	0.00	0.00	0.00	0.41	0.00	0.00	0.00	0.08	0.16	0.01	0.06	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.03
7	Average	0.38	0.87	0.59	1.00	1.00	0.00	0.80	1.00	0.00	0.00	0.77	0.11	0.09	0.60	0.03	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.63	0.01
	STD	0.11	0.10	0.34	0.00	0.00	0.00	0.41	0.00	0.00	0.00	0.07	0.14	0.09	0.08	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.02
3+4C+5	Average	0.59	0.88	0.77	1.00	1.00	0.00	0.80	1.00	0.00	0.00	0.74	0.10	0.08	0.61	0.03	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.60	0.01
	STD	0.00	0.05	0.31	0.00	0.00	0.00	0.41	0.00	0.00	0.00	0.08	0.13	0.09	0.06	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.02
8	Average	0.36	0.87	0.58	1.00	1.00	0.00	0.80	1.00	0.00	0.00	0.74	0.10	0.11	0.60	0.03	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.60	0.01
	STD	0.12	0.07	0.34	0.00	0.00	0.00	0.41	0.00	0.00	0.00	0.07	0.12	0.09	0.07	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.02

Notes: Average-U_s, U_t, and P_v values averaged over all river locations and over all seasons within the 25-year planning period
STD-Standard deviation of U_s, U_t, and P_v values over all river locations and over all seasons within the 25-year planning period

TABLE D-31. Space-Time Average and Standard Deviation of Performance Measures for Each Combined Management Strategy Applied during the Nov-Dec Season (Computed over All River Locations)

Strategy		High Criteria												Low Criteria											
		C_{TDS} (500 mg/L)			C_{NO_2} (10 mg/L)			C_N (15 mg/L)			C_{FC} (500 colonies/100 ml)			C_{TDS} (1000 mg/L)			C_{NO_2} (10 mg/L)			C_N (30 mg/L)			C_{FC} (1000 colonies/100 ml)		
		U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v
1	Average	0.73	0.98	0.90	1.00	1.00	0.00	0.00	0.30	0.01	0.46	0.91	0.32	0.00	0.59	0.11	1.00	1.00	0.00	0.07	0.55	0.00	0.00	0.70	0.11
	STD	0.01	0.00	0.24	0.00	0.00	0.00	0.00	0.20	0.02	0.02	0.01	0.17	0.00	0.12	0.11	0.00	0.00	0.00	0.16	0.29	0.00	0.00	0.07	0.13
2E+3	Average	0.51	0.95	0.71	1.00	1.00	0.00	0.00	0.69	0.01	0.48	0.91	0.31	0.00	0.86	0.05	1.00	1.00	0.00	0.06	0.48	0.00	0.00	0.70	0.11
	STD	0.11	0.02	0.32	0.00	0.00	0.00	0.00	0.20	0.01	0.03	0.01	0.16	0.00	0.10	0.06	0.00	0.00	0.00	0.17	0.30	0.00	0.00	0.08	0.12
6	Average	0.36	0.86	0.61	1.00	1.00	0.00	0.00	0.69	0.01	0.32	0.88	0.25	0.00	0.86	0.05	1.00	1.00	0.00	0.03	0.48	0.00	0.00	0.38	0.06
	STD	0.21	0.08	0.33	0.00	0.00	0.00	0.00	0.20	0.01	0.09	0.03	0.16	0.00	0.10	0.05	0.00	0.00	0.00	0.10	0.29	0.00	0.00	0.26	0.09
2E+5	Average	0.51	0.95	0.71	1.00	1.00	0.00	0.00	0.69	0.01	0.54	0.92	0.35	0.00	0.87	0.05	1.00	1.00	0.00	0.03	0.47	0.00	0.02	0.77	0.14
	STD	0.11	0.02	0.32	0.00	0.00	0.00	0.00	0.21	0.01	0.05	0.01	0.16	0.00	0.10	0.06	0.00	0.00	0.00	0.10	0.28	0.00	0.03	0.05	0.14
3+4C	Average	0.66	0.96	0.86	1.00	1.00	0.00	0.00	0.34	0.01	0.32	0.88	0.26	0.00	0.71	0.08	1.00	1.00	0.00	0.11	0.56	0.00	0.00	0.37	0.07
	STD	0.04	0.02	0.29	0.00	0.00	0.00	0.00	0.23	0.01	0.10	0.03	0.17	0.00	0.26	0.09	0.00	0.00	0.00	0.21	0.32	0.00	0.00	0.27	0.10
3+5	Average	0.71	0.97	0.88	1.00	1.00	0.00	0.00	0.64	0.01	0.53	0.92	0.35	0.00	0.74	0.08	1.00	1.00	0.00	0.11	0.56	0.00	0.02	0.76	0.14
	STD	0.01	0.01	0.25	0.00	0.00	0.00	0.00	0.24	0.01	0.05	0.01	0.16	0.00	0.11	0.09	0.00	0.00	0.00	0.21	0.31	0.00	0.03	0.05	0.14
4C+5	Average	0.69	0.97	0.84	1.00	1.00	0.00	0.00	0.64	0.01	0.39	0.90	0.29	0.00	0.84	0.07	1.00	1.00	0.00	0.07	0.57	0.00	0.00	0.54	0.10
	STD	0.03	0.01	0.26	0.00	0.00	0.00	0.00	0.23	0.01	0.07	0.02	0.17	0.00	0.11	0.08	0.00	0.00	0.00	0.16	0.30	0.00	0.01	0.19	0.12
2E+3+4C	Average	0.33	0.86	0.60	1.00	1.00	0.00	0.00	0.69	0.01	0.33	0.88	0.25	0.00	0.85	0.05	1.00	1.00	0.00	0.09	0.48	0.00	0.00	0.35	0.07
	STD	0.22	0.08	0.34	0.00	0.00	0.00	0.00	0.20	0.01	0.09	0.03	0.16	0.00	0.10	0.05	0.00	0.00	0.00	0.20	0.30	0.00	0.00	0.29	0.09
2E+3+5	Average	0.48	0.94	0.69	1.00	1.00	0.00	0.00	0.69	0.01	0.54	0.92	0.35	0.00	0.85	0.05	1.00	1.00	0.00	0.08	0.48	0.00	0.02	0.76	0.14
	STD	0.13	0.02	0.33	0.00	0.00	0.00	0.00	0.20	0.01	0.05	0.01	0.16	0.00	0.10	0.05	0.00	0.00	0.00	0.20	0.30	0.00	0.03	0.05	0.14
7	Average	0.31	0.83	0.58	1.00	1.00	0.00	0.00	0.69	0.01	0.40	0.90	0.29	0.00	0.85	0.05	1.00	1.00	0.00	0.03	0.48	0.00	0.00	0.53	0.09
	STD	0.23	0.10	0.34	0.00	0.00	0.00	0.00	0.20	0.01	0.07	0.02	0.17	0.00	0.10	0.05	0.00	0.00	0.00	0.10	0.29	0.00	0.01	0.19	0.11
3+4C+5	Average	0.67	0.95	0.83	1.00	1.00	0.00	0.00	0.63	0.01	0.39	0.90	0.29	0.00	0.85	0.07	1.00	1.00	0.00	0.10	0.57	0.00	0.00	0.53	0.09
	STD	0.03	0.02	0.27	0.00	0.00	0.00	0.00	0.23	0.01	0.07	0.02	0.17	0.00	0.11	0.07	0.00	0.00	0.00	0.21	0.31	0.00	0.01	0.19	0.11
8	Average	0.28	0.80	0.57	1.00	1.00	0.00	0.00	0.69	0.01	0.40	0.90	0.28	0.00	0.84	0.04	1.00	1.00	0.00	0.09	0.48	0.00	0.00	0.53	0.09
	STD	0.25	0.12	0.34	0.00	0.00	0.00	0.00	0.20	0.01	0.07	0.02	0.16	0.00	0.09	0.05	0.00	0.00	0.00	0.20	0.30	0.00	0.01	0.19	0.11

Notes: Average-U_s, U_t, and P_v values averaged over all river locations and over all seasons within the 25-year planning period
STD-Standard deviation of U_s, U_t, and P_v values over all river locations and over all seasons within the 25-year planning period

TABLE D-32. Space-Time Average and Standard Deviation of Performance Measures for Each Combined Management Strategy Applied during the Jan-Feb Season (Computed over All Irrigation Diversion Points and Downstream Station at Weldona)

Strategy		High Criteria												Low Criteria											
		C_{TDS} (500 mg/L)			C_{NO_2} (10 mg/L)			C_N (15 mg/L)			C_{FC} (500 colonies/100 ml)			C_{TDS} (1000 mg/L)			C_{NO_2} (10 mg/L)			C_N (30 mg/L)			C_{FC} (1000 colonies/100 ml)		
		U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v
1	Average	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.89	0.00	0.00	0.90	0.11	0.40	0.94	0.46	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.83	0.04
	STD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.16	0.21	0.02	0.01	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.09
2E+3	Average	0.68	0.96	0.88	1.00	1.00	0.00	0.80	0.98	0.00	0.00	0.90	0.11	0.08	0.76	0.22	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.84	0.04
	STD	0.16	0.02	0.27	0.00	0.00	0.00	0.41	0.05	0.00	0.00	0.16	0.20	0.17	0.13	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.08
6	Average	0.67	0.90	0.87	1.00	1.00	0.00	0.80	0.98	0.00	0.00	0.91	0.09	0.45	0.64	0.12	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.85	0.03
	STD	0.17	0.08	0.28	0.00	0.00	0.00	0.41	0.05	0.00	0.00	0.09	0.18	0.38	0.33	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.06
2E+5	Average	0.67	0.96	0.87	1.00	1.00	0.00	0.80	0.98	0.00	0.00	0.88	0.08	0.08	0.85	0.23	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.82	0.03
	STD	0.17	0.02	0.27	0.00	0.00	0.00	0.41	0.05	0.00	0.00	0.22	0.13	0.17	0.07	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.05
3+4C	Average	1.00	1.00	1.00	1.00	1.00	0.00	0.18	0.86	0.00	0.00	0.91	0.09	0.11	0.41	0.15	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.89	0.03
	STD	0.00	0.00	0.00	0.00	0.00	0.00	0.32	0.09	0.00	0.00	0.08	0.18	0.18	0.41	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.06
3+5	Average	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.93	0.00	0.00	0.88	0.09	0.35	0.89	0.41	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.83	0.03
	STD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.01	0.00	0.22	0.14	0.05	0.04	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.05
4C+5	Average	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.90	0.01	0.00	0.91	0.06	0.10	0.38	0.14	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.83	0.02
	STD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.02	0.00	0.08	0.11	0.18	0.39	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.04
2E+3+	Average	0.66	0.91	0.86	1.00	1.00	0.00	0.80	0.98	0.00	0.00	0.91	0.09	0.49	0.72	0.12	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.88	0.03
4C	STD	0.17	0.07	0.28	0.00	0.00	0.00	0.41	0.05	0.00	0.00	0.09	0.17	0.40	0.30	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.06
2E+3+	Average	0.67	0.96	0.87	1.00	1.00	0.00	0.80	0.98	0.00	0.00	0.88	0.08	0.08	0.84	0.22	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.83	0.03
5	STD	0.17	0.02	0.28	0.00	0.00	0.00	0.41	0.05	0.00	0.00	0.22	0.13	0.17	0.08	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.05
7	Average	0.63	0.90	0.85	1.00	1.00	0.00	0.80	0.98	0.00	0.00	0.91	0.06	0.43	0.65	0.12	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.83	0.02
	STD	0.19	0.08	0.30	0.00	0.00	0.00	0.41	0.05	0.00	0.00	0.08	0.10	0.37	0.30	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.04
3+4C+	Average	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.93	0.00	0.00	0.91	0.06	0.12	0.38	0.14	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.87	0.02
5	STD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.01	0.00	0.08	0.11	0.18	0.38	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.04
8	Average	0.63	0.91	0.85	1.00	1.00	0.00	0.80	0.98	0.00	0.00	0.91	0.06	0.49	0.74	0.12	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.86	0.02
	STD	0.19	0.07	0.30	0.00	0.00	0.00	0.41	0.05	0.00	0.00	0.08	0.10	0.40	0.29	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.04

Notes: Average-U_s, U_t, and P_v values averaged over all river locations and over all seasons within the 25-year planning period
STD-Standard deviation of U_s, U_t, and P_v values over all river locations and over all seasons within the 25-year planning period

TABLE D-33. Space-Time Average and Standard Deviation of Performance Measures for Each Combined Management Strategy Applied during the Mar-Apr Season (Computed over All Irrigation Diversion Points and Downstream Station at Weldona)

Strategy		High Criteria												Low Criteria											
		C_{TDS} (500 mg/L)			C_{NO_2} (10 mg/L)			C_N (15 mg/L)			C_{FC} (500 colonies/100 ml)			C_{TDS} (1000 mg/L)			C_{NO_2} (10 mg/L)			C_N (30 mg/L)			C_{FC} (1000 colonies/100 ml)		
		U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v
1	Average	0.81	0.99	0.94	1.00	1.00	0.00	0.26	0.73	0.00	0.02	0.69	0.09	0.44	0.86	0.51	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.41	0.00
	STD	0.01	0.00	0.18	0.00	0.00	0.00	0.33	0.23	0.00	0.03	0.06	0.09	0.03	0.08	0.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00
2E+3	Average	0.65	0.97	0.82	1.00	1.00	0.00	0.81	0.92	0.00	0.03	0.64	0.08	0.18	0.89	0.32	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.47	0.00
	STD	0.08	0.01	0.28	0.00	0.00	0.00	0.38	0.21	0.00	0.03	0.08	0.07	0.16	0.05	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.00
6	Average	0.62	0.94	0.81	1.00	1.00	0.00	0.81	0.92	0.00	0.00	0.41	0.05	0.11	0.60	0.20	1.00	1.00	0.00	1.00	1.00	0.00	0.59	0.75	0.00
	STD	0.10	0.03	0.29	0.00	0.00	0.00	0.38	0.21	0.00	0.01	0.28	0.05	0.19	0.25	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.48	0.36	0.00
2E+5	Average	0.65	0.97	0.82	1.00	1.00	0.00	0.81	0.92	0.00	0.04	0.67	0.08	0.22	0.90	0.34	1.00	1.00	0.00	1.00	1.00	0.00	0.03	0.38	0.00
	STD	0.08	0.01	0.28	0.00	0.00	0.00	0.38	0.21	0.00	0.04	0.07	0.08	0.14	0.05	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.23	0.00
3+4C	Average	0.75	0.98	0.92	1.00	1.00	0.00	0.35	0.78	0.00	0.00	0.39	0.05	0.15	0.77	0.25	1.00	1.00	0.00	1.00	1.00	0.00	0.58	0.74	0.00
	STD	0.04	0.01	0.23	0.00	0.00	0.00	0.38	0.23	0.00	0.01	0.29	0.06	0.21	0.09	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.49	0.37	0.00
3+5	Average	0.84	0.99	0.95	1.00	1.00	0.00	0.01	0.87	0.00	0.04	0.70	0.09	0.37	0.90	0.44	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.40	0.00
	STD	0.01	0.00	0.15	0.00	0.00	0.00	0.04	0.21	0.00	0.04	0.06	0.09	0.06	0.07	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.22	0.00
4C+5	Average	0.82	0.99	0.94	1.00	1.00	0.00	0.01	0.86	0.00	0.01	0.40	0.06	0.15	0.76	0.25	1.00	1.00	0.00	1.00	1.00	0.00	0.62	0.75	0.00
	STD	0.01	0.00	0.16	0.00	0.00	0.00	0.04	0.21	0.00	0.01	0.29	0.06	0.21	0.11	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.48	0.36	0.00
2E+3+4C	Average	0.61	0.93	0.80	1.00	1.00	0.00	0.81	0.92	0.00	0.00	0.40	0.04	0.10	0.56	0.19	1.00	1.00	0.00	1.00	1.00	0.00	0.59	0.77	0.00
	STD	0.11	0.04	0.30	0.00	0.00	0.00	0.38	0.21	0.00	0.01	0.27	0.05	0.19	0.27	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.48	0.33	0.00
2E+3+5	Average	0.64	0.97	0.82	1.00	1.00	0.00	0.81	0.92	0.00	0.04	0.66	0.08	0.17	0.89	0.32	1.00	1.00	0.00	1.00	1.00	0.00	0.04	0.37	0.00
	STD	0.09	0.01	0.28	0.00	0.00	0.00	0.38	0.21	0.00	0.04	0.08	0.07	0.16	0.05	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.23	0.00
7	Average	0.61	0.94	0.80	1.00	1.00	0.00	0.81	0.92	0.00	0.01	0.42	0.05	0.11	0.59	0.20	1.00	1.00	0.00	1.00	1.00	0.00	0.69	0.74	0.00
	STD	0.10	0.04	0.30	0.00	0.00	0.00	0.38	0.21	0.00	0.02	0.27	0.05	0.19	0.26	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.45	0.38	0.00
3+4C+5	Average	0.81	0.99	0.94	1.00	1.00	0.00	0.01	0.88	0.00	0.01	0.39	0.05	0.14	0.73	0.23	1.00	1.00	0.00	1.00	1.00	0.00	0.69	0.76	0.00
	STD	0.01	0.00	0.17	0.00	0.00	0.00	0.04	0.20	0.00	0.02	0.28	0.05	0.20	0.13	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.45	0.35	0.00
8	Average	0.60	0.92	0.79	1.00	1.00	0.00	0.81	0.92	0.00	0.01	0.41	0.04	0.10	0.55	0.19	1.00	1.00	0.00	1.00	1.00	0.00	0.70	0.76	0.00
	STD	0.11	0.04	0.30	0.00	0.00	0.00	0.38	0.21	0.00	0.02	0.28	0.04	0.19	0.27	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.44	0.35	0.00

Notes: Average-U_s, U_t, and P_v values averaged over all river locations and over all seasons within the 25-year planning period
STD-Standard deviation of U_s, U_t, and P_v values over all river locations and over all seasons within the 25-year planning period

TABLE D-34. Space-Time Average and Standard Deviation of Performance Measures for Each Combined Management Strategy Applied during the May-Jun Season (Computed over All Irrigation Diversion Points and Downstream Station at Weldona)

Strategy		High Criteria												Low Criteria											
		C_{TDS} (500 mg/L)			C_{NO_3} (10 mg/L)			C_N (15 mg/L)			C_{FC} (500 colonies/100 ml)			C_{TDS} (1000 mg/L)			C_{NO_3} (10 mg/L)			C_N (30 mg/L)			C_{FC} (1000 colonies/100 ml)		
		U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v
1	Average	0.68	0.96	0.64	1.00	1.00	0.00	0.52	0.87	0.27	0.31	0.87	0.26	0.00	0.65	0.11	1.00	1.00	0.00	0.03	0.56	0.05	0.00	0.52	0.08
	STD	0.01	0.02	0.20	0.00	0.00	0.00	0.01	0.02	0.13	0.02	0.02	0.18	0.00	0.06	0.12	0.00	0.00	0.00	0.03	0.11	0.04	0.00	0.12	0.10
2E+3	Average	0.55	0.95	0.55	1.00	1.00	0.00	0.55	0.85	0.24	0.33	0.87	0.25	0.00	0.44	0.08	1.00	1.00	0.00	0.03	0.49	0.03	0.00	0.51	0.07
	STD	0.07	0.01	0.24	0.00	0.00	0.00	0.02	0.05	0.11	0.04	0.02	0.17	0.00	0.15	0.09	0.00	0.00	0.00	0.04	0.14	0.03	0.00	0.12	0.09
6	Average	0.39	0.93	0.46	1.00	1.00	0.00	0.41	0.85	0.17	0.16	0.80	0.19	0.00	0.46	0.07	1.00	1.00	0.00	0.01	0.42	0.02	0.00	0.46	0.04
	STD	0.17	0.02	0.26	0.00	0.00	0.00	0.09	0.04	0.09	0.11	0.06	0.15	0.00	0.16	0.09	0.00	0.00	0.00	0.03	0.24	0.02	0.00	0.19	0.07
2E+5	Average	0.56	0.95	0.55	1.00	1.00	0.00	0.53	0.85	0.24	0.35	0.87	0.25	0.00	0.48	0.09	1.00	1.00	0.00	0.02	0.50	0.04	0.00	0.53	0.08
	STD	0.06	0.01	0.24	0.00	0.00	0.00	0.01	0.03	0.11	0.03	0.02	0.16	0.00	0.13	0.11	0.00	0.00	0.00	0.03	0.14	0.03	0.00	0.11	0.09
3+4C	Average	0.58	0.95	0.54	1.00	1.00	0.00	0.39	0.85	0.20	0.19	0.81	0.19	0.00	0.41	0.06	1.00	1.00	0.00	0.01	0.35	0.02	0.00	0.43	0.04
	STD	0.07	0.01	0.22	0.00	0.00	0.00	0.11	0.04	0.11	0.10	0.06	0.15	0.00	0.18	0.08	0.00	0.00	0.00	0.03	0.25	0.02	0.00	0.21	0.06
3+5	Average	0.65	0.96	0.62	1.00	1.00	0.00	0.55	0.85	0.26	0.37	0.88	0.26	0.00	0.57	0.09	1.00	1.00	0.00	0.02	0.51	0.04	0.00	0.54	0.07
	STD	0.02	0.01	0.21	0.00	0.00	0.00	0.02	0.04	0.12	0.04	0.02	0.16	0.00	0.09	0.10	0.00	0.00	0.00	0.03	0.13	0.04	0.00	0.10	0.08
4C+5	Average	0.55	0.94	0.54	1.00	1.00	0.00	0.38	0.85	0.20	0.22	0.81	0.20	0.00	0.46	0.08	1.00	1.00	0.00	0.01	0.37	0.02	0.00	0.46	0.04
	STD	0.09	0.03	0.23	0.00	0.00	0.00	0.10	0.04	0.12	0.08	0.05	0.15	0.00	0.17	0.09	0.00	0.00	0.00	0.03	0.24	0.02	0.00	0.18	0.06
2E+3+	Average	0.37	0.92	0.45	1.00	1.00	0.00	0.42	0.84	0.16	0.18	0.80	0.19	0.00	0.44	0.06	1.00	1.00	0.00	0.02	0.43	0.01	0.00	0.43	0.04
4C	STD	0.18	0.03	0.26	0.00	0.00	0.00	0.08	0.05	0.09	0.11	0.06	0.15	0.00	0.17	0.07	0.00	0.00	0.00	0.06	0.25	0.01	0.00	0.20	0.06
2E+3+	Average	0.55	0.95	0.54	1.00	1.00	0.00	0.55	0.85	0.23	0.37	0.87	0.25	0.00	0.46	0.07	1.00	1.00	0.00	0.02	0.46	0.03	0.00	0.53	0.07
5	STD	0.07	0.01	0.24	0.00	0.00	0.00	0.02	0.05	0.10	0.04	0.02	0.16	0.00	0.16	0.09	0.00	0.00	0.00	0.03	0.15	0.03	0.00	0.10	0.08
7	Average	0.39	0.92	0.46	1.00	1.00	0.00	0.41	0.85	0.17	0.22	0.81	0.19	0.00	0.47	0.07	1.00	1.00	0.00	0.01	0.42	0.02	0.00	0.44	0.04
	STD	0.17	0.02	0.25	0.00	0.00	0.00	0.09	0.04	0.09	0.08	0.06	0.14	0.00	0.15	0.09	0.00	0.00	0.00	0.03	0.25	0.02	0.00	0.19	0.06
3+4C+	Average	0.54	0.94	0.53	1.00	1.00	0.00	0.40	0.85	0.19	0.24	0.81	0.19	0.00	0.43	0.06	1.00	1.00	0.00	0.01	0.34	0.02	0.00	0.44	0.04
5	STD	0.09	0.01	0.23	0.00	0.00	0.00	0.10	0.04	0.10	0.08	0.05	0.14	0.00	0.17	0.07	0.00	0.00	0.00	0.03	0.27	0.02	0.00	0.19	0.06
8	Average	0.37	0.91	0.45	1.00	1.00	0.00	0.42	0.84	0.16	0.24	0.81	0.19	0.00	0.43	0.06	1.00	1.00	0.00	0.02	0.43	0.01	0.00	0.43	0.04
	STD	0.18	0.03	0.26	0.00	0.00	0.00	0.09	0.05	0.08	0.08	0.06	0.14	0.00	0.19	0.07	0.00	0.00	0.00	0.06	0.25	0.01	0.00	0.19	0.06

Notes: Average-U_s, U_t, and P_v values averaged over all river locations and over all seasons within the 25-year planning period
STD-Standard deviation of U_s, U_t, and P_v values over all river locations and over all seasons within the 25-year planning period

TABLE D-35. Space-Time Average and Standard Deviation of Performance Measures for Each Combined Management Strategy Applied during the Jul-Aug Season (Computed over All Irrigation Diversion Points and Downstream Station at Weldona)

Strategy		High Criteria												Low Criteria											
		C_{TDS} (500 mg/L)			C_{NO_2} (10 mg/L)			C_N (15 mg/L)			C_{FC} (500 colonies/100 ml)			C_{TDS} (1000 mg/L)			C_{NO_2} (10 mg/L)			C_N (30 mg/L)			C_{FC} (1000 colonies/100 ml)		
		U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v
1	Average	0.69	0.97	0.74	1.00	1.00	0.00	0.68	0.93	0.77	0.00	0.72	0.34	0.00	0.65	0.20	1.00	1.00	0.00	0.33	0.81	0.09	0.00	0.83	0.14
	STD	0.02	0.00	0.23	0.00	0.00	0.00	0.01	0.02	0.25	0.00	0.16	0.37	0.00	0.10	0.24	0.00	0.00	0.00	0.04	0.03	0.06	0.00	0.07	0.22
2E+3	Average	0.41	0.92	0.61	1.00	1.00	0.00	0.60	0.95	0.70	0.00	0.70	0.33	0.00	0.58	0.15	1.00	1.00	0.00	0.23	0.72	0.06	0.00	0.83	0.12
	STD	0.13	0.04	0.35	0.00	0.00	0.00	0.04	0.02	0.28	0.00	0.18	0.36	0.00	0.09	0.19	0.00	0.00	0.00	0.07	0.08	0.04	0.00	0.07	0.19
6	Average	0.29	0.83	0.56	1.00	1.00	0.00	0.54	0.94	0.60	0.00	0.79	0.29	0.00	0.53	0.13	1.00	1.00	0.00	0.07	0.37	0.03	0.00	0.87	0.09
	STD	0.21	0.11	0.38	0.00	0.00	0.00	0.08	0.02	0.26	0.00	0.10	0.34	0.00	0.12	0.18	0.00	0.00	0.00	0.12	0.36	0.02	0.00	0.07	0.16
2E+5	Average	0.44	0.93	0.63	1.00	1.00	0.00	0.61	0.96	0.72	0.00	0.73	0.33	0.00	0.64	0.18	1.00	1.00	0.00	0.20	0.78	0.07	0.00	0.85	0.13
	STD	0.12	0.04	0.34	0.00	0.00	0.00	0.04	0.02	0.28	0.00	0.17	0.37	0.00	0.08	0.22	0.00	0.00	0.00	0.07	0.05	0.06	0.00	0.07	0.20
3+4C	Average	0.57	0.93	0.66	1.00	1.00	0.00	0.62	0.89	0.65	0.00	0.80	0.28	0.00	0.49	0.12	1.00	1.00	0.00	0.11	0.50	0.03	0.00	0.84	0.08
	STD	0.07	0.03	0.28	0.00	0.00	0.00	0.03	0.04	0.23	0.00	0.10	0.33	0.00	0.13	0.17	0.00	0.00	0.00	0.14	0.29	0.02	0.00	0.07	0.13
3+5	Average	0.65	0.95	0.73	1.00	1.00	0.00	0.68	0.90	0.76	0.00	0.70	0.33	0.00	0.63	0.17	1.00	1.00	0.00	0.37	0.76	0.07	0.00	0.84	0.12
	STD	0.02	0.02	0.25	0.00	0.00	0.00	0.01	0.04	0.24	0.00	0.17	0.36	0.00	0.08	0.21	0.00	0.00	0.00	0.06	0.07	0.04	0.00	0.07	0.17
4C+5	Average	0.63	0.96	0.70	1.00	1.00	0.00	0.64	0.92	0.67	0.00	0.80	0.29	0.00	0.56	0.14	1.00	1.00	0.00	0.10	0.54	0.04	0.00	0.87	0.09
	STD	0.03	0.01	0.25	0.00	0.00	0.00	0.03	0.02	0.23	0.00	0.09	0.34	0.00	0.10	0.20	0.00	0.00	0.00	0.13	0.24	0.02	0.00	0.07	0.14
2E+3+	Average	0.26	0.82	0.55	1.00	1.00	0.00	0.52	0.93	0.57	0.00	0.81	0.27	0.00	0.45	0.11	1.00	1.00	0.00	0.07	0.42	0.03	0.00	0.84	0.08
4C	STD	0.22	0.10	0.38	0.00	0.00	0.00	0.09	0.03	0.25	0.00	0.10	0.32	0.00	0.16	0.15	0.00	0.00	0.00	0.12	0.38	0.02	0.00	0.07	0.13
2E+3+	Average	0.40	0.92	0.61	1.00	1.00	0.00	0.59	0.95	0.70	0.00	0.69	0.32	0.00	0.58	0.15	1.00	1.00	0.00	0.19	0.71	0.06	0.00	0.85	0.11
5	STD	0.14	0.04	0.35	0.00	0.00	0.00	0.04	0.02	0.28	0.00	0.19	0.36	0.00	0.09	0.19	0.00	0.00	0.00	0.09	0.09	0.04	0.00	0.07	0.17
7	Average	0.28	0.83	0.56	1.00	1.00	0.00	0.53	0.94	0.60	0.00	0.80	0.28	0.00	0.53	0.13	1.00	1.00	0.00	0.09	0.39	0.03	0.00	0.87	0.08
	STD	0.21	0.11	0.38	0.00	0.00	0.00	0.09	0.02	0.26	0.00	0.09	0.33	0.00	0.12	0.18	0.00	0.00	0.00	0.14	0.37	0.02	0.00	0.07	0.14
3+4C+	Average	0.58	0.94	0.68	1.00	1.00	0.00	0.64	0.89	0.65	0.00	0.82	0.27	0.00	0.50	0.12	1.00	1.00	0.00	0.11	0.48	0.03	0.00	0.84	0.07
5	STD	0.06	0.02	0.28	0.00	0.00	0.00	0.03	0.04	0.22	0.00	0.10	0.32	0.00	0.12	0.17	0.00	0.00	0.00	0.14	0.30	0.02	0.00	0.07	0.12
8	Average	0.25	0.80	0.55	1.00	1.00	0.00	0.51	0.93	0.57	0.00	0.81	0.27	0.00	0.46	0.11	1.00	1.00	0.00	0.30	0.45	0.03	0.00	0.83	0.07
	STD	0.22	0.12	0.38	0.00	0.00	0.00	0.10	0.03	0.26	0.00	0.10	0.31	0.00	0.15	0.15	0.00	0.00	0.00	0.31	0.37	0.02	0.00	0.07	0.11

Notes: Average-U_s, U_t, and P_v values averaged over all river locations and over all seasons within the 25-year planning period
STD-Standard deviation of U_s, U_t, and P_v values over all river locations and over all seasons within the 25-year planning period

TABLE D-36. Space-Time Average and Standard Deviation of Performance Measures for Each Combined Management Strategy Applied during the Sep-Oct Season (Computed over All Irrigation Diversion Points and Downstream Station at Weldona)

Strategy		High Criteria												Low Criteria											
		C_{TDS} (500 mg/L)			C_{NO_2} (10 mg/L)			C_N (15 mg/L)			C_{FC} (500 colonies/100 ml)			C_{TDS} (1000 mg/L)			C_{NO_2} (10 mg/L)			C_N (30 mg/L)			C_{FC} (1000 colonies/100 ml)		
		U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v
1	Average	0.69	0.96	0.85	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.81	0.11	0.00	0.68	0.10	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.75	0.02
	STD	0.00	0.00	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.15	0.00	0.09	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.03
2E+3	Average	0.54	0.88	0.71	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.81	0.10	0.06	0.69	0.05	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.75	0.01
	STD	0.08	0.06	0.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.13	0.07	0.06	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.02
6	Average	0.51	0.90	0.67	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.81	0.07	0.20	0.60	0.04	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.68	0.01
	STD	0.09	0.05	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.10	0.14	0.09	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.02
2E+5	Average	0.54	0.94	0.71	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.81	0.10	0.04	0.70	0.05	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.73	0.01
	STD	0.07	0.08	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.14	0.05	0.06	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.03
3+4C	Average	0.67	0.92	0.83	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.81	0.07	0.14	0.60	0.04	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.67	0.01
	STD	0.01	0.03	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.10	0.13	0.10	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.02
3+5	Average	0.75	0.95	0.86	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.79	0.10	0.00	0.70	0.07	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.73	0.01
	STD	0.03	0.02	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.14	0.00	0.06	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.03
4C+5	Average	0.74	0.97	0.84	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.81	0.07	0.18	0.60	0.04	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.65	0.01
	STD	0.03	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.10	0.15	0.08	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.02
2E+3+	Average	0.50	0.86	0.66	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.80	0.06	0.22	0.60	0.03	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.67	0.01
4C	STD	0.09	0.08	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.09	0.14	0.09	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.02
2E+3+	Average	0.54	0.95	0.70	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.80	0.09	0.08	0.69	0.05	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.73	0.01
5	STD	0.08	0.05	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.13	0.07	0.06	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.02
7	Average	0.50	0.93	0.65	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.81	0.07	0.21	0.60	0.03	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.65	0.01
	STD	0.10	0.08	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.10	0.14	0.09	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.02
3+4C+	Average	0.73	0.94	0.84	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.79	0.07	0.19	0.59	0.04	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.64	0.01
5	STD	0.03	0.02	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.10	0.16	0.08	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.02
8	Average	0.49	0.95	0.64	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.79	0.06	0.22	0.59	0.03	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.65	0.01
	STD	0.10	0.05	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.09	0.14	0.09	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.02

Notes: Average-U_s, U_t, and P_v values averaged over all river locations and over all seasons within the 25-year planning period
STD-Standard deviation of U_s, U_t, and P_v values over all river locations and over all seasons within the 25-year planning period

TABLE D-37. Space-Time Average and Standard Deviation of Performance Measures for Each Combined Management Strategy Applied during the Nov-Dec Season (Computed over All Irrigation Diversion Points and Downstream Station at Weldona)

Strategy		High Criteria												Low Criteria											
		C_{TDS} (500 mg/L)			C_{NO_2} (10 mg/L)			C_N (15 mg/L)			C_{FC} (500 colonies/100 ml)			C_{TDS} (1000 mg/L)			C_{NO_2} (10 mg/L)			C_N (30 mg/L)			C_{FC} (1000 colonies/100 ml)		
		U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v	U_s	U_t	P_v
1	Average	0.77	0.99	0.91	1.00	1.00	0.00	0.01	0.21	0.01	0.52	0.92	0.34	0.00	0.49	0.07	1.00	1.00	0.00	0.78	0.72	0.00	0.00	0.76	0.13
	STD	0.02	0.00	0.21	0.00	0.00	0.00	0.02	0.26	0.01	0.02	0.01	0.16	0.00	0.12	0.08	0.00	0.00	0.00	0.32	0.39	0.00	0.00	0.05	0.15
2E+3	Average	0.53	0.95	0.72	1.00	1.00	0.00	0.00	0.68	0.01	0.53	0.92	0.34	0.00	0.85	0.03	1.00	1.00	0.00	0.80	0.67	0.00	0.00	0.76	0.13
	STD	0.11	0.02	0.32	0.00	0.00	0.00	0.00	0.26	0.01	0.02	0.01	0.16	0.00	0.12	0.04	0.00	0.00	0.00	0.29	0.42	0.00	0.01	0.06	0.14
6	Average	0.33	0.81	0.58	1.00	1.00	0.00	0.00	0.67	0.01	0.38	0.89	0.27	0.00	0.85	0.03	1.00	1.00	0.00	0.77	0.67	0.00	0.00	0.53	0.08
	STD	0.24	0.13	0.32	0.00	0.00	0.00	0.00	0.26	0.01	0.09	0.03	0.16	0.00	0.12	0.04	0.00	0.00	0.00	0.31	0.41	0.00	0.00	0.24	0.13
2E+5	Average	0.52	0.95	0.70	1.00	1.00	0.00	0.00	0.68	0.01	0.59	0.93	0.37	0.00	0.86	0.04	1.00	1.00	0.00	0.76	0.67	0.00	0.16	0.81	0.15
	STD	0.12	0.02	0.31	0.00	0.00	0.00	0.00	0.26	0.01	0.05	0.01	0.15	0.00	0.12	0.04	0.00	0.00	0.00	0.31	0.39	0.00	0.09	0.04	0.13
3+4C	Average	0.69	0.98	0.87	1.00	1.00	0.00	0.00	0.34	0.01	0.41	0.90	0.29	0.00	0.69	0.05	1.00	1.00	0.00	0.81	0.71	0.00	0.00	0.50	0.09
	STD	0.04	0.01	0.26	0.00	0.00	0.00	0.00	0.33	0.01	0.08	0.02	0.17	0.00	0.30	0.06	0.00	0.00	0.00	0.29	0.42	0.00	0.00	0.26	0.13
3+5	Average	0.82	0.99	0.93	1.00	1.00	0.00	0.00	0.58	0.01	0.59	0.93	0.38	0.00	0.61	0.05	1.00	1.00	0.00	0.81	0.72	0.00	0.15	0.81	0.16
	STD	0.04	0.00	0.15	0.00	0.00	0.00	0.00	0.26	0.01	0.05	0.01	0.15	0.00	0.20	0.06	0.00	0.00	0.00	0.29	0.40	0.00	0.08	0.04	0.13
4C+5	Average	0.81	0.98	0.88	1.00	1.00	0.00	0.00	0.58	0.01	0.47	0.91	0.31	0.00	0.77	0.05	1.00	1.00	0.00	0.81	0.73	0.00	0.01	0.63	0.10
	STD	0.03	0.00	0.14	0.00	0.00	0.00	0.00	0.26	0.01	0.06	0.02	0.16	0.00	0.15	0.06	0.00	0.00	0.00	0.32	0.39	0.00	0.04	0.16	0.11
2E+3+ 4C	Average	0.30	0.83	0.57	1.00	1.00	0.00	0.00	0.67	0.01	0.40	0.89	0.27	0.00	0.84	0.03	1.00	1.00	0.00	0.79	0.67	0.00	0.00	0.47	0.08
	STD	0.26	0.13	0.32	0.00	0.00	0.00	0.00	0.26	0.01	0.08	0.03	0.16	0.00	0.12	0.03	0.00	0.00	0.00	0.32	0.42	0.00	0.00	0.27	0.12
2E+3+ 5	Average	0.50	0.95	0.69	1.00	1.00	0.00	0.00	0.68	0.01	0.59	0.93	0.37	0.00	0.84	0.03	1.00	1.00	0.00	0.79	0.68	0.00	0.16	0.80	0.15
	STD	0.13	0.02	0.32	0.00	0.00	0.00	0.00	0.26	0.01	0.05	0.01	0.15	0.00	0.12	0.04	0.00	0.00	0.00	0.32	0.42	0.00	0.09	0.04	0.13
7	Average	0.26	0.80	0.55	1.00	1.00	0.00	0.00	0.67	0.01	0.48	0.91	0.30	0.00	0.84	0.03	1.00	1.00	0.00	0.77	0.68	0.00	0.01	0.62	0.10
	STD	0.28	0.14	0.33	0.00	0.00	0.00	0.00	0.26	0.01	0.06	0.02	0.15	0.00	0.12	0.04	0.00	0.00	0.00	0.31	0.40	0.00	0.04	0.16	0.10
3+4C+ 5	Average	0.77	0.98	0.87	1.00	1.00	0.00	0.00	0.56	0.01	0.47	0.91	0.31	0.00	0.78	0.04	1.00	1.00	0.00	0.83	0.73	0.00	0.01	0.62	0.10
	STD	0.02	0.01	0.17	0.00	0.00	0.00	0.00	0.26	0.01	0.06	0.02	0.16	0.00	0.14	0.05	0.00	0.00	0.00	0.29	0.40	0.00	0.04	0.17	0.11
8	Average	0.24	0.79	0.54	1.00	1.00	0.00	0.00	0.67	0.01	0.48	0.91	0.30	0.00	0.83	0.03	1.00	1.00	0.00	0.79	0.68	0.00	0.01	0.61	0.10
	STD	0.29	0.14	0.33	0.00	0.00	0.00	0.00	0.26	0.01	0.06	0.02	0.15	0.00	0.12	0.03	0.00	0.00	0.00	0.32	0.42	0.00	0.04	0.17	0.10

Notes: Average-U_s, U_t, and P_v values averaged over all river locations and over all seasons within the 25-year planning period
STD-Standard deviation of U_s, U_t, and P_v values over all river locations and over all seasons within the 25-year planning period

TABLE D-38. Space-Time Average and Standard Deviation of Ensemble Statistical Moments of Computed Water Quality Concentrations for Each Combined Management Strategy Applied during the Jan-Feb Season (Computed over All River Locations)

Strategy		C_{TDS} 5%	C_{TDS} Mean	C_{TDS} 95%	C_{TDS} CV	C_{NO3} 5%	C_{NO3} Mean	C_{NO3} 95%	C_{NO3} CV	C_N 5%	C_N Mean	C_N 95%	C_N CV	C_{FC} 5%	C_{FC} Mean	C_{FC} 95%	C_{FC} CV
1	Avg.	770.3	911.4	1037.0	0.09	0.16	0.30	0.50	0.56	5.60	7.97	10.13	0.18	77.8	248.0	510.3	0.57
	STD_s	169.1	189.9	202.5	0.03	0.27	0.43	0.62	0.18	2.20	2.90	3.43	0.04	73.6	159.4	372.2	0.11
	STD_t	7.5	6.3	8.6	0.00	0.01	0.01	0.02	0.03	0.13	0.07	0.11	0.01	5.8	9.9	24.5	0.02
2E+3	Avg.	616.8	782.6	929.7	0.13	0.11	0.22	0.39	0.55	3.92	5.78	7.39	0.19	71.5	237.8	495.2	0.57
	STD_s	178.2	200.2	214.3	0.04	0.18	0.31	0.47	0.20	1.25	1.61	1.88	0.05	63.3	146.3	354.1	0.12
	STD_t	79.7	69.5	59.8	0.02	0.03	0.04	0.07	0.02	0.91	1.13	1.40	0.01	7.5	13.5	29.2	0.02
6	Avg.	584.2	701.6	805.1	0.10	0.10	0.20	0.35	0.54	3.79	5.39	6.80	0.17	68.2	206.1	416.6	0.55
	STD_s	150.9	156.4	159.8	0.04	0.17	0.28	0.42	0.19	1.23	1.61	1.87	0.04	66.8	136.8	305.9	0.11
	STD_t	97.2	116.5	134.5	0.01	0.03	0.05	0.09	0.02	0.98	1.33	1.72	0.01	8.9	32.7	75.3	0.02
2E+5	Avg.	628.1	794.3	942.3	0.13	0.11	0.22	0.39	0.55	3.69	5.56	7.23	0.20	76.2	247.6	511.5	0.57
	STD_s	176.2	197.7	211.0	0.04	0.17	0.30	0.47	0.20	1.14	1.42	1.70	0.06	67.5	149.3	354.8	0.12
	STD_t	74.1	63.8	53.8	0.02	0.03	0.05	0.07	0.03	1.03	1.24	1.49	0.01	6.3	10.3	24.7	0.02
3+4C	Avg.	711.9	817.2	919.2	0.08	0.15	0.28	0.46	0.55	5.25	7.48	9.63	0.18	71.9	208.4	414.6	0.54
	STD_s	153.3	160.2	166.3	0.02	0.25	0.40	0.57	0.18	2.18	2.94	3.52	0.03	70.1	137.8	301.8	0.10
	STD_t	38.1	63.0	78.5	0.01	0.01	0.02	0.04	0.03	0.30	0.33	0.35	0.01	7.7	31.7	75.6	0.02
3+5	Avg.	752.1	894.9	1022.0	0.10	0.15	0.28	0.46	0.55	5.15	7.34	9.38	0.18	79.2	247.9	506.2	0.56
	STD_s	173.8	193.7	206.2	0.03	0.24	0.38	0.56	0.19	1.99	2.51	2.97	0.04	70.7	149.9	349.1	0.11
	STD_t	13.5	13.5	14.5	0.00	0.01	0.02	0.03	0.03	0.32	0.35	0.42	0.01	5.8	10.1	25.7	0.02
4C+5	Avg.	708.6	813.0	912.9	0.08	0.14	0.26	0.42	0.56	4.88	6.95	9.00	0.19	75.4	215.8	427.0	0.54
	STD_s	143.3	151.6	158.4	0.02	0.23	0.36	0.52	0.19	1.98	2.58	3.13	0.04	74.0	141.3	303.6	0.11
	STD_t	39.1	65.0	82.4	0.01	0.01	0.03	0.06	0.04	0.45	0.56	0.62	0.01	6.9	29.4	71.6	0.02
2E+3+	Avg.	578.4	695.9	799.6	0.10	0.10	0.20	0.35	0.54	3.76	5.35	6.74	0.17	67.0	202.6	409.1	0.55
4C	STD_s	154.6	159.8	162.8	0.04	0.17	0.28	0.42	0.19	1.24	1.61	1.87	0.04	63.4	131.0	296.1	0.11
	STD_t	100.1	119.2	136.8	0.01	0.03	0.06	0.09	0.02	0.99	1.35	1.75	0.01	9.3	34.1	78.0	0.02
2E+3+	Avg.	620.3	786.2	934.2	0.13	0.10	0.21	0.38	0.55	3.67	5.52	7.17	0.20	74.7	242.8	501.4	0.57
5	STD_s	179.3	200.9	214.4	0.04	0.17	0.29	0.46	0.19	1.14	1.44	1.72	0.06	64.0	143.1	342.9	0.12
	STD_t	77.9	67.8	57.7	0.02	0.03	0.05	0.07	0.03	1.04	1.26	1.51	0.01	6.7	11.8	27.3	0.02
7	Avg.	586.3	703.7	808.1	0.10	0.10	0.20	0.34	0.54	3.54	5.13	6.54	0.18	71.0	210.6	422.0	0.55
	STD_s	151.5	156.8	159.9	0.04	0.16	0.27	0.41	0.19	1.12	1.42	1.67	0.05	67.5	134.4	297.4	0.11
	STD_t	96.5	116.0	133.7	0.01	0.03	0.06	0.10	0.03	1.10	1.46	1.85	0.01	8.0	31.4	73.6	0.02
3+4C+	Avg.	701.0	805.8	905.4	0.08	0.14	0.26	0.42	0.56	4.87	6.91	8.92	0.19	73.9	211.7	419.0	0.54
5	STD_s	150.3	157.0	162.4	0.02	0.23	0.36	0.51	0.19	1.98	2.57	3.10	0.04	70.5	135.5	293.9	0.10
	STD_t	42.4	68.1	85.7	0.01	0.01	0.03	0.06	0.03	0.46	0.59	0.66	0.01	7.3	30.9	74.3	0.02
8	Avg.	579.3	697.0	801.9	0.11	0.10	0.19	0.33	0.54	3.52	5.09	6.49	0.18	69.6	206.6	414.1	0.54
	STD_s	155.0	160.2	162.9	0.04	0.16	0.27	0.40	0.18	1.13	1.43	1.67	0.05	64.0	128.7	287.8	0.11
	STD_t	100.0	119.1	136.3	0.01	0.03	0.06	0.10	0.02	1.11	1.48	1.88	0.01	8.6	32.9	76.4	0.02

Notes: Avg.-Spatial and temporal-averaged ensemble statistical moments over all river locations and over all weeks in the season
STD_s-Standard deviation over all river locations of the values of the temporal-averaged ensemble statistical moments (averaged over all weeks in the seas
STD_t-Standard deviation over all years in the 25-year period of the values of the spatial-averaged ensemble statistical moments (averaged over all river lo

TABLE D-39. Space-Time Average and Standard Deviation of Ensemble Statistical Moments of Computed Water Quality Concentrations for Each Combined Management Strategy Applied during the Mar-Apr Season (Computed over All River Locations)

Strategy		C_{TDS}				C_{NO_2}				C_N				C_{FC}			
		5%	Mean	95%	CV	5%	Mean	95%	CV	5%	Mean	95%	CV	5%	Mean	95%	CV
1	Avg.	682.7	942.4	1246.0	0.20	0.04	0.09	0.19	0.50	4.29	6.47	8.84	0.22	65.5	206.5	479.3	0.76
	STD_s	250.0	288.2	439.3	0.11	0.03	0.08	0.21	0.14	1.58	2.29	2.99	0.05	59.8	110.7	184.1	0.27
	STD_t	9.1	13.3	29.3	0.04	0.00	0.00	0.01	0.02	0.18	0.12	0.11	0.01	4.3	8.3	24.7	0.04
2E+3	Avg.	558.2	824.7	1147.0	0.25	0.03	0.07	0.16	0.48	3.30	4.63	6.06	0.19	54.6	183.8	451.5	0.81
	STD_s	253.3	295.8	448.5	0.12	0.02	0.07	0.21	0.19	0.99	1.21	1.49	0.06	48.3	94.8	173.1	0.25
	STD_t	64.8	68.6	73.8	0.05	0.00	0.01	0.02	0.02	0.39	0.85	1.38	0.02	3.8	10.3	26.0	0.04
6	Avg.	531.8	740.9	994.7	0.21	0.03	0.06	0.14	0.47	3.06	4.42	5.85	0.19	54.0	165.6	385.3	0.76
	STD_s	220.6	247.5	371.1	0.10	0.02	0.06	0.17	0.16	0.93	1.25	1.62	0.05	49.7	87.4	143.9	0.26
	STD_t	80.6	120.0	168.0	0.05	0.00	0.01	0.03	0.02	0.51	0.96	1.49	0.02	4.0	19.0	56.0	0.06
2E+5	Avg.	569.5	839.8	1166.0	0.24	0.03	0.07	0.16	0.47	3.24	4.55	5.97	0.19	56.3	191.2	466.7	0.81
	STD_s	256.1	297.4	461.0	0.12	0.02	0.07	0.22	0.18	0.93	1.11	1.39	0.06	51.6	100.8	179.9	0.27
	STD_t	59.3	61.5	65.7	0.05	0.00	0.01	0.02	0.02	0.42	0.89	1.43	0.02	3.3	8.1	24.0	0.04
3+4C	Avg.	611.0	824.2	1065.0	0.19	0.04	0.08	0.17	0.49	3.97	6.12	8.51	0.23	64.6	186.4	404.5	0.69
	STD_s	217.8	243.1	343.9	0.10	0.02	0.06	0.17	0.12	1.53	2.29	3.04	0.05	57.2	98.2	148.8	0.23
	STD_t	44.6	80.9	132.8	0.04	0.00	0.00	0.02	0.02	0.13	0.14	0.19	0.01	3.8	10.9	47.9	0.08
3+5	Avg.	647.4	907.8	1214.0	0.22	0.03	0.08	0.18	0.49	4.09	6.05	8.27	0.22	66.5	208.8	480.0	0.74
	STD_s	249.8	285.5	428.4	0.11	0.02	0.08	0.21	0.14	1.44	2.01	2.68	0.06	58.7	109.5	182.5	0.24
	STD_t	21.5	27.5	41.2	0.04	0.00	0.00	0.01	0.02	0.12	0.17	0.30	0.01	4.6	8.7	24.0	0.05
4C+5	Avg.	609.4	823.5	1068.0	0.19	0.03	0.08	0.16	0.49	3.80	5.84	8.18	0.23	65.8	190.5	414.3	0.70
	STD_s	211.2	237.5	348.4	0.09	0.03	0.07	0.17	0.11	1.43	2.11	2.87	0.05	60.7	102.5	153.4	0.25
	STD_t	45.6	82.5	133.5	0.04	0.00	0.01	0.02	0.02	0.17	0.26	0.34	0.01	4.2	10.2	45.6	0.07
2E+3+ 4C	Avg.	516.9	725.9	978.0	0.22	0.03	0.06	0.14	0.47	3.04	4.37	5.78	0.19	53.9	164.8	381.0	0.74
	STD_s	220.9	246.9	362.7	0.11	0.02	0.06	0.17	0.16	0.94	1.24	1.60	0.05	48.0	85.2	141.0	0.24
	STD_t	87.6	126.1	173.9	0.05	0.01	0.01	0.03	0.02	0.52	0.99	1.53	0.02	4.0	19.4	57.4	0.06
2E+3+ 5	Avg.	552.1	821.3	1145.0	0.25	0.03	0.07	0.15	0.47	3.21	4.49	5.89	0.19	55.9	189.1	459.9	0.80
	STD_s	253.4	295.6	448.5	0.12	0.02	0.07	0.21	0.18	0.94	1.12	1.39	0.06	49.4	97.7	175.9	0.24
	STD_t	67.9	70.3	74.7	0.05	0.00	0.01	0.02	0.02	0.44	0.92	1.47	0.02	3.4	8.5	24.3	0.04
7	Avg.	525.2	736.3	991.8	0.22	0.03	0.06	0.14	0.47	2.97	4.27	5.67	0.19	55.5	170.8	393.0	0.75
	STD_s	221.0	247.2	371.2	0.10	0.02	0.06	0.17	0.15	0.87	1.14	1.50	0.05	51.3	90.2	146.4	0.26
	STD_t	83.9	122.4	169.5	0.05	0.01	0.01	0.03	0.02	0.56	1.04	1.58	0.02	3.5	17.2	53.5	0.06
3+4C+ 5	Avg.	595.4	807.7	1052.0	0.19	0.03	0.08	0.16	0.49	3.79	5.77	8.06	0.23	65.5	188.6	408.5	0.68
	STD_s	215.3	238.8	342.0	0.10	0.02	0.07	0.17	0.12	1.41	2.06	2.80	0.05	58.2	99.3	150.1	0.23
	STD_t	51.1	88.1	138.7	0.04	0.00	0.01	0.02	0.02	0.18	0.29	0.39	0.01	4.1	10.7	47.0	0.08
8	Avg.	510.3	721.2	975.1	0.22	0.02	0.06	0.13	0.47	2.95	4.22	5.60	0.19	55.2	169.0	387.4	0.73
	STD_s	220.7	246.5	362.7	0.11	0.02	0.06	0.17	0.16	0.88	1.14	1.48	0.05	49.1	87.5	143.1	0.24
	STD_t	90.9	128.5	175.4	0.05	0.01	0.01	0.03	0.02	0.57	1.06	1.62	0.02	3.6	17.9	55.3	0.06

Notes: Avg.-Spatial and temporal-averaged ensemble statistical moments over all river locations and over all weeks in the season
STD_s-Standard deviation over all river locations of the values of the temporal-averaged ensemble statistical moments (averaged over all weeks in the seas
STD_t-Standard deviation over all years in the 25-year period of the values of the spatial-averaged ensemble statistical moments (averaged over all river lo

TABLE D-40. Space-Time Average and Standard Deviation of Ensemble Statistical Moments of Computed Water Quality Concentrations for Each Combined Management Strategy Applied during the May-Jun Season (Computed over All River Locations)

Strategy		C_{TDS}				C_{NO_2}				C_N				C_{FC}			
		5%	Mean	95%	CV	5%	Mean	95%	CV	5%	Mean	95%	CV	5%	Mean	95%	CV
1	Avg.	297.7	619.3	948.4	0.58	0.02	0.17	0.48	0.67	2.08	4.14	8.07	0.46	28.2	370.9	1031.0	1.01
	STD_s	77.5	176.2	276.2	0.27	0.02	0.24	0.71	0.31	0.46	1.10	2.84	0.12	28.5	203.1	490.6	0.23
	STD_t	7.7	13.6	13.1	2.57	0.00	0.01	0.02	0.01	0.07	0.10	0.32	0.02	1.8	13.4	41.2	0.03
2E+3	Avg.	264.4	555.0	875.6	0.65	0.02	0.16	0.47	0.70	1.88	3.78	7.54	0.48	25.3	357.8	996.3	1.00
	STD_s	86.6	181.5	271.9	0.34	0.01	0.23	0.70	0.33	0.47	0.96	2.55	0.14	20.9	179.9	448.5	0.19
	STD_t	15.5	34.7	44.5	3.02	0.00	0.01	0.02	0.02	0.14	0.23	0.44	0.02	2.1	16.1	49.8	0.04
6	Avg.	239.0	523.7	838.1	0.60	0.02	0.14	0.39	0.66	1.77	3.36	6.45	0.44	22.9	295.4	825.1	1.02
	STD_s	67.6	174.4	296.5	0.29	0.01	0.19	0.57	0.33	0.38	0.80	2.16	0.13	22.6	162.9	393.7	0.23
	STD_t	29.6	52.4	64.8	2.49	0.00	0.02	0.06	0.02	0.20	0.48	1.04	0.02	2.7	49.6	144.9	0.04
2E+5	Avg.	262.3	565.7	900.2	0.66	0.02	0.17	0.48	0.70	1.88	3.84	7.70	0.48	25.1	370.1	1036.0	1.02
	STD_s	85.9	185.4	285.4	0.37	0.01	0.23	0.70	0.33	0.44	0.95	2.65	0.15	23.1	195.2	478.4	0.22
	STD_t	16.4	28.8	28.3	3.06	0.00	0.01	0.02	0.02	0.14	0.19	0.37	0.02	2.0	13.9	42.0	0.03
3+4C	Avg.	268.0	556.9	859.3	0.53	0.02	0.14	0.38	0.64	1.91	3.56	6.61	0.42	27.8	300.3	812.7	0.95
	STD_s	67.9	164.5	269.2	0.20	0.02	0.19	0.56	0.30	0.43	0.93	2.23	0.10	26.3	150.5	364.2	0.18
	STD_t	17.9	38.4	56.7	2.10	0.00	0.02	0.06	0.02	0.15	0.40	0.96	0.03	2.0	47.5	148.1	0.05
3+5	Avg.	287.7	592.5	909.8	0.59	0.02	0.17	0.47	0.68	2.03	4.00	7.77	0.46	30.2	371.3	1015.0	0.97
	STD_s	82.0	174.6	266.5	0.28	0.02	0.23	0.70	0.31	0.46	1.04	2.66	0.12	27.4	179.7	441.2	0.18
	STD_t	7.3	19.5	31.7	2.71	0.00	0.01	0.02	0.01	0.08	0.14	0.38	0.02	2.5	14.4	46.6	0.05
4C+5	Avg.	259.0	559.9	880.4	0.56	0.02	0.14	0.39	0.64	1.88	3.57	6.69	0.43	27.4	308.4	842.0	0.98
	STD_s	65.2	166.1	281.5	0.24	0.01	0.19	0.57	0.30	0.39	0.89	2.28	0.11	29.1	163.8	387.8	0.22
	STD_t	21.0	36.7	44.9	2.20	0.00	0.02	0.06	0.02	0.16	0.40	0.94	0.02	1.7	45.3	140.1	0.04
2E+3+ 4C	Avg.	237.3	509.0	809.1	0.60	0.02	0.13	0.38	0.67	1.75	3.29	6.29	0.44	23.8	291.8	804.9	0.98
	STD_s	70.0	170.3	280.1	0.28	0.01	0.19	0.56	0.33	0.41	0.80	2.07	0.13	21.0	147.4	362.8	0.18
	STD_t	30.4	59.3	79.6	2.50	0.00	0.03	0.07	0.02	0.21	0.51	1.09	0.02	2.6	50.9	151.4	0.05
2E+3+ 5	Avg.	260.7	550.4	871.7	0.66	0.02	0.16	0.47	0.70	1.86	3.76	7.50	0.48	25.8	363.7	1008.0	0.98
	STD_s	87.7	181.9	272.2	0.36	0.01	0.23	0.70	0.33	0.47	0.95	2.53	0.14	21.2	175.9	439.2	0.18
	STD_t	17.1	36.7	46.2	3.10	0.00	0.01	0.02	0.02	0.15	0.24	0.45	0.02	2.0	15.3	48.3	0.04
7	Avg.	234.8	518.5	834.4	0.62	0.02	0.14	0.38	0.67	1.75	3.33	6.41	0.45	23.6	301.0	835.0	1.00
	STD_s	69.2	175.5	297.4	0.31	0.01	0.19	0.56	0.33	0.37	0.78	2.14	0.14	23.1	159.5	385.6	0.22
	STD_t	31.5	54.7	66.4	2.58	0.00	0.03	0.06	0.02	0.21	0.49	1.06	0.02	2.4	48.2	142.8	0.04
3+4C+ 5	Avg.	259.4	546.6	850.0	0.55	0.02	0.14	0.38	0.64	1.88	3.50	6.53	0.42	28.2	303.7	820.6	0.95
	STD_s	67.3	163.3	269.1	0.23	0.01	0.19	0.56	0.30	0.41	0.88	2.18	0.10	27.0	148.5	357.9	0.18
	STD_t	21.0	42.2	60.2	2.21	0.00	0.02	0.07	0.02	0.16	0.42	0.99	0.03	2.1	46.7	146.4	0.06
8	Avg.	233.7	504.4	805.6	0.61	0.02	0.13	0.38	0.67	1.73	3.26	6.25	0.44	24.3	296.2	813.4	0.97
	STD_s	70.9	170.7	280.6	0.30	0.01	0.19	0.56	0.33	0.40	0.79	2.05	0.13	21.2	144.6	355.9	0.18
	STD_t	32.1	61.3	81.0	2.59	0.00	0.03	0.07	0.02	0.22	0.52	1.11	0.02	2.4	49.7	149.3	0.05

Notes: Avg.-Spatial and temporal-averaged ensemble statistical moments over all river locations and over all weeks in the season
STD_s-Standard deviation over all river locations of the values of the temporal-averaged ensemble statistical moments (averaged over all weeks in the seas
STD_t-Standard deviation over all years in the 25-year period of the values of the spatial-averaged ensemble statistical moments (averaged over all river lo

TABLE D-41. Space-Time Average and Standard Deviation of Ensemble Statistical Moments of Computed Water Quality Concentrations for Each Combined Management Strategy Applied during the Jul-Aug Season (Computed over All River Locations)

Strategy		C_{TDS}				C_{NO_2}				C_N				C_{FC}			
		5%	Mean	95%	CV	5%	Mean	95%	CV	5%	Mean	95%	CV	5%	Mean	95%	CV
1	Avg.	392.0	703.5	970.9	0.32	0.03	0.09	0.20	0.60	3.82	6.31	9.46	0.28	169.6	570.8	1107.0	0.50
	STD_s	179.1	259.6	347.3	0.14	0.03	0.10	0.28	0.29	1.43	1.94	2.75	0.11	131.6	396.1	892.9	0.19
	STD_t	12.8	13.2	30.3	0.17	0.00	0.00	0.01	0.03	0.13	0.13	0.20	0.01	7.4	16.0	36.0	0.01
2E+3	Avg.	346.4	628.9	886.2	0.35	0.02	0.08	0.19	0.58	3.40	5.74	8.78	0.31	159.8	532.0	1028.0	0.49
	STD_s	184.4	274.5	359.5	0.16	0.02	0.09	0.26	0.27	1.56	2.05	2.68	0.15	116.1	355.8	805.4	0.18
	STD_t	23.6	43.6	58.2	0.19	0.00	0.01	0.01	0.02	0.31	0.39	0.48	0.02	10.0	35.0	74.4	0.01
6	Avg.	336.1	602.6	849.2	0.33	0.02	0.07	0.16	0.57	3.21	5.12	7.56	0.28	148.7	472.6	902.2	0.48
	STD_s	176.9	266.1	363.2	0.15	0.02	0.08	0.23	0.27	1.36	1.70	2.20	0.14	114.0	322.8	719.2	0.18
	STD_t	27.9	58.1	76.2	0.18	0.00	0.01	0.03	0.02	0.42	0.77	1.22	0.02	16.3	73.8	155.2	0.02
2E+5	Avg.	356.5	651.0	918.6	0.35	0.02	0.08	0.19	0.59	3.49	5.90	9.00	0.31	165.9	563.9	1097.0	0.50
	STD_s	195.3	285.4	375.1	0.18	0.02	0.09	0.27	0.27	1.59	2.07	2.69	0.15	123.3	385.5	877.8	0.19
	STD_t	19.4	31.6	43.4	0.19	0.00	0.01	0.01	0.02	0.26	0.30	0.36	0.02	7.9	17.9	39.0	0.01
3+4C	Avg.	365.3	634.5	870.9	0.30	0.02	0.07	0.16	0.57	3.46	5.37	7.78	0.25	147.6	450.8	850.8	0.47
	STD_s	153.8	234.2	320.8	0.11	0.03	0.09	0.22	0.28	1.23	1.61	2.24	0.10	116.8	301.2	658.1	0.17
	STD_t	15.4	44.2	67.0	0.16	0.00	0.01	0.03	0.03	0.32	0.66	1.13	0.02	17.3	82.5	174.3	0.02
3+5	Avg.	383.8	680.3	935.7	0.31	0.03	0.08	0.19	0.58	3.73	6.12	9.14	0.28	164.3	534.0	1027.0	0.49
	STD_s	169.2	252.7	337.0	0.13	0.03	0.10	0.26	0.27	1.41	1.93	2.70	0.10	124.7	355.5	796.7	0.18
	STD_t	12.3	22.2	40.1	0.18	0.00	0.01	0.01	0.03	0.17	0.22	0.34	0.01	8.9	34.5	75.2	0.01
4C+5	Avg.	369.8	652.8	902.4	0.30	0.02	0.07	0.17	0.58	3.50	5.49	7.95	0.25	153.1	476.0	903.6	0.48
	STD_s	162.6	241.6	332.8	0.12	0.03	0.09	0.23	0.29	1.22	1.58	2.24	0.09	124.1	324.6	713.3	0.18
	STD_t	13.7	35.3	51.9	0.16	0.00	0.01	0.03	0.03	0.30	0.62	1.06	0.02	15.3	72.7	154.6	0.01
2E+3+4C	Avg.	327.8	582.4	817.4	0.33	0.02	0.07	0.16	0.56	3.12	4.97	7.36	0.28	143.6	446.3	846.3	0.47
	STD_s	167.7	255.2	346.2	0.13	0.02	0.08	0.22	0.26	1.34	1.70	2.18	0.14	108.1	296.0	655.4	0.17
	STD_t	31.9	68.1	91.7	0.18	0.00	0.01	0.03	0.02	0.46	0.83	1.31	0.02	18.5	84.2	176.2	0.02
2E+3+5	Avg.	346.3	628.3	884.8	0.35	0.02	0.08	0.18	0.58	3.40	5.72	8.73	0.31	159.9	529.2	1022.0	0.49
	STD_s	184.2	274.7	360.4	0.16	0.02	0.09	0.25	0.26	1.55	2.06	2.66	0.15	116.3	350.4	793.8	0.18
	STD_t	23.6	43.9	58.7	0.19	0.00	0.01	0.02	0.02	0.31	0.40	0.51	0.02	10.0	36.2	77.1	0.01
7	Avg.	336.0	601.9	848.3	0.33	0.02	0.07	0.16	0.57	3.20	5.10	7.53	0.28	149.1	471.1	898.6	0.47
	STD_s	177.0	266.4	363.8	0.15	0.02	0.08	0.22	0.26	1.35	1.70	2.18	0.13	114.8	318.7	710.0	0.18
	STD_t	27.9	58.3	76.5	0.18	0.00	0.01	0.03	0.02	0.42	0.78	1.24	0.02	16.3	74.4	156.6	0.02
3+4C+5	Avg.	364.8	634.1	870.4	0.30	0.02	0.07	0.16	0.56	3.45	5.36	7.75	0.25	147.7	448.9	846.8	0.47
	STD_s	153.7	233.8	320.4	0.11	0.03	0.09	0.21	0.27	1.22	1.60	2.23	0.09	116.9	297.7	650.0	0.17
	STD_t	15.5	44.1	66.9	0.16	0.00	0.01	0.03	0.02	0.33	0.67	1.14	0.02	17.3	83.2	176.0	0.02
8	Avg.	327.8	582.0	816.5	0.33	0.02	0.07	0.15	0.56	3.12	4.96	7.33	0.28	143.7	444.2	842.0	0.47
	STD_s	167.5	255.3	346.7	0.14	0.02	0.08	0.21	0.25	1.34	1.69	2.16	0.13	108.2	292.1	646.9	0.17
	STD_t	31.9	68.3	92.1	0.18	0.00	0.01	0.03	0.02	0.46	0.84	1.32	0.02	18.5	85.0	178.0	0.02

Notes: Avg.-Spatial and temporal-averaged ensemble statistical moments over all river locations and over all weeks in the season
STD_s-Standard deviation over all river locations of the values of the temporal-averaged ensemble statistical moments (averaged over all weeks in the seas
STD_t-Standard deviation over all years in the 25-year period of the values of the spatial-averaged ensemble statistical moments (averaged over all river lo

TABLE D-42. Space-Time Average and Standard Deviation of Ensemble Statistical Moments of Computed Water Quality Concentrations for Each Combined Management Strategy Applied during the Sep-Oct Season (Computed over All River Locations)

Strategy		C_{TDS}				C_{NO_2}				C_N				C_{FC}			
		5%	Mean	95%	CV	5%	Mean	95%	CV	5%	Mean	95%	CV	5%	Mean	95%	CV
1	Avg.	463.7	741.8	913.7	0.52	0.05	0.10	0.17	0.52	4.33	5.85	7.42	0.16	66.6	235.1	532.9	0.82
	STD_s	133.4	194.4	235.4	0.27	0.07	0.10	0.16	0.22	1.43	1.91	2.38	0.04	93.7	189.6	429.3	0.35
	STD_t	19.9	30.9	23.1	0.38	0.00	0.00	0.00	0.02	0.06	0.04	0.10	0.01	1.6	8.1	19.6	0.03
2E+3	Avg.	379.9	634.7	805.7	0.59	0.03	0.07	0.14	0.54	3.51	4.59	5.69	0.15	58.2	217.8	502.6	0.80
	STD_s	136.4	186.5	240.6	0.34	0.04	0.07	0.13	0.20	0.94	1.16	1.42	0.03	80.8	170.7	403.0	0.31
	STD_t	38.5	63.9	67.3	0.44	0.01	0.01	0.01	0.02	0.40	0.65	0.93	0.01	5.2	15.8	33.2	0.03
6	Avg.	358.3	584.4	736.0	0.55	0.03	0.07	0.12	0.52	3.27	4.33	5.42	0.15	58.6	196.7	437.4	0.80
	STD_s	119.4	153.9	186.5	0.31	0.04	0.07	0.11	0.19	0.87	1.08	1.33	0.04	82.9	160.0	347.5	0.34
	STD_t	49.4	88.9	106.8	0.41	0.01	0.01	0.02	0.02	0.53	0.80	1.08	0.01	4.9	28.5	71.4	0.03
2E+5	Avg.	376.3	636.7	814.4	0.60	0.04	0.09	0.15	0.54	3.39	4.49	5.64	0.16	59.1	226.4	525.8	0.82
	STD_s	135.5	182.7	240.7	0.36	0.06	0.09	0.15	0.22	0.84	1.04	1.33	0.03	82.6	181.7	423.5	0.31
	STD_t	39.9	63.1	62.9	0.45	0.00	0.01	0.01	0.02	0.46	0.70	0.95	0.01	4.7	11.2	22.2	0.03
3+4C	Avg.	432.0	672.3	821.7	0.47	0.05	0.09	0.15	0.49	4.03	5.48	6.98	0.17	63.2	198.2	431.6	0.80
	STD_s	127.1	173.9	195.6	0.22	0.07	0.10	0.14	0.20	1.42	1.93	2.44	0.04	89.6	159.2	332.5	0.36
	STD_t	22.1	50.8	66.3	0.35	0.00	0.01	0.01	0.02	0.20	0.26	0.35	0.01	3.2	28.2	73.8	0.03
3+5	Avg.	442.7	708.9	877.6	0.53	0.06	0.11	0.19	0.51	4.06	5.41	6.84	0.16	62.4	224.2	511.5	0.82
	STD_s	131.4	186.0	227.2	0.28	0.10	0.15	0.21	0.22	1.17	1.56	2.02	0.03	86.9	177.2	403.4	0.33
	STD_t	18.0	35.7	34.9	0.39	0.01	0.01	0.01	0.02	0.14	0.25	0.37	0.01	3.4	13.5	30.3	0.03
4C+5	Avg.	416.1	658.0	812.6	0.49	0.06	0.11	0.17	0.50	3.76	5.14	6.62	0.17	62.8	203.1	445.7	0.82
	STD_s	117.7	156.7	178.0	0.24	0.10	0.15	0.21	0.21	1.16	1.59	2.11	0.04	89.4	167.2	349.3	0.37
	STD_t	25.7	56.0	69.9	0.37	0.01	0.01	0.01	0.02	0.31	0.40	0.49	0.01	3.0	26.1	68.5	0.03
2E+3+	Avg.	355.4	575.4	722.2	0.54	0.03	0.07	0.12	0.51	3.26	4.28	5.33	0.15	56.9	189.8	421.4	0.79
4C	STD_s	120.9	156.7	187.7	0.30	0.04	0.07	0.11	0.19	0.89	1.10	1.35	0.04	80.1	150.8	329.1	0.33
	STD_t	50.9	92.9	113.3	0.41	0.01	0.02	0.02	0.02	0.54	0.82	1.13	0.01	5.9	31.7	78.4	0.03
2E+3+	Avg.	372.5	626.3	798.5	0.60	0.04	0.08	0.15	0.53	3.37	4.43	5.54	0.15	57.4	217.8	505.0	0.81
5	STD_s	136.5	184.8	239.8	0.35	0.06	0.09	0.15	0.21	0.86	1.08	1.36	0.03	79.6	170.7	400.2	0.30
	STD_t	41.7	67.8	70.7	0.45	0.00	0.01	0.01	0.02	0.47	0.73	1.01	0.01	5.6	16.0	32.7	0.03
7	Avg.	351.0	575.6	728.5	0.56	0.04	0.08	0.13	0.51	3.14	4.17	5.26	0.16	57.7	196.5	438.5	0.81
	STD_s	119.5	152.0	185.8	0.32	0.06	0.09	0.14	0.21	0.77	0.96	1.24	0.04	81.8	159.9	345.4	0.33
	STD_t	52.7	93.0	110.4	0.42	0.00	0.01	0.02	0.02	0.60	0.88	1.16	0.01	5.4	28.8	71.7	0.03
3+4C+	Avg.	414.1	649.5	799.3	0.49	0.06	0.11	0.17	0.49	3.76	5.10	6.52	0.16	60.9	195.8	429.4	0.81
5	STD_s	120.1	160.6	181.8	0.23	0.09	0.14	0.20	0.21	1.16	1.59	2.09	0.04	86.1	157.5	330.9	0.36
	STD_t	26.4	59.3	75.9	0.36	0.01	0.01	0.01	0.02	0.30	0.43	0.55	0.01	4.1	29.3	75.4	0.03
8	Avg.	348.0	566.6	714.5	0.55	0.04	0.08	0.13	0.51	3.12	4.12	5.17	0.15	56.0	189.4	422.4	0.80
	STD_s	120.6	154.6	186.4	0.31	0.06	0.09	0.13	0.20	0.79	0.99	1.26	0.03	78.9	150.6	327.2	0.32
	STD_t	54.2	97.0	116.9	0.42	0.00	0.01	0.02	0.02	0.61	0.90	1.21	0.01	6.3	32.0	78.6	0.03

Notes: Avg.-Spatial and temporal-averaged ensemble statistical moments over all river locations and over all weeks in the season

STD_s-Standard deviation over all river locations of the values of the temporal-averaged ensemble statistical moments (averaged over all weeks in the seas

STD_t-Standard deviation over all years in the 25-year period of the values of the spatial-averaged ensemble statistical moments (averaged over all river lo

TABLE D-43. Space-Time Average and Standard Deviation of Ensemble Statistical Moments of Computed Water Quality Concentrations for Each Combined Management Strategy Applied during the Nov-Dec Season (Computed over All River Locations)

Strategy		C_{TDS} 5%	C_{TDS} Mean	C_{TDS} 95%	C_{TDS} CV	C_{NO_2} 5%	C_{NO_2} Mean	C_{NO_2} 95%	C_{NO_2} CV	C_N 5%	C_N Mean	C_N 95%	C_N CV	C_{FC} 5%	C_{FC} Mean	C_{FC} 95%	C_{FC} CV
1	Avg.	557.4	757.8	1005.0	0.19	0.06	0.12	0.20	0.62	4.43	6.81	9.77	0.33	73.5	444.8	1139.0	0.86
	STD_s	129.2	150.5	211.4	0.08	0.08	0.14	0.20	0.36	1.84	2.22	2.66	0.14	67.5	231.1	513.6	0.13
	STD_t	6.4	5.5	18.0	0.01	0.00	0.01	0.01	0.12	0.23	0.36	0.75	0.03	4.1	18.9	52.0	0.03
2E+3	Avg.	443.2	628.1	858.0	0.21	0.04	0.09	0.16	0.59	3.43	5.28	7.84	0.34	65.6	434.6	1136.0	0.87
	STD_s	118.7	156.9	222.6	0.06	0.05	0.09	0.16	0.29	0.91	1.16	1.85	0.16	53.5	214.9	498.4	0.11
	STD_t	54.7	67.4	86.3	0.01	0.01	0.02	0.03	0.10	0.67	1.04	1.53	0.04	6.5	19.2	53.5	0.03
6	Avg.	421.1	599.0	824.9	0.21	0.04	0.08	0.14	0.59	3.25	5.00	7.62	0.37	64.4	359.5	914.3	0.84
	STD_s	95.5	149.9	249.4	0.07	0.05	0.09	0.14	0.32	0.90	1.11	1.86	0.20	55.3	183.6	410.3	0.13
	STD_t	66.7	83.7	105.1	0.01	0.01	0.03	0.04	0.10	0.76	1.20	1.66	0.05	7.1	51.1	140.0	0.03
2E+5	Avg.	435.0	627.1	864.3	0.22	0.03	0.08	0.15	0.66	3.30	5.12	7.67	0.35	68.4	490.8	1286.0	0.88
	STD_s	115.6	154.1	223.0	0.06	0.05	0.09	0.16	0.35	0.81	1.01	1.82	0.18	57.7	233.7	535.1	0.11
	STD_t	58.8	67.9	83.2	0.01	0.01	0.02	0.03	0.13	0.73	1.12	1.60	0.04	5.3	35.5	101.5	0.03
3+4C	Avg.	513.1	708.3	953.1	0.20	0.05	0.11	0.18	0.62	4.18	6.43	9.37	0.34	72.2	378.5	938.6	0.81
	STD_s	122.2	153.1	232.4	0.07	0.08	0.13	0.18	0.37	1.84	2.25	2.72	0.15	64.3	193.2	415.6	0.13
	STD_t	24.0	30.9	43.4	0.01	0.01	0.01	0.02	0.13	0.36	0.57	0.94	0.04	5.0	45.9	132.8	0.04
3+5	Avg.	514.0	711.3	953.4	0.20	0.05	0.10	0.17	0.67	4.09	6.22	8.93	0.33	75.2	497.3	1281.0	0.86
	STD_s	117.8	146.7	207.4	0.07	0.07	0.12	0.18	0.43	1.58	1.82	2.15	0.15	66.2	239.8	533.2	0.12
	STD_t	20.0	26.1	39.5	0.01	0.01	0.02	0.02	0.15	0.36	0.59	1.04	0.04	4.0	38.4	99.1	0.03
4C+5	Avg.	485.0	680.5	926.6	0.20	0.05	0.09	0.16	0.70	3.85	5.92	8.74	0.36	73.5	417.0	1047.0	0.83
	STD_s	97.3	137.8	227.1	0.07	0.07	0.11	0.17	0.50	1.59	1.86	2.21	0.18	68.1	207.5	442.0	0.14
	STD_t	35.7	43.4	54.8	0.01	0.01	0.02	0.03	0.17	0.49	0.77	1.17	0.05	4.5	46.0	125.8	0.03
2E+3+4C	Avg.	415.3	590.0	811.0	0.21	0.04	0.08	0.14	0.59	3.23	4.96	7.54	0.37	64.3	363.2	923.5	0.84
	STD_s	100.4	152.5	246.5	0.07	0.05	0.09	0.14	0.30	0.92	1.13	1.87	0.19	52.9	180.5	405.9	0.12
	STD_t	69.6	88.1	111.9	0.01	0.01	0.03	0.04	0.10	0.77	1.22	1.69	0.05	7.1	50.7	137.9	0.03
2E+3+5	Avg.	429.1	617.1	849.2	0.22	0.03	0.08	0.15	0.65	3.28	5.07	7.58	0.35	68.0	486.1	1271.0	0.87
	STD_s	119.2	156.7	221.7	0.06	0.05	0.09	0.15	0.34	0.83	1.05	1.83	0.17	55.0	227.8	523.9	0.11
	STD_t	61.7	72.9	90.7	0.01	0.01	0.03	0.04	0.13	0.74	1.15	1.64	0.04	5.5	33.9	95.4	0.03
7	Avg.	405.9	586.1	813.7	0.22	0.03	0.07	0.13	0.66	3.10	4.77	7.33	0.38	66.9	405.8	1037.0	0.85
	STD_s	95.3	150.3	248.6	0.06	0.05	0.08	0.13	0.39	0.81	0.97	1.83	0.21	57.1	195.1	432.6	0.12
	STD_t	74.2	90.1	110.7	0.01	0.02	0.03	0.04	0.13	0.84	1.31	1.79	0.05	6.0	47.0	127.2	0.03
3+4C+5	Avg.	479.4	671.5	912.6	0.20	0.05	0.09	0.16	0.69	3.84	5.87	8.64	0.36	73.2	413.2	1036.0	0.83
	STD_s	103.7	142.9	226.9	0.07	0.07	0.11	0.16	0.48	1.58	1.85	2.21	0.17	65.2	202.3	433.0	0.13
	STD_t	38.3	47.6	61.5	0.01	0.01	0.02	0.03	0.16	0.49	0.79	1.21	0.05	4.8	46.5	126.8	0.03
8	Avg.	400.5	577.3	800.0	0.22	0.03	0.07	0.13	0.65	3.08	4.73	7.24	0.37	66.5	402.0	1025.0	0.84
	STD_s	99.7	152.4	245.6	0.06	0.04	0.08	0.13	0.37	0.83	1.00	1.83	0.20	54.3	190.2	423.8	0.11
	STD_t	76.9	94.4	117.4	0.01	0.02	0.03	0.05	0.13	0.85	1.33	1.83	0.05	6.2	47.7	128.4	0.03

Notes: Avg.-Spatial and temporal-averaged ensemble statistical moments over all river locations and over all weeks in the season
STD_s-Standard deviation over all river locations of the values of the temporal-averaged ensemble statistical moments (averaged over all weeks in the seas
STD_t-Standard deviation over all years in the 25-year period of the values of the spatial-averaged ensemble statistical moments (averaged over all river lo

TABLE D-44. Space-Time Average and Standard Deviation of Ensemble Statistical Moments of Computed Water Quality Concentrations for Each Combined Management Strategy Applied during the Jan-Feb Season (Computed over All Irrigation Diversion Points and Downstream Station at Weldona)

Strategy		C_{TDS}				C_{NO_2}				C_N				C_{FC}			
		5%	Mean	95%	CV	5%	Mean	95%	CV	5%	Mean	95%	CV	5%	Mean	95%	CV
1	Avg.	833.7	960.3	1088.0	0.09	0.04	0.14	0.30	0.67	5.11	7.13	9.12	0.18	60.1	242.6	571.3	0.64
	STD_s	139.5	141.0	151.2	0.03	0.08	0.22	0.47	0.18	1.20	1.39	1.62	0.02	67.4	239.9	622.2	0.15
	STD_t	6.1	4.9	8.3	0.00	0.00	0.00	0.01	0.04	0.13	0.05	0.12	0.01	4.6	13.1	41.6	0.02
2E+3	Avg.	705.7	850.8	990.1	0.11	0.03	0.11	0.26	0.64	3.75	5.48	7.06	0.19	54.0	233.2	556.6	0.65
	STD_s	186.8	195.3	215.3	0.06	0.05	0.19	0.43	0.26	0.61	0.82	1.05	0.04	55.5	224.1	598.2	0.17
	STD_t	66.6	58.5	54.8	0.01	0.01	0.02	0.03	0.03	0.75	0.83	1.01	0.01	6.5	16.3	44.5	0.02
6	Avg.	653.4	753.3	852.7	0.09	0.03	0.10	0.23	0.65	3.54	4.97	6.31	0.17	50.3	197.9	462.4	0.64
	STD_s	154.8	149.2	158.0	0.05	0.05	0.16	0.36	0.22	0.65	0.77	0.87	0.03	56.1	196.5	504.2	0.15
	STD_t	96.0	116.1	137.7	0.01	0.01	0.02	0.05	0.03	0.86	1.11	1.42	0.01	8.2	37.1	94.8	0.02
2E+5	Avg.	716.8	853.6	984.0	0.10	0.03	0.10	0.22	0.65	3.74	5.57	7.27	0.20	50.0	210.9	514.3	0.66
	STD_s	184.2	203.7	229.1	0.04	0.05	0.15	0.33	0.25	0.82	0.71	0.73	0.05	44.8	166.4	505.0	0.18
	STD_t	61.2	57.0	57.5	0.01	0.00	0.03	0.05	0.04	0.76	0.78	0.91	0.02	8.2	25.7	59.1	0.02
3+4C	Avg.	752.4	850.5	954.7	0.08	0.04	0.12	0.26	0.68	4.67	6.54	8.49	0.18	56.2	201.4	461.3	0.62
	STD_s	111.1	104.0	101.8	0.03	0.07	0.20	0.39	0.15	1.19	1.45	1.77	0.02	66.1	200.9	500.7	0.12
	STD_t	52.7	71.3	87.6	0.01	0.00	0.01	0.04	0.04	0.36	0.37	0.37	0.01	6.0	35.4	94.4	0.02
3+5	Avg.	831.5	952.8	1072.0	0.08	0.05	0.12	0.25	0.65	5.16	7.21	9.21	0.18	57.2	216.7	514.2	0.64
	STD_s	126.2	138.7	157.8	0.02	0.08	0.19	0.37	0.18	1.69	1.86	2.09	0.03	58.0	177.4	504.7	0.15
	STD_t	6.7	8.0	13.9	0.00	0.00	0.01	0.04	0.05	0.13	0.07	0.14	0.01	5.4	22.9	58.4	0.02
4C+5	Avg.	763.0	857.5	957.7	0.07	0.04	0.11	0.22	0.67	4.82	6.72	8.68	0.18	53.0	185.6	430.7	0.63
	STD_s	87.1	86.8	90.7	0.02	0.07	0.17	0.33	0.16	1.82	2.15	2.51	0.03	57.9	160.6	433.8	0.13
	STD_t	48.7	68.2	85.4	0.01	0.00	0.02	0.05	0.06	0.28	0.30	0.31	0.01	7.1	40.8	104.3	0.02
2E+3+4C	Avg.	648.6	748.3	847.4	0.09	0.03	0.10	0.22	0.65	3.53	4.94	6.26	0.17	50.4	195.4	455.7	0.63
	STD_s	157.2	151.9	159.9	0.05	0.05	0.16	0.36	0.22	0.64	0.77	0.88	0.03	55.4	191.6	492.5	0.15
	STD_t	98.4	118.4	139.8	0.01	0.01	0.02	0.05	0.03	0.87	1.13	1.44	0.01	8.2	37.9	96.8	0.02
2E+3+5	Avg.	710.6	847.5	978.0	0.10	0.03	0.10	0.22	0.64	3.73	5.54	7.22	0.20	50.4	209.1	507.6	0.65
	STD_s	184.8	204.7	230.2	0.04	0.05	0.15	0.33	0.25	0.79	0.70	0.74	0.05	45.0	163.8	493.2	0.18
	STD_t	64.2	60.0	60.4	0.01	0.00	0.03	0.05	0.03	0.77	0.80	0.93	0.02	8.0	26.5	61.2	0.02
7	Avg.	656.9	751.2	844.4	0.08	0.03	0.09	0.19	0.65	3.54	5.03	6.43	0.18	46.2	177.9	423.8	0.64
	STD_s	152.4	155.1	168.1	0.03	0.05	0.14	0.28	0.22	0.85	0.83	0.84	0.04	44.6	146.5	421.9	0.15
	STD_t	94.8	116.9	140.3	0.01	0.00	0.03	0.07	0.04	0.86	1.08	1.37	0.01	10.0	44.2	107.4	0.02
3+4C+5	Avg.	757.7	851.6	950.6	0.07	0.04	0.11	0.22	0.66	4.80	6.68	8.60	0.18	53.1	184.1	425.6	0.62
	STD_s	92.6	92.1	96.0	0.02	0.08	0.17	0.32	0.16	1.76	2.08	2.42	0.03	57.7	158.2	424.6	0.13
	STD_t	50.5	70.6	88.4	0.01	0.00	0.02	0.05	0.05	0.29	0.32	0.34	0.01	7.1	41.4	106.0	0.02
8	Avg.	651.8	746.3	839.7	0.08	0.03	0.09	0.19	0.64	3.52	5.00	6.39	0.18	46.5	176.6	418.8	0.63
	STD_s	153.6	156.5	169.2	0.03	0.05	0.13	0.28	0.21	0.82	0.81	0.82	0.04	44.7	144.4	413.0	0.15
	STD_t	97.1	119.1	142.3	0.01	0.00	0.03	0.07	0.04	0.87	1.10	1.39	0.01	9.8	44.8	109.1	0.02

Notes: Avg.-Spatial and temporal-averaged ensemble statistical moments over all diversion points and downstream at Weldona and over all weeks in the seaso
STD_s-Standard deviation over all irrigation diversion points and downstream at Weldona of the values of the temporal-averaged ensemble statistical mc
(averaged over all weeks in the season)
STD_t-Standard deviation over all years in the 25-year period of the values of the spatial-averaged ensemble statistical moments
(average over all irrigation diversion points and downstream at Weldona)

TABLE D-45. Space-Time Average and Standard Deviation of Ensemble Statistical Moments of Computed Water Quality Concentrations for Each Combined Management Strategy Applied during the Mar-Apr Season (Computed over All Irrigation Diversion Points and Downstream Station at Weldona)

Strategy		C_{TDS}				C_{NO_2}				C_N				C_{FC}			
		5%	Mean	95%	CV	5%	Mean	95%	CV	5%	Mean	95%	CV	5%	Mean	95%	CV
1	Avg.	718.0	997.6	1307.0	0.19	0.04	0.09	0.20	0.50	4.36	6.73	9.37	0.23	61.1	213.7	512.9	0.80
	STD_s	199.5	228.4	408.6	0.08	0.02	0.08	0.23	0.15	1.11	1.66	2.33	0.06	56.5	110.6	182.0	0.24
	STD_t	10.4	14.4	30.6	0.05	0.00	0.00	0.01	0.02	0.21	0.15	0.13	0.01	5.0	9.4	28.0	0.05
2E+3	Avg.	582.9	874.5	1211.0	0.24	0.03	0.07	0.16	0.46	3.39	4.81	6.33	0.18	51.3	191.0	484.1	0.85
	STD_s	226.8	252.2	417.8	0.10	0.02	0.08	0.23	0.19	0.62	0.74	1.05	0.05	45.5	95.5	170.4	0.22
	STD_t	69.5	72.2	73.8	0.06	0.00	0.01	0.02	0.03	0.37	0.88	1.50	0.03	3.4	10.5	28.8	0.04
6	Avg.	553.2	781.3	1045.0	0.21	0.03	0.07	0.14	0.47	3.11	4.57	6.15	0.20	49.6	169.9	409.2	0.80
	STD_s	196.4	209.6	346.4	0.09	0.02	0.07	0.19	0.16	0.64	0.83	1.19	0.06	46.9	88.7	145.8	0.24
	STD_t	86.9	129.3	176.5	0.05	0.00	0.01	0.03	0.02	0.51	1.00	1.60	0.02	3.9	20.4	62.0	0.07
2E+5	Avg.	594.6	890.1	1228.0	0.23	0.03	0.07	0.15	0.46	3.35	4.76	6.28	0.19	51.3	195.0	493.1	0.86
	STD_s	229.5	253.6	434.6	0.10	0.02	0.07	0.21	0.18	0.65	0.70	0.98	0.06	48.0	97.7	168.6	0.23
	STD_t	63.7	64.9	66.4	0.06	0.00	0.01	0.03	0.03	0.39	0.90	1.53	0.03	3.6	9.5	27.5	0.04
3+4C	Avg.	644.6	870.8	1115.0	0.17	0.03	0.09	0.18	0.49	4.05	6.39	9.06	0.24	61.2	192.2	429.4	0.72
	STD_s	166.3	184.5	310.2	0.06	0.02	0.07	0.18	0.14	1.08	1.69	2.36	0.05	53.9	96.9	147.1	0.22
	STD_t	45.3	87.3	140.9	0.05	0.00	0.00	0.01	0.02	0.13	0.13	0.19	0.01	4.7	11.9	53.5	0.08
3+5	Avg.	687.1	968.1	1281.0	0.20	0.03	0.08	0.17	0.48	4.28	6.43	8.90	0.22	63.0	215.1	508.4	0.77
	STD_s	193.3	214.7	386.9	0.08	0.02	0.07	0.20	0.14	1.07	1.50	2.12	0.05	55.0	105.5	169.9	0.22
	STD_t	19.7	26.1	39.7	0.05	0.00	0.00	0.01	0.02	0.16	0.13	0.26	0.02	5.5	9.5	26.7	0.05
4C+5	Avg.	644.8	874.9	1124.0	0.17	0.03	0.08	0.16	0.49	3.93	6.20	8.84	0.25	60.9	194.1	435.1	0.73
	STD_s	156.0	169.0	307.2	0.07	0.02	0.07	0.17	0.11	1.18	1.69	2.33	0.06	56.9	99.6	146.9	0.23
	STD_t	45.7	87.0	139.0	0.05	0.00	0.01	0.02	0.02	0.15	0.20	0.28	0.01	4.6	11.6	52.1	0.08
2E+3+	Avg.	540.0	766.7	1028.0	0.21	0.03	0.06	0.14	0.46	3.11	4.53	6.08	0.20	50.5	169.8	405.0	0.78
4C	STD_s	194.1	207.8	336.3	0.09	0.01	0.06	0.19	0.17	0.60	0.80	1.16	0.05	45.2	85.7	141.3	0.22
	STD_t	93.0	135.1	182.2	0.06	0.00	0.01	0.03	0.03	0.51	1.02	1.63	0.03	3.5	20.5	63.3	0.07
2E+3+	Avg.	578.9	872.0	1208.0	0.24	0.03	0.07	0.14	0.45	3.35	4.71	6.21	0.18	52.1	194.0	486.7	0.84
5	STD_s	224.5	250.1	419.6	0.10	0.02	0.07	0.21	0.18	0.61	0.67	0.95	0.05	46.1	94.3	163.8	0.21
	STD_t	71.5	73.5	75.1	0.06	0.00	0.01	0.03	0.03	0.39	0.93	1.56	0.03	3.2	9.6	27.9	0.04
7	Avg.	548.1	778.0	1042.0	0.21	0.02	0.06	0.13	0.46	3.06	4.47	6.01	0.20	50.5	172.9	412.2	0.79
	STD_s	194.8	206.6	346.0	0.09	0.02	0.06	0.17	0.15	0.64	0.77	1.10	0.06	47.7	87.8	140.2	0.23
	STD_t	89.5	131.0	177.5	0.05	0.01	0.02	0.04	0.03	0.54	1.05	1.67	0.02	3.6	19.3	60.9	0.07
3+4C+	Avg.	632.3	859.5	1108.0	0.18	0.03	0.08	0.16	0.48	3.95	6.15	8.71	0.24	62.0	193.2	429.7	0.71
5	STD_s	158.3	169.5	299.0	0.07	0.02	0.06	0.16	0.11	1.10	1.60	2.24	0.05	54.5	96.1	142.6	0.22
	STD_t	50.3	92.3	143.9	0.05	0.00	0.01	0.02	0.02	0.15	0.23	0.34	0.01	5.0	11.8	53.4	0.09
8	Avg.	535.0	763.4	1026.0	0.21	0.02	0.06	0.13	0.46	3.06	4.43	5.93	0.20	51.4	172.1	407.2	0.77
	STD_s	191.7	204.5	335.6	0.09	0.02	0.06	0.17	0.16	0.60	0.73	1.06	0.05	45.8	84.9	136.3	0.21
	STD_t	95.6	136.9	183.2	0.06	0.01	0.02	0.04	0.03	0.54	1.07	1.70	0.03	3.3	19.7	62.4	0.07

Notes: Avg.-Spatial and temporal-averaged ensemble statistical moments over all diversion points and downstream at Weldona and over all weeks in the seaso
STD_s-Standard deviation over all irrigation diversion points and downstream at Weldona of the values of the temporal-averaged ensemble statistical mc
(averaged over all weeks in the season)
STD_t-Standard deviation over all years in the 25-year period of the values of the spatial-averaged ensemble statistical moments
(average over all irrigation diversion points and downstream at Weldona)

TABLE D-46. Space-Time Average and Standard Deviation of Ensemble Statistical Moments of Computed Water Quality Concentrations for Each Combined Management Strategy Applied during the May-Jun Season (Computed over All Irrigation Diversion Points and Downstream Station at Weldona)

Strategy		C_{TDS}				C_{NO_2}				C_N				C_{FC}			
		5%	Mean	95%	CV	5%	Mean	95%	CV	5%	Mean	95%	CV	5%	Mean	95%	CV
1	Avg.	296.7	630.0	979.2	0.65	0.02	0.16	0.44	0.65	2.14	4.40	8.78	0.49	24.0	358.3	1023.0	1.05
	STD_s	56.3	141.8	214.2	0.26	0.02	0.23	0.67	0.24	0.39	0.88	2.50	0.10	26.4	216.3	543.4	0.24
	STD_t	8.4	15.8	15.1	3.05	0.00	0.01	0.01	0.01	0.07	0.12	0.37	0.02	1.9	14.9	45.9	0.04
2E+3	Avg.	265.3	567.1	904.5	0.72	0.02	0.15	0.42	0.68	1.94	4.04	8.22	0.51	21.9	348.9	993.5	1.02
	STD_s	76.5	159.1	225.5	0.34	0.01	0.22	0.67	0.27	0.39	0.69	2.15	0.12	19.2	193.6	496.0	0.20
	STD_t	14.2	34.1	45.3	3.61	0.00	0.01	0.02	0.02	0.14	0.23	0.49	0.02	2.2	16.1	51.8	0.05
6	Avg.	237.2	529.9	858.1	0.67	0.02	0.13	0.35	0.65	1.82	3.56	7.01	0.48	18.8	284.6	818.6	1.05
	STD_s	57.3	160.1	267.9	0.28	0.01	0.18	0.54	0.26	0.32	0.61	1.89	0.11	20.4	173.1	436.4	0.24
	STD_t	29.5	55.0	71.2	2.99	0.00	0.02	0.06	0.02	0.21	0.51	1.15	0.02	2.6	48.5	145.5	0.04
2E+5	Avg.	262.4	577.8	926.3	0.74	0.02	0.15	0.42	0.69	1.95	4.10	8.37	0.51	21.6	351.8	1015.0	1.05
	STD_s	78.2	165.5	243.1	0.37	0.01	0.22	0.67	0.27	0.37	0.70	2.29	0.12	22.3	195.1	500.4	0.23
	STD_t	15.6	28.8	30.9	3.66	0.00	0.01	0.02	0.02	0.14	0.20	0.43	0.02	1.8	15.8	48.2	0.04
3+4C	Avg.	271.1	566.8	883.3	0.58	0.02	0.13	0.35	0.61	1.98	3.77	7.17	0.45	24.1	292.6	810.7	0.98
	STD_s	43.1	134.2	222.4	0.20	0.02	0.18	0.53	0.24	0.31	0.73	1.93	0.08	24.5	161.5	402.7	0.19
	STD_t	16.3	39.2	60.7	2.49	0.00	0.02	0.06	0.02	0.15	0.43	1.07	0.03	2.3	45.4	147.0	0.06
3+5	Avg.	295.8	613.1	945.6	0.65	0.02	0.15	0.42	0.65	2.15	4.29	8.46	0.48	27.7	358.8	1002.0	0.99
	STD_s	64.4	138.3	206.8	0.29	0.02	0.22	0.66	0.24	0.35	0.77	2.28	0.10	28.6	184.3	462.9	0.19
	STD_t	8.0	17.4	30.6	3.21	0.00	0.01	0.02	0.01	0.07	0.14	0.43	0.02	3.4	15.1	50.1	0.05
4C+5	Avg.	264.5	575.4	910.7	0.61	0.02	0.13	0.35	0.62	1.97	3.81	7.27	0.45	24.1	294.6	826.8	1.02
	STD_s	52.9	140.9	238.0	0.23	0.01	0.18	0.54	0.24	0.33	0.73	2.02	0.09	30.0	166.7	408.3	0.24
	STD_t	18.0	35.7	46.4	2.62	0.00	0.02	0.06	0.02	0.15	0.42	1.04	0.03	1.9	44.9	143.2	0.05
2E+3+4C	Avg.	238.4	517.5	830.0	0.66	0.02	0.12	0.34	0.64	1.81	3.49	6.84	0.47	20.3	284.0	802.4	1.01
	STD_s	58.4	153.4	249.5	0.28	0.01	0.18	0.53	0.27	0.32	0.58	1.76	0.11	19.2	158.4	401.5	0.20
	STD_t	29.0	60.5	85.0	3.00	0.00	0.02	0.06	0.02	0.21	0.54	1.20	0.02	2.4	48.8	150.4	0.05
2E+3+5	Avg.	264.3	564.8	899.4	0.73	0.02	0.15	0.42	0.69	1.93	4.02	8.15	0.51	22.9	350.3	994.0	1.01
	STD_s	77.7	158.5	227.2	0.36	0.01	0.22	0.66	0.27	0.36	0.67	2.13	0.12	20.9	178.7	460.2	0.19
	STD_t	14.7	35.0	47.3	3.69	0.00	0.01	0.02	0.02	0.14	0.24	0.51	0.02	2.1	16.0	52.2	0.05
7	Avg.	235.7	527.5	854.1	0.68	0.02	0.13	0.34	0.65	1.82	3.55	6.95	0.47	20.0	286.2	818.9	1.04
	STD_s	60.1	160.5	269.8	0.31	0.01	0.18	0.54	0.27	0.30	0.58	1.87	0.11	22.1	160.2	405.2	0.23
	STD_t	30.1	55.9	72.5	3.08	0.00	0.02	0.06	0.02	0.21	0.52	1.17	0.03	2.2	48.2	146.3	0.04
3+4C+5	Avg.	267.9	564.1	880.5	0.60	0.02	0.13	0.34	0.62	1.99	3.75	7.10	0.44	25.5	293.7	810.8	0.97
	STD_s	49.8	133.7	224.3	0.23	0.01	0.18	0.53	0.24	0.30	0.67	1.89	0.09	27.9	153.4	377.5	0.19
	STD_t	17.2	39.9	61.4	2.62	0.00	0.02	0.06	0.02	0.15	0.44	1.09	0.03	2.6	45.2	147.6	0.06
8	Avg.	237.5	515.6	826.5	0.67	0.02	0.12	0.34	0.65	1.81	3.48	6.78	0.47	21.2	285.1	802.8	1.00
	STD_s	59.5	152.6	250.7	0.30	0.01	0.18	0.53	0.27	0.29	0.55	1.74	0.11	20.7	147.6	374.7	0.19
	STD_t	29.4	61.2	86.3	3.10	0.00	0.02	0.06	0.02	0.21	0.55	1.22	0.03	2.2	48.6	150.9	0.05

Notes: Avg.-Spatial and temporal-averaged ensemble statistical moments over all diversion points and downstream at Weldona and over all weeks in the seaso

STD_s-Standard deviation over all irrigation diversion points and downstream at Weldona of the values of the temporal-averaged ensemble statistical mc (averaged over all weeks in the season)

STD_t-Standard deviation over all years in the 25-year period of the values of the spatial-averaged ensemble statistical moments (average over all irrigation diversion points and downstream at Weldona)

TABLE D-47. Space-Time Average and Standard Deviation of Ensemble Statistical Moments of Computed Water Quality Concentrations for Each Combined Management Strategy Applied during the Jul-Aug Season (Computed over All Irrigation Diversion Points and Downstream Station at Weldona)

Strategy		C_{TDS} 5%	C_{TDS} Mean	C_{TDS} 95%	C_{TDS} CV	C_{NO_2} 5%	C_{NO_2} Mean	C_{NO_2} 95%	C_{NO_2} CV	C_N 5%	C_N Mean	C_N 95%	C_N CV	C_{FC} 5%	C_{FC} Mean	C_{FC} 95%	C_{FC} CV
1	Avg.	378.7	729.1	1044.0	0.36	0.02	0.09	0.21	0.59	4.06	6.86	10.32	0.30	151.7	500.8	928.9	0.46
	STD_s	185.0	225.7	289.7	0.17	0.03	0.10	0.31	0.29	1.22	1.36	1.69	0.13	110.5	391.0	822.2	0.11
	STD_t	13.9	17.0	47.2	0.22	0.00	0.00	0.01	0.03	0.15	0.15	0.23	0.01	7.0	13.7	30.9	0.01
2E+3	Avg.	338.8	652.8	950.0	0.39	0.02	0.08	0.19	0.58	3.59	6.24	9.58	0.33	144.5	470.6	872.2	0.45
	STD_s	189.7	251.3	314.3	0.19	0.02	0.09	0.28	0.25	1.39	1.58	1.73	0.16	98.1	352.6	748.9	0.11
	STD_t	19.7	45.8	72.4	0.24	0.00	0.01	0.01	0.02	0.34	0.43	0.55	0.02	8.5	28.5	58.1	0.01
6	Avg.	324.4	618.4	900.5	0.38	0.02	0.07	0.17	0.58	3.37	5.54	8.25	0.30	132.1	413.2	756.6	0.44
	STD_s	184.7	248.1	323.9	0.18	0.02	0.08	0.25	0.26	1.21	1.29	1.44	0.15	94.3	316.8	662.6	0.11
	STD_t	25.5	64.5	94.9	0.22	0.00	0.01	0.03	0.02	0.46	0.86	1.37	0.02	15.1	65.8	131.8	0.02
2E+5	Avg.	345.5	673.9	986.5	0.40	0.02	0.08	0.19	0.58	3.70	6.43	9.78	0.32	147.8	483.6	898.4	0.46
	STD_s	202.8	262.2	332.8	0.21	0.02	0.09	0.26	0.24	1.39	1.61	1.73	0.13	103.6	361.6	767.7	0.11
	STD_t	17.4	34.9	59.1	0.24	0.00	0.01	0.01	0.02	0.28	0.33	0.43	0.01	7.4	19.7	41.0	0.01
3+4C	Avg.	359.0	655.2	921.2	0.33	0.02	0.07	0.16	0.57	3.67	5.81	8.45	0.27	131.6	396.4	720.1	0.44
	STD_s	153.4	205.5	271.8	0.13	0.03	0.08	0.23	0.28	1.02	1.08	1.28	0.11	95.8	295.2	611.9	0.11
	STD_t	11.9	48.2	84.5	0.21	0.00	0.01	0.03	0.03	0.34	0.75	1.27	0.02	15.8	72.3	144.9	0.02
3+5	Avg.	380.9	710.7	1004.0	0.35	0.03	0.08	0.19	0.56	4.01	6.68	9.93	0.29	148.0	463.3	852.7	0.45
	STD_s	168.9	215.5	278.0	0.16	0.03	0.10	0.26	0.25	1.11	1.30	1.56	0.09	104.2	336.2	706.4	0.11
	STD_t	13.5	23.2	54.6	0.22	0.00	0.01	0.02	0.03	0.17	0.24	0.40	0.01	7.8	31.2	65.4	0.01
4C+5	Avg.	362.0	675.0	958.5	0.34	0.02	0.07	0.16	0.57	3.76	5.97	8.63	0.26	135.1	407.9	741.7	0.44
	STD_s	167.1	211.4	279.6	0.15	0.03	0.09	0.23	0.27	0.96	1.04	1.28	0.08	101.5	303.8	628.2	0.11
	STD_t	11.6	39.3	69.2	0.21	0.00	0.01	0.03	0.03	0.30	0.68	1.19	0.02	14.6	67.3	136.3	0.01
2E+3+ 4C	Avg.	321.0	600.0	864.8	0.37	0.02	0.07	0.16	0.56	3.29	5.38	8.01	0.30	128.6	392.9	716.6	0.43
	STD_s	172.3	237.1	308.6	0.16	0.02	0.08	0.23	0.25	1.18	1.28	1.37	0.15	89.3	291.0	609.3	0.11
	STD_t	27.1	73.4	110.3	0.23	0.00	0.01	0.03	0.02	0.50	0.93	1.46	0.02	16.5	73.6	146.4	0.02
2E+3+ 5	Avg.	340.5	652.6	947.1	0.39	0.02	0.08	0.18	0.57	3.60	6.23	9.47	0.32	143.9	458.6	848.1	0.45
	STD_s	188.5	251.1	317.2	0.19	0.02	0.09	0.25	0.24	1.35	1.57	1.68	0.13	97.8	330.8	702.3	0.11
	STD_t	19.0	45.9	73.3	0.24	0.00	0.01	0.02	0.02	0.33	0.44	0.60	0.01	8.7	33.2	67.3	0.01
7	Avg.	326.2	618.2	898.3	0.37	0.02	0.07	0.16	0.57	3.38	5.53	8.17	0.29	131.3	403.0	736.8	0.44
	STD_s	183.8	248.0	326.0	0.18	0.02	0.08	0.22	0.24	1.18	1.29	1.36	0.11	93.9	297.5	623.5	0.11
	STD_t	24.7	64.5	95.6	0.22	0.00	0.01	0.03	0.02	0.45	0.86	1.40	0.02	15.5	69.1	138.3	0.02
3+4C+ 5	Avg.	362.6	658.4	923.4	0.33	0.02	0.07	0.16	0.55	3.71	5.84	8.41	0.26	131.7	388.6	703.5	0.43
	STD_s	152.5	202.2	268.6	0.14	0.03	0.08	0.22	0.26	0.93	1.03	1.27	0.08	95.8	280.3	578.7	0.11
	STD_t	11.2	46.7	83.1	0.21	0.00	0.01	0.03	0.03	0.32	0.73	1.28	0.02	15.8	74.8	150.8	0.02
8	Avg.	322.7	600.3	863.2	0.36	0.02	0.07	0.15	0.56	3.31	5.38	7.93	0.28	127.9	383.9	698.8	0.43
	STD_s	171.1	236.4	309.9	0.17	0.02	0.07	0.21	0.23	1.14	1.27	1.33	0.11	88.8	274.3	574.3	0.11
	STD_t	26.3	73.2	110.8	0.23	0.00	0.01	0.04	0.02	0.49	0.93	1.49	0.02	16.8	76.7	152.8	0.02

Notes: Avg.-Spatial and temporal-averaged ensemble statistical moments over all diversion points and downstream at Weldona and over all weeks in the seaso
STD_s-Standard deviation over all irrigation diversion points and downstream at Weldona of the values of the temporal-averaged ensemble statistical mc
(averaged over all weeks in the season)
STD_t-Standard deviation over all years in the 25-year period of the values of the spatial-averaged ensemble statistical moments
(average over all irrigation diversion points and downstream at Weldona)

TABLE D-48. Space-Time Average and Standard Deviation of Ensemble Statistical Moments of Computed Water Quality Concentrations for Each Combined Management Strategy Applied during the Sep-Oct Season (Computed over All Irrigation Diversion Points and Downstream Station at Weldona)

Strategy		C_{TDS} 5%	C_{TDS} Mean	C_{TDS} 95%	C_{TDS} CV	C_{NO_3} 5%	C_{NO_3} Mean	C_{NO_3} 95%	C_{NO_3} CV	C_N 5%	C_N Mean	C_N 95%	C_N CV	C_{FC} 5%	C_{FC} Mean	C_{FC} 95%	C_{FC} CV
1	Avg.	472.6	787.1	964.9	0.59	0.04	0.09	0.16	0.53	4.34	5.93	7.65	0.17	45.5	187.6	451.3	0.86
	STD_s	113.6	156.0	200.3	0.29	0.06	0.09	0.13	0.21	1.13	1.48	1.93	0.04	76.0	164.5	416.6	0.33
	STD_t	24.2	37.6	28.6	0.45	0.00	0.00	0.00	0.02	0.07	0.04	0.10	0.01	1.1	7.4	19.6	0.04
2E+3	Avg.	385.0	678.5	864.4	0.67	0.03	0.07	0.14	0.56	3.56	4.68	5.84	0.15	39.7	176.7	432.7	0.84
	STD_s	134.0	160.9	219.6	0.37	0.04	0.06	0.11	0.18	0.78	0.89	1.11	0.04	64.6	151.0	397.7	0.30
	STD_t	39.7	67.9	66.4	0.52	0.01	0.01	0.01	0.03	0.37	0.63	0.96	0.02	3.5	11.6	26.8	0.04
6	Avg.	361.3	617.0	776.4	0.63	0.03	0.07	0.12	0.53	3.28	4.38	5.56	0.16	38.8	155.1	369.3	0.84
	STD_s	119.1	134.1	168.9	0.33	0.04	0.06	0.10	0.18	0.74	0.83	1.01	0.04	65.3	134.4	334.5	0.32
	STD_t	51.5	97.7	115.7	0.50	0.01	0.01	0.02	0.02	0.53	0.80	1.12	0.01	3.9	24.6	62.9	0.04
2E+5	Avg.	382.3	682.8	875.6	0.69	0.04	0.08	0.15	0.55	3.49	4.63	5.83	0.16	38.9	177.3	434.6	0.85
	STD_s	135.7	153.4	216.1	0.39	0.05	0.08	0.13	0.20	0.68	0.78	1.04	0.03	64.5	153.2	400.5	0.30
	STD_t	40.9	66.5	61.5	0.54	0.00	0.00	0.01	0.02	0.41	0.66	0.97	0.01	3.8	11.0	24.8	0.04
3+4C	Avg.	442.7	709.6	861.7	0.53	0.04	0.08	0.14	0.50	4.02	5.55	7.24	0.18	43.5	159.3	369.8	0.84
	STD_s	101.2	131.8	153.0	0.24	0.06	0.08	0.12	0.19	1.12	1.51	1.98	0.05	73.1	139.1	326.8	0.34
	STD_t	24.1	58.1	74.8	0.42	0.00	0.01	0.01	0.02	0.21	0.25	0.33	0.01	1.8	22.8	62.4	0.04
3+5	Avg.	461.7	765.3	944.2	0.60	0.05	0.11	0.18	0.51	4.23	5.67	7.25	0.17	43.3	180.3	431.4	0.85
	STD_s	109.5	128.1	170.4	0.30	0.08	0.13	0.18	0.21	0.94	1.20	1.59	0.04	70.9	155.9	390.5	0.32
	STD_t	21.2	39.5	33.8	0.47	0.01	0.01	0.01	0.02	0.07	0.14	0.28	0.01	1.8	10.1	26.7	0.04
4C+5	Avg.	431.9	703.3	862.8	0.56	0.05	0.10	0.16	0.51	3.88	5.35	7.01	0.18	42.5	159.0	369.3	0.86
	STD_s	101.0	105.3	122.9	0.26	0.08	0.13	0.18	0.20	1.02	1.34	1.80	0.05	72.0	140.6	329.9	0.35
	STD_t	25.5	60.5	75.0	0.44	0.01	0.01	0.01	0.02	0.26	0.33	0.41	0.01	2.2	22.8	62.3	0.04
2E+3+4C	Avg.	360.7	609.5	764.6	0.62	0.03	0.07	0.12	0.53	3.28	4.34	5.48	0.16	38.4	152.2	361.4	0.83
	STD_s	117.2	133.4	166.3	0.32	0.04	0.06	0.09	0.17	0.73	0.82	1.01	0.04	63.9	130.3	322.9	0.31
	STD_t	51.7	100.9	121.0	0.49	0.01	0.01	0.02	0.02	0.53	0.82	1.16	0.01	4.1	25.7	66.1	0.04
2E+3+5	Avg.	380.8	673.8	861.5	0.69	0.04	0.08	0.15	0.54	3.48	4.59	5.75	0.15	38.5	173.9	424.9	0.84
	STD_s	132.9	151.7	210.9	0.38	0.05	0.08	0.13	0.20	0.67	0.77	1.03	0.03	63.0	148.6	386.5	0.29
	STD_t	41.4	70.4	67.7	0.54	0.00	0.01	0.01	0.02	0.41	0.68	1.01	0.02	4.0	12.6	29.3	0.04
7	Avg.	357.4	612.0	773.6	0.64	0.04	0.07	0.13	0.52	3.22	4.28	5.44	0.16	37.6	152.4	362.2	0.85
	STD_s	118.5	124.8	160.1	0.35	0.05	0.08	0.12	0.19	0.65	0.71	0.93	0.04	63.6	132.0	325.0	0.32
	STD_t	53.1	100.1	117.2	0.51	0.00	0.01	0.02	0.02	0.56	0.85	1.18	0.01	4.5	25.6	65.5	0.04
3+4C+5	Avg.	432.4	696.4	851.3	0.55	0.05	0.10	0.16	0.50	3.90	5.33	6.93	0.18	42.0	156.1	361.8	0.85
	STD_s	97.8	104.7	122.2	0.26	0.08	0.12	0.17	0.19	0.98	1.28	1.72	0.05	70.1	136.2	318.8	0.34
	STD_t	25.0	62.8	79.7	0.43	0.01	0.01	0.01	0.03	0.25	0.34	0.46	0.01	2.4	23.9	65.3	0.04
8	Avg.	356.7	604.4	761.5	0.63	0.04	0.07	0.13	0.52	3.21	4.25	5.37	0.16	37.3	149.7	354.9	0.84
	STD_s	116.0	123.9	156.9	0.34	0.05	0.08	0.11	0.19	0.63	0.70	0.91	0.03	62.2	128.1	314.3	0.31
	STD_t	53.4	103.3	122.5	0.50	0.00	0.01	0.02	0.02	0.56	0.86	1.21	0.01	4.6	26.6	68.5	0.04

Notes: Avg.-Spatial and temporal-averaged ensemble statistical moments over all diversion points and downstream at Weldona and over all weeks in the seaso

STD_s-Standard deviation over all irrigation diversion points and downstream at Weldona of the values of the temporal-averaged ensemble statistical mc (averaged over all weeks in the season)

STD_t-Standard deviation over all years in the 25-year period of the values of the spatial-averaged ensemble statistical moments (average over all irrigation diversion points and downstream at Weldona)

TABLE D-49. Space-Time Average and Standard Deviation of Ensemble Statistical Moments of Computed Water Quality Concentrations for Each Combined Management Strategy Applied during the Nov-Dec Season (Computed over All Irrigation Diversion Points and Downstream Station at Weldona)

Strategy		C_{TDS}				C_{NO_2}				C_N				C_{FC}			
		5%	Mean	95%	CV	5%	Mean	95%	CV	5%	Mean	95%	CV	5%	Mean	95%	CV
1	Avg.	557.2	743.1	968.4	0.17	0.05	0.12	0.22	0.71	4.51	7.03	10.00	0.30	67.3	504.2	1310.0	0.86
	STD_s	100.4	120.4	188.8	0.05	0.07	0.13	0.23	0.39	1.31	1.45	1.74	0.12	56.3	318.2	778.4	0.08
	STD_t	7.3	5.0	16.5	0.01	0.00	0.01	0.01	0.14	0.12	0.23	0.58	0.03	3.6	23.4	58.4	0.03
2E+3	Avg.	433.5	612.4	822.5	0.20	0.03	0.09	0.18	0.68	3.46	5.35	7.71	0.30	59.0	491.3	1299.0	0.88
	STD_s	102.3	143.1	208.0	0.04	0.04	0.10	0.21	0.31	0.49	0.53	1.07	0.14	44.1	296.3	736.2	0.06
	STD_t	58.5	66.7	83.4	0.01	0.01	0.02	0.03	0.11	0.60	1.02	1.56	0.03	5.6	23.9	60.0	0.03
6	Avg.	410.7	575.3	776.6	0.19	0.03	0.08	0.16	0.69	3.24	5.02	7.44	0.33	56.6	404.8	1051.0	0.85
	STD_s	83.3	136.6	232.0	0.06	0.04	0.09	0.18	0.34	0.55	0.52	1.01	0.17	44.6	256.6	627.9	0.07
	STD_t	70.7	87.3	109.1	0.01	0.01	0.03	0.04	0.12	0.71	1.19	1.71	0.04	6.6	62.4	170.0	0.03
2E+5	Avg.	428.7	613.6	826.5	0.20	0.03	0.08	0.16	0.76	3.42	5.26	7.55	0.30	59.8	513.8	1365.0	0.88
	STD_s	91.1	134.3	207.9	0.03	0.04	0.08	0.16	0.37	0.65	0.53	1.08	0.16	46.2	219.4	527.5	0.05
	STD_t	60.9	66.0	81.3	0.01	0.01	0.03	0.04	0.15	0.61	1.06	1.63	0.03	5.4	27.0	72.2	0.03
3+4C	Avg.	511.5	690.6	914.1	0.18	0.05	0.11	0.20	0.70	4.23	6.61	9.58	0.32	67.1	424.5	1071.0	0.82
	STD_s	90.8	116.0	200.5	0.06	0.07	0.12	0.20	0.40	1.32	1.54	1.82	0.13	54.1	250.1	601.6	0.09
	STD_t	24.3	31.6	42.5	0.01	0.00	0.02	0.03	0.14	0.27	0.46	0.79	0.03	3.7	56.3	163.1	0.04
3+5	Avg.	529.3	714.3	934.0	0.17	0.05	0.10	0.18	0.77	4.40	6.66	9.36	0.30	70.5	526.1	1365.0	0.85
	STD_s	55.6	90.4	166.1	0.04	0.06	0.11	0.18	0.47	1.51	1.41	1.32	0.13	56.2	225.9	525.3	0.07
	STD_t	12.3	16.3	29.3	0.01	0.00	0.02	0.03	0.17	0.15	0.37	0.79	0.03	3.9	29.5	71.2	0.03
4C+5	Avg.	497.0	676.9	899.9	0.18	0.04	0.09	0.17	0.81	4.12	6.34	9.18	0.34	67.2	439.5	1119.0	0.83
	STD_s	42.6	83.0	180.4	0.06	0.06	0.10	0.16	0.54	1.63	1.60	1.45	0.15	56.8	199.3	447.4	0.08
	STD_t	29.5	37.5	48.3	0.01	0.01	0.02	0.04	0.20	0.30	0.56	0.91	0.04	3.8	55.4	157.3	0.04
2E+3+ 4C	Avg.	407.4	568.9	766.1	0.19	0.03	0.08	0.16	0.68	3.23	4.99	7.36	0.33	57.7	407.8	1055.0	0.85
	STD_s	84.9	137.1	228.9	0.05	0.04	0.09	0.17	0.33	0.53	0.54	1.04	0.16	43.5	244.2	598.2	0.07
	STD_t	72.3	90.4	114.2	0.01	0.01	0.03	0.04	0.11	0.72	1.21	1.75	0.04	6.1	62.0	169.4	0.03
2E+3+ 5	Avg.	425.1	606.3	815.4	0.20	0.03	0.08	0.16	0.75	3.41	5.22	7.48	0.30	60.8	511.6	1352.0	0.88
	STD_s	92.6	134.5	205.4	0.03	0.04	0.08	0.15	0.36	0.61	0.53	1.08	0.15	45.1	214.0	516.1	0.05
	STD_t	62.7	69.7	86.9	0.01	0.01	0.03	0.04	0.14	0.62	1.08	1.66	0.03	4.9	26.9	69.3	0.03
7	Avg.	401.4	568.1	769.0	0.20	0.03	0.07	0.14	0.76	3.19	4.89	7.21	0.33	58.2	424.9	1105.0	0.85
	STD_s	70.9	128.5	227.4	0.05	0.04	0.08	0.14	0.42	0.70	0.54	0.99	0.18	45.6	186.7	437.9	0.06
	STD_t	75.2	90.8	112.7	0.01	0.01	0.03	0.05	0.15	0.74	1.26	1.82	0.04	6.0	59.5	161.9	0.03
3+4C+ 5	Avg.	493.0	669.9	888.8	0.18	0.04	0.09	0.16	0.79	4.12	6.30	9.07	0.33	68.3	437.7	1109.0	0.82
	STD_s	45.4	85.8	179.7	0.06	0.06	0.10	0.16	0.52	1.55	1.54	1.40	0.15	55.2	194.5	438.3	0.08
	STD_t	31.2	40.7	53.5	0.01	0.01	0.02	0.04	0.19	0.30	0.58	0.95	0.04	3.9	56.0	160.2	0.04
8	Avg.	398.2	561.9	758.8	0.19	0.03	0.07	0.14	0.75	3.18	4.85	7.14	0.33	59.2	423.1	1096.0	0.85
	STD_s	72.7	128.7	224.1	0.05	0.04	0.08	0.13	0.40	0.66	0.52	1.00	0.18	44.4	182.3	429.0	0.06
	STD_t	76.8	93.8	117.7	0.01	0.01	0.03	0.05	0.15	0.74	1.27	1.85	0.04	5.5	60.1	164.8	0.03

Notes: Avg.-Spatial and temporal-averaged ensemble statistical moments over all diversion points and downstream at Weldona and over all weeks in the seasc

STD_s-Standard deviation over all irrigation diversion points and downstream at Weldona of the values of the temporal-averaged ensemble statistical mc (averaged over all weeks in the season)

STD_t-Standard deviation over all years in the 25-year period of the values of the spatial-averaged ensemble statistical moments (average over all irrigation diversion points and downstream at Weldona)

TABLE D-50. Space-Time Average and Standard Deviation of Ensemble Statistical Moments of Computed Water Quality Concentrations for Each Individual Management Strategy Applied during the Jan-Feb Season (Computed on the Major Diversion Canals)

Strategy		C_{TDS}						C_{NO_3}						C_N						C_{PC}					
		5%	Mean	95%	P_{Vh}	P_{Vl}	CV	5%	Mean	95%	P_{Vh}	P_{Vl}	CV	5%	Mean	95%	P_{Vh}	P_{Vl}	CV	5%	Mean	95%	P_{Vh}	P_{Vl}	CV
1	D3	609.1	794.0	1006.0	1.00	0.06	0.16	0.06	0.57	1.33	0.00	0.00	0.76	5.22	6.78	8.52	0.00	0.00	0.15	195.2	769.9	1770.0	0.63	0.26	0.65
	D5	699.0	832.8	992.4	1.00	0.04	0.11	0.20	0.43	0.91	0.00	0.00	0.52	8.69	12.14	14.85	0.04	0.00	0.16	106.1	266.1	572.9	0.09	0.00	0.57
	D16	727.0	966.9	1121.0	1.00	0.46	0.12	0.01	0.07	0.16	0.00	0.00	0.68	4.29	7.00	9.57	0.00	0.00	0.23	27.4	167.0	318.3	0.00	0.00	0.54
	D21	884.4	979.8	1066.0	1.00	0.34	0.06	0.00	0.02	0.05	0.00	0.00	0.69	4.09	6.40	8.51	0.00	0.00	0.21	21.1	123.1	240.7	0.00	0.00	0.56
	Weldona	900.3	1056.0	1231.0	1.00	0.64	0.10	0.00	0.01	0.03	0.00	0.00	0.60	4.65	6.39	8.16	0.00	0.00	0.17	14.7	82.3	186.5	0.00	0.00	0.68
2A	D3	574.9	761.7	978.5	1.00	0.04	0.17	0.05	0.56	1.33	0.00	0.00	0.77	4.92	6.33	7.89	0.00	0.00	0.14	190.4	766.0	1767.0	0.63	0.26	0.66
	D5	649.4	784.4	950.9	1.00	0.02	0.12	0.19	0.42	0.89	0.00	0.00	0.55	8.08	11.22	13.71	0.01	0.00	0.15	103.7	262.9	570.1	0.09	0.00	0.58
	D16	700.0	946.4	1105.0	1.00	0.38	0.13	0.01	0.07	0.15	0.00	0.00	0.67	4.09	6.68	9.08	0.00	0.00	0.23	28.0	167.1	318.2	0.00	0.00	0.54
	D21	866.9	964.6	1045.0	1.00	0.24	0.06	0.00	0.02	0.05	0.00	0.00	0.68	3.93	6.16	8.18	0.00	0.00	0.22	21.5	123.1	240.5	0.00	0.00	0.55
	Weldona	887.2	1045.0	1224.0	1.00	0.59	0.11	0.00	0.01	0.03	0.00	0.00	0.59	4.51	6.22	7.91	0.00	0.00	0.17	14.8	82.3	186.4	0.00	0.00	0.68
2B	D3	540.3	729.3	951.4	0.99	0.03	0.18	0.05	0.56	1.32	0.00	0.00	0.78	4.62	5.87	7.26	0.00	0.00	0.14	185.7	762.1	1764.0	0.63	0.26	0.66
	D5	599.6	736.0	910.1	1.00	0.01	0.13	0.17	0.40	0.88	0.00	0.00	0.57	7.46	10.30	12.56	0.01	0.00	0.15	101.3	259.8	567.4	0.09	0.00	0.59
	D16	673.1	925.8	1089.0	1.00	0.31	0.13	0.01	0.06	0.13	0.00	0.00	0.66	3.88	6.36	8.63	0.00	0.00	0.23	28.6	167.2	318.0	0.00	0.00	0.54
	D21	848.0	949.4	1026.0	1.00	0.16	0.06	0.00	0.02	0.04	0.00	0.00	0.67	3.75	5.92	7.88	0.00	0.00	0.22	21.8	123.2	240.3	0.00	0.00	0.55
	Weldona	873.1	1034.0	1218.0	1.00	0.56	0.11	0.00	0.01	0.03	0.00	0.00	0.57	4.34	6.04	7.68	0.00	0.00	0.17	14.9	82.3	186.3	0.00	0.00	0.68
2C	D3	505.1	697.0	924.6	0.92	0.02	0.20	0.05	0.55	1.32	0.00	0.00	0.78	4.30	5.42	6.63	0.00	0.00	0.13	180.9	758.2	1761.0	0.62	0.26	0.67
	D5	549.6	687.6	871.4	0.98	0.01	0.15	0.16	0.39	0.87	0.00	0.00	0.60	6.84	9.39	11.42	0.01	0.00	0.15	99.0	256.6	564.7	0.08	0.00	0.60
	D16	646.0	905.3	1074.0	1.00	0.25	0.14	0.01	0.06	0.12	0.00	0.00	0.65	3.65	6.04	8.20	0.00	0.00	0.24	29.1	167.4	317.8	0.00	0.00	0.54
	D21	828.6	934.3	1011.0	1.00	0.11	0.06	0.00	0.02	0.04	0.00	0.00	0.65	3.56	5.68	7.61	0.00	0.00	0.22	22.1	123.3	240.2	0.00	0.00	0.55
	Weldona	858.1	1023.0	1211.0	1.00	0.53	0.11	0.00	0.01	0.02	0.00	0.00	0.56	4.15	5.86	7.48	0.00	0.00	0.18	15.0	82.4	186.3	0.00	0.00	0.68
2D	D3	469.2	664.7	898.1	0.79	0.02	0.22	0.04	0.55	1.32	0.00	0.00	0.79	3.98	4.96	6.00	0.00	0.00	0.12	175.8	754.3	1758.0	0.62	0.26	0.67
	D5	499.3	639.2	833.4	0.81	0.01	0.17	0.14	0.37	0.86	0.00	0.00	0.63	6.21	8.47	10.27	0.01	0.00	0.15	96.5	253.4	562.1	0.08	0.00	0.60
	D16	619.9	884.8	1060.0	1.00	0.21	0.15	0.01	0.05	0.11	0.00	0.00	0.64	3.39	5.71	7.82	0.00	0.00	0.25	29.6	167.5	317.6	0.00	0.00	0.53
	D21	808.5	919.1	996.8	1.00	0.09	0.06	0.00	0.02	0.04	0.00	0.00	0.63	3.35	5.44	7.37	0.00	0.00	0.23	22.4	123.4	240.0	0.00	0.00	0.55
	Weldona	842.3	1012.0	1205.0	1.00	0.51	0.12	0.00	0.01	0.02	0.00	0.00	0.55	3.92	5.69	7.32	0.00	0.00	0.18	15.2	82.4	186.2	0.00	0.00	0.67
2E	D3	432.2	632.3	872.1	0.73	0.02	0.23	0.04	0.54	1.32	0.00	0.00	0.80	3.65	4.51	5.38	0.00	0.00	0.11	170.9	750.4	1755.0	0.62	0.25	0.68
	D5	448.8	590.7	795.7	0.61	0.01	0.20	0.13	0.36	0.85	0.00	0.00	0.66	5.57	7.55	9.13	0.01	0.00	0.14	94.0	250.2	559.4	0.08	0.00	0.61
	D16	594.4	864.2	1047.0	0.98	0.18	0.16	0.01	0.05	0.10	0.00	0.00	0.62	3.12	5.39	7.50	0.00	0.00	0.26	30.2	167.7	317.4	0.00	0.00	0.53
	D21	787.4	903.9	984.8	1.00	0.08	0.07	0.00	0.02	0.03	0.00	0.00	0.61	3.12	5.20	7.16	0.00	0.00	0.25	22.7	123.4	239.9	0.00	0.00	0.55
	Weldona	825.9	1000.0	1200.0	1.00	0.49	0.12	0.00	0.01	0.02	0.00	0.00	0.54	3.67	5.51	7.17	0.00	0.00	0.20	15.3	82.4	186.1	0.00	0.00	0.67
3	D3	592.7	775.1	984.7	1.00	0.04	0.16	0.06	0.55	1.30	0.00	0.00	0.76	5.14	6.63	8.29	0.00	0.00	0.15	191.6	750.9	1737.0	0.62	0.25	0.66
	D5	694.1	827.9	987.9	1.00	0.04	0.11	0.20	0.43	0.90	0.00	0.00	0.52	8.62	11.99	14.66	0.03	0.00	0.15	106.0	266.2	571.0	0.09	0.00	0.57
	D16	726.2	963.1	1117.0	1.00	0.44	0.12	0.01	0.07	0.16	0.00	0.00	0.67	4.35	7.01	9.54	0.00	0.00	0.23	28.5	167.0	317.7	0.00	0.00	0.54
	D21	881.5	976.7	1062.0	1.00	0.31	0.06	0.00	0.02	0.05	0.00	0.00	0.68	4.13	6.41	8.50	0.00	0.00	0.21	21.9	123.3	240.6	0.00	0.00	0.55
	Weldona	897.3	1052.0	1227.0	1.00	0.62	0.10	0.00	0.01	0.03	0.00	0.00	0.60	4.68	6.40	8.14	0.00	0.00	0.17	15.0	82.5	186.6	0.00	0.00	0.68
4A	D3	604.2	775.2	969.5	1.00	0.03	0.15	0.06	0.53	1.25	0.00	0.00	0.75	5.14	6.73	8.51	0.00	0.00	0.15	194.1	730.6	1663.0	0.61	0.23	0.64
	D5	697.3	821.1	965.6	1.00	0.02	0.10	0.20	0.42	0.86	0.00	0.00	0.50	8.65	12.12	14.85	0.04	0.00	0.16	105.3	256.4	542.3	0.07	0.00	0.56
	D16	718.2	930.5	1068.0	1.00	0.27	0.11	0.01	0.07	0.16	0.00	0.00	0.68	4.19	6.83	9.38	0.00	0.00	0.24	26.0	156.8	298.5	0.00	0.00	0.54
	D21	864.9	945.2	1028.0	1.00	0.16	0.05	0.00	0.02	0.05	0.00	0.00	0.70	3.97	6.20	8.26	0.00	0.00	0.21	20.0	115.4	225.6	0.00	0.00	0.56
	Weldona	868.3	1008.0	1165.0	1.00	0.50	0.10	0.00	0.01	0.03	0.00	0.00	0.62	4.47	6.14	7.86	0.00	0.00	0.17	13.8	77.1	174.8	0.00	0.00	0.68
4B	D3	598.3	756.3	933.4	1.00	0.02	0.14	0.06	0.50	1.16	0.00	0.00	0.74	5.05	6.69	8.50	0.00	0.00	0.16	193.0	691.3	1555.0	0.59	0.20	0.63
	D5	695.2	809.5	941.8	1.00	0.01	0.09	0.20	0.40	0.81	0.00	0.00	0.48	8.60	12.10	14.84	0.04	0.00	0.16	104.4	246.6	511.5	0.06	0.00	0.54
	D16	707.7	894.1	1018.0	1.00	0.16	0.10	0.01	0.07	0.15	0.00	0.00	0.69	4.08	6.66	9.20	0.00	0.00	0.24	24.6	146.5	278.6	0.00	0.00	0.54
	D21	840.4	910.6	992.5	1.00	0.11	0.05	0.00	0.02	0.05	0.00	0.00	0.71	3.85	6.00	8.03	0.00	0.00	0.22	18.9	107.8	210.5	0.00	0.00	0.55
	Weldona	833.5	960.1	1100.0	1.00	0.31	0.09	0.00	0.01	0.03	0.00	0.00	0.63	4.28	5.88	7.59	0.00	0.00	0.18	12.9	72.0	163.0	0.00	0.00	0.68
4C	D3	590.9	737.4	898.1	1.00	0.02	0.13	0.06	0.47	1.08	0.00	0.00	0.73	4.96	6.64	8.49	0.00	0.00	0.16	191.5	652.0	1448.0	0.55	0.18	0.61
	D5	691.8	797.9	921.1	1.00	0.01	0.09	0.20	0.39	0.76	0.00	0.00	0.46	8.55	12.08	14.84	0.04	0.00	0.16	103.5	236.9	480.6	0.05	0.00	0.51
	D16	695.8	857.7	972.0	1.00	0.14	0.09	0.01	0.07	0.15	0.00	0.00	0.69	3.97	6.49	9.04	0.00	0.00	0.24	23.1	136.3	258.7	0.00	0.00	0.54
	D21	805.6	876.1	959.8	1.00	0.10	0.05	0.00	0.02	0.05	0.00	0.00	0.72	3.71	5.80	7.82	0.00	0.00	0.22	17.7	100.2	195.3	0.00	0.00	0.55
	Weldona	795.5	912.2	1038.0	1.00	0.22	0.08	0.00	0.01	0.03	0.00	0.00	0.65	4.07	5.62	7.33	0.00	0.00	0.18	12.0	66.8	151.3	0.00	0.00	0.68
5	D3	701.9	830.7	970.8	1.00	0.03	0.10	0.16	0.48	1.01	0.00	0.00	0.57	8.69	11.18	13.75	0.05	0.00	0.14	155.3	534.1	1288.0	0.39	0.13	0.68
	D5	676.0	813.7	985.3	1.00	0.04	0.12	0.23	0.50	0.98	0.00	0.00	0.49	7.79	10.74	13.37	0.01	0.00	0.16	111.6	291.0	616.2	0.12	0.00	0.57
	D16	717.6	959.5	1116.0	1.00	0.43	0.12	0.01	0.06	0.13	0.00	0.00	0.71	3.83	6.43	8.89	0.00	0.00	0.25	30.3	171.1	324.6	0.00	0.00	0.53
	D21	878.3	974.4	1060.0	1.00	0.30	0.06	0.00	0.02	0.04	0.00	0.00	0.73	3.71	5.97	8.07	0.00	0.00	0.23	22.9	125.6	244.7	0.00	0.00	0.55
	Weldona	895.2	1052.0	1229.0	1.00	0.62	0.10	0.00	0.01	0.02	0.00	0.00	0.60	4.31	6.08	7.80	0.00	0.00	0.18	15.2	83.8	189.6	0.00	0.00	0.68

Notes: P_{Vh}-Spatial and temporal-averaged probability of violation to the high criteria
P_{Vl}-Spatial and temporal-averaged probability of violation to the low criteria

TABLE D-51. Space-Time Average and Standard Deviation of Ensemble Statistical Moments of Computed Water Quality Concentrations for Each Individual Management Strategy Applied during the Mar-Apr Season (Computed on the Major Diversion Canals)

Strategy		C_{TDS}						C_{NO_3}						C_N						C_{FC}					
		5%	Mean	95%	P_{vh}	P_{vl}	CV	5%	Mean	95%	P_{vh}	P_{vl}	CV	5%	Mean	95%	P_{vh}	P_{vl}	CV	5%	Mean	95%	P_{vh}	P_{vl}	CV
1	D3	315.4	476.8	636.9	0.41	0.00	0.21	0.05	0.35	0.98	0.00	0.00	0.95	4.19	5.80	7.72	0.00	0.00	0.19	127.2	395.8	845.4	0.31	0.02	0.61
	D5	542.8	706.6	862.8	0.98	0.00	0.14	0.09	0.25	0.66	0.00	0.00	0.78	7.58	10.54	13.17	0.00	0.00	0.16	194.8	397.0	708.4	0.24	0.00	0.41
	D16	799.0	988.6	1118.0	1.00	0.50	0.10	0.02	0.05	0.10	0.00	0.00	0.47	3.91	6.04	8.66	0.00	0.00	0.25	33.5	171.0	476.7	0.05	0.00	0.85
	D21	944 0	1179.0	1637.0	1.00	0.83	0.20	0.02	0.04	0.07	0.00	0.00	0.50	3.76	5.28	7.18	0.00	0.00	0.20	21.4	120.3	362.5	0.02	0.00	0.95
	Weldona	897.7	1052.0	1189.0	1.00	0.73	0.09	0.01	0.03	0.06	0.00	0.00	0.51	4.18	5.52	7.00	0.00	0 00	0.16	5.1	75 7	259.5	0.01	0.00	1.21
2A	D3	302.4	461.2	621.7	0.34	0.00	0.22	0.05	0.35	0.98	0.00	0.00	0.95	3.99	5.49	7.24	0.00	0.00	0.18	122.7	390.3	841.5	0.30	0.01	0.62
	D5	513.5	664.3	820.0	0.96	0.00	0.14	0.08	0.25	0.66	0.00	0.00	0.80	7.12	9.79	12.17	0.00	0.00	0.16	188.9	387.7	701.4	0.23	0.00	0.42
	D16	774.1	971.1	1102.0	1.00	0.43	0.11	0.02	0.05	0.09	0.00	0.00	0.46	3.80	5.75	8.11	0.00	0.00	0.24	32.4	167.7	472.1	0.04	0.00	0.86
	D21	932.4	1167.0	1625.0	1.00	0.79	0.20	0.02	0.04	0.07	0.00	0.00	0.49	3.68	5.07	6.78	0.00	0.00	0.19	20.7	118 0	359.2	0.02	0.00	0.96
	Weldona	889.5	1043.0	1183.0	1.00	0.69	0.09	0.01	0.03	0.05	0.00	0.00	0.49	4.10	5.37	6.79	0.00	0.00	0.16	4.9	74.3	256.6	0 01	0.00	1.22
2B	D3	289.1	445.5	607.1	0.29	0.00	0.22	0.05	0.35	0.98	0.00	0.00	0.95	3.80	5.18	6.77	0.00	0.00	0.18	118.1	384.9	837.7	0.30	0.01	0.63
	D5	482.9	622.0	780.9	0.91	0.00	0.14	0.08	0.24	0.66	0.00	0.00	0.82	6.65	9.03	11.17	0.00	0.00	0.15	183.2	378.3	694.3	0.21	0.00	0.44
	D16	748.5	953.6	1087.0	1.00	0.37	0.11	0.02	0.05	0.08	0.00	0.00	0.45	3.69	5.45	7.57	0.00	0.00	0.23	31.3	164.3	467.5	0.04	0.00	0.87
	D21	919.2	1154.0	1614.0	1.00	0.75	0.20	0.02	0.04	0.06	0.00	0.00	0.47	3.58	4.85	6.38	0.00	0.00	0.18	19.9	115.8	356.0	0.01	0.00	0.98
	Weldona	880.0	1035.0	1177.0	1.00	0.65	0.10	0.01	0.03	0.05	0.00	0.00	0.48	4.01	5.23	6.61	0.00	0.00	0.16	4.7	72.9	253.9	0.01	0.00	1.23
2C	D3	274.8	429.8	592.8	0.24	0.00	0.23	0.04	0.35	0.98	0.00	0.00	0.96	3.61	4.87	6.30	0.00	0.00	0.17	113.5	379.4	833.8	0.29	0.01	0.64
	D5	451 7	579.7	743.3	0.75	0.00	0.15	0.07	0.24	0.65	0.00	0.00	0.85	6.18	8.28	10.17	0.00	0.00	0.14	177.0	369.0	687.2	0.20	0.00	0.45
	D16	723.1	936.1	1073.0	1.00	0.31	0.12	0.02	0.04	0.08	0.00	0.00	0.44	3.58	5.15	7.04	0.00	0.00	0.21	30.1	161.0	462.9	0.04	0.00	0.89
	D21	905.6	1141.0	1602.0	1.00	0.71	0.21	0.02	0.03	0.06	0.00	0.00	0.46	3.48	4.64	5.99	0.00	0.00	0.17	19.2	113.5	352.6	0.01	0.00	0.99
	Weldona	869 2	1027.0	1172.0	1.00	0.61	0.10	0.01	0.03	0.05	0.00	0.00	0.46	3.92	5.09	6.46	0.00	0.00	0.16	4.6	71.4	251.2	0.01	0.00	1.25
2D	D3	260.1	414 2	578 3	0.20	0.00	0.24	0.04	0.35	0.98	0.00	0.00	0.96	3.40	4.55	5.85	0.00	0.00	0.17	108.8	374.0	830.1	0.29	0.01	0.65
	D5	419.0	537.3	706.3	0.46	0.00	0.17	0.07	0.23	0.65	0.00	0.00	0.87	5.69	7.52	9.18	0.00	0.00	0.14	170.6	359.7	680.5	0.19	0.00	0.46
	D16	697 0	918.6	1061.0	1.00	0.26	0.13	0.02	0.04	0.07	0.00	0.00	0.43	3.46	4.85	6.51	0.00	0.00	0.20	28.9	157.7	458.6	0.04	0.00	0.90
	D21	891.7	1129.0	1591.0	1.00	0.67	0.21	0.02	0.03	0.06	0.00	0.00	0.44	3.37	4.42	5.60	0.00	0.00	0.15	18.5	111.2	349.1	0.01	0.00	1.00
	Weldona	857.9	1019.0	1168.0	1.00	0.57	0.10	0.01	0.02	0.04	0.00	0.00	0.44	3.81	4.95	6.35	0.00	0.00	0.16	4 4	70.0	248.7	0.01	0.00	1.26
2E	D3	244.9	398.5	564.4	0.17	0.00	0.25	0.04	0.35	0.98	0.00	0.00	0.96	3.18	4.24	5.41	0.00	0.00	0.16	104.0	368.6	826.4	0.28	0.01	0.66
	D5	383.0	495.0	671.4	0.35	0.00	0.18	0.06	0.23	0.65	0.00	0.00	0.89	5.19	6.77	8.20	0.00	0.00	0.13	163.9	350.4	674.0	0.18	0.00	0.48
	D16	670.7	901.1	1050.0	0.99	0.22	0.13	0.02	0.04	0.06	0.00	0.00	0.41	3.33	4.56	5.99	0.00	0.00	0.18	27.7	154.4	454.4	0.04	0.00	0.92
	D21	876.4	1116.0	1581.0	1.00	0.62	0.21	0.01	0.03	0.05	0.00	0.00	0.42	3.24	4.20	5.23	0.00	0.00	0.14	17.7	108.9	345.7	0.01	0.00	1.02
	Weldona	845.6	1011.0	1163.0	1.00	0.54	0.10	0.01	0.02	0.04	0.00	0.00	0.43	3.70	4.81	6.28	0.00	0.00	0.17	4.2	68.6	246.1	0.01	0.00	1.28
3	D3	293.1	457.5	623.8	0.34	0.00	0 22	0.04	0 33	0.94	0.00	0.00	0.96	3.92	5.54	7.48	0.00	0.00	0.20	118.7	376.7	814.8	0.28	0.01	0.61
	D5	526.6	690.8	850.7	0.97	0.00	0 14	0 08	0.25	0.66	0.00	0.00	0.79	7.38	10.27	12.96	0.00	0.00	0.17	189.8	390.2	699.0	0.23	0.00	0.42
	D16	776.0	972.5	1108.0	1.00	0.44	0.11	0 02	0.05	0.10	0.00	0.00	0.45	3.98	6.06	8.57	0.00	0.00	0.24	36.3	174.4	474.4	0.05	0.00	0.82
	D21	925 9	1160.0	1603.0	1.00	0.79	0.20	0.02	0 04	0.08	0.00	0.00	0.48	3.85	5.31	7.14	0.00	0.00	0.19	23.6	123.8	362.7	0.02	0.00	0.92
	Weldona	891.5	1045.0	1184.0	1.00	0.70	0.09	0.01	0 03	0.06	0.00	0.00	0.51	4.21	5.51	6.96	0.00	0.00	0 16	6 8	78 6	261.1	0.01	0.00	1.16
4A	D3	309.9	464.0	613.2	0.35	0.00	0.20	0.05	0.33	0.92	0.00	0.00	0.94	4.09	5.73	7.67	0.00	0.00	0.19	126.8	380.1	797.2	0.28	0.01	0.59
	D5	534.0	698.4	847.2	0.98	0.00	0.14	0.09	0.24	0.62	0.00	0.00	0.76	7.48	10.50	13.16	0.00	0.00	0.16	194.2	385.7	672.9	0.21	0.00	0.40
	D16	790.7	958.5	1078.0	1.00	0.33	0 10	0.02	0.05	0.10	0.00	0.00	0.47	3.80	5.97	8.61	0.00	0.00	0.26	33.3	164.8	451.8	0.04	0.00	0.83
	D21	909.5	1133.0	1566.0	1.00	0.69	0.19	0.02	0 04	0.07	0.00	0.00	0.50	3.66	5.17	7.11	0.00	0.00	0.21	21.2	115.9	343.6	0.01	0.00	0.93
	Weldona	859.1	1001.0	1126.0	1.00	0.51	0.09	0.01	0.03	0.06	0.00	0.00	0.52	4.01	5.30	6.79	0.00	0.00	0.16	5.0	72.8	246.9	0.01	0.00	1.19
4B	D3	303.6	451.2	591.4	0.29	0.00	0.20	0.05	0.31	0.86	0.00	0.00	0.93	4.00	5.65	7.64	0.00	0.00	0.20	126.3	364.4	749.2	0.25	0.01	0.56
	D5	524.8	690.2	834.9	0.97	0.00	0.14	0.09	0.23	0.58	0.00	0.00	0.74	7.38	10.45	13.15	0.00	0.00	0.17	193.6	374.5	638.1	0.18	0.00	0.38
	D16	778.3	928.4	1046.0	1.00	0.22	0.09	0.02	0.05	0.10	0.00	0.00	0.48	3.68	5.89	8.57	0.00	0.00	0.26	33.0	158.7	426.9	0.03	0.00	0.81
	D21	870.5	1088.0	1495.0	1.00	0.58	0.19	0.02	0.04	0.07	0.00	0.00	0.51	3.53	5.06	7.03	0.00	0.00	0.22	21.1	111.4	324.8	0.01	0.00	0.91
	Weldona	815.0	951.4	1066.0	1.00	0.29	0.09	0.01	0.03	0.06	0.00	0.00	0.54	3.83	5.09	6.61	0.00	0.00	0.17	4.9	70.0	234.4	0.00	0.00	1.16
4C	D3	296.1	438.4	571.3	0.23	0.00	0 19	0.05	0 29	0.79	0.00	0.00	0.92	3.89	5.57	7.60	0.00	0.00	0.21	125.7	348.7	700.9	0.22	0.00	0.54
	D5	515.0	682.0	825.2	0.96	0.00	0.14	0.08	0.22	0.54	0.00	0.00	0.71	7.27	10.40	13.13	0.00	0.00	0.17	192.9	363.2	603.4	0.15	0.00	0.36
	D16	758.7	898.2	1023.0	1.00	0 19	0.09	0 02	0.05	0.10	0.00	0.00	0.48	3.56	5.81	8.53	0.00	0.00	0.27	32.7	152.5	402.5	0.02	0.00	0.79
	D21	827.5	1042.0	1426.0	1.00	0.50	0.19	0.02	0 04	0.07	0.00	0.00	0.51	3.39	4.95	6.96	0.00	0.00	0.23	20.9	106.9	306.0	0.01	0.00	0.88
	Weldona	766.6	901.3	1015.0	1.00	0.23	0.09	0.01	0.03	0.05	0.00	0.00	0.55	3.64	4.88	6.46	0.00	0.00	0.18	4.8	67.1	222.0	0.00	0.00	1.14
5	D3	477.8	646.2	797.4	0.85	0.00	0.15	0.07	0.27	0.72	0.00	0.00	0.83	7.01	9.81	12.59	0.01	0.00	0.18	117.6	327.0	661.3	0.17	0.00	0.53
	D5	509.0	666.9	831.6	0.96	0.00	0.15	0.09	0.27	0.70	0.00	0.00	0.78	7.04	9.64	12.28	0.00	0.00	0.17	199.8	409.1	730.9	0.27	0.00	0.42
	D16	776.3	972.9	1105.0	1.00	0.44	0.11	0.02	0.05	0.09	0.00	0.00	0.47	3.76	5.69	8.10	0.00	0.00	0.24	34.1	175.8	486.9	0.05	0 00	0.85
	D21	934.2	1168.0	1625.0	1.00	0.80	0.20	0.02	0.04	0.07	0.00	0.00	0.49	3.64	5.03	6.79	0.00	0.00	0.20	21.8	123.6	368.9	0.02	0.00	0.94
	Weldona	890.2	1045.0	1183.0	1.00	0.70	0.09	0.01	0.03	0.05	0.00	0.00	0.49	4.07	5.35	6.81	0.00	0.00	0.16	5.2	77.6	265.0	0.01	0.00	1.20

Notes: P_{vh}-Spatial and temporal-averaged probability of violation to the high criteria
P_{vl}-Spatial and temporal-averaged probability of violation to the low criteria

TABLE D-52. Space-Time Average and Standard Deviation of Ensemble Statistical Moments of Computed Water Quality Concentrations for Each Individual Management Strategy Applied during the May-Jun Season (Computed on the Major Diversion Canals)

Strategy		C_{TDS}						C_{NO_2}						C_N						C_{FC}					
		5%	Mean	95%	P_{vh}	P_{vl}	CV	5%	Mean	95%	P_{vh}	P_{vl}	CV	5%	Mean	95%	P_{vh}	P_{vl}	CV	5%	Mean	95%	P_{vh}	P_{vl}	CV
1	D3	212.1	455.8	908.9	0 34	0.02	0.53	0.02	0.24	0.87	0.00	0.00	1.19	1.44	3.76	9.00	0.23	0.02	0.65	87.6	911.3	2436.0	0.65	0.34	0.83
	D5	250.3	517.8	897.3	0.46	0.02	0.39	0.02	0.20	0.60	0.00	0.00	1.00	1.86	5.02	10.23	0.42	0.06	0.56	68.9	464.9	1194.0	0.36	0.09	0.84
	D16	422.0	967.4	1298.0	0.84	0.29	0.40	0.01	0.03	0.05	0.00	0.00	0.56	2.29	4.16	8.47	0.21	0.03	0.48	1.6	154.3	596.8	0.08	0.01	1.38
	D21	327.2	880.5	1187.0	0.79	0.28	0.39	0.01	0.04	0.08	0.00	0.00	0.44	2.24	4.14	7.40	0.26	0.01	0.42	9.5	356.1	1040.0	0.29	0.06	0.98
	Weldona	309.5	694.6	901.0	0.75	0.02	0.30	0.02	0.04	0.06	0.00	0.00	0.35	2.19	3.50	5.13	0.06	0.00	0.31	8.8	204.0	460.8	0.03	0.00	0.77
2A	D3	208.1	449.3	903.4	0.33	0.02	0.53	0.02	0.24	0.87	0.00	0.00	1.20	1.41	3.71	8.97	0.23	0.02	0.66	84.2	908.7	2434.0	0.65	0.34	0.83
	D5	236.6	493.0	869.0	0.41	0.01	0.40	0.02	0.20	0.60	0.00	0.00	1.01	1.78	4.87	10.10	0.40	0 06	0.57	66.1	460.4	1191.0	0.36	0.09	0.85
	D16	418.6	960.4	1295.0	0.84	0.28	0.41	0.01	0.03	0.05	0.00	0.00	0.54	2.32	4.15	8.40	0.20	0.03	0.48	1.9	153.6	595.1	0.08	0.01	1.38
	D21	326.1	876.8	1185.0	0.78	0.28	0.39	0.01	0.04	0.08	0.00	0.00	0.44	2.24	4.13	7.37	0.26	0.01	0.42	9.4	355.8	1039.0	0.29	0.06	0.98
	Weldona	308.3	692.3	897.5	0.75	0.02	0.30	0.02	0.04	0.06	0.00	0.00	0.35	2.19	3.49	5.10	0.06	0.00	0.31	8.7	203.8	460.5	0.03	0.00	0.77
2B	D3	204.0	442.9	898.2	0.33	0.01	0.54	0.02	0.24	0.86	0.00	0.00	1.22	1.39	3.67	8.95	0.23	0.02	0.67	80.8	906.1	2432.0	0.65	0.34	0.83
	D5	222.8	468.2	843.9	0.36	0.01	0.41	0.02	0.20	0.60	0.00	0.00	1.02	1.69	4.72	9.97	0.39	0.05	0.59	63.4	455.9	1187.0	0.35	0.09	0.86
	D16	414.5	953.4	1291.0	0.83	0.28	0.41	0.01	0.03	0.05	0.00	0.00	0.53	2.35	4.13	8.34	0.20	0.03	0.48	2.2	152.8	593.4	0.08	0.01	1.38
	D21	324.8	873.1	1183.0	0.78	0.27	0.39	0.01	0.04	0.08	0.00	0.00	0.44	2.25	4.12	7.35	0.26	0.01	0.42	9.3	355.4	1039.0	0.29	0.06	0.98
	Weldona	307 0	690.2	894.1	0.75	0.02	0.30	0.02	0.04	0.06	0.00	0.00	0.35	2.19	3.48	5.08	0.06	0.00	0.31	8.6	203.6	460.2	0.03	0.00	0.77
2C	D3	199.8	436.4	893.0	0.33	0.01	0.55	0.02	0.23	0.86	0.00	0.00	1.23	1.36	3.63	8.92	0.23	0.02	0.68	77.1	903.4	2431.0	0.65	0.34	0.84
	D5	208.8	443.4	819.8	0.31	0.01	0.43	0.02	0.20	0.60	0.00	0.00	1.03	1.60	4.57	9.84	0.37	0.05	0.61	60.6	451.4	1184.0	0.35	0.09	0.87
	D16	409.9	946.3	1288.0	0.82	0.27	0.41	0.01	0.03	0.05	0.00	0.00	0.53	2.36	4.11	8.28	0.19	0.03	0.47	2.6	152.1	591.8	0.08	0.01	1.39
	D21	323.5	869.5	1181.0	0.78	0.27	0.40	0.01	0.04	0.08	0.00	0.00	0.44	2.25	4.11	7.32	0.26	0.01	0.42	9.2	355.1	1039.0	0.29	0.06	0.98
	Weldona	305.7	687.9	890.6	0.74	0.02	0.30	0.02	0.04	0.06	0.00	0.00	0.35	2.19	3.48	5.06	0.06	0.00	0.31	8.6	203.4	460.0	0.03	0.00	0.77
2D	D3	195.5	429.9	888.0	0.33	0.01	0.56	0.02	0.23	0.86	0.00	0.00	1.25	1.33	3.58	8.89	0.22	0.02	0.70	73.4	900.8	2429.0	0.65	0.34	0.84
	D5	194.8	418.6	796.7	0.28	0.00	0.45	0.02	0.20	0.60	0.00	0.00	1.04	1.52	4.43	9.72	0.36	0.05	0.63	57.7	446.9	1181.0	0.35	0.09	0.88
	D16	405.0	939.3	1284.0	0.81	0.27	0.42	0.01	0.03	0.05	0.00	0.00	0.52	2.37	4.09	8.22	0.19	0.02	0.47	3.0	151.4	590.2	0.08	0.01	1.39
	D21	322.2	865.8	1179.0	0.77	0.26	0.40	0.01	0.04	0.08	0.00	0.00	0.44	2.25	4.10	7.30	0.26	0.01	0.41	9.1	354.7	1038.0	0.29	0.06	0.98
	Weldona	304.4	685.7	887.3	0.74	0.02	0.30	0.02	0.04	0.06	0.00	0.00	0.35	2.19	3.47	5.04	0.05	0.00	0.31	8.5	203.2	459.8	0.03	0.00	0.77
2E	D3	190.8	423.4	883.1	0.32	0.01	0.57	0.02	0.23	0.86	0.00	0.00	1.26	1.30	3.54	8.87	0.22	0.02	0.71	69.7	898.2	2427.0	0.64	0.33	0.84
	D5	180.3	393.8	775.5	0.25	0.00	0.48	0.02	0.19	0.59	0.00	0.00	1.05	1.43	4.28	9.60	0.35	0.04	0.66	54.5	442.4	1178.0	0.34	0.09	0.89
	D16	400.2	932.3	1281.0	0.80	0.26	0.42	0.01	0.03	0.05	0.00	0.00	0.52	2.37	4.07	8.15	0.19	0.02	0.47	3.4	150.6	588.6	0.08	0.01	1.40
	D21	320.8	862.2	1178.0	0 77	0.26	0.40	0.01	0.04	0.08	0.00	0.00	0.44	2.25	4.09	7.28	0.25	0.01	0.41	9.0	354.4	1038.0	0.29	0.06	0.98
	Weldona	303.2	683.5	883.9	0.74	0.02	0 30	0.02	0.04	0.06	0.00	0.00	0.35	2.19	3.47	5.02	0.05	0.00	0.31	8.4	203.0	459.5	0.03	0.00	0.77
3	D3	198.5	420.0	852.0	0.30	0.01	0.53	0.02	0.22	0.81	0.00	0.00	1.21	1.36	3.47	8.41	0.20	0.02	0.66	81.3	859.2	2302.0	0.63	0.31	0.84
	D5	254.7	503.2	863.6	0.43	0.01	0.38	0.02	0.20	0.58	0.00	0.00	1.00	1.88	4.84	9.84	0.40	0.05	0.55	72.8	468.0	1181.0	0.37	0.09	0.82
	D16	421.8	943.1	1231.0	0.84	0.23	0.36	0.01	0.03	0.06	0.00	0.00	0.56	2.35	4.17	8.35	0.21	0.02	0.47	6.6	171.3	613.4	0.09	0.01	1.26
	D21	331.2	869.7	1156.0	0.79	0.24	0.37	0.01	0.04	0.07	0.00	0.00	0.44	2.28	4.12	7.31	0.26	0.01	0.41	11.0	348.7	990.6	0 28	0.05	0.95
	Weldona	311.8	695.1	883.0	0.76	0.02	0.32	0.02	0.04	0.06	0.00	0.00	0.35	2.21	3.51	5.18	0.06	0.00	0.31	10.2	212.9	470 1	0.04	0.00	0.75
4A	D3	205.8	440.2	859.0	0.33	0.01	0 51	0.02	0.23	0.81	0.00	0.00	1.18	1.40	3.58	8.45	0.22	0.01	0.64	86.9	855.1	2278.0	0.63	0.31	0.82
	D5	249.2	508.5	864.4	0.45	0.01	0.38	0.02	0.19	0.57	0.00	0.00	0.99	1.86	4.84	9.68	0.40	0.04	0.54	68.1	439.0	1118.0	0.34	0.08	0.83
	D16	402.5	941.6	1296.0	0.82	0.29	0.44	0.01	0.03	0.05	0.00	0.00	0.55	2.28	4.02	8.05	0.19	0.02	0.47	1.4	144.9	559.5	0.07	0.01	1.37
	D21	312.7	850.4	1163.0	0.78	0.24	0.39	0.01	0.04	0.07	0.00	0.00	0.43	2.17	3.95	6.98	0.23	0.01	0.41	9.0	333.3	972 9	0.27	0.05	0.98
	Weldona	295.8	663.2	885.5	0.71	0.02	0.31	0.02	0.04	0.06	0.00	0.00	0.34	2.11	3.31	4.84	0.05	0.00	0.31	8.3	190.7	430.7	0.02	0.00	0.77
4B	D3	199.3	424.6	809.6	0.31	0.01	0.49	0.02	0.22	0.76	0.00	0.00	1.16	1.36	3.41	7.90	0.20	0.01	0.62	86.3	798.8	2120.0	0.61	0.28	0.82
	D5	247.8	499.3	832.3	0.44	0.01	0.37	0.02	0.18	0.53	0.00	0.00	0.97	1.85	4.66	9.13	0.38	0.03	0.52	67.2	413.0	1043.0	0.31	0.06	0.82
	D16	382.4	915.7	1294 0	0.80	0.28	0.44	0.01	0.03	0.05	0.00	0.00	0.54	2.26	3.87	7.64	0.17	0.02	0.45	1.3	135.6	522.2	0.06	0.00	1.37
	D21	298.0	820.4	1143.0	0.76	0.20	0.39	0.01	0.04	0.07	0.00	0.00	0.42	2.10	3.75	6.57	0.19	0.00	0.40	8.5	310.5	905.9	0.24	0.04	0.98
	Weldona	281.9	631.8	872.7	0.64	0 02	0.32	0.02	0.04	0.06	0.00	0.00	0.33	2.03	3.13	4.56	0.04	0.00	0.31	7.9	177.4	400.7	0.02	0 00	0.77
4C	D3	192.7	409.0	760.7	0.29	0.01	0.46	0.02	0.20	0.70	0.00	0.00	1.14	1.31	3.24	7.35	0.18	0.01	0.59	85.7	742.5	1962.0	0.57	0.25	0.81
	D5	246.3	490.0	803.4	0.43	0.00	0.36	0.02	0.17	0.49	0.00	0.00	0.96	1.84	4.48	8.59	0.36	0.02	0.50	66.2	387.1	967.3	0.28	0.05	0.80
	D16	361.9	890.0	1292.0	0.78	0.28	0.45	0.01	0.03	0.05	0.00	0.00	0.53	2.22	3.73	7.23	0.16	0.01	0.44	1.1	126.2	484.8	0.05	0.00	1.36
	D21	283.0	790.3	1127.0	0.75	0.17	0.40	0.01	0.04	0.06	0.00	0.00	0.41	2.01	3.56	6.17	0.15	0.00	0.39	7.9	287.7	839.0	0.21	0.03	0 97
	Weldona	267.7	600.4	859.2	0.54	0.02	0.33	0.02	0.03	0.05	0.00	0.00	0.32	1.93	2.94	4.29	0.03	0.00	0.30	7.4	164.0	370.7	0.01	0.00	0.77
5	D3	416.9	715.1	1050.0	0.81	0.11	0.30	0.03	0.20	0.71	0.00	0.00	1.17	2.94	4.99	8.70	0.41	0.02	0.38	124.1	762.2	2044.0	0.57	0.25	0 81
	D5	216.6	476.0	869.9	0.37	0.01	0.43	0.02	0.20	0.60	0.00	0.00	1.00	1.69	4.80	10.05	0.40	0.06	0.59	69.7	488.7	1245.0	0.39	0.11	0.83
	D16	414.9	956.2	1293.0	0.83	0.28	0.41	0.01	0.03	0.05	0.00	0.00	0.55	2.26	4.11	8.36	0.20	0.03	0.49	2.0	160.0	610.0	0.08	0.01	1.36
	D21	325.1	874.6	1185.0	0.78	0.27	0.39	0.01	0.04	0.08	0.00	0.00	0.44	2.21	4.11	7.36	0.26	0.01	0.42	9.8	359.1	1043.0	0.30	0.06	0.97
	Weldona	307.3	691.0	896.0	0.75	0.02	0.30	0.02	0.04	0 06	0.00	0.00	0.35	2.17	3.48	5.09	0.06	0.00	0.31	9.1	205.8	463.7	0.04	0.00	0.76

Notes: P_{vh}-Spatial and temporal-averaged probability of violation to the high criteria
P_{vl}-Spatial and temporal-averaged probability of violation to the low criteria

TABLE D-53. Space-Time Average and Standard Deviation of Ensemble Statistical Moments of Computed Water Quality Concentrations for Each Individual Management Strategy Applied during the Jul-Aug Season (Computed on the Major Diversion Canals)

		C_{TDS}						C_{NO_3}						C_N						C_{FC}					
Strategy		5%	Mean	95%	P_{vh}	P_{vl}	CV	5%	Mean	95%	P_{vh}	P_{vl}	CV	5%	Mean	95%	P_{vh}	P_{vl}	CV	5%	Mean	95%	P_{vh}	P_{vl}	CV
1	D3	256.1	497.6	748.3	0.48	0.00	0.32	0.02	0.34	1.16	0.00	0.00	1.17	1.62	5.13	13.32	0.36	0.15	0.78	244.9	1289.0	2621.0	0.86	0.63	0.57
	D5	309.6	514.0	670.3	0.54	0.00	0.28	0.09	0.35	0.90	0.00	0.00	0.77	2.65	5.62	10.46	0.49	0.07	0.45	432.5	773.2	1205.0	0.89	0.15	0.32
	D16	586.8	1119.0	1614.0	0.97	0.67	0.29	0.00	0.02	0.06	0.00	0.00	1.12	5.39	7.68	10.28	0.96	0.08	0.20	33.4	104.4	197.2	0.00	0.00	0.51
	D21	407.8	816.1	1113.0	0.87	0.20	0.29	0.01	0.02	0.03	0.00	0.00	0.42	4.89	7.97	11.04	0.94	0.14	0.24	219.8	785.8	1593.0	0.67	0.29	0.57
	Weldona	637.8	895.5	1045.0	0.98	0.15	0.15	0.01	0.03	0.05	0.00	0.00	0.36	4.31	6.11	8.70	0.80	0.01	0.23	190.9	460.8	722.1	0.41	0.00	0.36
2A	D3	244.8	481.2	729.4	0.45	0 00	0.33	0.02	0.33	1.16	0.00	0.00	1.17	1.56	5.02	13.22	0.35	0.15	0.79	240.1	1285.0	2618.0	0.86	0.62	0.57
	D5	291.1	488.7	643.4	0.46	0.00	0.29	0.09	0.35	0.89	0.00	0.00	0.78	2.49	5.38	10.23	0.45	0.06	0.47	427.7	767.9	1200.0	0.89	0.15	0.32
	D16	582.0	1113.0	1611.0	0.97	0.66	0.30	0.00	0.02	0.06	0.00	0.00	1 08	5.42	7.68	10 27	0.97	0.08	0.20	35.7	105.6	197.6	0.00	0.00	0.49
	D21	406.3	813.0	1111.0	0.86	0.19	0.29	0.01	0.02	0.03	0.00	0.00	0.41	4.89	7.98	11.04	0.94	0.14	0.24	220.2	786.3	1594.0	0.67	0.29	0.57
	Weldona	636.2	893.8	1043.0	0.98	0.15	0.15	0.01	0.03	0.05	0.00	0.00	0.35	4.31	6.11	8.69	0.80	0.01	0.22	191.2	461.0	722.3	0.41	0.00	0.36
2B	D3	233.2	464.8	710.9	0.42	0.00	0.33	0.02	0.33	1.16	0.00	0.00	1.17	1.50	4.92	13.12	0.35	0.14	0.81	235.2	1282.0	2615.0	0.86	0.62	0.57
	D5	272.6	463.5	616.9	0.37	0.00	0.30	0.09	0.34	0.89	0.00	0.00	0.79	2.33	5.14	10.00	0.42	0.05	0.49	422.6	762.7	1195.0	0.88	0.14	0.32
	D16	577.3	1107.0	1608.0	0.97	0.65	0.30	0.00	0.02	0.06	0.00	0.00	1.04	5.44	7.69	10.27	0.97	0.08	0.20	38.0	106.9	198.0	0.00	0.00	0.48
	D21	404.8	809.9	1109.0	0.86	0.18	0.29	0.01	0.02	0.03	0.00	0.00	0.41	4.90	7.98	11.04	0.94	0.14	0.24	220.6	786.7	1594.0	0.68	0.29	0.57
	Weldona	634.7	892.2	1042.0	0.98	0.15	0.15	0.01	0.03	0.05	0.00	0.00	0.35	4.31	6.11	8.68	0.80	0.01	0.22	191.5	461.2	722.4	0.41	0.00	0.36
2C	D3	221.4	448.5	692.8	0.39	0.00	0.34	0.02	0.33	1.16	0.00	0.00	1.18	1.43	4.81	13.01	0.34	0.14	0.83	230.3	1278.0	2612.0	0.86	0.62	0.57
	D5	253.8	438.2	591.1	0.29	0.00	0.31	0.08	0.34	0.88	0.00	0.00	0.81	2.17	4.90	9.77	0.39	0.05	0.51	416.9	757.5	1190.0	0.87	0.14	0.32
	D16	572.4	1101.0	1605.0	0.97	0.63	0.30	0.00	0.02	0.06	0.00	0.00	1.00	5.45	7.70	10.27	0.97	0.08	0.20	40.2	108.1	198.4	0.00	0.00	0.47
	D21	403.2	806.8	1106.0	0.86	0.17	0.29	0.01	0.02	0.03	0.00	0.00	0.40	4.90	7.98	11.04	0.94	0.14	0.24	221.0	787.2	1594.0	0.68	0.29	0.57
	Weldona	633.0	890.5	1041.0	0.98	0.14	0.16	0.01	0.03	0.05	0.00	0.00	0.35	4.32	6 10	8.67	0.80	0.01	0.22	191.8	461.4	722.5	0.41	0.00	0.36
2D	D3	209.4	432.1	675.8	0.36	0.00	0.35	0.02	0.33	1.16	0.00	0.00	1.18	1.37	4.70	12.91	0.34	0.14	0.85	225.6	1274.0	2609.0	0.86	0.62	0.58
	D5	235.2	413.0	565.7	0.21	0.00	0.33	0.08	0.33	0.88	0.00	0.00	0.82	2.01	4 66	9.54	0.37	0.04	0.54	411.3	752.2	1185.0	0.87	0.14	0.33
	D16	567.6	1095.0	1602.0	0.97	0.62	0.30	0.00	0.02	0.06	0.00	0.00	0.96	5.45	7.71	10.27	0.97	0.08	0.20	42.4	109.4	198.8	0.00	0.00	0 46
	D21	401.7	803.7	1104.0	0.86	0.17	0.29	0.01	0.02	0.03	0.00	0.00	0.40	4.91	7.98	11.05	0.94	0.14	0.24	221.5	787.7	1595.0	0.68	0.29	0.57
	Weldona	631.4	888.8	1039.0	0.98	0.14	0.16	0.01	0.03	0.05	0.00	0.00	0.35	4.32	6.10	8.65	0.80	0.01	0.22	192.0	461 5	722.6	0.41	0.00	0.36
2E	D3	197.1	415.8	658.9	0.33	0.00	0.36	0.02	0.33	1.16	0.00	0.00	1.18	1.30	4.60	12.81	0.33	0.13	0.87	220.6	1271.0	2607.0	0.85	0.61	0.58
	D5	216.4	387.7	541.1	0.16	0.00	0.35	0.08	0.33	0.87	0.00	0.00	0.83	1.84	4.43	9.31	0.34	0.04	0.57	405.4	747.0	1181.0	0.86	0.13	0.33
	D16	562.4	1089.0	1598.0	0.97	0.61	0.31	0.00	0.02	0.06	0.00	0.00	0.91	5.44	7.72	10.28	0.97	0.08	0.20	44.6	110.7	199.1	0.00	0.00	0.45
	D21	400.2	*800.6*	*1102.0*	*0.86*	*0.16*	*0.29*	*0.01*	*0.02*	*0.03*	*0.00*	*0.00*	*0.39*	4.92	7.99	*11.05*	*0.94*	*0.14*	0.24	221.9	788.2	*1595.0*	*0.68*	*0.29*	*0.57*
	Weldona	629.8	887.2	1038.0	0.98	0.14	0.16	0.01	0.03	0.05	0.00	0.00	0.34	4.32	6.10	8.64	0.80	0.01	0.22	192.3	461.7	722.7	0.41	0.00	0.36
3	D3	240.9	457.5	687.4	0.39	0.00	0.31	0.02	0.30	1.04	0.00	0.00	1.17	1.53	4.66	12.04	0.33	0.11	0.77	221.7	1197.0	2463.0	0.84	0.57	0.58
	D5	305.2	498.2	649.5	0.49	0.00	0.27	0.09	0.34	0.86	0.00	0.00	0.77	2.59	5.41	10.11	0.46	0.06	0.45	414.2	757.2	1192.0	0.87	0.14	0.32
	D16	551.1	1051.0	1529.0	0.96	0.58	0.31	0.00	0.02	0.07	0.00	0.00	1.00	5.21	7.52	10.09	0.95	0.07	0.20	38.7	110.4	200.6	0.00	0.00	0.47
	D21	420.1	815 4	1101.0	0.87	0.18	0.29	0.01	0.02	0.03	0.00	0.00	0.43	4.80	7.78	10.76	0.93	0.12	0.24	212.1	701.1	1390 0	0.63	0.21	0.55
	Weldona	612.8	869.2	1023.0	0.98	0.11	0.16	0.01	0.03	0.04	0.00	0.00	0.34	4.33	6.11	8.57	0.81	0.01	0.22	185.0	459.9	718.1	0.41	0.00	0.36
4A	D3	254.8	487.6	723.3	0.47	0.00	0.31	0.02	0.31	1.08	0.00	0.00	1.17	1.60	4.92	12.56	0.35	0.13	0.76	242.3	1214.0	2456.0	0.85	0.59	0.56
	D5	309.3	506.0	653.4	0.52	0.00	0.27	0.09	0.34	0.84	0.00	0.00	0.75	2.64	5.48	9.98	0.47	0.05	0.43	426.2	749.6	1152.0	0.88	0.12	0.31
	D16	580.9	1101.0	1582.0	0.97	0.64	0.29	0.00	0.02	0.06	0.00	0.00	1.14	5.35	7.40	9.76	0.96	0.05	0.19	32.6	98 9	185.5	0.00	0.00	0.50
	D21	402.9	801.7	1099.0	0.86	0.17	0.29	0.01	0.01	0.03	0.00	0.00	0.42	4.72	7.56	10.39	0.92	0.09	0.23	207.0	736.7	1493.0	0.64	0 25	0.57
	Weldona	612.9	854.0	1004.0	0.98	0.09	0.15	0.01	0.03	0.05	0.00	0.00	0.36	4.07	5.76	8.21	0.69	0.01	0.22	179.4	430.6	674.4	0.32	0.00	0.36
4B	D3	253.3	477.7	699.3	0.45	0.00	0.30	0.02	0.29	1.01	0.00	0.00	1.16	1.57	4.71	11.80	0.34	0.11	0.73	239.4	1140.0	2292.0	0.84	0.54	0.55
	D5	308.9	498.0	637.5	0.49	0.00	0.26	0.09	0.32	0.79	0.00	0.00	0.73	2.63	5.33	9.52	0.46	0.04	0.41	419.4	726.1	1101.0	0.87	0.10	0.29
	D16	573.4	1083.0	1554.0	0.97	0.60	0.29	0.00	0.02	0.05	0.00	0.00	1.16	5.30	7.12	9.23	0.95	0.04	0.17	31.9	93.4	173.8	0.00	0.00	0.49
	D21	397.8	787.4	1085.0	0.85	0.15	0.29	0.01	0.01	0.02	0.00	0.00	0.42	4.56	7.15	9.73	0.89	0.06	0.22	194.2	687.5	1393.0	0.61	0.20	0.57
	Weldona	587.9	812.5	969.0	0.97	0.07	0.15	0.01	0 03	0.04	0.00	0.00	0.36	3.82	5.40	7.71	0.55	0.01	0.22	167.8	400.3	626.6	0.23	0.00	0.36
4C	D3	251.9	467.8	676.9	0.42	0.00	0 29	0.02	0 27	0.93	0.00	0.00	1.15	1.55	4.50	11.03	0.32	0.08	0.71	236.6	1065.0	2127.0	0.83	0.48	0.54
	D5	308.4	490.0	622.9	0.46	0.00	0.24	0.09	0.31	0.74	0.00	0.00	0.71	2.62	5.18	9.05	0.44	0.03	0.39	410.8	702.5	1051.0	0.85	0.08	0.28
	D16	563.6	1064.0	1532.0	0.97	0.57	0.29	0.00	0.02	0.05	0.00	0.00	1.17	5.23	6.85	8.71	0.93	0.03	0.16	31.1	87.9	162.2	0.00	0.00	0.49
	D21	392.4	773.0	1072.0	0.85	0.13	0.28	0.00	0.01	0.02	0.00	0.00	0.43	4.39	6.74	9.07	0.85	0.05	0.21	181.4	638.4	1292.0	0.56	0.16	0.57
	Weldona	561.7	771.0	936.6	0.97	0.06	0.16	0.01	0.03	0.04	0.00	0.00	0.36	3.57	5.05	7.21	0.44	0.00	0.22	156 3	370.0	578.8	0.17	0.00	0.36
5	D3	405.5	607.8	789.3	0.79	0.00	0.20	0.07	0.31	0.85	0.00	0.00	0.85	3.21	6.25	11.77	0.62	0.12	0.46	230.4	953 3	1946.0	0.79	0.38	0.56
	D5	299.1	505.3	666.8	0.51	0.00	0.29	0.09	0.35	0.89	0.00	0.00	0.78	2.51	5.51	10.39	0.47	0.07	0.46	435.9	786.4	1229.0	0.90	0.17	0.32
	D16	584.7	1117.0	1613.0	0.97	0.67	0.30	0.00	0.02	0.06	0.00	0.00	1.13	5.38	7.65	10.27	0.96	0.08	0.20	33.6	104.7	197.5	0.00	0.00	0.51
	D21	407.0	815.2	1113.0	0.87	0.19	0.29	0.01	0.02	0.03	0.00	0.00	0.42	4.88	7.96	11.04	0.94	0.14	0.24	219.9	785.9	1593.0	0.67	0.29	0.57
	Weldona	637.2	895.0	1044.0	0.98	0.15	0.15	0.01	0.03	0.05	0.00	0.00	0.36	4.30	6.10	8.69	0.79	0.01	0.22	191.1	460.9	722.2	0.41	0.00	0.36

Notes: P_{vh}-Spatial and temporal-averaged probability of violation to the high criteria
P_{vl}-Spatial and temporal-averaged probability of violation to the low criteria

TABLE D-54. Space-Time Average and Standard Deviation of Ensemble Statistical Moments of Computed Water Quality Concentrations for Each Individual Management Strategy Applied during the Sep-Oct Season (Computed on the Major Diversion Canals)

Strategy		C_{TDS}						C_{NO_3}						C_N						C_{FC}					
		5%	Mean	95%	P_{vh}	P_{vl}	CV	5%	Mean	95%	P_{vh}	P_{vl}	CV	5%	Mean	95%	P_{vh}	P_{vl}	CV	5%	Mean	95%	P_{vh}	P_{vl}	CV
1	D3	305.2	405.1	494 5	0.04	0.00	0.14	0.03	0.10	0.26	0.00	0.00	0.73	2.40	3.46	4.81	0.00	0.00	0.22	126.6	365 5	980.5	0.18	0.05	0.79
	D5	507.1	693 3	856.3	0.95	0.00	0.15	0.21	0.34	0.54	0.00	0.00	0.32	6.47	8.81	10.79	0.00	0.00	0.15	244.7	387.6	577.9	0.13	0.00	0.28
	D16	509.9	877.2	980.4	0.95	0.04	0.58	0.01	0.06	0.12	0.00	0.00	0.64	4.60	5.84	7.33	0.00	0.00	0.15	0.0	13.9	45.1	0.00	0.00	1.24
	D21	614.6	861.8	971.0	0.98	0.04	0.40	0.01	0.04	0.07	0.00	0.00	0.63	4.73	5.93	7.35	0.00	0.00	0.14	2.9	135.7	441.1	0.04	0.00	1.15
	Weldona	272.2	612.2	824.9	0.64	0.01	0.57	0.01	0.02	0.04	0.00	0.00	0.45	2.32	4.37	6.07	0.00	0.00	0.27	1.7	381.5	962.1	0.39	0.04	0.91
2A	D3	291.9	387.0	472.9	0.02	0.00	0.14	0.03	0.10	0.26	0.00	0.00	0.74	2.32	3.36	4.70	0.00	0.00	0.23	122.7	360.5	976.3	0.18	0.05	0.80
	D5	471.6	643.3	792.7	0.92	0.00	0.15	0.19	0.32	0.52	0.00	0.00	0.34	6.01	8.15	9.96	0.00	0.00	0.15	239.8	381.3	570.5	0.12	0.00	0.28
	D16	496.2	864.6	969.6	0.95	0.04	0.59	0.01	0.05	0.12	0.00	0.00	0.65	4.55	5.72	7.09	0.00	0.00	0.14	0.0	14.0	45.0	0.00	0.00	1.22
	D21	609.6	853.8	963.2	0.98	0.03	0.40	0.01	0.04	0.07	0.00	0.00	0.63	4.68	5.85	7.25	0.00	0.00	0.14	3.0	135.7	441.1	0.04	0.00	1.15
	Weldona	270.9	606.7	814.4	0.63	0.01	0.58	0.01	0.02	0.04	0.00	0.00	0.44	2.31	4.31	5.96	0.00	0.00	0.27	1.8	381.5	962.1	0.39	0.04	0.91
2B	D3	278.4	368.9	452.0	0.01	0.00	0.14	0.03	0.10	0.26	0.00	0.00	0.74	2.24	3.26	4.59	0.00	0.00	0.23	118.9	355.5	972.0	0.17	0.05	0.81
	D5	436.0	593.4	729.1	0.84	0.00	0.15	0.18	0.30	0.50	0.00	0.00	0.36	5.55	7 49	9.13	0.00	0.00	0.15	235.0	375.0	563.3	0.11	0.00	0.29
	D16	482.3	852.0	959.4	0.94	0.04	0.60	0.01	0.05	0.11	0.00	0.00	0.65	4.49	5.60	6.86	0.00	0.00	0.13	0.0	14.2	44.9	0.00	0 00	1.20
	D21	604.1	845.8	956.3	0.98	0.03	0.41	0.01	0.03	0.07	0.00	0.00	0.63	4.63	5.77	7.16	0.00	0.00	0.14	3.1	135.8	441.2	0.04	0.00	1.15
	Weldona	269.6	601.3	804.4	0.62	0.01	0.58	0.01	0.02	0.04	0.00	0.00	0.43	2.30	4.26	5.86	0.00	0.00	0.26	1.8	381.5	962.1	0.39	0.04	0.91
2C	D3	264.8	350 9	431 6	0.01	0.00	0.14	0.03	0.10	0.26	0.00	0.00	0.74	2.16	3.15	4.48	0.00	0.00	0.24	115.0	350.5	967.9	0.17	0.05	0.82
	D5	400.3	543.4	665.5	0.64	0.00	0.15	0.16	0.28	0.48	0.00	0.00	0.39	5.09	6.83	8.30	0.00	0.00	0.14	230 1	368.7	556.6	0.11	0.00	0.29
	D16	468.4	839.3	950 2	0.94	0.04	0.61	0.01	0.05	0.11	0.00	0.00	0.66	4.41	5.47	6.67	0.00	0.00	0.13	0.0	14.3	44.7	0.00	0.00	1.18
	D21	598.0	837.8	950.9	0.98	0.03	0.40	0.01	0 03	0.07	0.00	0 00	0.63	4.56	5.69	7.09	0.00	0.00	0.14	3.1	135.8	441 3	0.04	0 00	1.15
	Weldona	268.2	595.8	795.1	0.61	0.01	0.58	0.01	0.02	0.04	0 00	0.00	0.42	2.29	4.20	5.77	0.00	0.00	0.26	1.9	381.6	962.1	0.39	0.04	0.91
2D	D3	250.7	332.8	411.7	0.01	0.00	0.15	0.03	0.10	0.26	0.00	0.00	0.75	2.07	3.05	4.37	0.00	0.00	0.24	111.1	345.5	963.7	0.17	0.05	0.84
	D5	364.6	493.5	601.9	0.33	0.00	0.14	0.15	0.26	0.47	0.00	0.00	0.42	4.63	6.16	7.47	0.00	0.00	0.14	225.3	362.4	550.5	0.10	0.00	0.29
	D16	452.7	826.7	941.8	0.93	0.04	0.62	0.01	0.05	0.11	0.00	0.00	0.67	4.32	5.35	6.51	0.00	0.00	0.13	0.0	14.4	44.6	0.00	0.00	1.16
	D21	591.7	829.8	945.6	0.98	0.03	0.40	0.01	0.03	0.07	0.00	0.00	0.63	4.47	5.61	7.02	0.00	0.00	0.14	3.2	135.9	441.3	0.04	0.00	1.15
	Weldona	266.8	590.3	786.4	0.61	0.01	0.58	0.01	0.02	0.04	0.00	0.00	0.42	2.28	4.15	5.68	0.00	0.00	0.26	1.9	381.6	962.1	0.39	0.04	0.91
2E	D3	236.3	314.7	392.6	0.01	0.00	0.15	0.03	0.10	0.26	0.00	0.00	0.75	1.98	2.95	4.27	0.00	0.00	0.25	107.0	340.5	959.6	0.17	0.05	0.85
	D5	328.5	443.5	538.7	0.19	0.00	0.14	0.14	0.24	0.45	0.00	0.00	0.46	4.17	5.50	6.64	0.00	0.00	0.13	219.9	356.1	544.3	0.09	0.00	0.30
	D16	437.3	814.1	933.7	0.92	0.04	0.64	0.01	0.05	0.11	0.00	0.00	0.68	4.20	5.23	6.39	0.00	0.00	0.13	0.0	14.6	44.4	0.00	0.00	1.14
	D21	583.9	821.8	940.8	0.98	0.03	0.42	0.01	0.03	0.06	0.00	0.00	0.63	4.37	5.53	6.98	0.00	0.00	0.15	3.3	135.9	441.4	0.04	0.00	1.15
	Weldona	265.3	584.9	777.8	0.60	0.01	0.58	0.01	0.02	0.04	0.00	0.00	0.41	2.26	4.09	5.60	0.00	0.00	0 26	1.9	381.6	962.2	0.39	0.04	0 91
3	D3	294.9	387.6	472 0	0.02	0.00	0.14	0.03	0 10	0.24	0.00	0.00	0.72	2.33	3.29	4.52	0.00	0.00	0.21	122.0	351.0	939.5	0.17	0.05	0.79
	D5	500.3	679.8	836.5	0.95	0.00	0.15	0.21	0 34	0.53	0.00	0.00	0.32	6.36	8.60	10.48	0.00	0.00	0 15	238.9	380.2	570.5	0.12	0.00	0.28
	D16	507.1	874.7	976.3	0.95	0.04	0.59	0.01	0.06	0.12	0.00	0.00	0.63	4.62	5.86	7.32	0.00	0.00	0.14	0.0	14.9	46.8	0.00	0.00	1.20
	D21	613.3	859.7	961.3	0.98	0.03	0.40	0.01	0.04	0.08	0.00	0.00	0.61	4.75	5.92	7.32	0.00	0.00	0.14	3.1	131.2	422.6	0.03	0.00	1.14
	Weldona	284.4	617.5	822.3	0.65	0.01	0 56	0.01	0 03	0.05	0.00	0.00	0.45	2.44	4.41	6.06	0.00	0.00	0.26	1.9	374.2	946.2	0.38	0.04	0 92
4A	D3	301.4	401.5	492.0	0.04	0.00	0.14	0.03	0.10	0.24	0.00	0.00	0.72	2.38	3.43	4.80	0.00	0.00	0.22	126.0	351.7	924.8	0.17	0.04	0 76
	D5	506.0	692.3	855.7	0.95	0.00	0.15	0.21	0.33	0.52	0.00	0.00	0.31	6.45	8.81	10.79	0.00	0.00	0.15	243.9	383.4	563.4	0.12	0.00	0.27
	D16	504.3	848.0	934.2	0.95	0.03	0.56	0.01	0.05	0.11	0.00	0.00	0.63	4.47	5.75	7.29	0.00	0.00	0.15	0.0	13.2	42.9	0.00	0.00	1.25
	D21	593.3	834.1	944.6	0.98	0.03	0.41	0.01	0.04	0.07	0.00	0.00	0.63	4.59	5.72	7.09	0.00	0.00	0.14	2.7	127.1	412.9	0.03	0.00	1.15
	Weldona	259.2	589.5	797.9	0.61	0.01	0.59	0.01	0.02	0.04	0.00	0.00	0.46	2.20	4.20	5.85	0.00	0.00	0.28	1.6	356.8	899.1	0.35	0.03	0.91
4B	D3	297.2	397.9	489.6	0.04	0.00	0.15	0.03	0.09	0.23	0.00	0.00	0.69	2.35	3.41	4.78	0.00	0.00	0.23	125.3	338.0	869.4	0.15	0.04	0.73
	D5	504.8	691.4	855.1	0.95	0.00	0.15	0.20	0.33	0.50	0.00	0.00	0.29	6.43	8.80	10.78	0.00	0.00	0.15	243.0	379.2	550.4	0.11	0.00	0.26
	D16	497.0	818.8	891.7	0.95	0.03	0.53	0.01	0.05	0.10	0.00	0.00	0.63	4.34	5.65	7.25	0.00	0.00	0.16	0.0	12 5	40.8	0.00	0.00	1.27
	D21	570.8	806.3	920.6	0.97	0.02	0.39	0.01	0.03	0.07	0.00	0.00	0.64	4.43	5.51	6.83	0.00	0.00	0.14	2 5	118.5	384.8	0.02	0.00	1.15
	Weldona	246.3	566.8	773.7	0.57	0.01	0.57	0.01	0.02	0.04	0.00	0.00	0.47	2.08	4.03	5.64	0.00	0.00	0.28	1.5	332.1	836.1	0.31	0.02	0.91
4C	D3	292.9	394 3	487.5	0.03	0.00	0.15	0.03	0 09	0.22	0.00	0.00	0 67	2.31	3.38	4.76	0.00	0.00	0.23	124.7	324.3	814.0	0.14	0.03	0.70
	D5	503.5	690.4	854 5	0.95	0.00	0.15	0.20	0.33	0.49	0.00	0.00	0.28	6.40	8.79	10.78	0.00	0.00	0.15	242.1	375.0	539.1	0.10	0.00	0 25
	D16	487.6	789.6	855.1	0.95	0.03	0.50	0.01	0.05	0.10	0.00	0.00	0.62	4.19	5.56	7.22	0.00	0.00	0.17	0.0	11.7	38.8	0.00	0.00	1.29
	D21	547.2	778.5	899.3	0.96	0.02	0.41	0.01	0.03	0.07	0.00	0.00	0.64	4.25	5.31	6.59	0.00	0.00	0.14	2.3	110.0	356.7	0.02	0.00	1.15
	Weldona	233.0	544.1	751.9	0.54	0.01	0.56	0.01	0.02	0.04	0.00	0.00	0.48	1.96	3.86	5.45	0.00	0.00	0.29	1.4	307.3	773.2	0.26	0.02	0.91
5	D3	559.4	711.9	866.1	0.81	0.02	0.13	0.19	0.29	0.43	0.00	0.00	0.32	6.59	8.67	10.72	0.00	0.00	0.16	123.7	295.2	696.6	0.11	0.02	0.65
	D5	451.3	619.5	773.2	0.88	0.00	0.16	0.29	0.47	0.70	0.00	0.00	0.28	5.50	7.56	9.50	0.00	0.00	0.16	230.8	380.6	591.4	0.14	0.00	0.31
	D16	491.8	859.6	964.8	0.95	0.04	0.60	0.00	0.05	0.11	0.00	0.00	0.68	4.41	5.55	6.89	0.00	0.00	0.14	0.0	13.9	45.3	0.00	0.00	1.25
	D21	607.2	850.6	962.1	0.98	0.03	0.40	0.01	0.03	0.07	0.00	0.00	0.65	4.57	5.74	7.15	0.00	0.00	0.14	2.9	135.7	441.1	0.04	0.00	1.15
	Weldona	270.3	604.4	810.7	0.63	0 01	0.58	0.01	0.02	0.04	0.00	0.00	0.43	2.29	4.24	5.84	0.00	0.00	0.26	1.7	381.5	962.1	0.39	0.04	0.91

Notes: P_{vh}-Spatial and temporal-averaged probability of violation to the high criteria
P_{vl}-Spatial and temporal-averaged probability of violation to the low criteria

TABLE D-55. Space-Time Average and Standard Deviation of Ensemble Statistical Moments of Computed Water Quality Concentrations for Each Individual Management Strategy Applied during the Nov-Dec Season (Computed on the Major Diversion Canals)

		C_{TDS}						C_{NO_2}						C_N						C_{FC}					
Strategy		5%	Mean	95%	P_{vh}	P_{vl}	CV	5%	Mean	95%	P_{vh}	P_{vl}	CV	5%	Mean	95%	P_{vh}	P_{vl}	CV	5%	Mean	95%	P_{vh}	P_{vl}	CV
1	D3	301.2	451.2	619.0	0.32	0.00	0.22	0.08	0.38	0.86	0.00	0.00	0.71	5.33	6.83	8.43	0.00	0.00	0.14	121.1	1476 0	3765.0	0.63	0.53	0.87
	D5	590.5	731.3	872.1	1.00	0.00	0.12	0.27	0.42	0.60	0.00	0.00	0.24	7.95	10.78	13.49	0.01	0.00	0.16	205.5	807.5	1830.0	0 59	0.34	0.69
	D16	635.2	902.1	1250.0	1.00	0.27	0.22	0.00	0.02	0.03	0.00	0.00	0.61	3.69	6.13	10.38	0.03	0.00	0.54	15.2	269.8	818.7	0.17	0.02	1.01
	D21	569.1	829.6	1171.0	0.99	0.19	0.23	0 00	0.04	0.11	0.00	0.00	1.13	3.67	6.06	9.10	0.02	0.00	0.42	16.6	227.1	662.2	0.11	0.01	0.96
	Weldona	587.4	826.8	1151.0	1.00	0.16	0.21	0.00	0.05	0.13	0.00	0.00	1.05	3.26	5.69	8.57	0.01	0.00	0.41	16.9	413.8	1167.0	0.34	0.10	0.95
2A	D3	284.5	430.7	598.5	0.25	0.00	0.23	0.08	0.37	0.86	0.00	0.00	0.72	5.02	6.48	8.09	0.00	0.00	0.15	117.2	1472.0	3762.0	0.63	0.53	0.88
	D5	546.1	679.6	815.2	0.99	0.00	0.12	0.25	0.39	0.56	0.00	0.00	0.24	7.37	9.98	12.48	0.00	0.00	0.16	199.5	798.7	1823.0	0.58	0.33	0.70
	D16	622.8	882.4	1225.0	1.00	0.24	0.22	0.00	0.02	0.03	0.00	0.00	0.59	3.67	6.03	10.29	0.03	0.00	0.55	16.2	269.2	817.4	0.17	0.02	1.02
	D21	560.3	814.9	1150.0	0.99	0.17	0.23	0.00	0.04	0.11	0.00	0.00	1.10	3.64	5.98	9.02	0.02	0.00	0.42	17.2	226.7	661.2	0.11	0.01	0.96
	Weldona	579.8	814.4	1131.0	1.00	0.15	0.21	0.00	0.05	0.13	0.00	0.00	1.05	3.25	5.63	8.48	0.01	0.00	0.42	17.3	413.5	1167.0	0.34	0.10	0.95
2B	D3	267.8	410.2	578.5	0.19	0.00	0.24	0.07	0.37	0.85	0 00	0.00	0.73	4.71	6.13	7.77	0.00	0.00	0.16	113.2	1469.0	3760.0	0.63	0.53	0.88
	D5	501.6	627.9	761.8	0.93	0.00	0.13	0.23	0.36	0.52	0.00	0.00	0.25	6.78	9.18	11.48	0.00	0.00	0.16	193.3	789.8	1815.0	0.58	0.33	0.71
	D16	609 5	862 6	1200.0	1.00	0.21	0.22	0.00	0.01	0.03	0.00	0.00	0.58	3.66	5.93	10.25	0.03	0.00	0.56	17.4	268.6	816.1	0.17	0.02	1.02
	D21	551.5	800.2	1129.0	0.99	0.15	0.23	0.00	0.04	0.10	0.00	0.00	1.07	3.58	5.91	8.98	0.02	0.00	0.43	17.6	226.3	660.2	0.11	0.01	0.96
	Weldona	572.3	802.0	1111.0	0.99	0.13	0.21	0.00	0.05	0.13	0.00	0.00	1.06	3.23	5.56	8.43	0.01	0.00	0.42	17.7	413.1	1167.0	0.34	0.10	0.95
2C	D3	250.9	389.7	558.7	0.15	0.00	0.25	0.07	0.37	0.85	0.00	0.00	0.74	4.38	5.78	7.46	0.00	0.00	0.17	109.1	1465.0	3757.0	0.63	0.53	0.88
	D5	457.1	576.2	711.8	0.72	0.00	0.14	0.21	0.33	0.48	0.00	0.00	0.25	6.18	8.38	10.47	0.00	0.00	0.16	187.0	781.0	1808.0	0.57	0.33	0.72
	D16	595.0	842.9	1175.0	1.00	0.18	0.22	0.00	0.01	0.03	0.00	0.00	0.57	3 63	5.83	10.24	0.03	0.00	0.58	18.6	268.0	814 8	0.17	0.02	1.02
	D21	542.5	785.5	1109.0	0.98	0.13	0.23	0.00	0.03	0.09	0.00	0.00	1.03	3.51	5 83	8.96	0.02	0.00	0.44	18.1	225.8	659.3	0.11	0.01	0.96
	Weldona	564.6	789.6	1091.0	0.99	0.12	0.21	0.00	0.04	0.13	0.00	0.00	1.07	3.21	5.50	8.39	0.01	0.00	0 43	18.1	412.7	1167.0	0.34	0.10	0.95
2D	D3	233.7	369.2	539.3	0.12	0.00	0.26	0.07	0.36	0.85	0.00	0.00	0.75	4.05	5.43	7.15	0.00	0.00	0.18	105.0	1462.0	3755.0	0.63	0.53	0.88
	D5	412.4	524.5	665.7	0.44	0.00	0.15	0.19	0.30	0.44	0.00	0.00	0.26	5.59	7.58	9.48	0.00	0.00	0.16	180.3	772.2	1801.0	0.57	0.32	0.73
	D16	579.9	823.2	1151.0	1.00	0.16	0.22	0.00	0.01	0.03	0.00	0.00	0.56	3.59	5.73	10.26	0.03	0.00	0.59	19.7	267.4	813.6	0.17	0.02	1.02
	D21	533.3	770.8	1089.0	0.98	0.11	0.23	0.00	0.03	0.09	0.00	0.00	0.99	3.43	5.76	8.95	0.02	0.00	0.45	18.6	225.4	658.4	0.11	0.01	0.96
	Weldona	556.5	777.2	1072.0	0.99	0.10	0.21	0.00	0.04	0.13	0.00	0.00	1.08	3.18	5.44	8.37	0.01	0.00	0.44	18.4	412.4	1167.0	0.34	0.10	0.95
2E	D3	216.2	348.6	520.6	0.10	0.00	0.28	0.06	0.36	0.84	0.00	0.00	0.77	3.70	5.08	6.86	0.00	0.00	0 20	100.6	1458.0	3752.0	0.63	0.53	0.89
	D5	367.5	472.8	622.1	0.33	0.00	0.17	0.17	0.27	0.40	0.00	0.00	0.27	4.99	6.78	8.51	0.00	0.00	0.16	173.5	763.4	1793.0	0.56	0.32	0.74
	D16	564.4	803.5	1128.0	0.99	0.14	0.22	0.00	0.01	0.03	0.00	0.00	0.55	3.52	5.63	10.30	0.03	0.00	0.61	20.7	266.8	812.3	0.17	0.02	1.02
	D21	524.0	756.1	1070.0	0.97	0.10	0.23	0.00	0.03	0.08	0.00	0.00	0.94	3.34	5.69	8.96	0.02	0.00	0.46	19.1	225.0	657.4	0.11	0.01	0.96
	Weldona	547.6	764.9	1055.0	0.99	0.09	0.21	0.00	0.04	0.13	0.00	0.00	1.09	3.13	5.38	8.37	0.01	0.00	0.45	18.7	412.0	1166.0	0.34	0.10	0.95
3	D3	294.3	437.2	604.2	0.26	0.00	0.22	0.08	0.36	0.83	0.00	0 00	0.71	5.07	6.56	8.18	0.00	0.00	0.15	115.8	1408 0	3600.0	0.63	0 52	0.88
	D5	579.1	718.8	858.1	1.00	0.00	0.12	0.26	0.41	0.58	0.00	0.00	0.24	7.83	10.59	13.27	0.01	0.00	0.16	203.0	817.6	1864.0	0.59	0 35	0.70
	D16	633.2	892.3	1230.0	1.00	0.25	0.21	0.00	0.02	0.03	0.00	0.00	0.60	3.75	6.15	10.30	0.03	0.00	0.52	18.6	283.8	848.5	0.19	0.03	1.00
	D21	568.6	823.6	1157.0	0.99	0.18	0.22	0.00	0.04	0.11	0.00	0.00	1.09	3.74	6.08	9.06	0.02	0.00	0.41	18.9	237.8	686.3	0.12	0.01	0.95
	Weldona	586.5	821.5	1138.0	1.00	0.15	0.21	0.00	0.05	0.13	0.00	0.00	1.03	3.30	5.70	8.55	0.01	0.00	0.41	19.0	419.0	1161.0	0.35	0.10	0.93
4A	D3	299.5	444.4	602.7	0.29	0.00	0.21	0.08	0.36	0.81	0.00	0.00	0.70	5.27	6.71	8.21	0.00	0.00	0.14	120.1	1387.0	3526.0	0.63	0.52	0.87
	D5	589.4	727.2	865.0	1.00	0.00	0.12	0.27	0.42	0.59	0.00	0.00	0.24	7.91	10.74	13.44	0.01	0.00	0.16	204.5	768.5	1721.0	0.58	0.31	0.68
	D16	615.7	888.6	1245.0	1.00	0.26	0.22	0.00	0.02	0.03	0.00	0.00	0.61	3.57	6.02	10.30	0.03	0.00	0.55	14.9	254.8	768.1	0.16	0.02	1.01
	D21	554.7	819.0	1167.0	0.99	0.18	0.23	0.00	0.04	0.11	0.00	0.00	1.15	3.60	5.89	8.96	0.02	0.00	0.43	16.3	214.1	621.0	0.10	0.01	0.95
	Weldona	568.1	808 9	1138.0	0.99	0.15	0.22	0.00	0.04	0.13	0.00	0.00	1.04	3.13	5.51	8.41	0.01	0.00	0.43	16.7	388.1	1091.0	0.32	0.08	0.95
4B	D3	297.4	437.6	587.1	0.27	0.00	0.21	0.08	0.34	0.76	0.00	0.00	0.68	5.21	6.58	8.00	0.00	0.00	0.13	119.0	1299.0	3288.0	0.62	0.51	0.86
	D5	588.2	723.2	859.3	1.00	0.00	0.12	0.27	0.42	0.59	0.00	0.00	0.24	7.88	10.69	13.40	0.01	0.00	0.16	203.5	729.5	1612.0	0.57	0.28	0.66
	D16	595.9	875.0	1241.0	1.00	0.24	0 23	0.00	0.01	0 03	0.00	0.00	0.62	3.45	5.91	10.24	0.03	0.00	0.57	14 7	239.7	717.5	0.14	0.01	1.00
	D21	540.1	808.4	1162.0	0.98	0.17	0.24	0.00	0.04	0.11	0.00	0.00	1.17	3.52	5.72	8.83	0.02	0.00	0.45	15 9	201.0	579.9	0.08	0.00	0 94
	Weldona	547.7	791.1	1126.0	0.98	0.14	0.23	0.00	0.04	0.12	0.00	0.00	1.04	2.99	5.32	8.26	0.01	0.00	0.45	16.4	362.4	1016.0	0.30	0.06	0 94
4C	D3	295.3	430.8	572.5	0.24	0.00	0.20	0.08	0.32	0.71	0.00	0.00	0.66	5.13	6.46	7.82	0.00	0.00	0.13	117.9	1210.0	3049.0	0.61	0.48	0.86
	D5	586.2	719.2	854.6	1.00	0.00	0.11	0.27	0.41	0.58	0.00	0.00	0.24	7.84	10.65	13.36	0.01	0.00	0.16	202.4	690.5	1502.0	0.55	0.24	0.64
	D16	576.0	861.5	1237.0	0.99	0.23	0.24	0.00	0.01	0.03	0.00	0.00	0.64	3.32	5.80	10.17	0.03	0.00	0.59	14.3	224.6	667.3	0.12	0.01	0.98
	D21	525.3	797.8	1158.0	0.97	0.16	0.25	0.00	0.04	0.11	0.00	0.00	1.19	3.42	5.55	8.72	0.02	0.00	0.46	15.5	188.0	538.9	0.07	0.00	0.93
	Weldona	525.9	773.2	1115.0	0.97	0.13	0.24	0.00	0.04	0.11	0 00	0.00	1.03	2.84	5.14	8.13	0.01	0.00	0.47	16.1	336.7	939.6	0.27	0.04	0.93
5	D3	518.1	671.2	830.1	0.85	0.00	0.15	0.14	0.34	0.64	0.00	0.00	0.49	8.41	10.27	12.40	0.00	0.00	0.12	124.8	999.1	2511.0	0.58	0.41	0.83
	D5	489.3	642.4	796.8	0.91	0.00	0.15	0.22	0.34	0.49	0.00	0.00	0.25	6.90	9.32	11.65	0.00	0.00	0.15	211.8	952.5	2204.0	0.62	0.41	0.73
	D16	611.5	868.4	1209.0	1.00	0.22	0.22	0.00	0.01	0.03	0.00	0.00	0.62	3.48	5.72	9.93	0.03	0.00	0.58	16.1	323.4	983.7	0.23	0.05	1.02
	D21	553.6	804.5	1139.0	0 99	0.15	0.23	0.00	0.03	0.08	0.00	0.00	1.26	3.39	5.75	8.77	0.02	0.00	0.44	17.4	266.2	783.8	0.16	0.02	0.97
	Weldona	574.3	805.8	1119 0	0 99	0.14	0.21	0.00	0.04	0 13	0.00	0.00	1.22	3 12	5.42	8.23	0.01	0.00	0.43	17.7	444.9	1207.0	0.38	0.12	0.91

Notes P_{vh}-Spatial and temporal-averaged probability of violation to the high criteria
P_{vl}-Spatial and temporal-averaged probability of violation to the low criteria

TABLE D-56. Space-Time Average and Standard Deviation of Ensemble Statistical Moments of Computed Water Quality Concentrations for Each Combined Management Strategy Applied during the Jan-Feb Season (Computed on the Major Diversion Canals)

Strategy		C_{TDS}						C_{NO_2}						C_N						C_{FC}					
		5%	Mean	95%	P_{vh}	P_{vl}	CV	5%	Mean	95%	P_{vh}	P_{vl}	CV	5%	Mean	95%	P_{vh}	P_{vl}	CV	5%	Mean	95%	P_{vh}	P_{vl}	CV
1	D3	609.1	794.0	1006.0	1.00	0.06	0.16	0.06	0.57	1.33	0.00	0.00	0.76	5.22	6.78	8.52	0.00	0.00	0.15	195.2	769.9	1770.0	0.63	0.26	0.65
	D5	699.0	832.8	992.4	1.00	0.04	0.11	0.20	0.43	0.91	0.00	0.00	0.52	8.69	12.14	14.85	0.04	0.00	0.16	106.1	266.1	572.9	0.09	0.00	0.57
	D16	727.0	966.9	1121.0	1.00	0.46	0.12	0.01	0.07	0.16	0.00	0.00	0.68	4.29	7.00	9.57	0.00	0.00	0.23	27.4	167.0	318.3	0.00	0.00	0.54
	D21	884.4	979.8	1066.0	1.00	0.34	0.06	0.00	0.02	0.05	0.00	0.00	0.69	4.09	6.40	8.51	0.00	0.00	0.21	21.1	123.1	240.7	0.00	0.00	0.56
	Weldona	900.3	1056.0	1231.0	1.00	0.64	0.10	0.00	0.01	0.03	0.00	0.00	0.60	4.65	6.39	8.16	0.00	0.00	0.17	14.7	82.3	186.5	0.00	0.00	0.68
2E+3	D3	422.5	618.6	854.7	0.71	0.02	0.24	0.04	0.53	1.29	0.00	0.00	0.80	3.59	4.43	5.27	0.00	0.00	0.11	168.2	731.8	1724.0	0.60	0.24	0.68
	D5	447.6	589.3	793 0	0.61	0.01	0.20	0.13	0 36	0.85	0.00	0.00	0.66	5.53	7.48	9.04	0.01	0.00	0.14	94.1	250.5	557.9	0.08	0.00	0.61
	D16	593.0	859.5	1042.0	0 98	0.17	0.16	0.01	0.05	0.10	0.00	0.00	0.61	3.14	5.38	7.47	0.00	0.00	0.26	31.2	167.6	316.6	0.00	0.00	0.53
	D21	783.7	899.8	981.5	1.00	0.08	0.07	0 00	0.02	0.03	0.00	0.00	0.60	3.14	5.19	7.15	0.00	0.00	0.24	23.3	123.6	239.8	0.00	0.00	0.55
	Weldona	821.2	995.9	1195.0	1.00	0.48	0.12	0.00	0 01	0.02	0.00	0.00	0 54	3.67	5.50	7.16	0.00	0.00	0.19	15.5	82.6	186.1	0.00	0.00	0.67
6	D3	421.9	575.8	754.6	0.63	0.02	0.19	0.04	0.45	1.07	0.00	0.00	0.78	3.47	4.36	5.33	0.00	0.00	0.13	167.8	632.5	1434.0	0.53	0.17	0.64
	D5	446.7	555.8	702.5	0.50	0.01	0.15	0.13	0.31	0 71	0.00	0.00	0.59	5.46	7.49	9.11	0.01	0.00	0.15	91.9	221.1	467.2	0.04	0.00	0.55
	D16	569.0	755.0	877.3	0.98	0.11	0.12	0.01	0.05	0.10	0.00	0.00	0.63	2.99	4.88	6.62	0.00	0.00	0.23	26.1	137.0	257.8	0.00	0.00	0.53
	D21	*730.6*	*800.2*	*856.1*	*1.00*	*0.08*	*0.05*	*0.00*	*0.01*	*0.03*	*0.00*	*0.00*	*0.64*	*2.93*	*4.60*	*6.14*	*0.00*	*0.00*	*0.22*	*19.3*	*100.5*	*194.5*	*0.00*	*0 00*	*0.54*
	Weldona	737 6	856.6	996.1	1.00	0.18	0.10	0.00	0.01	0.02	0.00	0.00	0.56	3.37	4.74	6.04	0.00	0.00	0.17	12.5	67.0	150.7	0.00	0.00	0.67
2E+5	D3	441 4	572.1	731.1	0.63	0.01	0.16	0 09	0.41	0.95	0.00	0.00	0.71	5.28	6.47	7.79	0.00	0.00	0.12	120.4	498.0	1261.0	0.35	0.12	0.75
	D5	448.3	602.2	820.3	0.65	0.01	0.21	0.15	0.41	0.92	0.00	0.00	0.61	5.13	6.92	8.42	0.01	0.00	0.14	101.3	278.5	605.3	0.11	0.00	0.60
	D16	603.0	869.5	1051.0	0 99	0.19	0.16	0.01	0.04	0.09	0.00	0.00	0.64	2.84	5.14	7.30	0.00	0.00	0.28	33.7	172.3	324.2	0.00	0.00	0.52
	D21	794.1	907.9	989.5	1.00	0.09	0.07	0.00	0.01	0.03	0.00	0.00	0.63	2.90	5.01	7.03	0.00	0.00	0.26	24.7	126.3	244.4	0.00	0.00	0.54
	Weldona	828.7	1003.0	1201.0	1.00	0.49	0.12	0.00	0.01	0.02	0.00	0.00	0.57	3.44	5.37	7.09	0.00	0.00	0.21	15.8	84.2	189.5	0.00	0.00	0.67
3+4C	D3	575.3	720.8	879.3	1.00	0.02	0.13	0.06	0.46	1.06	0.00	0.00	0.73	4.89	6.49	8.26	0.00	0.00	0.16	188.0	637.2	1423.0	0.54	0.17	0.61
	D5	686 6	792.9	915.4	1.00	0.01	0.09	0.20	0.39	0.76	0.00	0.00	0.46	8.47	11.93	14.64	0.03	0.00	0.16	103.2	236.8	479.3	0.05	0.00	0.51
	D16	695.0	855.1	968.0	1.00	0.14	0.09	0.01	0.07	0.15	0.00	0.00	0.68	4.03	6.51	9.01	0.00	0.00	0.24	24.2	136 5	258.4	0.00	0.00	0.54
	D21	804.2	873.8	956.3	1.00	0.10	0.05	0.00	0.02	0.05	0.00	0.00	0.71	3.76	5.81	7.80	0.00	0.00	0.22	18.3	100.4	195.3	0.00	0.00	0.55
	Weldona	793.8	909.7	1035.0	1.00	0.21	0.08	0.00	0.01	0.03	0.00	0.00	0.64	4.09	5.63	7.32	0.00	0.00	0.18	12.2	67.0	151.4	0.00	0.00	0.68
3+5	D3	691.8	820.6	960.4	1.00	0.02	0.10	0.16	0.47	1.00	0.00	0.00	0.57	8.57	11.00	13.51	0.04	0.00	0.14	155.4	530.1	1278.0	0.38	0.13	0.68
	D5	669.6	806.4	977.0	1.00	0.03	0.12	0.22	0.49	0.97	0.00	0.00	0.49	7.74	10.63	13.21	0.01	0.00	0.16	110.7	288.5	611.4	0.11	0.00	0.57
	D16	714.9	954.4	1110.0	1.00	0.41	0.12	0.01	0.06	0.13	0.00	0.00	0.70	3.88	6.45	8.87	0.00	0.00	0.24	31.1	170.8	323.8	0.00	0.00	0.53
	D21	874.3	970.3	1056.0	1.00	0.27	0.06	0.00	0 02	0.04	0.00	0.00	0.72	3.75	5.98	8.06	0.00	0.00	0.22	23.4	125.6	244.4	0.00	0.00	0.55
	Weldona	891.1	1048.0	1224.0	1.00	0.61	0.10	0.00	0.01	0.02	0.00	0.00	0.60	4.33	6.08	7.79	0.00	0.00	0.18	15.4	84.0	189.4	0.00	0.00	0.67
4C+5	D3	686.6	801.6	929.7	1.00	0.02	0.09	0 16	0.43	0.86	0.00	0.00	0.51	8.49	11.11	13.73	0.05	0.00	0.14	151.8	471.2	1088.0	0.30	0.09	0.63
	D5	667.5	772.3	895.4	1.00	0.01	0.09	0.22	0.44	0.82	0.00	0.00	0.43	7.66	10.67	13.35	0.01	0.00	0.16	108.7	256.0	514.0	0.06	0.00	0.52
	D16	683 8	847.4	959.7	1.00	0 13	0.10	0.01	0.05	0.12	0.00	0.00	0.73	3.58	5.92	8.27	0.00	0.00	0.25	25.1	139.5	263.7	0.00	0.00	0.53
	D21	800.4	868.5	948.4	1 00	0.09	0.05	0.00	0.02	0.04	0.00	0.00	0.77	3.40	5.37	7.28	0.00	0.00	0.22	19.0	102 1	198.4	0.00	0.00	0.55
	Weldona	790.4	906.6	1033.0	1.00	0.21	0 08	0.00	0.01	0.02	0.00	0.00	0.64	3.82	5.30	6.88	0.00	0.00	0.18	12.4	68.0	153.8	0.00	0.00	0.68
2E+3+ 4C	D3	412.5	564.3	740.8	0.60	0.01	0.19	0.04	0.44	1.04	0.00	0.00	0.79	3 42	4.28	5.22	0.00	0.00	0.12	165.1	618.1	1410.0	0.51	0.16	0.64
	D5	445.2	554.2	700.5	0.49	0.01	0.15	0.13	0.31	0.70	0.00	0.00	0.59	5.42	7.42	9.01	0.01	0.00	0.15	91.8	221.1	466.0	0.04	0.00	0.55
	D16	567.2	751.4	873.7	0.98	0.11	0.12	0.01	0.05	0.10	0.00	0.00	0.62	3.01	4.88	6.60	0.00	0.00	0.23	26.9	137.1	257.3	0.00	0.00	0.52
	D21	727.1	796.9	853.0	1.00	0.08	0.05	0.00	0.02	0.03	0.00	0.00	0.63	2.94	4.60	6.13	0.00	0.00	0.22	19.8	100.7	194.5	0.00	0.00	0.54
	Weldona	734.4	853.3	992.5	1.00	0.18	0.10	0.00	0.01	0.02	0.00	0.00	0.55	3.38	4.73	6.02	0.00	0.00	0.17	12.7	67.2	150.8	0.00	0.00	0.67
2E+3+ 5	D3	437.5	566.9	724.7	0.60	0.01	0.16	0.09	0.40	0.95	0.00	0.00	0.71	5.21	6.38	7.68	0.00	0.00	0.12	121.1	494.6	1251.0	0.35	0.12	0.75
	D5	445.8	597.8	813.6	0.64	0.01	0.21	0 15	0.41	0.91	0.00	0.00	0.62	5.10	6.87	8.35	0.01	0.00	0.14	100.5	276.1	600.3	0.11	0.00	0.60
	D16	599.3	863.5	1045.0	0.98	0.18	0.16	0 01	0.04	0.09	0.00	0.00	0.63	2.86	5.13	7.27	0.00	0.00	0.28	34.3	171.9	323.3	0.00	0.00	0.52
	D21	788.7	902.9	985.4	1.00	0.09	0.07	0.00	0 01	0.03	0.00	0.00	0.62	2.91	5.00	7.01	0.00	0.00	0.26	25.1	126.2	244.1	0.00	0.00	0.54
	Weldona	823.0	998.2	1196.0	1 00	0.48	0.12	0.00	0.01	0.02	0.00	0.00	0.56	3.44	5.36	7.07	0.00	0.00	0.21	16.0	84.3	189.3	0.00	0.00	0.67
7	D3	436.9	543.0	664.7	0.48	0.01	0.13	0.09	0.36	0.80	0.00	0.00	0.65	5.11	6.39	7.77	0.00	0.00	0.13	118.4	435.1	1060.0	0.28	0.09	0.70
	D5	445.1	560.9	718.0	0.53	0.01	0 16	0.15	0 36	0.76	0.00	0.00	0.56	5.02	6.85	8.41	0.01	0.00	0.15	98.9	243.5	502.2	0.06	0.00	0.54
	D16	572.1	757.4	879.3	0.98	0.11	0.12	0 01	0.04	0.08	0.00	0.00	0.65	2.74	4.62	6.37	0.00	0.00	0.25	28.7	140.7	263.2	0.00	0.00	0.52
	D21	733.7	802.1	859.4	1.00	0.08	0.05	0.00	0.01	0.03	0.00	0.00	0.67	2.72	4.41	5.98	0.00	0.00	0.24	20.8	102.7	197 9	0.00	0.00	0.54
	Weldona	738.8	858.0	997.0	1.00	0.18	0.10	0.00	0.01	0.02	0.00	0.00	0.57	3.16	4.59	5.92	0.00	0.00	0.19	13.0	68.3	153.6	0.00	0.00	0.67
3+4C+ 5	D3	676.8	792.0	919.0	1.00	0.02	0.10	0.15	0.42	0.85	0.00	0.00	0.51	8.38	10.92	13.50	0.04	0.00	0.14	151.9	468.0	1080.0	0.30	0.09	0.62
	D5	660.9	765.7	888.2	1.00	0.01	0.09	0.22	0.44	0.82	0.00	0.00	0.43	7.60	10.56	13.20	0.01	0.00	0.16	107.8	253.9	510.0	0.06	0.00	0.52
	D16	681.3	843.8	955.1	1.00	0.13	0.09	0.01	0.06	0.12	0.00	0.00	0.72	3.63	5.94	8.25	0.00	0.00	0.24	25.9	139.4	263.0	0.00	0.00	0.53
	D21	798.1	865.5	944.0	1.00	0.09	0.05	0.00	0.02	0.04	0.00	0.00	0.76	3.44	5.39	7.28	0.00	0.00	0.22	19.5	102.2	198.2	0.00	0.00	0.55
	Weldona	788.1	903.6	1029.0	1.00	0.21	0.08	0.00	0.01	0.02	0.00	0.00	0.64	3.85	5.31	6.87	0.00	0.00	0.18	12.6	68.1	153.8	0.00	0.00	0.67
8	D3	432.8	538.2	659.5	0.45	0.01	0.13	0.09	0.35	0.80	0.00	0.00	0.65	5.04	6.30	7.66	0.00	0.00	0.13	119.0	432.5	1053.0	0.27	0.09	0.70
	D5	442.3	557.1	713.0	0.52	0.01	0.16	0.14	0.35	0.75	0.00	0.00	0.56	5.00	6.79	8.33	0.01	0.00	0.15	98.0	241.5	498.4	0.06	0.00	0.54
	D16	568.7	752.9	875.1	0.98	0.11	0.12	0 01	0.04	0.09	0.00	0.00	0.65	2.76	4.62	6.35	0.00	0.00	0.25	29.3	140.5	262.5	0.00	0.00	0.52
	D21	729.0	798.0	855.5	1.00	0.08	0.05	0.00	0 01	0.03	0.00	0.00	0.66	2.73	4.41	5.97	0.00	0.00	0.23	21.2	102.8	197.7	0.00	0.00	0.54
	Weldona	734.6	854.2	993.2	1 00	0.18	0.10	0.00	0.01	0.02	0.00	0.00	0.57	3.16	4.59	5.91	0.00	0.00	0.19	13.1	68.5	153.5	0.00	0.00	0.67

Notes: P_{vh}-Spatial and temporal-averaged probability of violation to the high criteria
P_{vl}-Spatial and temporal-averaged probability of violation to the low criteria

TABLE D-57. Space-Time Average and Standard Deviation of Ensemble Statistical Moments of Computed Water Quality Concentrations for Each Combined Management Strategy Applied during the Mar-Apr Season (Computed on the Major Diversion Canals)

Strategy		C_{TDS}						C_{NO_3}						C_N						C_{FC}					
		5%	Mean	95%	P_{vh}	P_{vl}	CV	5%	Mean	95%	P_{vh}	P_{vl}	CV	5%	Mean	95%	P_{vh}	P_{vl}	CV	5%	Mean	95%	P_{vh}	P_{vl}	CV
1	D3	315.4	476.8	636.9	0.41	0.00	0.21	0.05	0.35	0.98	0.00	0.00	0.95	4.19	5.80	7.72	0.00	0.00	0.19	127.2	395.8	845.4	0.31	0.02	0.61
	D5	542.8	706.6	862.8	0.98	0.00	0.14	0.09	0.25	0.66	0.00	0.00	0.78	7.58	10.54	13.17	0.00	0.00	0.16	194.8	397.0	708.4	0.24	0.00	0.41
	D16	799.0	988.6	1118.0	1.00	0.50	0.10	0.02	0.05	0.10	0.00	0.00	0.47	3.91	6.04	8.66	0.00	0.00	0.25	33.5	171.0	476.7	0.05	0.00	0.85
	D21	944.0	1179.0	1637.0	1.00	0.83	0.20	0.02	0.04	0.07	0.00	0.00	0.50	3.76	5.28	7.18	0.00	0.00	0.20	21.4	120.3	362.5	0.02	0.00	0.95
	Weldona	897.7	1052.0	1189.0	1.00	0.73	0.09	0.01	0.03	0.06	0.00	0.00	0.51	4.18	5.52	7.00	0.00	0.00	0.16	5.1	75.7	259.5	0.01	0.00	1.21
2E+3	D3	228.6	383.9	553.2	0.15	0.00	0.27	0.04	0.33	0.94	0.00	0.00	0.98	2.94	4.06	5.28	0.00	0.00	0.18	97.3	350.9	796.0	0.26	0.01	0.67
	D5	371.3	487.5	663.7	0.34	0.00	0.19	0.06	0.23	0.64	0.00	0.00	0.90	5.05	6.63	8.11	0.00	0.00	0.14	159.6	345.0	664.1	0.18	0.00	0.48
	D16	648.8	883.7	1040.0	0.99	0.19	0.14	0.02	0.04	0.06	0.00	0.00	0.40	3.35	4.54	5.94	0.00	0.00	0.17	29.9	157.2	452.0	0.04	0.00	0.89
	D21	852.6	1095.0	1544.0	1.00	0.58	0.21	0.01	0.03	0.05	0.00	0.00	0.42	3.28	4.20	5.19	0.00	0.00	0.14	19.4	111.9	346.8	0.01	0.00	0.98
	Weldona	833.7	1002.0	1158.0	1.00	0.50	0.11	0.01	0.02	0.04	0.00	0.00	0.43	3.70	4.78	6.21	0.00	0.00	0.17	5.5	71.1	247.4	0.01	0.00	1.23
6	D3	235.3	360.0	491.6	0.10	0.00	0.22	0.04	0.28	0.79	0.00	0.00	0.94	2.97	4.01	5.25	0.00	0.00	0.18	102.8	321.4	681.1	0.19	0.00	0.60
	D5	368.4	470.4	601.0	0.29	0.00	0.15	0.06	0.19	0.53	0.00	0.00	0.83	4.95	6.62	8.13	0.00	0.00	0.14	162.7	316.6	565.4	0.11	0.00	0.41
	D16	644.7	810.7	935.3	0.99	0.13	0.12	0.02	0.04	0.06	0.00	0.00	0.42	2.96	4.32	5.83	0.00	0.00	0.21	27.1	135.9	379.3	0.02	0.00	0.85
	D21	780.0	978.7	1371.0	1.00	0.38	0.20	0.01	0.03	0.05	0.00	0.00	0.44	2.95	3.87	4.97	0.00	0.00	0.16	17.3	95.6	288.8	0.01	0.00	0.95
	Weldona	735.7	860.3	967.9	1.00	0.19	0.09	0.01	0.02	0.04	0.00	0.00	0.45	3.23	4.18	5.27	0.00	0.00	0.15	4.0	60.1	207.2	0.00	0.00	1.21
2E+5	D3	318.7	426.5	531.0	0.13	0.00	0.15	0.05	0.25	0.70	0.00	0.00	0.94	4.48	5.85	7.28	0.00	0.00	0.15	86.1	274.5	618.6	0.13	0.00	0.65
	D5	366.8	487.2	670.0	0.35	0.00	0.20	0.07	0.25	0.68	0.00	0.00	0.87	4.91	6.40	7.85	0.00	0.00	0.14	169.7	368.1	700.6	0.22	0.00	0.48
	D16	665.2	898.0	1049.0	0.99	0.21	0.14	0.02	0.03	0.06	0.00	0.00	0.40	3.26	4.41	5.78	0.00	0.00	0.17	28.8	161.2	467.3	0.04	0.00	0.90
	D21	873.4	1114.0	1579.0	1.00	0.62	0.21	0.01	0.03	0.05	0.00	0.00	0.41	3.17	4.10	5.08	0.00	0.00	0.14	18.4	113.6	354.5	0.01	0.00	1.00
	Weldona	843.4	1009.0	1163.0	1.00	0.53	0.10	0.01	0.02	0.04	0.00	0.00	0.42	3.64	4.75	6.25	0.00	0.00	0.18	4.4	71.4	253.1	0.01	0.00	1.26
3+4C	D3	277.3	420.7	560.5	0.19	0.00	0.21	0.04	0.27	0.77	0.00	0.00	0.93	3.68	5.32	7.37	0.00	0.00	0.22	117.4	332.8	677.2	0.19	0.00	0.55
	D5	501.2	666.1	810.6	0.95	0.00	0.14	0.08	0.22	0.54	0.00	0.00	0.72	7.08	10.13	12.91	0.00	0.00	0.18	187.8	356.9	595.4	0.14	0.00	0.36
	D16	738.2	884.2	1010.0	1.00	0.17	0.10	0.02	0.05	0.10	0.00	0.00	0.47	3.62	5.83	8.44	0.00	0.00	0.26	35.5	155.6	400.1	0.02	0.00	0.76
	D21	817.7	1027.0	1400.0	1.00	0.47	0.19	0.02	0.04	0.07	0.00	0.00	0.50	3.47	4.99	6.92	0.00	0.00	0.22	23.1	110.0	306.4	0.01	0.00	0.85
	Weldona	768.9	896.9	1008.0	1.00	0.22	0.09	0.01	0.03	0.06	0.00	0.00	0.55	3.67	4.90	6.43	0.00	0.00	0.18	6.4	69.8	223.2	0.00	0.00	1.09
3+5	D3	460.4	627.4	781.4	0.84	0.00	0.16	0.06	0.26	0.70	0.00	0.00	0.84	6.75	9.47	12.33	0.01	0.00	0.18	114.9	319.2	647.5	0.16	0.00	0.54
	D5	494.6	652.9	819.7	0.94	0.00	0.15	0.09	0.26	0.68	0.00	0.00	0.78	6.87	9.42	12.07	0.00	0.00	0.17	193.0	399.3	716.9	0.25	0.00	0.42
	D16	753.4	956.6	1096.0	1.00	0.38	0.11	0.02	0.05	0.08	0.00	0.00	0.45	3.81	5.70	8.02	0.00	0.00	0.23	36.9	178.1	482.0	0.05	0.00	0.82
	D21	915.3	1149.0	1591.0	1.00	0.75	0.20	0.02	0.04	0.07	0.00	0.00	0.48	3.73	5.06	6.76	0.00	0.00	0.19	24.1	126.3	368.0	0.02	0.00	0.91
	Weldona	882.7	1037.0	1178.0	1.00	0.66	0.10	0.01	0.03	0.05	0.00	0.00	0.49	4.10	5.35	6.76	0.00	0.00	0.16	6.9	80.1	265.2	0.01	0.00	1.15
4C+5	D3	455.2	626.3	781.8	0.83	0.00	0.16	0.07	0.24	0.60	0.00	0.00	0.76	6.76	9.68	12.55	0.01	0.00	0.18	116.2	299.9	570.4	0.11	0.00	0.48
	D5	482.7	638.4	783.1	0.92	0.00	0.14	0.09	0.23	0.57	0.00	0.00	0.71	6.73	9.47	12.23	0.00	0.00	0.18	198.1	371.7	618.6	0.17	0.00	0.36
	D16	736.6	881.0	1006.0	1.00	0.17	0.10	0.02	0.05	0.08	0.00	0.00	0.48	3.39	5.44	7.95	0.00	0.00	0.26	33.3	155.8	409.3	0.02	0.00	0.78
	D21	819.5	1030.0	1414.0	1.00	0.47	0.19	0.02	0.03	0.07	0.00	0.00	0.51	3.28	4.68	6.55	0.00	0.00	0.22	21.3	109.2	310.2	0.01	0.00	0.88
	Weldona	762.6	893.5	1004.0	1.00	0.22	0.09	0.01	0.03	0.05	0.00	0.00	0.53	3.54	4.71	6.17	0.00	0.00	0.18	4.9	68.5	225.7	0.00	0.00	1.13
2E+3+4C	D3	220.0	347.1	482.2	0.09	0.00	0.24	0.04	0.27	0.76	0.00	0.00	0.95	2.79	3.84	5.11	0.00	0.00	0.19	96.4	306.9	657.8	0.17	0.00	0.60
	D5	358.1	462.8	594.9	0.27	0.00	0.15	0.06	0.19	0.52	0.00	0.00	0.83	4.83	6.49	8.03	0.00	0.00	0.15	158.4	311.7	557.7	0.10	0.00	0.41
	D16	621.8	795.4	922.4	0.99	0.13	0.12	0.02	0.04	0.06	0.00	0.00	0.41	2.99	4.31	5.78	0.00	0.00	0.20	29.3	138.4	377.4	0.02	0.00	0.82
	D21	763.8	961.7	1340.0	1.00	0.36	0.20	0.01	0.03	0.05	0.00	0.00	0.44	2.99	3.87	4.94	0.00	0.00	0.15	19.0	98.2	289.1	0.00	0.00	0.91
	Weldona	729.5	854.2	963.0	1.00	0.18	0.09	0.01	0.02	0.04	0.00	0.00	0.45	3.24	4.16	5.23	0.00	0.00	0.15	5.2	62.3	208.3	0.00	0.00	1.15
2E+3+5	D3	305.6	417.1	525.0	0.12	0.00	0.16	0.04	0.24	0.69	0.00	0.00	0.94	4.31	5.68	7.16	0.00	0.00	0.16	85.0	268.5	604.8	0.12	0.00	0.65
	D5	356.1	479.1	661.9	0.34	0.00	0.20	0.07	0.24	0.67	0.00	0.00	0.88	4.79	6.28	7.76	0.00	0.00	0.14	163.6	359.4	686.7	0.21	0.00	0.48
	D16	643.1	880.2	1039.0	0.99	0.19	0.14	0.02	0.03	0.06	0.00	0.00	0.39	3.27	4.39	5.74	0.00	0.00	0.17	30.9	163.0	462.6	0.04	0.00	0.88
	D21	848.5	1093.0	1541.0	1.00	0.57	0.21	0.01	0.03	0.05	0.00	0.00	0.41	3.20	4.10	5.05	0.00	0.00	0.13	20.2	115.8	353.4	0.01	0.00	0.97
	Weldona	830.6	1000.0	1157.0	1.00	0.50	0.11	0.01	0.02	0.04	0.00	0.00	0.42	3.63	4.71	6.18	0.00	0.00	0.17	5.8	73.5	253.6	0.01	0.00	1.21
7	D3	305.0	406.6	500.3	0.09	0.00	0.14	0.04	0.21	0.58	0.00	0.00	0.89	4.26	5.72	7.23	0.00	0.00	0.16	85.4	247.3	524.8	0.09	0.00	0.58
	D5	353.0	458.8	595.6	0.27	0.00	0.16	0.07	0.21	0.55	0.00	0.00	0.81	4.69	6.23	7.75	0.00	0.00	0.15	168.5	330.7	586.4	0.13	0.00	0.41
	D16	635.7	806.1	932.5	0.99	0.13	0.12	0.02	0.03	0.06	0.00	0.00	0.42	2.89	4.17	5.60	0.00	0.00	0.20	28.2	141.3	389.4	0.02	0.00	0.84
	D21	776.8	975.4	1368.0	1.00	0.38	0.20	0.01	0.03	0.05	0.00	0.00	0.43	2.89	3.76	4.80	0.00	0.00	0.15	18.0	99.2	295.2	0.01	0.00	0.93
	Weldona	733.4	858.2	966.4	1.00	0.19	0.09	0.01	0.02	0.04	0.00	0.00	0.44	3.17	4.11	5.21	0.00	0.00	0.16	4.1	62.3	212.6	0.00	0.00	1.19
3+4C+5	D3	439.4	607.6	765.5	0.81	0.00	0.17	0.06	0.23	0.59	0.00	0.00	0.77	6.52	9.35	12.28	0.01	0.00	0.19	113.5	293.0	559.4	0.10	0.00	0.48
	D5	471.3	624.8	771.0	0.89	0.00	0.15	0.08	0.23	0.56	0.00	0.00	0.71	6.58	9.25	12.02	0.00	0.00	0.18	191.2	363.0	607.2	0.16	0.00	0.36
	D16	716.4	866.8	993.3	1.00	0.16	0.10	0.02	0.05	0.08	0.00	0.00	0.47	3.45	5.46	7.88	0.00	0.00	0.26	36.0	158.1	405.4	0.02	0.00	0.76
	D21	809.7	1014.0	1387.0	1.00	0.45	0.19	0.02	0.03	0.07	0.00	0.00	0.50	3.35	4.72	6.52	0.00	0.00	0.21	23.5	111.7	309.8	0.01	0.00	0.85
	Weldona	763.3	888.9	997.8	1.00	0.21	0.09	0.01	0.03	0.05	0.00	0.00	0.53	3.57	4.73	6.15	0.00	0.00	0.17	6.5	70.8	225.8	0.00	0.00	1.08
8	D3	293.7	397.3	494.2	0.09	0.00	0.15	0.04	0.21	0.57	0.00	0.00	0.89	4.11	5.56	7.11	0.00	0.00	0.17	84.2	242.4	513.7	0.08	0.00	0.58
	D5	343.7	451.1	589.1	0.26	0.00	0.17	0.06	0.20	0.54	0.00	0.00	0.82	4.58	6.12	7.66	0.00	0.00	0.15	162.4	323.1	575.5	0.12	0.00	0.41
	D16	613.5	790.4	919.6	0.98	0.13	0.12	0.02	0.03	0.06	0.00	0.00	0.41	2.90	4.15	5.55	0.00	0.00	0.20	30.3	143.0	385.7	0.02	0.00	0.81
	D21	759.6	958.1	1337.0	1.00	0.35	0.20	0.01	0.03	0.05	0.00	0.00	0.43	2.92	3.76	4.78	0.00	0.00	0.15	19.8	101.2	294.5	0.01	0.00	0.90
	Weldona	726.6	851.9	961.4	1.00	0.18	0.09	0.01	0.02	0.04	0.00	0.00	0.44	3.18	4.09	5.17	0.00	0.00	0.15	5.5	64.2	213.0	0.00	0.00	1.14

Notes: P_{vh}-Spatial and temporal-averaged probability of violation to the high criteria
P_{vl}-Spatial and temporal-averaged probability of violation to the low criteria

TABLE D-58. Space-Time Average and Standard Deviation of Ensemble Statistical Moments of Computed Water Quality Concentrations for Each Combined Management Strategy Applied during the May-Jun Season (Computed on the Major Diversion Canals)

Strategy		C_{TDS}						C_{NO_3}						C_N						C_{FC}					
		5%	Mean	95%	P_{vh}	P_{vl}	CV	5%	Mean	95%	P_{vh}	P_{vl}	CV	5%	Mean	95%	P_{vh}	P_{vl}	CV	5%	Mean	95%	P_{vh}	P_{vl}	CV
1	D3	212.1	455.8	908.9	0.34	0.02	0.53	0.02	0.24	0.87	0.00	0.00	1.19	1.44	3.76	9.00	0.23	0.02	0.65	87.6	911.3	2436.0	0.65	0.34	0.83
	D5	250.3	517.8	897.3	0.46	0.02	0.39	0.02	0.20	0.60	0.00	0.00	1.00	1.86	5.02	10.23	0.42	0.06	0.56	68.9	464.9	1194.0	0.36	0.09	0.84
	D16	422.0	967.4	1298.0	0.84	0.29	0.40	0.01	0.03	0.05	0.00	0.00	0.56	2.29	4.16	8.47	0.21	0.03	0.48	1.6	154.3	596.8	0.08	0.01	1.38
	D21	327.2	880.5	1187.0	0.79	0.28	0.39	0.01	0.04	0.08	0.00	0.00	0.44	2.24	4.14	7.40	0.26	0.01	0.42	9.5	356.1	1040.0	0.29	0.06	0.98
	Weldona	309.5	694.6	901.0	0.75	0.02	0.30	0.02	0.04	0.06	0.00	0.00	0.35	2.19	3.50	5.13	0.06	0.00	0.31	8.8	204.0	460.8	0.03	0.00	0.77
2E+3	D3	176.8	391.4	829.8	0.28	0.01	0.57	0.02	0.21	0.80	0.00	0.00	1.28	1.21	3.27	8.29	0.19	0.01	0.71	65.9	847.5	2295.0	0.62	0.31	0.85
	D5	184.3	386.4	753.8	0.24	0.00	0.47	0.02	0.19	0.57	0.00	0.00	1.05	1.43	4.14	9.26	0.33	0.03	0.65	57.1	446.5	1167.0	0.35	0.09	0.86
	D16	395.9	904.1	1207.0	0.78	0.20	0.38	0.01	0.03	0.05	0.00	0.00	0.53	2.33	4.04	8.02	0.19	0.02	0.47	7.4	166.7	605.2	0.08	0.01	1.29
	D21	324.3	848.1	1142.0	0.77	0.21	0.37	0.01	0.04	0.07	0.00	0.00	0.44	2.26	4.05	7.16	0.24	0.01	0.41	10.3	346.3	988.1	0.28	0.05	0.95
	Weldona	305.2	681.9	864.2	0.74	0.02	0.32	0.02	0.04	0.06	0.00	0.00	0.35	2.18	3.47	5.07	0.06	0.00	0.31	9.5	211.5	468.8	0.04	0.00	0.75
6	D3	172.0	376.5	732.0	0.26	0.00	0.50	0.02	0.19	0.69	0.00	0.00	1.23	1.18	3.02	7.22	0.17	0.01	0.65	68.7	729.4	1954.0	0.56	0.25	0.83
	D5	178.5	366.0	665.6	0.20	0.00	0.41	0.02	0.16	0.48	0.00	0.00	1.02	1.41	3.73	7.92	0.27	0.02	0.59	52.8	364.6	951.0	0.26	0.05	0.86
	D16	346.1	854.8	1276.0	0.73	0.25	0.47	0.01	0.03	0.05	0.00	0.00	0.50	2.26	3.64	6.90	0.14	0.01	0.42	2.5	122.5	476.1	0.05	0.00	1.38
	D21	276.8	772.1	1114.0	0.73	0.16	0.41	0.01	0.04	0.06	0.00	0.00	0.41	2.01	3.51	6.04	0.14	0.00	0.39	7.6	286.0	837.0	0.21	0.03	0.98
	Weldona	261.7	589.4	839.5	0.52	0.02	0.34	0.01	0.03	0.05	0.00	0.00	0.33	1.92	2.91	4.18	0.03	0.00	0.29	7.0	163.0	369.4	0.01	0.00	0.77
2E+5	D3	287.5	501.3	836.8	0.41	0.00	0.36	0.02	0.18	0.70	0.00	0.00	1.28	1.95	3.75	7.86	0.20	0.01	0.51	86.2	719.1	2021.0	0.52	0.24	0.88
	D5	166.4	377.2	765.7	0.24	0.00	0.50	0.02	0.19	0.59	0.00	0.00	1.05	1.36	4.20	9.54	0.34	0.04	0.67	55.9	470.2	1231.0	0.37	0.10	0.86
	D16	396.3	927.9	1279.0	0.79	0.26	0.43	0.01	0.03	0.05	0.00	0.00	0.52	2.35	4.05	8.12	0.19	0.02	0.47	4.1	157.3	603.6	0.08	0.01	1.37
	D21	319.9	859.9	1177.0	0.77	0.25	0.40	0.01	0.04	0.08	0.00	0.00	0.44	2.24	4.08	7.26	0.25	0.01	0.41	9.4	357.8	1042.0	0.29	0.06	0.97
	Weldona	302.2	682.1	882.3	0.74	0.02	0.30	0.02	0.04	0.06	0.00	0.00	0.35	2.18	3.46	5.01	0.05	0.00	0.31	8.7	205.1	462.5	0.04	0.00	0.77
3+4C	D3	181.5	378.3	713.1	0.24	0.00	0.46	0.02	0.19	0.65	0.00	0.00	1.15	1.25	3.00	6.91	0.15	0.01	0.60	79.5	702.4	1860.0	0.54	0.23	0.82
	D5	250.4	476.0	772.0	0.39	0.00	0.34	0.02	0.16	0.47	0.00	0.00	0.95	1.85	4.32	8.27	0.33	0.02	0.49	69.7	389.0	957.4	0.28	0.05	0.78
	D16	363.7	861.3	1222.0	0.77	0.22	0.42	0.01	0.03	0.05	0.00	0.00	0.53	2.26	3.73	7.12	0.16	0.01	0.43	5.2	139.7	497.5	0.05	0.00	1.24
	D21	286.0	779.9	1094.0	0.75	0.15	0.37	0.01	0.04	0.06	0.00	0.00	0.41	2.04	3.56	6.12	0.15	0.00	0.38	9.3	282.4	801.9	0.20	0.02	0.94
	Weldona	269.1	601.9	840.1	0.56	0.02	0.34	0.01	0.03	0.05	0.00	0.00	0.33	1.94	2.96	4.35	0.03	0.00	0.30	8.6	171.0	378.0	0.02	0.00	0.74
3+5	D3	394.3	662.5	984.4	0.77	0.05	0.30	0.03	0.19	0.68	0.00	0.00	1.18	2.72	4.64	8.29	0.31	0.01	0.39	116.2	737.2	1967.0	0.56	0.24	0.81
	D5	225.3	468.5	839.8	0.36	0.01	0.41	0.02	0.20	0.58	0.00	0.00	1.00	1.73	4.65	9.69	0.38	0.04	0.57	72.2	485.9	1224.0	0.38	0.10	0.81
	D16	414.9	932.3	1225.0	0.83	0.23	0.37	0.01	0.03	0.05	0.00	0.00	0.55	2.31	4.11	8.26	0.20	0.02	0.47	7.0	176.2	626.2	0.09	0.01	1.25
	D21	329.2	863.7	1153.0	0.78	0.23	0.37	0.01	0.04	0.07	0.00	0.00	0.44	2.25	4.09	7.26	0.25	0.01	0.41	11.2	351.4	993.7	0.29	0.05	0.94
	Weldona	309.7	691.4	877.9	0.75	0.02	0.32	0.02	0.04	0.06	0.00	0.00	0.35	2.19	3.49	5.15	0.06	0.00	0.31	10.4	214.6	472.5	0.04	0.00	0.74
4C+5	D3	401.9	683.1	997.1	0.79	0.06	0.30	0.03	0.17	0.58	0.00	0.00	1.10	2.82	4.62	7.55	0.33	0.01	0.33	117.7	643.8	1674.0	0.48	0.19	0.77
	D5	212.8	447.6	769.7	0.34	0.00	0.39	0.02	0.17	0.49	0.00	0.00	0.96	1.66	4.25	8.39	0.33	0.02	0.52	66.8	403.2	1004.0	0.30	0.06	0.80
	D16	356.8	878.5	1287.0	0.76	0.27	0.46	0.01	0.02	0.05	0.00	0.00	0.52	2.19	3.67	7.12	0.15	0.01	0.44	1.3	130.1	494.0	0.05	0.00	1.34
	D21	280.9	784.4	1123.0	0.74	0.17	0.40	0.01	0.04	0.06	0.00	0.00	0.41	2.00	3.53	6.12	0.15	0.00	0.39	8.2	289.7	841.5	0.21	0.03	0.97
	Weldona	265.7	596.8	853.4	0.54	0.02	0.33	0.01	0.03	0.05	0.00	0.00	0.32	1.92	2.92	4.25	0.03	0.00	0.30	7.6	165.3	372.7	0.02	0.00	0.76
2E+3+ 4C	D3	160.5	349.6	690.4	0.21	0.00	0.50	0.02	0.17	0.65	0.00	0.00	1.25	1.11	2.80	6.78	0.14	0.01	0.66	65.0	690.6	1853.0	0.53	0.23	0.84
	D5	181.8	359.2	647.4	0.18	0.00	0.40	0.02	0.15	0.47	0.00	0.00	1.02	1.41	3.62	7.66	0.25	0.01	0.58	55.3	367.5	942.3	0.26	0.05	0.83
	D16	345.2	822.3	1198.0	0.70	0.19	0.44	0.01	0.03	0.05	0.00	0.00	0.51	2.23	3.60	6.79	0.14	0.01	0.42	6.0	135.1	488.9	0.05	0.00	1.27
	D21	279.2	758.3	1077.0	0.72	0.13	0.38	0.01	0.04	0.06	0.00	0.00	0.41	2.01	3.48	5.96	0.14	0.00	0.38	8.7	280.1	799.1	0.19	0.02	0.95
	Weldona	262.9	588.7	818.9	0.52	0.01	0.35	0.01	0.03	0.05	0.00	0.00	0.33	1.91	2.92	4.22	0.03	0.00	0.29	8.0	169.6	376.4	0.02	0.00	0.75
2E+3+ 5	D3	272.6	470.7	801.8	0.35	0.00	0.37	0.02	0.17	0.67	0.00	0.00	1.30	1.82	3.53	7.51	0.17	0.01	0.52	81.7	698.2	1948.0	0.52	0.23	0.87
	D5	172.2	371.8	743.4	0.23	0.00	0.49	0.02	0.19	0.57	0.00	0.00	1.05	1.37	4.07	9.19	0.32	0.03	0.66	57.3	467.6	1211.0	0.37	0.10	0.84
	D16	391.7	899.5	1205.0	0.77	0.20	0.39	0.01	0.03	0.05	0.00	0.00	0.53	2.31	4.02	7.98	0.19	0.02	0.47	7.8	172.5	619.8	0.09	0.01	1.27
	D21	323.5	845.6	1141.0	0.76	0.21	0.38	0.01	0.04	0.07	0.00	0.00	0.44	2.25	4.04	7.14	0.24	0.01	0.41	10.6	349.5	991.4	0.28	0.05	0.95
	Weldona	304.3	680.3	862.2	0.74	0.02	0.32	0.02	0.04	0.06	0.00	0.00	0.35	2.17	3.46	5.05	0.06	0.00	0.31	9.8	213.4	471.5	0.04	0.00	0.75
7	D3	272.5	469.3	730.8	0.38	0.00	0.32	0.02	0.15	0.57	0.00	0.00	1.23	1.86	3.38	6.62	0.14	0.01	0.44	82.7	600.6	1651.0	0.43	0.18	0.85
	D5	163.9	348.8	656.0	0.19	0.00	0.44	0.02	0.16	0.48	0.00	0.00	1.02	1.34	3.65	7.85	0.26	0.02	0.61	54.0	384.7	990.3	0.28	0.06	0.84
	D16	342.8	850.2	1274.0	0.72	0.25	0.48	0.01	0.03	0.05	0.00	0.00	0.51	2.24	3.62	6.86	0.14	0.01	0.42	2.9	127.4	487.1	0.05	0.00	1.36
	D21	275.8	769.7	1113.0	0.73	0.16	0.41	0.01	0.04	0.06	0.00	0.00	0.41	2.00	3.50	6.02	0.14	0.00	0.39	7.9	288.5	839.9	0.21	0.03	0.97
	Weldona	260.8	587.9	837.2	0.51	0.02	0.34	0.01	0.03	0.05	0.00	0.00	0.33	1.91	2.90	4.17	0.03	0.00	0.29	7.3	164.5	371.7	0.01	0.00	0.76
3+4C+ 5	D3	380.1	632.6	927.9	0.75	0.03	0.29	0.03	0.16	0.56	0.00	0.00	1.11	2.62	4.30	7.19	0.25	0.01	0.34	110.1	623.0	1616.0	0.46	0.18	0.77
	D5	221.3	441.1	743.6	0.32	0.00	0.37	0.02	0.16	0.47	0.00	0.00	0.96	1.70	4.13	8.09	0.31	0.02	0.51	69.2	401.1	988.2	0.29	0.05	0.78
	D16	358.7	850.5	1215.0	0.75	0.21	0.42	0.01	0.02	0.05	0.00	0.00	0.52	2.22	3.67	7.02	0.15	0.01	0.43	5.4	143.0	506.3	0.06	0.00	1.24
	D21	284.0	774.0	1089.0	0.74	0.14	0.38	0.01	0.04	0.06	0.00	0.00	0.41	2.02	3.52	6.07	0.14	0.00	0.39	9.4	284.2	804.1	0.20	0.02	0.94
	Weldona	267.3	598.3	834.3	0.55	0.01	0.34	0.01	0.03	0.05	0.00	0.00	0.33	1.92	2.94	4.31	0.03	0.00	0.30	8.7	172.1	379.6	0.02	0.00	0.74
8	D3	258.6	440.8	699.5	0.30	0.00	0.32	0.02	0.15	0.55	0.00	0.00	1.24	1.74	3.19	6.34	0.12	0.01	0.45	78.5	584.0	1594.0	0.42	0.17	0.85
	D5	169.3	344.4	638.2	0.17	0.00	0.43	0.02	0.15	0.46	0.00	0.00	1.02	1.35	3.54	7.59	0.24	0.01	0.60	55.5	382.8	975.2	0.27	0.05	0.82
	D16	342.1	817.7	1196.0	0.70	0.19	0.44	0.01	0.03	0.05	0.00	0.00	0.51	2.21	3.57	6.75	0.14	0.01	0.42	6.4	139.3	499.5	0.05	0.00	1.25
	D21	278.2	755.8	1075.0	0.72	0.13	0.38	0.01	0.04	0.06	0.00	0.00	0.41	2.00	3.47	5.95	0.14	0.00	0.38	8.9	282.3	801.7	0.20	0.02	0.94
	Weldona	262.1	587.2	816.6	0.52	0.01	0.35	0.01	0.03	0.05	0.00	0.00	0.33	1.90	2.91	4.21	0.03	0.00	0.29	8.3	171.0	378.4	0.02	0.00	0.74

Notes: P_{vh}-Spatial and temporal-averaged probability of violation to the high criteria
P_{vl}-Spatial and temporal-averaged probability of violation to the low criteria

TABLE D-59. Space-Time Average and Standard Deviation of Ensemble Statistical Moments of Computed Water Quality Concentrations for Each Combined Management Strategy Applied during the Jul-Aug Season (Computed on the Major Diversion Canals)

Strategy		C_{TDS}						C_{NO_2}						C_N						C_{FC}					
		5%	Mean	95%	P_{vh}	P_{vl}	CV	5%	Mean	95%	P_{vh}	P_{vl}	CV	5%	Mean	95%	P_{vh}	P_{vl}	CV	5%	Mean	95%	P_{vh}	P_{vl}	CV
1	D3	256.1	497.6	748.3	0.48	0.00	0.32	0.02	0.34	1.16	0.00	0.00	1.17	1.62	5.13	13.32	0.36	0.15	0.78	244.9	1289.0	2621.0	0.86	0.63	0.57
	D5	309.6	514.0	670.3	0.54	0.00	0.28	0.09	0.35	0.90	0.00	0.00	0.77	2.65	5.62	10.46	0.49	0.07	0.45	432.5	773.2	1205.0	0.89	0.15	0 32
	D16	586.8	1119.0	1614.0	0.97	0.67	0.29	0.00	0.02	0.06	0.00	0.00	1.12	5.39	7.68	10.28	0.96	0.08	0.20	33.4	104.4	197.2	0.00	0.00	0.51
	D21	407.8	816.1	1113.0	0.87	0.20	0.29	0.01	0.02	0.03	0.00	0.00	0.42	4.89	7.97	11.04	0.94	0.14	0.24	219.8	785.8	1593.0	0.67	0.29	0.57
	Weldona	637.8	895.5	1045.0	0.98	0.15	0.15	0.01	0.03	0.05	0.00	0.00	0.36	4.31	6.11	8.70	0.80	0.01	0.23	190.9	460.8	722.1	0.41	0.00	0.36
2E+3	D3	187.0	385.3	610.2	0.24	0.00	0.36	0.02	0.30	1.04	0.00	0.00	1.18	1.23	4.18	11.57	0.31	0.10	0.86	200.8	1181.0	2450.0	0.83	0.56	0.59
	D5	214.5	378.6	527.4	0.14	0.00	0.34	0.07	0.32	0.84	0.00	0.00	0.84	1.80	4.29	9.01	0.32	0.03	0.57	388.0	732.4	1170.0	0.84	0.13	0.34
	D16	520.9	1015.0	1504.0	0.95	0.50	0.32	0.00	0.03	0.06	0.00	0.00	0.83	5.14	7.48	10.03	0.95	0.06	0.20	47.8	115.5	202.3	0.00	0.00	0.43
	D21	408.3	795.3	1086.0	0.86	0.14	0.29	0.01	0.02	0.03	0 00	0.00	0.40	4.77	7.75	10.74	0.93	0.12	0.24	214.1	703.3	1392.0	0.63	0.21	0.54
	Weldona	602.4	858.2	1014.0	0.97	0.09	0.16	0.01	0.03	0.05	0.00	0.00	0.33	4.32	6.09	8.50	0.80	0.01	0.21	186.2	460.8	718.6	0.42	0.00	0.36
6	D3	193.1	386.0	579.5	0.19	0.00	0.32	0.02	0.27	0.93	0.00	0.00	1.16	1.24	3.96	10.51	0.29	0.07	0.80	213.8	1047.0	2113.0	0.81	0.47	0.56
	D5	215.3	363.7	484.0	0.11	0.00	0.30	0.08	0.28	0.71	0.00	0.00	0.78	1.82	3.99	7.86	0.27	0.02	0.50	385.3	676.3	1026.0	0.80	0.07	0 30
	D16	540.0	1034.0	1518.0	0.96	0.52	0.31	0.00	0.02	0.05	0.00	0.00	0.95	5.14	6.88	8.71	0.94	0.03	0.16	42.6	94.2	164 0	0.00	0.00	0.42
	D21	384.5	757.5	1060.0	0.84	0.11	0.29	0.01	0.01	0.02	0.00	0.00	0.39	4.41	6.75	9.08	0.85	0.05	0.21	183.7	640 8	1294.0	0.56	0.17	0.57
	Weldona	555.0	762 7	922.1	0.96	0.06	0.16	0.01	0.03	0.04	0.00	0.00	0.34	3.58	5.04	7.14	0.43	0.00	0.22	157.7	370.9	579.3	0.17	0.00	0.36
2E+5	D3	259.0	419.5	582.6	0.22	0.00	0.24	0.04	0.26	0.82	0.00	0.00	0.99	2.00	4.51	10.07	0.31	0.06	0.59	183.1	900.9	1902.0	0.74	0.35	0.60
	D5	213.0	385.4	540.1	0.16	0.00	0.35	0.08	0.33	0.87	0.00	0.00	0.84	1.78	4 38	9.27	0.34	0.04	0.58	410.1	761.8	1206.0	0.87	0.15	0.33
	D16	561.9	1088.0	1598.0	0.97	0.61	0.31	0.00	0.02	0.06	0.00	0.00	0.91	5.43	7.71	10.28	0.97	0.08	0.20	44.9	111.0	199.6	0.00	0.00	0.45
	D21	400.0	800.3	1102 0	0.86	0.16	0.29	0.01	0.02	0.03	0.00	0.00	0.39	4.91	7.98	11.05	0.94	0.14	0.24	222.1	788.3	1595.0	0.68	0.29	0.57
	Weldona	629.7	887 1	1038.0	0.98	0.14	0.16	0.01	0.03	0.05	0.00	0.00	0.34	4.32	6.10	8.64	0.80	0.01	0.22	192.5	461.8	722.8	0.41	0.00	0.36
3+4C	D3	236.8	431.6	624.2	0.30	0.00	0.28	0.02	0.25	0.84	0.00	0.00	1.15	1.46	4.10	10.05	0.29	0.06	0.70	215.2	993.7	2007.0	0.79	0.42	0.56
	D5	303 9	475.4	603.3	0.39	0.00	0.24	0.09	0.29	0.71	0.00	0.00	0.71	2.55	4.99	8.75	0.41	0.02	0.39	393.4	685.4	1037.0	0.82	0.07	0.29
	D16	533.3	997.7	1443.0	0.96	0.48	0.30	0.00	0.02	0.05	0.00	0.00	1.04	5.02	6.70	8.57	0.90	0.03	0.16	35.5	92.9	165.1	0.00	0.00	0.45
	D21	405.0	772.0	1056.0	0.85	0.11	0.28	0.00	0.01	0.02	0.00	0.00	0.44	4.35	6.62	8.89	0.83	0.05	0 21	175.9	574.8	1140.0	0.49	0.12	0.54
	Weldona	543.1	756.1	918.9	0.96	0.05	0.16	0.01	0.02	0.04	0.00	0.00	0.35	3.64	5.08	7.11	0.45	0.00	0.21	152.2	369.9	576.1	0.17	0 00	0.36
3+5	D3	385.9	575.4	750.3	0.74	0.00	0.20	0.07	0.29	0.81	0.00	0.00	0.85	3.04	5.88	11.14	0.55	0.09	0.46	220.0	921.6	1885.0	0.77	0.36	0.56
	D5	298.0	492.2	646.6	0.47	0.00	0.28	0.09	0.34	0.85	0.00	0.00	0.78	2.49	5.33	10.02	0.44	0 06	0.46	414.8	763.2	1205 0	0.87	0.15	0.32
	D16	549.4	1050.0	1527.0	0.96	0.57	0.31	0.00	0.02	0.06	0.00	0.00	1.01	5.19	7.50	10.07	0.95	0.06	0.20	38.8	110.6	200.6	0.00	0.00	0.47
	D21	419.4	814.6	1101.0	0.87	0.17	0.29	0.01	0.02	0.03	0.00	0.00	0.43	4.79	7.77	10.75	0.93	0.12	0.24	212.1	701.1	1390.0	0.63	0.21	0.55
	Weldona	612.1	868.8	1022.0	0.98	0.10	0.16	0.01	0.03	0.04	0.00	0.00	0.34	4.33	6.10	8.56	0.81	0.01	0.22	185.0	459.9	718.1	0.42	0.00	0.36
4C+5	D3	403.0	590.6	758.1	0.79	0.00	0.19	0.07	0.27	0.72	0.00	0.00	0.78	3.16	5.88	10.46	0.61	0.06	0.41	220.9	820.3	1631.0	0.71	0.27	0.53
	D5	297.7	481.3	618.1	0.42	0.00	0.25	0.09	0.30	0.74	0.00	0.00	0.72	2.48	5.07	8.99	0.42	0.03	0.41	414.3	712.2	1071.0	0.86	0.09	0.29
	D16	561.8	1063.0	1531.0	0.97	0.57	0.29	0.00	0.02	0.05	0.00	0.00	1.18	5.20	6.82	8.69	0.93	0.03	0.16	31.2	88.1	162.4	0.00	0.00	0.49
	D21	391.7	772.1	1071.0	0.84	0.13	0.28	0.00	0.01	0.02	0.00	0.00	0.43	4.38	6.73	9.06	0.84	0.05	0.21	181.6	638.5	1292.0	0.56	0.16	0.57
	Weldona	561.3	770.5	935.9	0.97	0.06	0.16	0.01	0.03	0.04	0.00	0.00	0.36	3.57	5.04	7.20	0.44	0.00	0.22	156.5	370.1	578.8	0.17	0.00	0.36
2E+3+4C	D3	182.8	359.4	541 5	0.13	0.00	0.32	0.02	0.25	0.84	0.00	0.00	1.16	1.18	3.63	9.58	0.26	0.05	0.79	194.9	977.3	1994 0	0.78	0.41	0.57
	D5	213.3	355.8	472.8	0.11	0.00	0.29	0.07	0.27	0.69	0.00	0.00	0.78	1.78	3.87	7.63	0.25	0.02	0.50	368.8	660.6	1013.0	0.77	0.07	0.31
	D16	502.8	961.3	1422 0	0.94	0.42	0.31	0.00	0.02	0.05	0.00	0.00	0.86	4.88	6.64	8.51	0.89	0 03	0.17	44.8	98.0	166 6	0.00	0.00	0.40
	D21	392.7	751.8	1040.0	0.84	0.10	0.28	0.01	0.01	0.02	0.00	0.00	0.40	4.31	6.59	8.87	0.82	0.05	0.21	178.0	577.1	1142 0	0.49	0 12	0.54
	Weldona	533.5	745.1	903.4	0.95	0.05	0.17	0.01	0.02	0.04	0.00	0.00	0.33	3.63	5.05	7.03	0.44	0.00	0.21	153.5	370.8	576 6	0.17	0.00	0.36
2E+3+5	D3	248.0	401.3	560.0	0.16	0.00	0.24	0.04	0.25	0.77	0.00	0.00	0.99	1.92	4.27	9.55	0.29	0.05	0.59	176.2	873.1	1844.0	0.72	0.33	0.60
	D5	212.1	376.2	525.5	0.14	0.00	0.34	0.07	0.31	0.83	0.00	0.00	0.84	1.77	4.24	8.94	0.32	0.03	0.57	389.4	739.3	1184.0	0.84	0.13	0.34
	D16	520.3	1014.0	1504.0	0.95	0.50	0.32	0.00	0.03	0.06	0.00	0.00	0.83	5.13	7.46	10.01	0.95	0.06	0.20	48.0	115.7	202.3	0.00	0.00	0.43
	D21	408.0	794.9	1086.0	0.86	0.14	0.29	0.01	0.02	0.03	0.00	0.00	0.40	4.77	7.74	10.74	0.93	0.12	0.24	214.1	703.4	1392.0	0.63	0.21	0.54
	Weldona	602.2	858.0	1014.0	0.97	0.09	0.16	0.01	0.03	0.05	0.00	0.00	0.33	4.32	6.08	8.49	0.80	0.01	0.21	186.2	460.8	718.7	0.42	0.00	0.36
7	D3	256.5	402.3	538.1	0.12	0.00	0.22	0.04	0.23	0.68	0.00	0.00	0.93	1.96	4.14	8.71	0.26	0.03	0.52	176.2	767.9	1585.0	0.64	0.24	0.57
	D5	211.9	361.3	483.3	0.11	0.00	0.30	0.07	0.28	0.71	0.00	0.00	0.78	1.76	3.94	7.84	0.26	0.02	0.51	389.3	687.6	1047.0	0.81	0.08	0.30
	D16	539.4	1034.0	1518.0	0.96	0.52	0.31	0.00	0.02	0.05	0.00	0.00	0.95	5.12	6.87	8.71	0.94	0.03	0.16	42.8	94.5	164.2	0.00	0.00	0.41
	D21	384.3	757.3	1060.0	0.84	0.11	0.29	0.01	0.01	0.02	0.00	0.00	0.39	4.40	6.74	9.08	0.85	0 05	0.21	183.9	641.0	1294.0	0.56	0.17	0.56
	Weldona	554.9	762.5	922.0	0.96	0.06	0.16	0.01	0.03	0.04	0.00	0.00	0.34	3.58	5.04	7.14	0.43	0.00	0 22	157.9	371.0	579.4	0.17	0.00	0.36
3+4C+5	D3	383.5	559.5	721.3	0.73	0.00	0.19	0.06	0.25	0.68	0.00	0.00	0.78	2.99	5.54	9.93	0.52	0.05	0.41	211.0	794.3	1585.0	0.68	0.25	0.53
	D5	296.6	469.6	600.3	0.37	0.00	0.24	0.09	0.29	0.70	0.00	0.00	0.72	2.46	4.91	8.68	0.39	0.02	0.40	394.0	689.9	1047.0	0.82	0.08	0.29
	D16	531.1	996.2	1442.0	0.96	0.48	0.30	0.00	0.02	0.05	0.00	0.00	1.05	5.01	6.68	8.55	0.90	0.03	0.16	35.6	93.0	165.1	0.00	0.00	0.45
	D21	404.3	771.2	1056.0	0.85	0.11	0.28	0.00	0.01	0.02	0.00	0.00	0.44	4.34	6.61	8.88	0.83	0.05	0.21	175.9	574.9	1140.0	0.49	0.12	0 54
	Weldona	542.5	755.7	918.4	0.96	0.05	0.16	0.01	0.02	0.04	0.00	0.00	0.35	3.64	5.07	7.10	0.44	0.00	0.21	152.2	369.9	576.1	0.17	0.00	0.36
8	D3	245.7	385.3	519.1	0.10	0.00	0.22	0.04	0.22	0.65	0.00	0.00	0.93	1.87	3.93	8.30	0.23	0.03	0.52	170.1	745.8	1541.0	0.61	0.23	0.57
	D5	210.8	353.7	471.5	0.11	0.00	0.29	0.07	0.27	0.68	0.00	0.00	0.78	1.74	3.82	7.57	0.24	0.02	0.51	370.1	666.0	1025.0	0.77	0.07	0.31
	D16	502.2	960.7	1421.0	0.94	0.42	0.31	0.00	0.02	0.05	0.00	0.00	0.86	4.87	6.63	8.50	0.89	0.03	0.17	44.9	98.2	166.5	0.00	0.00	0.40
	D21	392.4	751.5	1040.0	0.84	0.10	0.28	0.01	0.01	0.02	0 00	0.00	0.40	4.30	6.58	8.86	0.82	0.05	0.21	178.0	577.1	1142.0	0.49	0.12	0.54
	Weldona	533.3	745 0	903.2	0.95	0.05	0 17	0 01	0.02	0 04	0.00	0 00	0.33	3.63	5.05	7.02	0.44	0.00	0 21	153.6	370.8	576 7	0.17	0.00	0.36

Notes: P_{vh}-Spatial and temporal-averaged probability of violation to the high criteria
P_{vl}-Spatial and temporal-averaged probability of violation to the low criteria

TABLE D-60. Space-Time Average and Standard Deviation of Ensemble Statistical Moments of Computed Water Quality Concentrations for Each Combined Management Strategy Applied during the Sep-Oct Season (Computed on the Major Diversion Canals)

Strategy		C_{TDS}						C_{NO_3}						C_N						C_{FC}					
		5%	Mean	95%	Pv_h	P_{vl}	CV	5%	Mean	95%	Pv_h	P_{vl}	CV	5%	Mean	95%	Pv_h	P_{vl}	CV	5%	Mean	95%	Pv_h	P_{vl}	CV
1	D3	305.2	405.1	494.5	0.04	0.00	0.14	0.03	0.10	0.26	0.00	0.00	0.73	2.40	3.46	4.81	0.00	0.00	0.22	126.6	365.5	980.5	0.18	0.05	0.79
	D5	507.1	693.3	856.3	0.95	0.00	0.15	0.21	0.34	0.54	0.00	0.00	0.32	6.47	8.81	10.79	0.00	0.00	0.15	244.7	387.6	577.9	0.13	0.00	0.28
	D16	509.9	877.2	980.4	0.95	0.04	0.58	0.01	0.06	0.12	0.00	0.00	0.64	4.60	5.84	7.33	0.00	0.00	0.15	0.0	13.9	45.1	0.00	0.00	1.24
	D21	614.6	861.8	971.0	0.98	0.04	0.40	0.01	0.04	0.07	0.00	0.00	0.63	4.73	5.93	7.35	0.00	0.00	0.14	2.9	135.7	441.1	0.04	0.00	1.15
	Weldona	272.2	612.2	824.9	0.64	0 01	0.57	0.01	0.02	0.04	0.00	0.00	0.45	2.32	4.37	6.07	0.00	0.00	0.27	1 7	381.5	962.1	0.39	0.04	0.91
2E+3	D3	228.5	303.6	379.7	0.01	0.00	0.15	0.03	0.09	0.24	0.00	0.00	0.74	1.92	2.81	4.00	0.00	0.00	0.24	103.6	327.6	920.2	0.16	0.04	0.85
	D5	326.3	438.1	531.0	0.19	0.00	0.14	0.13	0.24	0.45	0.00	0.00	0.46	4.12	5.41	6.51	0.00	0.00	0.13	215 0	349.8	538.5	0.09	0 00	0.30
	D16	430.1	807.3	927.7	0.91	0 03	0.64	0.01	0.05	0.11	0.00	0.00	0.67	4.18	5.17	6.28	0.00	0.00	0.12	0.0	15.4	46.0	0.00	0.00	1.11
	D21	578.8	816.4	925.0	0.98	0.03	0.42	0.01	0.03	0.06	0.00	0.00	0.61	4.35	5.48	6.88	0.00	0.00	0.15	3.5	131.5	422.9	0.03	0.00	1.13
	Weldona	275.7	587.8	774.1	0.60	0.01	0.57	0.01	0.02	0.04	0.00	0.00	0.41	2.35	4.10	5.57	0.00	0.00	0.25	2.1	374.3	946.2	0.38	0.04	0.92
6	D3	225.8	303.9	382.9	0.01	0.00	0.16	0.03	0.09	0.21	0.00	0.00	0.69	1.90	2.87	4.22	0.00	0.00	0.26	105.5	299.3	792.9	0.13	0.03	0.77
	D5	326.0	440.6	536.8	0.19	0.00	0.14	0.13	0.22	0.39	0.00	0.00	0.39	4.10	5.48	6.63	0.00	0.00	0.14	217.8	343.5	502.0	0.06	0.00	0.26
	D16	425.1	726.4	790.4	0.89	0.02	0.54	0.01	0.04	0.09	0.00	0.00	0.66	3.81	4.94	6.28	0.00	0.00	0.16	0.0	12.3	38.1	0.00	0.00	1.18
	D21	524.1	738.5	865.4	0.95	0 02	0.43	0.01	0.03	0.05	0.00	0.00	0.61	3.97	4.91	6.09	0.00	0.00	0.14	2.6	110.2	357.0	0 02	0.00	1.14
	Weldona	226.6	516.8	700.0	0.49	0.01	0 57	0.01	0.02	0 03	0.00	0 00	0.42	1.90	3.58	4.90	0.00	0.00	0.26	1.6	307.4	773.2	0.26	0.02	0.91
2E+5	D3	347.0	427.3	507.6	0.08	0.00	0.12	0.11	0.17	0.27	0.00	0.00	0.33	3.91	5.05	6.22	0.00	0.00	0.15	89.2	244.7	654.5	0.10	0.02	0.80
	D5	308.3	416.2	507 3	0.19	0.00	0.14	0.19	0 31	0.51	0.00	0 00	0.35	3.74	4.99	6.15	0.00	0.00	0.15	216.3	362.2	574.7	0.12	0.00	0.32
	D16	429.9	807.6	929.3	0.91	0.03	0.64	0.00	0.05	0.11	0.00	0.00	0.70	4.07	5.10	6.29	0.00	0.00	0.13	0.0	14.7	45.1	0.00	0.00	1.15
	D21	579.7	817.6	938.5	0.98	0.03	0.42	0.01	0.03	0.06	0.00	0.00	0.65	4.27	5.45	6.93	0.00	0.00	0.15	3.3	136.0	441.4	0.04	0.00	1.15
	Weldona	264.6	582.0	773.7	0.59	0 01	0.57	0.01	0.02	0.04	0.00	0.00	0.41	2.25	4.04	5.53	0.00	0.00	0.25	2.0	381 7	962.2	0.39	0.04	0.91
3+4C	D3	283.2	377.4	465.0	0.02	0.00	0.15	0.03	0.08	0.20	0.00	0.00	0.66	2.24	3.22	4.47	0.00	0.00	0.22	120.3	311.5	781.8	0.13	0.03	0.71
	D5	496.5	676.7	834.6	0.95	0.00	0.15	0.20	0.32	0.48	0.00	0.00	0.28	6.29	8.57	10.47	0.00	0.00	0.15	236.4	367.2	530.4	0.09	0.00	0.25
	D16	486.2	787.7	851.6	0.94	0.03	0.50	0.01	0.05	0.10	0.00	0.00	0.60	4.23	5.57	7.21	0.00	0.00	0.17	0.0	12.5	40.5	0.00	0.00	1.24
	D21	547.2	*777.1*	891.7	*0.96*	*0.02*	*0.39*	*0.01*	*0.03*	*0.07*	*0.00*	*0.00*	*0.61*	4.27	5.32	*6.58*	*0.00*	*0.00*	*0.14*	2.4	*106.7*	342.9	*0.02*	*0.00*	*1.13*
	Weldona	244.9	549.2	749.6	0.55	0.01	0.55	0.01	0.02	0.04	0.00	0.00	0.48	2.06	3.91	5.46	0.00	0.00	0.28	1.5	301.9	761.4	0.25	0.02	0.92
3+5	D3	544.3	689.9	836.6	0 81	0.01	0.13	0.18	0.28	0.41	0.00	0.00	0.32	6.39	8.35	10.29	0.00	0.00	0.16	122.3	291.1	684.9	0.11	0.02	0.65
	D5	447.4	610.1	758.9	0.87	0.00	0.16	0.29	0.46	0.68	0.00	0.00	0.27	5.44	7.43	9.29	0.00	0.00	0.16	225.0	372.4	582.3	0.13	0.00	0.31
	D16	488.8	856.3	960.5	0.95	0.04	0.60	0.01	0.05	0.11	0.00	0.00	0.67	4.42	5.55	6.87	0.00	0.00	0.14	0.0	14.8	47.0	0.00	0.00	1.21
	D21	605.1	847 8	951 5	0.98	0.03	0.40	0.01	0.03	0.07	0.00	0.00	0.63	4.58	5.73	7.11	0.00	0.00	0.14	3.1	131.2	422.6	0.03	0.00	1.14
	Weldona	282.2	609 2	808 3	0.64	0.01	0.56	0.01	0.02	0.04	0.00	0.00	0.43	2.40	4.27	5.84	0.00	0.00	0.25	1.9	374.2	946.2	0.38	0.04	0.92
4C+5	D3	550.0	707.0	863.7	0.81	0.02	0.14	0.19	0.29	0.42	0.00	0.00	0.32	6.52	8.63	10.70	0.00	0.00	0.16	122.1	273.9	606.5	0.08	0.01	0.58
	D5	446.5	615.4	771.1	0.87	0.00	0.16	0.29	0.46	0.66	0.00	0.00	0.26	5.42	7.53	9.48	0.00	0.00	0.17	228.5	364.6	539.5	0.10	0.00	0.27
	D16	472.2	771.6	834.4	0.94	0.02	0.51	0.00	0.04	0.09	0.00	0.00	0.66	4.01	5.26	6.78	0.00	0.00	0.16	0.0	11.6	38.6	0.00	0.00	1.30
	D21	540.4	767.1	889.4	0.96	0.02	0.40	0.00	0.03	0.06	0.00	0.00	0.65	4.11	5.12	6.34	0.00	0.00	0.14	2.2	109.9	356.7	0.02	0.00	1.15
	Weldona	231.3	536.2	736.7	0.53	0.01	0.57	0.01	0.02	0.03	0.00	0.00	0.45	1.93	3.73	5.20	0.00	0.00	0.28	1.3	307.3	773.2	0.26	0.02	0.91
2E+3+4C	D3	218.9	293.4	370.2	0.01	0.00	0.16	0.03	0.08	0.20	0.00	0.00	0.68	1.85	2.73	3.95	0.00	0.00	0.25	102.1	288.2	762.5	0.12	0.02	0.77
	D5	323.6	435.0	528.9	0.19	0.00	0.14	0.13	0.22	0.39	0.00	0.00	0.39	4.05	5.38	6.50	0.00	0.00	0.14	212.9	336.8	495.1	0.06	0.00	0.27
	D16	418.6	720.2	785.5	0.88	0.02	0.55	0.01	0.04	0.09	0.00	0.00	0.65	3.80	4.89	6.16	0.00	0.00	0.15	0.0	13.0	39.6	0.00	0.00	1.14
	D21	521 1	733.7	852.1	0.95	0.02	0.42	0.01	0.03	0.06	0.00	0.00	0.59	3.95	4.88	6.03	0.00	0.00	0.13	2.8	106.9	343.2	0.02	0.00	1.13
	Weldona	236.4	519.6	695.6	0.49	0.01	0.56	0.01	0.02	0.03	0.00	0.00	0.42	1.98	3.60	4.88	0.00	0.00	0.25	1.7	302.0	761.4	0.25	0.02	0.92
2E+3+5	D3	338.9	417 0	495 0	0.05	0.00	0.11	0.11	0.17	0.26	0.00	0.00	0.33	3.81	4.90	6.02	0.00	0.00	0.15	89.0	242.7	644.5	0.09	0.02	0.79
	D5	306 7	411.8	501 0	0.19	0.00	0.14	0.18	0.30	0.51	0.00	0.00	0.35	3.71	4.92	6.05	0.00	0.00	0.14	210.8	354.4	566.0	0.11	0.00	0.33
	D16	422.5	800.3	923.0	0.90	0.03	0.68	0.01	0.05	0.11	0.00	0.00	0.70	4.04	5.05	6.17	0.00	0.00	0.13	0.0	15.6	46.8	0.00	0.00	1.12
	D21	574.2	811 9	922.0	0.97	0.03	0.42	0.01	0.03	0.06	0.00	0.00	0.63	4.24	5.40	6.82	0.00	0.00	0.15	3.5	131.5	422.9	0.03	0.00	1 13
	Weldona	274 7	584.7	769.9	0.60	0.01	0.57	0.01	0.02	0.04	0.00	0.00	0.41	2.33	4.05	5.50	0.00	0.00	0.24	2.1	374.3	946.2	0.38	0.04	0.92
7	D3	338.8	422.3	504.6	0.07	0.00	0.12	0.11	0.17	0.26	0.00	0.00	0.32	3.85	5.02	6.21	0.00	0.00	0.15	88.1	223.4	561.8	0.07	0.01	0.71
	D5	304.5	412.1	504.8	0.19	0.00	0.14	0.18	0.29	0.46	0.00	0.00	0.30	3.67	4.95	6.13	0.00	0.00	0.15	213.6	346.2	519.9	0.08	0.00	0.28
	D16	418.2	719.6	786.2	0.88	0.02	0.56	0.00	0.04	0.09	0.00	0.00	0.69	3.69	4.81	6.17	0.00	0.00	0.16	0.0	12.4	38.6	0.00	0.00	1.19
	D21	520.6	734.2	862.9	0.95	0.02	0.43	0.01	0.02	0.05	0.00	0.00	0.63	3.87	4.83	6.03	0.00	0.00	0.14	2.6	110.3	357.0	0.02	0.00	1.14
	Weldona	225.7	513.8	695.4	0.49	0.01	0.57	0.01	0.02	0.03	0.00	0.00	0.41	1.89	3.52	4.82	0.00	0.00	0.26	1.6	307.5	773.2	0.26	0.02	0.91
3+4C+5	D3	535 3	684.9	834.0	0.81	0.01	0.14	0.18	0.28	0.41	0.00	0.00	0.32	6.32	8.32	10.28	0.00	0.00	0.16	120.6	269.9	596.7	0.08	0.01	0.58
	D5	442.6	605.9	756.6	0.85	0.00	0.16	0.28	0.45	0.65	0.00	0.00	0.26	5.37	7.39	9.27	0.00	0.00	0.16	222.7	356.4	529.8	0.09	0.00	0.28
	D16	469.5	769.0	830.6	0.94	0.02	0.51	0.01	0.04	0.09	0.00	0.00	0.64	4.03	5.26	6.77	0.00	0.00	0.16	0.0	12.4	40.2	0.00	0.00	1.26
	D21	539.6	765.0	880.9	0.96	0.02	0.40	0.01	0.03	0.06	0.00	0.00	0.62	4.13	5.12	6.33	0.00	0.00	0.13	2.4	106.6	342.9	0.02	0.00	1.13
	Weldona	242.5	540.8	734.2	0.53	0.01	0.55	0.01	0.02	0.04	0.00	0.00	0.45	2.02	3.77	5.20	0.00	0.00	0.27	1.5	301.9	761.4	0.25	0.02	0.92
8	D3	331.0	412.1	491.9	0.04	0.00	0.12	0.10	0.16	0 25	0.00	0.00	0.32	3.74	4.86	6.00	0.00	0.00	0.15	88.0	221.4	553 7	0.07	0.01	0.70
	D5	302.8	407.6	498.5	0.19	0.00	0.14	0.18	0.29	0.45	0.00	0.00	0.30	3.64	4.88	6.03	0.00	0.00	0.15	208.3	338.4	510.5	0.07	0.00	0.29
	D16	411.2	712.9	780.9	0.87	0.02	0.57	0.00	0.04	0.09	0.00	0.00	0.68	3.68	4.76	6.04	0.00	0.00	0.15	0.0	13 1	40.1	0.00	0 00	1.15
	D21	517.0	729.0	848.7	0.95	0.02	0.41	0.01	0.03	0.05	0.00	0.00	0.61	3.85	4.80	5.96	0.00	0.00	0 14	2.8	106.9	343.2	0.02	0.00	1.13
	Weldona	235.3	516.3	690.9	0.49	0.01	0.54	0.01	0.02	0.03	0.00	0.00	0.41	1.96	3.54	4.80	0.00	0.00	0.25	1.7	302.0	761.4	0.25	0.02	0.92

Notes: P_{vh}-Spatial and temporal-averaged probability of violation to the high criteria
P_{vl}-Spatial and temporal-averaged probability of violation to the low criteria

TABLE D-61. Space-Time Average and Standard Deviation of Ensemble Statistical Moments of Computed Water Quality Concentrations for Each Combined Management Strategy Applied during the Nov-Dec Season (Computed on the Major Diversion Canals)

		C_{TDS}						C_{NO_3}						C_N						C_{FC}					
Strategy		5%	Mean	95%	P_{Vh}	P_{Vl}	CV	5%	Mean	95%	P_{Vh}	P_{Vl}	CV	5%	Mean	95%	P_{Vh}	P_{Vl}	CV	5%	Mean	95%	P_{Vh}	P_{Vl}	CV
1	D3	301.2	451.2	619.0	0.32	0.00	0.22	0.08	0.38	0.86	0.00	0.00	0.71	5.33	6.83	8.43	0.00	0.00	0.14	121.1	1476.0	3765.0	0.63	0.53	0.87
	D5	590.5	731.3	872.1	1.00	0.00	0.12	0.27	0.42	0.60	0.00	0.00	0.24	7.95	10.78	13.49	0.01	0.00	0.16	205.5	807.5	1830.0	0.59	0.34	0.69
	D16	635.2	902.1	1250.0	1.00	0.27	0.22	0.00	0.02	0.03	0.00	0.00	0.61	3.69	6.13	10.38	0.03	0.00	0.54	15.2	269.8	818.7	0.17	0.02	1.01
	D21	569.1	829.6	1171.0	0.99	0.19	0.23	0.00	0.04	0.11	0.00	0.00	1.13	3.67	6.06	9.10	0.02	0.00	0.42	16.6	227.1	662.2	0.11	0.01	0.96
	Weldona	587.4	826.8	1151.0	1.00	0.16	0.21	0.00	0.05	0.13	0.00	0.00	1.05	3.26	5.69	8.57	0.01	0.00	0.41	16.9	413.8	1167.0	0.34	0.10	0.95
2E+3	D3	213.3	340.3	509.7	0 09	0.00	0.28	0.06	0.34	0.81	0.00	0.00	0.77	3.54	4.90	6.65	0.00	0.00	0.21	97.2	1392.0	3587.0	0.62	0.52	0.89
	D5	364.0	468.3	614.5	0.31	0.00	0.17	0.16	0.27	0.39	0.00	0.00	0.27	4.94	6.71	8.43	0.00	0.00	0.16	171.3	774.8	1828.0	0.57	0.33	0.74
	D16	559.1	792.4	1107.0	0.99	0.12	0.22	0.00	0.01	0.03	0.00	0.00	0.54	3.53	5.61	10.16	0.03	0.00	0.60	23.3	280.3	842.4	0.19	0.03	1.00
	D21	521.2	748.7	1055.0	0.97	0.09	0.22	0.00	0.03	0.08	0.00	0.00	0.91	3.36	5.67	8.89	0.02	0.00	0.46	20.9	235.3	681.4	0.12	0.01	0.95
	Weldona	544.8	758.2	1042.0	0.98	0.08	0.21	0.00	0.04	0.13	0.00	0.00	1.07	3.14	5.37	8.31	0.01	0.00	0.44	20.4	416.9	1160.0	0.35	0.10	0.94
6	D3	211.6	328.3	466.7	0.06	0.00	0.24	0.06	0.30	0.69	0.00	0.00	0.73	3.60	4.70	6.03	0.00	0.00	0.16	98.7	1193.0	3037.0	0.60	0.48	0.87
	D5	365.2	460 7	572.0	0.24	0.00	0.14	0.17	0.26	0.38	0.00	0.00	0.25	4.91	6.65	8.31	0.00	0.00	0 15	170.8	646.4	1466.0	0.52	0.22	0.69
	D16	508.8	762.9	1113.0	0.93	0.12	0.26	0.00	0.01	0.02	0.00	0.00	0.55	3.20	5.30	10.09	0.03	0.00	0.67	20.0	221.6	660.0	0.11	0.01	0.99
	D21	481.1	724.3	1057.0	0.91	0 09	0.25	0.00	0.03	0.08	0.00	0.00	1.01	3.18	5.17	8.56	0.02	0.00	0.52	18.3	185.9	534.0	0.07	0.00	0.93
	Weldona	491.0	711.4	1017.0	0.91	0.07	0.23	0.00	0.04	0.11	0.00	0.00	1.06	2.75	4.83	7.93	0.01	0.00	0.51	18.1	334.8	938.8	0.27	0.04	0.94
2E+5	D3	313.6	417.8	529.2	0.11	0.00	0.16	0.09	0.28	0.59	0.00	0.00	0.62	5.12	6.31	7.60	0.00	0.00	0.12	89.9	953.8	2474.0	0.56	0.39	0.88
	D5	328.6	445.8	604.3	0.28	0.00	0.20	0.15	0.24	0.36	0.00	0.00	0.30	4.60	6.23	7.81	0.00	0.00	0.16	182.2	919.7	2179.0	0.60	0.40	0.76
	D16	554 7	793.1	1117.0	0.98	0.13	0.23	0.00	0.01	0.02	0.00	0.00	0.58	3.39	5.48	10.20	0.03	0.00	0.63	22.6	324.1	983.3	0.24	0.05	1.02
	D21	518 2	748.4	1061.0	0.96	0.09	0.23	0.00	0.03	0.06	0.00	0.00	1.00	3.18	5.57	8.88	0.02	0.00	0.48	20.6	266.8	783.1	0.16	0.02	0.97
	Weldona	542 1	758.5	1047.0	0.98	0.08	0.21	0.00	0.04	0.13	0.00	0.00	1.21	3.04	5.28	8.29	0.01	0.00	0.46	20.3	445.3	1207.0	0.38	0.12	0.91
3+4C	D3	288.5	417.3	557.9	0.18	0.00	0.20	0.08	0.31	0.68	0.00	0.00	0.66	4.90	6.20	7.59	0.00	0.00	0.13	113.0	1158.0	2925.0	0.60	0.47	0.86
	D5	574.2	706.4	840.3	1.00	0.00	0.12	0.26	0.40	0.57	0.00	0.00	0.24	7.72	10.45	13.13	0.00	0.00	0.16	199.5	697.0	1527.0	0.55	0.25	0.65
	D16	574.7	852.3	1216.0	0.99	0.22	0.24	0.00	0.01	0.03	0.00	0.00	0.63	3.39	5.82	10.09	0.02	0.00	0.57	17.6	235.6	689.7	0.13	0.01	0.97
	D21	525.1	792.1	1143.0	0.97	0.15	0.24	0.00	0.04	0.11	0.00	0.00	1.16	3.49	5.57	8.68	0.02	0.00	0.45	17.9	196.4	556.5	0.07	0.00	0.92
	Weldona	525.9	768.8	1103.0	0.97	0.12	0.24	0.00	0.04	0.11	0.00	0.00	1.02	2.88	5.16	8.11	0.01	0.00	0.46	18.1	340.9	935.5	0.27	0.04	0.92
3+5	D3	504.8	655.9	813.3	0.85	0.00	0.15	0.14	0.33	0.63	0.00	0.00	0.49	8.13	10.00	12.14	0.00	0.00	0.13	123.2	978.6	2458.0	0.57	0.40	0.83
	D5	484.2	634.5	786.8	0.90	0.00	0.15	0.22	0.34	0.49	0.00	0.00	0.25	6.84	9.19	11.50	0.00	0.00	0.15	207.4	936.5	2171.0	0.61	0.41	0.73
	D16	608.3	859.0	1189.0	1.00	0.20	0.21	0.00	0.01	0.03	0.00	0.00	0.61	3.54	5.73	9.86	0.02	0.00	0.56	19.3	329.3	989.5	0.24	0.05	1.00
	D21	552.6	798.6	1126.0	0.99	0.14	0.22	0 00	0 03	0.08	0 00	0 00	1.23	3.45	5.76	8.73	0.02	0.00	0.43	19.5	271.1	789.6	0.17	0.02	0.96
	Weldona	573.1	800.5	1107.0	0 99	0.13	0.21	0.00	0.04	0.13	0.00	0.00	1.20	3.15	5.43	8.20	0.01	0.00	0.42	19.7	445.7	1199.0	0.38	0.11	0.90
4C+5	D3	511.6	661.2	819.7	0.85	0.00	0.15	0.14	0.31	0.56	0.00	0.00	0.43	8.21	10.07	12.26	0.00	0.00	0.13	120.7	858.3	2112.0	0.54	0.32	0.79
	D5	483.5	626.0	769.8	0.90	0.00	0.14	0.22	0.33	0.47	0.00	0.00	0.24	6.71	9.13	11.50	0.00	0.00	0.16	207.5	797.3	1782.0	0.58	0.33	0.68
	D16	552.5	826.2	1194.0	0.98	0.19	0.25	0.00	0.01	0.02	0.00	0.00	0.63	3.14	5.37	9.72	0.02	0.00	0.63	15.0	263.9	789.9	0.17	0.02	1.00
	D21	509.2	771.5	1123.0	0.95	0.13	0.25	0.00	0.03	0.07	0.00	0.00	1.37	3.19	5.22	8.36	0.02	0.00	0.49	16.0	216.7	629.5	0.10	0.01	0.95
	Weldona	513.7	751.2	1081.0	0.95	0.10	0.24	0.00	0.03	0.10	0.00	0.00	1.22	2.72	4.86	7.74	0.01	0.00	0.49	16.6	359.5	970.0	0.29	0.05	0.90
2E+3+4C	D3	208.7	320.3	457.0	0.06	0.00	0.24	0.06	0.29	0.67	0.00	0.00	0.73	3.45	4.54	5.87	0.00	0.00	0.17	95.0	1142.0	2913.0	0.60	0.46	0.88
	D5	361.3	456.0	565.6	0.23	0.00	0.14	0.16	0.26	0.37	0.00	0.00	0.26	4.86	6.57	8.22	0.00	0.00	0.15	168.5	654.2	1491.0	0.52	0.23	0.70
	D16	505.0	752.5	1092.0	0.93	0.12	0.25	0.00	0.01	0.02	0.00	0.00	0.54	3.21	5.28	9.95	0.03	0.00	0.65	22.4	232.0	682.5	0.12	0.01	0.97
	D21	478.9	717.2	1041.0	0.91	0.08	0.25	0.00	0.03	0.08	0.00	0.00	0.98	3.20	5.16	8.49	0.02	0.00	0.51	20.0	193.9	551.8	0.07	0.00	0.92
	Weldona	489.3	705.5	1004.0	0.91	0.07	0.23	0.00	0.04	0.11	0.00	0.00	1.04	2.76	4.82	7.87	0.01	0.00	0.50	19.7	338 7	934.4	0.27	0.04	0.92
2E+3+5	D3	307.8	411.0	522.9	0.10	0.00	0.16	0.09	0.27	0.58	0.00	0.00	0.62	4.97	6.17	7.47	0.00	0.00	0.13	89.3	934.8	2423.0	0.56	0.38	0.88
	D5	326.7	442.0	596.5	0.27	0.00	0.20	0.14	0.24	0.36	0.00	0.00	0.30	4.57	6.16	7.74	0.00	0.00	0.16	178.4	904.3	2147.0	0.60	0.39	0.76
	D16	549.1	781.9	1095.0	0.98	0.12	0.22	0.00	0.01	0.02	0.00	0.00	0.57	3.39	5.45	10.05	0.03	0.00	0.62	24.8	329.4	988.3	0.24	0.05	1.00
	D21	515.2	740.8	1046.0	0.96	0.09	0.22	0.00	0.03	0.06	0.00	0.00	0.98	3 19	5.54	8.81	0.02	0.00	0.47	22.3	271.3	788.8	0.17	0.02	0.96
	Weldona	539.3	751.6	1033.0	0.98	0.08	0.21	0.00	0.04	0.13	0.00	0.00	1.19	3.05	5.26	8.23	0.01	0.00	0.45	21.8	445.7	1199.0	0.38	0.11	0.90
7	D3	309.9	407.7	508.6	0.08	0.00	0.15	0.09	0.24	0.51	0.00	0.00	0.56	5.01	6.11	7.33	0.00	0.00	0.12	87.6	813.0	2075.0	0.52	0.30	0.86
	D5	324.6	429.4	550.1	0.22	0.00	0.17	0.14	0.23	0.34	0.00	0.00	0.27	4.48	6.03	7.51	0.00	0.00	0.15	179.1	764.5	1757.0	0.57	0.32	0.72
	D16	498.2	750.9	1100.0	0.92	0.12	0.26	0.00	0.01	0.02	0.00	0.00	0.57	3.08	5.13	9.97	0.03	0.00	0.70	21.5	264.7	789.0	0.17	0.02	0.99
	D21	474.5	715.3	1046.0	0.90	0.08	0.25	0.00	0.02	0.06	0.00	0.00	1.09	3.02	5.04	8.47	0.02	0.00	0.54	19.5	217.3	628.6	0.10	0.01	0.95
	Weldona	486.0	703.9	1008.0	0.90	0.07	0.23	0.00	0.03	0.10	0.00	0.00	1.20	2.67	4.71	7.82	0.01	0.00	0.52	19.3	359.9	969.7	0.29	0.05	0.90
3+4C+5	D3	498.4	645.8	802.1	0.85	0.00	0.15	0.14	0.30	0.55	0.00	0.00	0.44	7.94	9.81	11.99	0.00	0.00	0.13	118.9	842.2	2073.0	0.53	0.31	0.79
	D5	478.4	618.2	759.3	0.88	0.00	0.14	0.21	0.33	0.47	0.00	0 00	0.24	6.65	9 00	11.35	0.00	0.00	0.16	203.0	784.2	1756.0	0.58	0.32	0.68
	D16	550.9	817.5	1173.0	0.98	0.17	0.24	0.00	0.01	0.02	0.00	0.00	0.62	3.20	5.39	9.63	0.02	0.00	0.62	18.0	268.8	794.3	0.17	0.02	0.98
	D21	508.7	766.0	1109.0	0.95	0.12	0.24	0.00	0.03	0.08	0.00	0.00	1.34	3.24	5.24	8.31	0.02	0.00	0.48	18.1	220.8	634.1	0.10	0.01	0.94
	Weldona	513.3	746.8	1070.0	0.95	0.10	0.23	0.00	0.03	0.10	0.00	0.00	1.20	2.75	4.88	7.72	0.01	0 00	0.48	18.5	360.4	964.8	0.29	0.05	0.89
8	D3	304.0	400.8	501.8	0.07	0.00	0.15	0.08	0.24	0.50	0.00	0.00	0.56	4.86	5.98	7.20	0.00	0.00	0.12	86.8	798.4	2037.0	0.51	0.29	0.85
	D5	323.0	425.7	543.8	0.21	0.00	0.17	0.14	0.23	0.33	0.00	0.00	0.27	4.45	5.97	7.43	0.00	0.00	0.15	175.2	752.0	1732.0	0.56	0.31	0.72
	D16	494.3	740.4	1078.0	0.91	0.11	0.25	0.00	0.01	0.02	0.00	0.00	0.57	3.09	5.10	9.82	0.03	0.00	0.68	23.7	268.9	792.8	0.17	0.02	0.98
	D21	472.2	708.1	1030.0	0.89	0.08	0.25	0.00	0.02	0.06	0.00	0.00	1.07	3.03	5.02	8.40	0.02	0.00	0.53	21.2	220.9	632.7	0.10	0.01	0.94
	Weldona	484.0	697.9	993 9	0.90	0.06	0.23	0.00	0.03	0.10	0.00	0.00	1.18	2.68	4.70	7.76	0.01	0.00	0.52	20.8	360.4	964.5	0.29	0.05	0.89

Notes: P_{Vh}-Spatial and temporal-averaged probability of violation to the high criteria
P_{Vl}-Spatial and temporal-averaged probability of violation to the low criteria

TABLE D-62. Spatial and Temporal Average of River Concentrations for Strategies 1 and 8 Predicted by the Deterministic Model Using Mean Values of the Parameters Compared to the Spatial and Temporal Average of the Mean of River Water Quality Concentrations Predicted by Stochastic Model for Strategies 1 and 8

Season	Strategy	C_{TDS} (mg/L)		C_{NO2} (mg/L)		C_N (mg/L)		C_{FC} (colonies/100 mL)	
		Deterministic	Stochastic-Mean	Deterministic	Stochastic-Mean	Deterministic	Stochastic-Mean	Deterministic	Stochastic-Mean
Jan-Feb	1	1090	911	0.04	0.30	8.1	8.0	38	248
	8	835	697	0.03	0.19	5.0	5.1	31	207
Mar-Apr	1	938	942	0.10	0.09	6.6	6.5	161	207
	8	708	721	0.06	0.06	4.1	4.2	131	169
May-Jun	1	554	619	0.17	0.17	2.3	4.1	128	371
	8	447	504	0.13	0.13	1.8	3.3	101	296
Jul-Aug	1	700	704	0.20	0.09	4.9	6.3	599	571
	8	578	582	0.16	0.07	3.9	5.0	507	444
Sep-Oct	1	835	742	0.03	0.10	6.0	5.9	225	235
	8	628	567	0.02	0.08	4.1	4.1	189	189
Nov-Dec	1	775	758	0.30	0.12	6.7	6.8	247	445
	8	585	577	0.19	0.07	4.5	4.7	224	402

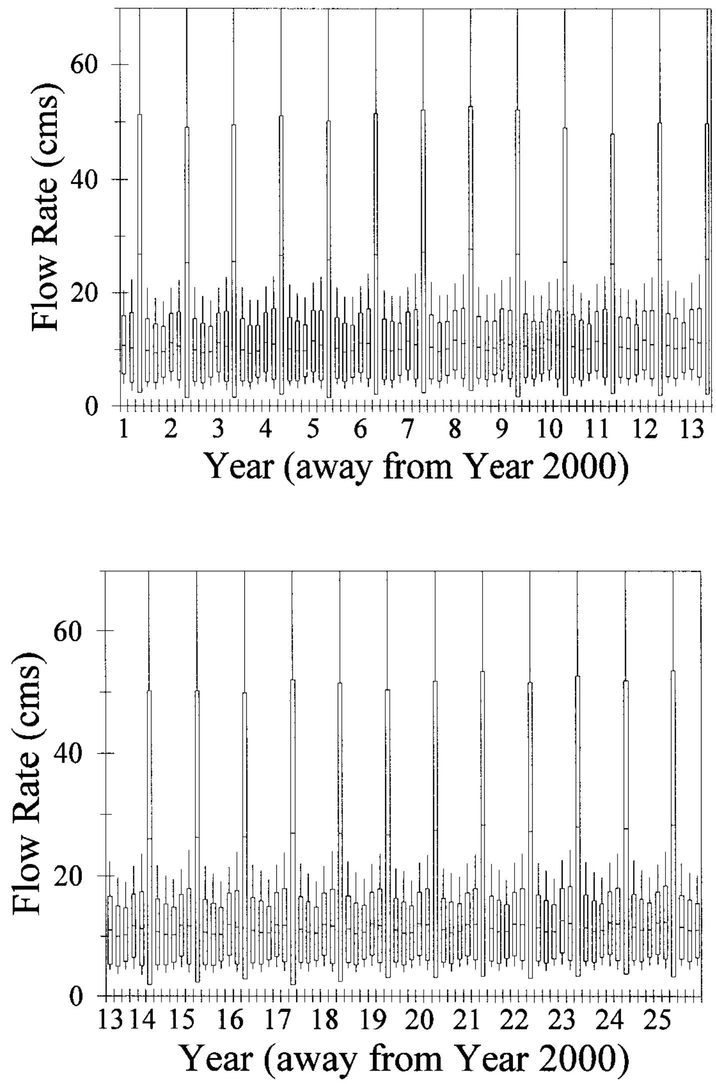

FIG. D-1. Space Average of Ensemble Statistical Moments of *Q* for Strategy 1 over the 25-year Planning Period (Computed over All Diversion Points and Downstream Station at Weldona)

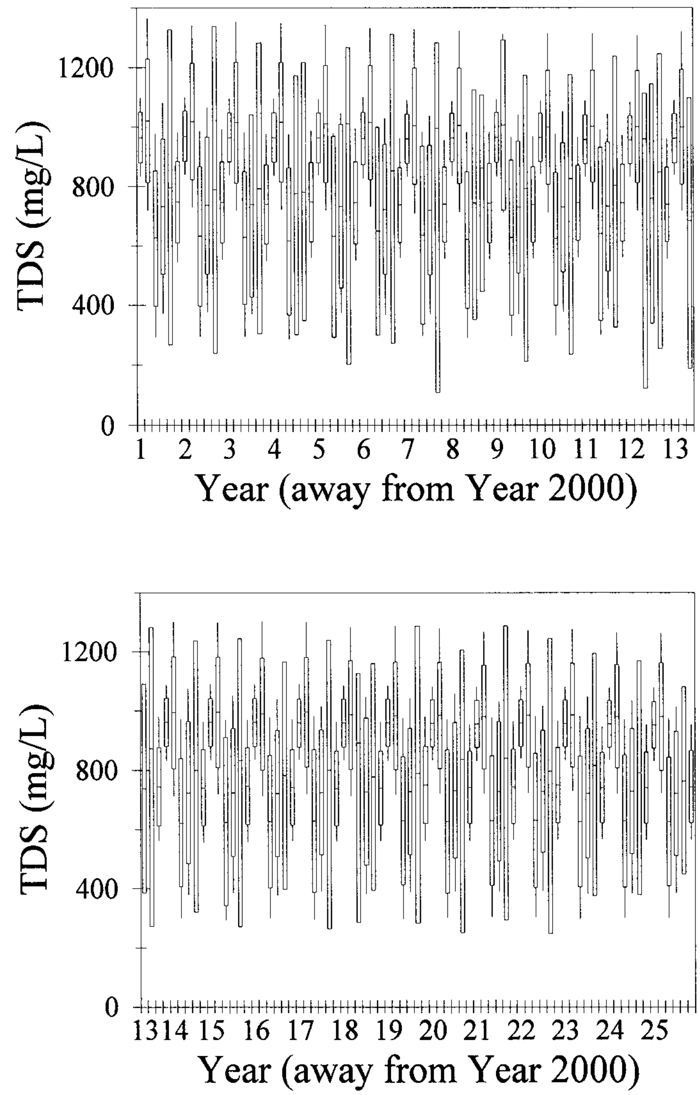

FIG. D-2. Space Average of Ensemble Statistical Moments of C_{TDS} for Strategy 1 over the 25-year Planning Period (Computed over All Diversion Points and Downstream Station at Weldona)

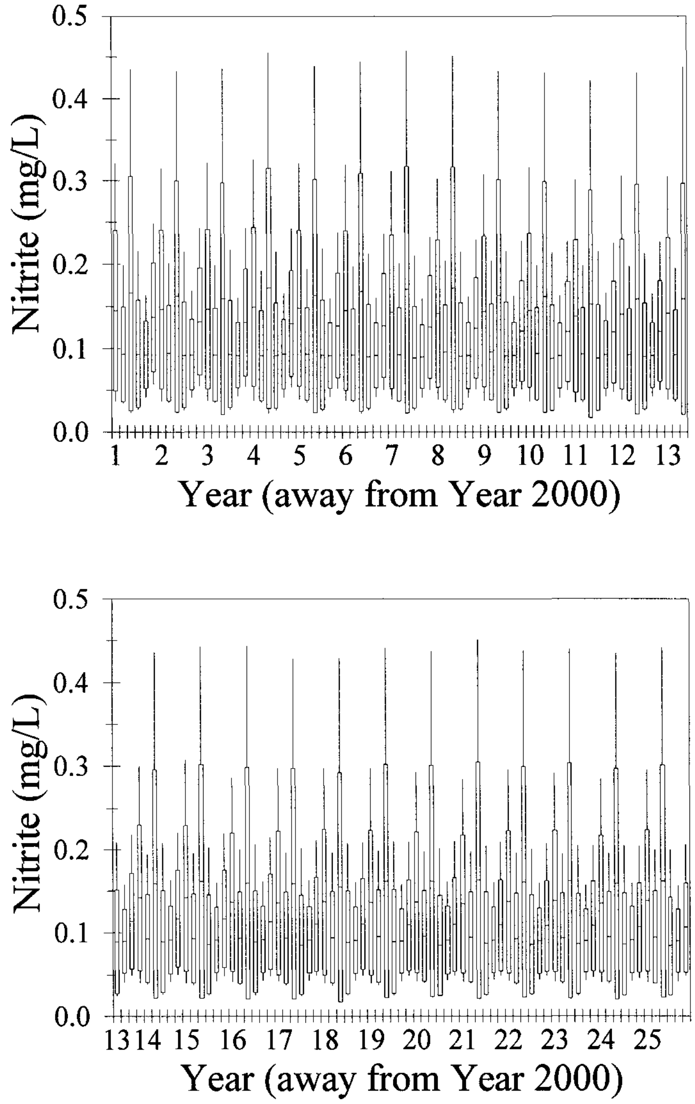

FIG. D-3. Space Average of Ensemble Statistical Moments of C_{NO2} for Strategy 1 over the 25-year Planning Period (Computed over All Diversion Points and Downstream Station at Weldona)

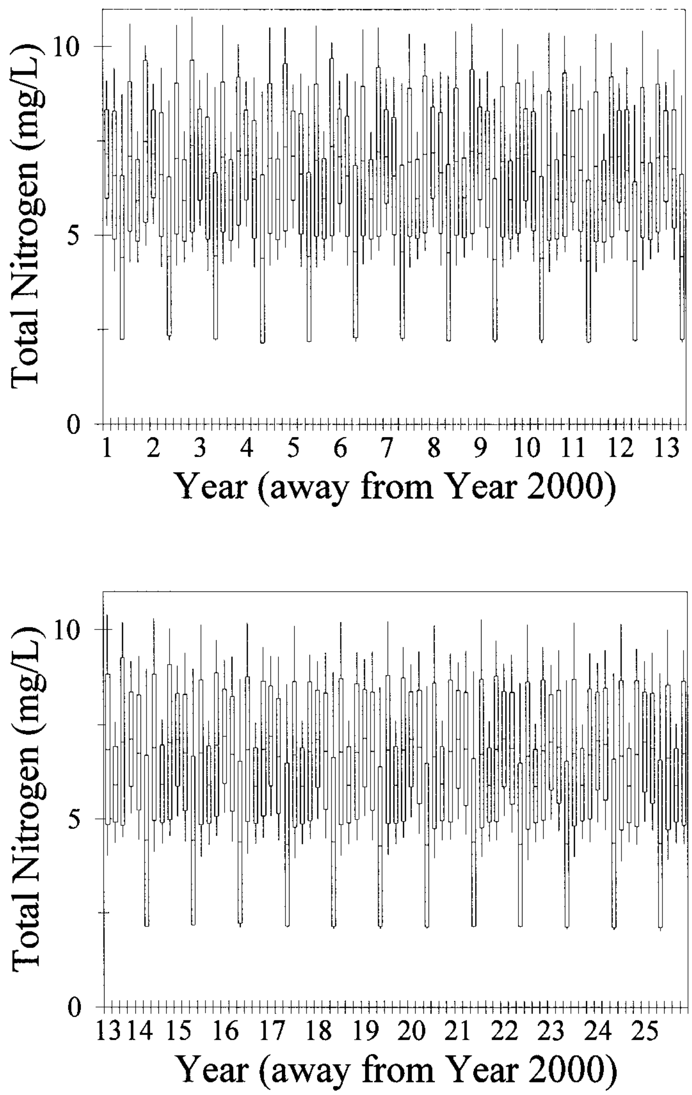

FIG. D-4. Space Average of Ensemble Statistical Moments of C_N for Strategy 1 over the 25-year Planning Period (Computed over All Diversion Points and Downstream Station at Weldona)

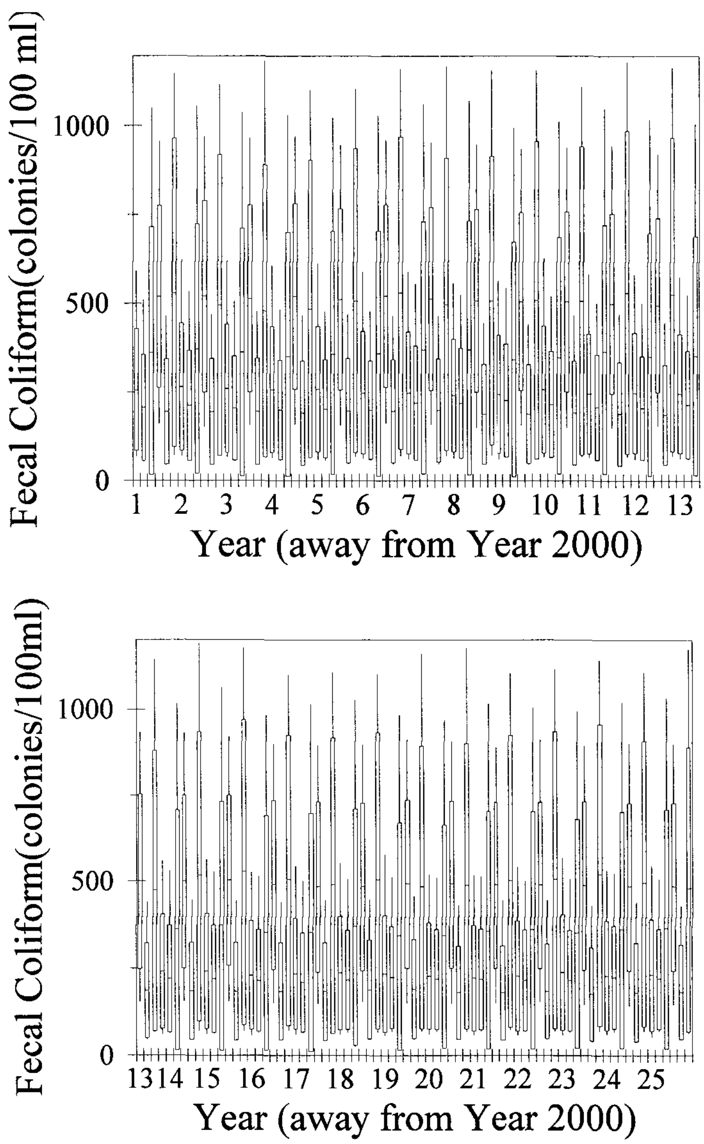

FIG. D-5. Space Average of Ensemble Statistical Moments of C_{FC} for Strategy 1 over the 25-year Planning Period (Computed over All Diversion Points and Downstream Station at Weldona)

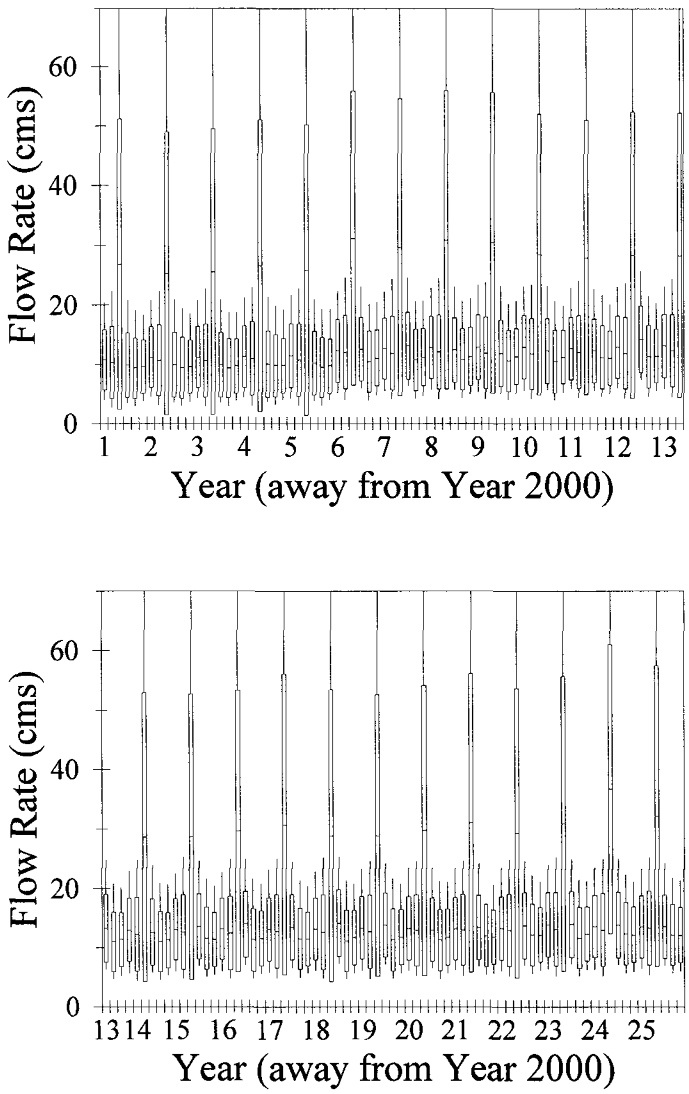

FIG. D-6. Space Average of Ensemble Statistical Moments of *Q* for Strategy 8 over the 25-year Planning Period (Computed over All Diversion Points and Downstream Station at Weldona)

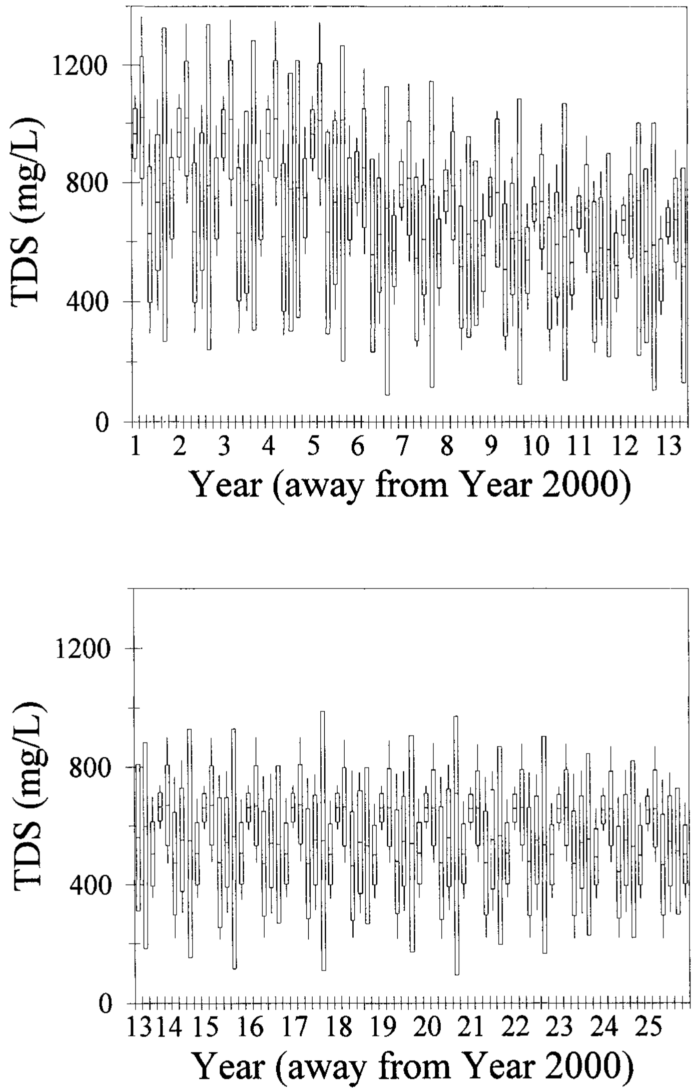

FIG. D-7. Space Average of Ensemble Statistical Moments of C_{TDS} for Strategy 8 over the 25-year Planning Period (Computed over All Diversion Points and Downstream Station at Weldona)

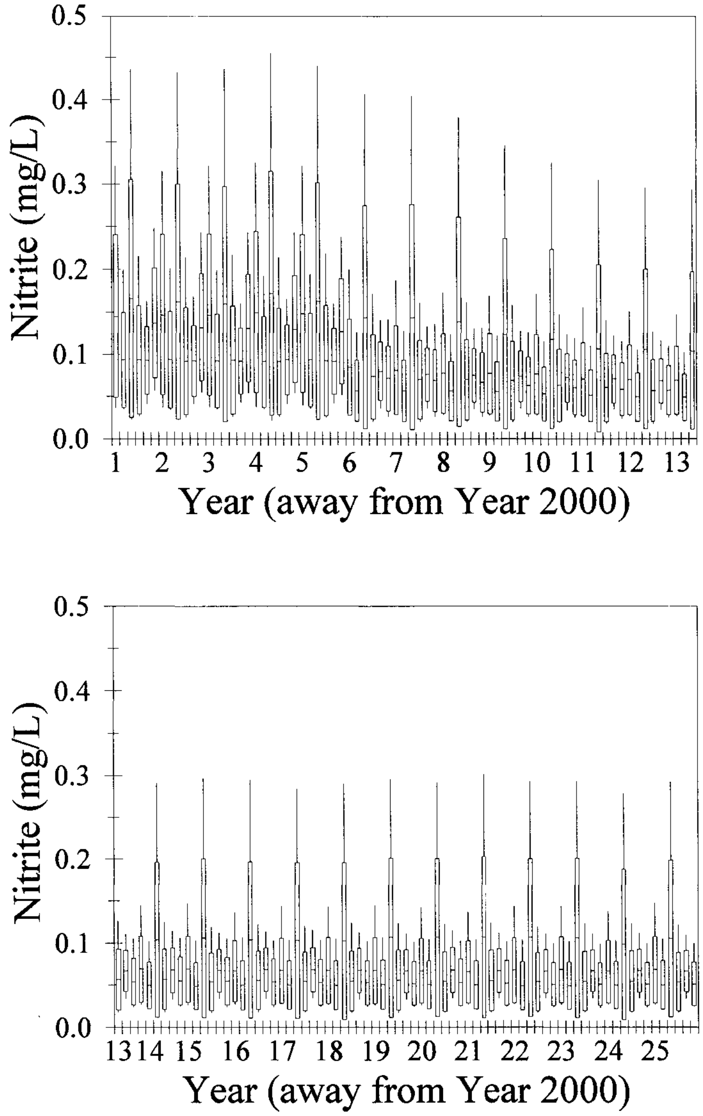

FIG. D-8. Space Average of Ensemble Statistical Moments of C_{NO2} for Strategy 8 over the 25-year Planning Period (Computed over All Diversion Points and Downstream Station at Weldona)

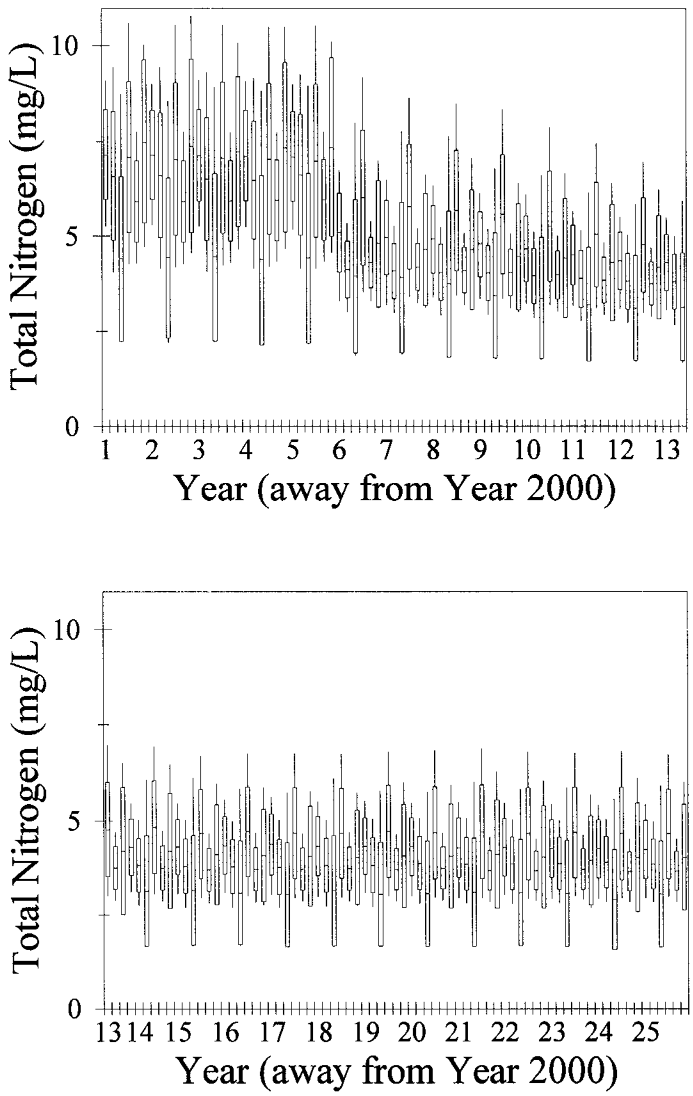

FIG. D-9. Space Average of Ensemble Statistical Moments of C_N for Strategy 8 over the 25-year Planning Period (Computed over All Diversion Points and Downstream Station at Weldona)

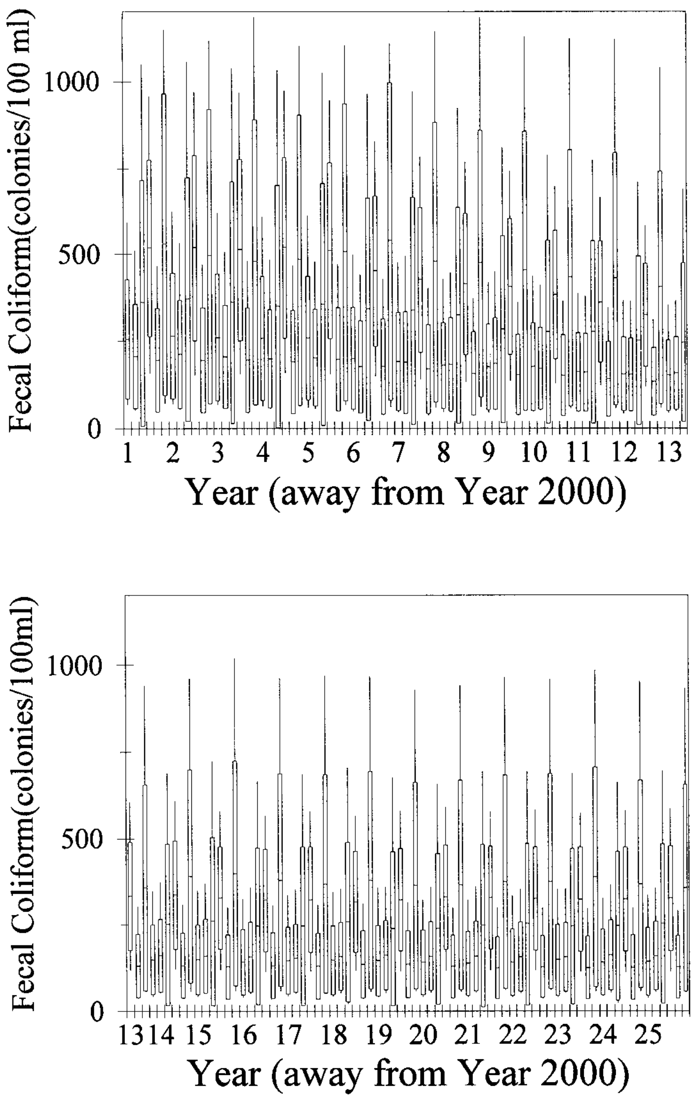

FIG. D-10. Space Average of Ensemble Statistical Moments of C_{FC} for Strategy 8 over the 25-year Planning Period (Computed over All Diversion Points and Downstream Station at Weldona)

APPENDIX E:
Computer Program Code

Introduction to Appendix E

This appendix presents a brief description of the computer programs used in this study, along with a CD containing copies of the program codes. These program codes were mainly modified from the US Environmental Protection Agency program QUAL2EU. The original QUAL2EU program is structured as one main program, called Q2E3P1, supported by 51 different subroutines to deterministically simulate the water quality concentrations along a river in steady flow. Besides these 51 subroutines, another major subroutine, UNCAS (containing 16 additional subroutines), is used to incorporate uncertainty analysis into the model. To overcome the limiting assumptions of the original QUAL2E uncertainty analysis which restricts users to generating random input variables with uncorrelated probability distributions, a modification was made to include the CARMA-GMCS empirical stochastic model to generate spatially and temporally correlated random numbers representing the model input variables. Hence, the program CARMA, with GMCS as a subroutine, was added as another subroutine to Q2E3P1. Another major subroutine, OPTIMA, was added to the program to implement the flexible tolerance optimization algorithm in calibrating the model parameters. The programs were stored under three separate folders, "Simplex" and "Alternatives" and "PM", on the accompanying CD. The first set of programs, under the "Simplex" folder, was used to calibrate and validate the model parameters. The second set, under "Alternatives", was applied to simulate river water quality concentrations under the alternative pollution control strategies. Lastly, the performance of each strategy was evaluated using a set of programs stored under the folder "PM".