Prepared in cooperation with the Milwaukee Metropolitan Sewerage District

Refinement of Regression Models to Estimate Real-Time Concentrations of Contaminants in the Menomonee River Drainage Basin, Southeast Wisconsin, 2008–11

Scientific Investigations Report 2013–5174

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Conversion Factors, Abbreviations, and Datum

Inch/Pound to SI

Multiply	By	To obtain
	Area	
square mile (mi^2)	2.590	square kilometer (km^2)
	Flow rate	
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

°F=(1.8×°C)+32

Horizontal coordinate information is referenced to the Wisconsin Transverse Mercator (WTM) Projection and the North American Datum of 1983 (NAD 83) with 1991 adjustment.

Concentrations of chemical constituents in water are given in milligrams per liter (mg/L). Counts of bacteria in water are given in colony forming units per 100 milliliters (CFU/100 mL) or most probable number per 100 milliliters (MPN/100 mL).

Specific conductance is expressed in microsiemens per centimeter at 25° Celsius (µs/Cm).

Turbidity is expressed in formazin nephelometric units (FNU).

Acronyms and Abbreviations:

ANCOVA	analysis of covariance
EPA	U.S. Environmental Protection Agency
EWI	equal-width increment
FNU	formazin nephelometric units
MLR	multiple linear regression
MMSD	Milwaukee Metropolitan Sewerage District
MSPE	model standard percent error
NWIS	National Water Information System
PRESS	prediction error sum of squares
QA/QC	quality assurance/quality control
RMSE	root-mean-squared error
SLR	simple linear regression
USGS	U.S. Geological Survey

Refinement of Regression Models to Estimate Real-Time Concentrations of Contaminants in the Menomonee River Drainage Basin, Southeast Wisconsin, 2008–11

By Austin K. Baldwin[1], Dale M. Robertson[1], David A. Saad[1], and Christopher Magruder[2]

Abstract

In 2008, the U.S. Geological Survey and the Milwaukee Metropolitan Sewerage District initiated a study to develop regression models to estimate real-time concentrations and loads of chloride, suspended solids, phosphorus, and bacteria in streams near Milwaukee, Wisconsin. To collect monitoring data for calibration of models, water-quality sensors and automated samplers were installed at six sites in the Menomonee River drainage basin. The sensors continuously measured four potential explanatory variables: water temperature, specific conductance, dissolved oxygen, and turbidity. Discrete water-quality samples were collected and analyzed for five response variables: chloride, total suspended solids, total phosphorus, *Escherichia coli* bacteria, and fecal coliform bacteria. Using the first year of data, regression models were developed to continuously estimate the response variables on the basis of the continuously measured explanatory variables. Those models were published in a previous report. In this report, those models are refined using 2 years of additional data, and the relative improvement in model predictability is discussed. In addition, a set of regression models is presented for a new site in the Menomonee River Basin, Underwood Creek at Wauwatosa.

The refined models use the same explanatory variables as the original models. The chloride models all used specific conductance as the explanatory variable, except for the model for the Little Menomonee River near Freistadt, which used both specific conductance and turbidity. Total suspended solids and total phosphorus models used turbidity as the only explanatory variable, and bacteria models used water temperature and turbidity as explanatory variables.

An analysis of covariance (ANCOVA), used to compare the coefficients in the original models to those in the refined models calibrated using all of the data, showed that only 3 of the 25 original models changed significantly. Root-mean-squared errors (RMSEs) calculated for both the original and refined models using the entire dataset showed a median improvement in RMSE of 2.1 percent, with a range of 0.0–13.9 percent. Therefore most of the original models did almost as well at estimating concentrations during the validation period (October 2009–September 2011) as the refined models, which were calibrated using those data.

Application of these refined models can produce continuously estimated concentrations of chloride, total suspended solids, total phosphorus, *E. coli* bacteria, and fecal coliform bacteria that may assist managers in quantifying the effects of land-use changes and improvement projects, establish total maximum daily loads, and enable better informed decision making in the future.

Introduction

Many contaminants in streams cannot easily be measured in near real-time (henceforth referred to as real-time); however, studies have demonstrated that some water-quality constituents can be estimated based on more easily measured surrogates, such as water temperature and turbidity (for example, Christensen and others, 2000; Rasmussen and others, 2005). Therefore, continuous monitoring of these surrogates allows for continuous concentration estimates of the constituent(s) of interest and, when combined with discharges, constituent loads. Real-time water-quality concentrations and loads can be beneficial to managers responsible for developing water-quality-management plans and managing ecosystem and public health, recreation, and improvement projects.

In November 2008, the U.S. Geological Survey (USGS) and the Milwaukee Metropolitan Sewerage District (MMSD) began a cooperative study to develop regression models to estimate continuous real-time concentrations of selected water-quality constituents. Continuous real-time sensors and water-quality samplers were installed at six sites in the Menomonee River Basin, near Milwaukee, Wisconsin (Wis.). The real-time sensors measured four potential explanatory variables as surrogates: water temperature, turbidity, specific conductance, and dissolved oxygen. Discrete water-quality samples were collected and analyzed for five response

[1]U.S. Geological Survey.

[2]Milwaukee Metropolitan Sewerage District.

variables: chloride, total suspended solids, total phosphorus, *Escherichia coli* bacteria, and fecal coliform bacteria. Regression models were developed to estimate the response variables on a continuous basis based on the explanatory variables.

This report updates the models published in Baldwin and others (2012) for five sites in the Menomonee River Basin. Those original models were based on 1 year of data. For this report, 2 years of additional data were added to the original dataset, and the models were recalibrated and compared with the predictive capability of the original models. The additional data more than doubled the number of coinciding observations per model, from an average of 63 to 164. Developing the models based on 3 years of data versus only 1 year should make the models more representative of the variability in water quality caused by changes in streamflow from year to year.

In addition, a new site, Underwood Creek at Wauwatosa, Wis., which was not included in Baldwin and others (2012), was included in the analysis. Underwood Creek is a tributary of the Menomonee River and of special interest because the city of Waukesha may begin discharging treated wastewater into the creek upstream of the monitoring site, potentially doubling the current base-flow discharge.

A detailed description of the methods used for data collection and the development of the original regression models is available in Baldwin and others (2012). Because the methods of data collection and model development have not changed from the original study, they are only briefly described in this report.

Purpose and Scope

The purpose of this report is twofold. The first objective is to refine the previously published regression models to estimate real-time concentrations and loads of selected water-quality constituents based on additional data from real-time water-quality monitors and compare the predictive capability of the refined models with the original models. The original models were based on 1 year of data. For this report, 2 additional years of data are used to recalibrate the models. The second objective is to present a set of regression models for a new site, Underwood Creek at Wauwatosa.

The regression models presented and refined in this report may provide staff at the MMSD and other water-quality managers with a means to document improvements in water quality related to capital projects, assist with basin planning efforts, and provide real-time water-quality information to communities served by the MMSD and the general public.

Description of the Study Area

The Menomonee River Basin drains 146 mi^2 in southeast Wisconsin (fig. 1). The basin is within the MMSD planning and service area and includes parts of Milwaukee, Waukesha, Ozaukee, and Washington Counties. The largest tributaries within the basin include Underwood Creek, Honey Creek, and the Little Menomonee River. The Menomonee River joins the Milwaukee and Kinnickinnic Rivers to form the Milwaukee estuary in Lake Michigan near downtown Milwaukee.

Six sites within the Basin were monitored and sampled as part of this study: the Little Menomonee River near Freistadt (USGS site number 04087050), the Menomonee River at Menomonee Falls (04087030), Honey Creek at Wauwatosa (04087119), Underwood Creek at Wauwatosa (04087088), the Menomonee River at Wauwatosa (04087120), and the Menomonee River at Milwaukee (04087142; fig. 1). General basin characteristics upstream of these sites, including land use, are listed in table 1.

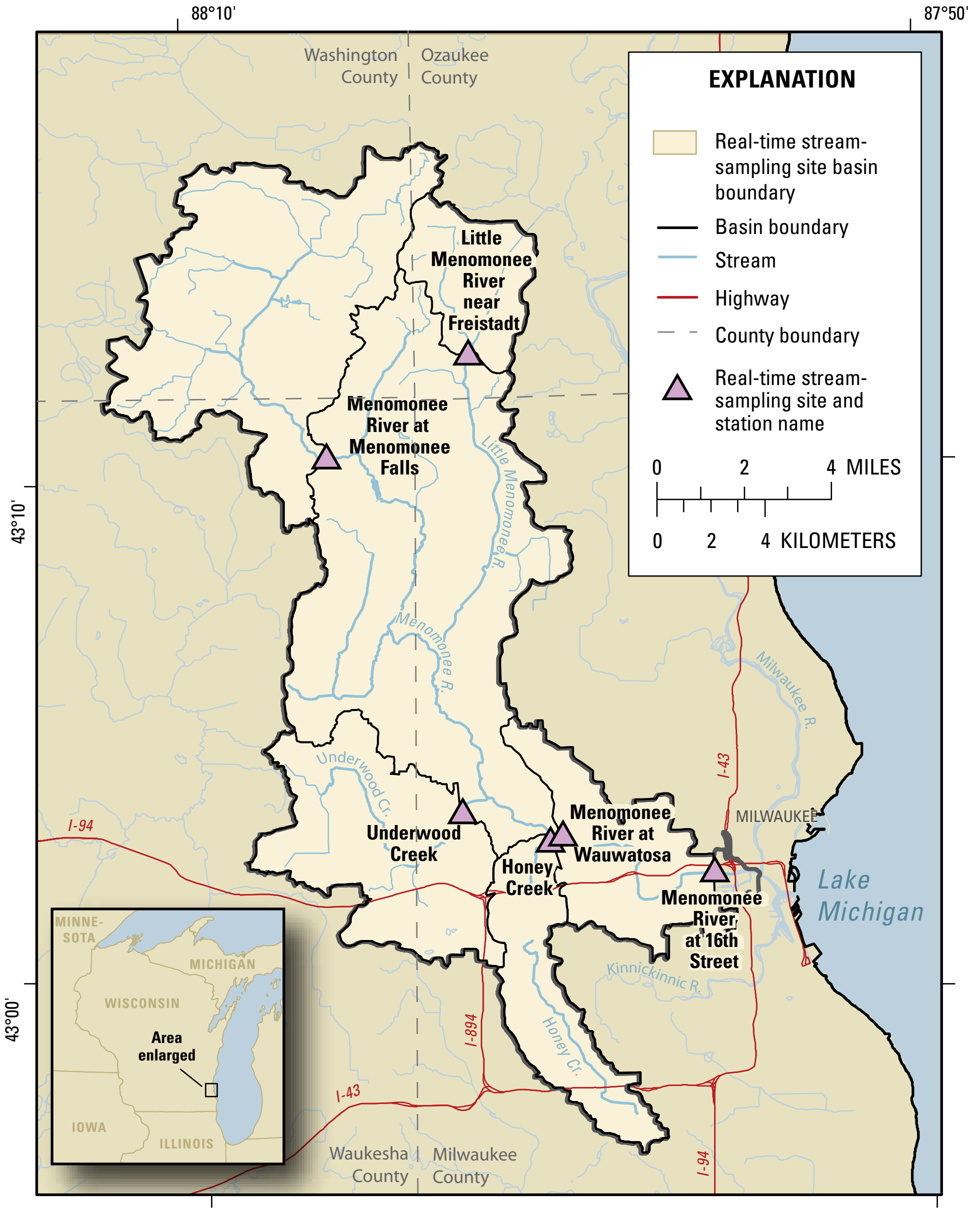

Figure 1. Location of real-time water-quality monitoring sites and drainage basins in the Menomonee River Basin, southeast Wisconsin.

Table 1. Basin characteristics of monitoring sites, Menomonee River Basin, southeast Wisconsin.

[Periods of record for annual mean discharge range from 4 years at Menomonee River at 16th Street (2008 to present) to 51 years at Menomonee River at Wauwatosa (1961 to present). Land use percentages are from 2000 (Southeastern Wisconsin Regional Planning Commission) and 2006 (National Land Cover Database). Population data from 2010 census. USGS, U.S. Geological Survey; mi^2, square miles; ft^3/s, cubic feet per second]

Monitoring site	USGS station number	Drainage area (mi^2)	Annual mean discharge (ft^3/s)	Urban area (percent)	Agricultural area (percent)	Natural area (percent)	Population density of basin (people/mi^2)
Little Menomonee River near Freistadt	04087050	8.0	7.3	20	63	17	242
Menomonee River at Menomonee Falls	04087030	34.7	31.5	35	38	27	786
Honey Creek at Wauwatosa	04087119	10.3	11.4	96	0	4	5,840
Menomonee River at Wauwatosa	04087120	123.0	106.0	61	19	20	1,850
Menomonee River at 16th Street at Milwaukee	04087142	146.0	184.5	64	17	19	2,230
Underwood Creek at Wauwatosa	04087088	18.1	15.2	84	1	15	1,850

Modeled Water-Quality Constituents

The five water-quality constituents modeled in this study are chloride, total suspended solids, total phosphorus, *Escherichia coli* bacteria, and fecal coliform bacteria.

Chloride

Chloride occurs naturally in streams, but at high concentrations chloride poses a significant threat to aquatic ecosystems. According to the EPA, chronic chloride ion concentrations above 230 milligrams per liter (mg/L), and acute chloride ion concentrations above 860 mg/L, pose a potential threat to aquatic life (U.S. Environmental Protection Agency, 1988). Road-salt runoff, caused by melting snow and ice that contains road salt, is a common source of elevated chloride concentrations in urban areas. Samples collected from 7 of 13 streams in the Milwaukee area during road-salt runoff periods exhibited toxicity in bioassays (Corsi and others, 2010). Chloride increases the conductivity of water and is, therefore, directly related to specific conductance (Christensen and others, 2000). The relation between chloride concentrations and specific conductance should make specific conductance an effective surrogate for estimating chloride concentrations in streams.

Total Suspended Solids

Total suspended solids are a combination of suspended sediment and organic matter. Because total suspended solids have numerous adverse effects on stream ecosystems, it is often considered a major pollutant or contaminant (Ritchie, 1972). Total suspended solids may be detrimental to stream communities by acting to enhance channel scour, reducing light penetration, reducing dissolved-oxygen levels (by providing substrate for microbes, which leads to increased respiration), smothering, reducing habitat through deposition, and introducing absorbed pollutants (Lenat and others, 1981; Alabaster and Lloyd, 1982). Effects on fish include mechanical abrasion, gill damage, fin rot, reduced survival of eggs, and death by clogging gills (Ritchie, 1972). Turbidity is often used as a surrogate for total suspended solids, because turbidity is a measurement of how well light rays are transmitted through a sample. Dissolved or suspended material in the water, such as clay, silt, and fine organic material, will cause light rays to be scattered and absorbed, resulting in a high turbidity value.

Total Phosphorus

Elevated concentrations of nutrients, especially phosphorus, are some of the most common stressors affecting rivers and streams throughout the United States (Robertson and others, 2006). High phosphorus concentrations may fuel excessive aquatic plant growth, which may result in low dissolved-oxygen concentrations from respiration and decomposing plants. Excessive phosphorus may also fuel nuisance algal blooms in receiving waters. Because phosphorus is likely to adsorb to suspended sediment, turbidity is often used as a surrogate for the estimation of total phosphorus.

Escherichia coli and Fecal Coliform Bacteria

Wastewater may enter surface waters through leaking sewage lines or septic tanks, wastewater-treatment plants, runoff from agricultural sources, and excretion by pets, wildlife, and waterfowl. *E. coli* and fecal coliform are common types of bacteria used as wastewater indicators. The presence of these bacteria suggests the presence of fecal wastes from either humans or other warm-blooded animals (Dufour, 1977). Pathogens that may be present in waters contaminated by fecal waste include *Cryptosporidium* spp., *Giardia* spp., hepatitis A, enteric adenovirus, Norwalk-like viruses, and rotavirus (Craun and others, 1999). Exposure to these and other pathogens is a serious human health risk.

Methods

Data Collection

Data collection for this study began in November 2008 at five of the sites: the Little Menomonee River near Freistadt, the Menomonee River at Menomonee Falls, Honey Creek at Wauwatosa, the Menomonee River at Wauwatosa, and the Menomonee River at Milwaukee. Data collection at a sixth site, Underwood Creek at Wauwatosa, was delayed because of channel restoration and began in March 2010. At all six sites, data collection is ongoing as of 2012. Types of data collected at these sites include continuous real-time data, discrete water-quality samples, and quality assurance/quality control (QA/QC) samples. A brief description of data collection for this study follows. For a more detailed description, see Baldwin and others (2012).

Continuous Real-Time Data

At all six sites, stream stage was measured every 15 minutes and was used to calculate stream discharge according to standard USGS methods (Turnipseed and Sauer, 2010; Oberg and others, 2005; Ruhl and Simpson, 2005).

A YSI 6920 V2 multiparameter water-quality sonde was installed at each site, and it was equipped with an optical dissolved-oxygen sensor, an optical turbidity sensor, and a specific conductance and temperature sensor. Water-quality measurements with the sonde were collected every 5 minutes, year round. Sonde maintenance, data correction, and reporting procedures followed standard USGS protocol (Wagner and others, 2006). Continuous streamflow and water-quality data are available at the USGS Web site at *http://waterdata.usgs.gov/wi/nwis* (accessed June 2012).

Discrete Water-Quality Samples

Each of the six sites was equipped with a stage-activated, refrigerated, automated sampler. Water samples were collected over a full range of hydrologic conditions (fig. 2). Samples were analyzed for chloride, total suspended solids, total phosphorus, *Escherichia coli* bacteria, and fecal coliform bacteria. During the first 2 years, samples were collected at each site during as many high-flow periods as possible, as well as once per month on a fixed schedule. Between 39 and 149 samples were collected per year at each site during the first 2 years. After the first 2 years, sampling frequency was reduced to 13 samples per year at each site.

Samples were prepared and analyzed by the MMSD laboratory. The preparatory steps included dividing samples into representative subsamples by using a splitting device developed for aqueous matrices and preserving the subsamples according EPA protocols. The analytical methods used by MMSD are based on procedures described by the

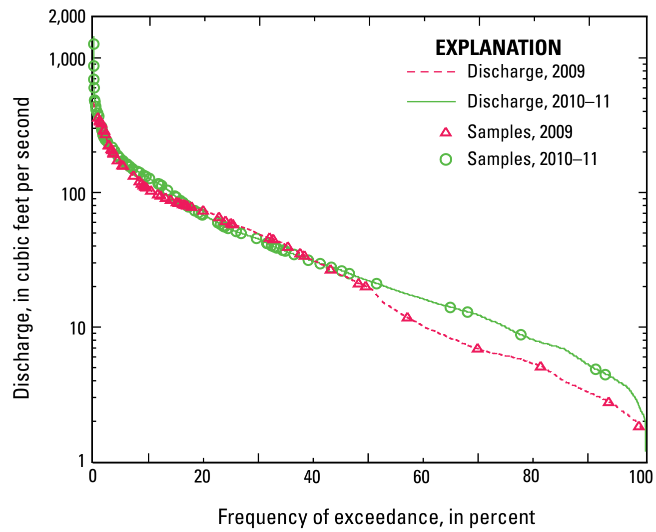

Figure 2. Comparison of discharge duration curves and associated samples for the periods November 2008–September 2009 and October 2009–September 2011, for the Menomonee River at Menomonee Falls, Wisconsin. Duration curves were developed from 15-minute discharge data.

U.S. Environmental Protection Agency (1993) or by Clesceri and others (1998). Specific procedure references are listed in appendix 1.

Quality Assurance/Quality Control

Quality-assurance and quality-control (QA/QC) samples collected during this study included sampler blanks to check for sampler contamination, splitter blanks to check for contamination from the sample processing equipment, and concurrent automated sampler and equal-width-increment (EWI) samples to evaluate whether the automated sampler samples were chemically and physically representative of the stream cross section. Additionally, water-quality cross sections were done at each site during varying flow conditions and seasons to evaluate whether the fixed placement of the water-quality sonde was representative of the stream cross section. Cross sections followed protocols described by Wagner and others (2006).

Model Development

The original regression models for the five sites published in Baldwin and others (2012) were refined (recalibrated) by using 2 years of additional data. The new additional data more than double the number of samples per model, from an average of 63 to 164. Calibrating the models with 3 years of data rather than only 1 year should better represent the variability in water-quality caused by changes in streamflow from year to year.

All of the models, including the new Underwood Creek models, were developed by using simple and multiple linear regression (SLR and MLR). The models were developed to estimate chloride, total suspended solids, total phosphorus, *E. coli* bacteria, and fecal coliform bacteria (the response variables). Response variables were log_{10}-transformed to remove nonlinearity, to make the residual variance more uniform, and (or) to make the residuals more normally distributed. Explanatory variables considered during the original model development included untransformed and log_{10}-transformed continuous in-stream temperature, specific conductance, turbidity, and dissolved oxygen sensor measurements, as well as seasonal variables (sine Julian day and cosine Julian day). The SAS software PROC REG command (SAS Institute Inc., 2004) was used to identify candidate explanatory variables for the original models; an alpha value of 0.05 was used for both entry into and removal from the model. From those candidate explanatory variables, subsets of explanatory variables were manually chosen for inclusion in the original models by using the following criteria: (1) simplicity of the model (preference for fewer variables), (2) consistency between sites (preference for a consistent set of variables), and (3) maximizing fit and explanatory power. A more detailed description of the process that was used to develop the original regression models can be found in Baldwin and others (2012).

The refined models for the original five sites were forced to use the same explanatory variables as their parent models (original models calibrated with one year of data). The explanatory variables used in the Underwood Creek models are the same for each constituent as those used in models for most other sites. This was partially by force (because of the preference for a consistent set of variables between sites), but it was also based on the explanatory variables selected by the stepwise regression.

In some situations, a sample was collected while one or more of the sonde sensors were fouled and giving erroneous data. Fouling may be determined from visual inspection of the data, such as measurements jumping up and down erratically, or from side-by-side comparison with a second, recently calibrated sonde (Wagner and others, 2006). When a sample was collected while a sensor was fouled, the sample would not be used in model(s) reliant on the fouled sensor. For example, if a sample was collected when the turbidity sensor was fouling but the specific conductance sensor was operating normally, that sample would be used in the chloride model that uses specific conductance as an explanatory variable, but it was omitted from the rest of the models that use turbidity as an explanatory variable. At some sites, one to five samples were not used in the final regression models because of fouling of the water-quality sondes.

To evaluate whether the new observations (those collected between October 2009 and September 2011) would significantly change the original models, an analysis of covariance (ANCOVA) was performed on each model (Helsel and Hirsch, 2002; Rasmussen and others, 2009). The ANCOVA compared the coefficients of the refined model with those of the original model. P-values indicate the level of significance of the difference in the coefficients between the original and refined models; p-values greater than 0.05 were used to maintain the null hypothesis that the original and refined models are not significantly different.

Evaluating Model Improvement

RMSEs were used to determine whether the original models were improved by the addition of 2 years of data. The RMSE is a measure of a model's residuals, or the differences between the measured and estimated values. A lower RMSE indicates a better model.

RMSEs were calculated for both the original models and the refined models using the entire dataset. Unlike the refined models, the original models had been calibrated by using only a subset of the entire dataset. Therefore, the RMSEs of the original models would be expected to be higher than those of the refined models. The percent change in RMSE from the original model to the revised model was calculated and used as a measure of model improvement.

Model Results

The refined models based on all 3 years of data and the model summary statistics are provided in tables in the following sections. Model-calibration datasets are provided in appendix 2. In appendixes 3–7, plots of the explanatory and response variables and residual plots are provided for visual evaluation of the fit of each model. A comparison of model predictability using RMSEs of the original models and the refined models, and the results of the ANCOVA tests, are provided in the Model Improvement section below.

Because the models use log_{10}-transformed response variables, model-computed values being retransformed back to the original units must be multiplied by a bias correction factor (Duan, 1983). The bias correction factor is calculated from the residual values and is therefore model-specific.

Rather than dividing the dataset into a calibration dataset and a validation dataset, the entire dataset was used to calibrate the refined models to maximize diversity in the measured conditions. Ideally, with more observations, each model would be validated with a separate dataset.

Chloride

Refined chloride regression models for five of the six sites, including the new model for Underwood Creek, use specific conductance as the only explanatory variable, with adjusted R^2 values between 0.86 and 0.97 and RMSE values between 0.08 and 0.18 (table 2). The model for the Little Menomonee River, a predominantly agricultural basin where specific conductance tends to be low (approximately 95 percent of measurements below 1,000 microsiemens per centimeter), uses both specific conductance and turbidity as explanatory variables, with an adjusted R^2 of 0.79 and an RMSE of 0.10. Figure 3 is an example from the Menomonee River at Menomonee Falls monitoring site showing estimated chloride values with 95-percent confidence intervals as well as the measured chloride values used to develop the regression model.

Table 2. Regression models and summary statistics for estimating concentrations of chloride in stream water at six sites in the Menomonee River Basin, southeast Wisconsin, November 2008–December 2011.

[CL, chloride, in milligrams per liter; Adj. R^2, adjusted coefficient of determination; RMSE, root mean square error; n, number of discrete samples; SC, specific conductance, in microsiemens per centimeter at 25 degrees Celsius; TUR, turbidity, in formazin nephelometric units (FNUs); log refers to $\log_{10}$]

Monitoring site (fig. 1)	Regression model	Adj. R^2	RMSE	Bias correction factor (Duan, 1983)	n	Range of values in variable measurements	Mean	Median	Standard deviation
Little Menomonee River near Freistadt	**logCL = -3.92 +1.91 logSC + 0.118 logTUR**	0.79	0.10	1.03	116	CL 10–150	48	45	24
						SC 301–1,123	674	684	185
						TUR 0.7–460	71	35	94
Menomonee River at Menomonee Falls	**logCL = -1.85 + 1.35 logSC**	0.94	0.08	1.02	150	CL 11–610	127	110	91
						SC 126–2,630	791	718	393
Honey Creek at Wauwatosa	**logCL = -1.34 + 1.22 logSC**	0.91	0.18	1.11	233	CL 7–2,400	224	110	324
						SC 74–10,300	959	471	1,210
Menomonee River at Wauwatosa	**logCL = -1.48 + 1.25 logSC**	0.92	0.12	1.04	220	CL 10–1,500	168	140	168
						SC 119–6,890	1,140	852	1,045
Menomonee River at 16th St. at Milwaukee	**logCL = -1.58 + 1.28 logSC**	0.97	0.08	1.01	190	CL 11–1,400	199	120	215
						SC 143–4,760	996	710	807
Underwood Creek at Wauwatosa	**logCL = -1.49 + 1.25 logSC**	0.86	0.14	1.05	187	CL 15–2,400	215	140	274
						SC 167–7,770	1,070	816	951

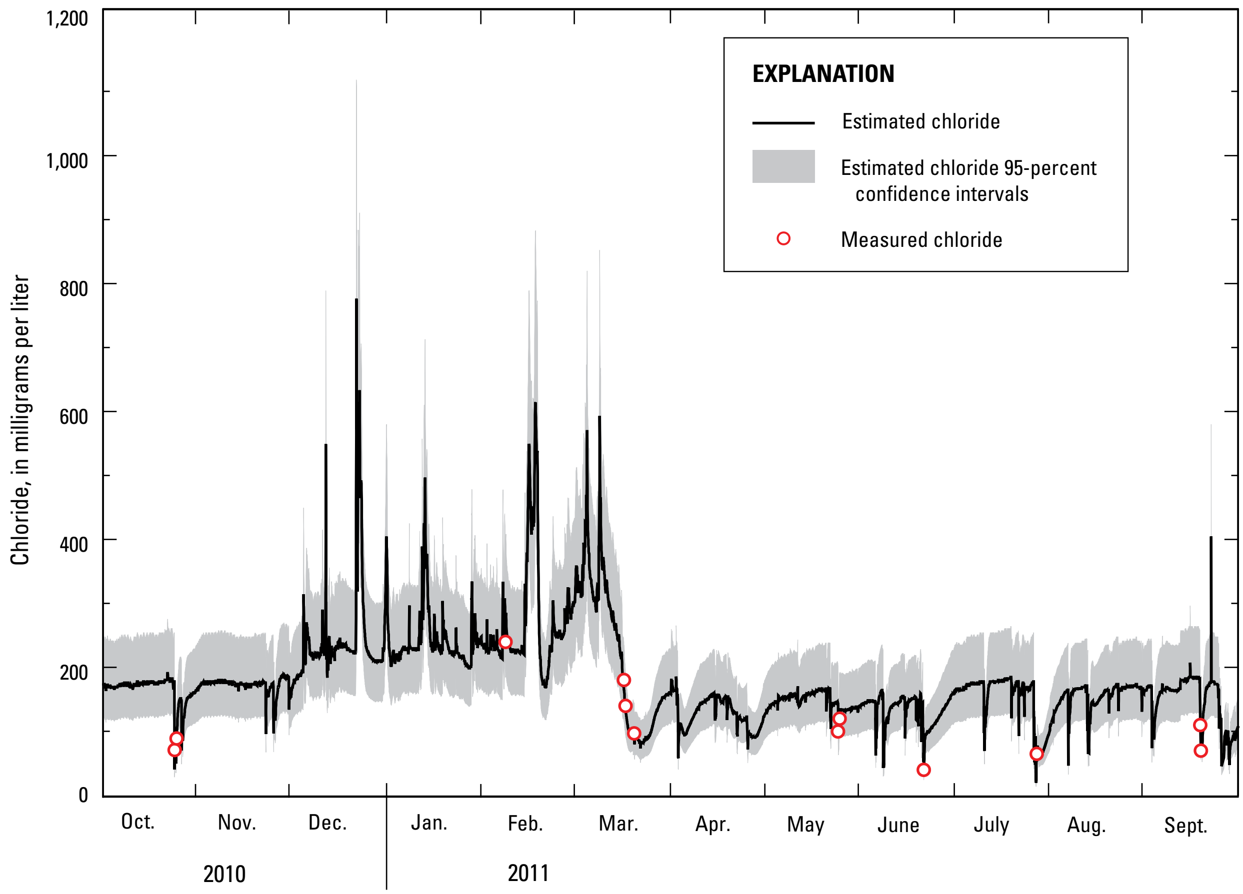

Figure 3. Estimated and measured chloride concentrations at the U.S. Geological Survey streamgage on the Menomonee River at Menomonee Falls, Wisconsin, October 2010–September 2011.

Total Suspended Solids

The refined regression models for total suspended solids at all six sites use turbidity as the explanatory variable (table 3). The adjusted R^2 values ranged from 0.71 to 0.91, and the RMSE values ranged from 0.18 to 0.31. Figure 4 is an example from the Menomonee River at Menomonee Falls showing estimated total suspended solids values with 95-percent confidence intervals as well as the measured total suspended solids values used to develop the regression model.

Table 3. Regression models and summary statistics for estimating concentrations of total suspended solids in stream water at six sites in the Menomonee River Basin, southeast Wisconsin, November 2008–December 2011.

[TSS, total suspended solids, in milligrams per liter; Adj. R^2, adjusted coefficient of determination; RMSE, root mean square error; n, number of discrete samples; TUR, turbidity, in formazin nephelometric units (FNUs); log refers to $\log_{10}$; <, less than]

Monitoring site (fig. 1)	Regression model	Adj. R^2	RMSE	Bias correction factor (Duan, 1983)	n	Range of values in variable measurements	Mean	Median	Standard deviation
Little Menomonee River near Freistadt	**logTSS = 0.274 + 0.958 logTUR**	0.90	0.20	1.11	116	TSS 1.6–1,100	125	45	192
						TUR 0.76–460	71	35	94
Menomonee River at Menomonee Falls	**logTSS = 0.131 + 1.04 logTUR**	0.91	0.18	1.11	148	TSS 1.16–2,600	137	38	305
						TUR 0.06–780	68	26	112
Honey Creek at Wauwatosa	**logTSS = 0.030 + 1.05 logTUR**	0.83	0.28	1.20	221	TSS <1.06–1,100	160	110	172
						TUR 0.06–440	99	72	92
Menomonee River at Wauwatosa	**logTSS = 0.297 + 0.924 logTUR**	0.77	0.25	1.17	202	TSS 1.36–400	105	62	106
						TUR 0.06–240	59	46	54
Menomonee River at 16th St. at Milwaukee	**logTSS = 0.103 + 0.972 logTUR**	0.82	0.23	1.17	189	TSS 4.46–1,900	111	36	249
						TUR 0.06–60	66	38	87
Underwood Creek at Wauwatosa	**logTSS = 0.405 + 0.905 logTUR**	0.71	0.31	1.29	184	TSS <1.06-–1,200	146	80	177
						TUR 0.06–74	75	53	84

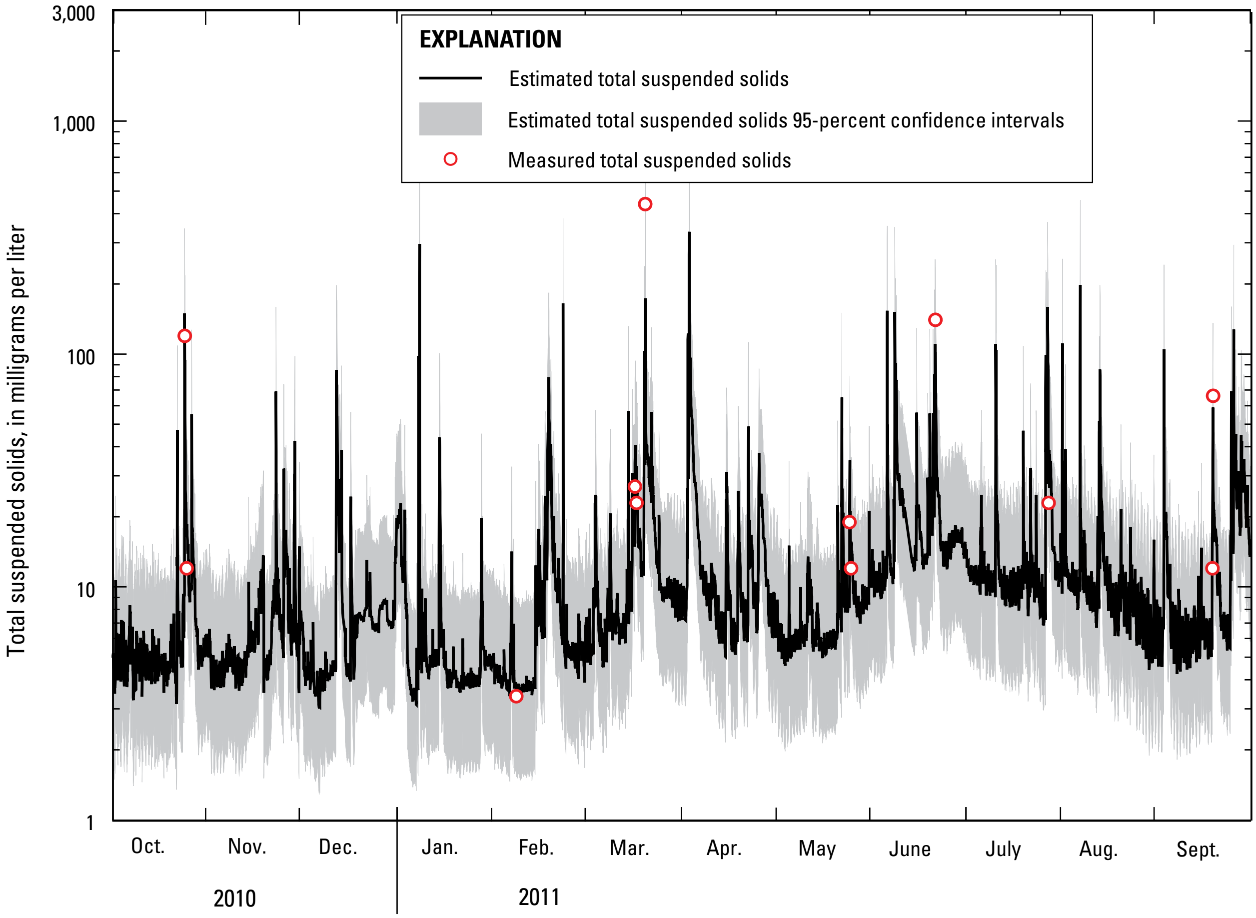

Figure 4. Estimated and measured total suspended solids concentrations (TSS) at the U.S. Geological Survey streamgage on the Menomonee River at Menomonee Falls, Wisconsin, October 2010–September 2011.

Total Phosphorus

The refined regression models for total phosphorus at each site all used turbidity as the explanatory variable (table 4). The adjusted R^2 values ranged from 0.53 to 0.82, and the RMSE values ranged from 0.17 to 0.27. Figure 5 is an example from the Menomonee River at Menomonee Falls showing estimated total phosphorus values with 95-percent confidence intervals as well as the measured total phosphorus values used to develop the regression model.

Table 4. Regression models and summary statistics for estimating concentrations of total phosphorus in stream water at six sites in the Menomonee River Basin, southeast Wisconsin, November 2008–December 2011.

[TP, total phosphorus, in milligrams per liter; Adj. R^2, adjusted coefficient of determination; RMSE, root mean square error; n, number of discrete samples; TUR, turbidity, in formazin nephelometric units (FNUs); log refers to $\log_{10}$; <, less than]

Monitoring site (fig. 1)	Regression model	Adj. R^2	RMSE	Bias correction factor (Duan, 1983)	n	Range of values in variable measurements	Mean	Median	Standard deviation
Little Menomonee River near Freistadt	**logTP = -1.51 + 0.568 logTUR**	0.82	0.17	1.10	116	TP 0.02–1.30	0.30	0.24	0.24
						TUR 0.7–460	71	35	94
Menomonee River at Menomonee Falls	**logTP = -1.66 + 0.563 logTUR**	0.77	0.17	1.10	148	TP 0.03–3.00	0.23	0.13	0.32
						TUR 0.0–780	68	26	112
Honey Creek at Wauwatosa	**logTP = -1.50 + 0.477 logTUR**	0.70	0.18	1.10	221	TP 0.03–1.20	0.28	0.25	0.20
						TUR 0.0–40	99	72	92
Menomonee River at Wauwatosa	**logTP = -1.56 + 0.494 logTUR**	0.62	0.19	1.10	198	TP 0.03–0.58	0.19	0.17	0.12
						TUR 0.0–240	60	46	53
Menomonee River at 16th St. at Milwaukee	**logTP = -1.55 + 0.473 logTUR**	0.64	0.18	1.10	187	TP 0.04–2.40	0.21	0.14	0.27
						TUR 0.0–560	66	38	87
Underwood Creek at Wauwatosa	**logTP = -1.56 + 0.530 logTUR**	0.53	0.27	1.37	186	TP <0.01–6.00	0.31	0.19	0.52
						TUR 0.0–74	75	53	84

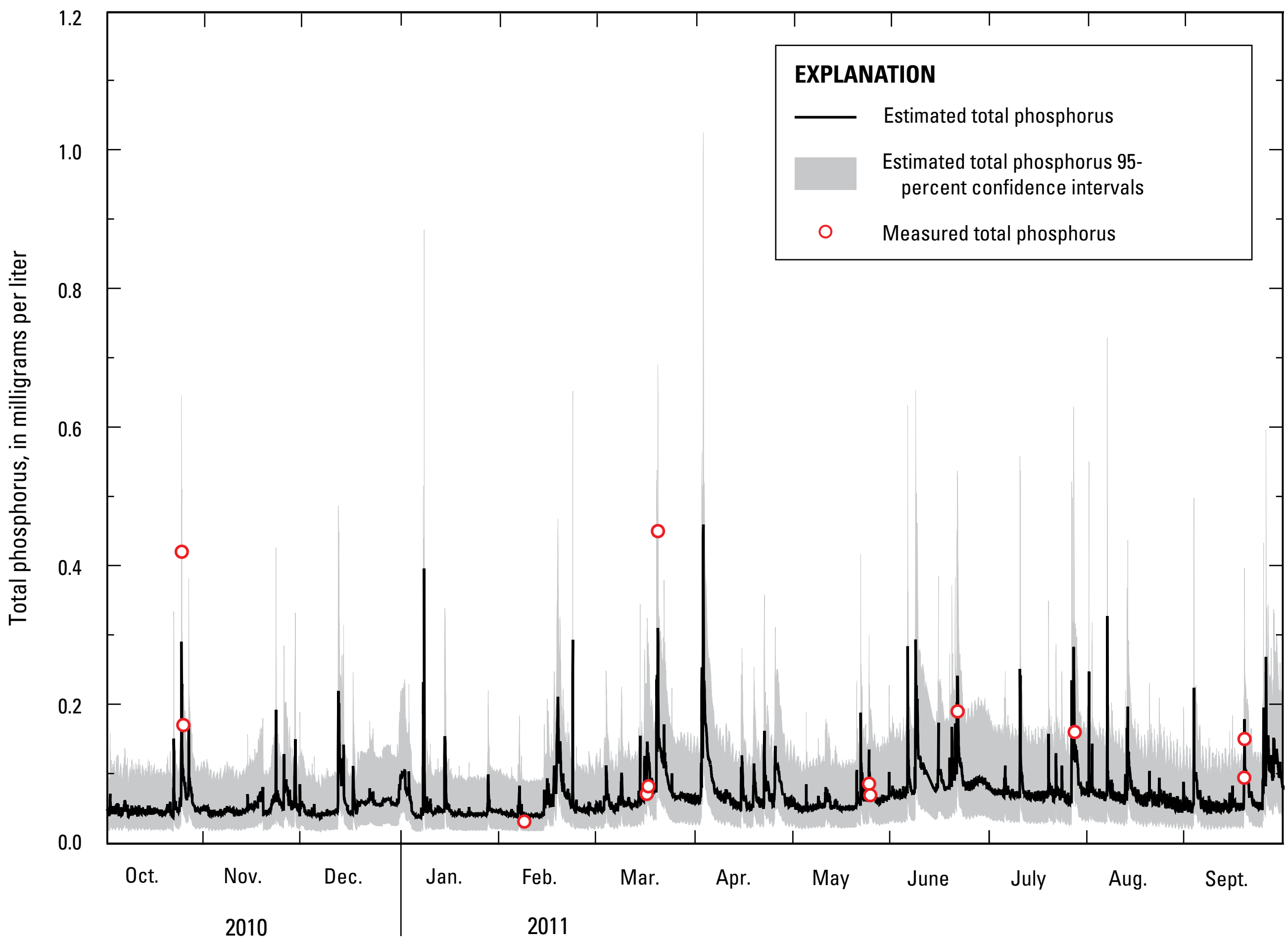

Figure 5. Estimated and measured total phosphorus concentrations at the U.S. Geological Survey streamgage on the Menomonee River at Menomonee Falls, Wisconsin, October 2010–September 2011.

Indicator Bacteria

Because suspended material is a medium for bacterial accumulation and transport, turbidity is often used as a surrogate for bacteria. In addition to turbidity, water temperature was determined to be a significant variable in the indicator bacteria regression models, likely because *E. coli* and fecal coliform bacteria prefer warmer temperatures (Madigan and others, 1997; Byappanahalli and others, 2003; Byappanahalli and others, 2006).

Escherichia coli

The refined regression models for *E. coli* bacteria for each site used water temperature and turbidity as explanatory variables (table 5). The adjusted R^2 values ranged from 0.45 to 0.65, and the RMSE values ranged from 0.49 to 0.57. Figure 6 is an example from the Menomonee River at Menomonee Falls showing estimated *E. coli* values with 95-percent confidence intervals as well as the measured *E. coli* values used to develop the regression model.

Table 5. Regression models and summary statistics for estimating concentrations of *Escherichia coli* bacteria in stream water at six sites in the Menomonee River Basin, southeast Wisconsin, November 2008–December 2011.

[EC, *Escherichia coli* bacteria, in colonies per 100 milliliter; Adj. R^2, adjusted coefficient of determination; RMSE, root mean square error; n, number of discrete samples; TUR, turbidity, in formazin nephelometric units (FNUs); WT, water temperature, in degrees Celsius; log refers to $\log_{10}$; <, less than]

Monitoring site (fig. 1)	Regression model	Adj. R^2	RMSE	Bias correction factor (Duan, 1983)	n	Range of values in variable measurements	Mean	Median	Standard deviation
Little Menomonee River near Freistadt	**logEC = 1.81 + 0.044WT + 0.713 logTUR**	0.65	0.49	1.95	102	EC <10–61,000	7,370	2,150	12,500
						WT 0.0–22.2	9.6	9.5	7.6
						TUR 0.7–460	77	39	99
Menomonee River at Menomonee Falls	**logEC = 1.38 + 0.050WT + 0.711 logTUR**	0.62	0.57	2.13	132	EC <1–52,000	5,530	1,400	9,180
						WT 0.0–25.8	13.0	13.5	8.1
						TUR 0.0–780	72	25	117
Honey Creek at Wauwatosa	**logEC = 1.97 + 0.062WT + 0.556 logTUR**	0.61	0.51	2.11	185	EC <1–200,000	20,400	8,800	34,400
						WT 0.0–25.7	13.4	14.7	7.6
						TUR 0.0–440	101	73	96
Menomonee River at Wauwatosa	**logEC = 1.60 + 0.055WT + 0.760 logTUR**	0.61	0.55	2.27	165	EC <10–73,000	12,100	3,900	16,100
						WT 0.0–25.8	12.2	12.0	8.3
						TUR 0.0–240	62	47	55
Menomonee River at 16th St. at Milwaukee	**logEC = 1.44 + 0.047WT + 0.895 logTUR**	0.60	0.51	2.31	171	EC <10–140,000	9,760	2,900	17,200
						WT 0.0–27.1	12.8	13.1	8.2
						TUR 0.0–560	69	38	91
Underwood Creek at Wauwatosa	**logEC = 2.34 + 0.033WT + 0.661 logTUR**	0.45	0.54	2.33	157	EC <1–240,000	20,500	9,950	30,200
						WT 0.0–33.9	14.6	16.4	7.2
						TUR 0.0–400	75	53	80

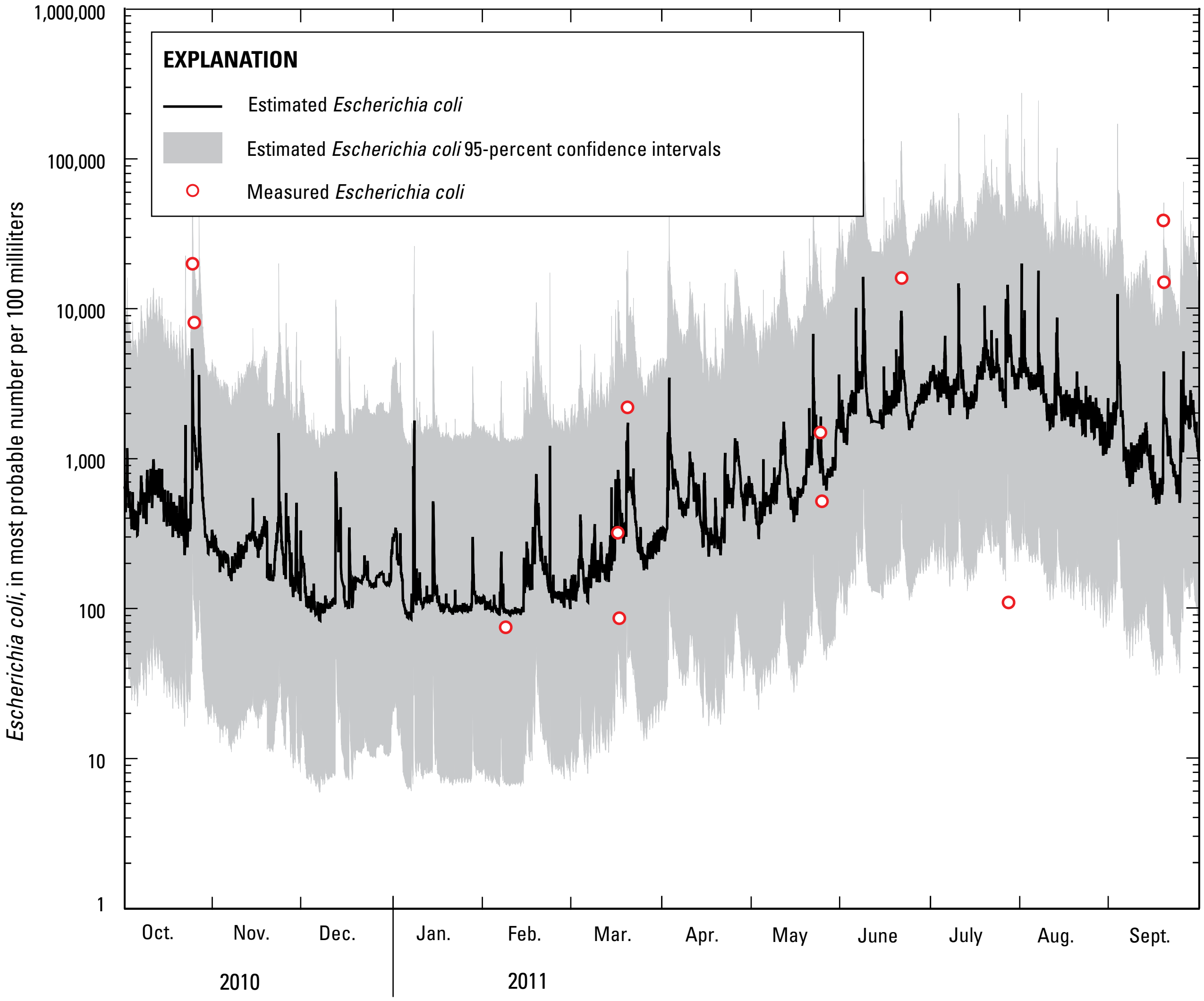

Figure 6. Estimated and measured *Escherichia coli* bacteria concentrations at the U.S. Geological Survey streamgage on the Menomonee River at Menomonee Falls, Wisconsin, October 2010–September 2011.

Fecal Coliform

The refined regression models for fecal coliform bacteria at each site used water temperature and turbidity as the explanatory variables (table 6). The adjusted R^2 values ranged from 0.54 to 0.71, and the RMSE ranged from 0.50 to 0.61. Figure 7 is an example from the Menomonee River at Menomonee Falls, showing estimated fecal coliform values with 95-percent confidence intervals as well as the measured fecal coliform values used to develop the regression model.

Table 6. Regression models and summary statistics for estimating concentrations of fecal coliform bacteria in stream water at six sites in the Menomonee River Basin, southeast Wisconsin, November 2008–December 2011.

[FC, fecal coliform bacteria, in colonies per 100 milliliter; Adj. R^2, adjusted coefficient of determination; RMSE, root mean square error; n, number of discrete samples; TUR, turbidity, in formazin nephelometric units (FNUs); WT, water temperature, in degrees Celsius; log refers to $\log_{10}$; <, less than]

Monitoring site (fig. 1)	Regression model	Adj. R^2	RMSE	Bias correction factor (Duan, 1983)	n	Range of values in variable measurements	Mean	Median	Standard deviation
Little Menomonee River near Freistadt	**logFC = 1.51 + 0.053WT + 0.825 logTUR**	0.68	0.54	2.13	95	FC <10–30,000	12,900	2,000	37,700
						WT 0.0–22.2	10.0	9.7	7.5
						TUR 0.7–460	78	40	100
Menomonee River at Menomonee Falls	**logFC = 1.30 + 0.061WT + 0.756 logTUR**	0.71	0.54	2.03	118	FC <10–52,000	8,780	1,900	12,600
						WT 0.0–25.8	13.3	13.7	8.1
						TUR 0.0–780	76	29	122
Honey Creek at Wauwatosa	**logFC = 1.89 + 0.076WT + 0.534 logTUR**	0.68	0.50	2.01	188	FC 24–170,000	27,100	10,500	36,300
						WT 0.0–25.7	13.7	16.2	7.6
						TUR 0.0–440	102	75	96
Menomonee River at Wauwatosa	**logFC = 1.57 + 0.067WT + 0.740 logTUR**	0.61	0.61	2.08	145	FC 10–83,000	18,200	7,600	22,100
						WT 0.0–25.8	13.4	14.5	8.1
						TUR 0.0–240	66	53	57
Menomonee River at 16th St. at Milwaukee	**logFC = 1.29 + 0.055WT + 0.983 logTUR**	0.63	0.57	2.52	144	FC 24–180,000	18,600	4,000	30,800
						WT 0.0–27.1	13.6	14.3	7.9
						TUR 0.0–560	73	38	97
Underwood Creek at Wauwatosa	**logFC = 2.19 + 0.042WT + 0.761 logTUR**	0.54	0.56	2.29	149	FC 32–320,000	31,700	20,000	40,700
						WT 0.0–33.9	14.9	16.6	7.2
						TUR 0.0–400	77	53	81

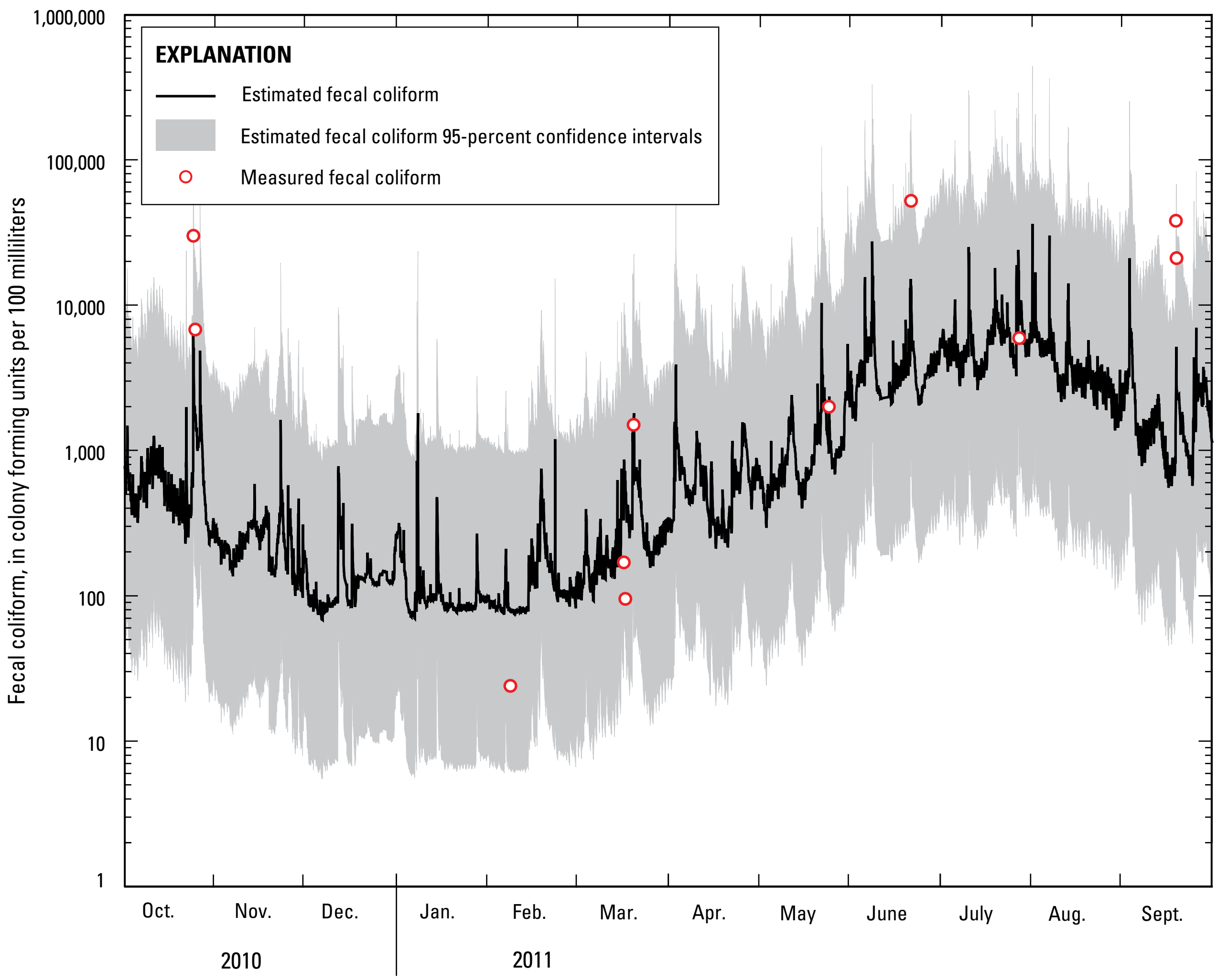

Figure 7. Estimated and measured fecal coliform bacteria concentrations at the U.S. Geological Survey streamgage on the Menomonee River at Menomonee Falls, Wisconsin, October 2010–September 2011.

Model Improvement

The percent changes in RMSE between the original and refined models are listed in table 7. Overall, the median improvement in RMSE from the original to the refined models was 2.1 percent, ranging from 0.0 percent for TSS at the Menomonee River at 16th Street to 13.9 percent for fecal coliform at the Little Menomonee River near Freistadt. Only 4 of the 25 models showed an improvement in RMSE greater than 5 percent, indicating that most of the original models did well at estimating the new values and the changes that were associated with changes in streamflow from year to year.

Figures 8*A* and *B* show examples of models with (*A*) a small improvement in RMSE and (*B*) a relatively large improvement in RMSE. Figure 8*A* is the entire total suspended solids dataset for Honey Creek, with the original and refined models shown for comparison. In this example, the improvement in RMSE is 1.8 percent, which is slightly less than the median improvement of all the models. Despite calibration of the original model with fewer than half of the data points shown, its predictive ability was only slightly less than the refined model, which was calibrated with twice the number of samples. Figure 8*B* shows the entire chloride dataset for Honey Creek, again with the original and refined models shown for comparison. The improvement in RMSE in this example is 12.3 percent, which is the second highest of all the models. Although this improvement is visible—the refined model fits the data better than the original model—the two models are similar.

An ANCOVA test was performed on each model to evaluate whether the new observations changed any of the coefficients in the original model significantly. Of the 25 models, only 3 showed a significant change in 1 or more of its coefficients (p-values less than 0.05; table 7). The three models with changes were each from different sites; one was the Honey Creek chloride model shown in figure 8*B*, which also showed a relatively large improvement in RMSE (12.3 percent, table 7). The other two models that showed significant changes were for total suspended solids at the Menomonee River at Menomonee Falls and at the Menomonee River at Wauwatosa. The improvement in RMSE of these two models was 3.4 percent and 4.7 percent, respectively.

Based on the minor improvements in RMSEs and the ANCOVA results, 1 year of detailed water-quality data covering the full range of hydrologic conditions may be adequate for developing satisfactory regression models to estimate future concentrations for the constituents sampled in this study. However, many of the models in this study did improve or change, if only modestly, with additional observations and a wider range of flows. These improvements will translate to better estimates of concentrations and loads. The ability of these models to estimate future concentrations is probably because the explanatory variables chosen have a cause-and-effect relationship with the response variables, rather than just simple correlations.

Table 7. Improvements in root-mean-squared errors of the regression models and analysis of covariance (ANCOVA) results.

[Root-mean-squared errors (RMSEs) for both the original models and the refined models were calculated using the complete dataset, November 2008–September 2011. ANCOVA, analysis of covariance; int, intercept; coef., coefficient; mg/L, milligrams per liter; mL, milliliters; SC, specific conductance, in microsiemens per centimeter at 25 degrees Celsius; TUR, turbidity, in formazin nephelometric units (FNUs); WT, water temperature, in degrees Celsius; log refers to $\log_{10}$; na, not applicable]

Monitoring site (fig. 1)	Original model	RMSE of original model and entire dataset	Refined model	RMSE of refined model and entire dataset	Improvement in RMSE (percent)	ANCOVA p-values (int., coef. 1, coef. 2)	Significant change in model? (ANCOVA)
			Chloride (CL, mg/L)				
Little Menomonee River near Freistadt	**logCL = -4.16 + 1.99 logSC + 0.1511 logTUR**	0.105	**logCL = -3.92 +1.91 logSC + 0.118 logTUR**	0.100	4.6	0.99, 0.99, 0.56	No.
Menomonee River at Menomonee Falls	**logCL = -1.63 + 1.28 logSC**	0.080	**logCL = -1.85 + 1.35 logSC**	0.078	3.1	0.13, 0.16	No.
Honey Creek at Wauwatosa	**logCL = -0.984 + 1.12 logSC**	0.206	**logCL = -1.34 + 1.22 logSC**	0.180	12.3	0.04, 0.10	Yes.
Menomonee River at Wauwatosa	**logCL = -1.41 + 1.23 logSC**	0.120	**logCL = -1.48 + 1.25 logSC**	0.118	1.3	0.59, 0.63	No.
Menomonee River at 16th St. at Milwaukee	**logCL = -1.50 + 1.26 logSC**	0.080	**logCL = -1.58 + 1.28 logSC**	0.076	5.0	0.43, 0.48	No.
Underwood Creek at Wauwatosa	**logCL = -1.49 + 1.25 logSC**	0.140	na	na	na	na	na.
			Total suspended solids (TSS, mg/L)				
Little Menomonee River near Freistadt	**logTSS = 0.33 + 0.91 logTUR**	0.203	**logTSS = 0.274 + 0.958 logTUR**	0.200	1.3	0.46, 0.34	No.
Menomonee River at Menomonee Falls	**logTSS = 0.256 + 0.953 logTUR**	0.189	**logTSS = 0.131 + 1.04 logTUR**	0.183	3.4	0.03, 0.03	Yes.
Honey Creek at Wauwatosa	**logTSS = 0.160 + 0.967 logTUR**	0.280	**logTSS = 0.030 + 1.05 logTUR**	0.275	1.8	0.19, 0.14	No.
Menomonee River at Wauwatosa	**logTSS = 0.567 + 0.779 logTUR**	0.262	**logTSS = 0.297 + 0.924 logTUR**	0.250	4.7	0.01, 0.01	Yes.
Menomonee River at 16th St. at Milwaukee	**logTSS = 0.108 + 0.974 logTUR**	0.232	**logTSS = 0.103 + 0.972 logTUR**	0.232	-0.0	0.92, 0.97	No.
Underwood Creek at Wauwatosa	**logTSS = 0.405 + 0.905 logTUR**	0.310	na	na	na	na	na.
			Total phosphorus (TP, mg/L)				
Little Menomonee River near Freistadt	**logTP = -1.372 + 0.486 logTUR**	0.177	**logTP = -1.51 + 0.568 logTUR**	0.168	5.3	0.07, 0.09	No.
Menomonee River at Menomonee Falls	**logTP = -1.55 + 0.492 logTUR**	0.179	**logTP = -1.66 + 0.563 logTUR**	0.175	2.6	0.14, 0.13	No.
Honey Creek at Wauwatosa	**logTP = -1.45 + 0.451 logTUR**	0.182	**logTP = -1.50 + 0.477 logTUR**	0.181	0.5	0.21, 0.30	No.
Menomonee River at Wauwatosa	**logTP = -1.42 + 0.431 logTUR**	0.194	**logTP = -1.56 + 0.494 logTUR**	0.188	3.0	0.08, 0.19	No.
Menomonee River at 16th St. at Milwaukee	**logTP = -1.510 + 0.462 logTUR**	0.181	**logTP = -1.55 + 0.473 logTUR**	0.180	0.8	0.61, 0.82	No.
Underwood Creek at Wauwatosa	**logTP = -1.56 + 0.530 logTUR**	0.270	na	na	na	na	na.

Table 7. Improvements in root-mean-squared errors of the regression models and analysis of covariance (ANCOVA) results.—Continued

[Root-mean-squared errors (RMSEs) for both the original models and the refined models were calculated using the complete dataset, November 2008–September 2011. ANCOVA, analysis of covariance; int, intercept; coef., coefficient; mg/L, milligrams per liter; mL, milliliters; SC, specific conductance, in microsiemens per centimeter at 25 degrees Celsius; TUR, turbidity, in formazin nephelometric units (FNUs); WT, water temperature, in degrees Celsius; log refers to log_{10}; na, not applicable]

Monitoring site (fig. 1)	Original model	RMSE of original model and entire dataset	Refined model	RMSE of refined model and entire dataset	Improvement in RMSE (percent)	ANCOVA p-values (int., coef. 1, coef. 2)	Significant change in model? (ANCOVA)
			Escherichia coli bacteria (EC, colonies per 100 mL)				
Little Menomonee River near Freistadt	**logEC = 1.81 + 0.025WT + 0.693 logTUR**	0.554	**logEC = 1.81 + 0.044WT + 0.713 logTUR**	0.488	11.9	0.97, 0.18, 0.90	No.
Menomonee River at Menomonee Falls	**logEC = 1.30 + 0.057WT + 0.674 logTUR**	0.572	**logEC = 1.38 + 0.050WT + 0.711 logTUR**	0.568	0.7	0.75, 0.80, 0.49	No.
Honey Creek at Wauwatosa	**logEC = 1.68 + 0.071WT + 0.626 logTUR**	0.515	**logEC = 1.97 + 0.062WT + 0.556 logTUR**	0.506	1.8	0.27, 0.31, 0.65	No.
Menomonee River at Wauwatosa	**logEC = 1.28 + 0.063WT + 0.884 logTUR**	0.563	**logEC = 1.60 + 0.055WT + 0.760 logTUR**	0.552	2.0	0.18, 0.35, 0.38	No.
Menomonee River at 16th St. at Milwaukee	**logEC = 1.29 + 0.059WT + 0.886 logTUR**	0.523	**logEC = 1.44 + 0.047WT + 0.895 logTUR**	0.514	1.8	0.56, 0.17, 0.95	No.
Underwood Creek at Wauwatosa	**logEC = 2.34 + 0.033WT + 0.661 logTUR**	0.540	na	na	na	na	na.
			Fecal coliform bacteria (FC, colonies per 100 mL)				
Little Menomonee River near Freistadt	**logFC = 1.49 + 0.035WT + 0.777 logTUR**	0.630	**logFC = 1.51 + 0.053WT + 0.825 logTUR**	0.542	13.9	0.92, 0.30, 0.78	No.
Menomonee River at Menomonee Falls	**logFC = 1.07 + 0.063WT + 0.834 logTUR**	0.550	**logFC = 1.30 + 0.061WT + 0.756 logTUR**	0.540	1.9	0.39, 0.74, 0.75	No.
Honey Creek at Wauwatosa	**logFC = 1.46 + 0.089WT + 0.648 logTUR**	0.517	**logFC = 1.89 + 0.076WT + 0.534 logTUR**	0.498	3.7	0.15, 0.12, 0.67	No.
Menomonee River at Wauwatosa	**logFC = 1.38 + 0.078WT + 0.79 logTUR**	0.618	**logFC = 1.57 + 0.067WT + 0.740 logTUR**	0.607	1.7	0.51, 0.26, 0.77	No.
Menomonee River at 16th St. at Milwaukee	**logFC = 1.07 + 0.062WT + 1.00 logTUR**	0.584	**logFC = 1.29 + 0.055WT + 0.983 logTUR**	0.572	2.1	0.48, 0.55, 0.91	No.
Underwood Creek at Wauwatosa	**logFC = 2.19 + 0.042WT + 0.761 logTUR**	0.560	na	na	na	na	na.

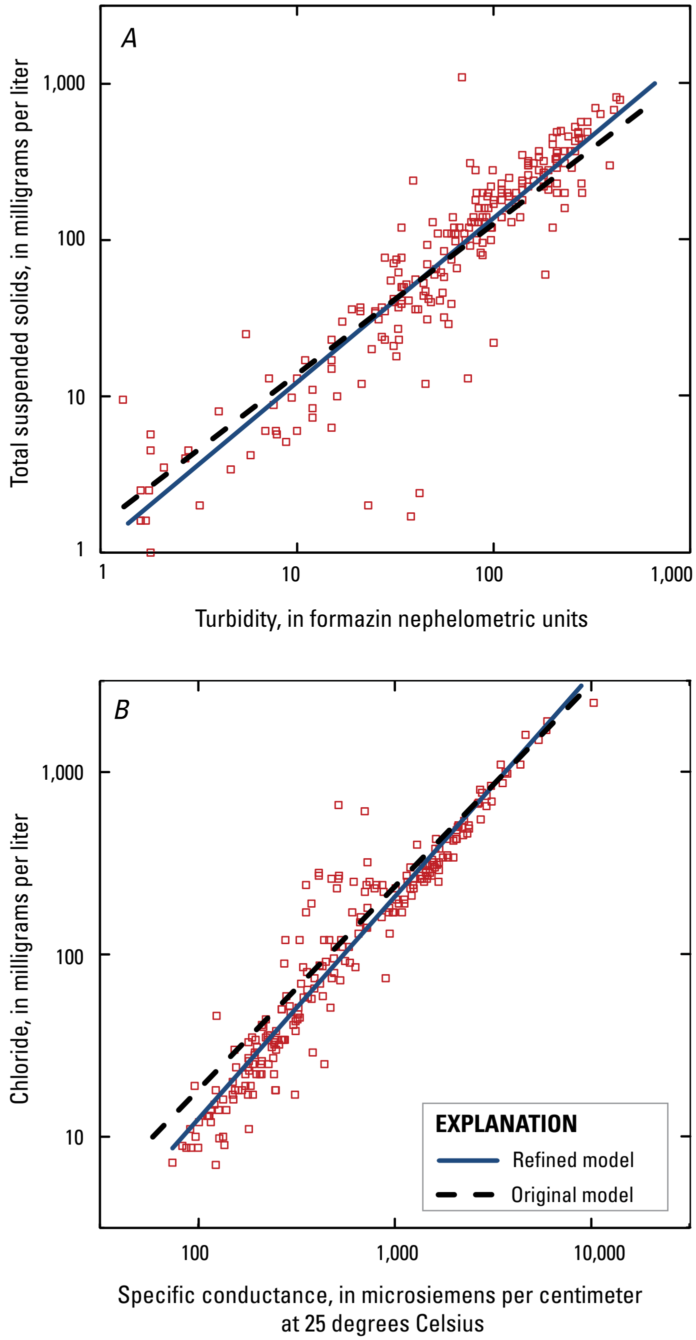

Figure 8. Examples of improvement between the original and refined models at the U.S. Geological Survey streamgage on Honey Creek at Wauwatosa, Wisconsin, December 2008–September 2011. *A*, Relation between turbidity and total suspended solids concentration; improvement in RMSE from the original to the refined model is 1.8 percent. *B*, Relation between specific conductance and chloride concentration; improvement in RMSE from the original to the refined model is 12.3 percent.

Summary and Conclusions

The U.S. Geological Survey and the Milwaukee Metropolitan Sewerage District initiated a study in 2008 to develop regression models to estimate real-time concentrations and loads of selected water-quality constituents in the Menomonee River Basin near Milwaukee in southeast Wisconsin. Water-quality sensors and automated samplers were installed at six sites in the Menomonee River Basin. The sensors continuously measured four potential explanatory variables: water temperature, specific conductance, dissolved oxygen, and turbidity. Discrete water-quality samples were collected and analyzed for five response variables: chloride, total suspended solids, total phosphorus, *Escherichia coli* bacteria, and fecal coliform bacteria. Regression models were developed to continuously estimate (every 5 minutes) the response variables on the basis of the explanatory variables.

Models calibrated with data from November 2008 to September 2009 were published for five of the six sites by Baldwin and others (2012). In this report, 2 years of additional data were used to refine those models and determine whether refined models significantly improved the relations found with 1 year of data. Additionally, new models are presented for a sixth site, Underwood Creek at Wauwatosa.

After refining the regression models, RMSEs were calculated for both the original and refined models by using the entire dataset, which covered the period from November 2008 to September 2011. The median improvement in RMSE from the original model to the refined model was 2.1 percent, ranging from 0.0 to 13.9 percent. Therefore, most of the original models did almost as well at estimating concentrations during the validation period (October 2009 to September 2011) as the refined models that were calibrated using those data.

ANCOVA tests comparing the original models to models created using all of the data showed that only 3 of the 25 models changed significantly (p-values less than 0.05). This suggests that future studies may be able to develop satisfactory predictive models with 1 year of detailed water-quality data, as long as the full range of hydrologic conditions is represented. However, ongoing sampling is recommended to periodically verify the validity of the regression models and determine whether changes in the watershed may have affected the relations between response and dependent variables.

The refined regression models in this report can be used to continuously estimate concentrations of chloride, total suspended solids, total phosphorus, *E. coli* bacteria, and fecal coliform bacteria. Managers can use the resulting estimates to understand variability in constituent concentrations, develop total maximum daily loads (by multiplying the estimated concentrations by the measured flows), assess the effects of improvement projects and land-use changes, provide real-time water-quality information to communities served by MMSD and the general public, and focus where future improvement projects could be implemented to maximize benefits.

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Appendix 1. Analytical Procedures Used for Water-Quality Samples

Variable	Method reference
Chloride	SM(20)4500-Cl E, Clesceri and others (1998)
Total suspended solids	SM(20)2540D, Clesceri and others (1998)
Total phosphorus	EPA 365.1, Environmental Protection Agency (1993)
Escherichia coli bacteria	SM(20)9223B, Clesceri and others (1998)
Fecal coliform bacteria	SM(20)9222D, Clesceri and others (1998)

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Appendix 2. Model Calibration Datasets

Regression models were developed using the data in tables 1.1–1.6. In situations where there was a gap of 30 minutes or more in the real-time monitor data (resulting from a fouled sensor, power outage, or equipment malfunction), samples collected during that data gap were not used in the models. When there was a gap of less than 30 minutes in the real-time monitor data, the gap was filled in with interpolated data and samples collected during that time were used in the models.

Table 2.1. Model calibration dataset for Little Menomonee River near Freistadt, Wisconsin.

[Dates are presented as month/day/year (mm/dd/year); °C, degrees Celsius; FNU, formazin nephelometric units; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; MPN/100 mL, most probable number per 100 milliliters; CFU/100 mL, colony forming units per 100 milliliters]

Date (mm/dd/year)	Time (hours:minutes)	Water temperature (°C)	Turbidity (FNU)	Specific conductance (µS/cm)	Chloride (mg/L)	Total suspended solids (mg/L)	Total phos-phorus (mg/L)	*Escherichia coli* (MPN/100 mL)	Fecal coliform (CFU/100 mL)
11/20/2008	9:45	1.6	1.2	877	44	2.4	0.042	51	16
12/17/2008	11:30	0.0	2.1	1,060	85	1.6	0.044	120	
12/27/2008	13:05	0.4	11.2	1,123	130	13	0.26		
12/28/2008	1:05	0.1	52.3	838	120	100	0.52	1,100	
12/28/2008	7:15	0.0	45.0	749	110	42	0.43		
1/20/2009	10:55	0.1	0.7	963	57	6.5	0.21	< 10	< 10
2/7/2009	18:50	0.0	20.3	780	80	37	0.24	860	590
2/9/2009	22:40	0.2	12.3	901	85	18	0.12	1,700	720
2/10/2009	10:45	0.3	38.0	668	69	67	0.36	1,300	760
2/10/2009	14:40	0.5	113.3	529	50	220	0.57	830	570
2/10/2009	20:40	0.3	46.0	495	42	92	0.41	1,600	950
2/11/2009	2:40	0.2	21.3	573	49	31	0.28	15,000	4,000
3/2/2009	7:10	0.0	4.2	910	62	5	0.049	230	
3/7/2009	12:55	1.8	130.0	747	77	180	0.37	400	71
3/7/2009	18:05	1.3	220.0	528	52	410	0.83	1,500	1,400
3/8/2009	7:05	1.0	62.0	602	51	84	0.35	760	2,800
3/8/2009	19:00	0.2	210.0	378	26	320	0.77	2,600	
3/9/2009	0:30	0.3	140.0	448	33	170	0.56	1,500	1,200
3/10/2009	3:20	1.9	68.0	562	43	100	0.3	570	330
3/10/2009	8:15	1.1	94.0	448	34	160	0.43	840	
3/10/2009	20:15	2.2	51.0	479	32	44	0.25	610	580
3/24/2009	10:40	4.0	2.8	844	57	8.5	0.043	110	95
4/23/2009	9:45	6.4	2.2	875	63	6	0.038	610	320
4/25/2009	15:10	10.7	100.0	676	53	130	0.24	860	370
4/26/2009	5:30	7.1	180.0	517	35	330	0.55	4,500	5,200
4/26/2009	19:30	9.7	200.0	413	23	310	0.56	4,000	4,000
4/27/2009	1:30	9.6	80.0	447	24	100	0.32	2,200	1,700
5/9/2009	7:25	11.7	81.0	638	41	110	0.26	3,400	4,600
5/9/2009	13:30	11.6	54.0	573	30	75	0.23	8,700	6,800
5/9/2009	19:30	12.0	15.0	636	33	24	0.11	2,200	1,800
5/14/2009	2:30	13.8	270.0	485	24	410	0.68	6,000	8,600
5/20/2009	9:00	14.0	4.5	787	48	14	0.076	140	100
6/8/2009	5:20	11.5	120.0	569	35	220	0.32	3,800	5,600
6/16/2009	8:45	14.0	12.0	803	50	18	0.11	260	240
6/19/2009	2:50	17.4	290.0	506	28	360	0.56	9,600	8,200
6/19/2009	8:50	17.4	89.0	600	34	160	0.37	25,000	30,000
7/16/2009	10:05	16.2	19.0	786	51	17	0.14	1,100	690
8/19/2009	10:00	16.0	7.9	786	46	9.5	0.085	250	300
9/15/2009	9:30	16.5	10.0	799	44	13	0.066	730	580
10/2/2009	1:25	11.1	14.0	744	46	19	0.084	1,900	1,000
10/2/2009	13:30	11.8	14.0	709	54	11	0.16	15,000	12,000

Table 2.1. Model calibration dataset for Little Menomonee River near Freistadt, Wisconsin.—Continued

[Dates are presented as month/day/year (mm/dd/year); °C, degrees Celsius; FNU, formazin nephelometric units; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; MPN/100 mL, most probable number per 100 milliliters; CFU/100 mL, colony forming units per 100 milliliters]

Date (mm/dd/year)	Time (hours:minutes)	Water temperature (°C)	Turbidity (FNU)	Specific conductance (µS/cm)	Chloride (mg/L)	Total suspended solids (mg/L)	Total phos-phorus (mg/L)	*Escherichia coli* (MPN/100 mL)	Fecal coliform (CFU/100 mL)
10/15/2009	9:45	6.8	4.4	871	57	2.2	0.025	75	39
10/23/2009	4:05	8.6	8.3	810	53	18	0.079	100	270
10/23/2009	16:05	9.7	35.0	773	47	46	0.24	1,500	1,800
10/24/2009	16:10	9.1	8.1	886	53	5	0.17	5,900	4,000
10/25/2009	16:15	10.8	10.5	921	52	3	0.098	630	480
11/19/2009	9:30	6.8	2.2	914	50	5	0.044	100	190
12/16/2009	9:30	0.1	1.2	1,100	69	1.6	0.035	150	83
12/25/2009	9:20	0.5	62.0	1,010	150	120	0.27		
12/25/2009	20:15	0.6	51.0	582	56	110	0.36		
12/26/2009	8:20	0.4	16.0	600	50	28	0.22		
1/13/2010	9:00	0.0	1.6	932	54	14	0.041	120	96
1/24/2010	8:45	1.4	12.8	968	99	20	0.084	580	460
1/24/2010	20:45	0.7	28.6	706	71	46	0.23	11,000	8,000
1/25/2010	2:45	0.5	13.8	674	59	18	0.17	3,400	2,200
2/18/2010	9:30	0.4	3.8	907	56	12	0.031	230	140
3/9/2010	19:25	3.1	8.6	861	78	16	0.21	2,100	2,100
3/10/2010	7:55	2.2	7.8	838	70	13	0.16	1,800	1,200
3/10/2010	13:55	2.4	17.0	795	66	50	0.2		
3/10/2010	19:55	1.5	35.0	679	54	63	0.34	1,200	1,500
3/11/2010	2:00	1.2	15.0	633	51	23	0.2		
3/11/2010	17:05	1.6	86.0	584	39	190	0.47	1,300	1,200
3/11/2010	23:05	1.3	34.0	527	35	82	0.29		
3/12/2010	11:10	2.1	10.0	596	38	17	0.21		
3/12/2010	17:10	3.1	23.0	562	29	49	0.23		
3/14/2010	6:20	2.9	12.0	579	32	22	0.17	110	95
3/18/2010	9:30	4.5	3.5	760	43	13	0.072	< 10	16
4/6/2010	15:35	9.4	17.0	823	86	27	0.12	2,300	580
4/21/2010	10:00	9.0	2.1	833	68	4.5	0.039	< 100	24
4/24/2010	8:40	8.6	21.6	703	48	32	0.12		
4/24/2010	14:40	8.6	28.0	719	59	41	0.14		
4/24/2010	20:40	8.7	15.2	777	58	24	0.11		
4/25/2010	3:40	8.3	324.0	569	37	600	0.86	2,100	4,400
4/25/2010	4:55	8.2	358.0	467	30	740	0.76	4,000	19,000
4/25/2010	10:55	8.4	71.8	456	23	160	0.35	8,600	13,000
4/26/2010	5:00	7.7	18.0	619	37	32	0.12		
5/11/2010	18:15	8.2	24.0	761	54	37	0.17	5,800	4,200
5/13/2010	6:05	8.6	86.0	668	42	140	0.34	3,100	2,200
5/13/2010	9:30	8.4	160.0	480	26	270	0.49	24,000	25,000
5/13/2010	15:05	9.8	47.0	508	28	41	0.19	6,100	7,000
5/19/2010	9:00	11.0	5.1	729	43	12	0.051	190	95
6/16/2010	9:00	16.0	19.0	832	55	31	0.14	1,700	1,200

Table 2.1. Model calibration dataset for Little Menomonee River near Freistadt, Wisconsin.—Continued

[Dates are presented as month/day/year (mm/dd/year); °C, degrees Celsius; FNU, formazin nephelometric units; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; MPN/100 mL, most probable number per 100 milliliters; CFU/100 mL, colony forming units per 100 milliliters]

Date (mm/dd/year)	Time (hours:minutes)	Water temperature (°C)	Turbidity (FNU)	Specific conductance (µS/cm)	Chloride (mg/L)	Total suspended solids (mg/L)	Total phos-phorus (mg/L)	*Escherichia coli* (MPN/100 mL)	Fecal coliform (CFU/100 mL)
6/23/2010	5:15	19.5	90.0	689	42	140	0.28	7,300	6,800
6/23/2010	11:15	19.5	59.0	699	48	81	0.28	5,900	6,000
6/24/2010	4:25	19.0	28.0	822	53	36	0.18	10,000	43,000
6/27/2010	11:10	18.3	87.0	703	41	170	0.3	7,000	5,800
6/27/2010	14:05	19.4	290.0	504	27	1,100	0.95	34,000	25,000
6/28/2010	2:10	19.8	44.0	737	41	69	0.28	34,000	47,000
7/14/2010	22:40	21.0	100.0	624	36	190	0.34	12,000	14,000
7/15/2010	2:00	20.9	330.0	354	10	640	0.82	34,000	27,000
7/15/2010	2:35	21.0	440.0	334	19	800	1	28,000	31,000
7/15/2010	3:35	20.9	460.0	321	16	900	1.3	49,000	49,000
7/15/2010	9:10	20.8	160.0	304	12	210	0.55	18,000	70,000
7/15/2010	9:15	20.8	150.0	304	12	250	0.61	20,000	50,000
7/15/2010	13:40	22.2	87.0	384	16	130	0.4	15,000	9,300
7/16/2010	4:55	20.3	40.0	530	24	70	0.28	9,900	13,000
7/22/2010	14:30	18.9	41.0	699	34	72	0.21	4,000	6,700
7/22/2010	22:40	21.5	130.0	301	11	200	0.64	61,000	73,000
7/23/2010	4:40	21.5	56.0	365	14	88	0.36	33,000	110,000
7/24/2010	4:45	21.3	27.0	540	22	44	0.24	2,900	2,800
7/24/2010	8:30	20.9	70.0	497	20	120	0.37	6,000	14,000
7/26/2010	2:35	19.2	11.0	664	29	20	0.2	2,400	2,600
8/10/2010	8:45	19.8	13.0	831	43	16	0.11	7,300	7,300
9/29/2010	8:45	12.1	6.6	844	48	14	0.058	860	540
10/24/2010	4:35	11.3	16.0	752	40	5	0.1	2,800	2,000
2/7/2011	10:00	0.8	1.9	934	54	9.9	0.017	63	24
2/17/2011	19:30	0.1	49.0	978	120	94	0.35	1,300	1,300
2/18/2011	4:05	0.1	46.0	742	74	93	0.67	4,600	4,000
3/20/2011	16:05	2.3	130.0	615	40	260	0.5	630	840
3/20/2011	23:50	2.2	168.0	476	30	240	0.6	1,600	1,700
5/23/2011	5:05	15.5	12.0	795	55	16	0.085	1,500	1,300
5/25/2011	19:40	10.5	19.0	747	53	22	0.11	4,400	
6/22/2011	1:40	17.2	270.0	519	27	560	0.87	52,000	55,000
7/28/2011	6:20	20.6	88.0	443	25	150	0.47	55,000	330,000
9/19/2011	3:05	13.8	11.0	726	42	13	0.11	5,800	7,200
9/25/2011	21:45	12.9	36.0	586	37	33	0.19	10,000	
MINIMUM		**0.0**	**0.7**	**301**	**10**	**1.6**	**0.02**	**51**	**16**
MAXIMUM		**22.2**	**460**	**1,123**	**150**	**1,100**	**1.30**	**61,000**	**330,000**
MEAN		**8.8**	**70.5**	**674**	**48**	**125**	**0.30**	**7,590**	**13,021**
MEDIAN		**8.6**	**34.5**	**684**	**45**	**45.0**	**0.24**	**2,200**	**2,050**
STANDARD DEVIATION		**7.5**	**94.1**	**185**	**24**	**192**	**0.24**	**12,596**	**37,853**

Table 2.2. Model calibration dataset for Menomonee River at Menomonee Falls, Wisconsin.

[Dates are presented as month/day/year (mm/dd/year); °C, degrees Celsius; FNU, formazin nephelometric units; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; MPN/100 mL, most probable number per 100 milliliters; CFU/100 mL, colony forming units per 100 milliliters]

Date (mm/dd/year)	Time (hours:minutes)	Water temperature (°C)	Turbidity (FNU)	Specific conduc-tance (µS/cm)	Chloride (mg/L)	Total suspended solids (mg/L)	Total phos-phorus (mg/L)	*Escherichia coli* (MPN/100 mL)	Fecal coliform (CFU/100 mL)
12/27/2008	14:20	0.1	100.7	2,387	560	110	0.42	490	520
12/27/2008	20:20	0.0	39.7	1,903	400	66	0.35		
12/28/2008	8:20	0.0	45.3	1,340	300	37	0.33		
1/20/2009	9:55	2.0	2.5	1,270	190	11	0.24	41	< 10
2/16/2009	11:00	0.2	3.1	1,110	160	5	0.054	50	32
2/26/2009	15:05	0.1	110.0	1,860	370	130	0.22	300	320
2/26/2009	18:15	0.2	100.0	1,370	280	110	0.24	730	550
2/27/2009	0:15	0.0	38.0	1,180	250	36	0.17	550	210
3/2/2009	7:15	0.0	3.9	1,170	190	22	0.068	70	
3/7/2009	9:30	1.9	31.0	976	180	47	0.13	160	170
3/7/2009	15:30	2.0	29.0	969	190	48	0.17	160	130
3/8/2009	10:30	0.7	26.0	848	150	39	0.18	150	
3/8/2009	14:00	0.8	70.0	745	140	130	0.27	370	540
3/9/2009	2:00	0.0	35.0	708	120	52	0.2	260	270
3/24/2009	10:00	4.1	4.1	1,020	160	8.5	0.038	190	170
3/25/2009	5:25	5.1	16.0	1,080	210	24	0.057	130	100
4/19/2009	23:00	10.5	20.0	866	150	46	0.1	410	720
4/20/2009	11:15	8.4	8.8	1,090	210	14	0.043	100	
4/20/2009	23:15	8.3	7.5	1,120	200	13	0.038	200	250
4/23/2009	9:15	7.3	3.8	1,050	150	4	0.034	150	210
4/25/2009	10:50	14.6	71.0	756	110	120	0.18	750	570
4/25/2009	11:00	14.3	170.0	642	80	350	0.38	850	
4/26/2009	5:00	8.9	27.0	749	120	44	0.1	410	
4/26/2009	16:00	9.8	34.0	671	96	50	0.12	520	1,000
4/27/2009	4:00	10.2	23.0	657	90	38	0.11	520	
5/9/2009	1:05	16.9	84.0	744	94	110	0.17	160	150
5/9/2009	1:15	16.7	110.0	654	72	210	0.35	1,000	1,200
5/9/2009	10:25	14.0	13.0	749	110	21	0.077	1,200	810
5/9/2009	22:25	13.5	15.0	839	120	24	0.066	400	380
5/10/2009	10:25	11.9	9.5	810	110	12	0.053	350	280
5/13/2009	23:00	15.8	83.0	703	60	120	0.2	2,300	2,800
5/20/2009	9:30	16.5	6.2	901	110	11	0.063	10	87
6/8/2009	3:15	14.0	91.0	547	71	180	0.32	1,800	4,300
6/8/2009	3:25	13.5	220.0	354	41	500	0.78	12,000	10,000
6/8/2009	9:35	13.4	28.0	670	110	51	0.096	4,600	4,600
6/16/2009	10:15	19.1	13.0	990	140	20	0.071	70	100
6/19/2009	0:10	21.2	160.0	529	72	250	0.55	4,000	6,200
6/19/2009	0:50	21.1	110.0	252	24	200	0.2	4,000	16,000
6/19/2009	2:00	20.9	65.0	361	42	110	0.1	8,800	23,000
6/20/2009	2:00	20.1	20.0	758	110	28	0.55	3,600	4,200

Table 2.2. Model calibration dataset for Menomonee River at Menomonee Falls, Wisconsin.—Continued

[Dates are presented as month/day/year (mm/dd/year); °C, degrees Celsius; FNU, formazin nephelometric units; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; MPN/100 mL, most probable number per 100 milliliters; CFU/100 mL, colony forming units per 100 milliliters]

Date (mm/dd/year)	Time (hours:minutes)	Water temperature (°C)	Turbidity (FNU)	Specific conductance (µS/cm)	Chloride (mg/L)	Total suspended solids (mg/L)	Total phosphorus (mg/L)	*Escherichia coli* (MPN/100 mL)	Fecal coliform (CFU/100 mL)
7/16/2009	9:30	20.4	4.9	984	180	5.2	0.082	5,200	210
8/7/2009	19:35	20.2	44.0	573	83	76	0.2	20,000	20,000
8/8/2009	9:05	20.5	78.0	327	46	150	0.21	12,000	10,000
8/19/2009	9:00	20.1	2.2	1,090	190	4.5	0.094	430	270
8/25/2009	18:20	23.1	210.0	601	120	250	0.36	8,100	7,600
8/25/2009	18:45	23.1	84.0	315	46	120	0.28	34,000	46,000
8/26/2009	1:30	22.3	29.0	524	88	20	0.11	8,600	28,000
8/26/2009	1:55	22.4	47.0	341	53	50	0.14	6,300	44,000
9/15/2009	8:45	18.8	2.8	1,120	190	6.4	0.06	140	160
9/22/2009	13:15	18.9	62.0	685	110	88	0.18	18,000	20,000
9/22/2009	14:05	19.3	130.0	308	33	270	0.4	52,000	43,000
9/22/2009	15:20	18.4	21.0	733	120	36	0.12	19,000	19,000
9/27/2009	19:25	18.0	82.0	658	120	100	0.23	11,000	9,400
9/27/2009	21:30	17.1	51.0	583	95	99	0.2	12,000	9,200
9/28/2009	5:55	15.2	13.0	592	100	10	0.088	3,900	4,800
10/1/2009	20:30	12.9	37.0	749	120	69	0.11	4,400	4,200
10/2/2009	0:15	12.5	20.0	486	74	40	0.088	4,500	3,900
10/2/2009	18:15	12.9	9.7	785	140	10	0.07	1,500	1,200
10/15/2009	9:20	7.1	2.7	1,160	180	2.5	0.032	75	110
10/22/2009	23:00	9.6	12.0	770	88	28	0.1	1,500	3,300
10/23/2009	5:05	8.8	19.0	582	120	23	0.092	1,600	1,000
10/23/2009	17:05	9.7	17.0	667	96	16	0.086	740	800
10/24/2009	11:05	8.4	9.7	873	130	11	0.078	630	420
10/25/2009	11:05	9.0	8.1	916	130	5.3	0.058	410	220
10/30/2009	4:20	11.6	16.4	783	110	24	0.078	1,500	1,900
10/31/2009	1:15	11.2	9.9	953	140	9.6	0.072	200	200
11/19/2009	8:45	6.6	5.5	1,110	150	8	0.069	2,300	2,700
12/16/2009	9:00	0.0	3.3	1,420	230	1.1	0.058	30	45
12/25/2009	0:45	0.0	31.0	2,630	610	28	0.12		
12/25/2009	6:55	0.1	82.0	1,310	240	130	0.29		
12/25/2009	18:55	0.3	29.0	1,110	240	43	0.15		
12/26/2009	6:55	0.1	16.0	981	190	23	0.12		
1/13/2010	8:30	0.0	1.9	1,150	160	3.5	0.03	10	10
1/24/2010	4:55	0.1	46.0	1,670	290	40	0.084	1,400	1,000
1/24/2010	12:55	0.1	22.0	1,520	280	20	0.092	690	590
1/24/2010	15:55	0.2	20.0	1,400	300	16	0.095	530	440
1/25/2010	3:55	0.2	14.0	1,110	210	10	0.09	510	430
2/18/2010	9:00	0.0	3.0	1,280	200	31	0.072	30	72
3/10/2010	3:00	3.0	9.8	1,360	260	12	0.051	300	200
3/10/2010	9:20	2.8	24.0	1,340	260	31	0.098	510	530

Table 2.2. Model calibration dataset for Menomonee River at Menomonee Falls, Wisconsin.—Continued

[Dates are presented as month/day/year (mm/dd/year); °C, degrees Celsius; FNU, formazin nephelometric units; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; MPN/100 mL, most probable number per 100 milliliters; CFU/100 mL, colony forming units per 100 milliliters]

Date (mm/dd/year)	Time (hours:minutes)	Water temperature (°C)	Turbidity (FNU)	Specific conduc-tance (µS/cm)	Chloride (mg/L)	Total suspended solids (mg/L)	Total phos-phorus (mg/L)	*Escherichia coli* (MPN/100 mL)	Fecal coliform (CFU/100 mL)
3/11/2010	3:20	2.0	14.0	1,050	190	18	0.092	100	
3/11/2010	15:20	3.0	46.0	934	180	53	0.16		
3/12/2010	3:20	1.3	16.0	801	130	26	0.13	< 100	
3/12/2010	21:20	1.9	16.0	675	83	22	0.097		
3/13/2010	21:20	2.4	11.0	610	73	18	0.087		
3/14/2010	10:20	2.3	8.6	606	71	13	0.081	31	40
3/18/2010	9:00	5.3	5.1	782	100	10	0.065	< 1	40
4/6/2010	1:25	12.6	210.0	653	100	380	0.4	4,000	3,700
4/6/2010	8:15	10.9	120.0	635	110	280	0.27	1,700	1,400
4/7/2010	2:15	10.1	21.0	965	180	31	0.085	410	520
4/21/2010	9:00	11.7	3.3	989	150	11	0.04	< 100	10
4/24/2010	4:30	11.1	120.0	678	92	210	0.28		
4/24/2010	5:40	10.7	76.0	533	66	150	0.2		
4/24/2010	11:40	10.0	18.0	695	120	23	0.077		
4/25/2010	0:45	9.6	38.0	653	110	63	0.11	840	
4/25/2010	1:20	9.4	63.0	531	79	120	0.22	750	6,200
4/25/2010	7:20	9.0	25.0	620	100	28	0.12	1,200	4,300
4/26/2010	1:20	8.9	21.0	615	91	26	0.12		
4/26/2010	13:20	10.6	15.0	582	72	16	0.11		
4/27/2010	1:20	11.2		580	62	17	0.094		
5/11/2010	8:50	9.2		625	84	27	0.1	1,600	1,800
5/12/2010	2:55	8.7	10.0	881	120	13	0.08	570	570
5/13/2010	4:45	9.1	25.0	554	76	32	0.084	1,400	1,200
5/19/2010	8:45	14.2	7.0	864	110	9.8	0.053	41	24
6/2/2010	18:50	21.1	130.0	801	110	210	0.38	18,000	
6/5/2010	19:35	21.1	29.0	637	93	45	0.13	2,300	29,000
6/15/2010	17:30	19.4	101.7	506	67	100	0.17	11,000	40,000
6/16/2010	8:45	18.2	21.8	811	120	59	0.21	9,300	
6/21/2010	22:10	22.4	550.0	860	110	1,400	1.2	8,900	20,000
6/23/2010	3:55	23.2	570.0	748	78	1,600	1.6	6,500	15,000
6/23/2010	4:10	22.6	780.0	444	26	2,600	3	18,000	27,000
6/23/2010	19:40	23.3	130.0	632	91	560	0.38	2,800	13,000
6/23/2010	21:55	23.4	270.0	550	64	740	0.79	5,000	9,700
6/24/2010	3:55	21.9	95.0	654	92	320	0.31	3,400	10,000
6/27/2010	9:55	21.4	260.0	507	45	490	0.71	6,500	12,000
7/7/2010	15:15	25.8	460.0	383	35	940	1	46,000	41,000
7/7/2010	18:35	25.4	55.8	615	86	110	0.19	34,000	36,000
7/14/2010	21:50	24.8	244.0	473	54	480	0.64	11,000	28,000
7/15/2010	0:10	23.7	306.7	242	27	740	0.73	9,300	9,700
7/15/2010	1:05	22.8	330.0	126	13	440	0.54	13,000	23,000

Table 2.2. Model calibration dataset for Menomonee River at Menomonee Falls, Wisconsin.—Continued

[Dates are presented as month/day/year (mm/dd/year); °C, degrees Celsius; FNU, formazin nephelometric units; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; MPN/100 mL, most probable number per 100 milliliters; CFU/100 mL, colony forming units per 100 milliliters]

Date (mm/dd/year)	Time (hours:minutes)	Water temperature (°C)	Turbidity (FNU)	Specific conductance (µS/cm)	Chloride (mg/L)	Total suspended solids (mg/L)	Total phosphorus (mg/L)	*Escherichia coli* (MPN/100 mL)	Fecal coliform (CFU/100 mL)
7/15/2010	8:25	21.7	61.2	283	29	100	0.25	14,000	24,000
7/15/2010	8:30	21.7	61.8	286	29	99	0.25	13,000	13,000
7/15/2010	14:55	23.5	48.0	371	39	88	0.23	5,600	11,000
7/16/2010	2:55	22.4	30.0	361	37	51	0.2	3,300	3,800
7/22/2010	17:25	23.0	226.0	166	11	430	0.34	21,000	35,000
7/22/2010	17:40	23.0	194.0	140	11	370	0.45	25,000	28,000
7/23/2010	3:45	22.4	25.0	323	28	34	0.19	8,400	21,000
7/23/2010	15:45	23.2	18.0	338	29	27	0.18	1,900	7,700
7/24/2010	6:45	22.8	16.0	306	23	27	0.16	1,200	
7/26/2010	3:45	22.3	9.7	444	31	23	0.18	100	
8/9/2010	4:10	23.9	110.0	364	55	50	0.14	12,000	21,000
8/10/2010	8:20	23.1	10.0	882	120	17	0.092	2,000	1,700
9/11/2010	7:35	16.7	44.0	511	56	82	0.18	9,900	5,600
9/29/2010	8:30	13.7	4.2	1,040	160	5.4	< 0.038	140	110
10/24/2010	3:05	12.8	63.2	561	71	120	0.42	20,000	30,000
10/24/2010	15:05	13.9	10.8	658	89	12	0.17	8,100	6,800
2/7/2011	10:45	0.0	2.4	1,410	240	3.4	0.031	75	24
3/17/2011	12:10	3.8	17.5	1,010	180	27	0.071	320	170
3/18/2011	0:10	4.1	17.4	860	140	23	0.082	86	95
3/20/2011	20:45	2.3	210.0	580	97	440	0.45	2,200	1,500
5/25/2011	9:50	12.9	18.0	728	100	19	0.085	1,500	2,000
5/25/2011	20:15	11.9	8.7	839	120	12	0.069	520	
6/21/2011	22:25	19.7	78.0	334	40	140	0.19	16,000	52,000
7/28/2011	6:20	21.7	20.0	442	65	23	0.16	110	5,900
9/18/2011	20:15	15.1	16.2	698	110	12	0.094	39,000	38,000
9/18/2011	22:50	15.6	38.8	509	70	66	0.15	15,000	21,000
MINIMUM		**0.0**	**1.9**	**126**	**11**	**1.1**	**0.03**	**10**	**10**
MAXIMUM		**25.8**	**780.0**	**2,630**	**610**	**2,600**	**3.00**	**52,000**	**52,000**
MEAN		**12.2**	**69.2**	**791**	**127**	**137**	**0.23**	**5,656**	**8,857**
MEDIAN		**12.2**	**26.5**	**718**	**110**	**38**	**0.13**	**1,500**	**1,950**
STANDARD DEVIATION		**8.2**	**112.2**	**393**	**91**	**305**	**0.32**	**9,246**	**12,635**

Table 2.3. Model calibration dataset for Honey Creek at Wauwatosa, Wisconsin.

[Dates are presented as month/day/year (mm/dd/year); °C, degrees Celsius; FNU, formazin nephelometric units; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; MPN/100 mL, most probable number per 100 milliliters; CFU/100 mL, colony forming units per 100 milliliters]

Date (mm/dd/year)	Time (hours:minutes)	Water temperature (°C)	Turbidity (FNU)	Specific conductance (µS/cm)	Chloride (mg/L)	Total suspended solids (mg/L)	Total phos-phorus (mg/L)	*Escherichia coli* (MPN/100 mL)	Fecal coliform (CFU/100 mL)
12/17/2008	13:45	0.2	1.8	4,360	1,100	< 1	0.04	640	570
1/20/2009	11:55	0.0	1.8	5,910	1,700	2.5	0.26	500	400
2/10/2009	10:10	1.7	46.0	2,253	540	31	0.28	3,300	1,300
2/10/2009	13:25	2.5	123.3	1,687	380	130	0.37	1,400	760
2/10/2009	19:25	1.2	82.0	2,097	500	100	0.26	580	410
2/11/2009	1:25	1.9	41.3	2,937	740	36	0.18	750	1,500
2/11/2009	11:25	2.7	21.3	3,660	1,000	12	0.12	530	530
2/11/2009	12:00	2.9	97.0	2,930	650	220	0.37	1,100	840
2/11/2009	15:30	3.3	210.0	1,610	380	230	0.4	1,200	1,300
2/12/2009	2:25	2.3	32.7	2,647	670	27	0.15	690	610
2/16/2009	12:20	0.0	53.3	3,737	980	41	0.14	270	130
3/7/2009	9:25	3.2	74.0	3,460	1,100	13	0.074	1,200	210
3/7/2009	10:25	2.9	210.0	1,300	400	310	0.47	1,300	210
3/7/2009	12:10	3.0	140.0	727	320	350	0.41	680	720
3/7/2009	16:05	3.7	71.0	520	270	110	0.26	530	420
3/7/2009	22:05	3.0	46.0	518	260	70	0.22	400	400
3/8/2009	14:25	2.0	140.0	354	170	180	0.28	570	680
3/9/2009	1:00	2.0	32.0	477	260	75	0.22	600	480
3/10/2009	0:50	3.3	40.0	704	610	36	0.1	620	500
3/10/2009	5:30	2.6	50.0	377	190	60	0.15	260	180
3/10/2009	9:30	2.8	55.0	354	240	46	0.15	450	420
3/10/2009	12:10	3.1	33.0	411	270	23	0.12	1,300	1,600
3/10/2009	12:15	3.1	31.0	411	280	21	0.12	910	1,200
3/24/2009	11:40	4.6	1.8	3,110	690	4.5	0.041	310	190
3/25/2009	1:20	7.1	280.0	809	240	230	0.37	17,000	4,000
3/25/2009	3:45	7.1	183.3	518	660	60	0.14	9,200	22,000
3/31/2009	16:15	5.0	61.0	2,110	510	75	0.16	2,800	1,700
3/31/2009	17:05	5.0	390.0	1,160	250	300	0.39	2,400	1,600
4/19/2009	17:10	9.1	17.0	2,050	430	30	0.081	2,300	2,300
4/19/2009	18:15	8.8	117.5	667	150	200	0.36	3,800	2,900
4/20/2009	2:30	8.3	34.3	429	86	50	0.12	310	
4/20/2009	17:20	8.5		1,460	260	10	0.045	740	880
4/23/2009	10:45	7.6	1.6	2,340	460	2.5	0.03	250	95
4/25/2009	10:50	12.3	21.0	2,380	510	37	0.064	520	840
4/25/2009	12:40	13.3		196	34				
4/25/2009	21:25	10.0		1,010	230				
4/26/2009	2:25	7.9		391	74				
4/26/2009	11:10	8.3		559	92				
4/26/2009	15:30	10.6		417	69				
4/26/2009	17:20	11.6		258	32				

Table 2.3. Model calibration dataset for Honey Creek at Wauwatosa, Wisconsin.—Continued

[Dates are presented as month/day/year (mm/dd/year); °C, degrees Celsius; FNU, formazin nephelometric units; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; MPN/100 mL, most probable number per 100 milliliters; CFU/100 mL, colony forming units per 100 milliliters]

Date (mm/dd/year)	Time (hours:minutes)	Water temperature (°C)	Turbidity (FNU)	Specific conductance (µS/cm)	Chloride (mg/L)	Total suspended solids (mg/L)	Total phos-phorus (mg/L)	*Escherichia coli* (MPN/100 mL)	Fecal coliform (CFU/100 mL)
4/26/2009	20:25	11.0		591	90				
5/13/2009	20:30	14.0	54.0	1,580	310	62	0.17	3,900	2,900
5/13/2009	20:50	16.6	280.0	281	59	440	0.67	9,800	16,000
5/13/2009	21:10	16.9	260.0	181	26	530	0.66	11,000	11,000
5/14/2009	0:55	16.2	130.0	190	17	170	0.3	7,300	6,200
5/14/2009	2:40	15.2		124	46	170	0.28	9,800	9,800
7/16/2009	11:00	18.6	4.0	1,050	190	8	0.13	200	400
8/7/2009	17:10	18.3	27.0	938	180	37	0.3		140,000
8/7/2009	20:20	19.6	170.0	241	27	340	0.83		27,000
8/7/2009	23:05	19.5	28.0	305	41	77	0.27		56,000
8/8/2009	9:10	20.4	240.0	179	24	460	0.71		93,000
8/8/2009	9:30	20.7	300.0	150	17	490	0.7	10,000	120,000
8/8/2009	19:55	21.4	59.0	715	140	29	0.13	17,000	35,000
8/10/2009	1:50	21.9	210.0	153	30	490	0.49		20,000
8/10/2009	4:10	21.5	100.0	181	11	170	0.21		67,000
8/19/2009	12:40	18.9	1.3	1,120	200	9.5	0.086	300	500
8/25/2009	20:55	21.0	63.0	1,360	270	120	0.28	10,000	12,000
8/25/2009	22:05	21.9	206.7	390	65	330	0.51	21,000	46,000
8/26/2009	4:05	21.5	34.0	276	34	120	0.28	16,000	28,000
9/15/2009	10:45	19.0	1.6	1,670	250	1.6	0.054	510	380
9/20/2009	20:20	17.8	44.0	1,240	240	53	0.14	11,000	7,600
9/20/2009	21:55	17.8	190.0	724	140	210	0.88	87,000	170,000
9/21/2009	3:55	18.2	34.0	431	59	41	0.3	200,000	160,000
9/22/2009	13:25	17.0	84.0	1,350	260	130	0.33	98,000	67,000
9/22/2009	14:05	19.7	210.0	237	31	370	0.7	160,000	140,000
9/22/2009	22:40	19.4	44.0	378	57	44	0.16	46,000	45,000
9/27/2009	20:20	18.0	110.0	533	120	140	0.35	160,000	120,000
9/27/2009	21:00	17.4	272.5	134	16	450	0.6	130,000	120,000
9/27/2009	23:35	17.1	99.0	182	23	280	0.4	39,000	38,000
9/28/2009	2:30	16.4	88.0	323	47	80	0.16	17,000	21,000
10/1/2009	20:40	13.3	31.0	1,440	280	40	0.12	2,900	2,600
10/1/2009	21:20	13.8	72.0	232	36	100	0.22	44,000	28,000
10/1/2009	22:05	13.9	56.0	150	20	85	0.26	31,000	42,000
10/2/2009	0:05	13.5	76.0	127	14	92	0.19	16,000	15,000
10/2/2009	1:35	13.4		113	13	51	0.14	14,000	11,000
10/2/2009	5:45	13.9		313	38	66	0.13	6,400	6,000
10/2/2009	11:05	14.2	16.0	492	79	10	0.085	4,900	5,600
10/15/2009	10:20	8.7	12.0	1,380	260	7.3	0.12	16,000	12,000
10/22/2009	6:55	12.3	11.0	1,470	270	17	0.11	3,200	3,200
10/22/2009	7:35	11.6	51.0	585	110	65	0.34	46,000	110,000

Table 2.3. Model calibration dataset for Honey Creek at Wauwatosa, Wisconsin.—Continued

[Dates are presented as month/day/year (mm/dd/year); °C, degrees Celsius; FNU, formazin nephelometric units; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; MPN/100 mL, most probable number per 100 milliliters; CFU/100 mL, colony forming units per 100 milliliters]

Date (mm/dd/year)	Time (hours:minutes)	Water temperature (°C)	Turbidity (FNU)	Specific conductance (µS/cm)	Chloride (mg/L)	Total suspended solids (mg/L)	Total phos-phorus (mg/L)	*Escherichia coli* (MPN/100 mL)	Fecal coliform (CFU/100 mL)
10/22/2009	19:35	10.9	56.0	313	43	32	0.18	6,300	11,000
10/23/2009	5:00	9.3	36.0	198	22	52	0.16	12,000	17,000
10/23/2009	14:00	10.6	37.0	210	22	41	0.14	4,300	4,000
10/23/2009	23:45	11.0	15.0	328	120	6.3	0.082	3,700	4,200
10/26/2009	4:00	12.2	25.0	320	44	35	0.19	14,000	15,000
10/30/2009	8:05	12.6	45.0	278	120	12	0.12	3,300	4,600
10/30/2009	22:00	12.9	23.0	618	250	2	0.07	1,700	2,200
11/19/2009	7:00	8.5	12.0	933	170	8.4	0.11	49,000	30,000
12/16/2009	10:30	0.0		2,740	550	1.8	0.048	640	
12/24/2009	19:25	1.7	190.0	4,630	1,600	230	0.43		
12/25/2009	5:00	1.3	90.0	865	240	130	0.26		
12/25/2009	6:10	1.1	92.0	608	170	140	0.28		
12/25/2009	11:35	2.0	34.0	878	220	50	0.18		
12/26/2009	8:05	2.1	7.6	1,680	320	8.8	0.08		
1/13/2010	10:00	0.0	2.8	3,540	870	4.5	0.058	1,900	2,100
1/23/2010	23:00	2.6	32.0	3,090	840	18	0.12	6,100	4,800
1/24/2010	9:15	1.2	110.0	1,390	310	140	0.28	4,100	4,200
1/24/2010	15:15	1.4	40.0	1,550	330	56	0.2	2,400	1,800
1/25/2010	3:15	1.9	10.0	2,200	500	6	0.087	1,600	1,000
2/18/2010	11:00	1.7	2.1	5,400	1500	3.5	0.038	300	72
3/8/2010	16:00	6.1	26.0	2,720	800	31	0.13	530	320
3/9/2010	14:45	5.5	10.0	2,680	680	13	0.09	610	510
3/9/2010	21:20	3.8	48.0	2,110	510	40	0.14	580	1,200
3/10/2010	9:15	3.5	245.7	1,851	430	370	0.66		
3/10/2010	9:50	3.3	350.0	1,430	310	640	1.2	4,300	4,400
3/10/2010	15:50	3.9	39.0	1,440	290	240	0.45		
3/11/2010	9:50	3.6	69.0	1,760	340	1100	0.31	< 100	24
3/11/2010	12:55	4.5	120.0	1,580	320	160	0.29		
3/11/2010	13:30	5.0	230.0	1,200	300	370	0.39	4,100	4,200
3/11/2010	17:45	5.0	49.0	1,150	270	130	0.27		
3/12/2010	5:45	3.7	9.4	1,640	310	9.8	0.086	310	360
3/12/2010	23:45	5.1	7.8	1,680	290	6	0.068		
3/13/2010	6:40	4.8	64.0	1,410	250	98	0.19		
3/14/2010	7:40	4.5	4.6	1,870	340	3.4	0.054	400	300
3/18/2010	10:45	5.8	1.6	2,390	490	1.6	0.039	< 1	87
4/5/2010	22:30	12.3	32.8	1,988	420	37	0.093	11,000	13,000
4/6/2010	8:20	9.7	410.0	358	80	680	0.34	9,100	10,000
4/6/2010	8:45	9.6	440.0	266	50	790	0.36	4,400	2,600
4/6/2010	9:00	9.6	421.8	215	40	820	0.72	4,900	5,400
4/6/2010	9:55	9.2	278.3	194	28	570	0.33	4,800	1,800

Table 2.3. Model calibration dataset for Honey Creek at Wauwatosa, Wisconsin.—Continued

[Dates are presented as month/day/year (mm/dd/year); °C, degrees Celsius; FNU, formazin nephelometric units; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; MPN/100 mL, most probable number per 100 milliliters; CFU/100 mL, colony forming units per 100 milliliters]

Date (mm/dd/year)	Time (hours:minutes)	Water temperature (°C)	Turbidity (FNU)	Specific conductance (µS/cm)	Chloride (mg/L)	Total suspended solids (mg/L)	Total phos-phorus (mg/L)	*Escherichia coli* (MPN/100 mL)	Fecal coliform (CFU/100 mL)
4/6/2010	11:55	9.4	282.0	415	87	200	0.28	2,200	2,400
4/7/2010	4:00	9.1	32.8	654	130	62	0.12	1,200	1,000
4/21/2010	13:20	11.2	1.7	2,230	450	1.6	< 0.038	410	72
4/24/2010	5:25	9.6	42.0	1,620	430	2.4	< 0.038		
4/24/2010	5:55	9.7	130.0	508	230	180	0.41		
4/24/2010	6:10	9.6	150.0	437	120	260	0.45		
4/24/2010	7:30	9.9	76.0	274	89	310	0.39		
4/25/2010	0:15	9.8	61.0	900	74	39	0.21		
4/25/2010	0:55	9.4	170.0	221	44	370	0.32	3,000	
4/25/2010	1:10	9.4	150.0	188	35	310	0.37	2,900	56,000
4/25/2010	3:00	9.2	81.0	194	29	280	0.37	11,000	49,000
4/25/2010	3:55	9.2	64.0	273	34	110	0.15		
4/25/2010	15:40	9.8	15.0	1,220	210	23	0.09		
5/7/2010	9:05	9.9	24.0	1,850	350	20	0.19		
5/7/2010	10:15	10.7	94.0	446	91	200	0.49		
5/7/2010	10:45	10.6	79.0	292	52	140	0.49		
5/7/2010	12:20	10.6	45.0	249	38	47	0.31		
5/7/2010	17:30	10.9	19.0	543	110	36	0.12		
5/11/2010	4:55	9.3	7.2	2,070	430	13	0.085	3,400	2,200
5/11/2010	5:45	9.2	80.0	495	110	130	0.34	9,200	6,000
5/11/2010	8:30	8.8	35.0	221	35	50	0.17	2,700	4,300
5/11/2010	11:30	8.8	46.7	244	32	42	0.15	2,900	2,400
5/12/2010	1:25	9.6	12.0	1,090	170	11	0.082	2,200	2,500
5/13/2010	1:05	10.0	38.0	745	250	1.7	0.042	730	450
5/13/2010	5:30	9.1	86.0	211	41	83	0.13	1,900	2,800
5/13/2010	9:30	9.2	52.0	383	29	110	0.23	2,600	2,600
5/19/2010	11:00	12.5	0.7	1,990	340	1.9	< 0.038	170	280
6/2/2010	18:10	18.6	210.0	791	230	360	0.82	77,000	67,000
6/2/2010	18:35	17.7	270.0	226	36	480	0.73	69,000	110,000
6/2/2010	18:55	17.0	270.0	114	13	490	0.57	33,000	37,000
6/2/2010	20:15	16.5	110.0	116	14	210	0.32	16,000	73,000
6/2/2010	22:50	16.8	98.0	344	58	120	0.2	14,000	47,000
6/5/2010	19:25	19.4	77.0	490	95	130	0.2	15,000	9,800
6/5/2010	21:15	19.5	64.0	190	25	110	0.22	14,000	52,000
6/6/2010	0:40	18.1	97.0	268	34	100	0.17	11,000	32,000
6/8/2010	17:00	16.2	28.0	362	58	35	0.13	6,600	24,000
6/15/2010	15:40	17.8	75.0	1,350	260	120	0.27	9,900	24,000
6/15/2010	16:10	18.8	150.0	156	24	300	0.27	40,000	49,000
6/15/2010	16:30	18.9	200.0	121	15	450	0.37	27,000	30,000
6/15/2010	17:10	18.8	210.0	74	7.2	340	0.3	31,000	37,000

Table 2.3. Model calibration dataset for Honey Creek at Wauwatosa, Wisconsin.—Continued

[Dates are presented as month/day/year (mm/dd/year); °C, degrees Celsius; FNU, formazin nephelometric units; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; MPN/100 mL, most probable number per 100 milliliters; CFU/100 mL, colony forming units per 100 milliliters]

Date (mm/dd/year)	Time (hours:minutes)	Water temperature (°C)	Turbidity (FNU)	Specific conductance (µS/cm)	Chloride (mg/L)	Total suspended solids (mg/L)	Total phos-phorus (mg/L)	*Escherichia coli* (MPN/100 mL)	Fecal coliform (CFU/100 mL)
6/15/2010	17:40	18.8	160.0	92	8.7	310	0.25	41,000	36,000
6/15/2010	18:45	18.8	110.0	209	25	180	0.22	49,000	51,000
6/16/2010	3:20	17.6	15.0	858	160	15	0.12	21,000	20,000
6/16/2010	10:00	17.9	7.9	1,020	200	5.7	0.1	12,000	9,400
6/21/2010	22:10	21.2	97.0	719	240	120	0.29	28,000	28,000
6/21/2010	22:25	21.9	120.0	180	33	190	0.35	20,000	29,000
6/21/2010	22:50	22.2	210.0	96	19	200	0.33	22,000	27,000
6/21/2010	23:05	22.0	190.0	91	11	280	0.44	16,000	14,000
6/21/2010	23:50	21.6	110.0	123	7	230	0.28	19,000	21,000
6/22/2010	3:05	20.6	130.0	439	25	200	0.42	31,000	26,000
6/23/2010	4:20	21.8	120.0	342	85	250	0.33	16,000	26,000
6/23/2010	5:25	22.2	120.0	116	12	160	0.27	14,000	33,000
6/23/2010	6:00	21.9	230.0	100	8.7	160	0.26	18,000	130,000
6/23/2010	6:35	21.9	230.0	134	10	200	0.32	29,000	68,000
6/23/2010	10:15	20.8	65.0	471	51	66	0.22	19,000	63,000
6/24/2010	2:35	21.4	31.0	528	72	42	0.12	18,000	55,000
6/27/2010	4:55	20.0	100.0	727	180	22	0.12	5,000	3,700
6/27/2010	5:50	20.6	100.0	199	31	180	0.29	15,000	21,000
6/27/2010	6:00	20.8	88.0	180	27	200	0.25	14,000	18,000
6/27/2010	8:45	20.2	180.0	248	18	220	0.27	31,000	33,000
6/27/2010	10:45	21.1	88.0	266	50	140	0.24	29,000	33,000
6/27/2010	13:25	21.1	31.0	311	17	71	0.15	19,000	21,000
7/7/2010	15:30	25.2	150.0	705	220	300	0.61	120,000	73,000
7/7/2010	16:00	25.3	170.0	101	12	280	0.36	41,000	34,000
7/7/2010	16:25	25.2	260.0	97	10	430	0.5	29,000	31,000
7/7/2010	17:25	25.7	140.0	160	18	210	0.24	24,000	36,000
7/7/2010	19:00	25.6	82.0	324	51	200	0.22	29,000	31,000
7/7/2010	20:40	24.5	34.0	243	33	39	0.1	12,000	18,000
7/14/2010	22:30	23.9	93.0	295	48	190	0.36	39,000	61,000
7/14/2010	23:15	24.1	94.0	174	19	160	0.27	13,000	80,000
7/15/2010	1:25	22.8	210.0	83	8.9	290	0.36	18,000	36,000
7/15/2010	2:10	22.4	260.0	87	8.7	370	0.34	19,000	43,000
7/15/2010	4:25	22.3	120.0	243	22	190	0.25	14,000	54,000
7/15/2010	10:30	22.1	28.0	631	85	23	0.11	16,000	26,000
7/16/2010	2:45	20.5	5.8	1,120	190	4.2	0.066	1,600	2,200
7/22/2010	12:10	22.5	160.0	151	16	240	0.34	37,000	42,000
7/22/2010	21:25	23.7	180.0	128	9.8	260	0.31	16,000	90,000
7/22/2010	22:30	23.3	180.0	136	9	270	0.35	24,000	73,000
7/23/2010	20:55	22.6	15.0	943	130	17	0.09	5,000	6,000
7/24/2010	7:30	23.0	56.0	247	18	58	0.12	7,900	55,000

Table 2.3. Model calibration dataset for Honey Creek at Wauwatosa, Wisconsin.—Continued

[Dates are presented as month/day/year (mm/dd/year); °C, degrees Celsius; FNU, formazin nephelometric units; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; MPN/100 mL, most probable number per 100 milliliters; CFU/100 mL, colony forming units per 100 milliliters]

Date (mm/dd/year)	Time (hours:minutes)	Water temperature (°C)	Turbidity (FNU)	Specific conductance (µS/cm)	Chloride (mg/L)	Total suspended solids (mg/L)	Total phos-phorus (mg/L)	*Escherichia coli* (MPN/100 mL)	Fecal coliform (CFU/100 mL)
7/24/2010	22:10	22.2	6.9	990	170	6	0.072	1,300	2,800
7/31/2010	3:15	19.8	67.0	1,260	260	120	0.21		
7/31/2010	4:20	21.3	88.0	247	34	96	0.28		
7/31/2010	7:45	21.0	25.0	206	22	34	0.094		
8/8/2010	10:10	21.7	250.0	249	30	290	0.53		
8/9/2010	6:00	22.9	110.0	265	34	200	0.31	98,000	120,000
8/10/2010	9:40	21.7	3.2	1,250	230	2	0.081	1,600	6,300
8/20/2010	19:00	24.7	34.0	1,200	230	77	0.24		
8/21/2010	0:40	23.1	180.0	139	14	320	0.46		
8/21/2010	3:20	22.8	30.0	228	25	55	0.12		
9/1/2010	3:50	22.4	46.0	1,600	300	93	0.21	7,600	9,000
9/1/2010	4:30	22.8	140.0	174	22	240	0.55	98,000	76,000
9/1/2010	6:45	22.9	61.0	185	19	110	0.27	52,000	47,000
9/11/2010	5:15	16.1	21.0	1,510	280	35	0.14	1,600	1,800
9/11/2010	6:50	17.6	90.0	154	18	160	0.4	82,000	77,000
9/11/2010	8:40	17.3	58.0	167	18	110	0.24	15,000	40,000
9/11/2010	17:20	18.2	8.8	478	74	5.1	0.087	6,000	6,200
9/18/2010	6:10	17.2	62.0	334	69	140	0.4	98,000	130,000
9/29/2010	10:30	15.0	1.8	1,540	270	5.7	0.067	560	510
10/24/2010	0:15	14.3	81.0	978	170	180	0.65	130,000	29,000
10/24/2010	1:30	15.0	150.0	179	17	220	1.1	140,000	130,000
2/7/2011	12:00	0.0	5.5	10,300	2,400	25	0.03	550	410
2/17/2011	14:10	1.7	230.0	2,780	770	310	0.5	1,700	2,300
2/17/2011	20:25	1.4	140.0	2,070	480	230	0.39	960	1,500
3/9/2011	14:50	2.4	136.7	5,970	1,900	140	0.18	1,200	1,300
3/20/2011	14:50	3.7	180.0	464	120	270	0.35	520	1,300
5/22/2011	22:40	16.4	150.0	671	160	320	0.61	9,600	9,200
5/22/2011	23:15	17.6	220.0	359	64	500	0.87	8,500	9,200
6/21/2011	20:35	19.6	300.0	123	18	570	0.54	25,000	32,000
6/21/2011	21:05	19.9	330.0	111	13	700	0.64	15,000	37,000
6/21/2011	22:15	20.0	200.0	211	26	410	0.36	33,000	28,000
9/18/2011	20:40	17.3	200.0	329	45	120	0.49	170,000	
9/18/2011	23:35	17.6	84.0	226	34	160	0.31	55,000	110,000
MINIMUM		**0.0**	**0.7**	**74**	**7**	**1.6**	**0.03**	**170**	**24**
MAXIMUM		**25.7**	**440.0**	**10,300**	**2,400**	**1,100**	**1.20**	**200,000**	**170,000**
MEAN		**13.1**	**101.0**	**959**	**224**	**160**	**0.28**	**20,634**	**27,095**
MEDIAN		**13.3**	**75.0**	**471**	**110**	**110**	**0.25**	**9,150**	**10,500**
STANDARD DEVIATION		**7.5**	**91.9**	**1,210**	**324**	**172**	**0.20**	**34,477**	**36,336**

Table 2.4. Model calibration dataset for Menomonee River at Wauwatosa, Wisconsin.

[Dates are presented as month/day/year (mm/dd/year); °C, degrees Celsius; FNU, formazin nephelometric units; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; MPN/100 mL, most probable number per 100 milliliters; CFU/100 mL, colony forming units per 100 milliliters]

Date (mm/dd/year)	Time (hours:minutes)	Water temperature (°C)	Turbidity (FNU)	Specific conductance (µS/cm)	Chloride (mg/L)	Total suspended solids (mg/L)	Total phos-phorus (mg/L)	*Escherichia coli* (MPN/100 mL)	Fecal coliform (CFU/100 mL)
11/20/2008	10:30	2.2	1.9	1,250	180	5.4	0.046	74	110
12/17/2008	12:30	0.0	6.8	2,120	450	5.2	0.053	500	
12/27/2008	1:15	0.0	25	6,520	2,300	56	0.31		
12/27/2008	3:45	0.0	46	6,890	2,100	78	0.34		
12/27/2008	5:50	0.0	66	6,127	1,800	87	0.39		
12/27/2008	6:05	0.0	63	6,100	1,900	94			
12/27/2008	10:15	0.0	89	4,640	1,300	150		1,700	1,000
12/27/2008	14:00	0.9	180	3,040	820	260	0.66		
12/27/2008	14:45	1.5	190	2,350	580	260			
12/28/2008	7:45	0.0	36	1,960	480	51		1,200	
1/20/2009	12:10	0.0	1.5	2,370	470	20	0.23	86	64
2/7/2009	11:25	0.0	72	3,520	920	92	0.33	3,400	2,100
2/7/2009	13:25	0.0	105	3,620	990	120	0.4	1,800	2,400
2/7/2009	13:40	0.0	110	3,590	1,000	230	0.54	2,400	2,400
2/7/2009	19:40	0.0	46	2,617	670	65	0.31	1,200	840
2/8/2009	13:40	0.0	26	2,593	640	22	0.22	340	300
2/9/2009	1:40	0.0	12	2,163	480	13	0.13	430	
2/9/2009	19:40	0.0	64	2,110	460	140	0.34	320	
2/9/2009	22:00	0.0	140	2,320	520	210	0.45	1,500	910
2/9/2009	23:15	0.1	140	2,100	460	110	0.3	2,100	1,300
2/10/2009	7:20	0.0	46	2,080	440	47	0.18	760	
2/10/2009	11:00	0.1	100	2,190	470	230	0.39	880	1,300
2/10/2009	17:05	0.5	71	1,913	410	110	0.28	750	800
2/10/2009	23:25	0.2	41	1,753	350	42	0.17	570	
2/16/2009	12:45	0.3	4.8	1,770	320	80	0.18	60	
2/26/2009	14:35	0.4	66	2,840	620	36	0.093	120	140
2/26/2009	19:00	0.7	140	1,610	630	38	0.097	320	260
2/26/2009	19:45	0.7	170	1,320	630	130	0.26	1,900	2,000
2/26/2009	22:50	0.6	130	1,160	330	210	0.29	1,700	1,200
2/27/2009	4:50	0.0	70	1,590	280	230	0.36	1,100	720
3/2/2009	7:20	0.0	7	1,670	270	6	0.068	220	270
3/10/2009	0:15	2.3	34	1,220	260	31	0.13	290	340
3/10/2009	5:50	2.1	38	981	210	46	0.14	200	
3/10/2009	11:45	1.9	38	958	200	38	0.15	370	
3/10/2009	14:50	1.9	41	938	200	51	0.14	240	
3/11/2009	1:10	2.2	46	892	180	28	0.13	150	
3/24/2009	11:55	4.9	1.1	1,460	280	11	0.046	62	71
3/25/2009	1:30	6.2	38	1,350	280	57	0.11	2,200	2,100
3/31/2009	17:00	5.1	14	1,720	330	19	0.053	2,000	1,700
3/31/2009	17:35	5.2	33	1,620	310	38	0.092	1,900	1,000

Table 2.4. Model calibration dataset for Menomonee River at Wauwatosa, Wisconsin.—Continued

[Dates are presented as month/day/year (mm/dd/year); °C, degrees Celsius; FNU, formazin nephelometric units; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; MPN/100 mL, most probable number per 100 milliliters; CFU/100 mL, colony forming units per 100 milliliters]

Date (mm/dd/year)	Time (hours:minutes)	Water temperature (°C)	Turbidity (FNU)	Specific conductance (µS/cm)	Chloride (mg/L)	Total suspended solids (mg/L)	Total phos-phorus (mg/L)	*Escherichia coli* (MPN/100 mL)	Fecal coliform (CFU/100 mL)
4/1/2009	5:35	4.3	20	1,520	280	33	0.058	610	480
4/19/2009	19:10	11.4	17	1,350	270	26	0.085	1,300	1,200
4/20/2009	5:05	9.1	24	899	190	48	0.064	1,400	
4/21/2009	5:05	7.7	7.1	1,300	270	12	0.042		380
4/23/2009	11:00	8.2	1.4	1,320	250	5.6	0.035	85	48
4/25/2009	11:15	14.2	22	1,250	240	41	0.082	1,100	800
4/25/2009	12:40	13.8	160	813	160	370	0.48	3,700	3,300
4/25/2009	21:35	11.1	77	735	140	100	0.17	1,200	
4/26/2009	2:35	9.6	68	637	120	87	0.18	2,200	
4/26/2009	14:35	8.9	36	725	130	50	0.098	850	2,400
4/26/2009	16:00	10.0	150	498	80	300	0.35	1,300	
4/26/2009	17:10	10.5	190	430	63	360	0.37	1,800	3,300
4/27/2009	0:30	10.2	76	564	86	94	0.14	1,600	
5/9/2009	0:30	16.6	37	992	180	66	0.15	700	500
5/9/2009	9:30	14.6	17	825	150	37	0.083	990	730
5/9/2009	15:50	14.7	15	807	150	21	0.065	510	
5/13/2009	20:40	15.2	68	816	140	120	0.28	2,400	1,900
5/13/2009	21:05	15.6	150	673	110	250	0.46	8,700	3,500
5/13/2009	22:00	15.9	140	513	85	250	0.37	5,500	5,600
5/14/2009	3:15	15.4	86	525	85	110	0.2	2,800	4,600
5/20/2009	11:15	17.4	4.8	1,150	190	11	0.11	73	56
6/8/2009	3:10	14.2		1,090	210				
6/8/2009	4:00	13.9		944	150				
6/8/2009	4:15	13.5		778	150				
6/8/2009	6:45	12.6		288	46				
6/8/2009	10:15	13.0		481	80				
6/9/2009	4:15	14.6		734	130				
6/16/2009	11:50	18.8	9.6	1,320	240	17	0.089	130	
6/19/2009	9:15	19.6	84	319	110	150	0.35	9,600	9,000
6/19/2009	18:15	20.4	52	361	39	75	0.17	12,000	19,000
6/19/2009	21:20	20.5	150	269	35	190	0.22	9,300	18,000
6/20/2009	3:10	19.7	45	496	54	120	0.18	9,300	42,000
7/16/2009	11:45	21.8	3.5	1,160	220	8.8	0.082	2,600	4,200
8/7/2009	18:00	19.6	32	1,180	240	57	0.26		29,000
8/7/2009	20:40	19.8	60	1,230	230	110	0.29		38,000
8/8/2009	0:55	19.3	37	699	120	59	0.2		60,000
8/8/2009	8:50	19.8	74	598	100	120	0.23		47,000
8/8/2009	9:45	20.1	210	402	62	390	0.56		70,000
8/8/2009	19:50	21.8	48	485	77	66	0.14	24,000	41,000

Table 2.4. Model calibration dataset for Menomonee River at Wauwatosa, Wisconsin.—Continued

[Dates are presented as month/day/year (mm/dd/year); °C, degrees Celsius; FNU, formazin nephelometric units; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; MPN/100 mL, most probable number per 100 milliliters; CFU/100 mL, colony forming units per 100 milliliters]

Date (mm/dd/year)	Time (hours:minutes)	Water temperature (°C)	Turbidity (FNU)	Specific conductance (µS/cm)	Chloride (mg/L)	Total suspended solids (mg/L)	Total phos-phorus (mg/L)	*Escherichia coli* (MPN/100 mL)	Fecal coliform (CFU/100 mL)
8/9/2009	19:50	22.5	39	861	170	51	0.19		
8/10/2009	2:00	22.3	110	739	130	150	0.25	24,000	27,000
8/10/2009	4:20	21.4	99	457	68	77	0.16	17,000	25,000
8/19/2009	12:20	21.9	2.7	1,370	47	13	0.11	320	
8/25/2009	20:50	22.3	68	623	82	120	0.3	87,000	83,000
8/25/2009	21:25	22.4	110	643	99	140	0.34	32,000	46,000
8/25/2009	21:30	21.9	96	944	150	170	0.37	20,000	35,000
8/26/2009	3:30	21.5	47	577	95	76	0.2	34,000	41,000
8/27/2009	3:35	20.0	18	587	94	20	0.11	3,500	5,400
9/15/2009	11:00	20.0	2.8	1,520	290	6.8	0.067	130	
9/20/2009	21:40	18.0	69	1,080	210	120	0.41	92,000	90,000
9/21/2009	3:40	17.8	51	740	140	46	0.26	200,000	180,000
9/22/2009	13:30	18.3	56	889	140	97	0.31	200,000	130,000
9/22/2009	13:40	18.4	71	848	82	280	0.56		140,000
9/22/2009	21:50	19.5	56	470	120	260	0.49	200,000	93,000
9/22/2009	23:10	19.0	53	675	120	76	0.19	49,000	42,000
9/27/2009	20:35	17.8	100	666	100	160	0.37	46,000	32,000
9/27/2009	21:05	18.0	150	758	140	270	0.49	37,000	43,000
9/27/2009	21:20	18.1	180	508	96	330	0.54	69,000	46,000
9/28/2009	0:05	17.1	70	235	29	110	0.22	55,000	42,000
9/28/2009	2:35	16.4	62	386	57	65	0.17	22,000	23,000
9/28/2009	20:35	14.8	25	584	100	55	0.16	8,000	8,300
10/1/2009	20:55	13.0	32	936	190	41	0.14	34,000	19,000
10/1/2009	21:50	12.8	58	814	150	110	0.2	16,000	9,800
10/2/2009	0:45	13.2	48	347	57	56	0.17	19,000	25,000
10/2/2009	3:15	13.2	40	326	46	67	0.14	15,000	1,100
10/3/2009	9:15	12.1	18	653	120	16	0.079	1,900	2,400
10/15/2009	10:45	7.9	3.9	1,340	250	4.3	0.063	5,500	4,600
10/22/2009	7:40	11.6	23	910	170	34	0.22	55,000	77,000
10/22/2009	14:35	10.9	24	666	120	26	0.21	14,000	16,000
10/23/2009	4:40	9.4	48	455	71	49	0.17	9,300	8,200
10/23/2009	11:35	9.4		414	59	50	0.17	4,900	6,800
10/24/2009	11:35	8.8	20	678	100	23	0.11	1,600	
10/25/2009	11:35	9.3	11	908	140	9.7	0.09	1,100	
10/26/2009	3:45	10.6	24	855	140	20	0.11	5,600	4,800
10/30/2009	2:15	11.5	17	984	170	25	0.14	12,000	10,000
10/30/2009	4:15	11.9	39	680	120	58	0.21	17,000	9,600
10/30/2009	14:10	12.9	24	695	110	24	0.098	2,800	3,500
10/30/2009	16:15	13.1	23	789	130	23	0.11	3,600	4,800
10/31/2009	16:15	10.1	11	882	140	12	0.084	1,300	650

Table 2.4. Model calibration dataset for Menomonee River at Wauwatosa, Wisconsin.—Continued

[Dates are presented as month/day/year (mm/dd/year); °C, degrees Celsius; FNU, formazin nephelometric units; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; MPN/100 mL, most probable number per 100 milliliters; CFU/100 mL, colony forming units per 100 milliliters]

Date (mm/dd/year)	Time (hours:minutes)	Water temperature (°C)	Turbidity (FNU)	Specific conductance (µS/cm)	Chloride (mg/L)	Total suspended solids (mg/L)	Total phos-phorus (mg/L)	*Escherichia coli* (MPN/100 mL)	Fecal coliform (CFU/100 mL)
11/19/2009	7:05	7.5	30	981	170	29	0.16	2,800	79
12/16/2009	11:00	0.1	4.7	2,442	460	12	0.048	310	400
12/24/2009	19:00	0.5	53	5,334	1,500	70	0.14		
12/25/2009	5:05	0.8	74	1,866	420	130	0.25		
12/25/2009	6:30	0.6	92	1,370	280	180	0.41		
12/25/2009	18:30	0.6	52	1,120	280	80	0.17		
12/26/2009	6:30	0.0	20	1,100	250	24	0.11		
1/13/2010	10:15	1.2	1.4	1,730	250	3	0.03	200	160
1/24/2010	1:35	0.2	10	2,090	420	26	0.059	2,900	2,000
1/24/2010	7:40	0.1	70	1,870	400	76	0.21	7,700	5,000
1/24/2010	10:25	0.3		1,530	330	94	0.26	3,700	2,800
1/24/2010	16:25	0.5		1,570	330	54	0.15	1,400	1,200
2/18/2010	11:15	0.5	3.1	2,170	410	7	0.03	150	
3/8/2010	16:05	3.4	8.7	2,080	440	11	0.05	260	
3/8/2010	22:05	2.2	24	1,850	360	19	0.077	800	560
3/9/2010	10:05	1.4	8.7	1,930	390	7.6	0.04	320	
3/9/2010	16:05	2.8	11	1,850	380	10	0.072	340	220
3/10/2010	4:05	2.1	14	1,760	350	14	0.058	880	520
3/10/2010	9:25	2.7	43	1,770	360	54	0.14		
3/10/2010	10:25	2.8	73	1,750	350	120	0.25	3,000	4,400
3/10/2010	16:25	3.3	43	1,440	280	58	0.13		
3/11/2010	10:25	2.1	17	1,280	270	21	0.084		
3/11/2010	13:15	2.6	28	1,220	260	32	0.1	750	650
3/11/2010	19:15	3.1		1,140	240	50	0.13		
3/12/2010	19:15	3.2	16	988	180	19	0.094		
3/13/2010	7:15	3.2	22	952	170	18	0.084		
3/14/2010	8:15	3.3	12	875	150	12	0.082	110	110
3/18/2010	11:00	6.5	4.1	1,060	180	5.2	0.056	< 10	48
4/5/2010	22:50	14.8	27	1,250	250	9.2	< 0.038	< 100	10
4/6/2010	8:40	11.0	190	755	260	4.4	< 0.038	100	10
4/6/2010	9:05	11.0		765	250	29	0.082	1,100	570
4/6/2010	11:40	10.5		639	220	87	0.14	1,200	1,800
4/6/2010	13:00	11.0		892	190	150	0.2	2,600	5,400
4/6/2010	13:15	11.1		931	220	130	0.18	1,200	1,600
4/7/2010	2:45	10.1		928	210	35	0.089	520	770
4/21/2010	12:30	13.0	4.9	1,300	250	1.3	< 0.038	100	16
4/24/2010	5:30	11.1	46	998	190	130	0.23		
4/24/2010	6:15	10.8	62	1,010	190	120	0.24		
4/24/2010	6:40	10.9	63	1,060	200	130	0.33		

Table 2.4. Model calibration dataset for Menomonee River at Wauwatosa, Wisconsin.—Continued

[Dates are presented as month/day/year (mm/dd/year); °C, degrees Celsius; FNU, formazin nephelometric units; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; MPN/100 mL, most probable number per 100 milliliters; CFU/100 mL, colony forming units per 100 milliliters]

Date (mm/dd/year)	Time (hours:minutes)	Water temperature (°C)	Turbidity (FNU)	Specific conductance (µS/cm)	Chloride (mg/L)	Total suspended solids (mg/L)	Total phos-phorus (mg/L)	*Escherichia coli* (MPN/100 mL)	Fecal coliform (CFU/100 mL)
4/24/2010	9:05	10.5	66	874	190	130	0.23		
4/24/2010	21:05	10.1	27	722	150	36	0.098		
4/25/2010	0:50	9.6	66	573	110	120	0.19		
4/25/2010	1:35	9.4	120	329	63	320	0.34	1,600	
4/25/2010	1:55	9.3	140	343	55	330	0.36	1,600	
4/25/2010	3:55	9.3	100	363	65	220	0.37	410	7,600
4/25/2010	13:45	9.4	54	612	110	75	0.15		
4/26/2010	1:45	9.2	27	733	120	32	0.1		
4/27/2010	1:45	11.1	25	769	110	22	0.09		
4/28/2010	1:45	11.3	19	790	110	18	0.071		
5/7/2010	9:35	12.0	20	1,100	200	42	0.27		
5/11/2010	5:30	10.0	23	1,070	200	26	0.14	3,100	3,700
5/11/2010	6:45	9.9	34	1,000	190	67	0.16	4,400	4,600
5/11/2010	9:25	9.2	39	555	100	41	0.25	3,100	2,600
5/12/2010	3:25	8.8	22	792	140	31	0.1	1,100	1,100
5/13/2010	1:30	9.4	21	924	160	38	0.1	1,300	770
5/13/2010	6:15	9.2	69	513	78	140	0.21	1,200	2,200
5/13/2010	11:10	9.2	66	576	86	88	0.15	2,400	5,000
5/19/2010	10:30	14.4	4.5	1,140	180	4.2	0.043	85	63
6/5/2010	19:30	20.5	42	838	160	68	0.17	5,300	6,000
6/5/2010	21:05	20.0	65	521	91	120	0.25	8,500	14,000
6/6/2010	15:00	20.4	21	748	140	28	0.1	2,000	5,800
6/8/2010	17:50	16.2	31	767	140	47	0.14	4,100	9,400
6/15/2010	15:35	18.6	78	683	97	200	0.32	65,000	60,000
6/15/2010	16:20	18.6	240	474	60	270	0.31	25,000	28,000
6/15/2010	16:50	19.0	190	182	31	400	0.46	37,000	49,000
6/15/2010	17:20	18.8	190	146	15	400	0.38	24,000	35,000
6/15/2010	19:25	18.8	200	256	28	270	0.29	44,000	70,000
6/16/2010	5:35	18.2	66	488	68	83	0.17	26,000	20,000
6/16/2010	10:15	18.7	70	528	75	53	0.13	13,000	12,000
6/21/2010	22:10	22.1	87	751	150	44	0.16	3,600	4,900
6/21/2010	22:35	22.1	130	680	84	170	0.3	25,000	17,000
6/21/2010	22:55	22.0	150	441	140	260	0.36	13,000	16,000
6/21/2010	23:15	21.8	130	249	130	260	0.38	10,000	12,000
6/22/2010	0:25	21.7	130	316	37	210	0.33	17,000	26,000
6/22/2010	4:55	20.8	57	642	34	160	0.24	17,000	34,000
6/23/2010	4:20	22.1	130	479	69	270	0.33	12,000	22,000
6/23/2010	5:40	21.9	120	270	28	210	0.32	19,000	51,000
6/23/2010	6:05	22.0	130	245	29	240	0.32	31,000	41,000
6/23/2010	11:45	21.5	71	441	51	110	0.22	14,000	43,000

Table 2.4. Model calibration dataset for Menomonee River at Wauwatosa, Wisconsin.—Continued

[Dates are presented as month/day/year (mm/dd/year); °C, degrees Celsius; FNU, formazin nephelometric units; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; MPN/100 mL, most probable number per 100 milliliters; CFU/100 mL, colony forming units per 100 milliliters]

Date (mm/dd/year)	Time (hours:minutes)	Water temperature (°C)	Turbidity (FNU)	Specific conductance (µS/cm)	Chloride (mg/L)	Total suspended solids (mg/L)	Total phos-phorus (mg/L)	*Escherichia coli* (MPN/100 mL)	Fecal coliform (CFU/100 mL)
6/24/2010	5:45	21.8	43	592	79	63	0.17	5,000	7,700
6/27/2010	4:55	20.9	79	666	99	150	0.29	18,000	14,000
7/7/2010	15:30	25.6	130	619	64	250	0.5	61,000	60,000
7/7/2010	16:00	25.1	140	500	64	270	0.4	55,000	42,000
7/7/2010	16:30	25.8	160	245	32	340	0.44	39,000	36,000
7/7/2010	17:40	25.7	130	293	39	250	0.36	73,000	74,000
7/7/2010	22:55	24.6	63	409	57	97	0.14	31,000	53,000
7/14/2010	22:15	24.6	52	645	76	140	0.32	26,000	83,000
7/15/2010	0:35	23.7	98	262	37	210	0.34	31,000	42,000
7/15/2010	1:40	22.8	140	123	11	360	0.35	19,000	32,000
7/15/2010	2:55	22.6	170	134	14	330	0.33	18,000	61,000
7/15/2010	11:00	22.4	83	262	22	120	0.24	13,000	70,000
7/15/2010	17:40	23.2	67	277	22	68	0.19	21,000	40,000
7/16/2010	5:40	22.5	29	411	40	34	0.14	3,200	15,000
7/22/2010	12:20	22.4	88	591	87	330	0.29	14,000	35,000
7/22/2010	19:50	23.6	130	119	9.6	260	0.31	28,000	29,000
7/23/2010	20:05	23.5		389	32	56	0.15	3,400	20,000
7/24/2010	8:00	23.0		393	33	62	0.15	2,300	10,000
7/26/2010	0:55	22.8		600	52	29	0.15	200	1,400
9/18/2011	19:50	15.7	41	1,060	200	62	0.24		
9/18/2011	23:35	16.3	85	676	130	140	0.32		
9/25/2011	15:45	14.1	190	293	45	400	0.58	31,000	39,000
MINIMUM		**0.0**	**1.1**	**119**	**9.6**	**1.3**	**0.03**	**60**	**10**
MAXIMUM		**25.8**	**240**	**6,890**	**2,300**	**400**	**0.66**	**200,000**	**180,000**
MEAN		**11.6**	**65**	**1,140**	**244**	**105**	**0.21**	**14,451**	**20,259**
MEDIAN		**11.1**	**52**	**852**	**150**	**67**	**0.18**	**2,800**	**5,500**
STANDARD DEVIATION		**8.1**	**53**	**1,045**	**319**	**99**	**0.13**	**30,149**	**29,144**

Table 2.5. Model calibration dataset for Menomonee River at Milwaukee, Wisconsin.

[Dates are presented as month/day/year (mm/dd/year); °C, degrees Celsius; FNU, formazin nephelometric units; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; MPN/100 mL, most probable number per 100 milliliters; CFU/100 mL, colony forming units per 100 milliliters]

Date (mm/dd/year)	Time (hours:minutes)	Water temperature (°C)	Turbidity (FNU)	Specific conductance (µS/cm)	Chloride (mg/L)	Total suspended solids (mg/L)	Total phos-phorus (mg/L)	*Escherichia coli* (MPN/100 mL)	Fecal coliform (CFU/100 mL)
11/20/2008	11:45	9.7	3.1	942	110	6.2	0.051	160	110
12/17/2008	14:15	0.0	7.3	2,480	520	6.8	0.061	440	
12/27/2008	9:35	2.2	20	4,033	1,100	22	0.26		
12/27/2008	12:35	0.3	52	4,763	1,400	50	0.28	1,500	840
12/27/2008	15:35	0.6	153	2,340	700	260			
12/27/2008	21:35	1.6	77	2,053	510	95	0.38		
12/28/2008	0:35	1.5	59	2,200	540	84	0.35	2,400	2,100
12/28/2008	6:35	0.5	44	2,130	520	49		930	
1/20/2009	12:40	8.2	5.4	1,740	150	8	0.26	63	24
2/7/2009	11:40	5.7	3.6	1,493	250	5	0.094	52	71
2/7/2009	20:40	0.0	79	3,477	920	68	0.34	1,500	1,800
2/8/2009	5:40	0.0	35	2,880	730	22	0.24	1,100	900
2/8/2009	14:40	0.8	28	2,843	680	16	0.19	730	870
2/8/2009	23:40	0.0	28	2,753	690	17	0.2	1,100	400
2/9/2009	17:40	0.1	13	2,300	520	30	0.18	780	1,000
2/10/2009	5:40	0.0	98	2,210	480	36	0.23	1,100	
2/11/2009	17:40	1.5	69	1,570	320	78	0.28	1,100	
2/16/2009	13:40	0.1	8.1	1,873	360	10	0.073	70	48
2/26/2009	16:00	8.9	8.2	2,090	420	12	0.096	610	32
2/26/2009	19:00	0.2	200	2,110	480	220	0.38	3,300	1,100
2/26/2009	22:00	0.7	130	1,090	280	170	0.3	1,500	1,700
2/27/2009	4:00	0.6	85	1,240	300	85	0.21	1,400	1,300
2/27/2009	12:00	0.1	51	1,550	370	13	0.12	210	
2/28/2009	12:00	0.0	19	1,860	320	35	0.19	990	
3/7/2009	11:10	2.9	19	1,710	300	97	0.1	460	270
3/7/2009	14:10	2.9	89	1,420	270	97	0.2	1,200	800
3/7/2009	23:10	2.6	54	1,290	290	58	0.17	360	
3/8/2009	12:10	1.2	35	1,300	280	34	0.14	430	
3/8/2009	18:10	1.6	90	743	160	120	0.25	1,000	
3/9/2009	0:10	0.9	61	1,100	240	66	0.19	570	720
3/10/2009	8:15	2.3	47	938	200	60	0.15	380	
3/10/2009	12:55	2.1	41	1,020	210	35	0.15	280	
3/10/2009	13:00	2.1	42	1,030	210	38	0.14	400	
3/10/2009	20:30	2.2	41	991	200	38	0.14	160	280
3/11/2009	4:30	2.0	29	984	190	23	0.12	170	
3/24/2009	12:25	12.0	4	1,335	270	11	0.057	63	71
4/1/2009	1:40	5.1	34	1,220	240	30	0.083	1,900	1,500
4/20/2009	3:05	10.9	12	866	180	12	0.046	520	1,700
4/20/2009	4:50	9.6	14	714	160	12	0.044	1,700	
4/23/2009	11:15	12.5	5.7	1,220	240	6.8	0.039	110	56

Table 2.5. Model calibration dataset for Menomonee River at Milwaukee, Wisconsin.—Continued

[Dates are presented as month/day/year (mm/dd/year); °C, degrees Celsius; FNU, formazin nephelometric units; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; MPN/100 mL, most probable number per 100 milliliters; CFU/100 mL, colony forming units per 100 milliliters]

Date (mm/dd/year)	Time (hours:minutes)	Water temperature (°C)	Turbidity (FNU)	Specific conductance (µS/cm)	Chloride (mg/L)	Total suspended solids (mg/L)	Total phos-phorus (mg/L)	*Escherichia coli* (MPN/100 mL)	Fecal coliform (CFU/100 mL)
4/25/2009	13:20	14.2	30	1,190	240	26	0.073	2,000	2,200
4/25/2009	20:00	11.8	61	611	120	57	0.097	2,400	
4/26/2009	8:00	8.8	48	639	120	48	0.1	1,600	2,400
4/26/2009	14:00	8.8	39	680	120	31	0.095	980	2,700
4/26/2009	16:25	9.6	82	601	100	190	0.26	11,000	12,000
4/26/2009	17:10	10.3	210	450	74	460	0.52	16,000	17,000
4/26/2009	19:30	10.9	210	411	59	340	0.38	3,700	2,400
4/26/2009	19:35	10.9	190	414	59	320	0.38	3,200	
5/13/2009	22:05	15.2	35	895	160	42	0.14	3,300	2,000
5/14/2009	0:35	16.4	67	374	51	73	0.17	5,200	4,000
5/14/2009	1:45	16.4	93	326	42	93	0.21	3,100	5,800
5/14/2009	3:35	16.0	70	378	49	71	0.16	4,100	3,500
5/20/2009	11:45	18.4	5	1,080	170	11	0.12	120	130
6/8/2009	12:40	13.1	42	395	66	37	0.1	3,600	
6/8/2009	15:30	13.6	50	478	79	37	0.12	3,100	5,800
6/9/2009	2:35	14.3	33	566	95	29	0.087	5,200	9,200
6/9/2009	5:00	14.3	31	600	100	24	0.088	7,100	6,200
6/16/2009	13:00	22.7	5.3	974	150	11	0.11	60	340
6/19/2009	0:55	20.1	530	307	50	1,800	1.8	27,000	50,000
6/19/2009	1:10	20.0	400	174	18	1,000	1.2	16,000	36,000
6/19/2009	1:45	20.1	340	174	20	820	0.96	26,000	37,000
6/19/2009	9:35	19.6	95	379	47	110	0.2	18,000	110
6/19/2009	20:45	21.1	160	315	39	230	0.27	24,000	63,000
6/20/2009	2:25	19.8	84	471	56	95	0.19	20,000	60,000
7/16/2009	12:30	24.4	4.9	883	150	12	0.1	11,000	41,000
8/8/2009	22:30	21.6	24	361	56	36	0.14	17,000	97,000
8/9/2009	10:30	22.1	17	508	82	19	0.1	8,700	4,600
8/19/2009	13:30	22.1	4.7	781	120	8.5	0.076	240	
8/26/2009	7:05	21.6	15	413	69	15	0.11	98,000	110,000
8/26/2009	17:00	22.0	13	522	84	12	0.099	16,000	34,000
8/26/2009	23:45	21.8	14	547	90	15	0.1	7,500	6,000
9/15/2009	11:30	26.3	2.9	725	96	6.4	0.074	41	71
9/23/2009	7:10	24.3	7.1	750	100	12	0.11	140,000	
9/24/2009	7:00	23.7	9.2	710	110	11	0.095	18,000	
9/28/2009	12:05	16.3	28	294	39	22	0.11	17,000	19,000
9/28/2009	18:05	15.6	30	472	76	22	0.12	12,000	9,600
9/29/2009	0:05	15.1	30	481	72	14	0.11	7,000	6,400
9/29/2009	3:05	16.8	17	492	75	11	0.1	6,200	5,600
9/29/2009	5:00	17.2	16	541	72	14	0.11	7,000	6,400
10/1/2009	9:35	18.9	8	628	89	6	0.075	310	560

Table 2.5. Model calibration dataset for Menomonee River at Milwaukee, Wisconsin.—Continued

[Dates are presented as month/day/year (mm/dd/year); °C, degrees Celsius; FNU, formazin nephelometric units; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; MPN/100 mL, most probable number per 100 milliliters; CFU/100 mL, colony forming units per 100 milliliters]

Date (mm/dd/year)	Time (hours:minutes)	Water temperature (°C)	Turbidity (FNU)	Specific conductance (µS/cm)	Chloride (mg/L)	Total suspended solids (mg/L)	Total phos-phorus (mg/L)	*Escherichia coli* (MPN/100 mL)	Fecal coliform (CFU/100 mL)
10/2/2009	2:05	13.6	26	523	86	26	0.12	21,000	23,000
10/2/2009	14:05	13.4	22	370	54	13	0.086	4,800	9,000
10/15/2009	11:15	12.6	6.1	940	140	36	0.13	480	540
10/22/2009	23:45	11.2	15	683	120	20	0.16	26,000	30,000
10/23/2009	14:25	9.9	30	334	42	28	0.11	5,000	5,800
10/24/2009	14:25	9.1	16	616	89	16	0.098	2,900	2,700
10/30/2009	6:45	12.1	19	717	120	18	0.13	5,900	5,000
10/30/2009	18:45	13.1	21	611	88	17	0.11	5,000	4,200
10/31/2009	6:45	11.9	16	710	110	12	0.11	3,600	2,700
11/19/2009	7:15	11.2	6.3	1,080	160	7.2	0.078	6,000	4,600
12/16/2009	11:45	5.3	4	1,940	340	12	0.067	310	200
12/25/2009	4:30	1.6	33	2,780	660	28	0.11		
12/25/2009	7:20	1.1	42	1,260	270	52	0.14		
12/26/2009	1:20	0.3	33	1,120	270	41	0.12		
1/13/2010	11:00	1.2	1.9	1,600	280	9	0.062	85	160
1/24/2010	9:25	0.6	40	2,060	420	24	0.13	3,100	2,800
1/24/2010	11:10	0.3	66	1,830	410	46	0.19	6,500	4,200
1/24/2010	17:10	0.6	42	1,460	300	38	0.13	2,400	1,700
1/24/2010	23:15	0.7	33	1,620	350	30	0.11	1,300	1,400
2/18/2010	11:45	10.7	3.7	1,740	270	8	0.066	20	32
3/9/2010	5:55	10.2	6	1,920	370	4.4	0.057	110	240
3/10/2010	12:15	3.0	37	1,940	390	20	0.073		
3/10/2010	12:25	3.2	55	1,890	390	56	0.12		
3/10/2010	12:35	3.3	65	1,810	370	55	0.16	2,000	2,000
3/10/2010	13:55	3.4	56	1,690	350	47	0.14		
3/11/2010	11:15	2.2	19	1,400	250	14	0.08	520	460
3/11/2010	15:35	3.3	36	1,300	280	26	0.1		
3/11/2010	17:40	3.7	45	1,230	270	37	0.12	740	1,100
3/12/2010	16:40	3.2	15	1,060	210	12	0.078		
3/13/2010	23:05	3.8	14	942	180	8.1	0.069		
3/14/2010	12:05	3.7	13	917	170	67	0.072	110	850
3/18/2010	11:15	6.0		1,080	200	9.2	0.058	< 10	230
4/6/2010	1:50	15.3	16	1,230	230	18	0.12	2,100	340
4/6/2010	4:45	14.6	12	1,330	190	24	0.11	1,200	
4/6/2010	11:05	10.6	79	569	120	43	0.25	1,800	2,100
4/6/2010	12:10	10.4	88	482	97	24	0.2	2,600	2,400
4/6/2010	14:20	10.3	82	491	100	28	0.17	1,800	2,400
4/6/2010	14:45	10.3	82	508	110	74	0.13	2,900	2,000
4/6/2010	18:15	10.6	94	702	160	56	0.19	1,800	1,400
4/21/2010	14:30	17.1	3.6	1,140	190	8.8	0.07	100	64

Table 2.5. Model calibration dataset for Menomonee River at Milwaukee, Wisconsin.—Continued

[Dates are presented as month/day/year (mm/dd/year); °C, degrees Celsius; FNU, formazin nephelometric units; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; MPN/100 mL, most probable number per 100 milliliters; CFU/100 mL, colony forming units per 100 milliliters]

Date (mm/dd/year)	Time (hours:minutes)	Water temperature (°C)	Turbidity (FNU)	Specific conductance (µS/cm)	Chloride (mg/L)	Total suspended solids (mg/L)	Total phos-phorus (mg/L)	*Escherichia coli* (MPN/100 mL)	Fecal coliform (CFU/100 mL)
4/24/2010	21:55	10.4	22	833	170	14	0.072		
4/25/2010	1:45	9.6	44	486	94	60	0.1		
4/25/2010	2:00	9.4	61	401	69	77	0.17		
4/25/2010	7:00	9.2	78	402	68	78	0.14	1,600	2,000
4/25/2010	7:55	9.3	88	464	82	75	0.14	1,800	
4/25/2010	9:30	9.3	74	541	99	72	0.14	3,000	
4/25/2010	14:00	9.5	37	686	130	33	0.097		
4/25/2010	20:50	9.2	44	652	110	28	0.11		
5/11/2010	8:00	12.5	6.7	1,120	200	8.3	0.092	1,400	
5/11/2010	18:35	9.2	24	506	86	15	0.1	2,900	2,000
5/12/2010	0:45	9.2	29	762	140	14	0.076	960	2,000
5/12/2010	5:25	9.0	19	763	140	10	0.077	1,400	
5/13/2010	6:50	9.4	35	446	72	36	0.12	1,800	1,700
5/13/2010	10:10	9.1	72	371	52	92	0.16	2,800	2,500
5/13/2010	15:20	9.9	46	603	92	44	0.11	2,800	5,600
5/19/2010	11:15	16.8	3.9	1,010	150	7.8	0.068	97	120
6/2/2010	19:50	18.7	58	681	130	69	0.26	21,000	21,000
6/2/2010	20:00	17.8	73	441	72	100	0.26	17,000	28,000
6/3/2010	4:25	17.0	76	355	53	63	0.16	10,000	26,000
6/3/2010	5:25	17.2	68	419	58	46	0.17	9,600	53,000
6/3/2010	5:40	17.5	61	431	64	33	0.14	9,100	43,000
6/5/2010	22:55	19.7	20	597	110	21	0.12	5,800	7,200
6/15/2010	16:50	20.1	34	1,140	200	78	0.24	12,000	7,600
6/15/2010	17:20	18.6	240	289	39	730	0.82	25,000	31,000
6/15/2010	18:20	18.8	240	163	18	570	0.61	26,000	34,000
6/15/2010	18:55	18.8	190	176	18	400	0.4	49,000	33,000
6/15/2010	19:05	18.8	170	191	20	330	0.36	21,000	52,000
6/16/2010	0:05	18.6	110	377	50	110	0.2	21,000	44,000
6/16/2010	10:45	18.6	39	529	80	23	0.12	15,000	15,000
6/22/2010	6:45	21.2	72	312	44	49	0.16	9,600	21,000
6/23/2010	5:25	22.2	83	463	82	100	0.13	11,000	22,000
6/23/2010	6:35	22.0	130	235	30	220	0.31	18,000	44,000
6/23/2010	8:05	21.8	130	212	20	200	0.3	28,000	37,000
6/23/2010	15:15	22.1	50	482	57	44	0.18	11,000	60,000
6/27/2010	6:40	21.0	38	744	120	59	0.15	5,000	7,400
6/27/2010	13:00	20.8	61	343	45	64	0.14	10,000	9,800
6/27/2010	15:15	21.5	38	495	68	42	0.14	9,600	8,100
7/7/2010	16:20	25.9	34	1,140	210	98	0.22	3,100	4,700
7/7/2010	16:40	25.5	160	283	41	280	0.41	33,000	38,000
7/7/2010	18:15	25.5	130	189	23	170	0.27	55,000	140,000

Table 2.5. Model calibration dataset for Menomonee River at Milwaukee, Wisconsin.—Continued

[Dates are presented as month/day/year (mm/dd/year); °C, degrees Celsius; FNU, formazin nephelometric units; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; MPN/100 mL, most probable number per 100 milliliters; CFU/100 mL, colony forming units per 100 milliliters]

Date (mm/dd/year)	Time (hours:minutes)	Water temperature (°C)	Turbidity (FNU)	Specific conductance (µS/cm)	Chloride (mg/L)	Total suspended solids (mg/L)	Total phos-phorus (mg/L)	*Escherichia coli* (MPN/100 mL)	Fecal coliform (CFU/100 mL)
7/8/2010	1:45	24.7	39	424	62	36	0.15	31,000	47,000
7/14/2010	22:45	26.0	24	875	150	23	0.1	3,200	2,600
7/15/2010	1:45	23.3	380	191	22	1200	1.4	44,000	120,000
7/15/2010	3:05	22.6	280	153	13	730	0.74	22,000	35,000
7/15/2010	11:55	22.5	79	324	30	95	0.2	30,000	67,000
7/16/2010	1:05	22.9	51	348	32	41	0.14	5,300	19,000
7/22/2010	18:55	23.5	330	235	24	670	0.8	52,000	100,000
7/22/2010	20:05	23.6	220	143	11	380	0.51	41,000	62,000
7/23/2010	4:50	22.7	240	256	17	340	0.39	29,000	93,000
7/23/2010	21:50	23.4	45	407	35	40	0.14	2,300	
7/25/2010	13:05	23.1	16	586	56	15	0.12	520	2,200
8/8/2010	16:35	23.5	13	872	150	15	0.12	36,000	180,000
8/10/2010	11:30	27.1	6.3	672	96	5.1	0.087	630	1,500
8/21/2010	1:40	23.1	34	424	61	39	0.14		
8/21/2010	13:40	24.3	20	493	59	19	0.1	7,300	37,000
9/19/2010	6:35	17.3	17	573	88	23	0.12	20,000	25,000
9/29/2010	11:15	20.0	4.9	875	110	11	0.098	96	79
10/24/2010	15:25	14.3	25	405	54	18	0.3	41,000	110,000
2/7/2011	12:35	8.8	3.2	2,000	350	21	0.14	130	110
2/17/2011	16:45	3.0	28	3,570	900	22	0.16	830	460
2/17/2011	19:10	0.4	62	3,160	860	66	0.22	2,500	1,700
3/9/2011	13:10	2.0	14	2,770	640	16	0.057	1,200	680
3/9/2011	23:15	1.3	23	3,350	920	19	0.053	790	870
3/20/2011	15:05	3.9	96	898	200	140	0.23	2,500	2,000
5/23/2011	0:05	19.7	12	1,220	230	14	0.076	100	
5/23/2011	1:05	18.5	38	684	160	38	0.13	3,700	5,200
6/21/2011	20:50	20.6	560	326	44	1900	2.4	69,000	87,000
6/21/2011	21:40	19.6	230	200	24	420	0.51	26,000	32,000
6/21/2011	22:55	19.8	250	202	22	520	0.52	22,000	37,000
6/22/2011	0:50	19.6	130	273	32	150	0.24	14,000	34,000
MINIMUM		**0.0**	**1.9**	**143**	**11**	**4.4**	**0.04**	**20**	**24**
MAXIMUM		**27.1**	**560**	**4,763**	**1,400**	**1,900**	**2.40**	**140,000**	**180,000**
MEAN		**12.1**	**67**	**996**	**199**	**111**	**0.21**	**9,819**	**18,610**
MEDIAN		**11.5**	**38**	**710**	**120**	**36**	**0.14**	**2,900**	**4,000**
STANDARD DEVIATION		**8.2**	**87**	**807**	**215**	**249**	**0.27**	**17,204**	**30,801**

Table 2.6. Model calibration dataset for Underwood Creek at Wauwatosa, Wisconsin.

[Dates are presented as month/day/year (mm/dd/year); °C, degrees Celsius; FNU, formazin nephelometric units; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; MPN/100 mL, most probable number per 100 milliliters; CFU/100 mL, colony forming units per 100 milliliters]

Date (mm/dd/year)	Time (hours:minutes)	Water temperature (°C)	Turbidity (FNU)	Specific conductance (µS/cm)	Chloride (mg/L)	Total suspended solids (mg/L)	Total phos-phorus (mg/L)	*Escherichia coli* (MPN/100 mL)	Fecal coliform (CFU/100 mL)
2/18/2010	10:30	2.4	4.1	2,780	580	8.5	0.04	100	96
3/8/2010	15:40	8.8	15	2,718	710	13	0.08	450	420
3/8/2010	21:40	3.8	10	2,650	660	34	0.13	3,400	1,600
3/9/2010	13:25	6.7	6.2	2,740	680	12	0.05	440	310
3/10/2010	1:25	3.4	8.5	2,552	590	14	0.05	1,600	1,200
3/10/2010	9:30	3.5	76	2,156	520	130	0.31	4,400	3,000
3/10/2010	10:40	3.6	170	1,896	450	270	0.64	9,900	7,600
3/10/2010	16:40	4.1	37	1,839	410	58	0.17		
3/11/2010	10:40	4.0	8.5	1,910	380	7.5	0.06	520	310
3/11/2010	13:20	4.4	70	1,566	300	95	0.24	2,000	8,200
3/11/2010	19:20	3.6	44	1,350	250	58	0.14		
3/12/2010	13:20	5.0	8.9	1,481	290	12	0.06		
3/13/2010	6:40	4.1	21	1,310	270	14	0.06		
3/14/2010	7:40	3.8	6.9	1,430	290	6.8	0.04	160	180
3/18/2010	10:00	6.3		1,717	280	6	0.05	< 1	300
4/5/2010	21:50	13.2	144	1,612	270	250	0.35	9,600	8,000
4/6/2010	8:00	10.4	67	1,102	250	130	0.32	4,900	3,400
4/6/2010	8:30	10.1	230	646	140	510	0.96	7,600	2,200
4/6/2010	8:35	10.0	264	660	140	340	1.90	3,300	3,600
4/6/2010	10:25	10.0	382	809	210	520	0.95	4,000	2,800
4/7/2010	1:25	9.7	37	1,480	260	84	0.17	5,000	6,200
4/21/2010	11:05	13.3	4.2	1,850	300	46	0.08	< 100	32
4/24/2010	5:25	10.0	82	1,306	210	420	0.68		
4/24/2010	6:15	9.8	78	882	170	290	0.68		
4/24/2010	6:25	9.8	112	1,122	210	500	0.92		
4/24/2010	8:05	9.9	44	1,007	240	310	0.10		
4/24/2010	22:15	10.0	7.2	1,390	290	5.8	0.04		
4/25/2010	0:25	9.4	64	519	110	120	0.25		
4/25/2010	0:55	9.5	88	663	130	180	0.26	2,700	5,800
4/25/2010	1:10	9.5	110	493	110	260	0.37	2,100	32,000
4/25/2010	4:40	9.3	132	633	130	170	0.22	3,200	20,000
4/26/2010	12:00	12.7	5.3	1,190	210	18	0.07		
5/7/2010	9:05	10.3	16	1,218	240	130	0.32		
5/7/2010	10:05	10.3	30	1,103	210	140	0.33		
5/7/2010	19:40	10.8	35	1,119	230	17	0.06		
5/11/2010	4:40	9.0	22	1,127	230	25	0.13	2,500	4,800
5/19/2010	10:15	15.3	3.4	1,560	280	36	0.10	280	240
6/2/2010	18:00	19.8	106	1,274	260	200	0.23	2,400	21,000
6/2/2010	18:30	17.8	340	328	30	260	0.53	33,000	83,000
6/2/2010	18:50	17.5	188	210	59	130	0.33	16,000	43,000

Table 2.6. Model calibration dataset for Underwood Creek at Wauwatosa, Wisconsin.—Continued

[Dates are presented as month/day/year (mm/dd/year); °C, degrees Celsius; FNU, formazin nephelometric units; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; MPN/100 mL, most probable number per 100 milliliters; CFU/100 mL, colony forming units per 100 milliliters]

Date (mm/dd/year)	Time (hours:minutes)	Water temperature (°C)	Turbidity (FNU)	Specific conductance (µS/cm)	Chloride (mg/L)	Total suspended solids (mg/L)	Total phos-phorus (mg/L)	*Escherichia coli* (MPN/100 mL)	Fecal coliform (CFU/100 mL)
6/2/2010	20:10	16.2	290	209	31	440	0.47	34,000	41,000
6/3/2010	2:00	16.3	34	832	160	44	0.14	3,400	29,000
6/5/2010	19:35	18.8	66	894	160	62	0.23	7,800	11,000
6/5/2010	21:35	19.0	58	326	63	84	0.18	6,400	26,000
6/6/2010	6:00	16.6		1,020	180	20	0.12	2,600	7,800
6/8/2010	17:45	15.8		618	120	62	0.13	5,800	6,600
6/15/2010	15:35	18.7	75	1,125	230	150	0.26	7,600	6,400
6/15/2010	16:05	18.9	161	334	43	360	0.38	33,000	40,000
6/15/2010	16:15	18.6	122	303	31	320	0.20	26,000	44,000
6/15/2010	16:30	18.8	139	201	20	250	0.29	49,000	41,000
6/15/2010	17:50	18.7	400	213	21	600	0.48	73,000	120,000
6/16/2010	0:25	17.9	53	640	90	73	0.17	24,000	53,000
6/16/2010	9:30	18.7	25	805	130	22	0.12	16,000	26,000
6/21/2010	22:05	22.0	93	839	65	170	0.25	7,800	8,000
6/21/2010	22:35	21.5	112	701	38	180	0.30	18,000	27,000
6/21/2010	22:45	21.7	156	555	39	270	0.37	22,000	27,000
6/22/2010	1:00	20.9	101	358	39	150	0.30	37,000	
6/22/2010	3:45	20.0	43	566	84	54	0.18	23,000	93,000
6/23/2010	4:15	22.3	172	716	60	270	0.25	8,600	58,000
6/23/2010	5:05	22.0	120	511	31	270	0.23	24,000	38,000
6/23/2010	10:10	20.7	52	449	47	79	0.21	15,000	90,000
6/24/2010	1:35	21.7	18	688	92	31	0.10	2,600	11,000
6/27/2010	4:50	20.6	122	914	75	200	0.25	7,300	29,000
6/27/2010	5:20	20.1	83	678	49	140	0.27	24,000	20,000
6/27/2010	5:35	20.1	127	715	59	230	0.35	21,000	22,000
6/27/2010	8:55	20.3	39	568	87	54	0.19	18,000	37,000
7/7/2010	15:20	27.3	81	1,290	250	140	0.13	6,800	11,000
7/7/2010	16:15	25.5	80	459	60	100	0.21	44,000	56,000
7/7/2010	16:30	25.8	180	328	53	180	0.21	34,000	31,000
7/7/2010	18:10	25.1	59	324	43	66	0.10	16,000	17,000
7/8/2010	4:50	22.1	10	997	180	16	0.09	25,000	43,000
7/14/2010	22:25	22.8	78	1,362	280	51	0.06	4,500	4,100
7/14/2010	23:00	23.2	54	599	83	52	0.14	44,000	36,000
7/22/2010	12:15	22.0	76	439	63	150	0.28	24,000	55,000
7/22/2010	18:55	23.6	122	167	15	190	0.25	27,000	100,000
7/23/2010	0:45	22.9	51	293	17	92	0.23	26,000	140,000
7/24/2010	0:45	23.3	15	484	47	35	0.14	2,300	38,000
7/24/2010	7:20	22.7	34	392	36	61	0.14	9,600	100,000
7/26/2010	4:15	19.5	6.9	992	140	42	0.15	1,300	2,800
7/31/2010	2:55	19.9	16	1,312	180	26	0.11		

Table 2.6. Model calibration dataset for Underwood Creek at Wauwatosa, Wisconsin.—Continued

[Dates are presented as month/day/year (mm/dd/year); °C, degrees Celsius; FNU, formazin nephelometric units; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; MPN/100 mL, most probable number per 100 milliliters; CFU/100 mL, colony forming units per 100 milliliters]

Date (mm/dd/year)	Time (hours:minutes)	Water temperature (°C)	Turbidity (FNU)	Specific conductance (µS/cm)	Chloride (mg/L)	Total suspended solids (mg/L)	Total phos-phorus (mg/L)	*Escherichia coli* (MPN/100 mL)	Fecal coliform (CFU/100 mL)
7/31/2010	4:10	20.6	53	678	100	150	0.20		
7/31/2010	4:55	20.8	50	431	54	92	0.14		
7/31/2010	7:10	20.9	37	410	51	59	0.11		
7/31/2010	14:30	21.1	11	788	120	56	0.14		
8/8/2010	10:10	20.9	102	711	110	130	0.29		
8/9/2010	5:40	21.9	43	694	88	66	0.14	25,000	
8/10/2010	9:20	22.5	4.1	1,290	210	4.5	0.07	2,600	3,500
8/20/2010	18:50	24.1	54	1,270	270	7.8	0.07		
8/20/2010	23:45	22.8	116	376	74	260	0.37		100,000
8/21/2010	1:45	22.8	43	404	31	270	0.44		100,000
8/21/2010	16:15	26.5	7.6	810	180	25	0.11		
9/1/2010	3:20	21.7	19	1,474	280	43	0.12	10,000	11,000
9/1/2010	4:35	21.9	110	659	100	220	0.55	92,000	100,000
9/1/2010	6:05	22.3	53	341	50	88	0.22	73,000	38,000
9/11/2010	4:55	16.4	12	1,260	230	24	0.11	7,300	21,000
9/11/2010	6:30	16.6	53	647	100	130	0.40	23,000	32,000
9/11/2010	6:50	16.7	74	506	91	140	0.39	28,000	29,000
9/11/2010	8:35	17.1	24	340	55	67	0.16	26,000	31,000
9/11/2010	22:55	15.8	5.8	803	140	28	0.08	4,100	4,400
9/18/2010	6:40	16.8	114	681	76	61	0.17	58,000	56,000
9/18/2010	6:55	17.0	126	634	99	20	0.11	24,000	28,000
9/18/2010	7:50	17.3	57	553	170	13	0.07	17,000	18,000
9/29/2010	10:00	14.5	2.3	1,737	300	6	0.04	320	240
10/23/2010	23:45	13.6	17	1,430	260	28	0.10	120,000	10,000
10/24/2010	0:55	14.3	84	513	81	110	1.20		
10/24/2010	1:35	14.3	236	462	78	310	1.30	170,000	120,000
10/24/2010	6:20	14.1	12	394	55	29	0.29	28,000	35,000
10/27/2010	6:15	9.7	5.2	908	170	24	0.18	5,200	5,200
11/17/2010	8:00	6.0	2.4	1,600	260	4	0.07	1,500	910
11/22/2010	8:20	9.8	62	938	140	120	0.34	17,000	19,000
11/22/2010	9:25	9.9	574	721	120	1,200	2.20		
11/22/2010	12:50	10.4	29	524	87	49	0.21	41,000	29,000
11/29/2010	20:35	6.1	23	881	140	43	0.21	87,000	130,000
11/30/2010	2:35	6.9	13	797	140	21	0.10	25,000	28,000
12/20/2010	7:40	0.0	3.6	2,220	330	4.8	0.08	370	320
1/11/2011	16:35	0.0	5.5	7,767	2,400	7.4	< 0.009	250	240
2/7/2011	11:30	0.0	4	6,366	1,800	9.2	0.05	660	450
2/16/2011	18:40	1.9	54	4,458	1,200	44	0.18	1,200	2,800
2/17/2011	16:30	2.3	84	3,046	840	130	0.39	2,500	2,400
2/23/2011	8:00	0.4	11	5,262	1,400	43	0.12	790	1,000

Table 2.6. Model calibration dataset for Underwood Creek at Wauwatosa, Wisconsin.—Continued

[Dates are presented as month/day/year (mm/dd/year); °C, degrees Celsius; FNU, formazin nephelometric units; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; MPN/100 mL, most probable number per 100 milliliters; CFU/100 mL, colony forming units per 100 milliliters]

Date (mm/dd/year)	Time (hours:minutes)	Water temperature (°C)	Turbidity (FNU)	Specific conductance (µS/cm)	Chloride (mg/L)	Total suspended solids (mg/L)	Total phos-phorus (mg/L)	*Escherichia coli* (MPN/100 mL)	Fecal coliform (CFU/100 mL)
3/8/2011	14:40	7.2	13	3,310	1,000	16	0.05	4,600	2,000
3/16/2011	6:40	2.5	7	2,580	560	8.5	0.04	460	280
3/17/2011	11:55	6.7	12	1,870	340	26	0.08	560	410
3/17/2011	21:40	6.0	37	1,540	260	110	0.18	1,100	1,200
3/18/2011	3:40	4.1	22	1,530	240	47	0.12	520	530
3/20/2011	11:35	4.0	180	1,440	280	130	0.19	4,500	2,500
3/20/2011	14:35	3.8	130	909	250	200	0.33	1,500	
3/20/2011	23:50	3.9	78	1,060	280	110	0.17	970	
4/15/2011	17:15	7.3	33	1,636	280	290	0.31	4,100	2,600
4/15/2011	18:25	7.0	75	1,210	260	70	0.16	11,000	12,000
4/16/2011	0:40	5.5	58	770	260	190	0.34	3,700	4,200
4/16/2011	9:10	6.2	14	1,398	240	80	0.12	1,200	
4/25/2011	16:30	15.5	3.3	1,680	290	< 1	0.02	100	76
4/26/2011	2:50	9.9	32	1,200	260	56	0.11	14,000	15,000
4/26/2011	4:45	9.2	48	608	110	100	0.13	4,000	4,200
4/26/2011	7:45	8.6	74	629	110	130	0.17	1,200	
4/26/2011	11:15	9.2	55	750	140	80	0.15	970	
4/26/2011	17:15	11.7	22	955	180	36	0.08	2,400	
4/27/2011	5:15	10.0	12	1,080	200	18	0.05	410	
5/9/2011	15:55	13.1	142	799	180	330	0.48		38,000
5/9/2011	16:40	12.7	122	1,186	250	310	0.38	17,000	14,000
5/9/2011	19:00	12.7	52	1,160	260	80	0.15	13,000	6,000
5/17/2011	9:10	10.6	4.5	1,726	280	4.2	0.04	8,100	680
5/22/2011	21:55	17.7	28	962	260	47	0.16	3,400	3,600
5/22/2011	22:35	17.5	120	856	230	59	0.22	5,800	5,000
5/22/2011	23:25	17.6	167	603	140	260	0.42	7,700	
5/23/2011	3:00	17.0	27	852	120	230	0.36	11,000	
5/25/2011	11:05	11.8	74	522	120	280	0.77	4,900	7,600
6/8/2011	21:35	20.9	254	629	65	840	1.40	20,000	20,000
6/8/2011	22:20	20.7	53	684	75	850	1.10	66,000	100,000
6/9/2011	3:15	20.2	32	816	140	140	0.26	21,000	28,000
6/14/2011	19:40	19.2	4.8	1,740	300	16	0.09	410	420
6/19/2011	10:25	19.4	86	1,130	100	200	0.40	33,000	23,000
6/19/2011	11:15	19.2	100	849	92	380	0.62	28,000	45,000
6/21/2011	2:35	17.3	46	776	160	170	0.27	5,700	8,600
6/21/2011	15:40	21.6	100	525	19	330	0.40	34,000	49,000
6/21/2011	16:00	21.3	170	369	51	390	0.41	22,000	58,000
6/21/2011	20:15	20.0	84	398	45	220	0.28	16,000	33,000
6/21/2011	20:50	19.9	170	320	28	230	0.39	26,000	67,000
7/11/2011	9:10	21.8	126	570	110	360	0.19	98,000	100,000

Table 2.6. Model calibration dataset for Underwood Creek at Wauwatosa, Wisconsin.—Continued

[Dates are presented as month/day/year (mm/dd/year); °C, degrees Celsius; FNU, formazin nephelometric units; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; MPN/100 mL, most probable number per 100 milliliters; CFU/100 mL, colony forming units per 100 milliliters]

Date (mm/dd/year)	Time (hours:minutes)	Water temperature (°C)	Turbidity (FNU)	Specific conductance (µS/cm)	Chloride (mg/L)	Total suspended solids (mg/L)	Total phos-phorus (mg/L)	*Escherichia coli* (MPN/100 mL)	Fecal coliform (CFU/100 mL)
7/11/2011	9:50	21.3	114	731	66	310	0.73	240,000	320,000
7/19/2011	16:10	33.9	2	1,448	300	2.4	0.04	2,000	2,400
7/20/2011	2:15	24.0	32	1,170	210	58	0.17	18,000	80,000
7/27/2011	9:00	19.8	75	962	180	140	0.35	55,000	97,000
7/27/2011	10:30	20.5	145	410	69	390	0.64	29,000	80,000
7/27/2011	11:45	21.1	66	446	80	220	0.35	23,000	49,000
8/7/2011	7:45	21.9	62	660	78	200	0.45	34,000	40,000
8/7/2011	8:25	21.4	200	607	120	700	1.20	37,000	90,000
8/7/2011	10:25	22.4	85	384	64	130	0.21	24,000	24,000
8/13/2011	18:05	21.4	320	873	220	32	0.15	29,000	23,000
8/13/2011	18:20	21.4	370	365	130	880	1.40	61,000	100,000
8/13/2011	20:50	21.1	30	458	52	280	0.36	49,000	77,000
8/22/2011	16:45	28.6	4.9	1,130	260	12	0.11	230	530
9/20/2011	8:35	13.2	5.9	1,140	230	4.4	0.10	8,800	6,800
9/25/2011	14:05	14.3	108	435	120	57	0.17	20,000	21,000
9/25/2011	14:45	14.0	176	396	59	300	0.40	65,000	59,000
10/18/2011	16:05	12.3	2.2	1,400	260	4.1	0.08	1,100	760
10/19/2011	16:50	10.8	23	857	180	13	0.23	69,000	87,000
10/19/2011	22:50	10.4	19	496	160	14	0.24	55,000	73,000
11/2/2011	21:00	10.0	46	768	130	38	0.17	18,000	13,000
11/3/2011	3:00	9.2	25	452	140	39	0.18	16,000	21,000
11/9/2011	11:15	8.3	33	409	65	32	0.11	19,000	16,000
11/9/2011	17:15	7.6	21	655	120	20	6.00	14,000	12,000
11/28/2011	20:05	4.3	2.7	1,420	240	22	0.07	880	4,200
12/3/2011	7:50	5.1	18	939	180	35	0.12	59,000	57,000
12/3/2011	9:50	5.9	31	821	220	76	0.21	20,000	30,000
12/3/2011	23:35	6.9	60	582	110	92	0.18	19,000	25,000
MINIMUM		**0.0**	**2.0**	**167**	**15**	**2.4**	**0.02**	**100**	**32**
MAXIMUM		**33.9**	**574**	**7,767**	**2,400**	**1,200**	**6.00**	**240,000**	**320,000**
MEAN		**14.5**	**76**	**1,072**	**215**	**147**	**0.32**	**20,734**	**31,724**
MEDIAN		**15.8**	**53**	**816**	**140**	**82**	**0.19**	**10,500**	**20,000**
STANDARD DEVIATION		**7.1**	**84**	**951**	**274**	**177**	**0.52**	**30,331**	**40,698**

Appendix 3. Regression Analysis Results for Estimating Chloride Concentration

All data were collected using USGS protocols and are stored in the USGS National Water Information System (NWIS) database (*http://waterdata.usgs.gov/nwis*). The regression models are based on measurements of specific conductance and turbidity and concurrent chloride samples collected from November 2008 to September 2011. Continuous water-quality data were collected at 5-minute intervals using a YSI model 6920 V2 multiparameter water-quality monitor with a 6560 specific conductance and water temperature sensor and a 6136 optical turbidity sensor. Specific conductance and turbidity values are instantaneous unit values temporally corresponding to the collection of the chloride samples. Samples were collected throughout the range of continuously observed hydrologic conditions. Summary statistics and the complete model calibration dataset are provided. A comparison of cross-section mean and corresponding time-series monitor readings is archived at the USGS Wisconsin Water Science Center and is available by request to the District Chief (dc_wi@usgs.gov).

Chloride at Little Menomonee River near Freistadt, WI (04087050)

MODEL SUMMARY—Summary of final regression results for estimating chloride concentrations at Little Menomonee River near Freistadt, WI.

$$\text{Log}_{10}\,(\text{Chloride}) = -3.92 + 1.91\,\log_{10}\,(\text{SC}) + 0.12\,\log_{10}\,(\text{Turb}),$$

Where:

Chloride	=	Chloride concentration in mg/L
SC	=	Specific Conductance in µS/cm at 25° C; and
Turb	=	Turbidity (YSI 6136) in FNU

Model Information (in log units unless otherwise specified):

Number of measurements = 116,
Root-mean-squared error (RMSE) = 0.10
Model standard percentage error (MPSE) = +26 and -21 percent
90-percent prediction intervals (based on units in mg/L) = +/- 40 percent
Adjusted coefficient of determination (Adj R^2) = 0.79
Sum of squared error = 1.12
PRESS = 1.18

Coefficients:

	Coefficient	Standard error	t statistic	p-value
Intercept	-3.92	0.34	-11.68	<0.0001
Log_{10} (SC)	1.91	0.11	17.36	<0.0001
Log_{10} (Turb)	0.12	0.02	5.27	0.0003

Correlation matrix of coefficients:

	Intercept	$\log_{10}$ (SC)	$\log_{10}$ (Turb)
Intercept	1		
Log_{10} (SC)	-0.998	1	
Log_{10} (Turb)	-0.797	0.757	1

Duan's bias correction factor **= 1.03**

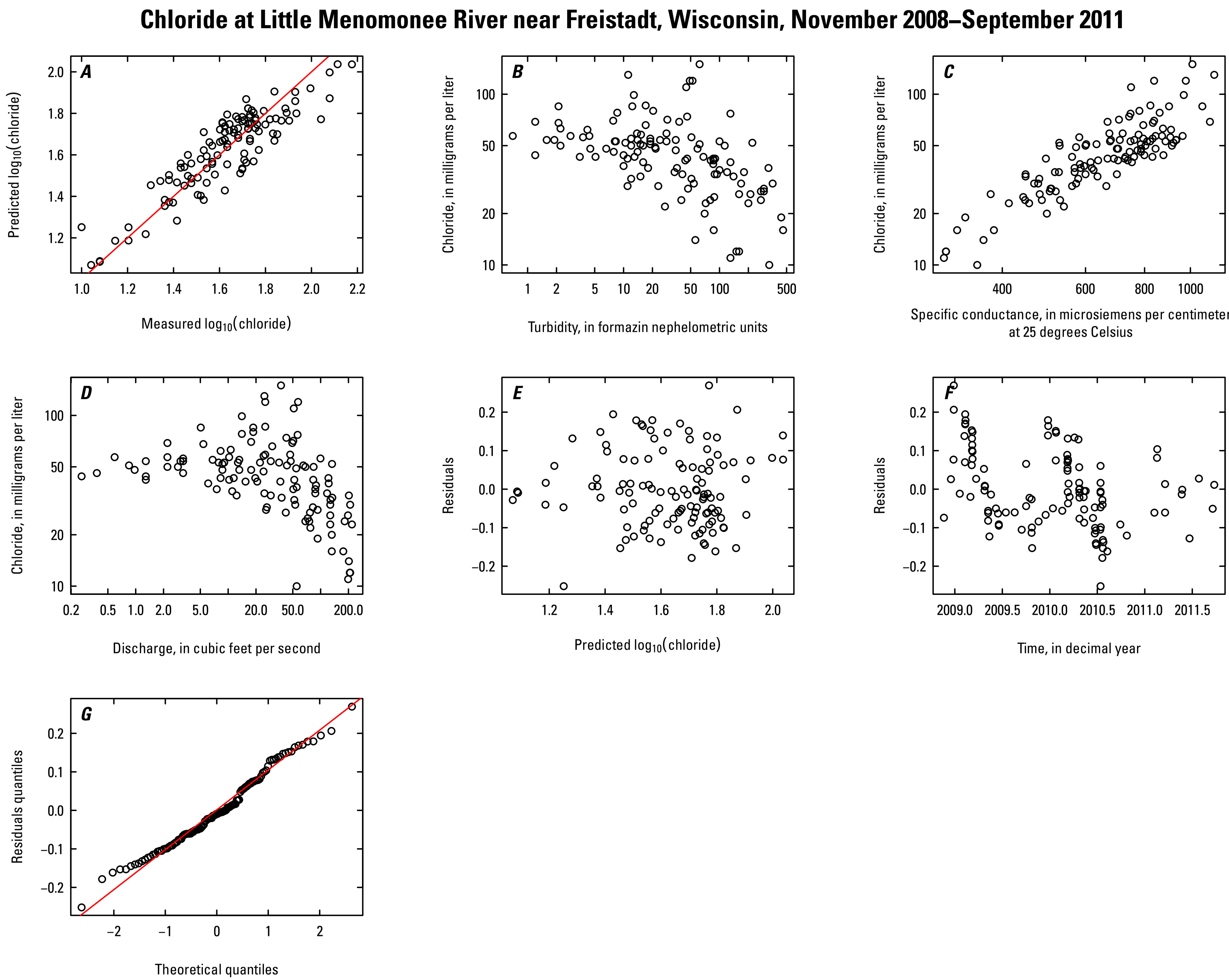

Figure 3.1. *A*, Relation between measured and predicted $\log_{10}$(chloride concentration); *B*, Relation between turbidity and chloride concentration in $\log_{10}$ space; *C*, Relation between specific conductance and chloride concentration in $\log_{10}$ space; *D*, Relation between discharge and chloride concentration in $\log_{10}$ space; *E*, Relation between predicted $\log_{10}$(chloride concentration) and regression residuals; *F*, Relation between time and chloride regression residuals; *G*, Probability plot of chloride regression residuals. U.S. Geological Survey streamgage on Little Menomonee River near Freistadt, Wisconsin, November 2008–September 2011.

Chloride at Menomonee River at Menomonee Falls, WI (04087030)

MODEL SUMMARY—Summary of final regression results for estimating chloride concentrations at Menomonee River at Menomonee Falls, WI.

$$\text{Log}_{10}\,(\text{Chloride}) = -1.84 + 1.35\ \log_{10}\,(\text{SC}),$$

Where:

Chloride	=	Chloride concentration in mg/L
SC	=	Specific Conductance in µS/cm at 25° C

Model Information (in log units unless otherwise specified):

Number of measurements = 150,
Root-mean-squared error (RMSE) = 0.08
Model standard percentage error (MPSE) = +20 and -16 percent
90-percent prediction intervals (based on units in mg/L) = +/- 31 percent
Adjusted coefficient of determination (Adj R^2) = 0.94
Sum of squared error = 0.90
PRESS = 0.92

Coefficients:

	Coefficient	**Standard error**	**t statistic**	**p-value**
Intercept	-1.84	0.08	-23.56	<0.0001
Log_{10} (SC)	1.35	0.03	49.53	<0.0001

Correlation matrix of coefficients:

	Intercept	**$\log_{10}$ (SC)**
Intercept	1	
Log_{10} (SC)	-0.997	1

Duan’s bias correction factor **= 1.02**

Chloride at Menomonee River at Menomonee Falls, Wisconsin, November 2008–September 2011

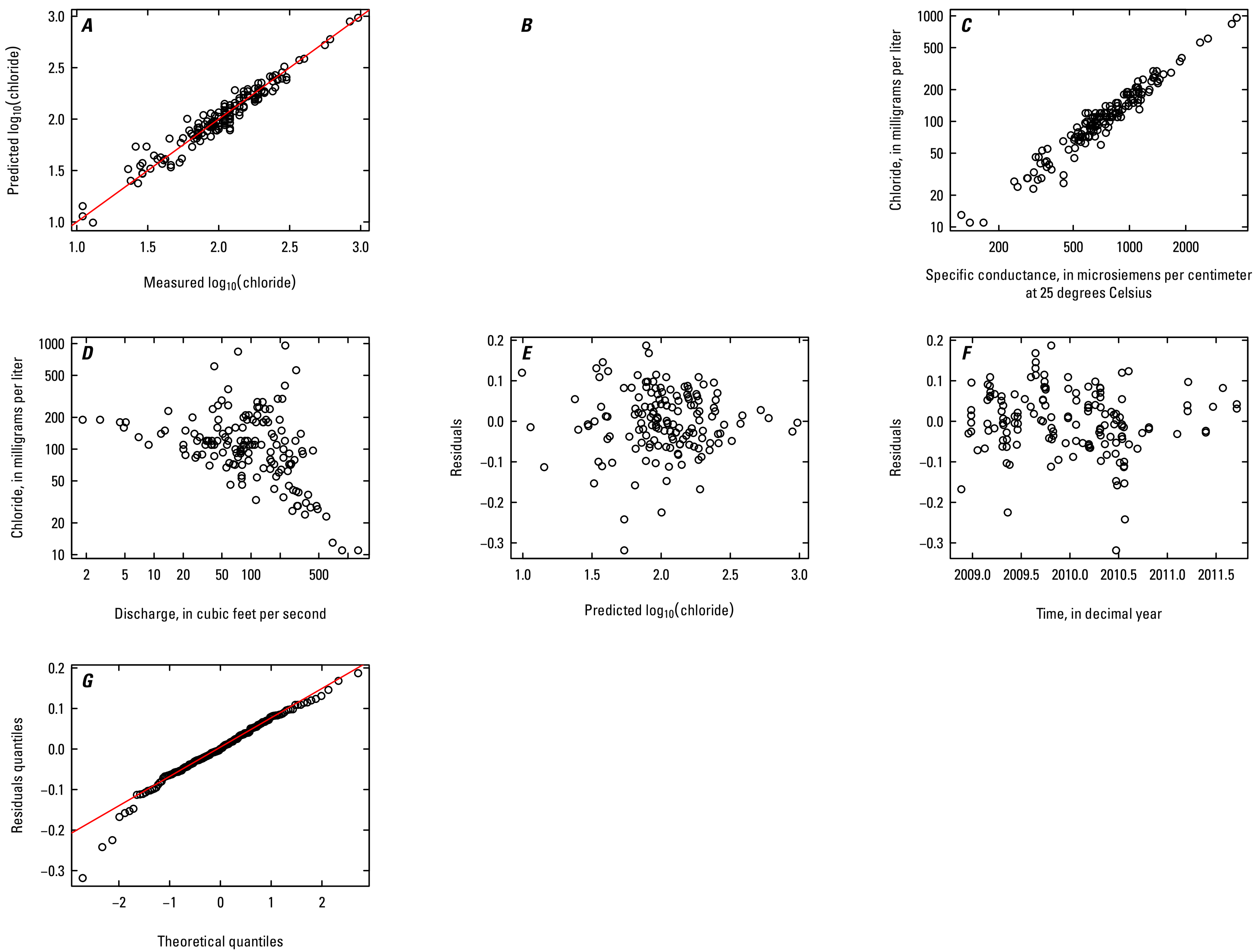

Figure 3.2. *A*, Relation between measured and predicted log_{10}(chloride concentration); *B*, No plot because only one explanatory variable used in model; *C*, Relation between specific conductance and chloride concentration in log_{10} space; *D*, Relation between discharge and chloride concentration in log_{10} space; *E*, Relation between predicted log_{10}(chloride concentration) and regression residuals; *F*, Relation between time and chloride regression residuals; *G*, Probability plot of chloride regression residuals; U.S. Geological Survey streamgage on Menomonee River at Menomonee Falls, Wisconsin, November 2008–September 2011.

Chloride at Honey Creek at Wauwatosa, WI (04087119)

MODEL SUMMARY—Summary of final regression results for estimating chloride concentrations at Honey Creek at Wauwatosa, WI.

$$\log_{10}(\text{Chloride}) = -1.34 + 1.22 \log_{10}(\text{SC}),$$

Where:

Chloride = Chloride concentration in mg/L

SC = Specific Conductance in µS/cm at 25° C

Model Information (in log units unless otherwise specified):

Number of measurements = 233,
Root-mean-squared error (RMSE) = 0.18
Model standard percentage error (MPSE) = +51 and -34 percent
90-percent prediction intervals (based on units in mg/L) = +/- 82 percent
Adjusted coefficient of determination (Adj R^2) = 0.91
Sum of squared error = 7.52
PRESS = 7.61

Coefficients:

	Coefficient	Standard error	t statistic	p-value
Intercept	-1.34	0.07	-19.0	<0.0001
$\log_{10}$ (SC)	1.22	0.03	47.85	<0.0001

Correlation matrix of coefficients:

	Intercept	$\log_{10}$(SC)
Intercept	1	
$\log_{10}$ (SC)	-0.986	1

Duan's bias correction factor **= 1.11**

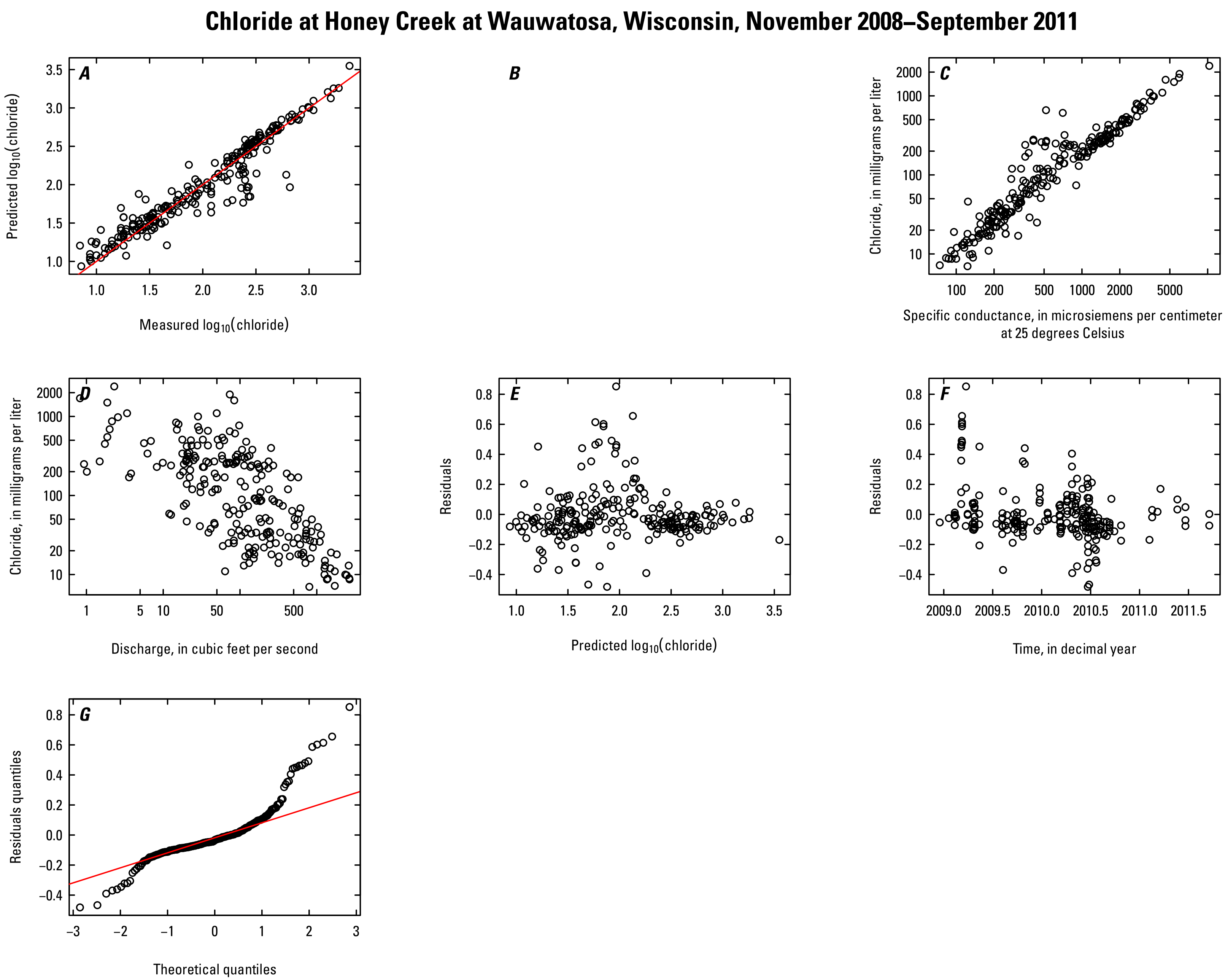

Figure 3.3. *A*, Relation between measured and predicted $\log_{10}$(chloride concentration); *B*, No plot because only one explanatory variable used in model; *C*, Relation between specific conductance and chloride concentration in $\log_{10}$ space; *D*, Relation between discharge and chloride concentration in $\log_{10}$ space; *E*, Relation between predicted $\log_{10}$(chloride concentration) and regression residuals; *F*, Relation between time and chloride regression residuals; *G*, Probability plot of chloride regression residuals; U.S. Geological Survey streamgage on Honey Creek at Wauwatosa, Wisconsin, November 2008–September 2011.

Chloride at Menomonee River at Wauwatosa, WI (04087120)

MODEL SUMMARY—Summary of final regression results for estimating chloride concentrations at Menomonee River at Wauwatosa, WI.

$$\mathrm{Log}_{10}\,(\mathrm{Chloride}) = -1.48 + 1.25\,\log_{10}\,(\mathrm{SC}),$$

Where:

Chloride = Chloride concentration in mg/L

SC = Specific Conductance in µS/cm at 25° C

Model Information (in log units unless otherwise specified):
Number of measurements = 220
Root-mean-squared error (RMSE) = 0.12
Model standard percentage error (MPSE) = +31 and -24 percent
90-percent prediction intervals (based on units in mg/L) = +/- 48 percent
Adjusted coefficient of determination (Adj R^2) = 0.92
Sum of squared error = 3.04
PRESS = 3.10

Coefficients:

	Coefficient	Standard error	t statistic	p-value
Intercept	-1.48	0.07	-19.99	<0.0001
Log_{10} (SC)	1.25	0.03	49.70	<0.0001

Correlation matrix of coefficients:

	Intercept	$\log_{10}$ (SC)
Intercept	1	
Log_{10} (SC)	-0.994	1

Duan’s bias correction factor **= 1.04**

Chloride at Menomonee River at Wauwatosa, Wisconsin, November 2008–September 2011

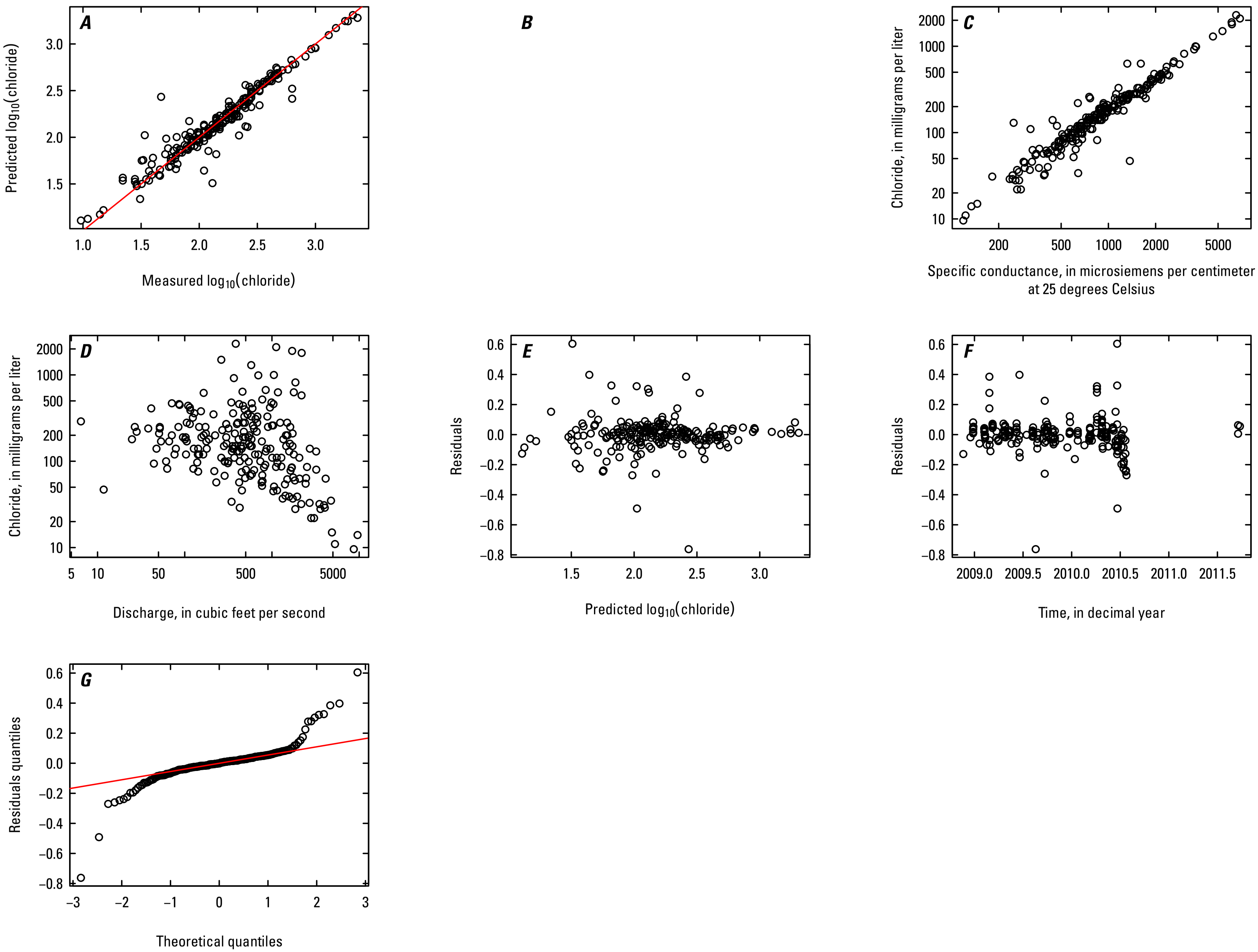

Figure 3.4. *A*, Relation between measured and predicted $\log_{10}$(chloride concentration); *B*, No plot because only one explanatory variable used in model; *C*, Relation between specific conductance and chloride concentration in $\log_{10}$ space; *D*, Relation between discharge and chloride concentration in $\log_{10}$ space; *E*, Relation between predicted $\log_{10}$(chloride concentration) and regression residuals; *F*, Relation between time and chloride regression residuals; *G*, Probability plot of chloride regression residuals; U.S. Geological Survey streamgage on Menomonee River at Wauwatosa, Wisconsin, November 2008–September 2011.

Chloride at Menomonee River at 16th Street at Milwaukee, WI (04087142)

MODEL SUMMARY—Summary of final regression results for estimating chloride concentrations at Menomonee River at 16th Street at Milwaukee, WI.

$$\text{Log}_{10}\text{(Chloride)} = -1.58 + 1.28\ \log_{10}\text{(SC)},$$

Where:

Chloride = Chloride concentration in mg/L

SC = Specific Conductance in µS/cm at 25° C

Model Information (in log units unless otherwise specified):

Number of measurements = 190,
Root-mean-squared error (RMSE) = 0.08
Model standard percentage error (MPSE) = +19 and -16 percent
90-percent prediction intervals (based on units in mg/L) = +/- 30 percent
Adjusted coefficient of determination (Adj R^2) = 0.97
Sum of squared error = 1.10
PRESS = 1.12

Coefficients:

	Coefficient	Standard error	t statistic	p-value
Intercept	-1.58	0.05	-32.24	<0.0001
Log_{10} (SC)	1.28	0.02	75.64	<0.0001

Correlation matrix of coefficients:

	Intercept	$\log_{10}$ (SC)
Intercept	1	
Log_{10} (SC)	-0.994	1

Duan's bias correction factor **= 1.01**

Chloride at Menomonee River at 16th Street at Milwaukee, Wisconsin, November 2008–September 2011

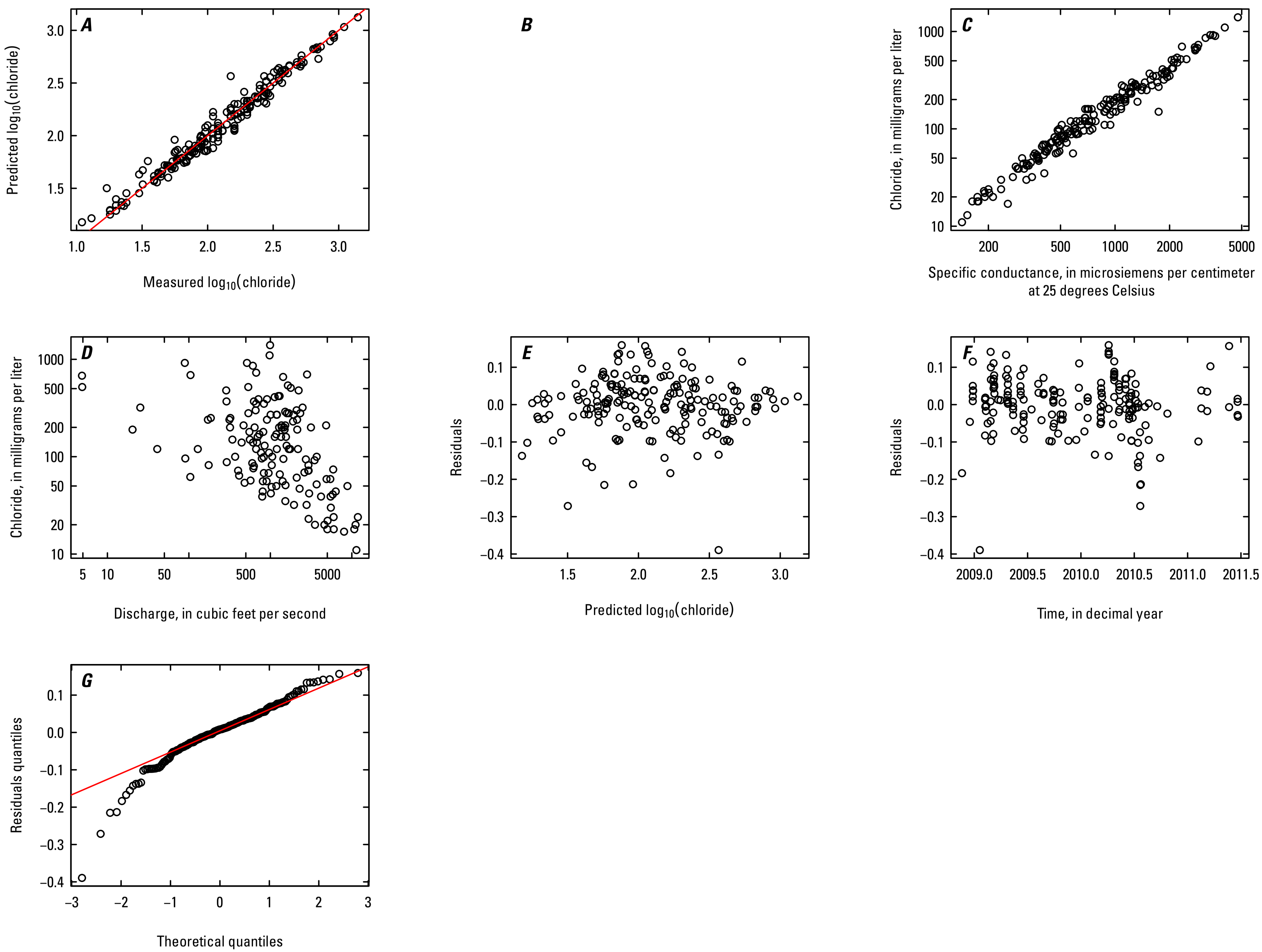

Figure 3.5. *A*, Relation between measured and predicted $\log_{10}$(chloride concentration); *B*, No plot because only one explanatory variable used in model; *C*, Relation between specific conductance and chloride concentration in $\log_{10}$ space; *D*, Relation between discharge and chloride concentration in $\log_{10}$ space; *E*, Relation between predicted $\log_{10}$(chloride concentration) and regression residuals; *F*, Relation between time and chloride regression residuals; *G*, Probability plot of chloride regression residuals; U.S. Geological Survey streamgage on Menomonee River at 16th Street at Milwaukee, Wisconsin, November 2008–September 2011.

Chloride at Underwood Creek at Wauwatosa, WI (04087088)

MODEL SUMMARY—Summary of final regression results for estimating chloride concentrations at Underwood Creek at Wauwatosa, WI.

$$\text{Log}_{10}\text{(Chloride)} = -1.49 + 1.25\ \log_{10}\text{(SC)}$$

Where:

Chloride = Chloride concentration in mg/L

SC = Specific Conductance in µS/cm at 25° C

Model Information (in log units unless otherwise specified):

Number of measurements = 187,
Root-mean-squared error (RMSE) = 0.14
Model standard percentage error (MPSE) = +39 and -28 percent
90-percent prediction intervals (based on units in mg/L) = +/- 61 percent
Adjusted coefficient of determination (Adj R^2) = 0.86
Sum of squared error = 3.85
PRESS = 3.92

Coefficients:

	Coefficient	Standard error	t statistic	p-value
Intercept	-1.49	0.11	-13.70	<0.0001
Log_{10} (SC)	1.25	0.04	33.62	<0.0001

Correlation matrix of coefficients:

	Intercept	$\log_{10}$ (SC)
Intercept	1	
Log_{10} (SC)	-0.995	1

Duan’s bias correction factor **= 1.0**5

Chloride at Underwood Creek at Wauwatosa, Wisconsin, February 2010–December 2011

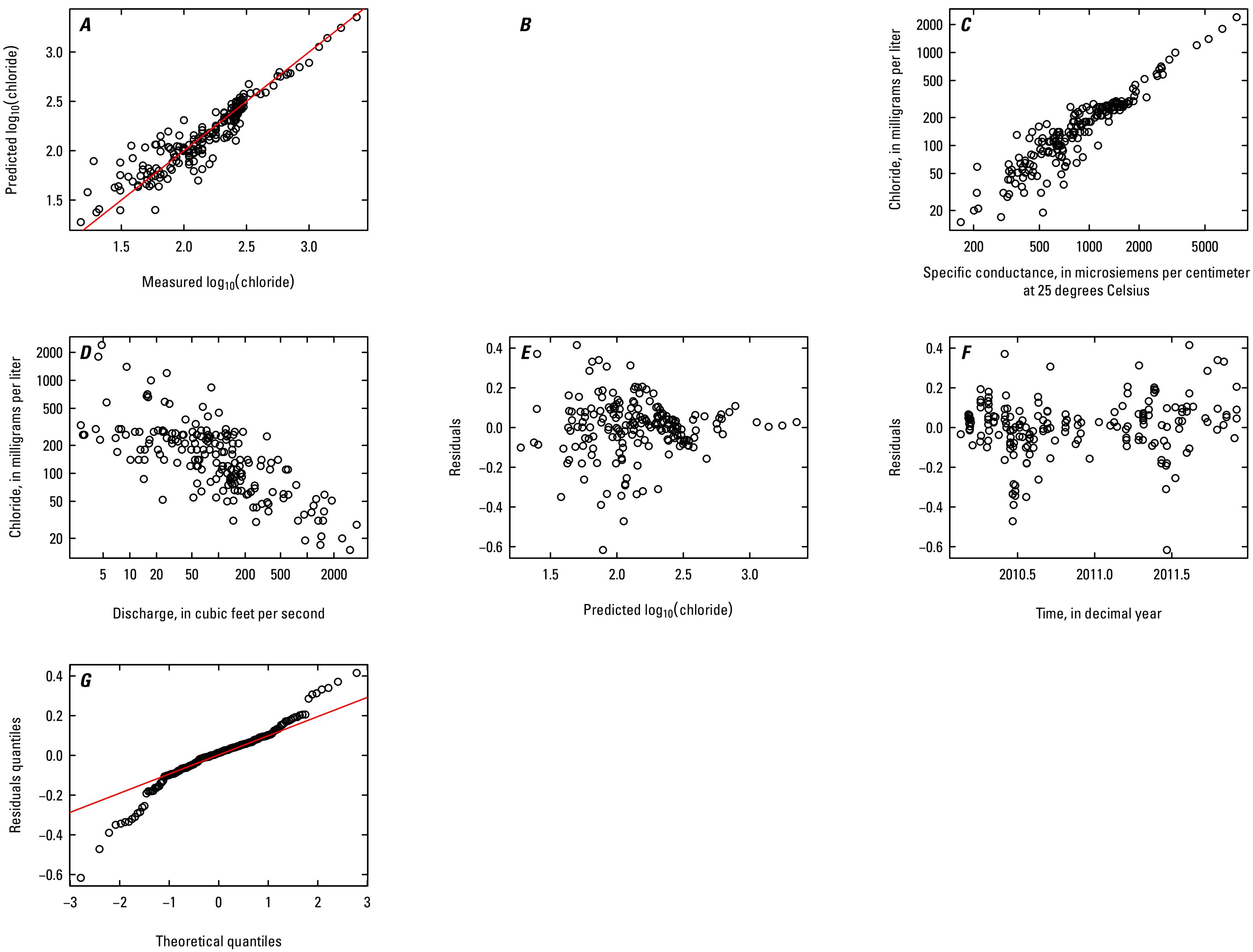

Figure 3.6. *A*, Relation between measured and predicted $\log_{10}$(chloride concentration); *B*, No plot because only one explanatory variable used in model; *C*, Relation between specific conductance and chloride concentration in $\log_{10}$ space; *D*, Relation between discharge and chloride concentration in $\log_{10}$ space; *E*, Relation between predicted $\log_{10}$(chloride concentration) and regression residuals; *F*, Relation between time and chloride regression residuals; *G*, Probability plot of chloride regression residuals; U.S. Geological Survey streamgage on Underwood Creek at Wauwatosa, Wisconsin, February 2010–December 2011.

Appendix 4. Regression Analysis Results for Estimating Total Suspended Solids Concentration

All data were collected using USGS protocols and are stored in the USGS National Water Information System (NWIS) database (*http://waterdata.usgs.gov/nwis*). The regression models are based on measurements of turbidity and concurrent total suspended solids samples collected from November 2008 to September 2011. Continuous water-quality data were collected at 5-minute intervals using a YSI model 6920 V2 multiparameter water-quality monitor with a 6560 specific conductance and water temperature sensor and a 6136 optical turbidity sensor. Turbidity values are instantaneous unit values temporally corresponding to the collection of the total suspended solids samples. Samples were collected throughout the range of continuously observed hydrologic conditions. Summary statistics and the complete model calibration dataset are provided. A comparison of cross-section mean and corresponding time-series monitor readings is archived at the Wisconsin Water Science Center and is available by request to the District Chief (dc_wi@usgs.gov).

Total Suspended Solids at Little Menomonee River near Freistadt, WI (04087050)

Samples collected on 2/26/2009 were not used in the regression analysis. From inspection of the scatter plots, these samples appear to be outliers.

MODEL SUMMARY—Summary of final regression results for estimating total suspended solids concentrations at Little Menomonee River near Freistadt, WI.

$$\text{Log}_{10}\,(\text{Suspended Solids}) = 0.27 + 0.96\,\log_{10}\,(\text{Turb}),$$

Where:

Suspended Solids = Total suspended solids concentration in mg/L

Turb = Turbidity (YSI 6136), in FNU

Model Information (in log units unless otherwise specified):

Number of measurements = 116,
Root-mean-squared error (RMSE) = 0.20
Model standard percentage error (MPSE) = +59 and -37 percent
90-percent prediction intervals (based on units in mg/L) = +/- 94 percent
Adjusted coefficient of determination (Adj R^2) = 0.90
Sum of squared error = 4.57
PRESS = 4.82

Coefficients:

	Coefficient	Standard error	t statistic	p-value
Intercept	0.27	0.05	5.82	<0.001
Log_{10} (Turb)	0.96	0.03	32.66	<0.001

Correlation matrix of coefficients:

	Intercept	$\log_{10}$(Turb)
Intercept	1	
Log_{10} (Turb)	-0.918	1

Duan's bias correction factor **= 1.11**

Total suspended solids at Little Menomonee River near Freistadt, Wisconsin, November 2008–September 2011

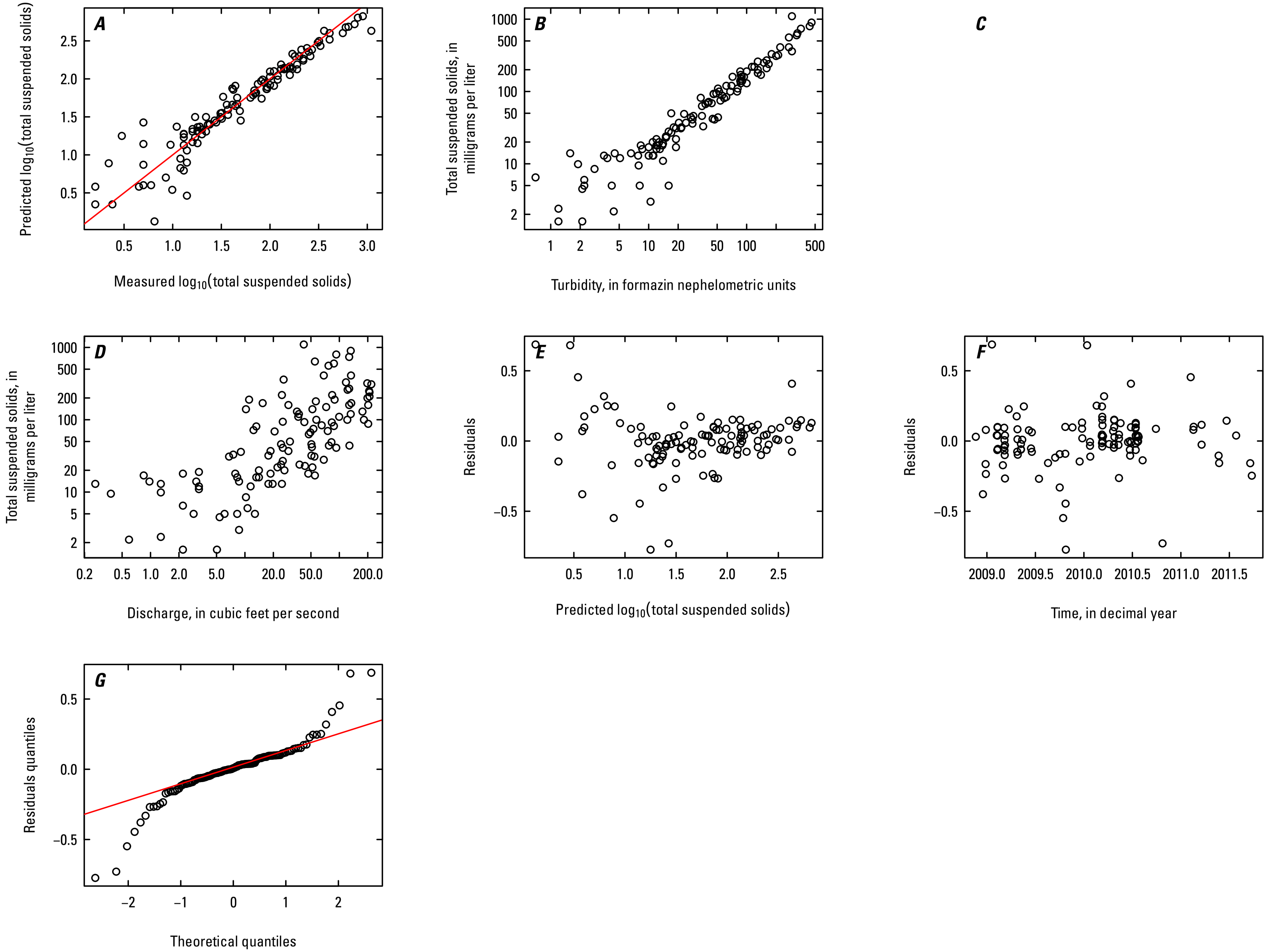

Figure 4.1. *A*, Relation between measured and predicted $\log_{10}$(total suspended solids concentration); *B*, Relation between turbidity and total suspended solids concentration in $\log_{10}$ space; *C*, No plot because only one explanatory variable used in model; *D*, Relation between discharge and total suspended solids concentration in $\log_{10}$ space; *E*, Relation between predicted $\log_{10}$(total suspended solids concentration) and regression residuals; *F*, Relation between time and total suspended solids regression residuals; *G*, Probability plot of total suspended solids regression residuals; U.S. Geological Survey streamgage on Little Menomonee River near Freistadt, Wisconsin, November 2008–September 2011.

Total Suspended Solids at Menomonee River at Menomonee Falls, WI (04087030)

MODEL SUMMARY—Summary of final regression results for estimating total suspended solids concentrations at Menomonee River at Menomonee Falls, WI.

$$\text{Log}_{10}\,(\text{Suspended Solids}) = 0.13 + 1.04\,\log_{10}\,(\text{Turb}),$$

Where:

Suspended Solids = Total suspended solids concentration in mg/L

Turb = Turbidity (YSI 6136), in FNU

Model Information (in log units unless otherwise specified):

Number of measurements = 148,
Root-mean-squared error (RMSE) = 0.18
Model standard percentage error (MPSE) = +52 and -34 percent
90-percent prediction intervals (based on units in mg/L) = +/- 84 percent
Adjusted coefficient of determination (Adj R^2) = 0.91
Sum of squared error = 4.89
PRESS = 5.08

Coefficients:

	Coefficient	Standard error	t statistic	p-value
Intercept	0.13	0.04	3.19	0.0018
Log_{10} (Turb)	1.04	0.03	39.65	<0.0001

Correlation matrix of coefficients:

	Intercept	$\log_{10}$(Turb)
Intercept	1	
Log_{10} (Turb)	-0.931	1

Duan’s bias correction factor **= 1.11**

Total suspended solids at Menomonee River at Menomonee Falls, Wisconsin, November 2008–September 2011

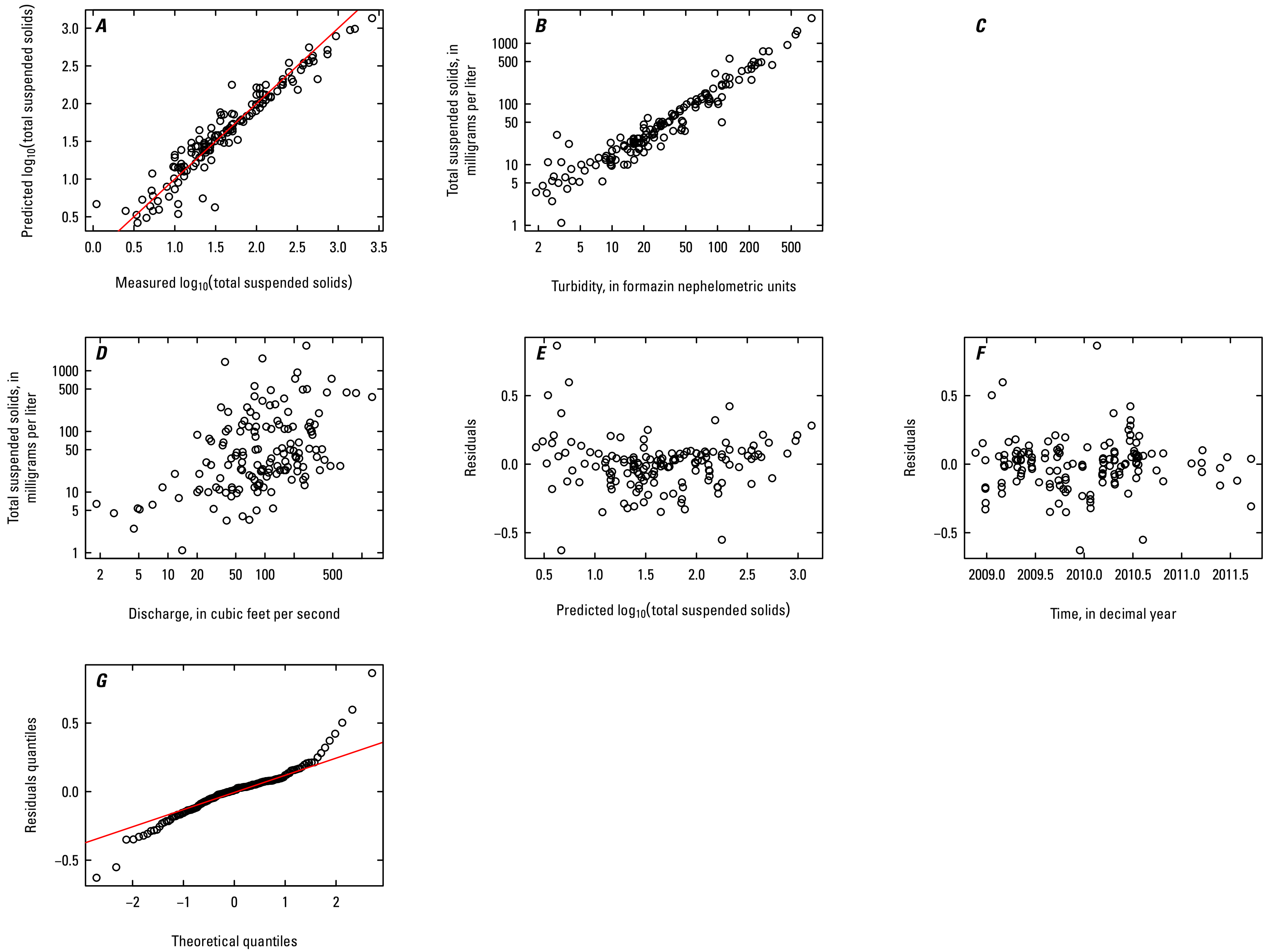

Figure 4.2. *A*, Relation between measured and predicted $\log_{10}$(total suspended solids concentration); *B*, Relation between turbidity and total suspended solids concentration in $\log_{10}$ space; *C*, No plot because only one explanatory variable used in model; *D*, Relation between discharge and total suspended solids concentration in $\log_{10}$ space; *E*, Relation between predicted $\log_{10}$(total suspended solids concentration) and regression residuals; *F*, Relation between time and total suspended solids regression residuals; *G*, Probability plot of total suspended solids regression residuals; U.S. Geological Survey streamgage on Menomonee River at Menomonee Falls, Wisconsin, November 2008–September 2011.

Total Suspended Solids at Honey Creek at Wauwatosa, WI (04087119)

MODEL SUMMARY—Summary of final regression results for estimating total suspended solids concentrations at Honey Creek at Wauwatosa, WI.

$$\text{Log}_{10}\text{ (Suspended Solids)} = 0.03 + 1.05 \log_{10}\text{ (Turb)},$$

Where:

Suspended solids = Total suspended solids concentration in mg/L

Turb = Turbidity (YSI 6136), in FNU

Model Information (in log units unless otherwise specified):

Number of measurements = 221,
Root-mean-squared error (RMSE) = 0.28
Model standard percentage error (MSPE) = +88 and -47 percent
90-percent prediction intervals (based on units in mg/L) = +/- 149 percent
Adjusted coefficient of determination (Adj R^2) = 0.83
Sum of squared error = 16.7
PRESS = 17.01

Coefficients:

	Coefficient	**Standard error**	**t statistic**	**p-value**
Intercept	0.03	0.06	0.51	0.611
Log_{10} (Turb)	1.05	0.03	32.58	<0.0001

Correlation matrix of coefficients:

	Intercept	$\log_{10}$ (Turb)
Intercept	1	
Log_{10} (Turb)	-0.95	1

Duan's bias correction factor **= 1.20**

Total suspended solids at Honey Creek at Wauwatosa, Wisconsin, November 2008–September 2011

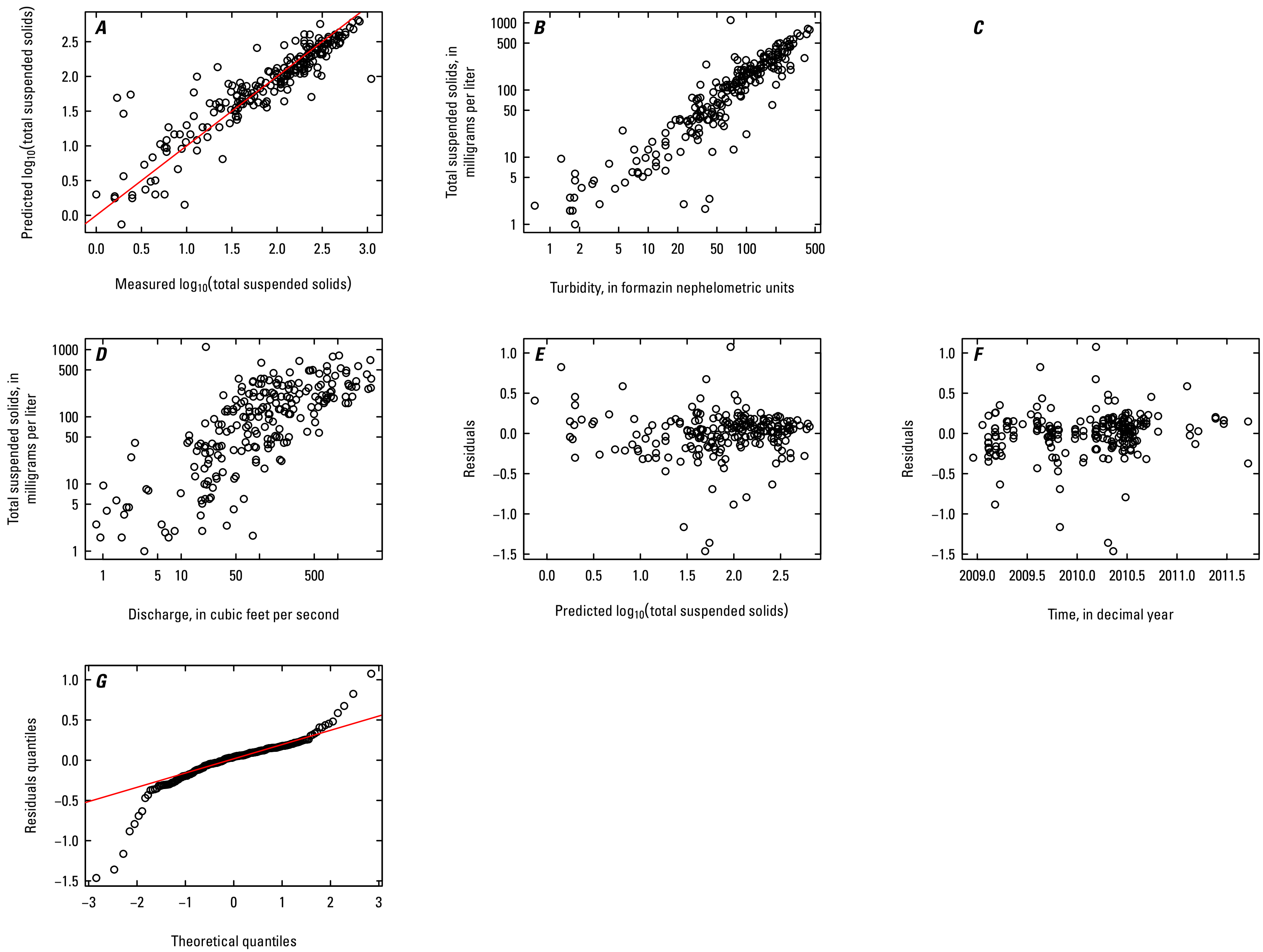

Figure 4.3. *A*, Relation between measured and predicted $\log_{10}$(total suspended solids concentration); *B*, Relation between turbidity and total suspended solids concentration in $\log_{10}$ space; *C*, No plot because only one explanatory variable used in model; *D*, Relation between discharge and total suspended solids concentration in $\log_{10}$ space; *E*, Relation between predicted $\log_{10}$(total suspended solids concentration) and regression residuals; *F*, Relation between time and total suspended solids regression residuals; *G*, Probability plot of total suspended solids regression residuals; U.S. Geological Survey streamgage on Honey Creek at Wauwatosa, Wisconsin, November 2008–September 2011.

Total Suspended Solids at Menomonee River at Wauwatosa, WI (04087120)

MODEL SUMMARY—Summary of final regression results for estimating total suspended solids concentrations at Menomonee River at Wauwatosa, WI.

$$\text{Log}_{10}\,(\text{Suspended Solids}) = 0.30 + 0.92\,\log_{10}\,(\text{Turb}),$$

Where:

Suspended Solids = Total suspended solids concentration in mg/L

Turb = Turbidity (YSI 6136), in FNU

Model Information (in log units unless otherwise specified):

Number of measurements = 202,
Root-mean-squared error (RMSE) = 0.25
Model standard percentage error (MSPE) = +78 and -44 percent
90-percent prediction intervals (based on units in mg/L) = +/- 128 percent
Adjusted coefficient of determination (Adj R^2) = 0.77
Sum of squared error = 12.5
PRESS = 12.9

Coefficients:

	Coefficient	**Standard error**	**t statistic**	**p-value**
Intercept	0.30	0.06	4.87	<0.0001
Log_{10} (Turb)	0.92	0.04	25.61	<0.0001

Correlation matrix of coefficients:

	Intercept	**$\log_{10}$ (Turb)**
Intercept	1	
Log_{10} (Turb)	-0.958	1

Duan’s bias correction factor **= 1.17**

Total suspended solids at Menomonee River at Wauwatosa, Wisconsin, November 2008–September 2011

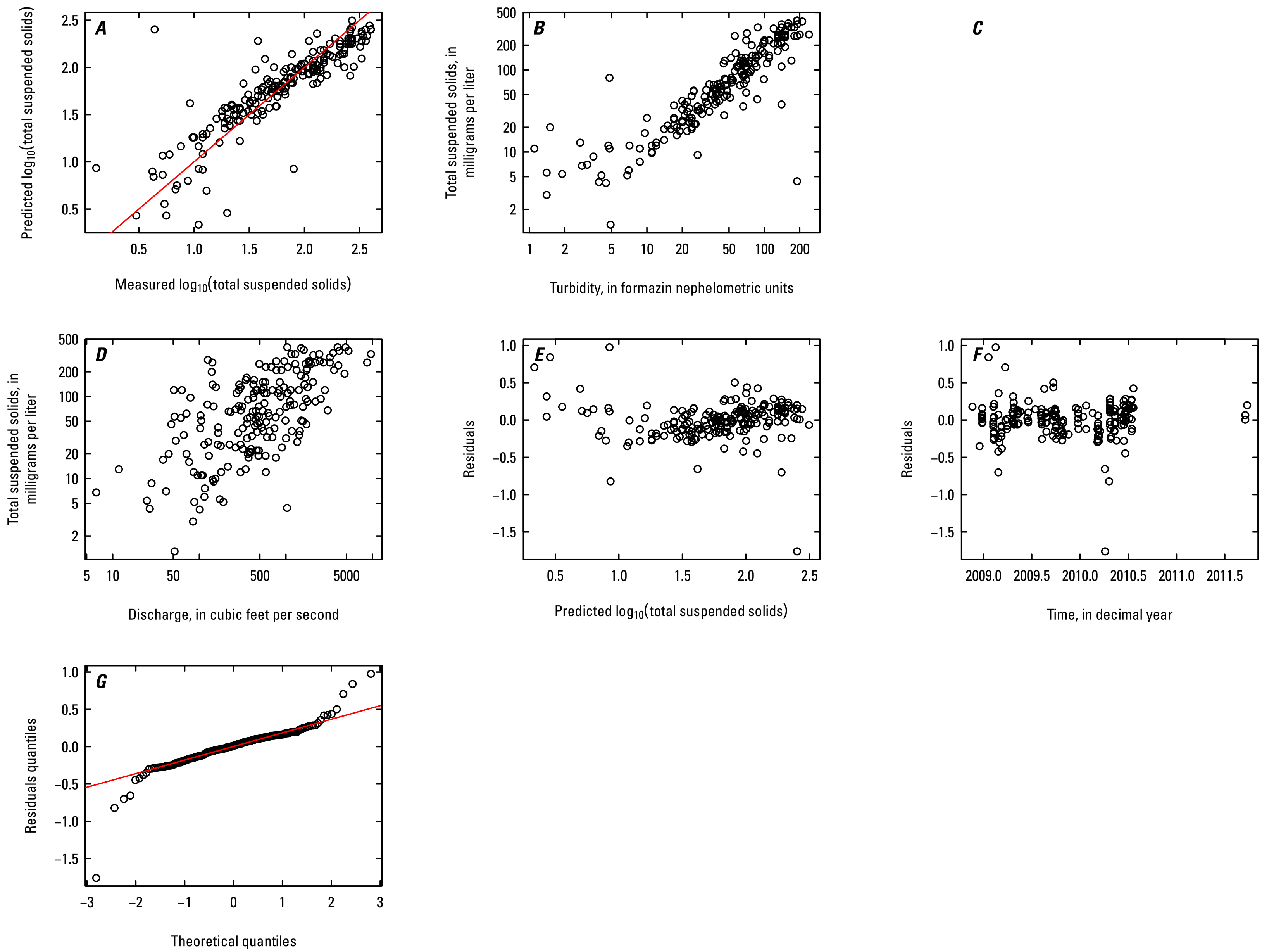

Figure 4.4. *A*, Relation between measured and predicted $\log_{10}$(total suspended solids concentration); *B*, Relation between turbidity and total suspended solids concentration in $\log_{10}$ space; *C*, No plot because only one explanatory variable used in model; *D*, Relation between discharge and total suspended solids concentration in $\log_{10}$ space; *E*, Relation between predicted $\log_{10}$(total suspended solids concentration) and regression residuals; *F*, Relation between time and total suspended solids regression residuals; *G*, Probability plot of total suspended solids regression residuals; U.S. Geological Survey streamgage on Menomonee River at Wauwatosa, Wisconsin, November 2008–September 2011.

Total Suspended Solids at Menomonee River at 16th Street at Milwaukee, WI (04087142)

MODEL SUMMARY—Summary of final regression results for estimating total suspended solids concentrations at Menomonee River at 16th Street at Milwaukee, WI.

$$\text{Log}_{10}\,(\text{Suspended Solids}) = 0.10 + 0.97\,\log_{10}\,(\text{Turb}),$$

Where:

Suspended Solids = Total suspended solids concentration in mg/L

Turb = Turbidity (YSI 6136), in FNU

Model Information (in log units unless otherwise specified):

Number of measurements = 189,
Root-mean-squared error (RMSE) = 0.23
Model standard percentage error (MPSE) = +70 and -41 percent
90-percent prediction intervals (based on units in mg/L) = +/- 117 percent
Adjusted coefficient of determination (Adj R^2) = 0.82
Sum of squared error = 10.0
PRESS = 10.3

Coefficients:

	Coefficient	Standard error	t statistic	p-value
Intercept	0.10	0.05	1.90	0.0590
Log $_{10}$ (Turb)	0.97	0.03	29.17	<0.0001

Correlation matrix of coefficients:

	Intercept	log$_{10}$ (Turb)
Intercept	1	
Log$_{10}$ (Turb)	-0.951	1

Duan's bias correction factor **= 1.17**

Total suspended solids at Menomonee River at 16th Street at Milwaukee, Wisconsin, November 2008–September 2011

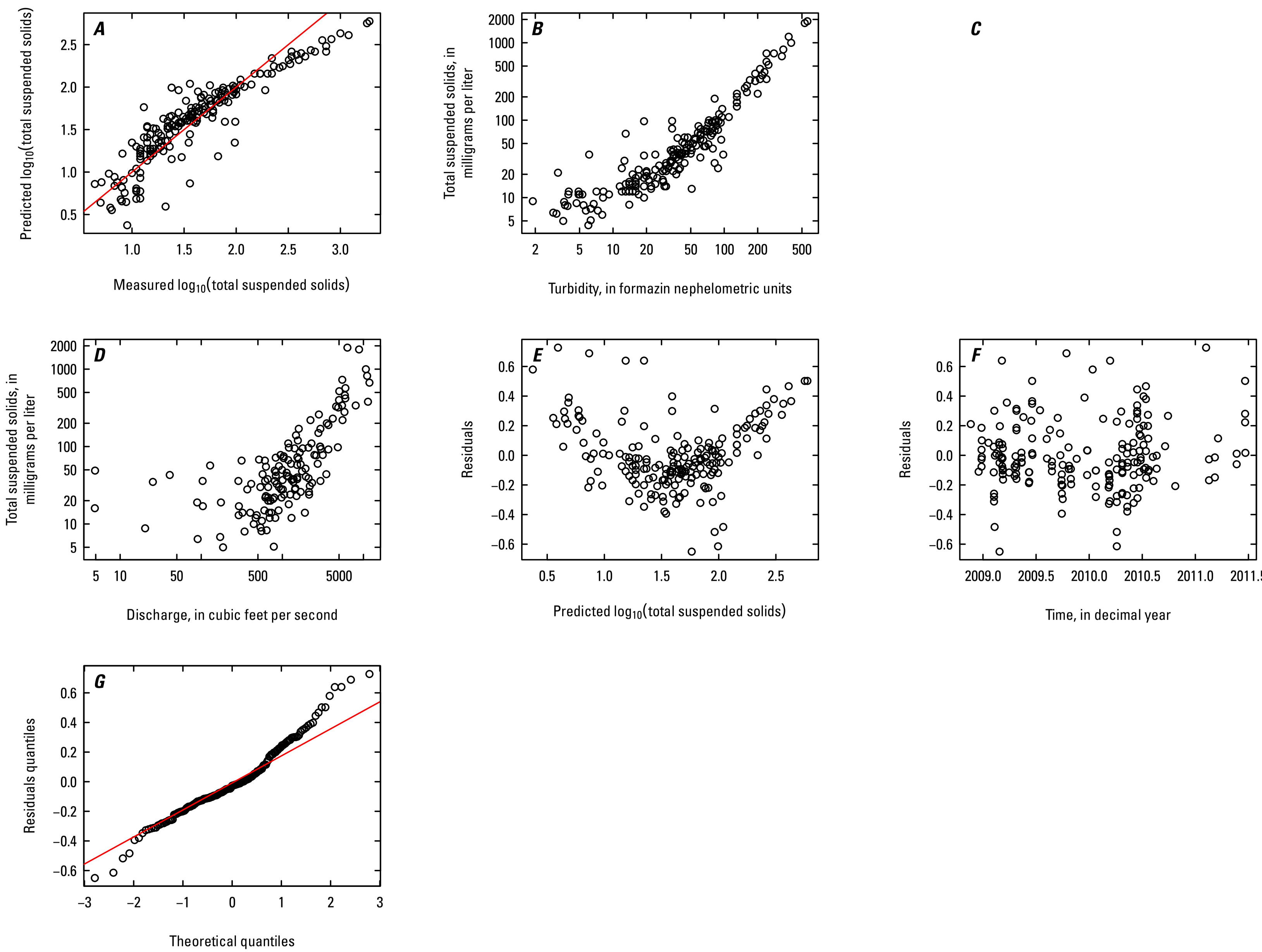

Figure 4.5. *A*, Relation between measured and predicted log_{10}(total suspended solids concentration); *B*, Relation between turbidity and total suspended solids concentration in log_{10} space; *C*, No plot because only one explanatory variable used in model; *D*, Relation between discharge and total suspended solids concentration in log_{10} space; *E*, Relation between predicted log_{10}(total suspended solids concentration) and regression residuals; *F*, Relation between time and total suspended solids regression residuals; *G*, Probability plot of total suspended solids regression residuals; U.S. Geological Survey streamgage on Menomonee River at 16th Street at Milwaukee, Wisconsin, November 2008–September 2011.

Total Suspended Solids at Underwood Creek at Wauwatosa, WI (04087088)

MODEL SUMMARY—Summary of final regression results for estimating total suspended solids concentrations at Underwood Creek at Wauwatosa, WI.

$$Log_{10}(TSS) = 0.41 + 0.91 \log_{10}(Turb)$$

Where:

TSS = Total suspended solids concentration in mg/L

Turb = turbidity, in nephelometric turbidity units

Model Information (in log units unless otherwise specified):

Number of measurements = 184,
Root-mean-squared error (RMSE) = 0.31
Model standard percentage error (MPSE) = +106 and -52 percent
90-percent prediction intervals (based on units in mg/L) = +/- 193 percent
Adjusted coefficient of determination (Adj R^2) = 0.71
Sum of squared error = 18.0
PRESS = 18.5

Coefficients:

	Coefficient	Standard error	t statistic	p-value
Intercept	0.41	0.07	5.58	<0.0001
Log_{10} (Turb)	0.91	0.04	21.20	<0.0001

Correlation matrix of coefficients:

	Intercept	log_{10}(Turb)
Intercept	1	
Log_{10} (Turb)	-0.948	1

Duan's bias correction factor **= 1.29**

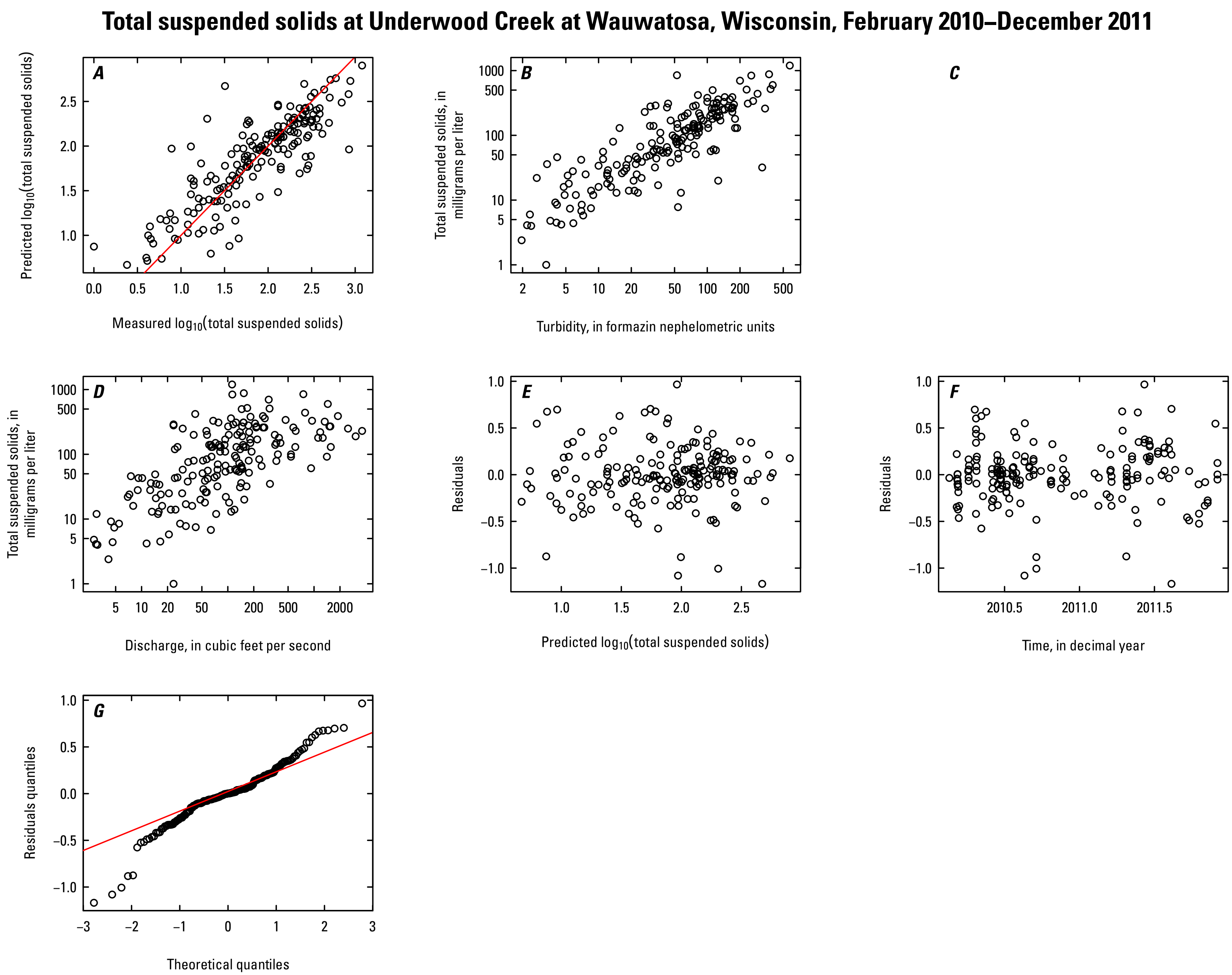

Figure 4.6. *A*, Relation between measured and predicted log_{10}(total suspended solids concentration); *B*, Relation between turbidity and total suspended solids concentration in log_{10} space; *C*, No plot because only one explanatory variable used in model; *D*, Relation between discharge and total suspended solids concentration in log_{10} space; *E*, Relation between predicted log_{10}(total suspended solids concentration) and regression residuals; *F*, Relation between time and total suspended solids regression residuals; *G*, Probability plot of total suspended solids regression residuals; U.S. Geological Survey streamgage on Underwood Creek at Wauwatosa, Wisconsin, February 2010–December 2011.

Appendix 5. Regression Analysis Results for Estimating Total Phosphorus Concentration

All data were collected using USGS protocols and are stored in the USGS National Water Information System (NWIS) database (*http://waterdata.usgs.gov/nwis*). The regression models are based on measurements of turbidity and concurrent total phosphorus samples collected from November 2008 to September 2011. Continuous water-quality data were collected at 5-minute intervals using a YSI model 6920 V2 multiparameter water-quality monitor with a 6560 specific conductance and water temperature sensor and a 6136 optical turbidity sensor. Turbidity values are instantaneous unit values temporally corresponding to the collection of the total phosphorus samples. Samples were collected throughout the range of continuously observed hydrologic conditions. Summary statistics and the complete model calibration dataset are provided. A comparison of cross-section mean and corresponding time-series monitor readings is archived at the Wisconsin Water Science Center and is available by request to the District Chief (dc_wi@usgs.gov).

Total Phosphorus at Little Menomonee River near Freistadt, WI (04087050)

MODEL SUMMARY—Summary of final regression results for estimating total phosphorus concentrations at Little Menomonee River near Freistadt, WI.

$$\log_{10}(\text{Total Phosphorus}) = -1.51 + 0.57 \log_{10}(\text{Turb}),$$

Where:

Total Phosphorus = Total phosphorus concentration in mg/L

Turb = Turbidity, (YSI 6136), in FNU

Model Information (in log units unless otherwise specified):

Number of measurements = 116,
Root-mean-squared error (RMSE) = 0.17
Model standard percentage error (MPSE) = +47 and -32 percent
90-percent prediction intervals (based on units in mg/L) = +/- 75 percent
Adjusted coefficient of determination (Adj R^2) = 0.82
Sum of squared error = 3.20
PRESS = 3.41

Coefficients:

	Coefficient	Standard error	t statistic	p-value
Intercept	-1.51	0.04	-38.45	<0.0001
Log_{10} (Turb)	0.57	0.02	23.14	<0.0001

Correlation matrix of coefficients:

	Intercept	$\log_{10}$ (Turb)
Intercept	1.00	
Log_{10} (Turb)	-0.918	1.00

Duan's bias correction factor **= 1.10**

Total phosphorus at Little Menomonee River near Freistadt, Wisconsin, November 2008–September 2011

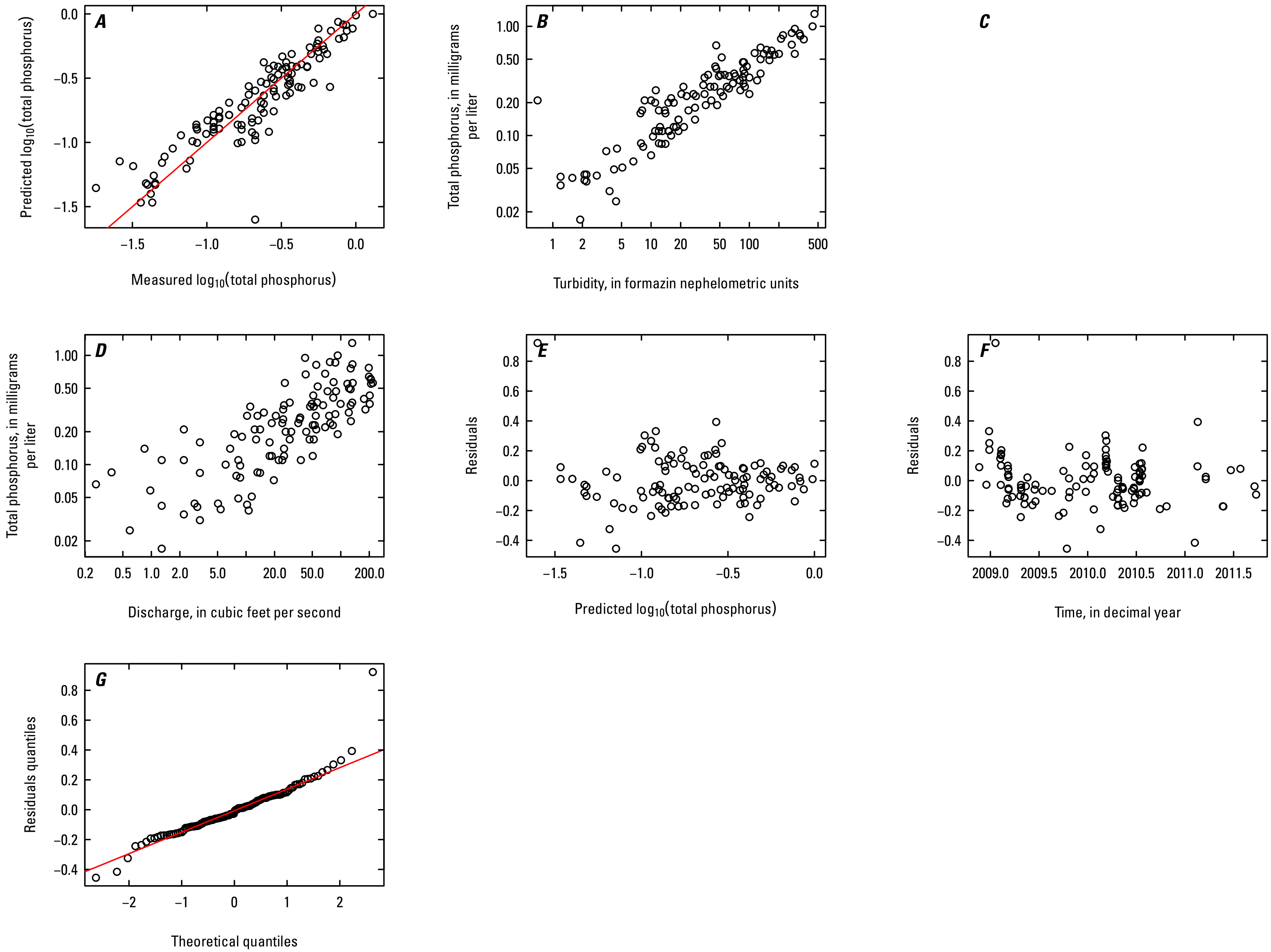

Figure 5.1. *A*, Relation between measured and predicted $\log_{10}$(total phosphorus concentration); *B*, Relation between turbidity and total phosphorus concentration in $\log_{10}$ space; *C*, No plot because only one explanatory variable used in model; *D*, Relation between discharge and total phosphorus concentration in $\log_{10}$ space; *E*, Relation between predicted $\log_{10}$(total phosphorus concentration) and regression residuals; *F*, Relation between time and total phosphorus regression residuals; *G*, Probability plot of total phosphorus regression residuals; U.S. Geological Survey streamgage on Little Menomonee River near Freistadt, Wisconsin, November 2008–September 2011.

Total Phosphorus at Menomonee River at Menomonee Falls, WI (04087030)

MODEL SUMMARY—Summary of final regression results for estimating total phosphorus concentrations at Menomonee River at Menomonee Falls, WI.

$$\text{Log}_{10}\text{ (Total Phosphorus)} = -1.65 + 0.56 \log_{10}\text{ (Turb)},$$

Where:

Total Phosphorus = Total phosphorus concentration in mg/L
Turb = Turbidity, (YSI 6136), in FNU

Model Information (in log units unless otherwise specified):

Number of measurements = 148,
Root-mean-squared error (RMSE) = 0.17
Model standard percentage error (MPSE) = +50 and -33 percent
90-percent prediction intervals (based on units in mg/L) = +/- 79 percent
Adjusted coefficient of determination (Adj R^2) = 0.77
Sum of squared error = 4.45
PRESS = 4.62

Coefficients:

	Coefficient	Standard error	t statistic	p-value
Intercept	-1.65	0.04	-42.21	<0.0001
Log $_{10}$ (Turb)	0.56	0.02	22.52	<0.0001

Correlation matrix of coefficients:

	Intercept	$\log_{10}$ (Turb)
Intercept	1	
Log_{10} (Turb)	-0.931	1

Duan's bias correction factor **= 1.10**

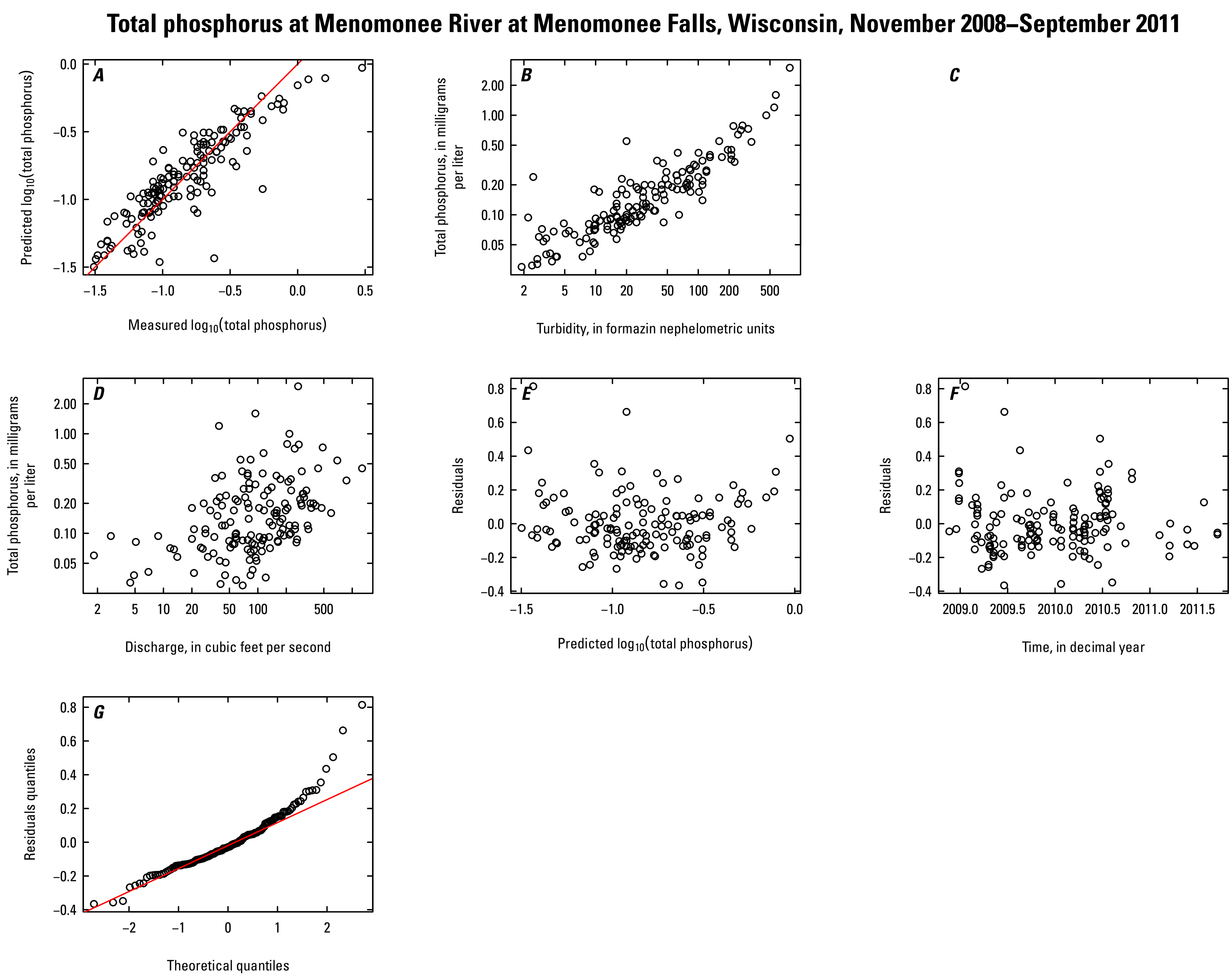

Figure 5.2. *A*, Relation between measured and predicted $\log_{10}$(total phosphorus concentration); *B*, Relation between turbidity and total phosphorus concentration in $\log_{10}$ space; *C*, No plot because only one explanatory variable used in model; *D*, Relation between discharge and total phosphorus concentration in $\log_{10}$ space; *E*, Relation between predicted $\log_{10}$(total phosphorus concentration) and regression residuals; *F*, Relation between time and total phosphorus regression residuals; *G*, Probability plot of total phosphorus regression residuals; U.S. Geological Survey streamgage on Menomonee River at Menomonee Falls, Wisconsin, November 2008–September 2011.

Total Phosphorus at Honey Creek at Wauwatosa, WI (04087119)

MODEL SUMMARY—Summary of final regression results for estimating total phosphorus concentrations at Honey Creek at Wauwatosa, WI.

$$\log_{10}(\text{Total Phosphorus}) = -1.50 + 0.48 \log_{10}(\text{Turb}),$$

Where:

Total Phosphorus = Total phosphorus concentration in mg/L
Turb = Turbidity, (YSI 6136), in FNU

Model Information (in log units unless otherwise specified):

Number of measurements = 221,
Root-mean-squared error (RMSE) = 0.18
Model standard percentage error (MPSE) = +52 and -34 percent
90-percent prediction intervals (based on units in mg/L) = +/- 82 percent
Adjusted coefficient of determination (Adj R^2) = 0.70
Sum of squared error = 7.26
PRESS = 7.42

Coefficients:

	Coefficient	**Standard error**	**t statistic**	**p-value**
Intercept	-1.50	0.04	-38.45	<0.0001
$\log_{10}$ (Turb)	0.48	0.02	22.51	<0.0001

Correlation matrix of coefficients:

	Intercept	**$\log_{10}$ (Turb)**
Intercept	1.00	
$\log_{10}$ (Turb)	-0.950	1.00

Duan's bias correction factor **= 1.10**

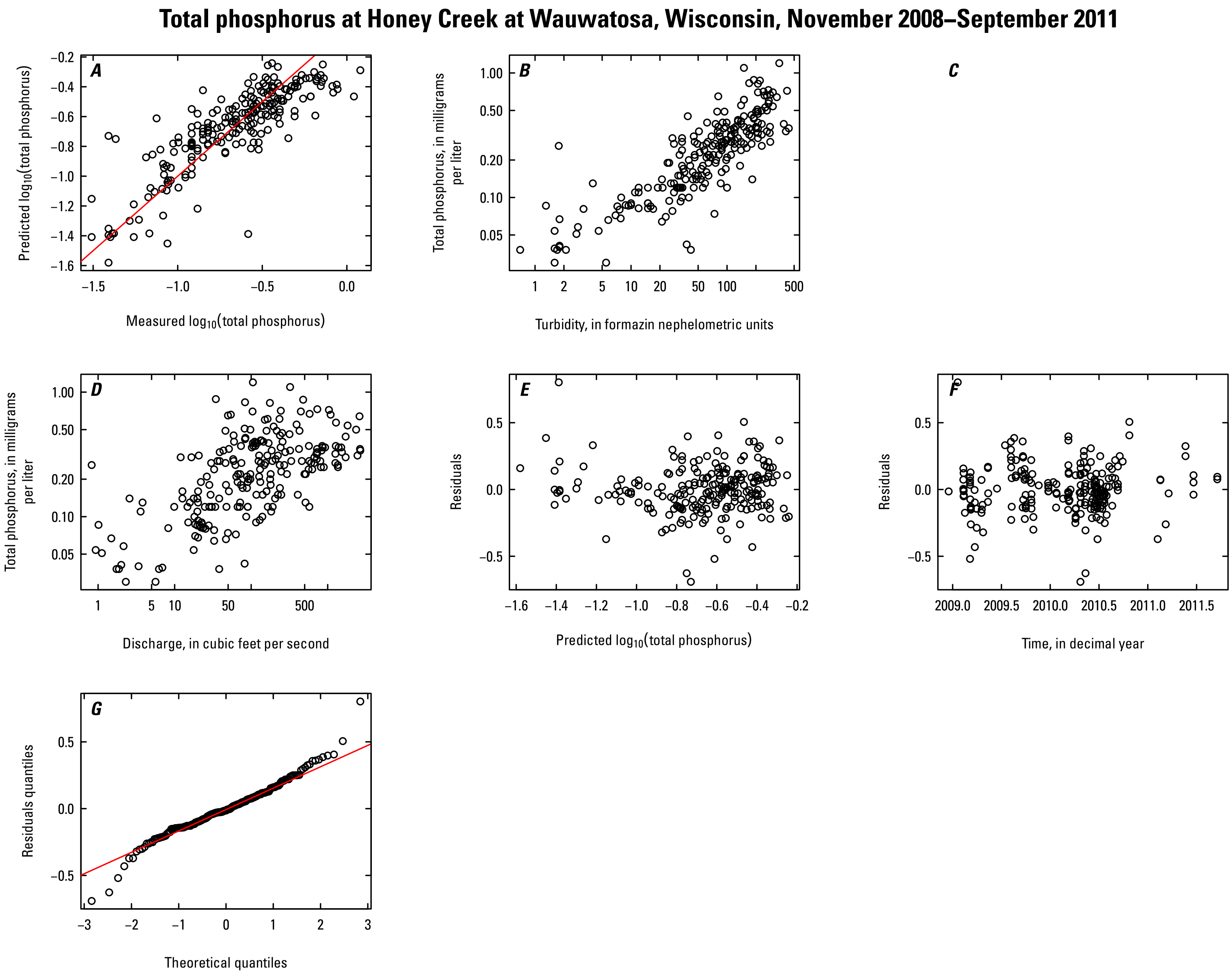

Figure 5.3. *A*, Relation between measured and predicted $\log_{10}$(total phosphorus concentration); *B*, Relation between turbidity and total phosphorus concentration in $\log_{10}$ space; *C*, No plot because only one explanatory variable used in model; *D*, Relation between discharge and total phosphorus concentration in $\log_{10}$ space; *E*, Relation between predicted $\log_{10}$(total phosphorus concentration) and regression residuals; *F*, Relation between time and total phosphorus regression residuals; *G*, Probability plot of total phosphorus regression residuals; U.S. Geological Survey streamgage on Honey Creek at Wauwatosa, Wisconsin, November 2008–September 2011.

Total Phosphorus at Menomonee River at Wauwatosa, WI (04087120)

MODEL SUMMARY—Summary of final regression results for estimating total phosphorus concentrations at Menomonee River at Wauwatosa, WI.

$$\text{Log}_{10}\ (\text{Total Phosphorus}) = -1.56 + 0.49\ \log_{10}\ (\text{Turb}),$$

Where:

Total Phosphorus = Total phosphorus concentration in mg/L

Turb = Turbidity, (YSI 6136), in FNU

Model Information (in log units unless otherwise specified):

Number of measurements = 198,
Root-mean-squared error (RMSE) = 0.19
Model standard percentage error (MPSE) = +54 and -35 percent
90-percent prediction intervals (based on units in mg/L) = +/- 85 percent
Adjusted coefficient of determination (Adj R^2) = 0.62
Sum of squared error = 6.92
PRESS = 7.14

Coefficients:

	Coefficient	**Standard error**	**t statistic**	**p-value**
Intercept	-1.56	0.05	-33.87	<0.0001
Log_{10} (Turb)	0.49	0.03	18.07	<0.0001

Correlation matrix of coefficients:

	Intercept	**$\log_{10}$ (Turb)**
Intercept	1	
Log_{10} (Turb)	-0.957	1

Duan's bias correction factor **= 1.10**

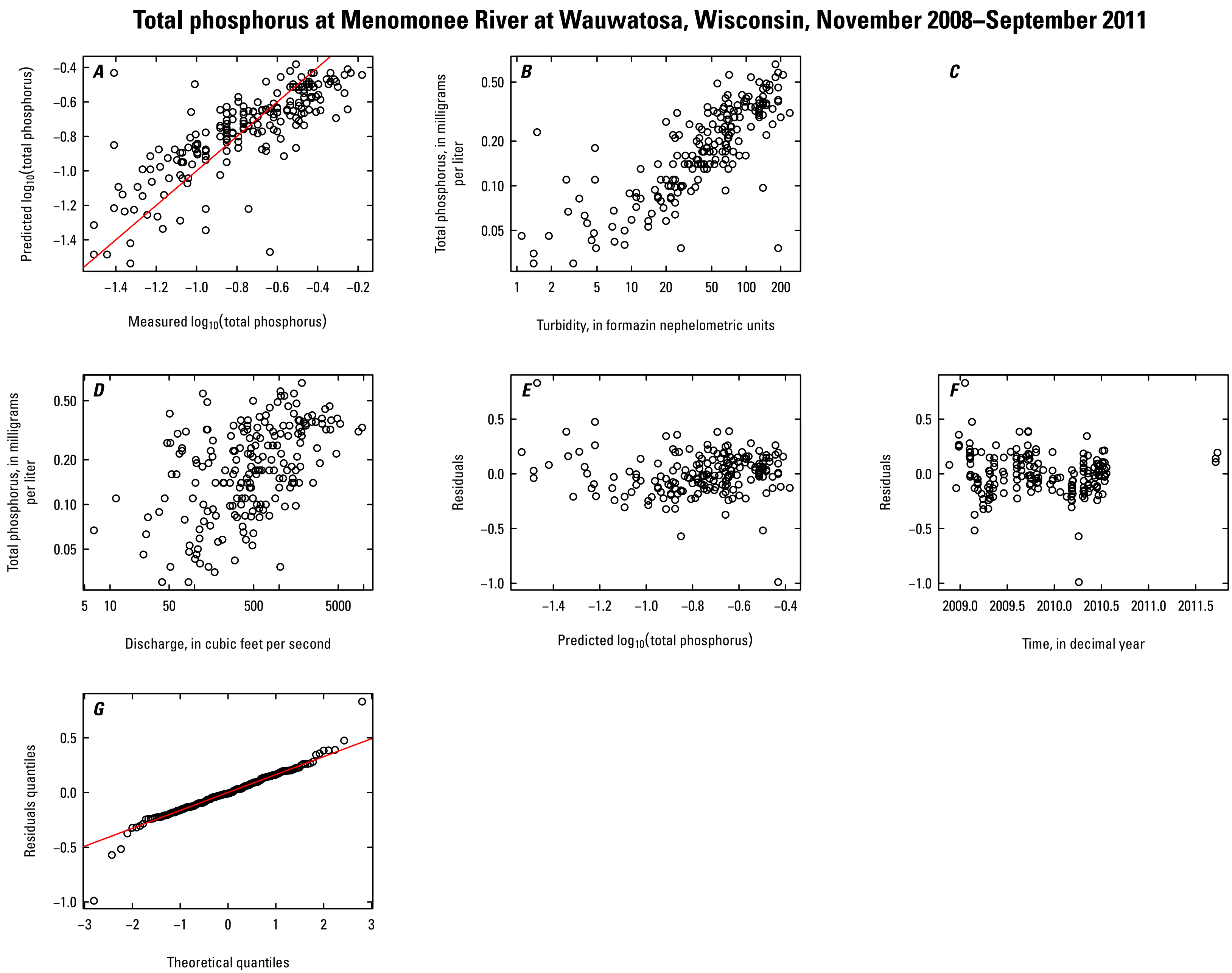

Figure 5.4. *A*, Relation between measured and predicted $\log_{10}$(total phosphorus concentration); *B*, Relation between turbidity and total phosphorus concentration in $\log_{10}$ space; *C*, No plot because only one explanatory variable used in model; *D*, Relation between discharge and total phosphorus concentration in $\log_{10}$ space; *E*, Relation between predicted $\log_{10}$(total phosphorus concentration) and regression residuals; *F*, Relation between time and total phosphorus regression residuals; *G*, Probability plot of total phosphorus regression residuals; U.S. Geological Survey streamgage on Menomonee River at Wauwatosa, Wisconsin, November 2008–September 2011.

Total Phosphorus at Menomonee River at 16th Street at Milwaukee, WI (04087142)

MODEL SUMMARY—Summary of final regression results for estimating total phosphorus concentrations at Menomonee River at 16th Street at Milwaukee, WI.

$$\text{Log}_{10}\text{ (Total Phosphorus)} = -1.55 + 0.47 \log_{10}\text{ (Turb)},$$

Where:

Total Phosphorus = Total phosphorus concentration in mg/L
Turb = Turbidity, (YSI 6136), in FNU

Model Information (in log units unless otherwise specified):

Number of measurements = 187,
Root-mean-squared error (RMSE) = 0.18
Model standard percentage error (MPSE) = +51 and -34 percent
90-percent prediction intervals (based on units in mg/L) = +/- 81 percent
Adjusted coefficient of determination (Adj R^2) = 0.64
Sum of squared error = 5.99
PRESS = 6.18

Coefficients:

	Coefficient	**Standard error**	**t statistic**	**p-value**
Intercept	-1.55	0.04	-36.56	<0.0001
Log_{10} (Turb)	0.47	0.03	18.17	<0.0001

Correlation matrix of coefficients:

	Intercept	**$\log_{10}$ (Turb)**
Intercept	1	
Log_{10} (Turb)	-0.951	1

Duan's bias correction factor **= 1.10**

Total phosphorus at Menomonee River at 16th Street at Milwaukee, Wisconsin, November 2008–September 2011

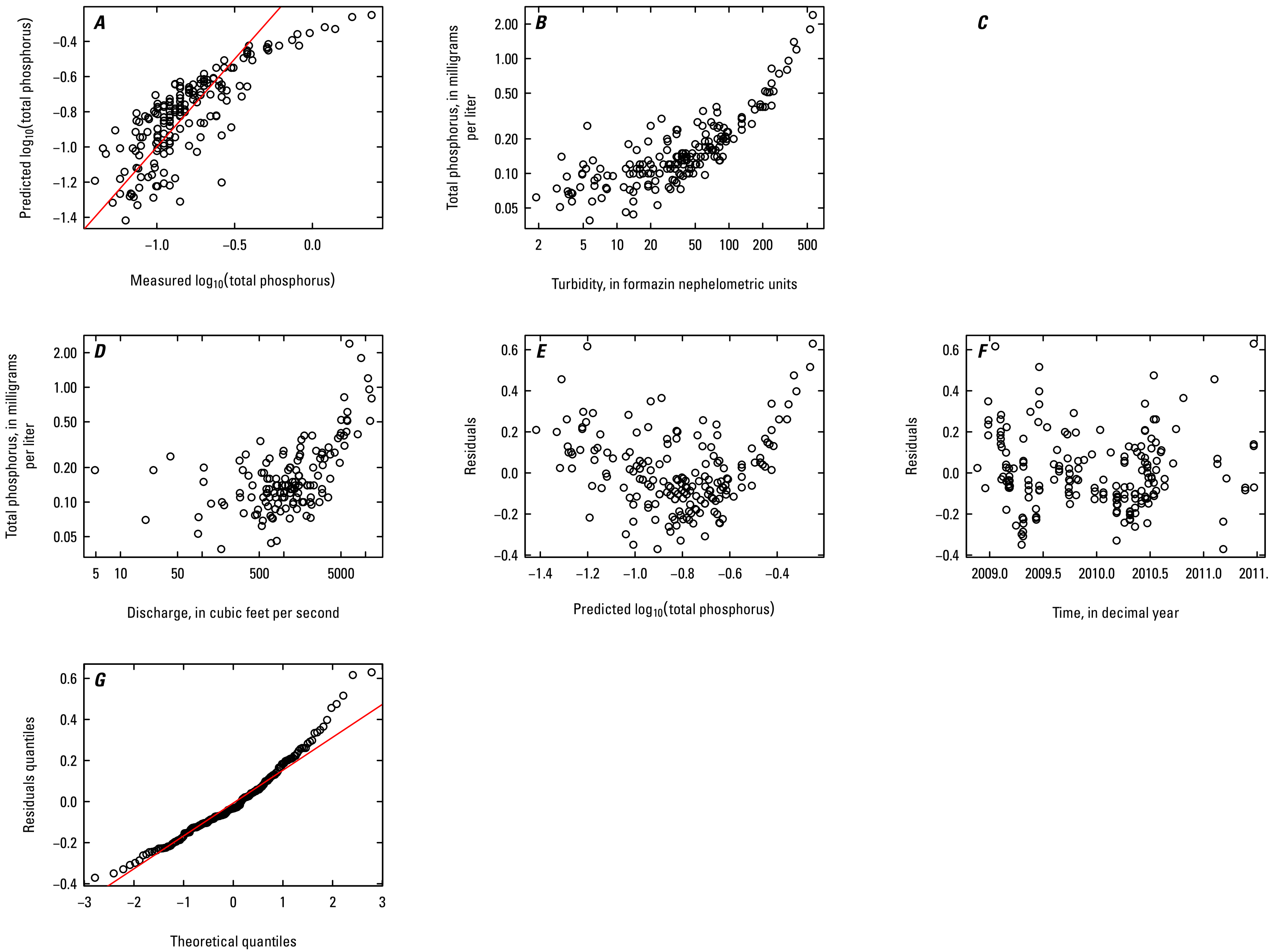

Figure 5.5. *A*, Relation between measured and predicted $\log_{10}$(total phosphorus concentration); *B*, Relation between turbidity and total phosphorus concentration in $\log_{10}$ space; *C*, No plot because only one explanatory variable used in model; *D*, Relation between discharge and total phosphorus concentration in $\log_{10}$ space; *E*, Relation between predicted $\log_{10}$(total phosphorus concentration) and regression residuals; *F*, Relation between time and total phosphorus regression residuals; *G*, Probability plot of total phosphorus regression residuals; U.S. Geological Survey streamgage on Menomonee River at 16th Street at Milwaukee, Wisconsin, November 2008–September 2011.

Total Phosphorus at Underwood Creek at Wauwatosa, WI (04087088)

MODEL SUMMARY—Summary of final regression results for estimating total phosphorus concentrations at Underwood Creek at Wauwatosa, WI.

$$\text{Log}_{10}\text{ (TP)} = -1.56 + 0.53 \log_{10}\text{ (Turb)}$$

Where:

TP = Total phosphorus concentration in mg/L
Turb = Turbidity, in nephelometric turbidity units

Model Information (in log units unless otherwise specified):

Number of measurements = 186,
Root-mean-squared error (RMSE) = 0.27
Model standard percentage error (MPSE) = +86 and -43 percent
90-percent prediction intervals (based on units in mg/L) = +/- 167 percent
Adjusted coefficient of determination (Adj R^2) = 0.53
Sum of squared error = 13.46
PRESS = 13.76

Coefficients:

	Coefficient	Standard error	t statistic	p-value
Intercept	-1.56	0.06	-25.06	<0.0001
Log $_{10}$ (Turb)	0.53	0.04	14.47	<0.0001

Correlation matrix of coefficients:

	Intercept	$\log_{10}$ (Turb)
Intercept	1	
Log_{10} (Turb)	-0.948	1

Duan's bias correction factor **= 1.37**

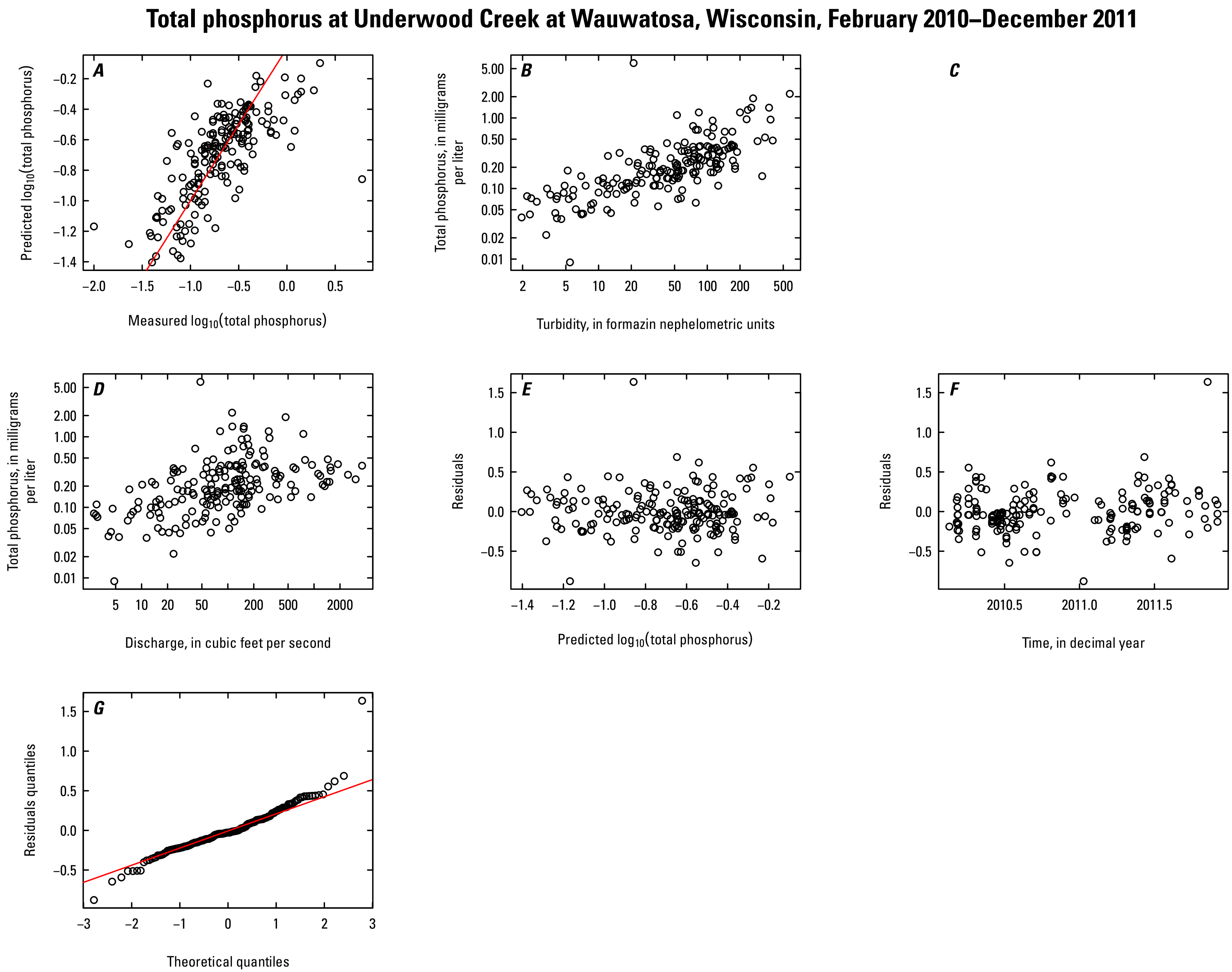

Figure 5.6. *A*, Relation between measured and predicted $\log_{10}$(total phosphorus concentration); *B*, Relation between turbidity and total phosphorus concentration in $\log_{10}$ space; *C*, No plot because only one explanatory variable used in model; *D*, Relation between discharge and total phosphorus concentration in $\log_{10}$ space; *E*, Relation between predicted $\log_{10}$(total phosphorus concentration) and regression residuals; *F*, Relation between time and total phosphorus regression residuals; *G*, Probability plot of total phosphorus regression residuals; U.S. Geological Survey streamgage on Underwood Creek at Wauwatosa, Wisconsin, February 2010–December 2011.

Appendix 6. Regression Analysis Results for Estimating *E. coli* Bacteria Concentration

All data were collected using USGS protocols and are stored in the USGS National Water Information System (NWIS) database (*http://waterdata.usgs.gov/nwis*). The regression models are based on measurements of turbidity and water temperature and concurrent E. coli bacteria samples collected from November 2008 to September 2011. Continuous water-quality data were collected at 5-minute intervals using a YSI model 6920 V2 multiparameter water-quality monitor with a 6560 specific conductance and water temperature sensor, and a 6136 optical turbidity sensor. Turbidity and water temperature values are instantaneous unit values temporally corresponding to the collection of the *E. coli* bacteria samples. Samples were collected throughout the range of continuously observed hydrologic conditions. Summary statistics and the complete model calibration dataset are provided. A comparison of cross-section mean and corresponding time-series monitor readings is archived at the Wisconsin Water Science Center and is available by request to the District Chief (dc_wi@usgs.gov).

Escherichia coli Bacteria at Little Menomonee River near Freistadt, WI (04087050)

Sample data collected on 2/26/2010 were not used, because it was believed the samples at 09:50 and 15:20 were switched and the concentration may be in error.

MODEL SUMMARY—Summary of final regression results for estimating Escherichia coli (*E. coli*) concentrations at Little Menomonee River near Freistadt, WI.

$$\text{Log}_{10}\,(E.\ coli) = 1.81 + 0.04\,(\text{WT}) + 0.71\,\log_{10}\,(\text{Turb}),$$

Where:

E. coli = Most Probable Number of *E. coli* per 100 ml (MPN/100ml)
WT = Water Temperature in °C
Turb = Turbidity (YSI 6136), in FNU

Model Information (in log units unless otherwise specified):

Number of measurements = 102,
Root-mean-squared error (RMSE) = 0.49
Model standard percentage error (MPSE) = +207 and -67 percent
90-percent prediction intervals (based on units in MPN/100ml) = +/- 613 percent
Adjusted coefficient of determination (Adj R^2) = 0.65
Sum of squared error = 23.6
PRESS = 24.9

Coefficients:

	Coefficient	Standard error	t statistic	p-value
Intercept	1.81	0.12	14.92	<0.0001
WT	0.04	0.01	6.53	<0.0001
Log_{10} (Turb)	0.71	0.08	9.34	<0.0001

Correlation matrix of coefficients:

	Intercept	WT	$\log_{10}$ (Turb)
Intercept	1.00		
WT	-0.231	1.00	
Log_{10} (Turb)	-0.765	-0.324	1.00

Duan's bias correction factor **= 1.95**

Escherichia coli at Little Menomonee River near Freistadt, Wisconsin, November 2008–September 2011

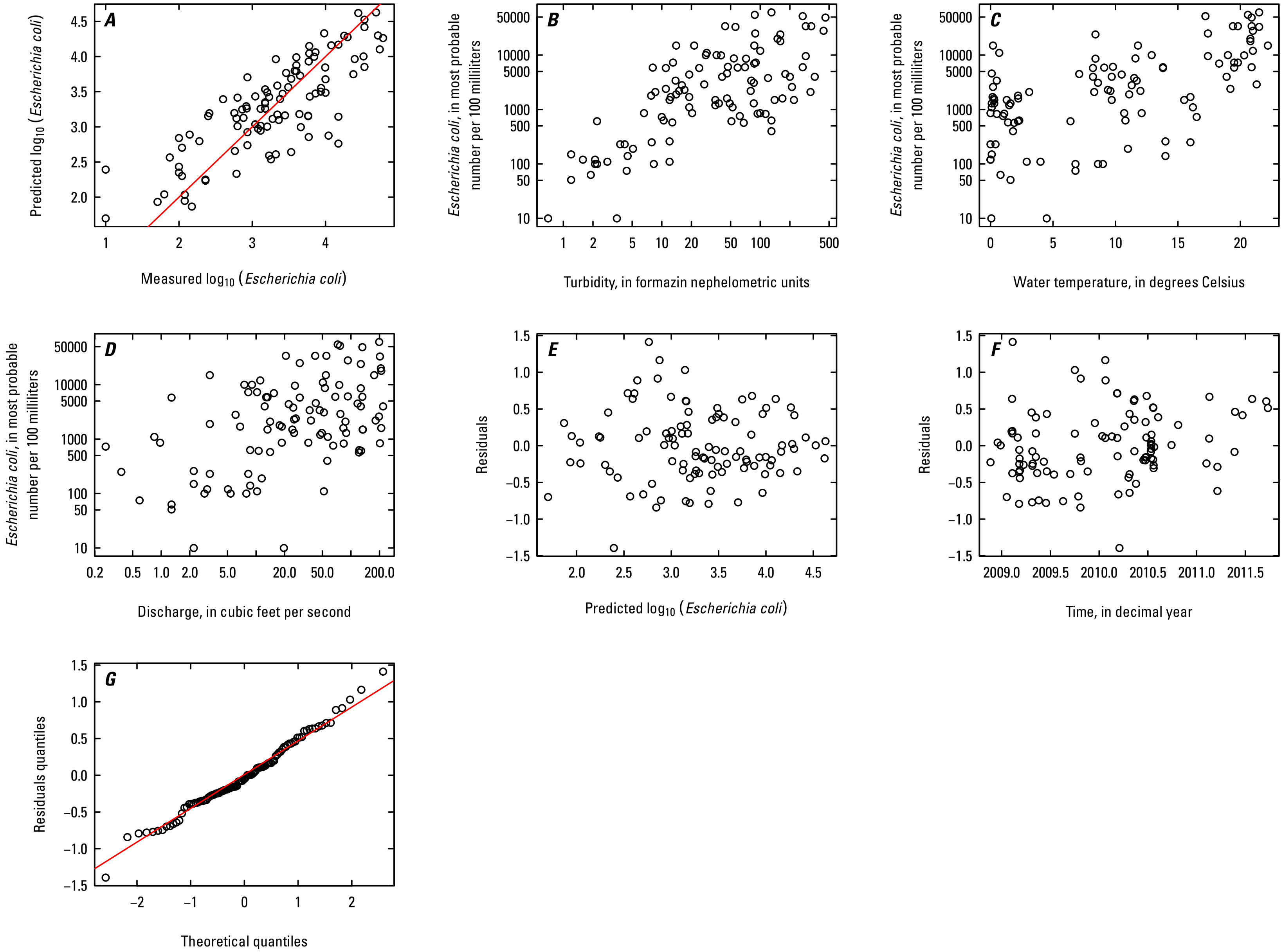

Figure 6.1. *A*, Relation between measured and predicted $\log_{10}$(*Escherichia coli* concentration); *B*, Relation between turbidity and *Escherichia coli* concentration in $\log_{10}$ space; *C*, Relation between water temperature and *Escherichia coli* concentration in $\log_{10}$ space; *D*, Relation between discharge and *Escherichia coli* concentration in $\log_{10}$ space; *E*, Relation between predicted $\log_{10}$(*Escherichia coli* concentration) and regression residuals; *F*, Relation between time and *Escherichia coli* regression residuals; *G*, Probability plot of *Escherichia coli* regression residuals; U.S. Geological Survey streamgage on Little Menomonee River near Freistadt, Wisconsin, November 2008–September 2011.

Escherichia coli Bacteria at Menomonee River at Menomonee Falls, WI (04087030)

MODEL SUMMARY—Summary of final regression results for estimating *Escherichia coli* (*E. coli*) concentrations at Menomonee River at Menomonee Falls, WI.

$$\text{Log}_{10}\,(E.\ coli) = 1.38 + 0.05\,(\text{WT}) + 0.71\,\log_{10}\,(\text{Turb}),$$

Where:

E. coli	=	Most Probable Number of *E. coli* per 100 ml (MPN/100ml)
WT	=	Water Temperature in °C
Turb	=	Turbidity (YSI 6136), in FNU

Model Information (in log units unless otherwise specified):

Number of measurements = 132,
Root-mean-squared error (RMSE) = 0.57
Model standard percentage error (MPSE) = +270 and -73 percent
90-percent prediction intervals (based on units in MPN/100ml) = +/- 921 percent
Adjusted coefficient of determination (Adj R^2) = 0.62
Sum of squared error = 41.6
PRESS = 43.3

Coefficients:

	Coefficient	Standard error	t statistic	p-value
Intercept	1.38	0.13	10.51	<0.0001
WT	0.05	0.01	7.23	<0.0001
Log_{10} (Turb)	0.71	0.09	7.50	<0.0001

Correlation matrix of coefficients:

	Intercept	WT	$\log_{10}$ (Turb)
Intercept	1		
WT	-0.162	1	
Log_{10} (Turb)	-0.714	-0.493	1

Duan's bias correction factor **= 2.13**

Escherichia coli at Menomonee River at Menomonee Falls, Wisconsin, November 2008–September 2011

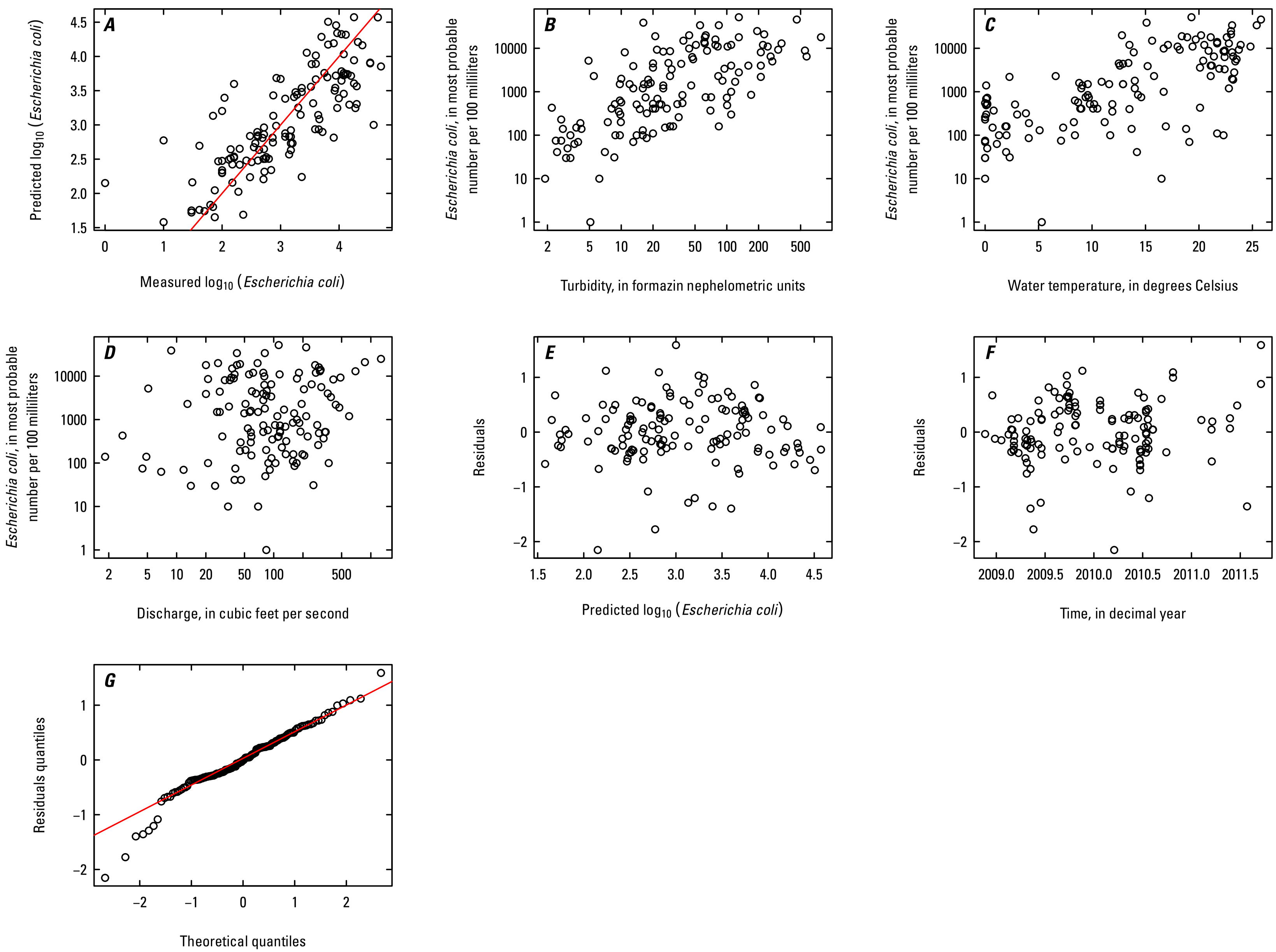

Figure 6.2. *A*, Relation between measured and predicted $\log_{10}$(*Escherichia coli* concentration); *B*, Relation between turbidity and *Escherichia coli* concentration in $\log_{10}$ space; *C*, Relation between water temperature and *Escherichia coli* concentration in $\log_{10}$ space; *D*, Relation between discharge and *Escherichia coli* concentration in $\log_{10}$ space; *E*, Relation between predicted $\log_{10}$(*Escherichia coli* concentration) and regression residuals; *F*, Relation between time and *Escherichia coli* regression residuals; *G*, Probability plot of *Escherichia coli* regression residuals; U.S. Geological Survey streamgage on Menomonee River at Menomonee Falls, Wisconsin, November 2008–September 2011.

Escherichia coli Bacteria at Honey Creek at Wauwatosa, WI (04087119)

MODEL SUMMARY—Summary of final regression results for estimating *Escherichia coli* (*E. coli*) concentrations at Honey Creek at Wauwatosa, WI.

$$\mathrm{Log}_{10}(E.\ coli) = 1.97 + 0.06\,(\mathrm{WT}) + 0.56\,\log_{10}(\mathrm{Turb}),$$

Where:

E. coli	=	Most Probable Number of *E. coli* per 100 ml (MPN/100ml)
WT	=	Water Temperature in °C
Turb	=	Turbidity (YSI 6136), in FNU

Model Information (in log units unless otherwise specified):

Number of measurements = 185
Root-mean-squared error (RMSE) = 0.51
Model standard percentage error (MPSE) = +220 and -69 percent
90-percent prediction intervals (based on units in MPN/100ml) = +/- 704 percent
Adjusted coefficient of determination (Adj R^2) = 0.61
Sum of squared error = 47.1
PRESS = 48.9

Coefficients:

	Coefficient	**Standard error**	**t statistic**	**p-value**
Intercept	1.97	0.12	16.19	<0.0001
WT	0.06	0.01	12.19	<0.0001
Log_{10} (Turb)	0.56	0.06	8.71	<0.0001

Correlation matrix of coefficients:

	Intercept	**WT**	**$\log_{10}$ (Turb)**
Intercept	1		
WT	-0.336	1	
Log_{10} (Turb)	-0.781	-0.244	1

Duan’s bias correction factor **= 2.11**

Escherichia coli at Honey Creek at Wauwatosa, Wisconsin, November 2008–September 2011

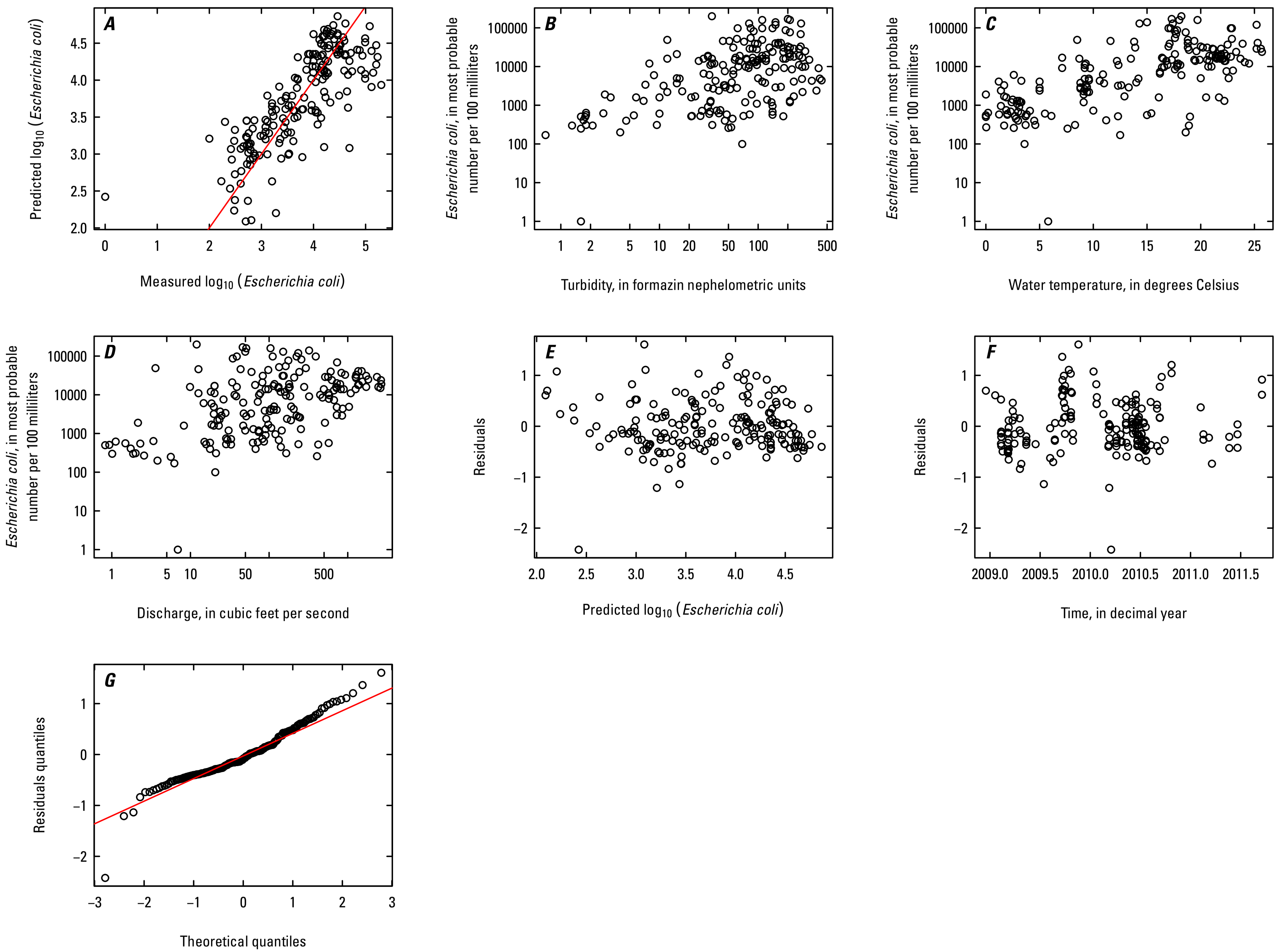

Figure 6.3. *A*, Relation between measured and predicted log_{10}(*Escherichia coli* concentration); *B*, Relation between turbidity and Escherichia coli concentration in log_{10} space; *C*, Relation between water temperature and *Escherichia coli* concentration in log_{10} space; *D*, Relation between discharge and *Escherichia coli* concentration in log_{10} space; *E*, Relation between predicted log_{10}(*Escherichia coli* concentration) and regression residuals; *F*, Relation between time and *Escherichia coli* regression residuals; *G*, Probability plot of *Escherichia coli* regression residuals; U.S. Geological Survey streamgage on Honey Creek at Wauwatosa, Wisconsin, November 2008–September 2011.

Escherichia coli Bacteria at Menomonee River at Wauwatosa, WI (04087120)

MODEL SUMMARY—Summary of final regression results for estimating *Escherichia coli* (*E. coli*) concentrations at Menomonee River at Wauwatosa, WI.

$$\text{Log}_{10}(E.\ coli) = 1.60 + 0.05\,(\text{WT}) + 0.76\,\log_{10}(\text{Turb}),$$

Where:

E. coli	=	Most Probable Number of *E. coli* per 100 ml (MPN/100ml)
WT	=	Water Temperature in °C
Turb	=	Turbidity (YSI 6136), in FNU

Model Information (in log units unless otherwise specified):

Number of measurements = 165,
Root-mean-squared error (RMSE) = 0.55
Model standard percentage error (MPSE) = +257 and -72 percent
90-percent prediction intervals (based on units in MPN/100ml) = +/- 911 percent
Adjusted coefficient of determination (Adj R^2) = 0.61
Sum of squared error = 49.4
PRESS = 51.2

Coefficients:

	Coefficient	Standard error	t statistic	p-value
Intercept	1.60	0.14	11.35	<0.0001
WT	0.05	0.01	9.93	<0.0001
Log_{10} (Turb)	0.76	0.09	8.61	<0.0001

Correlation matrix of coefficients:

	Intercept	WT	$\log_{10}$ (Turb)
Intercept	1		
WT	-0.133	1	
Log_{10} (Turb)	-0.841	-0.342	1

Duan's bias correction factor **= 2.27**

Escherichia coli at Menomonee River at Wauwatosa, Wisconsin, November 2008–September 2011

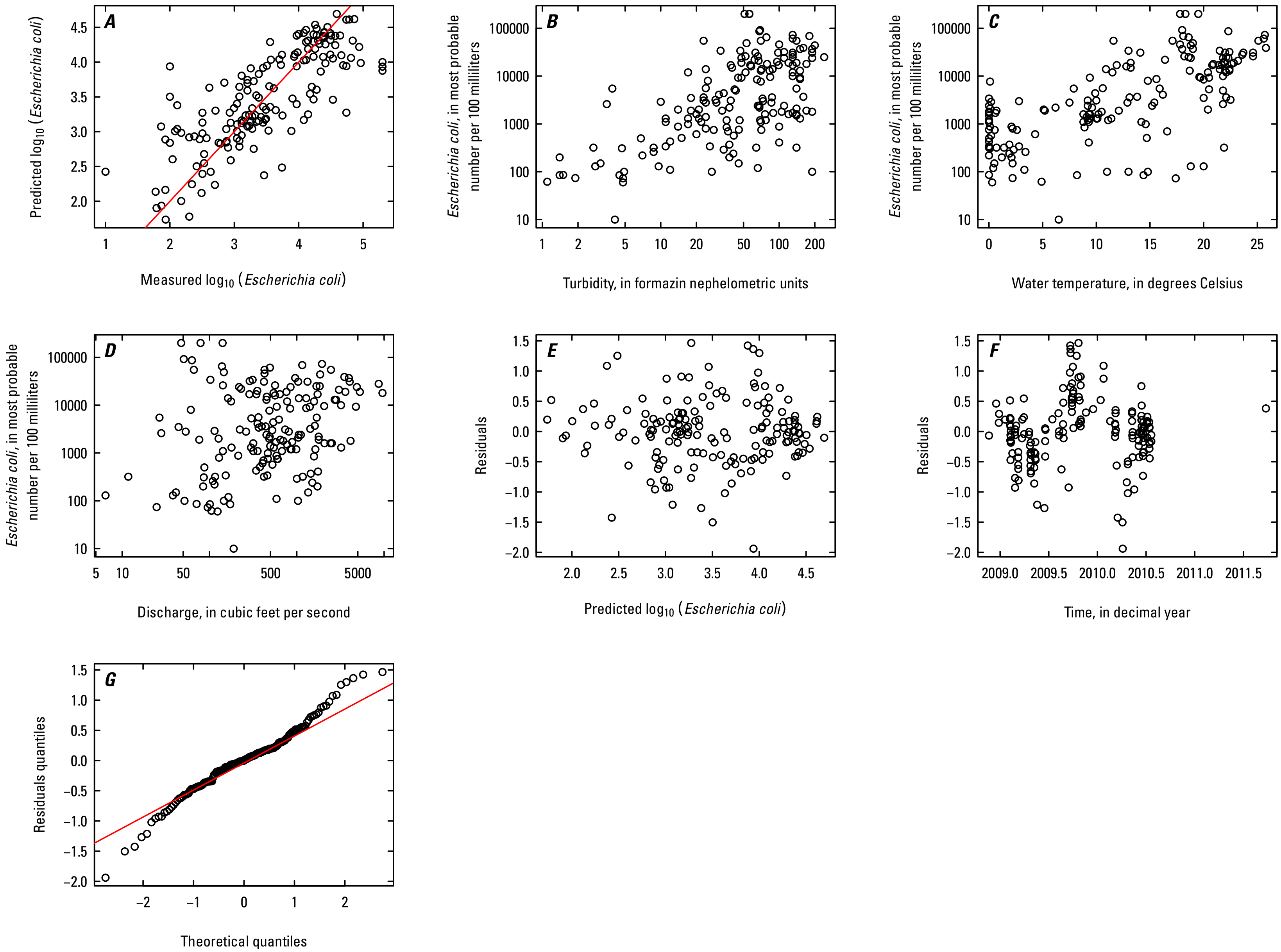

Figure 6.4. *A*, Relation between measured and predicted $\log_{10}$(*Escherichia coli* concentration); *B*, Relation between turbidity and *Escherichia coli* concentration in $\log_{10}$ space; *C*, Relation between water temperature and *Escherichia coli* concentration in $\log_{10}$ space; *D*, Relation between discharge and *Escherichia coli* concentration in $\log_{10}$ space; *E*, Relation between predicted $\log_{10}$(*Escherichia coli* concentration) and regression residuals; *F*, Relation between time and *Escherichia coli* regression residuals; *G*, Probability plot of *Escherichia coli* regression residuals; U.S. Geological Survey streamgage on Menomonee River at Wauwatosa, Wisconsin, November 2008–September 2011.

Escherichia coli Bacteria at Menomonee River at 16th Street at Milwaukee, WI (04087142)

MODEL SUMMARY—Summary of final regression results for estimating *Escherichia coli* (*E. coli*) concentrations at Menomonee River at 16th Street at Milwaukee, WI.

$$\text{Log}_{10}\ (E.\ coli) = 1.44 + 0.05\ (\text{WT}) + 0.89\ \log_{10}\ (\text{Turb}),$$

Where:

E. coli	=	Most Probable Number of *E. coli* per 100 ml (MPN/100ml)
WT	=	Water Temperature in °C
Turb	=	Turbidity (YSI 6136), in FNU

Model Information (in log units unless otherwise specified):

Number of measurements = 171
Root-mean-squared error (RMSE) = 0.51
Model standard percentage error (MPSE) = +227 and -69 percent
90-percent prediction intervals (based on units in MPN/100ml) = +/- 797 percent
Adjusted coefficient of determination (Adj R^2) = 0.60
Sum of squared error = 44.4
PRESS = 46.3

Coefficients:

	Coefficient	Standard error	t statistic	p-value
Intercept	1.44	0.13	10.83	<0.0001
WT	0.05	0.005	9.71	<0.0001
Log_{10} (Turb)	0.89	0.08	11.91	<0.0001

Correlation matrix of coefficients:

	Intercept	WT	$\log_{10}$ (Turb)
Intercept	1		
WT	-0.392	1	
Log_{10} (Turb)	-0.835	0.084	1

Duan's bias correction factor **= 2.31**

Escherichia coli at Menomonee River at 16th Street at Milwaukee, Wisconsin, November 2008–September 2011

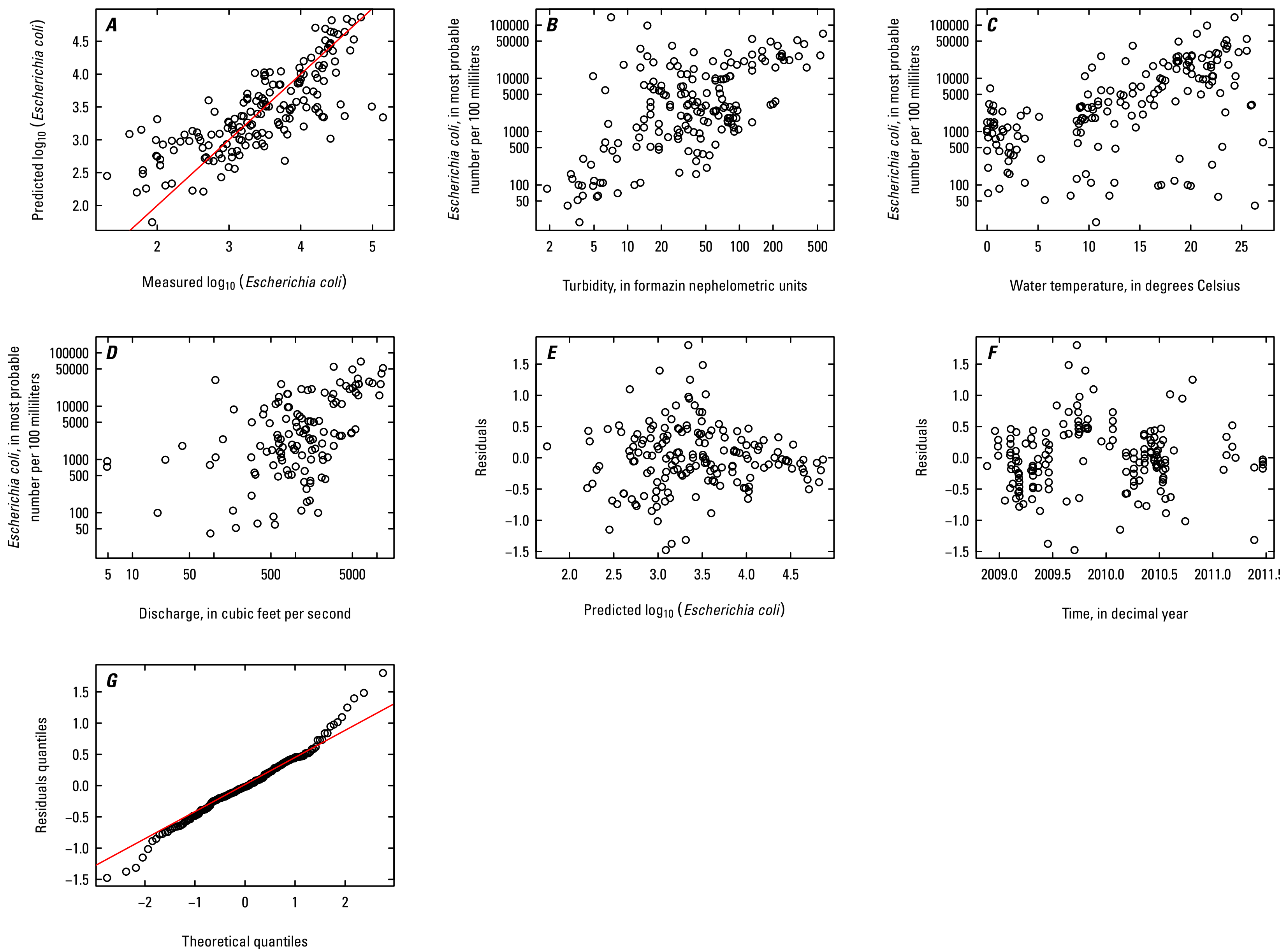

Figure 6.5. *A*, Relation between measured and predicted $\log_{10}$(*Escherichia coli* concentration); *B*, Relation between turbidity and *Escherichia coli* concentration in $\log_{10}$ space; *C*, Relation between water temperature and *Escherichia coli* concentration in $\log_{10}$ space; *D*, Relation between discharge and *Escherichia coli* concentration in $\log_{10}$ space; *E*, Relation between predicted $\log_{10}$(*Escherichia coli* concentration) and regression residuals; *F*, Relation between time and *Escherichia coli* regression residuals; *G*, Probability plot of *Escherichia coli* regression residuals; U.S. Geological Survey streamgage on Menomonee River at 16th Street at Milwaukee, Wisconsin, November 2008–September 2011.

Escherichia coli Bacteria at Underwood Creek at Wauwatosa, WI (04087088)

MODEL SUMMARY—Summary of final regression results for estimating *Escherichia coli* (*E. coli*) bacteria concentrations at Underwood Creek at Wauwatosa, WI.

$$\mathrm{Log}_{10}\,(E.\ coli) = 2.34 + 0.03\,(\mathrm{WT}) + 0.66\,\log_{10}\,(\mathrm{Turb}),$$

Where:

E. coli	=	Most Probable Number of *E. coli* per 100 ml (MPN/100ml)
WT	=	Water Temperature in °C
Turb	=	Turbidity (YSI 6136), in FNU

Model Information (in log units unless otherwise specified):

Number of measurements =157,
Root-mean-squared error (RMSE) = 0.54
Model standard percentage error (MPSE) = +247 and -71 percent
90-percent prediction intervals (based on units in MPN/100ml) = +/- 893 percent
Adjusted coefficient of determination (Adj R^2) = 0.45
Sum of squared error = 45.0
PRESS = 46.9

Coefficients:

	Coefficient	Standard error	t statistic	p-value
Intercept	2.34	0.14	16.44	<0.0001
WT	0.03	0.01	5.28	<0.0001
Log_{10} (Turb)	0.66	0.08	8.15	<0.0001

Correlation matrix of coefficients:

	Intercept	WT	$\log_{10}$ (Turb)
Intercept	1		
WT	-0.370	1	
Log_{10} (Turb)	-0.727	-0.299	1

Duan’s bias correction factor **= 2.33**

Escherichia coli at Underwood Creek at Wauwatosa, Wisconsin, February 2010–December 2011

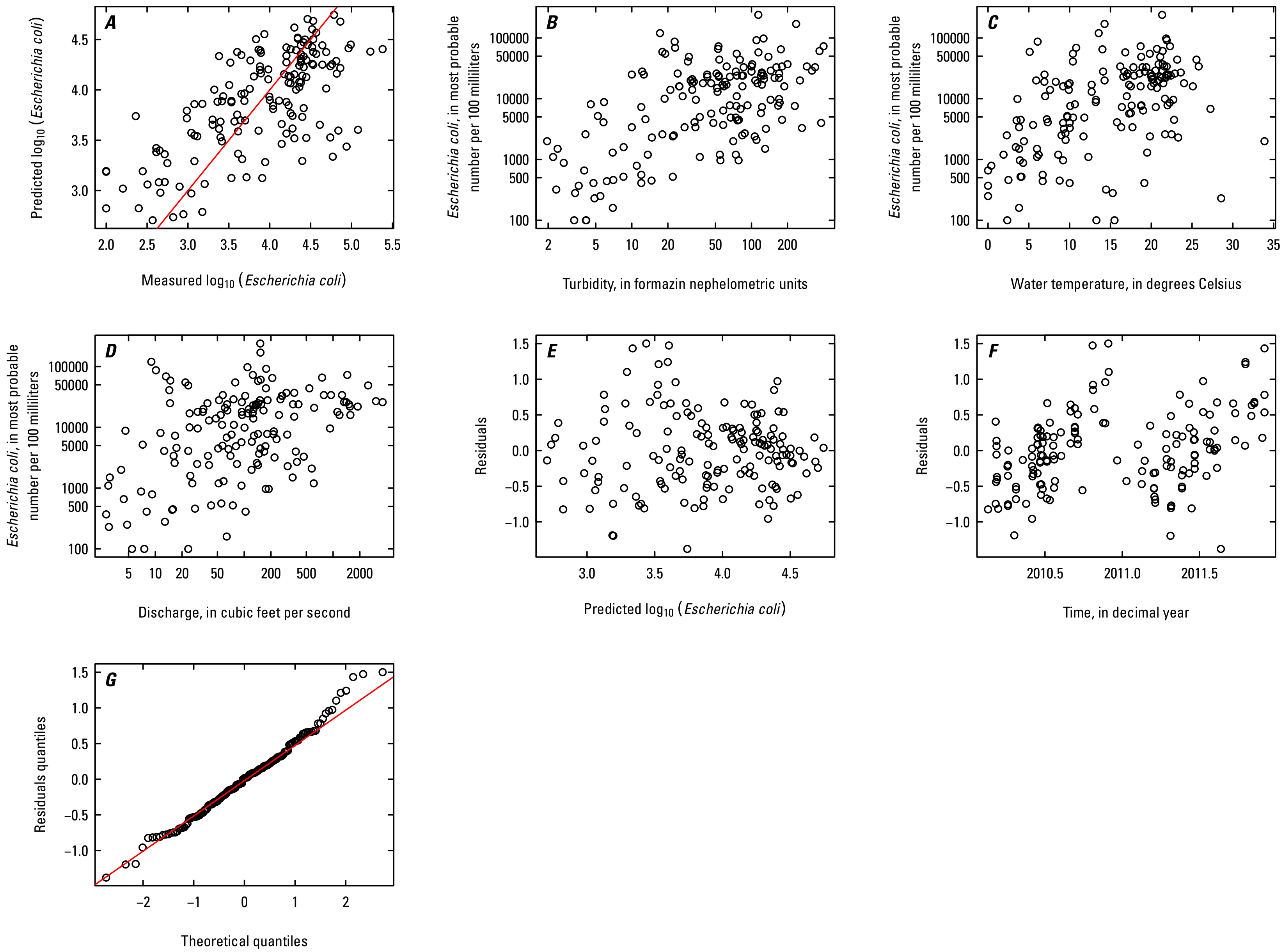

Figure 6.6. *A*, Relation between measured and predicted $\log_{10}$(*Escherichia coli* concentration); *B*, Relation between turbidity and *Escherichia coli* concentration in $\log_{10}$ space; *C*, Relation between water temperature and *Escherichia coli* concentration in $\log_{10}$ space; *D*, Relation between discharge and *Escherichia coli* concentration in $\log_{10}$ space; *E*, Relation between predicted $\log_{10}$(*Escherichia coli* concentration) and regression residuals; *F*, Relation between time and *Escherichia coli* regression residuals; *G*, Probability plot of *Escherichia coli* regression residuals; U.S. Geological Survey streamgage on Underwood Creek at Wauwatosa, Wisconsin, February 2010–December 2011.

Appendix 7. Regression Analysis Results for Estimating Fecal Coliform Bacteria Concentration

All data were collected using USGS protocols and are stored in the USGS National Water Information System (NWIS) database (*http://waterdata.usgs.gov/nwis*). The regression models are based on measurements of turbidity and water temperature and concurrent fecal coliform bacteria samples collected from November 2008 to September 2011. Continuous water-quality data were collected at 5-minute intervals using a YSI model 6920 V2 multiparameter water-quality monitor with a 6560 specific conductance and water temperature sensor, and a 6136 optical turbidity sensor. Turbidity and water temperature values are instantaneous unit values temporally corresponding to the collection of the fecal coliform bacteria samples. Samples were collected throughout the range of continuously observed hydrologic conditions. Summary statistics and the complete model calibration dataset are provided. A comparison of cross-section mean and corresponding time-series monitor readings is archived at the Wisconsin Water Science Center and is available by request to the District Chief (dc_wi@usgs.gov).

Fecal Coliform Bacteria at Little Menomonee River near Freistadt, WI (04087050)

MODEL SUMMARY—Summary of final regression results for estimating fecal coliform concentrations at Little Menomonee River near Freistadt, WI.

$$\text{Log}_{10}\text{ (fecal coliform)} = 1.51 + 0.05\text{ (WT)} + 0.83\log_{10}\text{ (Turb)},$$

Where:

fecal coliform = colony forming units of fecal coliform per 100 ml (CFU/100ml)
WT = Water Temperature in °C
Turb = Turbidity (YSI 6136), in FNU

Model Information (in log units unless otherwise specified):

Number of measurements = 95,
Root-mean-squared error (RMSE) = 0.54
Model standard percentage error (MPSE) = +249 and -71 percent
90-percent prediction intervals (based on units in CFU/100ml) = +/- 832 percent
Adjusted coefficient of determination (Adj R^2) = 0.68
Sum of squared error = 27.1
PRESS = 28.8

Coefficients:

	Coefficient	Standard error	t statistic	p-value
Intercept	1.51	0.14	10.75	<0.0001
WT	0.05	0.01	6.77	<0.0001
Log_{10} (Turb)	0.83	0.09	9.33	<0.0001

Correlation matrix of coefficients:

	Intercept	WT	Log_{10}(Turb)
Intercept	1		
WT	-0.244	1	
Log_{10} (Turb)	-0.750	-0.339	1

Duan's bias correction factor **= 2.13**

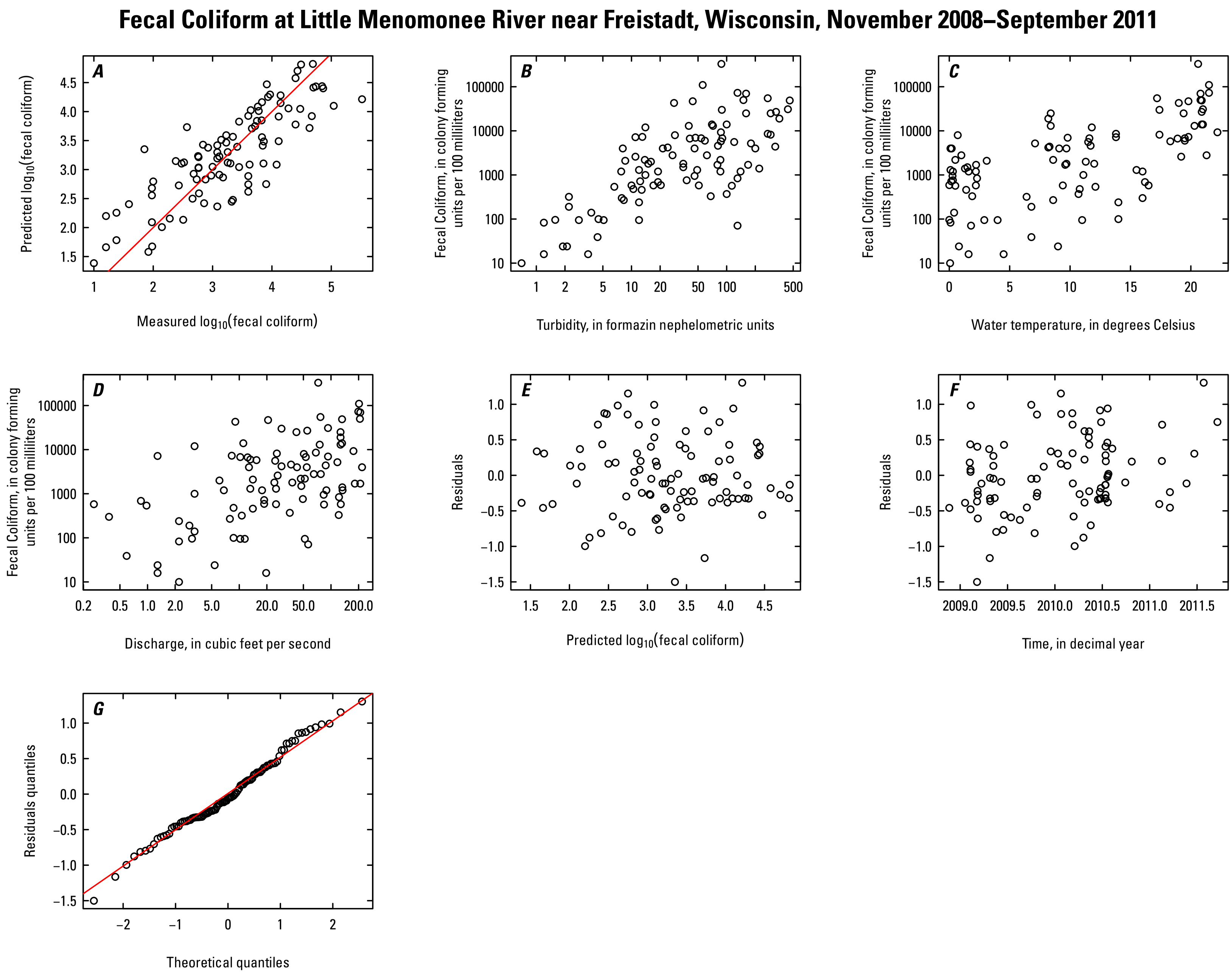

Figure 7.1. *A*, Relation between measured and predicted $\log_{10}$(fecal coliform concentration); *B*, Relation between turbidity and fecal coliform concentration in $\log_{10}$ space; *C*, Relation between water temperature and fecal coliform concentration in $\log_{10}$ space; *D*, Relation between discharge and fecal coliform concentration in $\log_{10}$ space; *E*, Relation between predicted $\log_{10}$(fecal coliform concentration) and regression residuals; *F*, Relation between time and fecal coliform regression residuals; *G*, Probability plot of fecal coliform regression residuals; U.S. Geological Survey streamgage on Little Menomonee River near Freistadt, Wisconsin, November 2008–September 2011.

Fecal Coliform Bacteria at Menomonee River at Menomonee Falls, WI (04087030)

MODEL SUMMARY—Summary of final regression results for estimating fecal coliform concentrations at Menomonee River at Menomonee Falls, WI.

$$\text{Log}_{10}\text{ (fecal coliform)} = 1.30 + 0.06\text{ (WT)} + 0.76\log_{10}\text{ (Turb)},$$

Where:

fecal coliform = colony forming units of fecal coliform per 100 ml (CFU/100ml)
WT = Water Temperature in °C
Turb = Turbidity (YSI 6136), in FNU

Model Information (in log units unless otherwise specified):

Number of measurements = 118,
Root-mean-squared error (RMSE) = 0.54
Model standard percentage error (MPSE) = +247 and -71 percent
90-percent prediction intervals (based on units in CFU/100ml) = +/- 788 percent
Adjusted coefficient of determination (Adj R^2) = 0.71
Sum of squared error = 33.5
PRESS = 35.1

Coefficients:

	Coefficient	Standard error	t statistic	p-value
Intercept	1.30	0.13	9.95	<0.0001
WT	0.06	0.01	8.64	<0.0001
Log_{10} (Turb)	0.76	0.09	8.08	<0.0001

Correlation matrix of coefficients:

	Intercept	WT	$\log_{10}$ (Turb)
Intercept	1		
WT	-0.173	1	
Log_{10} (Turb)	-0.698	0.504	1

Duan's bias correction factor **= 2.03**

Fecal Coliform at Menomonee River at Menomonee Falls, Wisconsin, November 2008–September 2011

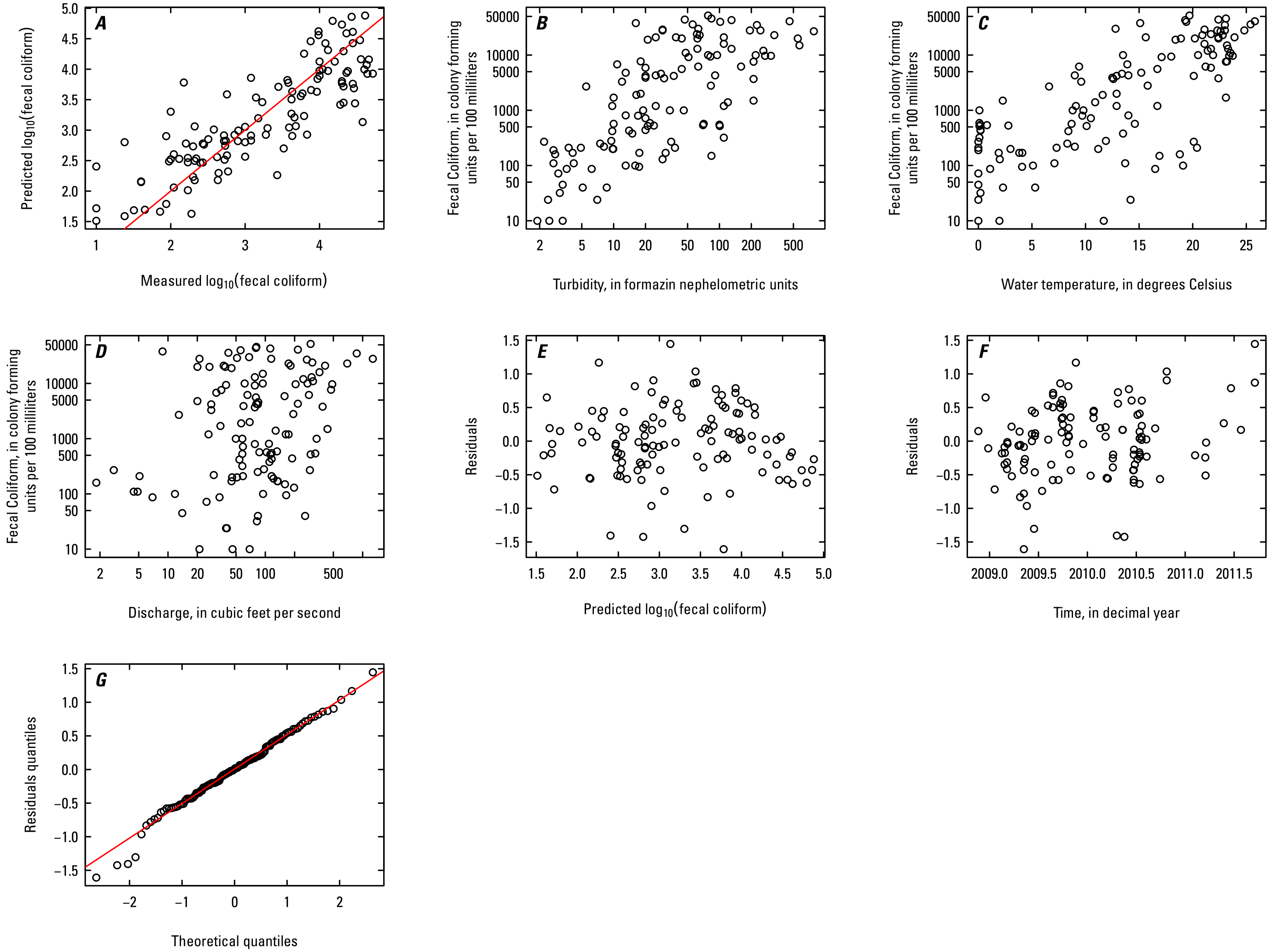

Figure 7.2. *A*, Relation between measured and predicted $\log_{10}$(fecal coliform concentration); *B*, Relation between turbidity and fecal coliform concentration in $\log_{10}$ space; *C*, Relation between water temperature and fecal coliform concentration in $\log_{10}$ space; *D*, Relation between discharge and fecal coliform concentration in $\log_{10}$ space; *E*, Relation between predicted $\log_{10}$(fecal coliform concentration) and regression residuals; *F*, Relation between time and fecal coliform regression residuals; *G*, Probability plot of fecal coliform regression residuals; U.S. Geological Survey streamgage on Menomonee River at Menomonee Falls, Wisconsin, November 2008–September 2011.

Fecal Coliform Bacteria at Honey Creek at Wauwatosa, WI (04087119)

MODEL SUMMARY—Summary of final regression results for estimating fecal coliform concentrations at Honey Creek at Wauwatosa, WI.

$$\text{Log}_{10}\text{(fecal coliform)} = 1.89 + 0.08\text{ (WT)} + 0.53\log_{10}\text{(Turb)},$$

Where:

fecal coliform = colony forming units of fecal coliform per 100 ml (CFU/100ml)
WT = Water Temperature in °C
Turb = Turbidity (YSI 6136), in FNU

Model Information (in log units unless otherwise specified):

Number of measurements = 188
Root-mean-squared error (RMSE) = 0.50
Model standard percentage error (MPSE) = +215 and -68 percent
90-percent prediction intervals (based on units in CFU/100ml) = +/- 651 percent
Adjusted coefficient of determination (Adj R^2) = 0.68
Sum of squared error = 46.4
PRESS = 48.0

Coefficients:

	Coefficient	Standard error	t statistic	p-value
Intercept	1.89	0.12	15.98	<0.0001
WT	0.08	0.005	15.46	<0.0001
Log_{10} (Turb)	0.53	0.06	8.55	<0.0001

Correlation matrix of coefficients:

	Intercept	WT	$\log_{10}$ (Turb)
Intercept	1		
WT	-0.336	1	
Log_{10} (Turb)	-0.777	-0.252	1

Duan's bias correction factor **= 2.01**

Fecal Coliform at Honey Creek at Wauwatosa, Wisconsin, November 2008–September 2011

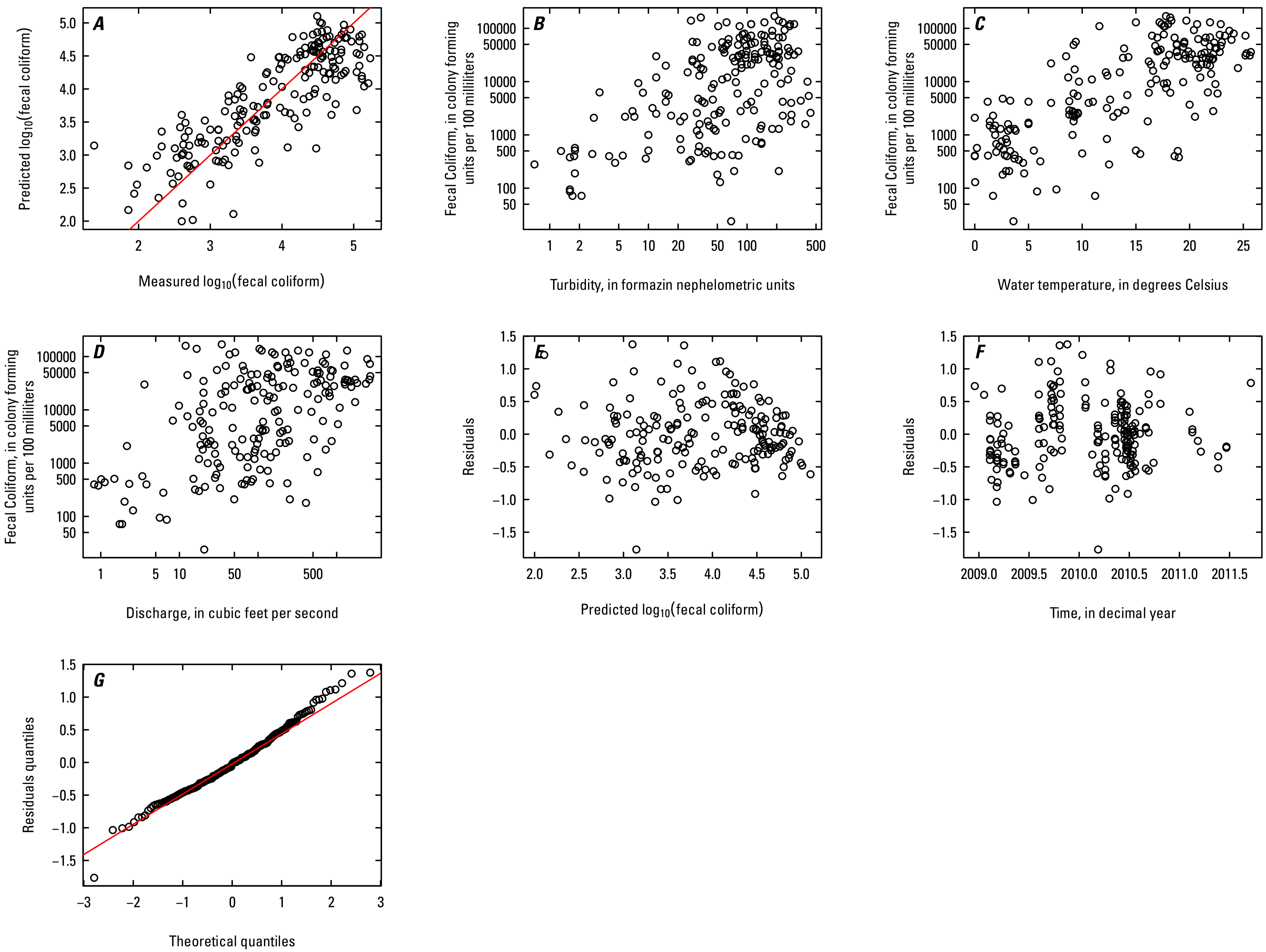

Figure 7.3. *A*, Relation between measured and predicted $\log_{10}$(fecal coliform concentration); *B*, Relation between turbidity and fecal coliform concentration in $\log_{10}$ space; *C*, Relation between water temperature and fecal coliform concentration in $\log_{10}$ space; *D*, Relation between discharge and fecal coliform concentration in $\log_{10}$ space; *E*, Relation between predicted $\log_{10}$(fecal coliform concentration) and regression residuals; *F*, Relation between time and fecal coliform regression residuals; *G*, Probability plot of fecal coliform regression residuals; U.S. Geological Survey streamgage on Honey Creek at Wauwatosa, Wisconsin, November 2008–September 2011.

Fecal Coliform Bacteria at Menomonee River at Wauwatosa, WI (04087120)

MODEL SUMMARY—Summary of final regression results for estimating fecal coliform concentrations at Menomonee River at Wauwatosa, WI.

$$\text{Log}_{10}\,(\text{fecal coliform}) = 1.57 + 0.07\,(\text{WT}) + 0.74\,\log_{10}\,(\text{Turb}),$$

Where:

fecal coliform = colony forming units of fecal coliform per 100 ml (CFU/100ml)

WT = Water Temperature in °C

Turb = Turbidity (YSI 6136), in FNU

Model Information (in log units unless otherwise specified):

Number of measurements = 145
Root-mean-squared error (RMSE) = 0.61
Model standard percentage error (MPSE) = +305 and -75 percent
90-percent prediction intervals (based on units in CFU/100ml) = +/- 1050 percent
Adjusted coefficient of determination (Adj R^2) = 0.61
Sum of squared error = 52.4
PRESS = 54.6

Coefficients:

	Coefficient	Standard error	t statistic	p-value
Intercept	1.57	0.18	8.98	<0.0001
WT	0.07	0.01	9.82	<0.0001
Log_{10} (Turb)	0.74	0.11	6.80	<0.0001

Correlation matrix of coefficients:

	Intercept	WT	$\log_{10}$ (Turb)
Intercept	1		
WT	-0.130	1	
Log_{10} (Turb)	-0.827	-0.382	1

Duan’s bias correction factor **= 2.08**

Fecal Coliform at Menomonee River at Wauwatosa, Wisconsin, November 2008–September 2011

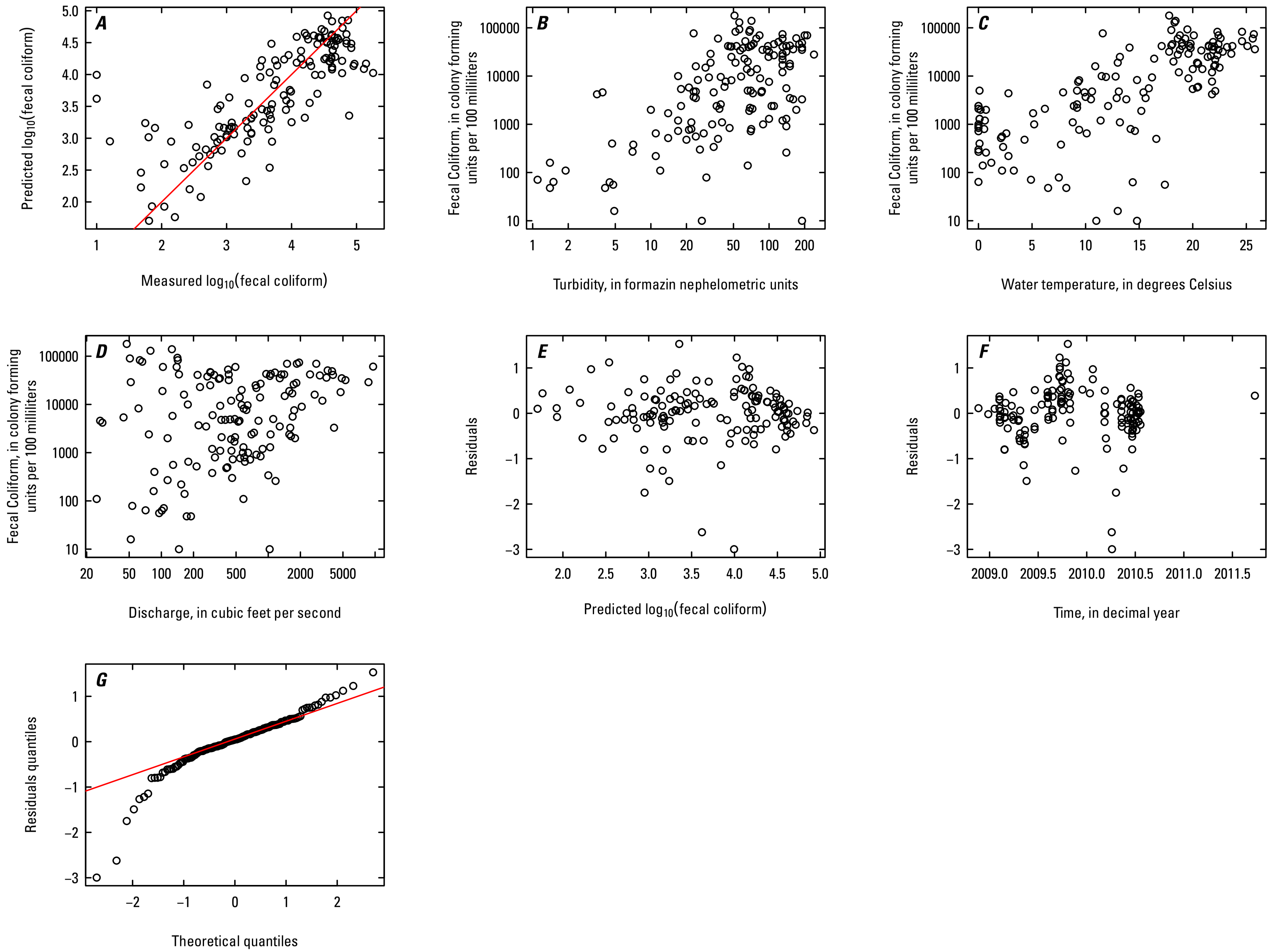

Figure 7.4. *A*, Relation between measured and predicted $\log_{10}$(fecal coliform concentration); *B*, Relation between turbidity and fecal coliform concentration in $\log_{10}$ space; *C*, Relation between water temperature and fecal coliform concentration in $\log_{10}$ space; *D*, Relation between discharge and fecal coliform concentration in $\log_{10}$ space; *E*, Relation between predicted $\log_{10}$(fecal coliform concentration) and regression residuals; *F*, Relation between time and fecal coliform regression residuals; *G*, Probability plot of fecal coliform regression residuals; U.S. Geological Survey streamgage on Menomonee River at Wauwatosa, Wisconsin, November 2008–September 2011.

Fecal Coliform Bacteria at Menomonee River at 16th Street at Milwaukee, WI (04087142)

MODEL SUMMARY—Summary of final regression results for estimating fecal coliform concentrations at Menomonee River at 16th Street at Milwaukee, WI.

$$\text{Log}_{10}\text{(fecal coliform)} = 1.29 + 0.06\text{ (WT)} + 0.98\log_{10}\text{(Turb)},$$

Where:

fecal coliform = colony forming units of fecal coliform per 100 ml (CFU/100ml)
WT = Water Temperature in °C
Turb = Turbidity (YSI 6136), in FNU

Model Information (in log units unless otherwise specified):

Number of measurements = 144,
Root-mean-squared error (RMSE) = 0.57
Model standard percentage error (MPSE) = +273 and -73 percent
90-percent prediction intervals (based on units in CFU/100ml) = +/- 1110 percent
Adjusted coefficient of determination (Adj R^2) = 0.63
Sum of squared error = 46.1
PRESS = 48.3

Coefficients:

	Coefficient	Standard error	t statistic	p-value
Intercept	1.29	0.16	8.18	<0.0001
WT	0.06	0.01	9.07	<0.0001
Log_{10} (Turb)	0.98	0.09	11.05	<0.0001

Correlation matrix of coefficients:

	Intercept	WT	$\log_{10}$ (Turb)
Intercept	1		
WT	-0.392	1	
Log_{10} (Turb)	-0.798	-0.155	1

Duan’s bias correction factor **= 2.52**

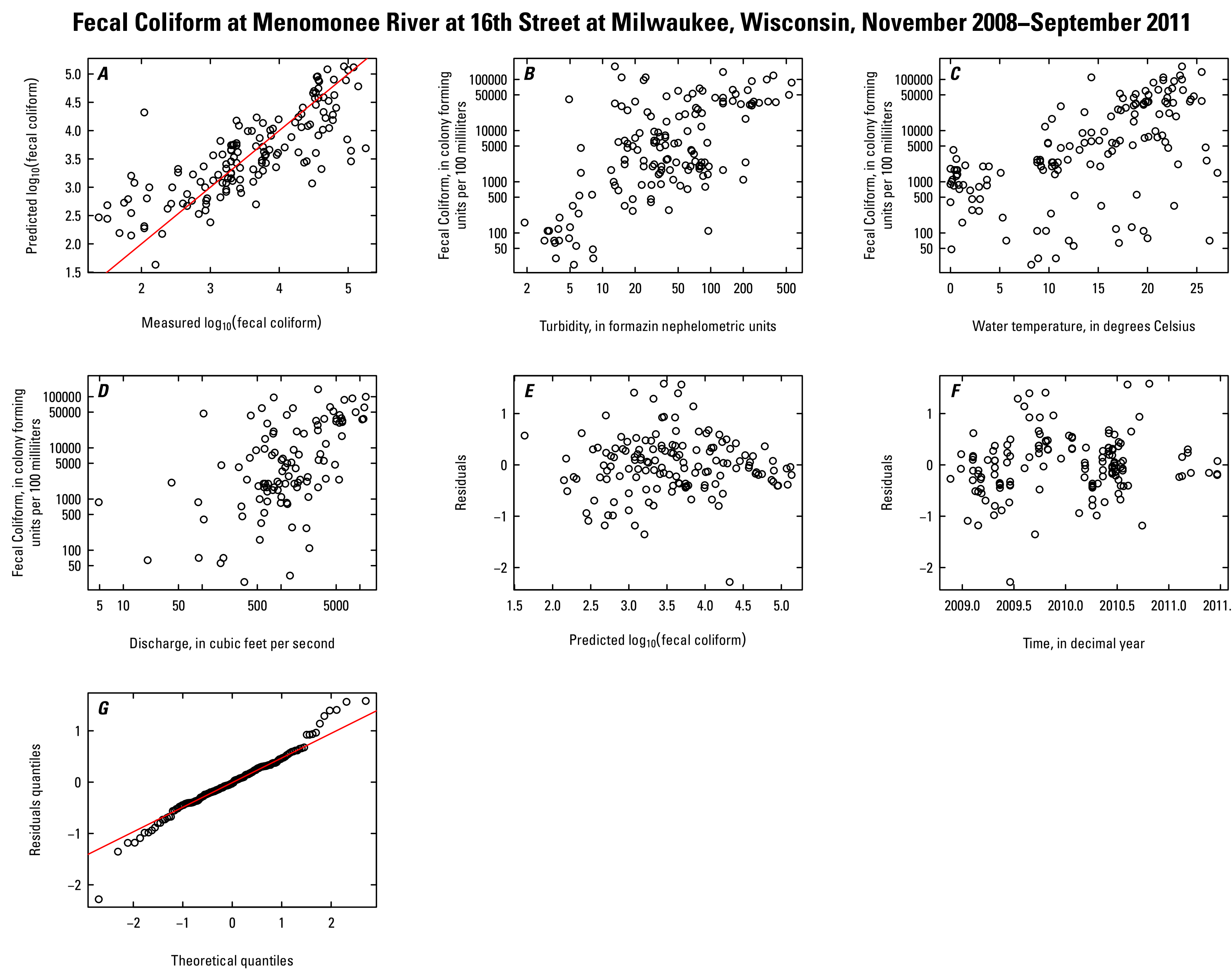

Figure 7.5. *A*, Relation between measured and predicted $\log_{10}$(fecal coliform concentration); *B*, Relation between turbidity and fecal coliform concentration in $\log_{10}$ space; *C*, Relation between water temperature and fecal coliform concentration in $\log_{10}$ space; *D*, Relation between discharge and fecal coliform concentration in $\log_{10}$ space; *E*, Relation between predicted $\log_{10}$(fecal coliform concentration) and regression residuals; *F*, Relation between time and fecal coliform regression residuals; *G*, Probability plot of fecal coliform regression residuals; U.S. Geological Survey streamgage on Menomonee River at 16th Street at Milwaukee, Wisconsin, November 2008–September 2011.

Fecal Coliform Bacteria at Underwood Creek at Wauwatosa, WI (04087088)

MODEL SUMMARY—Summary of final regression results for estimating fecal coliform concentrations at Underwood Creek at Wauwatosa, WI.

$$\text{Log}_{10}\text{(fecal coliform)} = 2.19 + 0.04\,(\text{WT}) + 0.76\,\log_{10}(\text{Turb}),$$

Where:

fecal coliform = colony forming units of fecal coliform per 100 ml (CFU/100ml)
WT = Water Temperature in °C
Turb = Turbidity (YSI 6136), in FNU

Model Information (in log units unless otherwise specified):

Number of measurements = 149,
Root-mean-squared error (RMSE) = 0.56
Model standard percentage error (MPSE) = +259 and -72 percent
90-percent prediction intervals (based on units in CFU/100ml) = +/- 943 percent
Adjusted coefficient of determination (Adj R^2) = 0.54
Sum of squared error = 45.0
PRESS = 47.2

Coefficients:

	Coefficient	Standard error	t statistic	p-value
Intercept	2.19	0.15	14.76	<0.0001
WT	0.04	0.01	6.36	<0.0001
Log_{10} (Turb)	0.76	0.08	8.99	<0.0001

Correlation matrix of coefficients:

	Intercept	WT	$\log_{10}$ (Turb)
Intercept	1		
WT	-0.378	1	
Log_{10} (Turb)	-0.712	-0.314	1

Duan's bias correction factor **= 2.29**

Fecal Coliform at Underwood Creek at Wauwatosa, Wisconsin, February 2010–December 2011

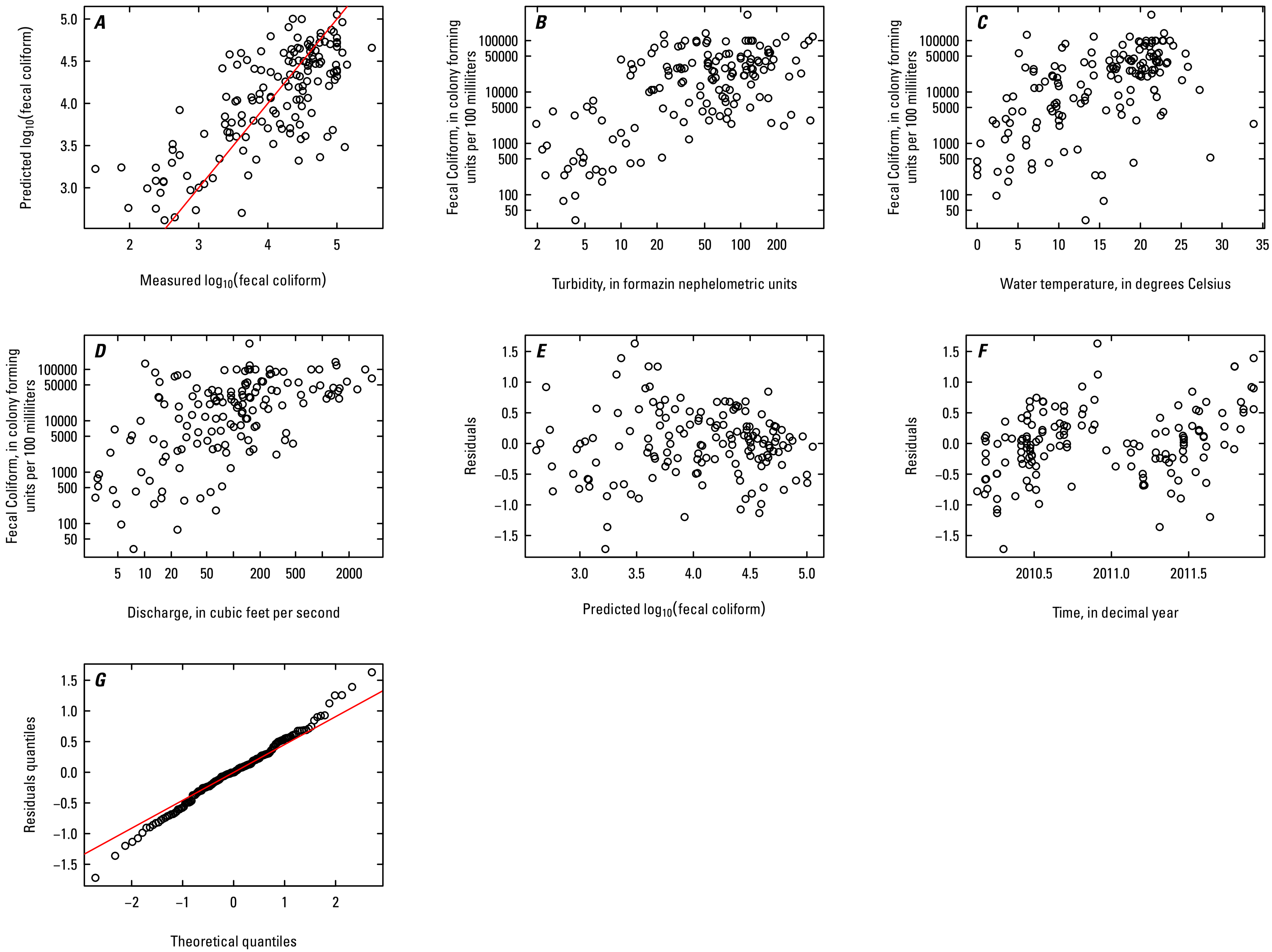

Figure 7.6. *A*, Relation between measured and predicted $\log_{10}$(fecal coliform concentration); *B*, Relation between turbidity and fecal coliform concentration in $\log_{10}$ space; *C*, Relation between water temperature and fecal coliform concentration in $\log_{10}$ space; *D*, Relation between discharge and fecal coliform concentration in $\log_{10}$ space; *E*, Relation between predicted $\log_{10}$(fecal coliform concentration) and regression residuals; *F*, Relation between time and fecal coliform regression residuals; *G*, Probability plot of fecal coliform regression residuals; U.S. Geological Survey streamgage on Underwood Creek at Wauwatosa, Wisconsin, February 2010–December 2011.

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