TRIHALOMETHANE AND NONPURGEABLE TOTAL ORGANIC-HALIDE FORMATION POTENTIALS FOR THE MISSISSIPPI RIVER AND SOME OF ITS TRIBUTARIES, SEPTEMBER-OCTOBER 1991

By R.E. Rathbun and L.M. Bishop

U.S. GEOLOGICAL SURVEY

Open-File Report 94-36

Denver, Colorado
1994

U.S. DEPARTMENT OF THE INTERIOR
MARCH 3, 1849

U.S. DEPARTMENT OF THE INTERIOR

BRUCE BABBITT, Secretary

U.S. GEOLOGICAL SURVEY

Gordon P. Eaton, Director

For additional information write to:

Chief, Branch of Regional Research
U.S. Geological Survey
Box 25046, MS 418
Denver Federal Center
Denver, CO 80225

Copies of this report can be purchased from:

U.S. Geological Survey
Earth Science Information Center
Open-File Reports Section
Box 25286, MS 517
Denver Federal Center
Denver, CO 80225

CONTENTS

FIGURES

TABLES

Page

CONVERSION FACTORS

Multiply	By	To obtain
nanometer (nm)	3.937×10^{-8}	inch
micrometer (µm)	3.937×10^{-5}	inch
millimeter (mm)	3.937×10^{-2}	inch
meter (m)	3.937×10^{1}	inch
kilometer (km)	0.6214	mile
microgram per liter (µg/L)	6.243×10^{-8}	pound per cubic foot
milligram per liter (mg/L)	6.243×10^{-5}	pound per cubic foot
microliter (µL)	3.531×10^{-8}	cubic foot
milliliter (mL)	3.531×10^{-5}	cubic foot
liter (L)	3.531×10^{-2}	cubic foot
cubic meter per second (m^3/s)	3.531×10^{1}	cubic foot per second

Temperature in degree Celsius (°C) may be converted to degree Fahrenheit (°F) using:

$$°F = °C(1.8) + 32.0$$

TRIHALOMETHANE AND NONPURGEABLE TOTAL ORGANIC-HALIDE FORMATION POTENTIALS FOR THE MISSISSIPPI RIVER AND SOME OF ITS TRIBUTARIES, SEPTEMBER-OCTOBER 1991

R.E. Rathbun and L.M. Bishop

ABSTRACT

Trihalomethane and nonpurgeable total organic-halide formation potentials were determined for the Mississippi River and some of its tributaries from water samples collected between September 25, 1991, and October 7, 1991. Formation potentials were measured for 12 sites along the Mississippi River between Minneapolis, Minnesota, and New Orleans, Louisiana, and for the Missouri and Ohio Rivers at sites 1.6 kilometers upstream from their confluences with the Mississippi River. Formation potentials were determined as a function of initial pH and initial free-chlorine concentration for one reaction time of 168.0 hours at a temperature of 25 degrees Celsius. The formation potentials also were determined as a function of reaction time over a 168.0-hour period for an initial pH of 7.50 and an initial free-chlorine concentration of 30.0 milligrams per liter. Ancillary measurements include determinations of pH as a function of reaction time, pH values at the end of the formation-potential experiments, dissolved organic-carbon and bromide concentrations, ultraviolet absorbances, and specific conductances. All experiments except the reaction-time experiments were done in duplicate, thus permitting an analysis of the errors involved in determining the trihalomethane and nonpurgeable total organic-halide formation potentials. Results of the formation-potential determinations, the ancillary measurements, and the error analysis are listed in tables.

INTRODUCTION

The Mississippi River begins in Lake Itasca in north-central Minnesota and drains into the Gulf of Mexico, 3,720 km downstream at a point in Louisiana called Head of Passes. The river flows through Minnesota and Louisiana and forms parts of the borders of Wisconsin, Iowa, Illinois, Missouri, Kentucky, Tennessee, Arkansas, and Mississippi. Numerous cities, towns, and villages in these States use the Mississippi River as a source of drinking water. Other population centers along the river might begin to use the Mississippi River as a source of drinking water as ground-water supplies are depleted and as the population increases.

To make water from the Mississippi River safe for drinking, the water first must be disinfected, usually with free chlorine, to eliminate the possibility of the transmission of water-borne diseases such as typhoid fever. Research (Rook, 1974; Bellar and others, 1974; Fleischacker and Randtke, 1983; and Johnson and Jensen, 1986) has indicated, however, that chlorination of natural waters results in the formation of various byproducts, some of which may be health hazards. Therefore, the potential for the formation of these byproducts must be considered when the Mississippi River is used as a source of drinking water.

These byproduct compounds are divided into two classes. The first class consists of the trihalomethane (THM) compounds, which are chlorinated and brominated derivatives of methane. The four compounds commonly included in this class are chloroform, bromodichloromethane, chlorodibromomethane, and bromoform. These compounds are volatile and can be determined by gas chromatography techniques. The second class consists of chlorinated and brominated compounds with molecular weights higher than those of the THM compounds. Compounds in this second class are more polar and generally are nonvolatile. They are more difficult to determine as individual compounds; consequently, they commonly are determined together as a bulk parameter called the total organic-halide (TOX) concentration. Because this measurement also includes the THM compounds, the samples usually are purged with an inert gas before analysis to remove the volatile THM compounds. This procedure results in the nonpurgeable total organic-halide (NPTOX) concentration.

The U.S. Geological Survey Mississippi River project is a multidisciplinary study of the water-quality characteristics of the river. Specific topics of study include the distribution of agricultural pesticides and herbicides, trace metals, and industrial organic chemicals among the water, sediment, and biotic phases of the river system and how these substances are transported by the river. Also of interest are the water-quality characteristics of the Mississippi River related to its use as a source of drinking water. Water characteristics affecting this use include constituents already present in the water as well as constituents that are formed when the water is chlorinated to make it safe for drinking. The objective of this report is to describe the results of the determination of disinfection byproducts that could be formed when water from the Mississippi River is chlorinated.

Purpose and Scope

This report presents the results of the determination of THM and NPTOX formation potentials for the Mississippi River and some of its tributaries. Formation potentials for the THM and NPTOX compounds are defined as the concentrations of these compounds that are formed when water samples are chlorinated at specific conditions of pH, free-chlorine concentration, reaction time, and temperature. In this study, formation potentials were determined for water from 12 sites along the Mississippi River between Minneapolis, Minn., and New Orleans, La., and for water from the Missouri and Ohio Rivers at sites 1.6 km upstream from their confluences with the Mississippi River. Water samples were collected between September 25, 1991, and October 7, 1991. Formation potentials were determined as a function of initial pH and initial free-chlorine concentration for one reaction time of 168.0 hours at a temperature of 25°C. Also, the formation potentials were determined as a function of reaction time over a 168.0-hour period for an initial pH of 7.50 and an initial free-chlorine concentration of 30.0 mg/L.

Acknowledgments

Water samples upon which this work was based were collected as a part of the U.S. Geological Survey Mississippi River project under the direction of R.H. Meade. J.A. Moody provided logistical support. Craig LeBoeuf and George Collier piloted the research vessel ACADIANA, and Chuck Guidry was the cook. L.B. Barber II, D.A. Goolsby, Dick Martin, Harold Wiegner, and Charles Tabor assisted with the sampling. J.A. Moody collected the Minneapolis, Minn., sample. Appreciation is expressed to all who helped with this study.

PROCEDURE FOR DETERMINATION OF TRIHALOMETHANE AND NONPURGEABLE TOTAL ORGANIC-HALIDE FORMATION POTENTIALS

Sampling Procedure

The 17-m research vessel ACADIANA, owned and operated by the Louisiana Universities Marine Consortium, was used for collecting samples. Grab samples of water were collected by dropping a stainless-steel bucket off the port side of the vessel. The bucket was rinsed once with river water before collecting the sample. Single samples usually were collected from the midpoint of the navigation channel. One exception was the Ohio River, where there was a question about whether the various tributaries flowing into the Ohio River would be mixed at the sampling location. Consequently, a composite sample of equal volumes was collected from points located at 0.1, 0.5, and 0.9 of the width measured from the left edge of the water.

On the Mississippi River, the sampling locations generally were slightly upstream from metropolitan areas. General locations in terms of the metropolitan area and specific locations in terms of cumulative river kilometers upstream from Head of Passes, La., for the sampling sites, dates and times of sample collection, and water discharges at the sampling times are listed in table 1. Location of the sampling sites is shown in figure 1.

Table 1.--General location and cumulative river kilometers upstream from Head of Passes, La., for the sampling sites, dates and times of sampling, and water discharges

[m^3/s, cubic meters per second; NQ, water discharge not available]

General location	Cumulative river kilometers	Date	Time (hours)	Water discharge[1] (m^3/s)
Minneapolis, Minn.	2,915.2	10-07-91	1030	230
LaCrosse, Wis.	2,666.9	10-04-91	0151	940
Dubuque, Iowa	2,470.7	10-03-91	0904	1,300
Davenport, Iowa	2,325.2	10-02-91	2141	1,400
Quincy, Ill.	2,068.4	10-01-91	2107	2,000
Missouri River[2]	1,850.8	09-30-91	2333	1,100
St. Louis, Mo.	1,825.1	09-30-91	2140	3,200
Cairo, Ill.	1,552.3	09-30-91	0039	3,700
Ohio River[2]	1,536.5	09-29-91	2122	1,800
Memphis, Tenn.	1,194.1	09-28-91	1811	5,600
Greenville, Miss.	877.1	09-27-91	1544	6,200
Natchez, Miss.	597.4	09-26-91	1752	7,200
Baton Rouge, La.	386.9	09-26-91	0241	4,500
New Orleans, La.	169.1	09-25-91	0833	NQ

[1] Discharge data from Moody and Meade (U.S. Geological Survey, written commun., 1993).

[2] Sampling site 1.6 kilometers upstream from confluence with Mississippi River.

Figure 1.--Location of sampling sites in the Mississippi River basin.

The water sample collected at each site was transferred from the bucket to a stainless-steel reservoir for pressure filtration. The water was filtered through low-extractable 0.45-µm membrane filters that were prerinsed with about 2 L of high-purity water from a Barnstead Nanopure water system. The first 600 mL of sample water through the filter was discarded. The water collected at each site was filtered into six 1-L amber glass bottles with Teflon-lined caps. The sample bottles were chilled with ice until shipment to the laboratory in Arvada, Colo. Shipment was by overnight air freight in insulated coolers containing refrigerant cold packs. Water samples in the laboratory were stored at 4°C until the formation-potential experiments were done.

Formation-Potential Experiments

The formation potentials for the THM and NPTOX compounds were determined as a function of initial pH and initial free-chlorine concentration at 25°C for a reaction time of 168.0 hours. Initial pH values of 5.50, 7.50, and 10.00 and initial free-chlorine concentrations of 15.0, 30.0, and 50.0 mg/L were used, giving nine THM and nine NPTOX formation potentials for each water sample. These large initial free-chlorine concentrations were used to satisfy any initial chlorine demand of the water sample and to ensure a residual free-chlorine concentration at the end of the 168.0-hour reaction time. The 168.0-hour reaction time was used to cover the maximum possible time water might be in a distribution system before use. Formation potentials also were determined as a function of time during the 168.0-hour period for an initial pH of 7.50 and an initial free-chlorine concentration of 30.0 mg/L.

The formation-potential experiments were done in 40-mL amber glass vials with Teflon-faced septum caps. Initiation of an experiment consisted of adjusting the pH of the water sample to the desired initial pH using 0.1 normal and 1.0 normal sulfuric acid and sodium hydroxide. The desired initial free-chlorine concentration was obtained by adding the appropriate volume of a reagent-grade sodium hypochlorite solution. The free-chlorine concentration of this solution was determined prior to the start of each experiment by using an amperometric titration procedure. Blank samples of each water sample were taken before the addition of the sodium hypochlorite solution.

Sample vials were filled completely so that no head space existed. Vials were placed in an incubator at 25°C. All 168.0-hour experiments were done with duplicate vials. At the end of 168.0 hours, the experiments were terminated by quenching the remaining free chlorine with a sodium thiosulfate solution for the THM experiments and sodium sulfite crystals for the NPTOX experiments. For the reaction-time experiments, samples were quenched at approximate times of 0, 2, 6, 12, 24, 48, 72, 120, and 168.0 hours.

Before quenching the NPTOX samples, 5.0 mL of sample was removed from each of the vials and used to estimate the residual free-chlorine concentrations. The concentration of residual free-chlorine was estimated using a Hach chlorine test kit, which has a range from 0 to 3.5 mg/L with 0.1-mg/L divisions. After acidification to a pH of about 2 with nitric acid, the NPTOX samples were purged for 10 minutes with ultrahigh-purity nitrogen gas to remove the THM compounds. Samples were stored in an incubator at 4°C until analysis.

Analysis of Trihalomethane Samples

Concentrations of the THM compounds in the samples were determined with a solvent-extraction procedure (Federal Register, 1979) with pentane as the solvent. The procedure was modified slightly in that the sample extractions were done directly in the sample vials to avoid having to transfer a sample containing volatile constituents. The procedure consisted of removing and discarding 4.5 mL of sample, adding 4.0 mL of pentane, and shaking the mixture for 1.5 minutes. The Burdick and Jackson brand of pentane especially formulated for THM analyses was used. The vials containing the water and pentane layers were stored upside down at 4°C until analysis. Storing the samples upside down precluded any loss of the pentane or the THM compounds from the sample vial during storage.

The pentane extracts were analyzed with a Hewlett-Packard 5880-A gas chromatograph equipped with an electron-capture detector. A 12-m Hewlett-Packard, cross-linked, methyl silicone-gum capillary column was used with the purged splitless technique. Retention times on this column were 0.92, 1.42, 2.49, and 4.77 minutes for chloroform, bromodichloromethane, chlorodibromomethane, and bromoform, respectively.

Volumes of the 40-mL sample vials were not precisely 40.0 mL and were not consistent. To adjust for variations in the vial volumes, the vials were weighed at each step of the extraction process, beginning with the empty vial and ending with the final sample/pentane step. These weights permitted determination of the exact water/pentane volume ratio for each sample. The peak areas for each sample were adjusted from the volume ratio of that sample to the average volume ratio for the standard samples for that particular run. This procedure resulted in all samples and standards being adjusted to a single water/pentane ratio.

Standard samples of known concentrations of each of the four THM compounds were prepared according to an established procedure (Federal Register, 1979). The procedure consists of adding each of the four THM compounds to methanol in a 10-mL volumetric flask. The amount added was determined approximately by volume and precisely by weighing on a five-place analytical balance. Two additional primary standards were prepared by serial dilution of this standard using gas-tight syringes. Secondary standards covering the expected range of sample concentrations were prepared by injecting microliter quantities of the primary standards into river water contained in 40-mL septum vials. River water was used to prepare the standards to eliminate any possible effect of the water chemistry on the efficiency of the extraction procedure. These secondary standards were treated exactly as the samples from the experiments except that sodium hypochlorite was not added to the standards. A new set of standards was prepared for each river-water sample.

A large number of standards was necessary because the response of the electron-capture detector was somewhat nonlinear. Also, the standards had to cover a wide range of concentrations so that the peak areas of each of the four THM compounds in every sample were bracketed by the peak areas of the standards. The number of standards ranged from 16 for the Minneapolis sample to 11 for the New Orleans sample. These standards were analyzed twice each day, resulting in 42 to 53 percent of the samples analyzed each day being standards.

Analysis of Nonpurgeable Total Organic-Halide Samples

Concentrations of the NPTOX compounds in the samples were determined using a Dohrmann DX-20A TOX analyzer with an AD-3 adsorption module. This procedure involved adsorption of the organic compounds from the water sample onto granular activated carbon packed in glass columns. Two of these columns were used in series for each sample. Following adsorption of the sample, the contents of the columns were washed with 2 mL of a 0.08 normal potassium nitrate solution to remove inorganic halides. The granular activated carbon then was removed from the columns and burned in a furnace at 800°C where the chlorinated and brominated compounds were converted to an equivalent amount of halide ions. These ions were titrated in a microcoulometric cell, resulting in the determination of the mass of NPTOX compounds in the original sample. The NPTOX concentration was computed from this mass and the volume of sample sorbed in the adsorption step.

The high concentrations of NPTOX compounds resulting from the formation-potential experiments required dilution of the samples to get the concentration within the response range of the instrument. Samples were diluted with high-purity water from a Barnstead Nanopure system. A blank determination for this dilution water was done each day samples were run. Usually, 30 mL of mixture was prepared, with the amount of sample ranging from 5 to 25 mL, depending on the expected concentration. All aliquots were measured with Class A pipets, and 25 mL of this 30-mL sample was forced through the glass columns containing the granular activated carbon using ultrahigh-purity nitrogen gas.

Operation of the microcoulometric cell was verified at the beginning of each day by injections of a sodium chloride standard directly into the electrolyte of the cell. These verifications also were done any time during the day when it became necessary to change the cell electrolyte. Recovery of the instrument was checked at the beginning of each day by injections of a trichlorophenol standard onto granular activated-carbon ash in the instrument boat and subsequent analysis of the trichlorophenol standard. These recovery checks also were repeated any time during the day when it became necessary to change the cell electrolyte and on any other occasion when operation of the instrument might be questionable. If results of these checks deviated by more than ±10 percent from the expected values, steps were taken to improve the performance of the instrument by changing the cell electrolyte and the inlet and exit tube liners and by cleaning the hatch area.

Determination of pH

Initial pH values of the water samples were 5.50, 7.50, and 10.00. Because these water samples were not buffered, the pH of the 5.50 and 7.50 water samples increased, and the pH of the 10.00 water samples decreased slightly when the basic sodium hypochlorite solution was added to provide the free-chlorine concentration. To determine the variation of the pH with time, the pH values of each of the nine combinations of initial pH and initial free-chlorine concentration were determined at reaction times of approximately 0, 24, 48, 72, 120, 144, and 168 hours.

Measurements were made using an Orion Model 811 pH meter with a 91–02 research-grade pH probe. These samples were prepared at the same time the vials for the formation-potential experiments were filled. Amber glass bottles having Teflon-lined caps, a volume of 70 mL, and a mouth wide enough to accommodate the pH and temperature probes of the instrument were used for this purpose. The pH meter was calibrated each day before the measurements were done. A two-point calibration using buffers of 6.86 and 10.00 bracketed all the experimental pH values.

The pH values of the THM formation-potential experiments also were determined after completion of the gas chromatographic analyses. The pentane was evaporated, and the pH of the remaining water was determined for each of the nine samples.

Determination of Dissolved Organic-Carbon and Bromide Concentrations

Dissolved organic-carbon (DOC) and bromide concentrations of the water samples were determined at the U.S. Geological Survey National Water Quality Laboratory in Arvada, Colo. DOC concentration was determined using the wet-oxidation method (Wershaw and others, 1987). Duplicate samples were analyzed for all samples. Bromide concentrations were determined using segmented-flow automated colorimetry (Fishman and Friedman, 1989).

Determination of Specific Conductances

Specific conductances of the sample waters were measured using a Yellow Springs Instrument Company model 32 conductance meter. Temperatures of the water samples were adjusted to 25.0°C so that no temperature corrections were necessary.

Determination of Ultraviolet Absorbances

The ultraviolet (UV) absorbance of natural waters has been used as a predictor of the DOC concentration. Various UV wavelengths have been used (Buffle and others, 1978; Oliver and Thurman, 1981; Edzwald and others, 1985; Ceraso, 1987; Chadick and Amy, 1987; Moore, 1987). Therefore, UV absorbances of the water samples were determined at wavelengths of 254, 280, 330, and 400 nm. A Spectronics model 2000 spectrophotometer with a 50-mm cell was used for these determinations. Absorbances were measured for both the pH-adjusted water samples and the natural water samples.

RESULTS OF SAMPLE COLLECTION AND FORMATION-POTENTIAL EXPERIMENTS

Trihalomethane and Nonpurgeable Total Organic-Halide Formation Potentials

The potentials for formation of THM and NPTOX compounds when the water samples were treated with free chlorine are expressed as the concentrations of these compounds formed in the experiments. Two types of results were obtained. The first type consisted of concentrations of the THM and NPTOX compounds formed during a reaction time of 168.0 hours for nine combinations of initial pH and initial free-chlorine concentration. The second type consisted of concentrations of the THM and NPTOX compounds formed as a function of time during the reaction time of 168.0 hours for an initial pH of 7.50 and an initial free-chlorine concentration of 30.0 mg/L. Typical results of the first type (fig. 2) show THM and NPTOX concentrations as a function of cumulative river kilometers upstream from Head of Passes, La., for an initial pH of 10.00 and an initial free-chlorine concentration of 30.0 mg/L. The DOC concentrations also are shown in figure 2. Typical results of the second type (fig. 3) show THM and NPTOX concentrations as a function of reaction time for several sampling sites along the Mississippi River.

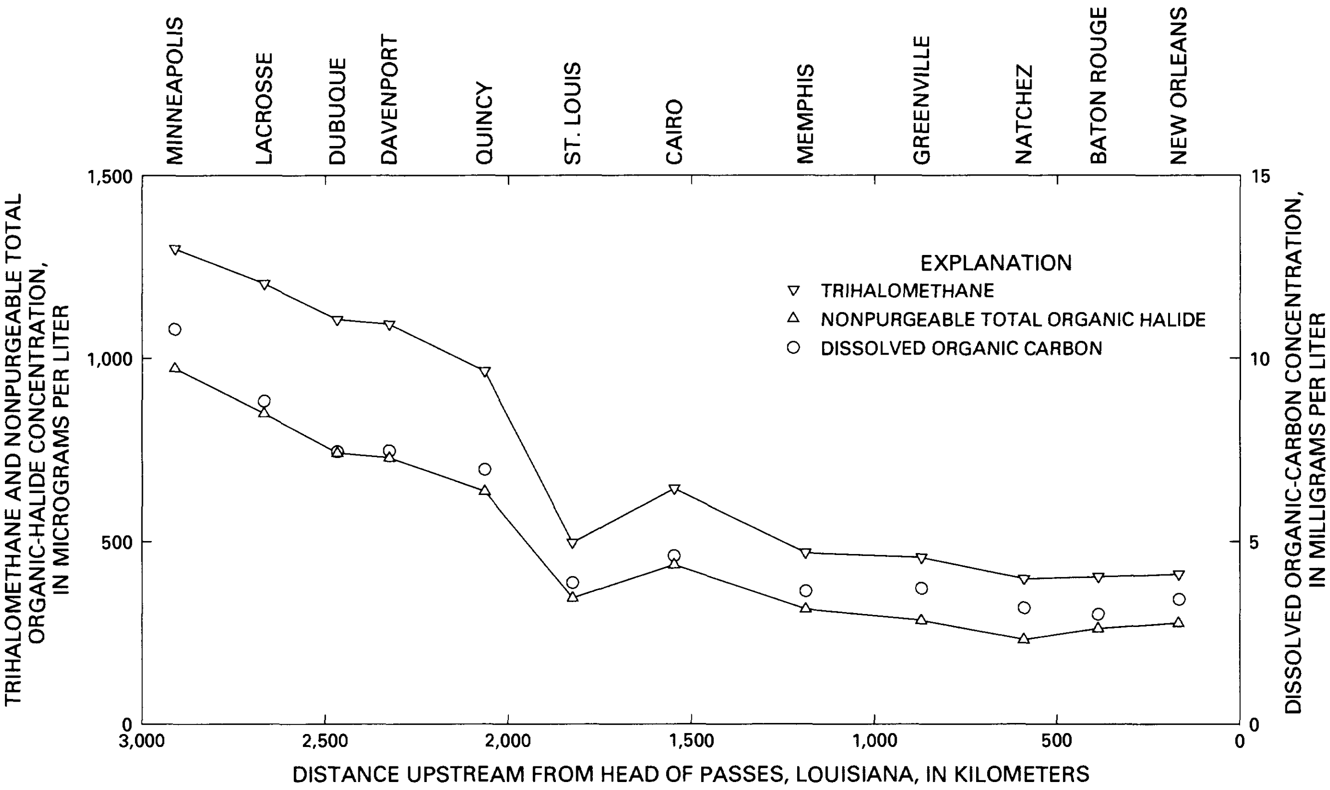

Figure 2.--Trihalomethane, nonpurgeable total organic-halide, and dissolved organic-carbon concentrations as a function of cumulative river kilometers upstream from Head of Passes, La.; initial pH of 10.00 and initial free-chlorine concentration of 30.0 milligrams per liter.

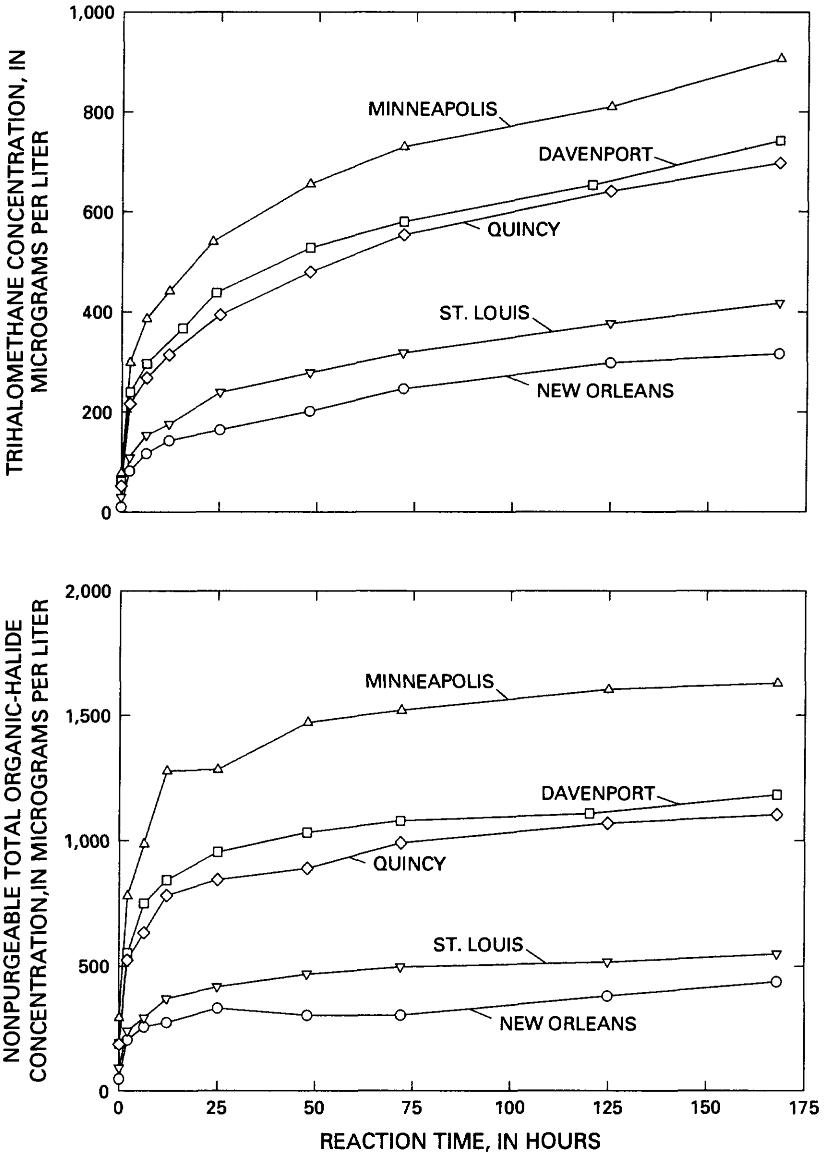

Figure 3.--Trihalomethane and nonpurgeable total organic-halide concentrations as a function of reaction time for several sampling sites along the Mississippi River; initial pH of 7.50 and initial free-chlorine concentration of 30.0 milligrams per liter.

All concentrations were corrected for blank contributions. The blank corrections for chloroform ranged from 0.15 to 0.97 µg/L and averaged 0.47 µg/L for 42 determinations. Average blank corrections for the other three THM compounds were less than 0.02 µg/L. Blank corrections for the NPTOX concentrations ranged from 6.12 to 29.1 µg/L and averaged 17.1 µg/L for 36 determinations for samples from the Mississippi River. Corrections for the Missouri River water sample ranged from 4.85 to 8.05 µg/L and averaged 6.38 µg/L. Corrections for the Ohio River water sample ranged from 15.6 to 18.8 µg/L and averaged 17.4 µg/L.

The three chlorinated THM compounds (chloroform, bromodichloromethane, and chlorodibromomethane) were detected in all samples. Bromoform was not detected in 36 percent of the samples. The detection limit for bromoform for the analytical procedure used in this study was estimated to be about 0.01 µg/L.

For the first type of results, duplicate experiments were done for all nine combinations of initial pH and initial free-chlorine concentration for each water sample. Some of the vials for the Minneapolis, LaCrosse, and Dubuque water samples had no detectable free-chlorine concentrations at the end of the reaction time. The limit of detection of the procedure used for these free-chlorine measurements was 0.1 mg/L. Concentrations for these samples are flagged with an asterisk in tables 2–4 to indicate that these concentrations could have been affected by the lack of a free-chlorine residual at the end of the experiments.

For the second type of results, duplicate experiments were done for a reaction time of 168.0 hours and single experiments were done for all other reaction times. The 0.00-hour reaction-time samples were samples taken and quenched immediately after addition of the sodium hypochlorite solution to the water sample. The time required to add the sodium hypochlorite solution to the water sample in a separatory funnel, to mix the contents, to fill the 0.00-hour time vials already containing the quenching agent, and to shake these vials ranged from 30 to 45 seconds.

The first type of results consisting of concentrations of the four THM compounds and the total THM and NPTOX concentrations for a reaction time of 168.0 hours and nine combinations of initial pH and free-chlorine concentration are listed in tables 2–15. The second type of results consisting of concentrations of the four THM compounds and the total THM and NPTOX concentrations as a function of reaction time for an initial pH of 7.50 and an initial free-chlorine concentration of 30.0 mg/L are listed in tables 16–29. The concentrations for the 168.0-hour reaction time for an initial pH of 7.50 and an initial free-chlorine concentration of 30.0 mg/L are parts of both the first and second types of results. Therefore, these concentrations are presented in both tables 2–15 and tables 16–29.

Table 2.--Concentrations of the four trihalomethane compounds and the total trihalomethane and nonpurgeable total organic-halide concentrations for a reaction time of 168.0 hours as a function of initial pH and initial free-chlorine concentration, Mississippi River at Minneapolis, Minn., October 7, 1991

[µg/L, microgram per liter; CL, free-chlorine concentration; mg/L, milligram per liter; $CHCl_3$, chloroform; $BrCHCl_2$, bromodichloromethane; $ClCHBr_2$, chlorodibromomethane; $CHBr_3$, bromoform; THM, trihalomethane; NPTOX, nonpurgeable total organic halide; ND, not detected]

Initial pH	Initial CL (mg/L)	Concentration (µg/L)					
		$CHCl_3$	$BrCHCl_2$	$ClCHBr_2$	$CHBr_3$	Total THM	NPTOX
5.50	15.0	425*	22.5*	0.33*	ND*	448*	1,250*
5.50	15.0	426*	22.1*	.31*	ND*	448*	1,330*
5.50	30.0	603	23.4	.31	ND	627	1,830
5.50	30.0	606	22.9	.44	ND	629	1,960
5.50	50.0	771	23.8	.33	ND	795	2,210
5.50	50.0	750	22.9	.31	ND	773	2,290
7.50	15.0	585*	25.6*	.45*	ND*	611*	1,040*
7.50	15.0	592*	26.4*	.45*	ND*	619*	1,020*
7.50	30.0	873	31.1	.47	ND	905	1,640
7.50	30.0	883	31.0	.47	ND	914	1,620
7.50	50.0	1,150	30.8	.50	ND	1,180	1,740
7.50	50.0	1,120	28.2	.45	ND	1,150	1,740
10.00	15.0	856*	23.4*	.50*	ND*	880*	768*
10.00	15.0	873*	23.7*	.53*	ND*	897*	780*
10.00	30.0	1,300	28.6	.58	ND	1,330	981
10.00	30.0	1,290	28.7	.61	ND	1,320	1,020
10.00	50.0	1,500	30.6	.60	ND	1,530	1,020
10.00	50.0	1,510	30.5	.59	ND	1,540	1,180

*Free-chlorine concentration less than the detection limit at reaction time of 168.0 hours.

Table 3.--Concentrations of the four trihalomethane compounds and the total trihalomethane and nonpurgeable total organic-halide concentrations for a reaction time of 168.0 hours as a function of initial pH and initial free-chlorine concentration, Mississippi River at LaCrosse, Wis., October 4, 1991

[µg/L, microgram per liter; CL, free-chlorine concentration; mg/L, milligram per liter; $CHCl_3$, chloroform; $BrCHCl_2$, bromodichloromethane; $ClCHBr_2$, chlorodibromomethane; $CHBr_3$, bromoform; THM, trihalomethane; NPTOX, nonpurgeable total organic halide; ND, not detected]

Initial pH	Initial CL (mg/L)	Concentration (µg/L)					
		$CHCl_3$	$BrCHCl_2$	$ClCHBr_2$	$CHBr_3$	Total THM	NPTOX
5.50	15.0	447	20.4	0.33	ND	468	1,310
5.50	15.0	436	20.3	.59	ND	457	1,320
5.50	30.0	554	19.4	.36	ND	574	1,660
5.50	30.0	556	20.0	.32	ND	576	1,630
5.50	50.0	691	21.0	.52	ND	713	1,880
5.50	50.0	685	20.4	.38	ND	706	1,930
7.50	15.0	607*	23.7*	.49*	ND*	631*	1,020*
7.50	15.0	609*	24.2*	.49*	ND*	634*	987*
7.50	30.0	822	28.2	.52	ND	851	1,390
7.50	30.0	818	27.8	.51	ND	846	1,360
7.50	50.0	1,030	26.7	.52	ND	1,060	1,460
7.50	50.0	995	26.4	.51	ND	1,020	1,470
10.00	15.0	926*	23.3*	.57*	ND*	950*	757*
10.00	15.0	933*	23.6*	.69*	ND*	957*	700*
10.00	30.0	1,200	28.0	.60	ND	1,230	840
10.00	30.0	1,170	26.5	.55	ND	1,200	938
10.00	50.0	1,340	28.1	.57	ND	1,370	993
10.00	50.0	1,350	28.4	.56	ND	1,380	1,060

*Free-chlorine concentration less than the detection limit at reaction time of 168.0 hours.

Table 4.--Concentrations of the four trihalomethane compounds and the total trihalomethane and nonpurgeable total organic-halide concentrations for a reaction time of 168.0 hours as a function of initial pH and initial free-chlorine concentration, Mississippi River at Dubuque, Iowa, October 3, 1991

[µg/L, microgram per liter; CL, free-chlorine concentration; mg/L, milligram per liter; $CHCl_3$, chloroform; $BrCHCl_2$, bromodichloromethane; $ClCHBr_2$, chlorodibromomethane; $CHBr_3$, bromoform; THM, trihalomethane; NPTOX, nonpurgeable total organic halide; ND, not detected]

Initial pH	Initial CL (mg/L)	Concentration (µg/L)					
		$CHCl_3$	$BrCHCl_2$	$ClCHBr_2$	$CHBr_3$	Total THM	NPTOX
5.50	15.0	397	20.6	0.40	ND	418	1,130
5.50	15.0	383	19.2	.38	ND	403	1,180
5.50	30.0	506	20.2	.38	ND	527	1,370
5.50	30.0	495	20.1	.37	ND	515	1,460
5.50	50.0	633	20.9	.37	ND	654	1,620
5.50	50.0	637	21.1	.38	ND	658	1,660
7.50	15.0	563*	22.9*	.44*	ND*	586*	920*
7.50	15.0	578*	23.8*	.47*	ND*	602*	941*
7.50	30.0	729	25.9	.48	ND	755	1,210
7.50	30.0	736	25.6	.49	ND	762	1,240
7.50	50.0	882	25.2	.47	ND	908	1,240
7.50	50.0	885	25.5	.58	ND	911	1,270
10.00	15.0	873	23.1	.57	ND	897	619
10.00	15.0	832	22.5	.57	ND	855	642
10.00	30.0	1,090	25.3	.59	ND	1,120	728
10.00	30.0	1,100	25.2	.59	ND	1,130	804
10.00	50.0	1,170	25.5	.55	ND	1,200	795
10.00	50.0	1,190	26.3	.58	ND	1,220	865

*Free-chlorine concentration less than the detection limit at reaction time of 168.0 hours.

Table 5.--Concentrations of the four trihalomethane compounds and the total trihalomethane and nonpurgeable total organic-halide concentrations for a reaction time of 168.0 hours as a function of initial pH and initial free-chlorine concentration, Mississippi River at Davenport, Iowa, October 2, 1991

[µg/L, microgram per liter; CL, free-chlorine concentration; mg/L, milligram per liter; $CHCl_3$, chloroform; $BrCHCl_2$, bromodichloromethane; $ClCHBr_2$, chlorodibromomethane; $CHBr_3$, bromoform; THM, trihalomethane; NPTOX, nonpurgeable total organic halide; ND, not detected]

Initial pH	**Initial CL (mg/L)**	**Concentration (µg/L)**					
		$CHCl_3$	**$BrCHCl_2$**	**$ClCHBr_2$**	**$CHBr_3$**	**Total THM**	**NPTOX**
5.50	15.0	381	21.1	0.44	ND	403	1,180
5.50	15.0	386	21.1	.43	ND	408	1,160
5.50	30.0	491	21.3	.45	ND	513	1,460
5.50	30.0	491	21.8	.44	ND	513	1,480
5.50	50.0	583	21.8	.42	ND	605	1,540
5.50	50.0	601	22.5	.74	ND	624	1,540
7.50	15.0	568	26.1	.62	ND	595	917
7.50	15.0	561	25.9	.60	ND	588	875
7.50	30.0	720	29.1	.67	ND	750	1,150
7.50	30.0	709	28.9	.70	ND	739	1,200
7.50	50.0	842	27.3	.61	ND	870	1,190
7.50	50.0	844	27.2	.60	ND	872	1,210
10.00	15.0	835	24.4	.72	ND	860	606
10.00	15.0	845	24.6	.72	ND	870	644
10.00	30.0	1,080	27.2	.73	ND	1,110	754
10.00	30.0	1,070	26.8	.70	ND	1,100	752
10.00	50.0	1,170	27.4	.68	ND	1,200	815
10.00	50.0	1,180	27.4	.69	ND	1,210	834

Table 6.--Concentrations of the four trihalomethane compounds and the total trihalomethane and nonpurgeable total organic-halide concentrations for a reaction time of 168.0 hours as a function of initial pH and initial free-chlorine concentration, Mississippi River at Quincy, Ill., October 1, 1991

[µg/L, microgram per liter; CL, free-chlorine concentration; mg/L, milligram per liter; $CHCl_3$, chloroform; $BrCHCl_2$, bromodichloromethane; $ClCHBr_2$, chlorodibromomethane; $CHBr_3$, bromoform; THM, trihalomethane; NPTOX, nonpurgeable total organic halide; ND, not detected]

Initial pH	Initial CL (mg/L)	Concentration (µg/L)					
		$CHCl_3$	$BrCHCl_2$	$ClCHBr_2$	$CHBr_3$	Total THM	NPTOX
5.50	15.0	337	23.2	0.67	ND	361	1,050
5.50	15.0	336	22.1	.66	ND	359	1,060
5.50	30.0	440	24.1	.69	ND	465	1,340
5.50	30.0	439	23.9	.65	ND	464	1,350
5.50	50.0	554	25.8	.71	ND	581	1,410
5.50	50.0	554	25.5	.65	ND	580	1,470
7.50	15.0	539	30.3	1.04	ND	570	916
7.50	15.0	553	30.7	1.05	ND	585	941
7.50	30.0	664	34.0	1.07	ND	699	1,070
7.50	30.0	662	34.2	1.03	ND	697	1,120
7.50	50.0	812	32.9	1.08	ND	846	1,130
7.50	50.0	809	32.3	1.01	ND	842	1,140
10.00	15.0	807	30.7	1.34	ND	839	603
10.00	15.0	800	30.0	1.22	ND	831	626
10.00	30.0	949	32.7	1.16	ND	983	661
10.00	30.0	958	32.6	1.14	ND	992	679
10.00	50.0	797	30.0	1.21	ND	828	592
10.00	50.0	778	29.1	1.18	ND	808	635

Table 7.--Concentrations of the four trihalomethane compounds and the total trihalomethane and nonpurgeable total organic-halide concentrations for a reaction time of 168.0 hours as a function of initial pH and initial free-chlorine concentration, Missouri River 1.6 kilometers upstream from confluence with Mississippi River, September 30, 1991

[µg/L, microgram per liter; CL, free-chlorine concentration; mg/L, milligram per liter; $CHCl_3$, chloroform; $BrCHCl_2$, bromodichloromethane; $ClCHBr_2$, chlorodibromomethane; $CHBr_3$, bromoform; THM, trihalomethane; NPTOX, nonpurgeable total organic halide]

Initial pH	Initial CL (mg/L)	Concentration (µg/L)					
		$CHCl_3$	$BrCHCl_2$	$ClCHBr_2$	$CHBr_3$	Total THM	NPTOX
5.50	15.0	89.9	36.0	10.3	0.68	137	357
5.50	15.0	90.6	35.7	10.1	.67	137	372
5.50	30.0	115	36.4	8.60	.43	160	401
5.50	30.0	115	34.8	8.21	.44	158	411
5.50	50.0	140	35.2	7.22	.27	183	445
5.50	50.0	145	36.5	7.51	.29	189	448
7.50	15.0	158	52.0	18.5	1.62	230	281
7.50	15.0	157	53.0	19.2	1.65	231	284
7.50	30.0	184	57.7	18.8	1.27	262	309
7.50	30.0	182	57.5	18.9	1.29	260	351
7.50	50.0	232	56.6	16.8	1.23	307	334
7.50	50.0	253	59.8	16.9	1.31	331	367
10.00	15.0	218	53.9	22.2	3.57	298	190
10.00	15.0	213	52.7	21.5	3.49	291	223
10.00	30.0	245	54.9	21.2	3.01	324	219
10.00	30.0	253	55.6	21.1	2.99	333	232
10.00	50.0	277	55.1	19.8	2.54	354	237
10.00	50.0	284	56.4	20.8	2.55	364	256

Table 8.--Concentrations of the four trihalomethane compounds and the total trihalomethane and nonpurgeable total organic-halide concentrations for a reaction time of 168.0 hours as a function of initial pH and initial free-chlorine concentration, Mississippi River at St. Louis, Mo., September 30, 1991

[μg/L, microgram per liter; CL, free-chlorine concentration; mg/L, milligram per liter; $CHCl_3$, chloroform; $BrCHCl_2$, bromodichloromethane; $ClCHBr_2$, chlorodibromomethane; $CHBr_3$, bromoform; THM, trihalomethane; NPTOX, nonpurgeable total organic halide]

Initial pH	Initial CL (mg/L)	Concentration (μg/L)					
		$CHCl_3$	$BrCHCl_2$	$ClCHBr_2$	$CHBr_3$	Total THM	NPTOX
5.50	15.0	181	35.2	5.55	0.15	222	596
5.50	15.0	182	35.5	5.59	.16	223	626
5.50	30.0	220	35.8	4.74	.10	261	690
5.50	30.0	225	37.2	4.81	.10	267	685
5.50	50.0	270	37.7	4.46	.06	312	787
5.50	50.0	269	36.5	4.38	.07	310	775
7.50	15.0	290	53.7	8.29	.24	352	482
7.50	15.0	294	52.3	8.23	.25	355	485
7.50	30.0	350	64.5	9.07	.21	424	549
7.50	30.0	344	60.8	8.55	.19	414	551
7.50	50.0	415	59.1	8.19	.19	482	546
7.50	50.0	409	58.0	8.11	.19	475	551
10.00	15.0	398	53.6	9.60	.52	462	306
10.00	15.0	400	53.9	9.63	.53	464	314
10.00	30.0	442	54.9	9.11	.42	506	350
10.00	30.0	443	55.5	9.34	.43	508	391
10.00	50.0	466	55.1	8.92	.38	530	372
10.00	50.0	479	57.7	9.26	.40	546	373

Table 9.--Concentrations of the four trihalomethane compounds and the total trihalomethane and nonpurgeable total organic-halide concentrations for a reaction time of 168.0 hours as a function of initial pH and initial free-chlorine concentration, Mississippi River at Cairo, Ill., September 30, 1991

[µg/L, microgram per liter; CL, free-chlorine concentration; mg/L, milligram per liter; $CHCl_3$, chloroform; $BrCHCl_2$, bromodichloromethane; $ClCHBr_2$, chlorodibromomethane; $CHBr_3$, bromoform; THM, trihalomethane; NPTOX, nonpurgeable total organic halide; ND, not detected]

Initial pH	Initial CL (mg/L)	Concentration (µg/L)					
		$CHCl_3$	$BrCHCl_2$	$ClCHBr_2$	$CHBr_3$	Total THM	NPTOX
5.50	15.0	258	35.0	3.30	0.11	296	789
5.50	15.0	256	34.3	3.23	.10	294	786
5.50	30.0	315	36.3	3.46	.04	355	886
5.50	30.0	357	39.7	3.86	ND	401	843
5.50	50.0	369	36.4	3.13	ND	409	705
5.50	50.0	364	35.2	2.96	ND	402	785
7.50	15.0	366	47.5	5.54	.10	419	542
7.50	15.0	380	48.5	5.65	.10	434	606
7.50	30.0	449	54.9	5.91	.08	510	730
7.50	30.0	437	54.2	5.85	.08	497	723
7.50	50.0	540	51.0	5.35	.08	596	716
7.50	50.0	544	52.2	5.46	.08	602	698
10.00	15.0	530	48.4	6.63	.24	585	411
10.00	15.0	535	49.8	6.90	.26	592	419
10.00	30.0	633	55.2	7.05	.22	695	442
10.00	30.0	602	49.6	6.19	.19	658	456
10.00	50.0	658	52.5	6.45	.19	717	464
10.00	50.0	656	52.1	6.35	.18	715	499

Table 10.--Concentrations of the four trihalomethane compounds and the total trihalomethane and nonpurgeable total organic-halide concentrations for a reaction time of 168.0 hours as a function of initial pH and initial free-chlorine concentration, Ohio River 1.6 kilometers upstream from confluence with Mississippi River, September 29, 1991

[µg/L, microgram per liter; CL, free-chlorine concentration; mg/L, milligram per liter; $CHCl_3$, chloroform; $BrCHCl_2$, bromodichloromethane; $ClCHBr_2$, chlorodibromomethane; $CHBr_3$, bromoform; THM, trihalomethane; NPTOX, nonpurgeable total organic halide]

Initial pH	Initial CL (mg/L)	Concentration (µg/L)					
		$CHCl_3$	$BrCHCl_2$	$ClCHBr_2$	$CHBr_3$	Total THM	NPTOX
5.50	15.0	92.8	26.6	5.44	0.21	125	338
5.50	15.0	92.3	26.5	5.41	.22	124	350
5.50	30.0	126	27.3	4.77	.15	158	367
5.50	30.0	130	28.3	4.87	.15	163	355
5.50	50.0	166	29.4	4.76	.13	200	376
5.50	50.0	167	30.0	4.88	.13	202	405
7.50	15.0	143	34.0	8.88	.57	186	250
7.50	15.0	161	37.5	9.38	.61	208	258
7.50	30.0	202	39.8	9.31	.53	252	291
7.50	30.0	197	39.8	9.61	.55	247	270
7.50	50.0	237	39.5	8.96	.51	286	276
7.50	50.0	237	40.7	9.45	.54	288	280
10.00	15.0	216	36.2	10.5	1.12	264	169
10.00	15.0	215	36.4	10.4	1.11	263	181
10.00	30.0	242	38.1	10.5	.97	292	163
10.00	30.0	240	37.3	10.2	.93	288	180
10.00	50.0	272	40.1	10.5	.86	323	186
10.00	50.0	271	38.7	10.0	.81	321	199

Table 11.--Concentrations of the four trihalomethane compounds and the total trihalomethane and nonpurgeable total organic-halide concentrations for a reaction time of 168.0 hours as a function of initial pH and initial free-chlorine concentration, Mississippi River at Memphis, Tenn., September 28, 1991

[µg/L, microgram per liter; CL, free-chlorine concentration; mg/L, milligram per liter; $CHCl_3$, chloroform; $BrCHCl_2$, bromodichloromethane; $ClCHBr_2$, chlorodibromomethane; $CHBr_3$, bromoform; THM, trihalomethane; NPTOX, nonpurgeable total organic halide]

Initial pH	Initial CL (mg/L)	Concentration (µg/L)					
		$CHCl_3$	$BrCHCl_2$	$ClCHBr_2$	$CHBr_3$	Total THM	NPTOX
5.50	15.0	172	34.0	4.45	0.12	211	559
5.50	15.0	165	32.1	4.19	.11	201	568
5.50	30.0	217	34.5	3.80	.09	255	659
5.50	30.0	216	33.9	3.69	.07	254	675
5.50	50.0	280	37.4	3.81	.06	321	791
5.50	50.0	272	35.5	3.68	.05	311	752
7.50	15.0	277	48.0	7.38	.18	333	444
7.50	15.0	271	46.2	6.99	.18	324	468
7.50	30.0	322	51.8	7.40	.15	381	515
7.50	30.0	333	52.8	7.52	.15	393	541
7.50	50.0	388	50.0	7.00	.13	445	536
7.50	50.0	388	49.9	6.82	.14	445	544
10.00	15.0	375	44.0	7.65	.38	427	315
10.00	15.0	373	44.1	7.65	.38	425	305
10.00	30.0	424	45.5	7.27	.30	477	343
10.00	30.0	433	48.0	7.75	.32	489	340
10.00	50.0	463	48.4	7.52	.28	519	404
10.00	50.0	465	48.7	7.52	.28	522	403

Table 12.--Concentrations of the four trihalomethane compounds and the total trihalomethane and nonpurgeable total organic-halide concentrations for a reaction time of 168.0 hours as a function of initial pH and initial free-chlorine concentration, Mississippi River at Greenville, Miss., September 27, 1991

[µg/L, microgram per liter; CL, free-chlorine concentration; mg/L, milligram per liter; $CHCl_3$, chloroform; $BrCHCl_2$, bromodichloromethane; $ClCHBr_2$, chlorodibromomethane; $CHBr_3$, bromoform; THM, trihalomethane; NPTOX, nonpurgeable total organic halide]

Initial pH	Initial CL (mg/L)	Concentration (µg/L)					
		$CHCl_3$	$BrCHCl_2$	$ClCHBr_2$	$CHBr_3$	Total THM	NPTOX
5.50	15.0	153	33.2	4.94	0.17	191	468
5.50	15.0	149	32.5	5.01	.16	187	572
5.50	30.0	197	35.2	4.48	.15	237	571
5.50	30.0	197	35.3	4.67	.17	237	688
5.50	50.0	246	36.5	4.35	.13	287	669
5.50	50.0	241	35.1	4.21	.12	280	715
7.50	15.0	248	47.6	8.22	.30	304	409
7.50	15.0	245	45.2	7.76	.28	298	390
7.50	30.0	311	56.5	9.25	.22	377	433
7.50	30.0	307	56.4	9.20	.22	373	463
7.50	50.0	366	50.4	7.69	.20	424	480
7.50	50.0	374	54.8	8.10	.27	437	454
10.00	15.0	358	47.4	9.02	.58	415	243
10.00	15.0	364	47.7	9.04	.57	421	243
10.00	30.0	407	47.7	8.41	.46	464	282
10.00	30.0	426	50.1	8.79	.48	485	317
10.00	50.0	465	52.3	8.93	.60	527	306
10.00	50.0	458	50.0	8.62	.47	517	316

Table 13.--Concentrations of the four trihalomethane compounds and the total trihalomethane and nonpurgeable total organic-halide concentrations for a reaction time of 168.0 hours as a function of initial pH and initial free-chlorine concentration, Mississippi River at Natchez, Miss., September 26, 1991

[µg/L, microgram per liter; CL, free-chlorine concentration; mg/L, milligram per liter; $CHCl_3$, chloroform; $BrCHCl_2$, bromodichloromethane; $ClCHBr_2$, chlorodibromomethane; $CHBr_3$, bromoform; THM, trihalomethane; NPTOX, nonpurgeable total organic halide]

Initial pH	Initial CL (mg/L)	Concentration (µg/L)					
		$CHCl_3$	$BrCHCl_2$	$ClCHBr_2$	$CHBr_3$	Total THM	NPTOX
5.50	15.0	146	32.8	5.22	0.16	184	412
5.50	15.0	140	31.3	4.99	.15	176	436
5.50	30.0	176	32.8	4.51	.09	213	531
5.50	30.0	177	33.6	4.66	.09	215	472
5.50	50.0	215	34.0	4.32	.07	253	495
5.50	50.0	216	34.1	4.26	.06	254	507
7.50	15.0	237	51.4	9.80	.37	299	342
7.50	15.0	232	48.0	8.86	.34	289	343
7.50	30.0	278	50.7	8.91	.29	338	406
7.50	30.0	276	49.8	8.72	.28	335	389
7.50	50.0	328	52.5	8.67	.28	389	370
7.50	50.0	328	52.0	8.56	.28	389	429
10.00	15.0	311	45.0	9.32	.64	366	260
10.00	15.0	304	43.8	8.92	.60	357	247
10.00	30.0	343	46.2	8.81	.50	399	250
10.00	30.0	351	47.5	9.05	.52	408	237
10.00	50.0	373	47.1	8.73	.45	429	286
10.00	50.0	378	46.5	8.52	.43	433	304

Table 14.--Concentrations of the four trihalomethane compounds and the total trihalomethane and nonpurgeable total organic-halide concentrations for a reaction time of 168.0 hours as a function of initial pH and initial free-chlorine concentration, Mississippi River at Baton Rouge, La., September 26, 1991

[µg/L, microgram per liter; CL, free-chlorine concentration; mg/L, milligram per liter; $CHCl_3$, chloroform; $BrCHCl_2$, bromodichloromethane; $ClCHBr_2$, chlorodibromomethane; $CHBr_3$, bromoform; THM, trihalomethane; NPTOX, nonpurgeable total organic halide]

Initial pH	Initial CL (mg/L)	Concentration (µg/L)					
		$CHCl_3$	$BrCHCl_2$	$ClCHBr_2$	$CHBr_3$	Total THM	NPTOX
5.50	15.0	140	36.6	7.18	0.27	184	480
5.50	15.0	136	35.1	6.90	.27	178	408
5.50	30.0	169	35.1	6.18	.16	210	512
5.50	30.0	170	36.1	6.33	.18	213	535
5.50	50.0	216	39.8	6.35	.15	262	541
5.50	50.0	211	38.2	6.15	.15	256	542
7.50	15.0	209	45.0	9.91	.46	264	337
7.50	15.0	217	45.8	10.0	.46	273	360
7.50	30.0	230	46.8	9.96	.41	287	398
7.50	30.0	239	47.4	10.1	.41	297	369
7.50	50.0	305	49.3	9.75	.39	364	418
7.50	50.0	308	52.4	10.6	.42	371	394
10.00	15.0	293	49.6	12.4	.95	356	216
10.00	15.0	292	47.8	11.9	.86	353	238
10.00	30.0	348	53.8	12.6	.81	415	295
10.00	30.0	339	52.4	12.2	.79	404	255
10.00	50.0	369	53.3	12.0	.74	435	268
10.00	50.0	386	53.8	12.1	.70	453	258

Table 15.--Concentrations of the four trihalomethane compounds and the total trihalomethane and nonpurgeable total organic-halide concentrations for a reaction time of 168.0 hours as a function of initial pH and initial free-chlorine concentration, Mississippi River at New Orleans, La., September 25, 1991

[µg/L, microgram per liter; CL, free-chlorine concentration; mg/L, milligram per liter; $CHCl_3$, chloroform; $BrCHCl_2$, bromodichloromethane; $ClCHBr_2$, chlorodibromomethane; $CHBr_3$, bromoform; THM, trihalomethane; NPTOX, nonpurgeable total organic halide]

Initial pH	Initial CL (mg/L)	Concentration (µg/L)					
		$CHCl_3$	$BrCHCl_2$	$ClCHBr_2$	$CHBr_3$	Total THM	NPTOX
5.50	15.0	148	34.9	6.07	0.23	189	520
5.50	15.0	151	38.1	6.73	.26	196	523
5.50	30.0	181	39.9	6.27	.19	227	395
5.50	30.0	179	38.2	5.87	.18	223	418
5.50	50.0	215	41.5	5.82	.15	262	611
5.50	50.0	216	41.9	5.70	.14	264	596
7.50	15.0	215	41.7	11.5	.66	269	393
7.50	15.0	220	42.7	11.4	.64	275	390
7.50	30.0	251	53.7	11.0	.49	316	439
7.50	30.0	255	54.9	11.4	.50	322	445
7.50	50.0	323	59.8	11.4	.50	395	521
7.50	50.0	311	54.5	10.1	.42	376	434
10.00	15.0	302	55.8	13.3	1.17	372	308
10.00	15.0	306	55.4	13.1	1.14	376	275
10.00	30.0	348	62.2	13.8	1.06	425	296
10.00	30.0	347	60.6	13.4	1.02	422	287
10.00	50.0	377	58.5	12.3	.81	449	329
10.00	50.0	386	61.7	13.0	.88	462	321

Table 16.--Concentrations of the four trihalomethane compounds and the total trihalomethane and nonpurgeable total organic-halide concentrations as a function of reaction time for an initial pH of 7.50 and an initial free-chlorine concentration of 30.0 milligrams per liter, Mississippi River at Minneapolis, Minn., October 7, 1991

[µg/L, microgram per liter; $CHCl_3$, chloroform; $BrCHCl_2$, bromodichloromethane; $ClCHBr_2$, chlorodibromomethane; $CHBr_3$, bromoform; THM, trihalomethane; NPTOX, nonpurgeable total organic halide; ND, not detected]

Reaction time (hours)	Concentration (µg/L)					
	$CHCl_3$	$BrCHCl_2$	$ClCHBr_2$	$CHBr_3$	Total THM	NPTOX
0.00	77.5	5.33	0.07	ND	82.9	300
2.00	283	19.9	.27	ND	303	794
6.22	369	23.0	.33	ND	392	998
12.00	422	24.3	.35	ND	447	1,280
22.78	516	27.0	.41	ND	543	1,280
47.00	626	28.9	.56	ND	655	1,480
72.00	701	29.6	.45	ND	731	1,530
125.0	781	29.1	.45	ND	811	1,600
168.0	873	31.1	.47	ND	905	1,640
168.0	883	31.0	.47	ND	914	1,620

Table 17.--Concentrations of the four trihalomethane compounds and the total trihalomethane and nonpurgeable total organic-halide concentrations as a function of reaction time for an initial pH of 7.50 and an initial free-chlorine concentration of 30.0 milligrams per liter, Mississippi River at LaCrosse, Wis., October 4, 1991

[µg/L, microgram per liter; $CHCl_3$, chloroform; $BrCHCl_2$, bromodichloromethane; $ClCHBr_2$, chlorodibromomethane; $CHBr_3$, bromoform; THM, trihalomethane; NPTOX, nonpurgeable total organic halide; ND, not detected]

Reaction time (hours)	Concentration (µg/L)					
	$CHCl_3$	$BrCHCl_2$	$ClCHBr_2$	$CHBr_3$	Total THM	NPTOX
0.00	64.5	4.21	0.07	ND	68.8	225
2.00	253	16.5	.23	ND	270	709
6.00	336	19.8	.33	ND	356	842
12.00	387	20.4	.36	ND	408	1,020
24.00	485	23.4	.43	ND	509	1,150
48.00	592	22.3	.41	ND	615	1,170
72.00	666	26.4	.49	ND	693	1,240
121.0	758	27.5	.51	ND	786	1,380
168.0	822	28.2	.52	ND	851	1,390
168.0	818	27.8	.51	ND	846	1,360

Table 18.--Concentrations of the four trihalomethane compounds and the total trihalomethane and nonpurgeable total organic-halide concentrations as a function of reaction time for an initial pH of 7.50 and an initial free-chlorine concentration of 30.0 milligrams per liter, Mississippi River at Dubuque, Iowa, October 3, 1991

[μg/L, microgram per liter; $CHCl_3$, chloroform; $BrCHCl_2$, bromodichloromethane; $ClCHBr_2$, chlorodibromomethane; $CHBr_3$, bromoform; THM, trihalomethane; NPTOX, nonpurgeable total organic halide; ND, not detected]

Reaction time (hours)	Concentration (μg/L)					
	$CHCl_3$	$BrCHCl_2$	$ClCHBr_2$	$CHBr_3$	Total THM	NPTOX
0.00	56.7	3.71	0.03	ND	60.4	211
2.00	223	15.8	.26	ND	239	591
6.00	278	17.6	.33	ND	296	747
12.00	341	20.3	.38	ND	362	907
24.00	427	22.2	.44	ND	450	975
48.00	510	23.1	.44	ND	534	1,100
72.00	585	24.8	.48	ND	610	1,150
125.0	661	24.2	.45	ND	686	1,200
168.0	729	25.9	.48	ND	755	1,210
168.0	736	25.6	.49	ND	762	1,240

Table 19.--Concentrations of the four trihalomethane compounds and the total trihalomethane and nonpurgeable total organic-halide concentrations as a function of reaction time for an initial pH of 7.50 and an initial free-chlorine concentration of 30.0 milligrams per liter, Mississippi River at Davenport, Iowa, October 2, 1991

[μg/L, microgram per liter; $CHCl_3$, chloroform; $BrCHCl_2$, bromodichloromethane; $ClCHBr_2$, chlorodibromomethane; $CHBr_3$, bromoform; THM, trihalomethane; NPTOX, nonpurgeable total organic halide; ND, not detected]

Reaction time (hours)	Concentration (μg/L)					
	$CHCl_3$	$BrCHCl_2$	$ClCHBr_2$	$CHBr_3$	Total THM	NPTOX
0.00	56.6	4.60	0.08	ND	61.3	195
2.00	221	17.9	.35	ND	239	551
6.00	278	20.9	.43	ND	299	743
13.05	345	23.0	.51	ND	369	852
24.00	417	25.0	.60	ND	443	954
48.00	504	26.2	.62	ND	531	1,030
72.00	554	26.9	.62	ND	582	1,080
120.1	629	27.6	.63	ND	657	1,110
168.0	720	29.1	.67	ND	750	1,150
168.0	709	28.9	.70	ND	739	1,200

Table 20.--Concentrations of the four trihalomethane compounds and the total trihalomethane and nonpurgeable total organic-halide concentrations as a function of reaction time for an initial pH of 7.50 and an initial free-chlorine concentration of 30.0 milligrams per liter, Mississippi River at Quincy, Ill., October 1, 1991

[μg/L, microgram per liter; $CHCl_3$, chloroform; $BrCHCl_2$, bromodichloromethane; $ClCHBr_2$, chlorodibromomethane; $CHBr_3$, bromoform; THM, trihalomethane; NPTOX, nonpurgeable total organic halide; ND, not detected]

Reaction time (hours)	Concentration (μg/L)					
	$CHCl_3$	$BrCHCl_2$	$ClCHBr_2$	$CHBr_3$	Total THM	NPTOX
0.00	50.7	5.73	0.14	ND	56.6	196
2.00	195	21.4	.57	ND	217	531
6.00	246	24.2	.71	ND	271	635
12.00	289	25.4	.75	ND	315	782
24.00	368	29.0	.87	ND	398	845
48.00	454	30.5	.93	ND	485	896
72.00	521	32.8	.98	ND	555	991
126.0	607	33.8	1.01	ND	642	1,070
168.0	664	34.0	1.07	ND	699	1,070
168.0	662	34.2	1.03	ND	697	1,120

Table 21.--Concentrations of the four trihalomethane compounds and the total trihalomethane and nonpurgeable total organic-halide concentrations as a function of reaction time for an initial pH of 7.50 and an initial free-chlorine concentration of 30.0 milligrams per liter, Missouri River 1.6 kilometers upstream from confluence with Mississippi River, September 30, 1991

[μg/L, microgram per liter; $CHCl_3$, chloroform; $BrCHCl_2$, bromodichloromethane; $ClCHBr_2$, chlorodibromomethane; $CHBr_3$, bromoform; THM, trihalomethane; NPTOX, nonpurgeable total organic halide]

Reaction time (hours)	Concentration (μg/L)					
	$CHCl_3$	$BrCHCl_2$	$ClCHBr_2$	$CHBr_3$	Total THM	NPTOX
0.00	7.77	4.50	2.30	0.14	14.7	44.2
2.00	31.2	22.6	10.4	.82	65.0	165
6.00	43.0	28.5	13.0	1.04	85.5	202
12.00	54.5	31.9	14.0	1.07	101	214
24.00	77.1	38.4	15.4	1.15	132	258
48.00	100	43.7	16.5	1.21	161	281
72.00	129	49.5	17.8	1.27	198	307
120.0	155	52.7	18.0	1.22	227	329
168.0	184	57.7	18.8	1.27	262	309
168.0	182	57.5	18.9	1.29	260	351

Table 22.--Concentrations of the four trihalomethane compounds and the total trihalomethane and nonpurgeable total organic-halide concentrations as a function of reaction time for an initial pH of 7.50 and an initial free-chlorine concentration of 30.0 milligrams per liter, Mississippi River at St. Louis, Mo., September 30, 1991

[μg/L, microgram per liter; $CHCl_3$, chloroform; $BrCHCl_2$, bromodichloromethane; $ClCHBr_2$, chlorodibromomethane; $CHBr_3$, bromoform; THM, trihalomethane; NPTOX, nonpurgeable total organic halide]

Reaction time (hours)	Concentration (μg/L)					
	$CHCl_3$	$BrCHCl_2$	$ClCHBr_2$	$CHBr_3$	Total THM	NPTOX
0.00	20.7	5.80	1.25	0.04	27.8	85.8
2.00	79.7	28.4	5.47	.13	114	234
6.07	111	34.6	6.39	.15	152	285
12.00	128	37.6	6.78	.16	173	376
24.02	179	48.0	8.05	.18	235	415
48.00	220	51.4	8.14	.19	280	475
72.00	254	55.0	8.63	.18	318	502
125.0	310	60.3	8.85	.20	379	522
168.0	350	64.5	9.07	.21	424	549
168.0	344	60.8	8.55	.19	414	551

Table 23.--Concentrations of the four trihalomethane compounds and the total trihalomethane and nonpurgeable total organic-halide concentrations as a function of reaction time for an initial pH of 7.50 and an initial free-chlorine concentration of 30.0 milligrams per liter, Mississippi River at Cairo, Ill., September 30, 1991

[μg/L, microgram per liter; $CHCl_3$, chloroform; $BrCHCl_2$, bromodichloromethane; $ClCHBr_2$, chlorodibromomethane; $CHBr_3$, bromoform; THM, trihalomethane; NPTOX, nonpurgeable total organic halide]

Reaction time (hours)	Concentration (μg/L)					
	$CHCl_3$	$BrCHCl_2$	$ClCHBr_2$	$CHBr_3$	Total THM	NPTOX
0.00	28.8	7.86	0.78	0.02	37.5	117
2.00	105	24.0	3.12	.06	132	309
6.00	141	30.6	4.11	.07	176	406
12.50	182	34.7	4.59	.07	221	506
24.00	226	39.3	4.86	.07	270	551
48.00	282	43.5	5.15	.07	331	564
72.05	333	48.3	5.47	.08	387	594
120.0	408	55.0	6.29	.08	469	677
168.0	449	54.9	5.91	.08	510	730
168.0	437	54.2	5.85	.08	497	723

Table 24.—Concentrations of the four trihalomethane compounds and the total trihalomethane and nonpurgeable total organic-halide concentrations as a function of reaction time for an initial pH of 7.50 and an initial free-chlorine concentration of 30.0 milligrams per liter, Ohio River 1.6 kilometers upstream from confluence with Mississippi River, September 29, 1991

[μg/L, microgram per liter; $CHCl_3$, chloroform; $BrCHCl_2$, bromodichloromethane; $ClCHBr_2$, chlorodibromomethane; $CHBr_3$, bromoform; THM, trihalomethane; NPTOX, nonpurgeable total organic halide]

Reaction time (hours)	Concentration (μg/L)					
	$CHCl_3$	$BrCHCl_2$	$ClCHBr_2$	$CHBr_3$	Total THM	NPTOX
0.00	12.1	3.36	0.92	0.04	16.4	64.8
2.00	39.4	18.8	6.18	.36	64.7	148
6.00	55.1	24.6	7.83	.45	88.0	203
15.00	70.6	27.8	8.10	.46	107	225
24.00	84.7	30.3	8.59	.48	124	202
48.00	117	34.9	9.27	.51	162	206
72.00	141	38.3	9.75	.54	190	271
122.0	172	41.3	10.0	.53	224	252
168.0	202	39.8	9.31	.53	252	291
168.0	197	39.8	9.61	.55	247	270

Table 25.—Concentrations of the four trihalomethane compounds and the total trihalomethane and nonpurgeable total organic-halide concentrations as a function of reaction time for an initial pH of 7.50 and an initial free-chlorine concentration of 30.0 milligrams per liter, Mississippi River at Memphis, Tenn., September 28, 1991

[μg/L, microgram per liter; $CHCl_3$, chloroform; $BrCHCl_2$, bromodichloromethane; $ClCHBr_2$, chlorodibromomethane; $CHBr_3$, bromoform; THM, trihalomethane; NPTOX, nonpurgeable total organic halide]

Reaction time (hours)	Concentration (μg/L)					
	$CHCl_3$	$BrCHCl_2$	$ClCHBr_2$	$CHBr_3$	Total THM	NPTOX
0.00	23.2	5.64	1.13	0.03	30.0	85.6
2.00	76.7	25.8	4.50	.09	107	219
6.00	99.0	30.7	5.25	.11	135	314
12.00	120	33.7	5.78	.13	160	324
24.00	165	40.5	6.62	.14	212	403
48.00	210	45.0	7.06	.13	262	465
72.07	243	47.6	7.38	.14	298	509
120.0	287	50.3	7.50	.13	345	535
168.0	322	51.8	7.40	.15	381	515
168.0	333	52.8	7.52	.15	393	541

Table 26.—Concentrations of the four trihalomethane compounds and the total trihalomethane and nonpurgeable total organic-halide concentrations as a function of reaction time for an initial pH of 7.50 and an initial free-chlorine concentration of 30.0 milligrams per liter, Mississippi River at Greenville, Miss., September 27, 1991

[μg/L, microgram per liter; $CHCl_3$, chloroform; $BrCHCl_2$, bromodichloromethane; $ClCHBr_2$, chlorodibromomethane; $CHBr_3$, bromoform; THM, trihalomethane; NPTOX, nonpurgeable total organic halide]

Reaction time (hours)	Concentration (μg/L)					
	$CHCl_3$	$BrCHCl_2$	$ClCHBr_2$	$CHBr_3$	Total THM	NPTOX
0.00	18.1	4.33	1.02	0.04	23.5	62.7
2.00	65.8	23.1	4.73	.14	93.8	261
6.00	85.2	30.3	6.29	.18	122	242
12.00	108	33.6	6.76	.18	149	331
24.00	143	38.5	7.24	.19	189	384
48.00	187	44.4	8.02	.20	240	439
72.00	224	48.2	8.41	.21	281	440
120.2	267	52.0	8.79	.21	328	415
168.0	311	56.5	9.25	.22	377	433
168.0	307	56.4	9.20	.22	373	463

Table 27.—Concentrations of the four trihalomethane compounds and the total trihalomethane and nonpurgeable total organic-halide concentrations as a function of reaction time for an initial pH of 7.50 and an initial free-chlorine concentration of 30.0 milligrams per liter, Mississippi River at Natchez, Miss., September 26, 1991

[μg/L, microgram per liter; $CHCl_3$, chloroform; $BrCHCl_2$, bromodichloromethane; $ClCHBr_2$, chlorodibromomethane; $CHBr_3$, bromoform; THM, trihalomethane; NPTOX, nonpurgeable total organic halide]

Reaction time (hours)	Concentration (μg/L)					
	$CHCl_3$	$BrCHCl_2$	$ClCHBr_2$	$CHBr_3$	Total THM	NPTOX
0.00	15.5	3.44	0.82	0.03	19.8	70.8
2.00	59.2	19.8	4.70	.18	83.9	191
6.00	82.0	25.0	5.73	.21	113	256
12.00	97.9	27.7	6.09	.22	132	302
24.00	125	31.8	6.67	.23	164	285
48.00	174	39.4	7.68	.25	221	334
72.00	193	40.3	7.81	.25	241	348
125.0	242	46.0	8.25	.26	297	405
168.0	278	50.7	8.91	.29	338	406
168.0	276	49.8	8.72	.28	335	389

Table 28.--Concentrations of the four trihalomethane compounds and the total trihalomethane and nonpurgeable total organic-halide concentrations as a function of reaction time for an initial pH of 7.50 and an initial free-chlorine concentration of 30.0 milligrams per liter, Mississippi River at Baton Rouge, La., September 26, 1991

[µg/L, microgram per liter; $CHCl_3$, chloroform; $BrCHCl_2$, bromodichloromethane; $ClCHBr_2$, chlorodibromomethane; $CHBr_3$, bromoform; THM, trihalomethane; NPTOX, nonpurgeable total organic halide]

Reaction time (hours)	Concentration (µg/L)					
	$CHCl_3$	$BrCHCl_2$	$ClCHBr_2$	$CHBr_3$	Total THM	NPTOX
0.00	13.1	2.92	0.80	0.05	16.9	94.7
2.00	50.3	19.2	5.76	.24	75.5	207
6.00	70.9	24.4	6.96	.30	103	235
12.00	86.3	28.4	7.74	.32	123	341
24.00	112	33.1	8.47	.35	154	384
48.00	140	35.8	8.58	.33	185	338
72.00	177	41.2	9.43	.36	228	320
127.0	220	45.2	9.75	.38	275	405
168.0	230	46.8	9.96	.41	287	398
168.0	239	47.4	10.1	.41	297	369

Table 29.--Concentrations of the four trihalomethane compounds and the total trihalomethane and nonpurgeable total organic-halide concentrations as a function of reaction time for an initial pH of 7.50 and an initial free-chlorine concentration of 30.0 milligrams per liter, Mississippi River at New Orleans, La., September 25, 1991

[µg/L, microgram per liter; $CHCl_3$, chloroform; $BrCHCl_2$, bromodichloromethane; $ClCHBr_2$, chlorodibromomethane; $CHBr_3$, bromoform; THM, trihalomethane; NPTOX, nonpurgeable total organic halide]

Reaction time (hours)	Concentration (µg/L)					
	$CHCl_3$	$BrCHCl_2$	$ClCHBr_2$	$CHBr_3$	Total THM	NPTOX
0.00	16.8	4.29	1.17	0.08	22.3	53.8
2.00	59.2	22.5	6.51	.34	88.6	217
6.00	80.3	26.9	7.42	.37	115	279
12.00	101	32.0	8.76	.43	142	264
24.00	125	33.2	8.43	.38	167	339
48.00	158	38.4	9.04	.40	206	304
72.00	193	47.4	10.6	.48	251	313
125.0	233	52.7	11.2	.52	297	391
168.0	251	53.7	11.0	.49	316	439
168.0	255	54.9	11.4	.50	322	445

Ancillary Data

Values of pH as a Function of Reaction Time

Values of pH as a function of reaction time for the different combinations of initial pH and initial free-chlorine concentration are listed in tables 30–43.

Table 30.--Variation of pH with reaction time for different combinations of initial pH and initial free-chlorine concentration, Mississippi River at Minneapolis, Minn., October 7, 1991

[CL, initial free-chlorine concentration; mg/L, milligram per liter]

CL = 15.0 mg/L		CL = 30.0 mg/L		CL = 50.0 mg/L	
Reaction time (hours)	pH	Reaction time (hours)	pH	Reaction time (hours)	pH
		Initial pH = 5.50			
0.00	5.50	0.00	5.50	0.00	5.50
1.48	6.54	1.38	6.59	1.30	6.73
21.78	6.52	21.68	6.55	21.60	6.64
46.22	6.56	46.05	6.55	45.90	6.63
78.98	6.60	78.92	6.61	78.83	6.62
124.6	6.68	124.5	6.75	124.4	6.65
170.3	6.87	170.2	6.78	170.2	6.67
		Initial pH = 7.50			
.00	7.50	.00	7.50	.00	7.50
2.52	8.22	2.43	8.16	2.32	8.49
22.82	8.09	22.73	8.00	22.62	8.34
47.00	8.10	46.85	7.97	46.67	8.37
80.05	8.12	79.98	8.06	79.87	8.42
125.7	8.18	125.6	8.16	125.5	8.51
171.4	8.20	171.3	8.27	171.2	8.56
		Initial pH = 10.00			
.00	10.00	.00	10.00	.00	10.00
.90	9.79	.82	9.87	.73	9.91
21.18	9.63	21.10	9.72	21.02	9.75
45.17	9.60	45.02	9.71	44.87	9.74
78.43	9.57	78.37	9.67	78.28	9.70
124.0	9.56	124.0	9.66	123.9	9.67
169.8	9.53	169.7	9.64	169.6	9.64

Table 31.--Variation of pH with reaction time for different combinations of initial pH and initial free-chlorine concentration, Mississippi River at LaCrosse, Wis., October 4, 1991

[CL, initial free-chlorine concentration; mg/L, milligram per liter]

CL = 15.0 mg/L		CL = 30.0 mg/L		CL = 50.0 mg/L	
Reaction time (hours)	pH	Reaction time (hours)	pH	Reaction time (hours)	pH
Initial pH = 5.50					
0.00	5.50	0.00	5.50	0.00	5.50
1.43	6.58	1.35	6.64	1.23	6.93
26.42	6.53	26.32	6.53	26.20	6.76
54.73	6.57	54.55	6.55	54.37	6.76
78.90	6.68	78.72	6.62	78.53	6.79
121.0	6.77	120.8	6.75	120.6	6.97
170.5	7.08	170.3	6.90	170.1	6.99
Initial pH = 7.50					
.00	7.50	.00	7.50	.00	7.50
2.57	8.27	2.32	8.27	2.50	8.56
27.52	8.05	27.27	8.03	27.45	8.34
55.60	8.06	55.25	7.99	55.37	8.29
79.75	8.09	79.43	7.98	79.55	8.28
121.8	8.10	121.5	8.19	121.6	8.27
171.3	8.20	171.0	8.23	171.1	8.31
Initial pH = 10.00					
.00	10.00	.00	10.00	.00	10.00
.83	9.97	.73	10.06	.65	10.08
25.78	9.65	25.68	9.71	25.60	9.69
53.63	9.63	53.45	9.69	53.30	9.60
77.82	9.59	77.65	9.65	77.50	9.54
119.8	9.57	119.7	9.62	119.5	9.45
169.4	9.57	169.2	9.62	169.1	9.38

Table 32.–Variation of pH with reaction time for different combinations of initial pH and initial free-chlorine concentration, Mississippi River at Dubuque, Iowa, October 3, 1991

[CL, initial free-chlorine concentration; mg/L, milligram per liter]

CL = 15.0 mg/L		CL = 30.0 mg/L		CL = 50.0 mg/L	
Reaction time (hours)	pH	Reaction time (hours)	pH	Reaction time (hours)	pH
		Initial pH = 5.50			
0.00	5.50	0.00	5.50	0.00	5.50
1.78	6.65	1.62	6.74	1.45	7.04
31.37	6.55	31.20	6.60	31.03	6.87
53.73	6.58	53.57	6.62	53.35	6.87
78.83	6.63	78.65	6.66	78.48	6.88
124.0	6.70	123.9	6.81	123.7	6.92
170.4	6.73	170.2	6.80	170.1	6.93
		Initial pH = 7.50			
.00	7.50	.00	7.50	.00	7.50
2.67	8.27	2.33	8.33	2.47	8.59
32.25	8.15	31.92	8.19	32.03	8.41
54.58	8.12	54.25	8.20	54.38	8.37
79.72	8.12	79.38	8.24	79.52	8.36
124.9	8.12	124.6	8.32	124.7	8.41
171.3	8.12	171.0	8.39	171.1	8.38
		Initial pH = 10.00			
.00	10.00	.00	10.00	.00	10.00
.77	9.99	.60	10.03	.43	10.05
30.32	9.70	30.13	9.75	29.97	9.75
52.63	9.69	52.47	9.73	52.30	9.71
77.82	9.65	77.65	9.70	77.47	9.66
123.0	9.64	122.8	9.69	122.7	9.58
169.4	9.63	169.2	9.67	169.1	9.53

Table 33.–Variation of pH with reaction time for different combinations of initial pH and initial free-chlorine concentration, Mississippi River at Davenport, Iowa, October 2, 1991

[CL, initial free-chlorine concentration; mg/L, milligram per liter]

CL = 15.0 mg/L		CL = 30.0 mg/L		CL = 50.0 mg/L	
Reaction time (hours)	pH	Reaction time (hours)	pH	Reaction time (hours)	pH
Initial pH = 5.50					
0.00	5.50	0.00	5.50	0.00	5.50
1.42	6.63	1.32	6.70	1.22	6.93
27.07	6.54	26.90	6.59	26.73	6.76
55.35	6.57	55.18	6.62	54.98	6.79
79.82	6.64	79.63	6.69	79.47	6.85
120.0	6.65	119.8	6.68	119.6	6.83
170.4	6.74	170.2	6.72	170.0	6.86
Initial pH = 7.50					
.00	7.50	.00	7.50	.00	7.50
2.57	8.30	2.32	8.34	2.50	8.62
27.97	8.11	27.65	8.17	27.77	8.42
56.25	8.09	55.93	8.13	56.05	8.38
80.70	8.13	80.37	8.11	80.48	8.40
120.9	8.07	120.6	8.03	120.7	8.32
171.3	8.06	171.0	8.05	171.0	8.30
Initial pH = 10.00					
.00	10.00	.00	10.00	.00	10.00
.80	10.03	.70	10.05	.63	10.07
25.97	9.71	25.80	9.77	25.65	9.79
54.27	9.69	54.10	9.73	53.90	9.77
78.68	9.71	78.48	9.74	78.33	9.77
118.9	9.66	118.8	9.70	118.6	9.73
169.3	9.65	169.1	9.67	169.0	9.71

Table 34.--Variation of pH with reaction time for different combinations of initial pH and initial free-chlorine concentration, Mississippi River at Quincy, Ill., October 1, 1991

[CL, initial free-chlorine concentration; mg/L, milligram per liter]

CL = 15.0 mg/L		CL = 30.0 mg/L		CL = 50.0 mg/L	
Reaction time (hours)	pH	Reaction time (hours)	pH	Reaction time (hours)	pH
		Initial pH = 5.50			
0.00	5.50	0.00	5.50	0.00	5.50
1.78	6.40	1.62	6.53	1.42	6.80
31.00	6.40	30.82	6.50	30.63	6.72
54.82	6.47	54.65	6.54	54.47	6.74
79.50	6.52	79.33	6.58	79.13	6.78
124.9	6.59	124.7	6.64	124.6	6.82
170.5	6.61	170.4	6.68	170.2	6.84
		Initial pH = 7.50			
.00	7.50	.00	7.50	.00	7.50
2.68	8.18	2.33	8.22	2.40	8.49
31.83	8.10	31.48	8.10	31.62	8.39
55.73	8.08	55.40	8.07	55.53	8.35
80.40	8.08	80.07	8.08	80.18	8.33
125.8	8.16	125.5	8.10	125.6	8.31
171.4	8.19	171.1	8.15	171.2	8.31
		Initial pH = 10.00			
.00	10.00	.00	10.00	.00	10.00
.73	9.90	.52	9.95	.35	9.94
29.83	9.66	29.63	9.70	29.47	9.68
53.73	9.64	53.58	9.67	53.42	9.65
78.38	9.61	78.23	9.65	78.07	9.64
123.9	9.60	123.7	9.64	123.6	9.63
169.5	9.62	169.3	9.65	169.1	9.64

Table 35.--Variation of pH with reaction time for different combinations of initial pH and initial free-chlorine concentration, Missouri River 1.6 kilometers upstream from confluence with Mississippi River, September 30, 1991

[CL, initial free-chlorine concentration; mg/L, milligram per liter]

CL = 15.0 mg/L		CL = 30.0 mg/L		CL = 50.0 mg/L	
Reaction time (hours)	pH	Reaction time (hours)	pH	Reaction time (hours)	pH
		Initial pH = 5.50			
0.00	5.50	0.00	5.50	0.00	5.50
1.53	6.39	1.43	6.56	1.35	6.84
27.07	6.40	26.90	6.54	26.73	6.79
55.18	6.51	55.02	6.62	54.83	6.86
77.42	6.57	77.25	6.68	77.05	6.91
120.0	6.59	119.9	6.70	119.7	6.93
170.3	6.67	170.2	6.75	170.0	7.00
		Initial pH = 7.50			
.00	7.50	.00	7.50	.00	7.50
2.65	8.23	2.38	8.30	2.58	8.58
27.95	8.13	27.62	8.18	27.75	8.47
56.00	8.16	55.67	8.23	55.80	8.48
78.27	8.16	77.92	8.23	78.05	8.48
120.9	8.13	120.5	8.22	120.6	8.46
171.2	8.11	170.8	8.31	171.0	8.45
		Initial pH = 10.00			
.00	10.00	.00	10.00	.00	10.00
.97	9.79	.88	9.83	.80	9.86
26.03	9.57	25.88	9.63	25.73	9.66
54.12	9.58	53.97	9.63	53.82	9.66
76.35	9.55	76.20	9.61	76.03	9.65
118.9	9.54	118.8	9.57	118.6	9.63
169.3	9.51	169.1	9.56	169.0	9.60

Table 36.--Variation of pH with reaction time for different combinations of initial pH and initial free-chlorine concentration, Mississippi River at St. Louis, Mo., September 30, 1991

[CL, initial free-chlorine concentration; mg/L, milligram per liter]

CL = 15.0 mg/L		CL = 30.0 mg/L		CL = 50.0 mg/L	
Reaction time (hours)	pH	Reaction time (hours)	pH	Reaction time (hours)	pH
		Initial pH = 5.50			
0.00	5.50	0.00	5.50	0.00	5.50
1.78	6.44	1.63	6.55	1.45	6.81
30.58	6.48	30.50	6.53	30.38	6.78
53.08	6.61	53.00	6.58	52.88	6.83
79.03	6.71	78.95	6.62	78.83	6.86
123.8	6.88	123.7	6.66	123.6	6.88
170.8	6.97	170.6	6.67	170.4	6.90
		Initial pH = 7.50			
.00	7.50	.00	7.50	.00	7.50
2.67	8.17	2.33	8.25	2.47	8.50
31.70	8.10	31.47	8.18	31.67	8.44
54.25	8.12	53.98	8.18	54.18	8.44
80.15	8.09	79.90	8.17	80.10	8.42
124.9	8.12	124.6	8.17	124.8	8.42
171.6	8.12	171.2	8.16	171.4	8.40
		Initial pH = 10.00			
.00	10.00	.00	10.00	.00	10.00
.78	9.79	.62	9.81	.45	9.85
31.07	9.64	30.98	9.66	30.93	9.70
52.58	9.62	52.48	9.65	52.40	9.68
78.50	9.59	78.40	9.63	78.32	9.65
123.2	9.58	123.2	9.62	123.1	9.62
169.7	9.55	169.5	9.60	169.4	9.60

Table 37.--Variation of pH with reaction time for different combinations of initial pH and initial free-chlorine concentration, Mississippi River at Cairo, Ill., September 30, 1991

[CL, initial free-chlorine concentration; mg/L, milligram per liter]

CL = 15.0 mg/L		CL = 30.0 mg/L		CL = 50.0 mg/L	
Reaction time (hours)	pH	Reaction time (hours)	pH	Reaction time (hours)	pH
		Initial pH = 5.50			
0.00	5.50	0.00	5.50	0.00	5.50
1.82	6.45	1.65	6.56	1.50	6.82
27.10	6.41	27.00	6.51	26.92	6.74
54.95	6.44	54.78	6.54	54.63	6.79
77.08	6.48	76.90	6.58	76.75	6.84
119.9	6.53	119.7	6.66	119.6	6.88
170.1	6.58	169.9	6.70	169.8	6.99
		Initial pH = 7.50			
.00	7.50	.00	7.50	.00	7.50
2.98	8.19	2.40	8.25	2.55	8.50
28.48	8.18	27.97	8.14	28.18	8.41
56.13	8.29	55.55	8.12	55.70	8.37
78.23	8.35	77.62	8.13	77.67	8.38
121.0	8.45	120.4	8.13	120.6	8.37
171.2	8.55	170.6	8.13	170.8	8.37
		Initial pH = 10.00			
.00	10.00	.00	10.00	.00	10.00
.75	9.84	.60	9.88	.43	9.88
26.47	9.70	26.38	9.73	26.28	9.74
53.90	9.66	53.75	9.69	53.57	9.72
75.85	9.67	75.70	9.68	75.47	9.72
118.8	9.63	118.7	9.67	118.5	9.71
169.0	9.62	168.9	9.64	168.7	9.69

Table 38.–Variation of pH with reaction time for different combinations of initial pH and initial free-chlorine concentration, Ohio River 1.6 kilometers upstream from confluence with Mississippi River, September 29, 1991

[CL, initial free-chlorine concentration; mg/L, milligram per liter]

CL = 15.0 mg/L		CL = 30.0 mg/L		CL = 50.0 mg/L	
Reaction time (hours)	pH	Reaction time (hours)	pH	Reaction time (hours)	pH
		Initial pH = 5.50			
0.00	5.50	0.00	5.50	0.00	5.50
2.08	6.67	2.00	6.96	1.90	7.40
31.33	6.74	31.18	6.94	31.02	7.35
54.43	6.82	54.27	6.99	54.10	7.34
78.63	6.93	78.47	7.00	78.30	7.34
121.9	7.00	121.7	7.02	121.6	7.35
171.4	7.06	171.2	7.10	171.1	7.37
		Initial pH = 7.50			
.00	7.50	.00	7.50	.00	7.50
2.92	8.41	3.27	8.62	2.87	8.89
31.93	8.32	32.18	8.54	31.72	8.82
55.00	8.27	55.27	8.51	54.78	8.80
79.23	8.26	79.50	8.46	79.03	8.77
122.5	8.22	122.7	8.44	122.3	8.74
172.0	8.23	172.3	8.51	171.8	8.72
		Initial pH = 10.00			
.00	10.00	.00	10.00	.00	10.00
.72	10.04	.62	10.06	.52	10.10
29.50	9.82	29.32	9.82	29.15	9.91
52.53	9.77	52.33	9.77	52.17	9.85
76.82	9.71	76.65	9.72	76.48	9.81
120.0	9.66	119.9	9.68	119.7	9.79
169.6	9.61	169.4	9.66	169.2	9.76

Table 39.--Variation of pH with reaction time for different combinations of initial pH and initial free-chlorine concentration, Mississippi River at Memphis, Tenn., September 28, 1991

[CL, initial free-chlorine concentration; mg/L, milligram per liter]

CL = 15.0 mg/L		CL = 30.0 mg/L		CL = 50.0 mg/L	
Reaction time (hours)	pH	Reaction time (hours)	pH	Reaction time (hours)	pH
Initial pH = 5.50					
0.00	5.50	0.00	5.50	0.00	5.50
2.72	6.48	2.52	6.64	2.32	6.96
23.12	6.57	22.95	6.71	22.77	6.99
54.53	6.68	54.37	6.72	54.20	6.99
76.47	6.94	76.30	6.78	76.12	7.01
119.6	7.30	119.4	6.81	119.2	7.03
172.8	7.35	172.7	6.86	172.6	7.08
Initial pH = 7.50					
.00	7.50	.00	7.50	.00	7.50
3.23	8.16	3.47	8.21	3.02	8.53
23.68	8.18	23.93	8.23	23.48	8.56
55.13	8.14	55.38	8.18	54.93	8.50
77.05	8.09	77.30	8.15	76.83	8.48
120.2	8.08	120.4	8.13	120.0	8.46
173.8	8.14	174.1	8.16	173.7	8.46
Initial pH = 10.00					
.00	10.00	.00	10.00	.00	10.00
.72	9.94	.55	9.96	.40	10.02
21.22	9.76	21.03	9.79	20.88	9.85
52.65	9.74	52.48	9.75	52.33	9.79
74.57	9.71	74.38	9.72	74.23	9.77
117.7	9.68	117.5	9.71	117.4	9.76
171.6	9.68	171.5	9.71	171.4	9.74

Table 40.--Variation of pH with reaction time for different combinations of initial pH and initial free-chlorine concentration, Mississippi River at Greenville, Miss., September 27, 1991

[CL, initial free-chlorine concentration; mg/L, milligram per liter]

CL = 15.0 mg/L		CL = 30.0 mg/L		CL = 50.0 mg/L	
Reaction time (hours)	pH	Reaction time (hours)	pH	Reaction time (hours)	pH
		Initial pH = 5.50			
0.00	5.50	0.00	5.50	0.00	5.50
1.98	6.43	1.88	6.55	1.80	6.90
29.12	6.40	29.02	6.53	28.93	6.85
54.70	6.51	54.60	6.65	54.53	6.92
77.65	6.55	77.55	6.68	77.47	6.99
119.4	6.73	119.3	6.73	119.2	7.04
171.4	6.79	171.3	6.92	171.2	7.10
		Initial pH = 7.50			
.00	7.50	.00	7.50	.00	7.50
2.88	8.25	3.20	8.31	2.82	8.63
30.03	8.14	30.35	8.21	29.97	8.51
55.63	8.13	55.98	8.21	55.62	8.50
78.55	8.13	78.88	8.21	78.50	8.48
120.3	8.14	120.7	8.22	120.3	8.47
172.3	8.22	172.6	8.27	172.2	8.45
		Initial pH = 10.00			
.00	10.00	.00	10.00	.00	10.00
.75	10.03	.65	10.05	.55	10.06
27.87	9.67	27.77	9.71	27.67	9.72
53.53	9.62	53.48	9.67	53.42	9.68
76.40	9.60	76.30	9.65	76.20	9.68
118.2	9.59	118.1	9.63	118.0	9.66
170.2	9.60	170.0	9.64	170.0	9.67

Table 41.–Variation of pH with reaction time for different combinations of initial pH and initial free-chlorine concentration, Mississippi River at Natchez, Miss., September 26, 1991

[CL, initial free-chlorine concentration; mg/L, milligram per liter]

CL = 15.0 mg/L		CL = 30.0 mg/L		CL = 50.0 mg/L	
Reaction time (hours)	pH	Reaction time (hours)	pH	Reaction time (hours)	pH
Initial pH = 5.50					
0.00	5.50	0.00	5.50	0.00	5.50
4.25	6.45	4.17	6.73	4.07	6.98
30.63	6.50	30.55	6.83	30.45	6.95
52.65	6.55	52.57	6.95	52.47	6.98
77.98	6.58	77.90	7.07	77.83	7.01
123.6	6.66	123.6	7.30	123.4	7.06
146.8	6.79	146.7	7.42	146.5	7.16
173.0	6.77	172.9	7.43	172.8	7.15
Initial pH = 7.50					
.00	7.50	.00	7.50	.00	7.50
5.23	8.28	5.65	8.37	5.20	8.63
31.53	8.17	31.95	8.27	31.55	8.55
53.57	8.18	53.98	8.26	53.52	8.55
78.93	8.16	79.35	8.25	78.90	8.52
124.6	8.12	125.0	8.22	124.5	8.48
147.5	8.20	147.9	8.27	147.4	8.55
173.9	8.14	174.3	8.23	173.8	8.49
Initial pH = 10.00					
.00	10.00	.00	10.00	.00	10.00
.75	10.03	.67	10.02	.57	10.07
27.12	9.69	27.02	9.70	26.97	9.74
49.10	9.69	49.00	9.71	48.90	9.75
74.48	9.63	74.38	9.65	74.28	9.71
120.1	9.61	120.0	9.62	119.9	9.67
142.8	9.65	142.7	9.68	142.5	9.75
169.4	9.60	169.3	9.62	169.2	9.66

Table 42.--Variation of pH with reaction time for different combinations of initial pH and initial free-chlorine concentration, Mississippi River at Baton Rouge, La., September 26, 1991

[CL, initial free-chlorine concentration; mg/L, milligram per liter]

CL = 15.0 mg/L		CL = 30.0 mg/L		CL = 50.0 mg/L	
Reaction time (hours)	pH	Reaction time (hours)	pH	Reaction time (hours)	pH
		Initial pH = 5.50			
0.00	5.50	0.00	5.50	0.00	5.50
4.10	6.50	4.00	6.71	3.88	7.02
29.45	6.56	29.35	6.74	29.23	7.02
55.72	6.59	55.63	6.78	55.55	7.09
79.53	6.65	79.43	6.80	79.32	7.18
103.7	6.71	103.6	6.86	103.5	7.30
128.1	6.79	128.0	6.90	127.9	7.33
171.8	6.90	171.7	6.95	171.6	7.41
		Initial pH = 7.50			
.00	7.50	.00	7.50	.00	7.50
3.32	8.20	3.07	8.33	3.30	8.62
28.65	8.16	28.37	8.27	28.58	8.57
54.97	8.14	54.68	8.26	54.90	8.57
78.73	8.14	78.45	8.26	78.68	8.55
102.9	8.19	102.6	8.27	102.8	8.53
127.3	8.19	127.0	8.27	127.2	8.49
171.0	8.22	170.7	8.31	171.0	8.50
		Initial pH = 10.00			
.00	10.00	.00	10.00	.00	10.00
1.63	9.97	1.62	9.95	1.52	9.99
26.90	9.70	26.80	9.70	26.70	9.76
53.27	9.66	53.17	9.67	53.07	9.73
77.00	9.63	76.90	9.65	76.82	9.71
101.2	9.60	101.1	9.61	101.0	9.68
125.6	9.57	125.5	9.59	125.4	9.66
169.3	9.56	169.2	9.61	169.1	9.67

Table 43.--Variation of pH with reaction time for different combinations of initial pH and initial free-chlorine concentration, New Orleans, La., September 25, 1991

[CL, initial free-chlorine concentration; mg/L, milligram per liter]

CL = 15.0 mg/L		CL = 30.0 mg/L		CL = 50.0 mg/L	
Reaction time (hours)	pH	Reaction time (hours)	pH	Reaction time (hours)	pH
Initial pH = 5.50					
0.00	5.50	0.00	5.50	0.00	5.50
2.07	6.44	2.02	6.60	1.93	6.94
31.12	6.49	31.03	6.67	30.93	6.94
54.35	6.52	54.27	6.70	54.17	6.96
78.87	6.66	78.80	6.81	78.70	7.02
124.4	6.72	124.4	6.88	124.3	7.04
170.6	6.85	170.6	6.94	170.4	7.09
Initial pH = 7.50					
.00	7.50	.00	7.50	.00	7.50
3.05	8.28	3.38	8.36	3.05	8.65
32.12	8.18	32.43	8.28	32.05	8.57
55.28	8.15	55.60	8.23	55.22	8.52
79.82	8.16	80.28	8.23	79.90	8.52
125.4	8.17	125.7	8.22	125.3	8.51
171.6	8.19	171.9	8.23	171.5	8.51
Initial pH = 10.00					
.00	10.00	.00	10.00	.00	10.00
.92	10.03	.83	10.05	.75	10.06
29.92	9.74	29.82	9.77	29.72	9.80
53.08	9.65	53.00	9.69	52.92	9.71
77.77	9.67	77.67	9.70	77.57	9.72
123.2	9.61	123.1	9.66	123.0	9.69
169.4	9.57	169.3	9.66	169.2	9.68

Values of pH at the End of the Trihalomethane Formation-Potential Experiments

Values of pH at the end of the trihalomethane formation-potential experiments for each of the different combinations of initial pH and initial free-chlorine concentration are listed in table 44. These pH values differ somewhat from the pH values in tables 30–43 because they were determined on samples that had been quenched with a sodium thiosulfate solution and extracted with pentane, followed by evaporation of the pentane. Most of the small differences are believed to be from the addition of the sodium thiosulfate, which generally increased the pH values of the 5.50 and 7.50 samples and had little or no effect on the pH values of the 10.00 samples.

Dissolved Organic-Carbon and Bromide Concentrations and Specific Conductances

DOC and bromide concentrations and specific conductances for each of the water samples are listed in table 45. Replicate analyses were done for DOC for all samples. Coefficients of variation of the replicate analyses ranged from ±0.00 to ±1.30 and averaged ±0.43 percent for 14 comparisons. Bromide concentrations ranged from less than the detection limit of 0.005 mg/L for the Minneapolis, LaCrosse, and Dubuque water samples to 0.085 mg/L for the Missouri River water sample. An interference problem prevented the determination of the bromide concentrations for the Davenport and Quincy water samples.

Ultraviolet Absorbances

Ultraviolet absorbances of the natural water samples and the water samples adjusted to pH values of 5.50, 7.50, and 10.00 were measured at 254, 280, 330, and 400 nm, and the results are listed in table 46. The pH value of the natural water sample for each sample location is the average of the pH values for the three volumes of water used for the formation-potential experiments and the one volume used for the preparation of the THM standards. Meaningful absorbance measurements were not obtained for the pH=10.00 condition for the Minneapolis and LaCrosse water samples because a slight precipitate formed, resulting in a cloudy solution when the natural water pH was adjusted to 10.00. Much less intense precipitates were observed in the Dubuque, Davenport, Quincy, Missouri River, St. Louis, and Cairo water samples for the pH=10.00 condition. The extent to which the UV absorbances of these samples were affected by this precipitate is not known.

Table 44.–Values of pH at the end of the trihalomethane formation-potential experiments

[CL, initial free-chlorine concentration; mg/L, milligram per liter]

General location	Initial pH	CL (mg/L)		
		15.0	30.0	50.0
Minneapolis, Minn.	5.50	6.76	6.82	7.08
	7.50	8.28	8.21	8.57
	10.00	9.47	9.58	9.68
LaCrosse, Wis.	5.50	6.78	6.87	7.19
	7.50	8.17	8.21	8.73
	10.00	9.59	9.60	9.70
Dubuque, Iowa	5.50	7.12	7.25	7.55
	7.50	8.28	8.41	8.84
	10.00	9.48	9.58	9.69
Davenport, Iowa	5.50	6.64	6.83	7.18
	7.50	8.17	8.36	8.83
	10.00	9.51	9.62	9.72
Quincy, Ill.	5.50	6.88	7.01	7.28
	7.50	8.26	8.39	8.84
	10.00	9.49	9.59	9.50
Missouri River near confluence with Mississippi River	5.50	7.02	7.19	7.54
	7.50	8.40	8.62	8.93
	10.00	9.25	9.35	9.47
St. Louis, Mo.	5.50	6.81	6.96	7.27
	7.50	8.22	8.50	8.89
	10.00	9.42	9.58	9.71
Cairo, Ill.	5.50	6.72	7.04	7.15
	7.50	8.02	8.28	8.69
	10.00	9.51	9.60	9.72
Ohio River near confluence with Mississippi River	5.50	6.99	7.37	8.27
	7.50	8.41	8.83	9.19
	10.00	9.39	9.63	9.85
Memphis, Tenn.	5.50	6.92	7.12	7.50
	7.50	8.26	8.56	8.98
	10.00	9.50	9.65	9.81
Greenville, Miss.	5.50	7.33	7.41	7.76
	7.50	8.48	8.69	9.04
	10.00	9.44	9.55	9.61

Table 44.--Values of pH at the end of the trihalomethane formation-potential experiments --Continued

General location	Initial pH	CL (mg/L) 15.0	CL (mg/L) 30.0	CL (mg/L) 50.0
Natchez, Miss.	5.50	7.15	7.35	7.72
	7.50	8.49	8.84	9.15
	10.00	9.58	9.69	9.80
Baton Rouge, La.	5.50	6.93	7.21	7.65
	7.50	8.49	8.88	9.25
	10.00	9.66	9.78	9.90
New Orleans, La.	5.50	7.03	7.26	7.58
	7.50	8.44	8.76	9.09
	10.00	9.51	9.62	9.72

Table 45.--Dissolved organic-carbon and bromide concentrations and specific conductances of the water samples

[DOC, dissolved organic carbon; Br, bromide; Rep 1, replicate number 1; Rep 2, replicate number 2; mg/L, milligram per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius; ND, not detected; IF, interference problem]

General location	Concentration DOC Rep 1 (mg/L)	Concentration DOC Rep 2 (mg/L)	Concentration Br (mg/L)	Specific conductance (µS/cm)
Minneapolis, Minn.	11	11	ND	473
LaCrosse, Wis.	8.9	9.1	ND	447
Dubuque, Iowa	7.6	7.7	ND	395
Davenport, Iowa	7.7	7.6	IF	404
Quincy, Ill.	7.2	7.1	IF	469
Missouri River[1]	2.7	2.7	.085	719
St. Louis, Mo.	4.0	4.0	.044	622
Cairo, Ill.	4.8	4.8	.031	564
Ohio River[1]	2.2	2.2	.042	280
Memphis, Tenn.	3.8	3.8	.040	463
Greenville, Miss.	3.8	3.9	.040	464
Natchez, Miss.	3.3	3.3	.039	434
Baton Rouge, La.	3.1	3.2	.044	433
New Orleans, La.	3.5	3.5	.044	457

[1] Sampling site 1.6 kilometers upstream from confluence with Mississippi River.

Table 46.–Ultraviolet absorbances of the water samples

[nm, nanometer; PP, precipitate problem]

General location	pH	Ultraviolet absorbance, in absorbance units, at wavelengths			
		254 (nm)	280 (nm)	330 (nm)	400 (nm)
Minneapolis, Minn.	8.15	1.743	1.263	0.545	0.155
	5.50	1.737	1.249	.519	.135
	7.50	1.733	1.255	.536	.150
	10.00	PP	PP	PP	PP
LaCrosse, Wis.	8.08	1.550	1.135	.508	.146
	5.50	1.540	1.117	.481	.126
	7.50	1.548	1.127	.499	.141
	10.00	PP	PP	PP	PP
Dubuque, Iowa	8.01	1.307	.950	.409	.117
	5.50	1.300	.938	.392	.103
	7.50	1.304	.947	.406	.114
	10.00	1.355	.994	.472	.183
Davenport, Iowa	8.03	1.222	.882	.370	.102
	5.50	1.217	.874	.358	.090
	7.50	1.219	.879	.367	.100
	10.00	1.225	.886	.388	.118
Quincy, Ill.	8.19	1.135	.817	.338	.093
	5.50	1.128	.811	.324	.084
	7.50	1.126	.813	.333	.090
	10.00	1.094	.790	.332	.095
Missouri River near confluence with Mississippi River	8.34	.339	.237	.091	.025
	5.50	.336	.238	.089	.024
	7.50	.338	.239	.091	.025
	10.00	.324	.227	.088	.028
St. Louis, Mo.	8.27	.598	.427	.170	.048
	5.50	.595	.422	.163	.043
	7.50	.596	.426	.167	.046
	10.00	.565	.419	.174	.063

Table 46.--Ultraviolet absorbances of the water samples --Continued

General location	pH	Ultraviolet absorbance, in absorbance units, at wavelengths			
		254 (nm)	280 (nm)	330 (nm)	400 (nm)
Cairo, Ill.	8.11	.756	.544	.216	.060
	5.50	.752	.537	.209	.054
	7.50	.753	.540	.214	.058
	10.00	.714	.519	.213	.063
Ohio River near confluence with Mississippi River	7.92	.293	.212	.080	.022
	5.50	.295	.213	.079	.023
	7.50	.298	.217	.082	.026
	10.00	.294	.214	.084	.025
Memphis, Tenn.	8.14	.562	.400	.158	.044
	5.50	.563	.400	.153	.041
	7.50	.563	.402	.157	.044
	10.00	.560	.398	.164	.048
Greenville, Miss.	8.06	.501	.357	.139	.039
	5.50	.497	.354	.135	.037
	7.50	.500	.357	.139	.038
	10.00	.488	.349	.137	.039
Natchez, Miss.	8.17	.456	.327	.128	.036
	5.50	.454	.325	.124	.034
	7.50	.456	.327	.128	.037
	10.00	.446	.320	.127	.036
Baton Rouge, La.	8.17	.435	.313	.124	.036
	5.50	.434	.313	.122	.035
	7.50	.435	.313	.123	.036
	10.00	.426	.308	.123	.037
New Orleans, La.	7.94	.478	.339	.135	.038
	5.50	.471	.335	.131	.036
	7.50	.476	.340	.135	.038
	10.00	.486	.350	.145	.045

Error Analysis

The coefficient of variation normalized with respect to the mean concentration and expressed as a percentage was used to indicate reproducibility between duplicate samples. This coefficient of variation was computed from

$$C_v = \pm\{[C_1^2 + C_2^2 - (C_1 + C_2)^2/2]/2\}^{0.5}\,100/C_{12} \qquad (1)$$

where

C_v is the coefficient of variation;

C_1 is concentration number 1;

C_2 is concentration number 2; and

C_{12} is the mean of concentrations 1 and 2.

Values of the coefficients of variation for the analysis of duplicate THM samples and NPTOX samples are summarized in table 47. Minimum, maximum, and mean values of the coefficient of variation together with the number of pairs of values in each comparison are listed.

Table 47.--Minimum, maximum, and mean values of the coefficient of variation for analysis of duplicate trihalomethane and nonpurgeable total organic-halide samples

[THM, trihalomethane; NPTOX, nonpurgeable total organic halide]

Sample type	Number of pairs	Coefficient of variation, in percent		
		Minimum	Maximum	Mean
THM	126	±0.00	±6.08	±0.95
NPTOX	126	±.00	±10.0	±2.45

REFERENCES CITED

Bellar, T.A., Lichtenberg, J.J., and Kroner, R.C., 1974, The occurrence of organohalides in chlorinated drinking waters: Journal of American Water Works Association, v. 66, no. 12, p. 703–706.

Buffle, J., Deladoey, P., and Haerdi, W., 1978, The use of ultrafiltration for the separation and fractionation of organic ligands in fresh waters: Analytica Chimica Acta, v. 101, no. 2, p. 339–357.

Ceraso, Jane, 1987, Development of a surrogate parameter to determine the trihalomethane formation potential of two reservoirs: Journal of New England Water Works Association, v. 101, no. 4, p. 382–400.

Chadick, P.A., and Amy, G.L., 1987, Coagulation and adsorption of humic substances—An analysis of surrogate parameters for predicting effects of trihalomethane formation potential: Environmental Technology Letters, v. 8, p. 261–268.

Edzwald, J.K., Becker, W.C., and Wattier, K.L., 1985, Surrogate parameters for monitoring organic matter and THM precursors: Journal of American Water Works Association, v. 77, no. 4, p. 122–132.

Federal Register, 1979, Analysis of trihalomethanes in drinking water, v. 44, no. 231, p. 68672–68690.

Fishman, M.J., and Friedman, L.C., 1989, Methods for determination of inorganic substances in water and fluvial sediments: U.S. Geological Survey Techniques of Water-Resources Investigations Report, book 5, chap. A1, 545 p.

Fleischacker, S.J., and Randtke, S.J., 1983, Formation of organic chlorine in public water supplies: Journal of American Water Works Association, v. 75, no. 3, p. 132–138.

Johnson, J.D., and Jensen, J.N., 1986, THM and TOX formation—Routes, rates, and precursors: Journal of American Water Works Association, v. 78, no. 4, p. 156–162.

Moore, T.R., 1987, Assessment of a simple spectrophotometric method for the determination of dissolved organic carbon in freshwaters: New Zealand Journal of Marine and Freshwater Research, v. 21, no. 4, p. 585–589.

Oliver, B.G., and Thurman, E.M., 1981, Influence of aquatic humic substances on trihalomethane potential, in Proceedings, Fourth Conference on Water Chlorination, October 18–23, 1981, Environmental Impact and Health Effects: Ann Arbor, Mich., Ann Arbor Science Publishers, p. 231–241.

Rook, J.J., 1974, Formation of haloforms during chlorination of natural waters: Water Treatment and Examination, v. 23, no. 2, p. 234–243.

Wershaw, R.L., Fishman, M.J., Grabbe, R.R., and Lowe, L.E., 1987, Methods for the determination of organic substances in water and fluvial sediments: U.S. Geological Survey Techniques of Water-Resources Investigations, book 5, chap. A3, 80 p.

☆ U.S. GOVERNMENT PRINTING OFFICE: 1994 - 673-211 / 00004 REGION NO. 8