AVAILABILITY AND SUITABILITY OF MUNICIPAL WASTEWATER INFORMATION FOR USE IN A NATIONAL WATER-QUALITY ASSESSMENT: A CASE STUDY OF THE UPPER ILLINOIS RIVER BASIN IN ILLINOIS, INDIANA, AND WISCONSIN

By John S. Zogorski, Stephen F. Blanchard, Randal D. Romack, and
Faith A. Fitzpatrick

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MANUEL LUJAN, JR., Secretary

U.S. GEOLOGICAL SURVEY

Dallas L. Peck, Director

For additional information write to:

District Chief
U.S. Geological Survey
4th Floor
102 E. Main Street
Urbana, IL 61801

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The inch-pound units used in this report may be converted to other inch-pound units and metric units by using the following factors:

Multiply inch-pound unit	By	To obtain these units
million gallons per day (Mgal/d)	1.55	cubic foot per second (ft^3/s)
million gallons per day (Mgal/d)	0.04381	cubic meter per second (m^3/s)

ACRONYMS

Listed below are acronyms that are used frequently in this report.

DMR	Discharge Monitoring Report
IEPA	Illinois Environmental Protection Agency
IFD	Industrial Facilities Discharge
MWRDGC	Metropolitan Water Reclamation District of Greater Chicago
NAWQA	National Water-Quality Assessment
NPDES	National Pollutant Discharge Elimination System
NWIS	National Water Information System
PCS	Permit Compliance System
QA	Quality Assurance
STORET	Storage and Retrieval System
SWUDS	State Water-Use Data System
UIRB	Upper Illinois River Basin
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey

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ABSTRACT

The availability and suitability of existing information on municipal wastewater-treatment practices and effluent characteristics for use in a national water-quality assessment were evaluated. The information will be used to determine the effects of changes in wastewater-treatment practices on stream quality and ecosystem health. A large amount of information on treatment practices and effluent characteristics exists, and some of this information is available from Federal and State computer data bases. However, the suitability of existing information to accomplish the objectives of a national water-quality assessment is limited.

The suitability of this information would be improved by (1) increasing the number of water-quality constituents routinely analyzed for in samples of municipal effluent, (2) increasing the frequency of effluent sampling at some facilities, (3) developing a quality-assurance plan for wastewater flow-rate determinates, and (4) increasing the amount of effluent water-quality data entered into Federal and State computer data bases.

INTRODUCTION

In 1986, the U.S. Geological Survey (USGS) began testing and refining concepts and approaches for a National Water-Quality Assessment (NAWQA) program. The goals of the NAWQA program are to (1) provide a nationally consistent description of current water-quality conditions for a large part of the Nation's water resources; (2) define long-term trends (or lack of trends) of water quality, and (3) identify, describe, and explain, as possible, the major factors that affect observed conditions and trends in water quality.

The goals of the NAWQA program will be accomplished through hydrologic investigations of a number of study units, combinations of river basins and aquifer systems, that are distributed throughout the Nation and that incorporate a large percentage of the Nation's water use (Hirsch and others, 1988, p. 1). In addition to providing an assessment of water-quality conditions and trends for each of the study units, information from the study units will be aggregated in different ways to address a number of regional- and national-scope questions. One of the national-scope questions to be addressed is "What have been the effects of changes in municipal wastewater treatment on stream quality and ecosystem health?" This question is of particular interest because of the costs associated with improving wastewater-treatment plants.

More than 30 years have elapsed since the first Federal wastewater-treatment plant construction-grants program began in 1956. During these years, Federal, State, and local governments and industry have made substantial investments to protect water quality. According to estimates made by the Bureau of Economic Analysis (U.S. Department of Commerce, 1983), about $184 billion was spent for water-pollution abatement and control in the period 1972-82. Future expenditures for pollution abatement and control through the year 2000 have been projected to be as much as $600 billion in 1984 dollars (U.S. Department of the Interior, 1986). Many of these expenditures have been for upgrading municipal wastewater-treatment plants. Given the already large financial investment for pollution abatement and the potential for continued investments in the future, it is reasonable to ask "What has been the result of this effort?"

The effectiveness of most wastewater-treatment plants has been judged on whether they are in compliance with effluent limits specified on the plant's National Pollutant Discharge Elimination System (NPDES) permit. An NPDES permit is required for all point-source effluents, both municipal and industrial, that are discharged to surface waters. The purpose of these permits is to establish the maximum and, in some cases, average allowable conditions for effluent flow rate and concentration of select effluent water-quality constituents. Because one goal of wastewater treatment is to improve the quality of the Nation's surface waters, it is also necessary that the effectiveness of these plants, and changes thereto, be judged in terms of changes in the quality of receiving waters. Evaluation of water-quality improvements in streams, subsequent to upgrading wastewater-treatment levels from secondary to advanced treatment, is especially important because the incremental cost of the upgrade is relatively large compared to the incremental amount of contamination prevented.

In general, few comprehensive data are available to evaluate the effects of changes in municipal wastewater treatment on stream quality and ecosystem health. For example, Leo and others (1983) contacted a large number of Federal and State agencies to determine the availability of data to address this issue. None of the organizations contacted had all of the information judged necessary to make a complete assessment (for example, stream-discharge data, ambient chemical and biological data, effluent-discharge and -quality data, and modeling data for waste-load allocation) before and after a wastewater-treatment plant was upgraded. Eventually, a partial data base was compiled for 52 water bodies. Of the 52 water bodies, data for only 13 were considered to be adequate for detailed review.

Purpose and Scope

This report describes the availability and suitability of existing municipal wastewater-treatment-plant information for use in a national water-quality assessment such as the NAWQA program. Existing information is evaluated according to its usefulness in addressing the national-scope question "What have been the effects of changes in municipal wastewater treatment on stream quality and ecosystem health?" The report describes the results obtained from this study in the upper Illinois River basin (UIRB) in Illinois, Indiana, and Wisconsin, and the implications these results have on the NAWQA program. Although this study was completed to assist in planning the NAWQA program, the results are applicable to other national assessments concerning the effects of changes in wastewater treatment on stream quality and ecosystem health.

Relevance to a National Water-Quality Assessment

A variety of information about municipal wastewater treatment and effluent quality is relevant to the goals of the NAWQA program. Information about wastewater treatment and regulatory requirements includes, but is not limited to, (1) level of wastewater treatment, (2) type of wastewater-treatment technology, (3) NPDES permit requirements, (4) Discharge Monitoring Reports (DMRs), (5) chronology of wastewater-treatment changes, and (6) planned wastewater-treatment changes. Relevant information about municipal effluents includes such factors as (1) existence and location, (2) effluent flow rate, (3) water-quality constituents monitored, (4) frequency and type of effluent sampling, (5) quality-assurance plans, (6) determination of mass loadings, and (7) effluent toxicity testing. The four categories of information about municipal wastewater treatment and effluents that are especially relevant to the NAWQA program are (1) current level of wastewater treatment, (2) type of wastewater-treatment technology, (3) effluent flow rate, concentrations and mass loadings of water-quality constituent, and (4) chronology of wastewater-treatment changes.

Information on the level of treatment for wastewater-treatment plants in a study unit is valuable to the NAWQA program because it "paints the picture" of wastewater-abatement programs at this scale. For example, the extent to which the transition from primary treatment (solids removal only) to secondary treatment (removal of solids and organic substances) can be determined from this information. Information about the type and extent of tertiary treatment throughout a study unit also provides insight as to which contaminants most effect the quality of receiving water bodies. Treatment technologies used at municipal wastewater-treatment plants are commonly used to abate water contamination from floatable and suspended solids, pathogenic organisms, oxygen-demanding substances, and toxicity due to chlorine and ammonia. Less frequently used technologies include those to control the release of nitrogen and(or) phosphorus, so as to limit algae growth in streams.

The third category of information about wastewater-treatment plants of value to the NAWQA program concerns effluent flow rate, water-quality constituent concentrations, and mass loadings. Daily, monthly, seasonal, and annual information about dissolved oxygen, indicator bacteria, nutrients, major ions, trace elements, and other constituents is important for discerning the effects of changes in municipal wastewater treatment on conditions, trends, and causal relations. This information is probably the most valuable to the NAWQA program but the most difficult and costly to obtain.

The final category of information concerns the chronology of changes in wastewater treatment. Many changes in wastewater treatment, either wastewater or sludges, affect the concentration and mass loadings of constituents in wastewater effluent. As such, knowledge of the time when changes in wastewater treatment were made and the type of treatment change are important to properly describe trends in stream and effluent quality and their causal relations.

Selection of Wastewater-Treatment Plants for a National Water-Quality Assessment

The U.S. Environmental Protection Agency (USEPA) (1989, p. 1) reported that 15,591 municipal wastewater-treatment plants were in operation in 1988. It will not be possible to assess the effects of all of these facilities, nor to assess all of the wastewater-treatment plants located in the NAWQA study units. Thus, it is tentatively planned that the NAWQA program will focus on those wastewater-treatment plants that account for a large percentage of the Nation's total municipal effluent (W.G. Wilber, U.S. Geological Survey, written commun., 1989). Nationally, about 2,873 (18 percent) of the treatment plants discharge more than 1 Mgal/d (million gallons per day) of effluent (U.S. Environmental Protection Agency, 1989, p. C-7). In aggregate, these major wastewater-treatment plants account for about 90 percent of the Nation's total effluent discharge. The USEPA refers to wastewater-treatment plants with greater than or equal to 1 Mgal/d as "major" plants and those wastewater-treatment plants with less flow as "minor" plants.

Selection of wastewater-treatment plants to be included in each NAWQA study unit will be done in two parts (W.G. Wilber, U.S. Geological Survey, written commun., 1989). First, a small number (5 to 10) of very large wastewater-treatment plants that account for a large percentage of the total municipal effluent in each study unit will be selected. Second, 10 to 15 additional major wastewater-treatment plants in each study unit will be randomly selected from subpopulations representing different levels of wastewater treatment and stream:effluent dilution ratio. In the full-scale NAWQA program, about 800 to 1,200 wastewater-treatment plants would be studied nationwide to address the previously noted national-scope question. The selection of specific wastewater-treatment plants for inclusion in the NAWQA program has not been determined to date; however, the selected wastewater-treatment plants collectively will represent approximately 50 percent of the Nation's municipal effluent.

Organizations Collecting and Compiling Information

Wastewater-treatment-plant effluents are monitored by a variety of interested parties including operators of wastewater-treatment plants, Federal and State regulatory agencies, and nonregulatory agencies. Operators of municipal wastewater-treatment plants are required by Federal and State laws to monitor the quality of their untreated sewage and treated wastewater effluent, and to report this information on a DMR form. This form contains information on flow rates, concentrations, and mass loadings, and is submitted to the appropriate State regulatory agency and sometimes also to the USEPA. State regulatory agencies and the USEPA maintain a number of computer data bases containing information about the NPDES permits and DMRs, such as the Permit Compliance System (PCS) and Industrial Facilities Discharge (IFD) data bases. The USEPA also conducts periodic inventories of needed wastewater-engineering projects that are computerized in the Needs Survey data base. Most district offices of the USGS also maintain a State Water-Use Data System (SWUDS), and these data bases may contain information on effluent flow rate and quality.

Other agencies and organizations also collect and compile data about wastewater-treatment plants for water-quality management planning. Examples include consulting firms, regional planning commissions, university researchers, and nonregulatory agencies. These entities provide municipalities, counties, and drainage districts with impact statements and water-resource management plans. These plans, in accordance with Federal and State regulations, are based on many factors, such as effluent characteristics, stream quality, projected land use, and nonpoint sources of pollution.

Study Objectives and Approach

Many types of ancillary data are needed for large water-quality assessments, such as the NAWQA program. The kinds of ancillary data needed are determined, in part, by the types of target variables chosen for analyses on samples from water, sediment, and tissue. For example, if the target variable was a group of manmade organic compounds, the explanation of conditions and trends of these compounds requires ancillary data relating to point-source dischargers, application rates of agricultural pesticides, atmospheric inputs, and an inventory of toxic-waste disposal sites. This study focused on one particular type of ancillary data that affects many parameter groups--municipal wastewater-treatment plants and their effluents. The objectives of the study are to

(1) describe the availability of municipal wastewater-treatment information,

(2) describe sources and types of effluent-monitoring data currently available for municipal wastewater-treatment plants, and

(3) describe the suitability of effluent-monitoring data and wastewater-treatment information for use in the NAWQA program.

The UIRB, a surface-water NAWQA pilot project area, was chosen for this study because of the large metropolitan area of Chicago, its many associated wastewater-treatment plants, and the availability of comprehensive data bases on stream quality. There are approximately 181 NPDES-permitted municipal wastewater-treatment plants that discharge effluent to streams in the UIRB. Within the UIRB, four subbasins (fig. 1) were selected for which sources and types of wastewater information were identified and the availability and suitability of the data determined. The basins were intentionally selected in

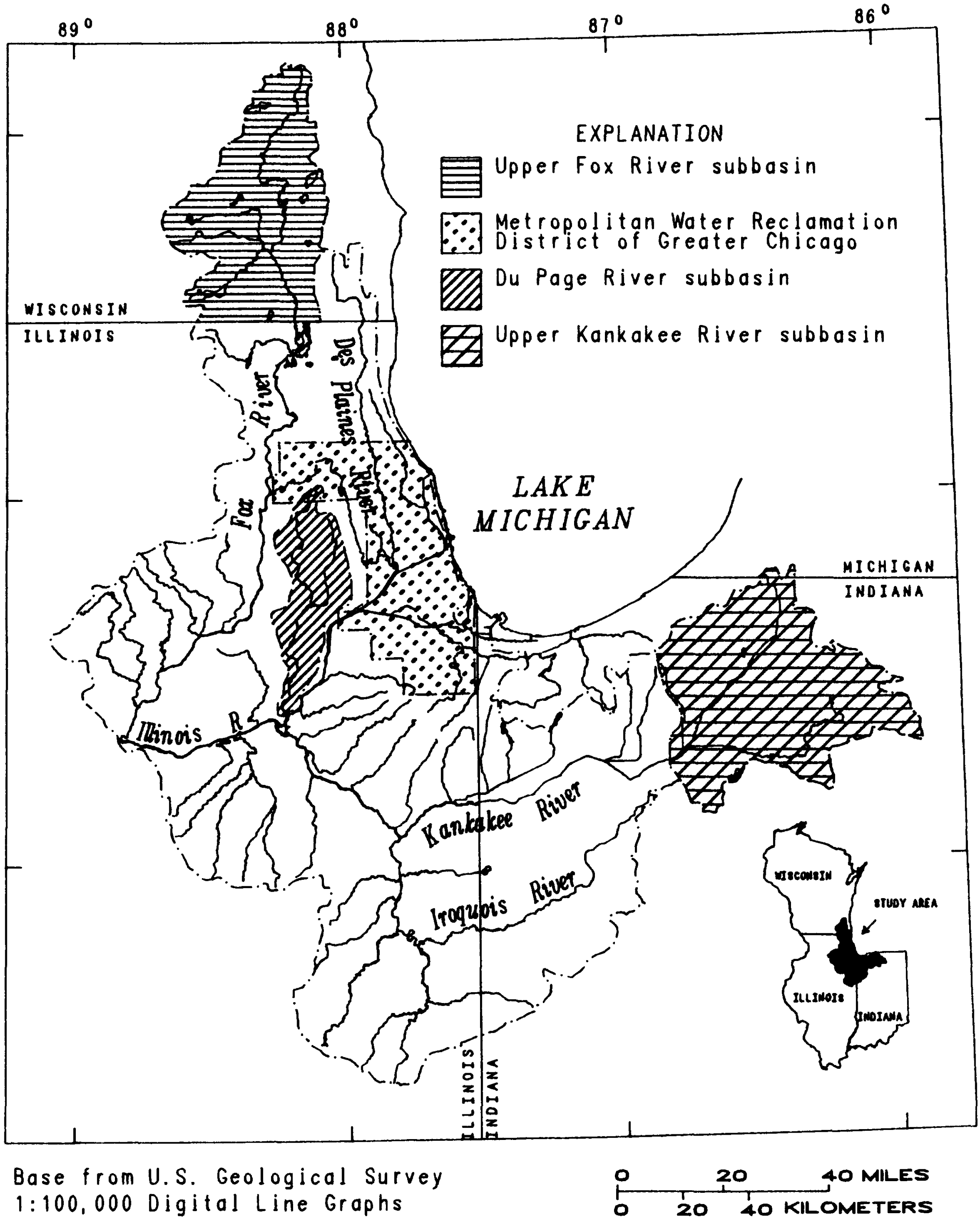

Figure 1.--General location of the four subbasins in the upper Illinois River basin.

three different States to examine the variation in wastewater-treatment-plant and effluent information from one State to another. These subbasins include (1) the Du Page River subbasin in Illinois, (2) the upper Fox River subbasin in Wisconsin, (3) the upper Kankakee River subbasin in Indiana, and (4) the Metropolitan Water Reclamation District of Greater Chicago (MWRDGC) service area in Illinois. The MWRDGC service area will be referred to as a subbasin for simplicity even though the service area is based on political boundaries (Cook County) and not drainage area. General information characterizing these four subbasins is given in table 1.

Table 1.--General information for the four subbasins in the upper Illinois River basin

Subbasin	Estimated drainage area (square miles)	Estimated population[1] (1985)	Estimated land use[2] (percentage)
Du Page River	[3]376	555,000	38 urban 50 agriculture 4 forest 7 barren 1 water
Upper Fox River	[3]869	250,000	10 urban 67 agriculture 12 forest 2 barren 5 wetland 4 water
Upper Kankakee River	[4]1,108	134,000	4 urban 87 agriculture 6 forest 1 barren 1 wetland 1 water
MWRDGC[5] service area (Cook County)	[6]961	4,900,000	71 urban 18 agriculture 8 forest 3 barren

[1]Estimated from data of U.S. Bureau of Census 1980 decennial census files, adjusted to the 1985 U.S. Bureau of Census data for county populations.

[2]Estimated from Fegeas and others, 1983.

[3]Estimated from Coupe and others, 1989.

[4]Estimated from Hoggatt, 1975.

[5]Metropolitan Water Reclamation District of Greater Chicago.

[6]Estimated from Edgar, 1982.

Acknowledgments

This study has depended heavily on cooperation and information from many sources including Federal, State, and local agencies; the Metropolitan Water Reclamation District of Greater Chicago; and operators of municipal wastewater-treatment plants. The assistance and cooperation of all are gratefully appreciated.

METHODS OF ACQUIRING, COMPILING, AND EVALUATING INFORMATION

Information used for this investigation was obtained from a variety of sources including contact with officials at Federal, State, and local agencies, retrievals from computer data bases, and interviews with wastewater-treatment-plant operators (engineers or managers). The process of obtaining, compiling, and evaluating this information is explained below.

Acquiring Information from Local, State, and Federal Agencies

A large number of agencies were contacted including the MWRDGC, Illinois Environmental Protection Agency (IEPA), Indiana Department of Environmental Management, Wisconsin Department of Natural Resources, USEPA, and USGS district offices in Illinois, Indiana, and Wisconsin. These agencies were contacted to (1) request specific data for inclusion in this investigation, (2) gain access to and explain computer data bases containing information on wastewater-treatment plants, and (3) explain relevant aspects of their water-pollution-abatement programs. In some cases, the agencies were contacted again with hypothetical inquiries to ascertain their ability to provide various other information relevant to the NAWQA program. The purpose of the inquiries was to evaluate the ability of the agencies to provide information in a timely fashion, not to obtain data.

The MWRDGC provided a variety of detailed information including descriptive material for their wastewater-treatment plants, a chronology of treatment improvement projects, NPDES permits for each plant, and a computer data base containing daily effluent flow rates and effluent water quality. State regulatory agencies provided information on mailing addresses, State data bases, data from the PCS data base, sources for their data, and general procedures describing data entry into the PCS. The staffs of the IEPA and USEPA provided information on access to the PCS and Needs Survey data bases. The USGS district offices in Illinois and Wisconsin provided wastewater information from the SWUDS.

Description and Use of State and Federal Data Bases

Several computer data bases contain information on municipal effluents, and these data are available through, and maintained by, both Federal and State agencies. The USEPA maintains three data bases that contain information about effluents. These include the PCS, the IFD, and the Needs Survey. The

PCS is used to monitor the compliance of all major discharges (municipal and nonmunicipal) with the conditions of their NPDES permits. This computer data base contains information about site characteristics, effluent flow rates, and concentrations and mass loadings of some water-quality constituents, as reported by wastewater-treatment-plant operators on their DMRs. The IFD data base only contains information about general site characteristics and permitted flow rates. Each State regulatory agency updates the PCS and has access to their own State's data base. Data from the PCS for the UIRB are available from about 1986 and were obtained from the USEPA or through appropriate State regulatory agencies. Data retrievals from the PCS were used extensively in this investigation. The IFD was used on a limited basis to estimate the number of wastewater-treatment plants in each State in the UIRB. This estimate was compared to estimates from other sources.

The Needs Survey data base contains (1) cost estimates for wastewater-improvement projects in each State to meet the goals of the Clean Water Act and (2) estimates of effluent flow rate and concentration of biochemical oxygen demand discharged from municipal wastewater-treatment plants. Needs Surveys were conducted by the USEPA in 1973, 1974, 1976, 1978, 1980, 1982, 1984, 1986, and 1988. Needs Survey data bases are available through the Priority and Needs Section, Office of Water Program Operation, USEPA. This computer data base was not used in this investigation.

Information from the Illinois and Wisconsin SWUDS data bases were made available through the district offices of the USGS, Water Resources Division. The SWUDS data bases are accessible from the USGS's National Water Information System (NWIS). These data bases include information from DMRs and describe each wastewater-treatment plant's location, effluent flow rate, and water-quality data. The time period covered by the data bases varied. Presently (1989), data from 1985 are available for Wisconsin, and data from 1986 through 1987 are available for Illinois. Information on wastewater-treatment plants is not maintained in the Indiana SWUDS data base. Illinois and Wisconsin SWUDS data bases were used in this investigation to determine mailing addresses, level of treatment, location of discharge points, and effluent flow rate for wastewater-treatment plants. Permitted wastewater flow rates in the IFD data base were used to estimate Indiana's contribution of effluent flow rate in the UIRB.

Resources For the Future maintains an Environmental Data Inventory (REDI) that summarizes information for 80,000 point and nonpoint sources for the periods 1977-81, and 1981-85 (Gianessi and Peskin, 1984). This national data base is a compilation of three data bases maintained by the USEPA--the IFD, the PCS, and the 1978 Needs Survey. Other sources of information for the REDI in the UIRB are the IEPA, Michigan Area Council of Government, Northwest Indiana Planning Commission, Wisconsin Department of Natural Resources, and the Southeastern Wisconsin Regional Planning Commission. The REDI data base is available through the Office of National Water Summary and Long Range Planning, USGS. The REDI was not used in this investigation because direct access to the PCS and IFD data bases was available.

Interviews with Operators of Wastewater-Treatment Plants

Interviews with the operators of wastewater-treatment plants in the Du Page River, upper Fox River, and upper Kankakee River subbasins were conducted to obtain the most complete, current, and accurate information on wastewater treatment and effluent quality available. One use of this information was to judge the accuracy of information in the SWUDS, PCS, and other computer data bases versus information reported on DMRs. Such interviews were not deemed necessary for wastewater-treatment plants in the MWRDGC subbasin since current information for these wastewater-treatment plants was already available to the authors. A standard questionnaire for the interview with wastewater-treatment-plant operators was developed for use in this study (see Appendix A).

A preliminary list of wastewater-treatment plants in the Du Page River, upper Fox River, and upper Kankakee River subbasins was retrieved from the SWUDS and later used to obtain addresses from State regulatory agencies. A letter was sent to each of the operators with the questionnaire attached. This letter described the objectives of the investigation and requested their cooperation in providing answers to questions on the questionnaire during a site visit by USGS personnel and by providing copies of their NPDES permits and DMRs. A follow-up phone call was made to each operator to schedule the interview. Interviews took place over a 2-month period during the summer of 1989. During the interview, the operator's response to each question on the questionnaire was recorded and discussed. Copies of the plant's NPDES permits from 1978 to the present, and DMRs for 1986 and 1987 also were obtained. In some cases, all of the desired information was not readily available, and it was requested that information be sent as soon as possible. In a few cases, phone calls were made and letters were written to wastewater-treatment-plant operators to obtain information that was not made available during the interview. The interviews and questionnaires provided information for 43 wastewater-treatment plants in the Du Page River, upper Fox River, and upper Kankakee River subbasins. Operators of a few small wastewater-treatment plants could not be contacted. The information for the 43 wastewater-treatment plants was combined with information for 5 wastewater-treatment plants in the MWRDGC subbasin.

Compilation and Evaluation of Wastewater Information

The MWRDGC operates seven wastewater-treatment plants in their service area. For this report, the MWRDGC Hanover plant was included in the Du Page River subbasin and the Lemont plant was not included in the study because of its extremely small size relative to other MWRDGC wastewater-treatment plants.

The information obtained from wastewater-treatment-plant operators, computer data bases, and regulatory agencies was compiled to assess variations between subbasins, and size of the wastewater-treatment plants. The variation from one subbasin to another can be the result of differing land use, population, and regulatory policies and procedures. Four effluent flow-rate categories--less than 1 Mgal/d, 1 to less than 10 Mgal/d; 10 to 99.9 Mgal/d, and greater than 99.9 Mgal/d--were used to describe the variation of information based on treatment-plant size. In this investigation, three effluent flow-rate categories were used for the major wastewater-treatment plants to identify variations in the availability of information for these wastewater-treatment plants, above and beyond what differentiation a comparison of only minor and major wastewater-treatment plants would have achieved.

This report discusses the utility of wastewater-treatment and effluent information relative to its potential use in the NAWQA program. The availability of this information was evaluated relative to one or more of several factors. These included the extent to which the information was available to the public from computer data bases and the lag time in entering the data. The extent to which regulatory agencies and wastewater-treatment-plant operators were cooperative in providing information also was considered in determining the availability of the information. To the extent possible, each of these factors was assessed in a quantitative fashion; however, for some factors, a qualitative evaluation such as "Yes," "No," or "Partially" was necessary.

The suitability of information on wastewater-treatment plants and their effluents also was determined for use in the NAWQA program. The fact that existing data or information about wastewater-treatment plants and their effluents was not suitable for use in the NAWQA program does not imply that it is not useful for meeting the objective for which it was originally collected, or that it could not be used for water-quality assessments with different objectives than the NAWQA program. Five questions were formulated to evaluate the suitability of municipal effluent information:

(1) Are the water-quality constituents analyzed comparable to those measured in the NAWQA program?

(2) Do quality-assurance plans exist for laboratory analyses and measurements of flow rates?

(3) Are the frequency and type of effluent-quality sampling appropriate?

(4) Can daily, monthly, and annual mass loadings be calculated?

(5) Were the data reported on DMRs accurately entered into computer data bases?

AVAILABILITY AND SUITABILITY OF INFORMATION ON MUNICIPAL WASTEWATER TREATMENT FOR A NATIONAL WATER-QUALITY ASSESSMENT

Information on municipal wastewater treatment is described in this section with particular reference to its utility in the NAWQA program. Included is a description of the availability of current information to (1) describe municipal wastewater treatment on both subbasin and study-unit scales, (2) determine the level of wastewater treatment at individual wastewater-treatment plants, (3) determine the type of wastewater-treatment technology used at each plant, (4) reconstruct the chronology of past wastewater-treatment changes, and (5) describe wastewater-improvement projects planned 5 to 10 years hence. The ability to obtain NPDES permits from State regulatory agencies and wastewater-treatment-plant operators also is described. In addition, the concluding section describes how existing wastewater-treatment information can be enhanced for use in the NAWQA program.

A large amount of information exists on municipal wastewater treatment to address the national-scope issue "What have been the effects of changes in municipal wastewater treatment on stream quality and ecosystem health?" Some of this information is entered in Federal and State computer data bases and is readily available for public use. Municipal wastewater information not presently entered in these data bases can be obtained from the operators and managers of wastewater-treatment plants. The success of the interviews conducted in this study and the comprehensiveness of the information thereby obtained was due to the excellent cooperation of these officials. Without their full cooperation, the scope of this study, and the ability to address the aforementioned national-scope issue in the NAWQA program, would be greatly reduced.

General Description of Wastewater-Treatment Plants

Upper Illinois River Basin

Three data bases were used to estimate the number and volume of municipal effluent discharged in the UIRB including the IFD, Wisconsin SWUDS (1985), and Illinois SWUDS (1986). There are 181 wastewater-treatment plants discharging effluent to streams in the UIRB (table 2). The Illinois and Wisconsin SWUDS data bases were considered to most closely represent the number of active wastewater-treatment plants in the Du Page River and upper Fox River subbasins. The IFD data base contains many inactive wastewater-treatment plants, and the PCS data base for Illinois does not include flow-rate and water-quality data for some of the minor plants in Illinois.

Wastewater-treatment plants in Illinois contribute about 97 percent (1,768 Mgal/d) of the 1,815 Mgal/d of effluent discharged to streams in the UIRB (table 2). Wastewater-treatment plants in Indiana and Wisconsin contribute 1 and 2 percent, respectively.

The size of wastewater-treatment plants, categorized by the amount of effluent discharged to streams, also were estimated from the IFD and SWUDS data bases (table 3). The "zero" flow-rate category in table 3 includes wastewater-treatment plants with no discharge to a stream, inactive plants, and discontinued plants.

In Wisconsin and Indiana, approximately 80 percent of the wastewater-treatment plants discharge less than 1 Mgal/d. In contrast, only about 55 percent of the wastewater-treatment plants in Illinois discharge less than 1 Mgal/d. Thirty-five percent of the wastewater-treatment plants in Illinois discharge from 1 to less than 10 Mgal/d, compared with 23 percent in Indiana and 15 percent in Wisconsin. Nine percent of the plants in Illinois discharge from 10 to 99.9 Mgal/d, compared to 2 percent in Indiana and Wisconsin. Only three Illinois wastewater-treatment plants discharge greater than 99.9 Mgal/d.

Table 2.--Wastewater-treatment plants and effluent flow rates for the upper Illinois River basin[1]

[Mgal/d, million gallons per day]

State	Wastewater-treatment plants: Number	Wastewater-treatment plants: Percentage of total number	Effluent flow rate: Mgal/d	Effluent flow rate: Percentage of total effluent flow
Illinois	[2]139	77	1,768	97
Indiana	[3]22	12	16.5	1
Wisconsin	[4]20	11	30.5	2
Total	181	100	1,815	100

[1]Includes wastewater-treatment plants with an effluent discharged to a stream.
[2]Determined from Illinois State Water Use Data System.
[3]Determined from Industrial Facilities Discharge data base.
[4]Determined from Wisconsin State Water Use Data System.

Table 3.--Wastewater-treatment plants, by size of effluent flow rates to streams, in the upper Illinois River basin

State	Total number of wastewater-treatment plants in computer data base	Total number of wastewater-treatment plants discharging to a stream	Zero[1]	Number of wastewater-treatment plants with flow rates in the following size ranges: Less than 1 million gallons per day	1 to less than 10 million gallons per day	10 to 99.9 million gallons per day	Greater than 99.9 million gallons per day
Illinois	188	139	49	76	48	12	3
Indiana	54	22	32	17	5	0	0
Wisconsin	28	20	8	16	3	1	0
Total	270	181	89	109	56	13	3

[1]Zero flow-rate category includes wastewater-treatment plants with no discharge to a stream, inactive plants, and discontinued plants.

Four Subbasins

Fifty-six wastewater-treatment plants were identified in the four subbasins selected for study in the UIRB. Eight of these were later deleted from detailed analyses because of one or more of the following: (1) inability to locate or contact the owner or operator of the wastewater-treatment plant to conduct a site interview (typically this situation was for very small wastewater-treatment plants), (2) the effluent was not discharged to a stream, or (3) the plant had a general-use NPDES permit with no site-specific information. The number of wastewater-treatment plants in each of the four subbasins for four size categories is presented in table 4. Fifty percent of the 48 wastewater-treatment plants are minor plants with an average flow rate of less than 1 Mgal/d. Most of these minor wastewater-treatment plants are located in the upper Fox River and upper Kankakee River subbasins. In contrast, 10 of the 17 wastewater-treatment plants in the Du Page River subbasin have average flow rates in the range of 1 to less than 10 Mgal/d. The MWRDGC operates three wastewater-treatment plants with individual flow rates exceeding 99.9 Mgal/d. These wastewater-treatment plants are the Calumet plant, the Northside plant, and the Southwest plant, with 1988 mean average flow rates of 253, 270, and 808 Mgal/d, respectively. The Southwest plant is the largest wastewater-treatment plant in the world. Because of the very large wastewater-treatment plants in the Chicago area, the four subbasins represent 82 percent of the effluent discharged to streams in the entire UIRB.

Table 4.--Wastewater-treatment plants, by size of effluent flow rates to streams, in the four subbasins in the upper Illinois River basin

Subbasin	Total number of wastewater-treatment plants	Number of wastewater-treatment plants with flow rates[1] in the following size ranges			
		Less than 1 million gallons per day	1 to less than 10 million gallons per day	10 to 99.9 million gallons per day	Greater than 99.9 million gallons per day
Du Page River	17	4	10	3	0
Upper Fox River	11	8	2	1	0
Upper Kankakee River	15	12	3	0	0
MWRDGC[2]	5	0	0	2	3
Total	48	24	15	6	3

[1]Determined from Discharge Monitoring Reports.
[2]Metropolitan Water Reclamation District of Greater Chicago.

The total flow rate of effluents in each of the four subbasins varies markedly (table 5). The smallest effluent flow rate occurs in the upper Kankakee River subbasin with a total average effluent flow rate of 8.3 Mgal/d. The upper Fox River and Du Page River subbasins have average wastewater flow rates of 20.5 and 75.6 Mgal/d, respectively. The MWRDGC subbasin has the largest total effluent flow rate with an average flow of approximately 1,385 Mgal/d.

Table 5.--Total effluent flow rates to streams for the four subbasins in the upper Illinois River basin

Subbasin	Number of wastewater-treatment plants	Total effluent flow rate (million gallons per day)	Effluent flow rates[1] for the following size ranges (number in parentheses is percent of total flow rate): Less than 1 million gallons per day	1 to less than 10 million gallons per day	10 to 99.9 million gallons per day	Greater than 99.9 million gallons per day
Du Page River	17	75.6	1.6(2)	40.0(53)	34.0(45)	0.0(0)
Upper Fox River	11	20.5	2.0(10)	7.5(37)	11.0(54)	.0(0)
Upper Kankakee River	15	8.3	2.1(25)	6.2(75)	.0(0)	.0(0)
MWRDGC[2]	5	1,385	.0(0)	.0(0)	55.0(4)	1,330(96)
Total	48	1,489	5.7(0.4)	53.7(3.6)	100(6.7)	1,330(89.3)

[1]Determined from Discharge Monitoring Reports.
[2]Metropolitan Water Reclamation District of Greater Chicago.

The information in tables 4 and 5 indicates that a few of the largest wastewater-treatment plants within each subbasin contribute nearly 50 percent or more of the total effluent flow rate for that subbasin. Further, the nine largest wastewater-treatment plants in the four subbasins, each with a flow rate in excess of 10 Mgal/d, comprised 96 percent of the combined total effluent flow rate of the four subbasins and 79 percent of the total effluent flow rate in the UIRB. Three of MWRDGC's treatment plants--the Calumet, Northside, and Southwest--contribute 73 percent of the total effluent discharged to streams in the UIRB.

Level of Wastewater Treatment

The level of municipal wastewater treatment is categorized as either primary, secondary, or tertiary (advanced). The determination of these categories depends upon the removal of suspended solids, biochemical oxygen demand, and other constituents. For the purpose of this report, primary treatment includes technologies used for the removal of floatable and settleable solids; secondary treatment includes technologies used for the removal of approximately 85 percent of the organic, oxygen-demanding substances; and tertiary treatment includes technologies used for the removal of substances such as ammonia, phosphorus, suspended solids, and biochemical oxygen demand, above and beyond levels accomplished during primary and secondary treatment.

A flow diagram of a wastewater-treatment plant with primary, secondary, and tertiary treatment is illustrated in figure 2. Note especially the sections of the wastewater-treatment plant designated as primary, secondary, and tertiary. The designation of a plant as a secondary-treatment plant usually indicates that it contains both primary and secondary treatment, whereas the designation of a plant as a tertiary-treatment plant denotes the plant usually

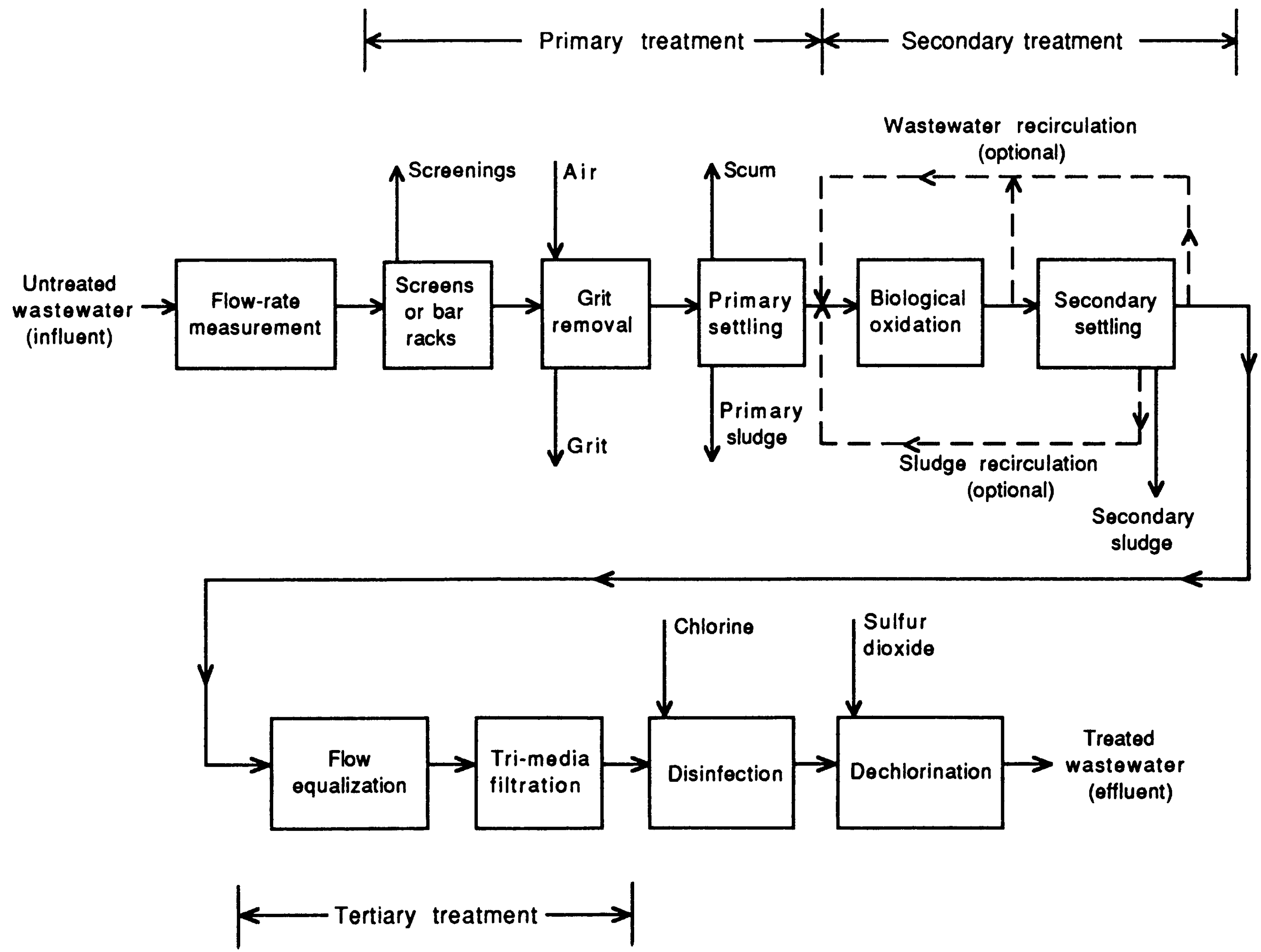

Figure 2.--Flow diagram of a wastewater-treatment plant with primary, secondary, and tertiary treatment.

includes primary-, secondary-, and tertiary-treatment technologies. At some wastewater-treatment plants, secondary and tertiary treatments are accomplished in a single treatment step and not in separate stages as shown in figure 2.

As part of this investigation, answers to two questions related to the level of wastewater treatment were sought:

- Can the level of treatment at each wastewater-treatment plant be accurately determined from site interviews?
- Can the level of treatment at each wastewater-treatment plant be accurately determined from a computer data base?

The site visit to each wastewater-treatment plant, provided accurate information to characterize the level of treatment for each plant, as well as for the four subbasins. The results of the questionnaire are compiled in table 6 and illustrate the extent of primary, secondary, and tertiary treatment in each of the four subbasins. Each wastewater-treatment plant in the four subbasins had at least secondary-level treatment, and most of the wastewater-treatment plants have some form of tertiary treatment. For example, 14 of the 17 wastewater-treatment plants in the Du Page River subbasin provide some form of tertiary treatment.

Table 6.--Number and percentage of wastewater-treatment plants with differing levels of treatment

Subbasin	Number of wastewater-treatment plants	Level of treatment: Only primary treatment		Primary and secondary treatment		Primary secondary, and tertiary treatment	
		Number	Percent	Number	Percent	Number	Percent
Du Page River	17	0	0	3	18	14	82
Upper Fox River	11	0	0	5	45	6	55
Upper Kankakee River	15	0	0	7	47	8	53
MWRDGC[1]	5	0	0	3	60	2	40
Total	48	0	0	18	38	30	62

[1]Metropolitan Water Reclamation District of Greater Chicago.

The flow rate of effluent receiving secondary or tertiary treatment also was determined from the completed questionnaires. This information was tallied and is summarized for each subbasin in table 7. The percentages of total effluent in the Du Page River, upper Fox River, and upper Kankakee River subbasins receiving tertiary treatment were 96, 97, and 80 percent, respectively. Only 4 percent of the municipal effluents in the MWRDGC subbasin receives tertiary treatment.

Table 7.--Effluent flow rate receiving differing levels of treatment in the four subbasins in the upper Illinois River basin

Subbasin	Flow rate of effluent receiving the following level of treatment (million gallons per day)		Percent of effluent receiving tertiary treatment
	Secondary treatment	Tertiary treatment	
Du Page River	2.9	72.4	96
Upper Fox River	.69	19.8	97
Upper Kankakee River	1.7	6.6	80
MWRDGC[1]	1,330	55.0	4
Total	1,335	154	10

[1]Metropolitan Water Reclamation District of Greater Chicago.

The various types of tertiary-treatment technologies used at each wastewater-treatment plant was determined from the questionnaires and, in some cases, from a review of the plant's flow diagram. Nitrification, denitrification, phosphorus removal, and additional removal of suspended solids and biochemical oxygen demand were the various tertiary-treatment practices in the four subbasins (table 8). Many of the wastewater-treatment plants practiced more than one type of tertiary treatment. This is evident from table 8, which shows that 53 tertiary-treatment practices were in operation at 30 wastewater-treatment plants. Substantial differences in tertiary treatment are evident from subbasin to subbasin. For example, five of the seven tertiary wastewater-treatment plants practicing phosphorus removal were located in the upper Fox River subbasin. Also, a large number of wastewater-treatment plants providing nitrification and additional removal of biochemical oxygen demand and suspended solids are located in the Du Page River subbasin.

Computer codes describing the level of treatment at wastewater-treatment plants in Wisconsin are available in the Wisconsin SWUDS data base. The Illinois and Indiana SWUDS data bases do not contain information for this code. The level of treatment code in the Wisconsin SWUDS data base is a 1-digit identifier and can be used to define primary, secondary, or tertiary treatment for each wastewater-treatment plant. However, the tertiary code may be substituted by an identifier describing the type of technology used (activated sludge, rotating biological contactors, and so forth) or by an identifier for the method of effluent and sludge disposal.

Information on the level of treatment code was available for 11 wastewater-treatment plants in the upper Fox River subbasin. The lag time in getting this code entered into the SWUDS varies but is typically between 2 to 12 months.

Table 8.--Number and percentage of wastewater-treatment plants with differing forms of tertiary treatment

Subbasin	Number of wastewater-treatment plants with tertiary treatment	Total number of tertiary treatment practices	Type of tertiary treatment: Nitrification		Denitrification		Phosphorus removal		Advanced biochemical-oxygen-demand and suspended-solids removal	
			Number	Percent[1]	Number	Percent[1]	Number	Percent[1]	Number	Percent[1]
Du Page River	14	27	11	79	2	14	0	0	14	100
Upper Fox River	6	12	2	33	0	0	5	83	5	83
Upper Kankakee River	8	10	3	38	0	0	2	25	5	62
MWRDGC[2]	2	4	2	100	0	0	0	0	2	100
Total	30	53	18	60	2	7	7	23	26	87

[1]Percentage of wastewater-treatment plants with tertiary treatment of this type.
[2]Metropolitan Water Reclamation District of Greater Chicago.

The accuracy of the level of treatment code entered in the Wisconsin SWUDS data base for wastewater-treatment plants in the upper Fox River subbasin was determined by comparison with information on each plant's level of treatment determined during the site interviews. Entries for 2 of the 11 wastewater-treatment plants in the upper Fox River subbasin were incorrect or outdated. On the basis of this limited sampling, it appears that information in the Wisconsin SWUDS data base characterizing the level of treatment was incorrect, and the use of this data base without field verification to ascertain site specific or a basin-scale perspective of the level of wastewater treatment may give erroneous results.

While reviewing information from the Wisconsin SWUDS data base on the level of treatment code, another difficulty became apparent. Specifically, the 1-digit code in this data base is ambiguous and does not explicitly specify, for some wastewater-treatment plants, if primary, secondary, or tertiary treatment is used. Instead, for some wastewater-treatment plants, it gives a code for the type of treatment technology or disposal method used. Some of these technologies, however, can be used in either the secondary or tertiary part of a wastewater-treatment plant and, therefore, these codes are ambiguous for determining if secondary or tertiary treatment is actually accomplished. Examples include codes for rotating biological contactors and activated sludge. Four of the eleven wastewater-treatment plants with level of treatment codes in the Wisconsin SWUDS data base had this difficulty. This ambiguity was resolved by contacting the staff of the Wisconsin Department of Natural Resources, who maintain a 2-digit treatment code that clearly distinguishes the level of treatment at each wastewater-treatment plant in Wisconsin.

Type of Wastewater-Treatment Technology

Many technologies are used to treat municipal wastewater and associated sludges. Knowledge about the particular type of technologies used at a wastewater-treatment plant can provide insight about the expected occurrence of various water-quality constituents in the plant's effluent, as well as a general idea of the concentration range to be expected. For example, a plant with tertiary nitrification would be expected to have an effluent with a relatively low concentration of ammonia nitrogen [0 to 5 mg/L (milligrams per liter)] and high concentration of nitrate nitrogen (10 to 30 mg/L). Similarly, a plant with tertiary filtration would be expected to have an effluent with low concentration of suspended solids and biochemical oxygen demand, possibly as low as (or lower than) 5 mg/L each. Such insights into the expected occurrence of water-quality constituents in effluents are useful in an investigation of the status and trends of water-quality data for streams, as well as in elucidating cause and effect relations between effluent discharges and stream quality.

Two questions relating to the type of wastewater-treatment technology were evaluated in this study:

- Can the type of treatment technology used at each wastewater-treatment plant be determined from the interview results or a plant's flow diagram?

- Can the type of treatment technology be determined from a computer data base?

During the interview process, flow diagrams, which usually illustrate the specific technologies used to treat wastewater, were obtained for 36 of the 48 wastewater-treatment plants (table 9). Many of the 12 wastewater-treatment plants that did not have a flow diagram available during the interview agreed to forward it at a later date, but this document had not been received 30 days after the interview. Four of the twelve wastewater-treatment plants that did not provide a flow diagram were major plants with flow rates ranging of 2 to 11 Mgal/d. In future studies, the questionnaire (Appendix A) should be modified to include a sketch of the plant's flow diagram. As an alternative, flow diagrams may be obtained from some State regulatory agencies through their construction-permit files.

The USEPA has developed a coding system to describe the type of technologies used to treat wastewater and wastewater sludges, and to identify how the effluent is disposed of (for example, discharge to surface water, land application, underground injection, recycle/reuse, and ocean disposal). The treatment-type code, called "TRET," can be retrieved from USEPA's PCS data base. The code consists of up to twelve 2-digit identifiers. For example, a TRET code of "1L1M1U3H5B5P1U2F4A" for a particular wastewater-treatment plant describes the following treatment and disposal scheme: grinding (1L); grit removal (1M); sedimentation (1U); trickling filtration (3H); anaerobic digestion (5B); land application (5P); sedimentation (1U); disinfection with chlorine (2F), and discharge to surface water (4A). From this code, the plant's flow diagram can be reconstructed (see fig. 3).

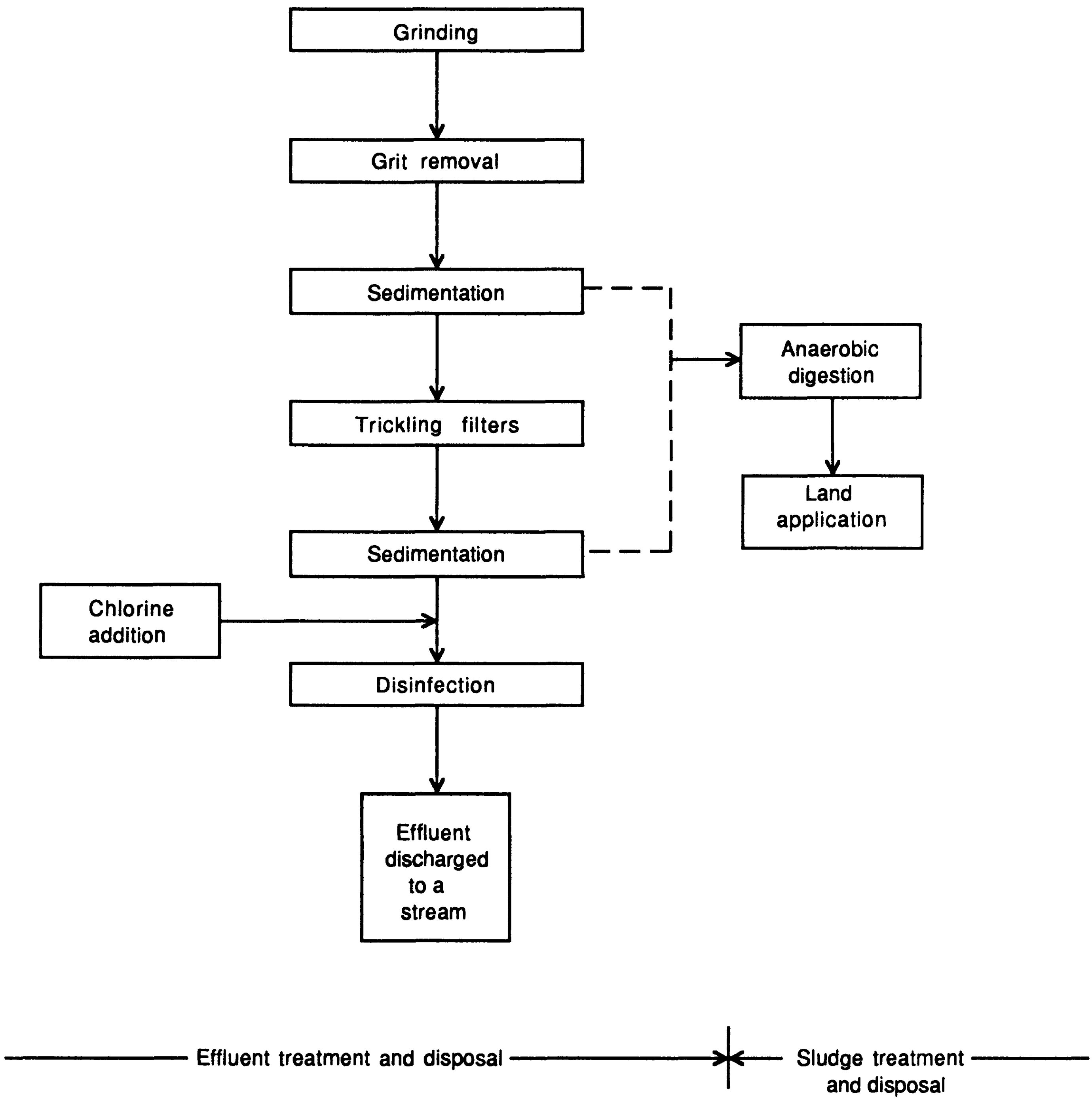

Figure 3.--Flow diagram for a wastewater-treatment plant reconstructed from the treatment-type code.

Table 9.--Ability to obtain flow diagrams of wastewater-treatment plants from wastewater-treatment-plant operators

Subbasin	Total number of wastewater-treatment plants	Able to obtain flow diagram of wastewater-treatment plant? "Yes" Number	"Yes" Percent	"No" Number	"No" Percent
Du Page River	17	12	71	5	29
Upper Fox River	11	10	91	1	9
Upper Kankakee River	15	9	60	6	40
MWRDGC[1]	5	5	100	0	0
Total	48	36	75	12	25

[1]Metropolitan Water Reclamation District of Greater Chicago.

Presently, the entry of information by State regulatory agencies into the TRET code is voluntary. A review of the PCS data bases for the wastewater-treatment plants located in the four subbasins indicated that the TRET code was entered for only three wastewater-treatment plants--two in the Du Page River subbasin and one in the MWRDGC subbasin. A check of the TRET code with the plant's flow diagram indicated that the three entries in the computer data bases were correct. Some State regulatory agencies maintain a local computer data base containing information on treatment technologies used at individual wastewater-treatment plants. For example, IEPA maintains such a data base of wastewater-treatment plants in Illinois. The accuracy of the information in local computer data bases should be verified prior to use in a national assessment. Until a national data base exists, direct contact with wastewater-treatment-plant operators is another alternative for obtaining information on treatment technologies.

National Pollutant Discharge Elimination System Permits

Each municipal wastewater-treatment plant that discharges effluent to receiving waters is required to have an NPDES permit. Among many other requirements, this permit stipulates the conditions under which effluent can be discharged and, in many cases, establishes site-specific numerical limits for effluent flow rate, concentrations, and mass loadings of select water-quality constituents. An NPDES permit also contains information on the required sampling frequency (daily, weekly, and so forth) and sample type (grab, continuous, and so forth) for flow rate and water-quality constituents. Information about compliance schedules for changes in wastewater treatment and implementation of additional treatment technologies also may be contained in an NPDES permit. Thus, NPDES permits contain much information that is relevant to water-quality assessments including the NAWQA program. The complete text of of an NPDES permit is not entered into a national computerized data base; however, specific effluent limits for water-quality constituents are entered into the PCS data base.

Two questions about NPDES permits were evaluated as part of this study:

- o Can NPDES permits be obtained from wastewater-treatment-plant operators?
- o Can NPDES permits be readily obtained from State regulatory agencies?

A copy of each wastewater-treatment plant's current NPDES permit was requested during the site interviews. Current permits were obtained for 38 of the 48 wastewater-treatment plants (table 10). The reasons for not being able to obtain a copy of the current NPDES permit from 10 operators included (1) permit could not be located at the time of the interviews so the operators were asked to mail it but never did, (2) permit was too lengthy to copy during the interview, and (3) permit was kept at another location (city hall, mayor's office, or public works director's office) and was not readily available. It is noteworthy that three of the wastewater-treatment plants not providing their NPDES permits were major plants with average flow rates of 2 to 8 Mgal/d.

Table 10.--Ability to obtain current National Pollutant Discharge Elimination System permits from wastewater-treatment-plant operators

Subbasin	Total number of wastewater-treatment plants	Able to obtain current National Pollutant Discharge Elimination System permit?			
		"Yes"		"No"	
		Number	Percent	Number	Percent
Du Page River	17	12	71	5	29
Upper Fox River	11	8	73	3	27
Upper Kankakee River	15	13	87	2	13
MWRDGC[1]	5	5	100	0	0
Total	48	38	79	10	21

[1]Metropolitan Water Reclamation District of Greater Chicago.

Information on NPDES permits also is maintained by State regulatory agencies. These agencies attempt to accommodate all reasonable requests for copies of agencies' NPDES files. A hypothetical request was made to three State regulatory agencies in the UIRB for copies of about 50 NPDES permits. In each case, the agency stated that the permits are on record and available but that the resources to copy them were not available. The possibility of copying the permits ourselves or reimbursing the agency for the extra costs were presented as options.

In summary, wastewater-treatment-plant operators generally were willing to provide a copy of their NPDES permit. It is probable that all of the current NPDES permits for the four subbasins could have been obtained if some additional follow-up work was conducted with operators or with officials at State regulatory agencies.

Chronology of Wastewater-Treatment Changes

An important aspect of the NAWQA program is to delineate trends in stream quality and to document the probable causes for such trends. In some watersheds, trends in water quality may be directly attributable to changes in wastewater treatment, whereas, in other basins, trends in water quality may reflect a combination of other point and nonpoint source effects. For some NAWQA study units, therefore, it may be relevant to perform a retrospective analysis to document past changes in wastewater treatment and to correlate such changes with past trends in effluent and stream quality.

Three questions concerning past wastewater-treatment changes were evaluated in this study:

- Can the chronology of wastewater-treatment-plant changes, upgrades, and plant expansions be determined from interviews with wastewater-treatment-plant operators?
- Can the chronology of wastewater-treatment-plant changes, upgrades, and plant expansions be determined from NPDES permits?
- Can the chronology of wastewater-treatment-plant changes, upgrades, and plant expansions be determined from construction-permit files maintained by State regulatory agencies?

The chronology of wastewater-treatment-plant changes for the past 11 years was obtained during the interviews. Changes in wastewater treatment occurred at all but 2 of the 48 wastewater-treatment plants. Both the type of change and the year in which the alteration was made could be determined from the interview. In summary, the ability to ascertain information on past wastewater-treatment-plant changes from plant operators was excellent. However, changes at large wastewater-treatment plants (such as at MWRDGC's three largest wastewater-treatment plants) are nearly continuous and, as such, it could be difficult to establish that any single wastewater-treatment project specifically was responsible for a change in stream quality or ecosystem health at a downstream ambient-monitoring station.

The second question addresses the utility of past NPDES permits to recreate a chronology of wastewater-treatment-plant changes. This question was evaluated in two parts:

- o Can we obtain past NPDES permits dating back to 1978?
- o Are these permits useful in determining the chronology?

The ability to obtain past NPDES permits during interviews is summarized in table 11. The response "partially" indicates that we were able to obtain past NPDES permits for only some of the years from 1978 to the present (1989). The ability to obtain past permits varied considerably from subbasin to subbasin, ranging from a 12-percent response in the Du Page River subbasin to a 100-percent response in the MWRDGC subbasin. The reasons for not being able to obtain all of the past permits from operators varied considerably and are similar to the reasons previously noted for not being able to obtain current NPDES permits. Of the 24 major wastewater-treatment plants in the 4 subbasins, 11 furnished NPDES permits for all years.

Table 11.--Ability to obtain past National Pollutant Discharge Elimination System permits from wastewater-treatment-plant operators

Subbasin	Number of wastewater-treatment plants	Able to obtain past National Pollutant Discharge Elimination System permits?					
		"Yes"		"No"		"Partially"	
		Number	Percent	Number	Percent	Number	Percent
Du Page River	17	2	12	10	59	5	29
Upper Fox River	11	6	55	4	36	1	9
Upper Kankakee River	15	3	20	9	60	3	20
MWRDGC[1]	5	5	100	0	0	0	0
Total	48	16	33	23	48	9	19

[1]Metropolitan Water Reclamation District of Greater Chicago.

Records for 9 of the 11 wastewater-treatment plants with complete NPDES permits dating back to as early as 1974 were reviewed to ascertain if NPDES permits could be used to reconstruct a chronology of wastewater-treatment changes. Information contained in these permits concerning changes in wastewater treatment varied markedly from one plant to another within a subbasin and from subbasin to subbasin. The differences apparently reflect differences in permitting procedures by the various States. Very little or no useful information on recreating the chronology was available from the permits for most wastewater-treatment plants. A few permits contained descriptions of plant expansions for flow capacity, upgrades for ammonia removal, and indications when their new wastewater-treatment plant began operation. However, in Indiana, detailed information about a wastewater-treatment plant's history-of-treatment changes is included as part of the NPDES permit. In summary, NPDES permits may provide a detailed chronology of wastewater-treatment changes if the regulatory agency includes this information with permit records, otherwise NPDES permits typically contain little or no chronological information about changes in wastewater treatment.

The third question addresses the utility of construction-permit files to recreate a chronology of wastewater-treatment-plant changes. These permits must be obtained prior to any construction or structural modification of the wastewater-treatment plant. Construction permits are typically not computerized; rather, current permits are usually kept in hard copy form, while old permits are microfiched or sent to State record centers. Upon review, construction permits also were found to be an excellent source of information on past wastewater-treatment changes.

Wastewater-Engineering Projects Planned

The ability to document the influence of changes in wastewater treatment, sludge treatment, and elimination of combined sewer overflows on stream quality is, in part, determined by the ability to learn when and where such changes are planned. Having such knowledge enables the proper selection of upstream, downstream, and effluent sampling sites, as well as the determination of when water-quality sampling should be conducted to get a before and after evaluation of stream and effluent water quality. In addition, knowledge about the type of wastewater-engineering project planned provides insight about the proper water-quality constituents to be analyzed. In short, if planned wastewater-engineering changes are known, the NAWQA program could more accurately address the question, "What have been the effects of changes in municipal wastewater treatment on stream quality and ecosystem health?"

Two questions were addressed with regards to planned wastewater-treatment changes:

- o Can the scheduling and type of wastewater-engineering projects be determined during the interviews with wastewater-treatment-plant operators?
- o Are State regulatory agencies able to provide information about planned wastewater-engineering projects?

The interviews with wastewater-treatment-plant operators provided insights about wastewater-engineering projects and the ability to determine when and where such changes may occur. With few exceptions, the operators provided information about planned engineering projects that would be of sufficient detail for the planning of water-quality sampling for the NAWQA program. Approximately 23 percent of the 48 wastewater-treatment plants in the 4 subbasins had firm plans for future improvement projects, and another 15 percent were anticipating changes but had no plans (table 12). A commonly expressed comment by the operators was, "We really don't know what will be required on our next NPDES permit." This uncertainty may, in part, be responsible for the large percentage of wastewater-treatment plants not planning any improvement project but rather taking a "wait and see" attitude as to what would be required for their next NPDES permit.

The information regarding when and where wastewater-engineering projects will occur also may be obtained from Federal and State regulatory agencies and the cost of the projects from USEPA's Needs Survey computer data bases.

Table 12.--Number and percentage of wastewater-treatment plants planning future improvement projects

Subbasin	Number of wastewater-treatment plants	Are wastewater-treatment improvement projects planned?					
		"Yes"[1]		"Anticipated"[2]		"Uncertain"[3]	
		Number	Percent	Number	Percent	Number	Percent
Du Page River	17	5	29	2	12	10	59
Upper Fox River	11	3	27	2	18	6	55
Upper Kankakee River	15	3	20	3	20	9	60
MWRDGC[4]	5	0	0	0	0	5	100
Total	48	11	23	7	15	30	62

[1]Firm plans for improvements in the near future.
[2]Anticipated improvements in the near future, but no firm plans at present.
[3]Uncertain or no plans for any improvements in the near future.
[4]Metropolitan Water Reclamation District of Greater Chicago.

Typically, State regulatory agencies maintain a list of wastewater-engineering projects planned to receive construction grants. The USEPA's Needs Survey is updated every second year as part of a national survey on information about municipal wastewater engineering.

Enhancement of Wastewater-Treatment Information

A voluminous amount of information exists on municipal wastewater treatment. This information is available to the public through provisions of the Clean Water Act and related regulations and can be obtained from the USEPA, State regulatory agencies, and wastewater-treatment-plant operators. Federal and State computer data bases contain some of this information, such as (1) existence and location of wastewater-treatment plants and the volume of their dischargers, (2) level of wastewater treatment, (3) treatment technologies for specific wastewater-treatment plants, and (4) NPDES effluent limits.

Improvement in the availability of information on municipal wastewater treatment must be made before this information can be efficiently used in the NAWQA program or other national water-quality assessments. The uniform entry of the following information by all State regulatory agencies into national computer data bases would greatly enhance its utility in a national water-qualty assessment: (1) level of wastewater treatment, (2) wastewater-treatment technologies used at specific plants, (3) chronology of wastewater-treatment changes, (4) the entire text of NPDES permits, and (5) a list of wastewater-engineering projects planned. Based on the findings of this study, the most expedient way to obtain complete information for the NAWQA program for the five categories of information noted above is through interviews with wastewater-treatment-plant operators. Much of the wastewater information obtained in this study from the interviews of wastewater-treatment-plant operators was not reported to State regulatory agencies or USEPA, because such reporting was not required. In summary, State regulatory agencies and USEPA may have some, but not necessarily all, of the wastewater-treatment-plant information sought for use in the NAWQA program.

As previously noted, IFD and SWUDS data bases were used to determine the existence and location of municipal wastewater-treatment plants in the UIRB and the four subbasins, and the volume of their discharges. These data bases, although helpful, contained inaccurate information for some existing wastewater-treatment plants, information for discontinued wastewater-treatment plants, and no information for several new treatment plants. The suitability of this information for use in the NAWQA program would be enhanced if these computer data bases were updated and verified on an annual basis to ensure that the wastewater treatment related information contained in these data bases is timely and accurate.

Also, there is a need to revise the level of treatment code used by some USGS district offices in their SWUDS data base. The usefulness of this information in the NAWQA program would be enhanced if (1) a uniform code were used by all district offices, (2) the code was modified to eliminate the current potential for ambiguity, and (3) the entered code were verified on an annual basis.

AVAILABILITY AND SUITABILITY OF INFORMATION ON WASTEWATER-TREATMENT-PLANT EFFLUENTS FOR A NATIONAL WATER-QUALITY ASSESSMENT

The availability and suitability of various types of information on effluents from municipal wastewater-treatment plants that is important to the NAWQA program is described in this section. Subjects discussed include existence and location of effluents; Discharge Monitoring Reports; effluent flow rates; water-quality constituents; toxicological testing; frequency and type of sampling; calculation of effluent mass loadings; and quality assurance of laboratory analyses, flow-rate determinations, and Federal and State computer data bases. The concluding section describes how existing information on municipal effluents can be enhanced for use in the NAWQA program.

Existence and Location of Effluents

The ability to learn of the existence, as well as the location of effluent discharge points, is important both in planning the location of stream-sampling sites and in the interpretation of stream-quality records to determine trends and cause and effect relations. In this study, two questions were evaluated:

- Can the existence of all wastewater-treatment plants be determined?

- Can the location of their discharge points be determined?

Identifying the existence of all effluent dischargers in a particular watershed can be a difficult task. Information on wastewater-treatment plants is contained in the PCS, IFD, and SWUDS data bases, but these sources of information, especially the IFD data base, are not always current and, as such, they may contain a listing for a wastewater-treatment plant that no longer exists or may not contain an entry for a new plant. Trying to obtain an accurate mailing list also is difficult. A list of mailing addresses corresponding to the wastewater-treatment plants in the four subbasins was obtained from State regulatory agencies and the SWUDS. Similar to the list of wastewater-treatment plants, the list of mailing addresses and contact persons also contained some out-of-date information. For example, in one case, the contact person listed for the wastewater-treatment plant had been deceased for 6 years. Another problem with the mailing addresses is that they sometimes are for absentee owners of the wastewater-treatment plant who live in another State. In summary, the listing of wastewater-treatment plants in computer data bases cannot be assumed to be current. As such, additions or deletions to the computer data bases must be made based upon further inquiry with Federal and State regulatory agencies. Further, the listing of wastewater-treatment plants should be reviewed with wastewater-treatment-plant operators during interviews to determine if they are aware of any omissions or inaccuracies. Wastewater-treatment-plant operators usually are aware of neighboring wastewater-treatment plants, and checking a listing of plants with them is another way to verify this information.

The specific location of the discharge point of each plant's effluent can be easily determined during the interviews with wastewater-treatment-plant operators. Most operators were willing to escort the authors to the effluent discharge point so as to locate the point's latitude and longitude. The latitude and longitude of effluent discharge points are contained in the SWUDS and PCS. Field verification of this information was not done as part of this study. It is noteworthy that a wastewater-treatment plant's NPDES permit and DMRs do not usually contain a latitude or longitude for the discharge point's location. In summary, the latitude and longitude of a plant's effluent discharge point are entered in computer data bases; however, there does not appear to be a way to verify that this information is current or accurate except by field verification during interviews with each wastewater-treatment-plant operator.

Discharge Monitoring Reports

To fulfill NPDES requirements, the operators of wastewater-treatment plants must report the results of their self-monitoring of effluent flow rate, water quality, and other information to the USEPA, their respective State regulatory agency, or both. In Illinois and Wisconsin, the report form is called a Discharge Monitoring Report and, in Indiana, it is called a Monthly Report of Operation. For simplicity, these latter reports will also be referred to as DMRs. The reporting process is done monthly, and DMRs contain such information as effluent flow rate, sampling frequency, sample type, and analytical results for select water-quality constituents for the plant's influent and effluent. Most wastewater-treatment plants are not required to report all analyses completed but rather report the month's mean, maximum, and minimum values, as specified in their NPDES permit. There is some variation by State, and some wastewater-treatment plants do report daily values on their DMRs for certain water-quality constituents.

The USEPA requires State regulatory agencies to enter data reported on the DMRs for major wastewater-treatment plants into the PCS. This is currently being done by Illinois and Wisconsin for major wastewater-treatment plants and for other facilities receiving Federal funding. Indiana, however, enters data reported on DMRs into the PCS for all wastewater-treatment plants regardless of size.

For this investigation, a request was made to the IEPA and USEPA for a retrieval of all data in the PCS for the UIRB from 1977 to the present (1989). The USEPA provided data for all of the UIRB, and the IEPA provided information for the State of Illinois.

The two questions addressed in this study about the DMRs were

- o Can DMRs be readily obtained from the operators of wastewater-treatment plants?
- o Can effluent water-quality data reported on DMRs be obtained from computer data bases?

Because wastewater-treatment-plant operators were extremely cooperative, there was a high success rate in obtaining DMRs from them during the interviews for the 1986 and 1987 calendar years (table 13). It is probable that the DMRs could have been obtained with some additional follow-up work at the seven wastewater-treatment plants that did not provide this information.

Table 13.--Ability to obtain current Discharge Monitoring Reports from wastewater-treatment-plant operators

Subbasin	Number of wastewater-treatment plants	Able to obtain Discharge Monitoring Reports?			
		"Yes"		"No"	
		Number	Percent	Number	Percent
Du Page River	17	12	71	5	29
Upper Fox River	11	10	91	1	9
Upper Kankakee River	15	14	93	1	7
MWRDGC[1]	5	5	100	0	0
Total	48	41	85	7	15

[1]Metropolitan Water Reclamation District of Greater Chicago.

As noted previously, data from the completed DMR forms are entered into the PCS for all major wastewater-treatment plants in the four subbasins. This computerization is done only for monthly data and is typically completed 1 to 3 months after the data are collected. A review of the PCS indicated that

State regulatory agencies for the four subbasins have been entering influent or effluent flow-rate and water-quality data since about 1986. Some of the PCS data base for the four subbasins was retrieved and used to ascertain its ease of use and to determine the accuracy of data entries versus information reported on DMRs.

It is noteworthy that many wastewater-treatment plants have daily effluent water-quality data, and this information is not entered into the PCS, even though it may be reported on their DMR form. Direct contact with the operators may be the most expedient way to obtain daily data. In some cases, State regulatory agencies or the USEPA also can provide this information in paper copy or on microfiche. For example, in the UIRB, the IEPA maintains past DMRs for 10 years. The most current 3 years are kept in paper copy in agency files, while an additional 7 years are kept at a State record center.

Flow Rate of Effluents

Flow-rate information for municipal effluents is essential to the NAWQA program, primarily for the calculation of effluent mass loadings for various water-quality constituents. Having accurate effluent mass loadings would enable the statistical determination of their temporal trend and, thereby, enable correlation with similar trend determinations at upstream and downstream stream-quality-monitoring stations. Also, effluent mass loadings for certain constituents could be totaled from all major point sources in a subbasin and compared to mass loadings at downstream monitoring stations to help determine the relative contribution from point and nonpoint sources of pollution.

Two aspects of effluent flow-rate information were evaluated in this study:

- o Can current information on daily, monthly, seasonal, and annual wastewater flow rate be obtained?

- o What type of sampling frequency for flow-rate information can be expected?

Information to address these two questions was available from NPDES permits, DMRs, PCS, and SWUDS for 40 wastewater-treatment plants in the 4 subbasins. All of the wastewater-treatment plants are required to report effluent flow rate on their DMRs. A review of this information indicated that typically only monthly flow-rate statistics are reported on the DMRs with the monthly maximum flow rate and monthly average flow rate commonly required. Wastewater-treatment plants in the upper Fox River subbasin in Wisconsin also listed daily average flow rates on their DMRs.

The monthly flow-rate statistics reported on DMRs by major plants are entered into USEPA's PCS computer data base by State regulatory agencies. If accurate, these monthly average flows can be used to determine monthly, seasonal, and annual mass loadings for certain water-quality constituents.

Effluent flow rates were monitored continuously at each of the 40 wastewater-treatment plants for which information was available. As mentioned previously, Wisconsin requires the reporting of daily flow rate; however, Indiana and Illinois require monthly flow statistics only. For most wastewater-treatment plants in Indiana or Illinois, data for daily flow rate would need to be obtained directly from the wastewater-treatment-plant operator. Some wastewater-treatment plants have their flow-rate data entered into local computer data bases. Although not required in their NPDES permit, in a few cases, the wastewater-treatment-plant operators in Indiana and Illinois report daily effluent flow-rate data on their DMR and, therefore, this information may be available from State regulatory agencies as paper copies. As noted previously, only monthly effluent data are entered into the PCS.

In summary, monthly average flow rates are entered into the PCS for major wastewater-treatment plants and can be used to determine monthly, seasonal, and annual mass loadings. Daily data for effluent flow rate are not entered into the PCS. The computation of daily mass loadings, if required for certain aspects of the NAWQA program, will require direct contact with wastewater-treatment-plant operators who, based on the results of this study, would be cooperative and provide a copy of their flow-rate data. This latter information might be available in paper copy or in computer data base. About 50 percent of the major wastewater-treatment plants in the four subbasins have their effluent flow-rate data entered into a computer data base. Very few of the minor wastewater-treatment plants have their effluent data in a computer data base.

Water-Quality Constituents

The testing of effluents for select water-quality constituents is required by the USEPA and State regulatory agencies at most wastewater-treatment plants, and the results are reported to these agencies monthly on a DMR. The purposes of this required self-monitoring are to determine the efficiency of wastewater treatment and to document if the wastewater-treatment plant is complying with effluent limits specified in the plant's NPDES permit. These objectives are quite different from the broad objectives of the NAWQA program; however, some of the effluent water-quality information reported may be applicable to certain components of the NAWQA program.

Information for the 48 wastewater-treatment plants in the 4 subbasins was reviewed to address several questions concerning the current status of effluent water-quality testing:

- o What water-quality analyses are routinely included in effluent monitoring?
- o Are the water-quality constituents analyzed by wastewater-treatment-plant operators the same as target variables specified in the NAWQA program?
- o Are all of the analyses conducted by the plant's operator (or contract lab) reported on a DMR?

- o Are daily and monthly water-quality data entered into a computer data base?

Eight water-quality constituents--fecal coliform bacteria, total chlorine residual, total phosphorus, ammonia nitrogen, suspended solids, carbonaceous biochemical oxygen demand (CBOD), biochemical oxygen demand (BOD), and pH--are reported for effluents at many wastewater-treatment plants. Table 14 presents a summary of monitoring information for selected constituents. Suspended solids and pH are the only two analyses reported on a DMR for all, or nearly all, wastewater-treatment plants in the four subbasins. The next most frequently reported constituent is BOD with reporting required at nearly all wastewater-treatment plants, except in the Du Page River subbasin where only about 47 percent of the 17 wastewater-treatment plants report BOD analyses for their effluent and in the MWRDGC subbasin where CBOD analyses are completed.

Table 14.--Water-quality constituents reported on Discharge Monitoring Reports for the four subbasins in the upper Illinois River basin

Water-quality constituent	Water-quality-monitoring requirements											
	Du Page River			Upper Fox River			Upper Kankakee River			MWRDGC[1]		
	I[2]	II[3]	III[4]	I	II	III	I	II	III	I	II	III
Flow rate	X			X			X			X		
Fecal coliform bacteria	X			X					X		X	
Total chlorine residual		X		X					X		X	
Total phosphorus			X	X					X			X
Ammonia nitrogen		X			X			X		X		
Suspended solids	X			X			X			X		
Carbonaceous biochemical oxygen demand			X			X		X		X		
Biochemical oxygen demand		X		X			X					X
pH	X			X			X			X		
Water temperature			X			X			X			X
Dissolved oxygen			X			X			X		X	
Hardness			X			X			X			X
Chloride			X			X			X			X
Total dissolved solids			X			X			X			X
Trace elements			X			X			X		X	
Trace organics			X			X			X			X

[1]Metropolitan Water Reclamation District of Greater Chicago.
[2]Required by all or nearly all wastewater-treatment plants in the subbasin.
[3]Required by one-third to two-thirds of wastewater-treatment plants in the subbasin.
[4]Required by none or few wastewater-treatment plants in the subbasin.

The influence of differing State regulatory monitoring requirements also is evident from table 14. For example, the reporting of effluent sampling for fecal coliform bacteria is rarely required by wastewater-treatment plants in the upper Kankakee River subbasin in Indiana, whereas routine monitoring for this constituent is required at all, or nearly all, wastewater-treatment plants in the upper Fox River subbasin in Wisconsin and the Du Page River subbasin in Illinois. Similar differences in monitoring and reporting of effluent water-quality data are evident for total phosphorus and CBOD. It is noteworthy that effluent analyses for ammonia nitrogen are reported for many of the wastewater-treatment plants in all four subbasins. As shown in table 14, reporting is rarely required for dissolved oxygen, water temperature, hardness, chloride, total dissolved solids, trace elements, and trace organics.

A list of national target variables for samples collected at fixed water-quality monitoring stations for the pilot phase of the NAWQA program (Hirsch and others, 1988, p. 27) is presented in table 15. A comparison of the NAWQA program's target variables in table 15 to those analyses routinely conducted by wastewater-treatment plants (table 14) indicates that only a few of the national target variables are routinely reported for municipal effluents. In general, information required by the NAWQA program that is not routinely included in effluent sampling includes alkalinity, specific conductance, water temperature, chloride, dissolved solids, sulfate, major metals, trace elements, organic carbon, phosphorus, nitrate, and radionuclides.

Table 15.--Inorganic constituents and physical measurements selected as target variables in the pilot phase of the National Water-Quality Assessment program

Major metals and trace elements		Nutrients
Aluminum	Iron	Ammonium
Antimony	Lead	Nitrate
Arsenic	Manganese	Nitrite
Barium	Mercury	Total nitrogen
Beryllium	Molybdenum	Orthophosphate
Boron	Nickel	Total phosphorus
Cadmium	Selenium	
Chromium	Silver	
Copper	Vanadium	**Radionuclides**
Fluoride	Zinc	
		Gross alpha
		Gross beta
Major ions and dissolved solids		
		Field measurements
Calcium		
Magnesium		Acidity
Potassium		Alkalinity
Sodium		Dissolved oxygen
Chloride		pH
Sulfate		Specific conductance
Dissolved solids		Temperature

Exceptions to this "general picture" of effluent monitoring do exist. Especially noteworthy from this investigation is the comprehensive effluent-testing program conducted by the MWRDGC. Effluents are tested daily for 43 water-quality constituents (table 16), including many physical and chemical

Table 16.--Effluent water-quality constituents monitored by the Metropolitan Water Reclamation District of Greater Chicago

Flow rate	Mercury	Chloride	Arsenic
Nickel	pH	Barium	Dissolved oxygen
Selenium	Fecal coliform	Cadmium	Silver
Suspended solids	Chromium	Zinc	Nitrite
Ammonium	Copper	Antimony	Nitrate
Cyanide	Total iron	Beryllium	Total phosphorus
Fluoride	Soluble iron	Thallium	Soluble phosphorus
Lead	Chromium +6	Sulfate	Phenol
Manganese	Total solids	Sulfite	Sulfur ion
Total volatile solids		Volatile suspended solids	
Specific conductance		Biochemical oxygen demand	
Total Kjeldahl nitrogen		Fats, oils, and greases	
Chemical oxygen demand		Carbonaceous biochemical oxygen demand	

properties, indicator bacteria, major ions, trace elements, and nutrients. Only 14 of the 43 constituents analyzed by the MWRDGC are required by their NPDES permit (table 17). Further, the MWRDGC reports only the results of these 14 constituents on their DMRs to the IEPA. In summary, a comprehensive list of effluent water-quality constituents may be available in large urbanized areas. Based upon the results of this study, however, one cannot expect comprehensive testing programs to be in existence at many wastewater-treatment plants.

Results of effluent water-quality testing are typically reported on a DMR as monthly statistics for maximum, average, and possibly minimum values. Only monthly statistics of effluent-quality data for major plants are entered into the PCS. Thus, if daily information on effluent water quality is desired, it usually must be obtained directly from the operators of wastewater-treatment plants. Some of this latter information is entered into local computer data bases. For example, the MWRDGC has daily effluent-quality data for all of its wastewater-treatment plants entered into their computer data base back to at least 1978.

As previously described, the chronology of wastewater-treatment plant changes can be reconstructed from interviews with the operators of wastewater-treatment plants. If past effluent and stream-quality data also are available, it would then be possible, at least at certain sites in each NAWQA study unit, to determine the effect(s) of past changes in wastewater treatment on stream quality. Such retrospective analyses are an essential aspect of the NAWQA program, and they will provide additional insight to the benefits of water-pollution-abatement programs, such as the Construction Grant Program. A number of questions were evaluated to determine the availability of past effluent water-quality data for the NAWQA program and included

Table 17.--Water-quality constituents included in National Pollutant Discharge Elimination System permits for wastewater-treatment plants in the Metropolitan Water Reclamation District of Greater Chicago

[An "X" denotes the analyses is required by a regulatory agency]

Water-quality constituent	Wastewater-treatment plants				
	West-southwest	Northside	Calumet	John Egan	O'Hare
Fecal coliform bacteria				X	X
Total chlorine residual				X	X
Ammonia nitrogen	X	X	X	X	X
Suspended solids	X	X	X	X	X
Carbonaceous biochemical oxygen demand	X	X	X		X
Biochemical oxygen demand				X	
pH	X	X	X	X	X
Dissolved oxygen	X				X
Chromium		X	X		
Zinc		X	X		
Copper		X	X		X
Phenols		X	X		
Lead	X	X	X		
Cyanide	X	X	X		

- Are past effluent-quality data kept by wastewater-treatment-plant operators? If so, for which constituents?
- Are past effluent-quality data available from other sources? If so, for how many years?
- How many of the wastewater-treatment plants have their past effluent-quality data in a local computer data base?
- Was the location of the effluent discharge point moved during the period when effluent-quality data were kept?

Wastewater-treatment-plant operators were questioned about their past effluent-quality data during the interviews. Essentially all of the 48 wastewater-treatment plants maintain effluent data for the past 15 to 20 years, and the data would be made available for the NAWQA program, if needed. Many of the operators noted that these data were stored in boxes, but most felt they would be able to retrieve their past data. The ability of the wastewater-treatment-plant operators to produce these data and the completeness of the data were not assessed in this study. Wastewater-treatment-plant operators are required by State regulatory agencies to keep effluent data a specified period of time, usually 3 years. Keeping records beyond this time frame is done at the operator's discretion.

The number of water-quality constituents available from wastewater-treatment-plant operators, regardless of whether the data are in a computer data base or not, probably mimics the constituents listed in table 14.

The availability of past effluent-quality data from various sources for some of the wastewater-treatment plants in the Du Page River, upper Fox River, and upper Kankakee River subbasins is summarized in table 18. Note especially that the PCS contains monthly effluent water-quality information since 1986. In contrast, most of wastewater-treatment-plant operators have been reporting effluent water-quality data on a DMR to the USEPA and State regulatory agencies since about 1974 or 1975. As shown, a few of the wastewater-treatment plants have effluent water-quality data prior to 1974.

Table 18.--Availability of past water-quality data for major[1] wastewater-treatment plants from operators, Discharge Monitoring Reports, and the Permit Compliance System

Subbasin	Wastewater-treatment plant number	Starting year of water-quality records		
		From operators[2]	From Discharge Monitoring Reports	In Permit Compliance System
Du Page River	1	1971	1974	1986
Du Page River	2	1970	1975	[3]1986
Du Page River	3	1968	1974	1986
Du Page River	4	([4])	1978	1986
Du Page River	5	([4])	1976	1986
Du Page River	6	([4])	1974	1986
Du Page River	7	1975	1975	1986
Du Page River	8	1974	1974	1986
Du Page River	9	([4])	1974	1986
Upper Fox River	1	1975	1975	1986
Upper Fox River	2	1974	1974	1986
Upper Fox River	3	([4])	1974	1986
Upper Kankakee River	1	([4])	1974	1986
Upper Kankakee River	2	1974	1974	[3]1986
Upper Kankakee River	3	1969	([4])	1986

[1]Major wastewater-treatment plants are those with flow rates greater than or equal to 1 million gallons per day.

[2]Estimated starting year from interview with wastewater-treatment-plant operator. Effluent-quality data may not be continuous from this year to when operator began reporting Discharge Monitoring Reports.

[3]There are one to five values with dates earlier than that listed in the table; these values are presumed to be errors.

[4]Wastewater-treatment-plant operator did not know the exact starting year.

The entry of past effluent water-quality data into local computer data bases for the 48 wastewater-treatment plants in the 4 subbasins is shown in table 19. An average of 25 percent of the wastewater-treatment plants have their past data in a computer data base or are in the process of doing it. In general, these data were so entered for the past 5 years, although for some wastewater-treatment plants, such as those operated by the MWRDGC, effluent data dating back at least to 1978 is entered into a computer data base. A review of the size of the 12 wastewater-treatment plants with past water-quality data in a local computer data base noted that all but 3 were major plants. In summary, very few of the minor wastewater-treatment plants have effluent water-quality data in local computer data bases, whereas, about one of every two major wastewater-treatment plants may have their past effluent-quality data in such a data base. Verification of the effluent data in these local data bases was not attempted in this investigation.

Table 19.--Availability of effluent water-quality data in computer data bases

Subbasin	Total number of wastewater-treatment plants	Wastewater-treatment plants with effluent-quality data in computer data bases	
		Number	Percent
Du Page River	17	3	18
Upper Fox River	11	3	27
Upper Kankakee River	15	1	7
MWRDGC[1]	5	5	100
Total	48	12	25

[1]Metropolitan Water Reclamation District of Greater Chicago.

The effluent-discharge point was relocated for only 4 of the 48 wastewater-treatment plants during the period of available water-quality data. In all four cases, the exact location of the past discharge point and year during which relocation of the effluent-discharge point occurred could be determined by the operators.

Frequency and Type of Sampling

The extent to which effluent water-quality analyses completed by wastewater-treatment-plant operators are suitable for the NAWQA program depends on both the type and frequency of water sampling conducted and the specific use of the data in the NAWQA program. Because the composition of municipal wastewater typically exhibits a diurnal variation, flow-rate-composited samples best describe the average daily content of constituents in the effluent. Some properties of effluents are unstable, however, and analyses for these properties cannot be delayed until a 24-hour-composited sample is obtained. Grab samples and immediate laboratory analyses are best suited for unstable properties and constituents, such as pH, total chlorine residual, and fecal coliform bacteria.

The sampling frequency of wastewater effluent required by State regulatory agencies can vary considerably from one wastewater-treatment plant to another. The suitability of a specific plant's sampling frequency for the NAWQA program depends largely on the specific application intended. For example, 24-hour-composited samples collected three to five times per week would be suitable for calculating the annual effluent loading of a constituent discharged to a stream. In contrast, 24-hour-composited samples for each day of the week would be most appropriate for determining the weekly loading to a receiving stream. In summary, the specific intended use of effluent water-quality data in the NAWQA program will determine how suitable the sampling frequency of a specific effluent may be.

Three questions were posed concerning the frequency and type of effluent water-quality sampling:

- What type of effluent samples are collected for the analyses of commonly reported water-quality constituents?
- What is the frequency of effluent sampling?
- Does the type and frequency of sampling vary with wastewater-treatment-plant size?

Information on the type of sample collected at wastewater-treatment plants in the four subbasins was compiled from their DMRs or NPDES permit. Only eight water-quality constituents are determined routinely at a large number of wastewater-treatment plants; these constituents were used for this compilation. These include fecal coliform bacteria, total chlorine residual, total phosphorus, ammonia nitrogen, suspended solids, CBOD, BOD, and pH. Grab samples and 24-hour-composited samples were the only types of samples collected (table 20). As shown in table 20, grab samples are used at wastewater-treatment plants for analyses of fecal coliform bacteria, total chlorine residual, and pH, whereas 24-hour-composited samples were used for total phosphorus and CBOD. The type of sample collected for the analysis of ammonia nitrogen, suspended solids, and BOD varied; some wastewater-treatment plants used grab samples and others 24-hour-composited samples. Grab samples were collected for suspended solids and BOD from all minor wastewater-treatment plants with flow rates less than 0.4 Mgal/d. In contrast, the five wastewater-treatment plants that use grab samples for ammonia nitrogen were located in the Du Page River subbasin, and four of these five wastewater-treatment plants were major plants with flow rates ranging from 1 to 4 Mgal/d.

Table 20.--Type of effluent sample collected for the analysis of selected water-quality constituents

Water-quality constituent	Number of wastewater-treatment plants reporting	Type of sample	
		Grab	24-hour composite
Fecal coliform bacteria	29	29	0
Total chlorine residual	24	24	0
Total phosphorus	13	0	13
Ammonia nitrogen	27	5	22
Suspended solids	40	3	37
Carbonaceous biochemical oxygen demand	16	0	16
Biochemical oxygen demand	34	4	30
pH	38	38	0

The frequency of sampling effluents for the most routinely reported water-quality constituents also was determined. Tables 21 and 22 summarize this information for each of the four subbasins and four flow-rate categories. In both tables, and for each water-quality constituent, the frequency of sampling is reported as the number of daily samples per week. The two most commonly required frequencies of sampling are 7 and 5 daily samples per week representing 33 and 31 percent of all analyses completed, respectively. Sampling frequencies of one, two, and three samples per week represented about 10, 10, and 15 percent of all analyses reported, respectively. It also is evident that the frequency of sampling differs from one subbasin to another, probably reflecting differing State regulatory requirements and the size of the wastewater-treatment plant. For example, testing for total chlorine residual is required daily at all but one wastewater-treatment plant in the upper Fox River subbasin, whereas, in the Du Page River subbasin, the sampling frequency for 8 of the 10 wastewater-treatment plants is 5 times per week. The frequency of sampling also can vary within a particular subbasin. Especially noteworthy is the wide range of sampling frequency for suspended solids in the Du Page River subbasin ranging from one sample per month to six samples per week.

The relation between wastewater-treatment-plant size and sampling frequency is shown in table 22. In general, large wastewater-treatment plants conduct more frequent sampling than do smaller wastewater-treatment plants, especially in comparison to minor plants. This general pattern is evident for most water-quality constituents investigated. With but a few exceptions, wastewater-treatment plants with an average flow rate greater than 1 Mgal/d conduct effluent water-quality testing either five or seven times per week. In contrast to the major wastewater-treatment plants, the sampling frequency for minor wastewater-treatment plants has a much larger variation, ranging from one daily sample per month to seven daily samples per week (see entry for suspended solids, table 22).

Table 21.--Frequency of sampling effluents for the most routinely reported water-quality constituents in the four subbasins in the upper Illinois River basin

Subbasin	Total number of wastewater-treatment plants	Number of wastewater-treatment plants reporting	Sampling frequency for selected constituents: Number of wastewater-treatment plants with the following daily samples per week						
			1	2	3	4	5	6	7
		Fecal coliform bacteria							
Du Page River	17	12	[1]1	2	1	0	8	0	0
Upper Fox River	11	9	3	5	0	0	0	0	1
Upper Kankakee River	15	2	1	0	0	0	1	0	0
MWRDGC[2]	5	5	0	0	0	0	0	0	5
Total	48	28	5	7	1	0	9	0	6
		Total chlorine residual							
Du Page River	17	10	0	1	1	0	8	0	0
Upper Fox River	11	8	0	0	1	0	0	0	7
Upper Kankakee River	15	4	0	0	1	0	3	0	0
MWRDGC[2]	5	2	0	0	0	0	0	0	2
Total	48	24	0	1	3	0	11	0	9
		Total phosphorus							
Du Page River	17	0	0	0	0	0	0	0	0
Upper Fox River	11	7	0	0	2	0	1	0	4
Upper Kankakee River	15	0	0	0	0	0	0	0	0
MWRDGC[2]	5	5	0	0	0	0	0	0	5
Total	48	12	0	0	2	0	1	0	9
		Ammonia nitrogen							
Du Page River	17	11	[1]1	1	1	0	8	0	0
Upper Fox River	11	3	0	0	1	0	0	0	2
Upper Kankakee River	15	5	0	0	3	0	1	0	1
MWRDGC[2]	5	5	0	0	0	0	0	0	5
Total	48	24	1	1	5	0	9	0	8
		Suspended solids							
Du Page River	17	12	[1]1	2	1	0	7	1	0
Upper Fox River	11	9	0	0	3	0	2	0	4
Upper Kankakee River	15	14	4	2	5	0	2	0	1
MWRDGC[2]	5	5	0	0	0	0	0	0	5
Total	48	40	5	4	9	0	11	1	10
		Carbonaceous biochemical oxygen demand							
Du Page River	17	3	0	0	0	0	3	0	0
Upper Fox River	11	0	0	0	0	0	0	0	0
Upper Kankakee River	15	6	0	1	2	0	2	0	1
MWRDGC[2]	5	4	0	0	0	0	0	0	4
Total	48	13	0	1	2	0	5	0	5

Table 21.--Frequency of sampling effluents for the most routinely reported water-quality constituents in the four subbasins in the upper Illinois River basin--Continued

Subbasin	Total number of wastewater-treatment plants	Number of wastewater-treatment plants reporting	Sampling frequency for selected constituents: Number of wastewater-treatment plants with the following daily samples per week						
			1	2	3	4	5	6	7
		Biochemical oxygen demand							
Du Page River	17	8	[1]1	2	2	0	3	0	0
Upper Fox River	11	10	0	0	5	0	1	0	4
Upper Kankakee River	15	12	[1]7	1	2	0	2	0	0
MWRDGC[2]	5	5	0	0	0	0	0	0	5
Total	48	35	8	3	9	0	6	0	9
		pH							
Du Page River	17	12	0	3	1	0	8	0	0
Upper Fox River	11	9	0	0	0	0	0	0	9
Upper Kankakee River	15	14	2	2	1	0	7	0	2
MWRDGC[2]	5	5	0	0	0	0	0	0	5
Total	48	40	2	5	2	0	15	0	16
Percent[3]			9.7	10.2	15.3	0	31.0	0.5	33.3

[1]One sample per month.
[2]Metropolitan Water Reclamation District of Greater Chicago.
[3]Percentage of all water-quality analyses completed.

Table 22.--Frequency of sampling effluents for the most routinely reported water-quality constituents compared to effluent flow-rate-size category in the four subbasins in the upper Illinois River basin

[Mgal/d, million gallons per day; <, less than; >, greater than]

Water-quality constituent	Wastewater-treatment plants reporting analysis	Wastewater-treatment plant effluent flow-rate category (Mgal/d)	Sampling frequency: Number of wastewater-treatment plants with the following daily samples per week						
			1	2	3	4	5	6	7
Fecal coliform bacteria	10	<1	[1]5	5	0	0	0	0	0
	9	1-<10	0	1	1	0	6	0	1
	6	10-99.9	0	1	0	0	3	0	2
	3	>99.9	0	0	0	0	0	0	3
	28								
Total chlorine residual	10	<1	0	1	2	0	3	0	4
	8	1-<10	0	0	1	0	5	0	2
	6	10-99.9	0	0	0	0	3	0	3
	0	>99.9	0	0	0	0	0	0	0
	24								
Total phosphorus	4	<1	0	0	2	0	1	0	1
	2	1-<10	0	0	0	0	0	0	2
	3	10-99.9	0	0	0	0	0	0	3
	3	>99.9	0	0	0	0	0	0	3
	12								
Ammonia nitrogen	6	<1	[1]1	1	3	0	1	0	0
	9	1-<10	0	0	2	0	5	0	2
	6	10-99.9	0	0	0	0	3	0	3
	3	>99.9	0	0	0	0	0	0	3
	24								
Suspended solids	20	<1	[1]5	4	8	0	2	0	1
	11	1-<10	0	0	1	0	7	0	3
	6	10-99.9	0	0	0	0	2	1	3
	3	>99.9	0	0	0	0	0	0	3
	40								
Carbonaceous biochemical oxygen demand	4	<1	0	1	2	0	1	0	0
	3	1-<10	0	0	0	0	2	0	1
	3	10-99.9	0	0	0	0	2	0	1
	3	>99.9	0	0	0	0	0	0	3
	13								
Biochemical oxygen demand	20	<1	[2]8	3	7	0	1	0	1
	8	1-<10	0	0	2	0	4	0	2
	4	10-99.9	0	0	0	0	1	0	3
	3	>99.9	0	0	0	0	0	0	3
	35								
pH	20	<1	2	5	1	0	5	0	7
	11	1-<10	0	0	1	0	7	0	3
	6	10-99.9	0	0	0	0	3	0	3
	3	>99.9	0	0	0	0	0	0	3
	40								

[1]Samples by one plant are taken once per month.
[2]Samples by two plants are taken once per month.

Determination of Mass Loadings

The determination of mass loadings for certain constituents in wastewater-treatment-plant effluents is considered to be an essential part of the NAWQA program. Information on daily mass loadings may be required for certain intensive stream-reach investigations, whereas monthly, seasonal, and annual effluent mass loads will be required to identify point-source versus nonpoint source causes for observed trends at stream-monitoring stations. Two questions were evaluated for constituent mass loadings:

- o Can daily, monthly, seasonal, and annual mass loadings be determined?
- o Can these records be obtained from computer data bases?

As noted previously, the PCS contains monthly information for wastewater flow rates and effluent concentrations. This computer data base also contains information on mass loadings for some, but not necessarily all, constituents for which concentration data also are entered. Mass loading information in the PCS may include monthly maximum, minimum, and average values depending on the particular water-quality constituent and other factors. In summary, monthly average mass loadings can be calculated from the concentration and flow-rate data in the PCS; sometimes this information is directly entered into the PCS. Seasonal and annual loads also can be calculated from the monthly records in the PCS.

The determination of daily mass loadings is, however, more difficult because data for daily frequencies are not entered into the PCS. This information, therefore, must be obtained directly from the wastewater-treatment-plant operators. Because the sampling frequency for routinely analyzed constituents at most major wastewater-treatment plants is five or seven times per week, the likelihood of being able to obtain daily information to calculate mass loadings is very good. The availability of daily effluent water-quality data for other constituents, such as trace elements, trace organics, nutrients, major ions, and radiochemicals, is not as good, although some major wastewater-treatment plants may have extensive data bases for some of these constituent groups. For example, all five wastewater-treatment plants in the MWRDGC subbasin have computerized, daily records of trace elements for their effluents dating back to 1978. This latter case is atypical for most wastewater-treatment plants, but it does suggest that comprehensive effluent water-quality data may be available on a daily basis at some of the larger wastewater-treatment plants. As noted previously, 50 percent of the major wastewater-treatment plants in the four subbasins have at least some of their past water-quality records entered in a local computer data base. Five of the nine major wastewater-treatment plants in the four subbasins that have their effluent water-quality data in a computer data base are operated by the MWRDGC.

Quality Assurance

Quality assurance (QA) is essential in all aspects of the NAWQA program. As such, the extent of quality assurance of information reported for effluent flow-rate measurements and water-quality analyses was assessed to address the following issues:

- o Is there a QA plan for effluent water-quality analyses?
- o Is there a QA plan for wastewater-flow-rate determinations?
- o Are the flow-rate and water-quality data accurately entered into the PCS data base?

Thirty-eight of the forty-eight wastewater-treatment plants (79 percent) in the 4 subbasins have a written QA plan for effluent water-quality analyses, and 7 of the 10 wastewater-treatment plants that did not have a written QA plan anticipated the development of such a plan (table 23). Only 2 of the 10 wastewater-treatment plants not having a QA plan for constituent analyses were major wastewater-treatment plants with average flow rates of 2 and 4 Mgal/d. It should be noted that the Wisconsin Department of Natural Resources requires all laboratories analyzing effluent samples to be State-certified laboratories. In summary, written QA plans for effluent water-quality analyses existed for all but two of the major wastewater-treatment plants in the four subbasins.

Table 23.--Quality-assurance plans provided by wastewater-treatment-plant operators

Subbasin	Number of wastewater-treatment plants	Number of wastewater-treatment plants		
		With an existing quality-assurance plan	Without a quality-assurance plan	Anticipating a quality-assurance plan
Du Page River	17	12	5	2
Upper Fox River	11	10	1	1
Upper Kankakee River	15	11	4	4
MWRDGC[1]	5	5	0	0
Total	48	38	10	7

[1]Metropolitan Water Reclamation District of Greater Chicago.

The USEPA's Office of Water Enforcement and Permits, in conjunction with State regulatory agencies, conducts the Discharge Monitoring Report Quality-Assurance program. The program evaluates the ability of operators of the major wastewater-treatment plants or their contract laboratories to analyze and report accurate laboratory data. Each laboratory receives performance evaluation samples with known concentrations of constituents similar to those found in municipal wastewater. Polvi and others (1985) have reported the results of this program for 1980 and 1982. Table 24 shows the results for Illinois, Indiana, and Wisconsin. The national average for samples outside

Table 24.--Summary of U.S. Environmental Protection Agency Discharge Monitoring Report quality-assurance data for 1980 and 1982

State	Total number of chemical analyses	Chemical analyses outside acceptable limits	
		Number	Percent
	1980		
Illinois	1,839	463	25
Indiana	735	254	35
Wisconsin	684	147	21
National average			26
	1982		
Illinois	1,635	401	25
Indiana	644	171	27
Wisconsin	733	106	14
National average			21

acceptable limits (that is, the failure rate) was 26 percent in 1980 and 21 percent in 1982. Polvi and others (1985) also report the average percent failure rate by water-quality constituent for the 1982 study; this information is presented in table 25. The total average failure rate for all water-quality constituents was 21.6 percent, with higher average failure rates for the nutrient constituent group (36.5 percent). This information shows that the accuracy of laboratory analyses of wastewater effluents varies by State (table 24) and by water-quality constituent (table 25) and appears to be improving (table 24). There is, however, no information available for describing the accuracy of laboratory analyses of municipal effluents at minor wastewater-treatment plants.

Typically, effluent flow rate is determined be recording stage in a Parshall flume, which is converted to a flow rate from a standardized rating curve. Problems in accurately determining effluent flow rate are analogous to the determination of streamflow records at gaging stations. The accuracy of effluent flow-rate determinations can be affected by debris buildup, growth of a biological film, settlement, and instrument error.

In contrast to the QA plans for effluent water-quality analyses, there appears to be no quality assurance of flow-rate measurement at municipal

Table 25.--Average percent failure of effluent analyses, by water-quality constituent, for U.S. Environmental Protection Agency Discharge Monitoring Report quality-assurance data for 1982

Water-quality constituent	Average percent failure
pH	14.1
Total suspended solids	17.1
Nutrients	36.9
Ammonia	37.8
Nitrate	43.2
Kjeldahl nitrogen	29.8
Total phosphorus	37.8
Ortho phosphorus	34.1
Demands	19.7
Chemical oxygen demand	25.8
Total organic carbon	17.0
Biochemical oxygen demand (5 day)	17.9
Metals	20.8
Average for all water-quality constituents	21.6

wastewater-treatment plants. The extent of QA plans for effluent flow rate was assessed by three approaches: (1) Asking wastewater-treatment-plant operators about their QA plan during the interviews, (2) reviewing several NPDES permits, and (3) contacting officials at Federal and State regulatory agencies. None of the wastewater-treatment-plant operators were aware of a QA plan for flow-rate determinations, nor were they planning to develop such a plan. The authors' review of NPDES permits also showed no evidence of any QA requirement for wastewater flow-rate measurement. Direct contact with Federal and State officials gave a similar result. In summary, a QA plan for effluent flow-rate determinations does not exist in the four subbasins.

The completeness and accuracy of flow-rate and water-quality data entered into the PCS was evaluated. For this purpose, data entries in the PCS for four wastewater-treatment plants in each of the Du Page River, upper Fox River, and upper Kankakee River subbasins were verified by comparing the data to each wastewater-treatment plant's DMRs. The results are given for effluent flow rate in table 26 and for effluent concentration and mass loadings in

Table 26.--Verification of effluent flow-rate data in the Permit Compliance System

Subbasin	Period of record checked	Number of data entries				
		Total	Accurate		Inaccurate	
			Number	Percent	Number	Percent
Du Page River	January 1986 through December 1987	97	97	100	0	0
Upper Fox River	January 1986 through December 1987	106	94	87	12	13
Upper Kankakee River	January 1986 through December 1987	85	85	100	0	0
Total		288	276		12	
Percent				96		4

table 27. In these two tables, the "period of record checked" corresponded to the period for which DMRs were available to the authors.

Of 288 monthly flow rates in the PCS that were checked, 96 percent were accurate. As noted in table 26, the accuracy of the flow-rate data for the Du Page River and upper Kankakee River subbasins were far superior to the upper Fox River subbasin. Similarly, 96 percent of the 1,085 concentration data entries checked were accurate (table 27). Mass-loading data are not entered into the PCS for wastewater-treatment plants in the upper Fox River subbasin. These data, however, are entered for the Du Page River and upper Kankakee River subbasins. Essentially 100 percent of the data were accurate. Nearly all of the flow-rate, concentration, and mass-loading data entered into PCS by State regulatory agencies is accurate.

Effluent Toxicity Testing

Whether or not each wastewater-treatment plant conducted effluent toxicity testing was not addressed in the questionnaire. Contacts with State regulatory agencies and examination of NPDES permits showed, however, that effluent toxicity testing is becoming a common requirement. In fact, IEPA is requiring all major wastewater-treatment plants to conduct periodic effluent toxicity testing. The toxicity testing in Illinois generally involves acute-toxicity tests for fish, invertebrates, and sometimes for aquatic plants.

Enhancement of Effluent Information

The availability of information on municipal effluents, especially effluent flow rates, concentrations and mass loadings, generally is very good. Monthly statistics for these data are routinely entered into Federal and State data bases (SWUDS and PCS). Also, approximately 50 percent of the major

Table 27.--Verification of concentration and mass-loading data in the Permit Compliance System

[Dashes indicate no data available; <, less than]

Subbasin	Period of record checked	Number of data entries									
		Concentrations					Mass loadings				
		Total	Accurate		Inaccurate		Total	Accurate		Inaccurate	
			Number	Percent	Number	Percent		Number	Percent	Number	Percent
Du Page River	January 1986 through April 1989	393	393	100	0	0	200	200	100	0	0
Upper Fox River	January 1986 through December 1988	414	381	92	33	8	--	--	--	--	--
Upper Kankakee River	January 1986 through December 1987	278	272	98	6	2	135	134	99	1	1
Total		1,085	1,046		39		335	334		1	
Percent				96		4			100		<1

wastewater-treatment plants in the four subbasins have at least some of their daily effluent flow-rate, concentration, and mass-loading data entered into local computer data bases. Although atypical of most wastewater-treatment plants, extremely comprehensive effluent data bases exist for some of the larger wastewater-treatment plants. Especially noteworthy in this study was effluent monitoring by the MWRDGC, which monitors effluents for 43 water-quality constituents, and these data, back at least to 1978, are entered into a local computer data base. Further, effluent information in Federal, State, and local data bases is readily accessible to USGS personnel for use in the NAWQA program.

In contrast to the availability of information on municipal effluents, some of the effluent data in its current form is not suitable for use in the NAWQA program. The use of unsuitable data in regional or national assessments can be much worse than a lack of information altogether. As described by Cohen (1989, p. III) the use of inaccurate data can lead to incorrect conclusions having far-reaching consequences. From this study of existing effluent information in four subbasins in the UIRB, it is evident that improvements to existing computer data bases must be made before effluent flow rates, concentrations, and mass loadings can be used in the NAWQA program.

The unsuitability of some existing information on municipal effluents for use in the NAWQA program is due primarily to (1) the limited number of water-quality constituents routinely determined in effluent samples and (2) the lack of a quality-assurance plan for effluent flow-rate measurements. The suitability of existing information on municipal effluents would be enhanced for use in the NAWQA program if the following steps were taken:

- Implement a national program to quality assure effluent flow-rate measurements.
- Increase the number of water-quality constituents routinely determined for effluent samples to also include analyses for water temperature, dissolved oxygen, total dissolved solids, total nitrogen, nitrate, dissolved and total phosphorus, and select trace elements.
- Increase the frequency of effluent monitoring at some locations and implement the use of flow-weighted, 24-hour-composited samples for some constituent analyses including ammonia nitrogen, suspended solids, BOD, CBOD, total dissolved solids, total nitrogen, nitrate, dissolved and total phosphorus, and select trace elements.

SUMMARY AND CONCLUSIONS

The general purpose of this study was to describe the availability and suitability of existing information on municipal wastewater treatment and effluent characteristics for its potential use in a national water-quality assessment such as the National Water-Quality Assessment (NAWQA) program. This information is especially relevant to NAWQA's third program objective:

"Identify, describe, and explain, as possible, the major factors that affect observed water-quality conditions and trends" (Hirsch and others, 1988, p. 1). Significant changes in municipal wastewater engineering have occurred in the past 10 to 15 years, and such changes are likely to continue into the future. For example, the U.S. Environmental Protection Agency's (USEPA) 1988 Needs Survey Report to Congress indicated that 6,428 treatment plants in the United States have documented water-quality or public-health problems (USEPA, 1989, p. 1). As these wastewater-management needs are met across the Nation, changes in water quality of many of the streams receiving municipal effluents can be expected. The national-scope question "What have been the effects of changes in municipal wastewater treatment on stream quality and ecosystem health?" is relevant to the NAWQA program, both in terms of past changes in wastewater treatment, as well as for wastewater-engineering projects planned in the future.

Major results of this study are summarized below:

1. Wastewater-treatment-plant operators, managers of a large water reclamation district, and Federal and State agencies were cooperative and provided information on municipal wastewater-treatment and effluent characteristics. While all parties provided assistance, interviews with wastewater-treatment-plant operators (engineers or managers) appear to be the most expedient way to obtain accurate and complete wastewater information for a large number of treatment plants. Wastewater information from State regulatory agencies varied, and some of the desired information could only be obtained from wastewater-treatment-plant operators.

2. Determining the existence and addresses of all wastewater-treatment plants in the upper Illinois River basin (UIRB) was difficult. Lists and information on wastewater-treatment plants were obtained from two computer data bases--Industrial Facilities Discharge (IFD) and the Wisconsin and Illinois State Water-Use Data System (SWUDS). These two data bases, although helpful, contained (1) inaccurate information for some existing treatment plants, (2) information for discontinued treatment plants, and (3) no information for several new treatment plants. The information in these two computer data bases needs to be verified before the information can be used in the NAWQA program. The Permit Compliance System (PCS) was used in this investigation to confirm the existence of treatment plants in the UIRB. This computer data base appeared to be suitable for this purpose.

3. Although the contents of the PCS, IFD, and SWUDS varied, collectively these data bases generally were adequate for determining the number of wastewater-treatment plants and permitted volume of effluent discharged in the UIRB and the four subbasins more extensively investigated in this study. The SWUDS data bases for Illinois and Wisconsin most closely represented the number of active wastewater-treatment plants in the UIRB. The IFD data base contained many inactive wastewater-treatment plants. About 181 wastewater-treatment plants discharge municipal effluent to streams in the UIRB. In each subbasin, a few relatively large wastewater-treatment plants accounted for a majority of the municipal effluent discharged.

4. All 48 wastewater-treatment plants in the 4 subbasins have at least secondary treatment, and 30 of these plants have some form of tertiary treatment. Nitrification, and additional removal of biochemical oxygen demand and

suspended solids are the most common forms of tertiary treatment being practiced at 18 and 26 wastewater-treatment plants, respectively.

5. National Pollutant Discharge Elimination System (NPDES) permits contain useful information to determine the level of treatment but not the type of tertiary treatment. Also, some of the information on the level of treatment in the Wisconsin SWUDS was found to be inaccurate. In addition, the definition of the level of treatment for the Wisconsin SWUDS seemed ambiguous for some wastewater-treatment plants and could not be used to distinguish whether a plant had secondary or tertiary treatment.

6. About 75 percent of the wastewater-treatment-plant operators interviewed in this study were able to provide a detailed flow diagram of their plant, from which the specific treatment technologies used could be determined. States are not required to store this information in the PCS and SWUDS and, thus, it was available for only 3 of the 48 wastewater-treatment plants in the 4 subbasins. Information on the technologies used at each wastewater-treatment plant is available in paper copy from State regulatory agencies and, in some States, treatment codes are entered into a local computer data base. Similar to obtaining information on the level of treatment, the most expedient way to obtain complete and accurate information on the technologies used at a large number of wastewater-treatment plants is through interviews with wastewater-treatment-plant operators.

7. Wastewater-treatment-plant operators were able to provide a chronology of wastewater-treatment changes back to at least 1976, the approximate time period when most wastewater-treatment plants began to report monthly Discharge Monitoring Reports (DMR) to State regulatory agencies. Since 1976, changes in wastewater treatment occurred at all but 2 of the 48 plants in the 4 subbasins. Information on past or planned changes in wastewater treatement is not currently in Federal or State computer data bases. State regulatory agencies maintain paper copies of construction permits which, upon review, were suitable for ascertaining the chronology of wastewater-treatment changes. Also, in some States, the chronology of changes in wastewater treatment can be determined from a review of past NPDES permits.

8. Information on planned wastewater-engineering projects was available in this study from two sources--State regulatory agencies and wastewater-treatment-plant operators. Information from both sources was considered suitable for use in the NAWQA program. It is noteworthy that firm plans for wastewater-engineering projects exist for only 11 (23 percent) of the 48 wastewater-treatment plants in the 4 subbasins. Changes in wastewater treatment are anticipated for 7 (15 percent) other wastewater-treatment plants, but firm plans have been developed.

9. Monthly statistics of effluent flow rates are reported on DMRs by all 48 wastewater-treatment plants in the 4 subbasins. Usually, these data are entered into the PCS by State regulatory agencies within 1 to 3 months after data are collected. Ninety-six percent of the effluent flow-rate records in the PCS were accurate.

10. All 48 of the municipal wastewater-treatment plants in the 4 subbasins maintained continuous records of effluent flow rates. Daily average, maximum, and minimum flow rates are available from wastewater-treatment-plant operators. Only Wisconsin required the reporting of daily flow-rate information on DMRs. However, these daily data are not entered into the PCS. About 50 percent of the major wastewater-treatment plants in the four subbasins had their plant's daily flow-rate data entered into a local computer data base.

11. Effluent water-quality monitoring was required at each wastewater-treatment plant in the four subbasins as part of their NPDES permit. However, the number of water-quality constituents and sampling frequency varied from one wastewater-treatment plant to another. Except for wastewater-treatment plants in the Metropolitan Water Reclamation District of Greater Chicago (MWRDGC), which monitor 43 water-quality constituents daily, only 8 water-quality parameters--fecal coliform bacteria, total chlorine residual, total phosphorus, ammonia nitrogen, suspended solids, CBOD, BOD, and pH--were commonly measured in effluent samples. Other constituents that would be useful in an assessment of the effects of wastewater effluent include dissolved oxygen, total dissolved solids, total nitrogen, nitrate, dissolved and total phosphorus, and select trace elements. Few data for these latter constituents are available for municipal effluents.

12. The sampling frequency at most of the major wastewater-treatment plants is either one sample per day or five samples per week. The sampling frequency at wastewater-treatment plants discharging less than 1 Mgal/d varied from one sample per month to one sample per day. Grab samples generally are collected for analyses of fecal coliform bacteria, total chlorine residual, and pH, whereas 24-hour-composited samples are collected for analyses of total phosphorus and CBOD. For analysis of ammonia nitrogen, suspended solids, and BOD, some wastewater-treatment plants collect grab samples, while others collect 24-hour-composited samples.

13. The results of water-quality analyses made by wastewater-treatment-plant operators (or their contract labs) are reported monthly to State regulatory agencies on DMRs. Typically, average concentrations and mass loadings for each month are reported (as well as other statistics). These monthly data are entered into the PCS by the staff of State regulatory agencies, typically within 1 to 3 months after the data are collected. A check of the completeness and accuracy of water-quality data in the PCS for 12 wastewater-treatment plants in the 4 subbasins showed that 96 percent of the concentration data and nearly 100 percent of mass-loading data were accurate.

14. State regulatory agencies have been entering monthly water-quality records for municipal effluents into the PCS data base since about 1986. Monthly effluent water-quality records, prior to 1986, are available from DMRs, which can be obtained either from State regulatory agencies or from wastewater-treatment-plant operators. Discharge Monitoring Reports have been required since about 1976, and some wastewater-treatment plants may have effluent water-quality data prior to this time, although, in many cases, it would be difficult to locate, reproduce, and compile these data. About 50 percent of the major wastewater-treatment plants in the four subbasins have entered at least some of their past water-quality data in local computer data bases, whereas very few of the smaller wastewater-treatment plants have done so.

15. In general, wastewater-treatment-plant operators are the only source of information for daily data on effluent water quality. Only the wastewater-treatment plants in Wisconsin are required to report daily effluent water-quality data to their State regulatory agency on DMRs. These data are not entered into the PCS data base; however, the data may be available from the Wisconsin Department of Natural Resources.

16. The PCS data base contains monthly statistics for effluent flow rate and effluent concentrations and, for some plants, estimates of effluent mass loadings. This information, after appropriate verification, can be used in the NAWQA program to determine monthly, seasonal, and annual effluent mass loadings for wastewater-treatment plants in a study unit. None of the Federal or State computer data bases examined in this study contained daily effluent flow rates, concentrations, or mass loadings. Daily mass-loading data are available from wastewater-treatment-plant operators, and the data are entered into local computer data bases for approximately 50 percent of the major wastewater-treatment plants in the four subbasins.

17. Thirty-eight of the forty-eight wastewater-treatment plants (79 percent) in the four subbasins had a written quality assurance (QA) plan for the analysis of water-quality constituents in municipal effluents. Twenty-two of the twenty-four major wastewater-treatment plants in the four subbasins have a written QA plan. In contrast, none of the wastewater-treatment plants in the four subbasins had a written QA plan for flow-rate measurements.

The major conclusions from this study are summarized below:

1. A large amount of information exists on wastewater treatment and effluent characteristics to address the proposed national-scope question, "What have been the effects of changes in municipal wastewater treatment on stream quality and ecosystem health?" Some of this information is entered in Federal, State, and local computer data bases and is readily available to anyone who can access the data bases. Information on the number and location of wastewater-treatment plants in the UIRB and their permitted effluent volumes, and effluent flow rates, concentrations, and mass loadings of a limited number of constituents since 1986 are entered into national computer data bases.

2. Although much information on wastewater-treatment and effluent characteristics exists, several improvements would enhance its availability for use in the NAWQA program. Especially important is the entry of the following information into a national data base: (1) level of treatment; (2) chronology of wastewater-treatment changes; (3) wastewater-treatment technologies used at specific plants; (4) NPDES permits; (5) monthly data collected prior to 1986 on effluent flow rates, concentrations, and mass loadings; and (6) daily data on effluent flow rates, concentrations, and mass loadings.

In contrast to the general availability of information on wastewater treatment and effluent characteristics, the suitability of this information to accomplish the objectives of the NAWQA program is significantly limited. The suitability of this information for use in the NAWQA program would be markedly improved by (1) increasing the number of water-quality constituents routinely determined in municipal effluent samples, (2) increasing the frequency of effluent monitoring at many locations and using flow-weighted-composite samples for selected constituents, and (3) developing and using a QA plan for effluent flow-rate determinations.

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APPENDIXES

APPENDIX A

WASTEWATER-TREATMENT-PLANT QUESTIONNAIRE

Date: ______________

By: ______________

I. General information:

1. Name and location of wastewater-treatment plant (WWTP)

    (Name) ______________________________

    (Street/road) ______________________________

    (City/state) ______________________________

    (County) ______________________________

    (Township) ______________________________

2. Person interviewed

    (Name) ______________________________

    (Title) ______________________________

    (Address) ______________________________

    ____

    ____

    (Phone) ( ) - ______________________________

3. Names and phone numbers of the following:

	Name	Phone
A) Chief operator		
B) Chief lab chemist		
C) Chief design engineer		

II. Historical profile

1. Who is the best person(s) to talk to about the history of wastewater-treatment-plant improvements? elimination of bypasses? (exclude sludge treatment unless the improvement may have resulted in changes in water quality)

(Name) ______________________________

(Title) ______________________________

(Address) ______________________________

______________________ ph# __________

(Name) ______________________________

(Title) ______________________________

(Address) ______________________________

______________________ ph# __________

2. History of improvements (most recent first)

Date Description

a) ______________________________

b) ______________________________

c) ______________________________

d) ______________________________

e) ______________________________

f) ______________________________

g) ______________________________

h) ______________________________

i) ______________________________

j) ______________________________

3. Has there been a change in:

   a) Location of WWTP? (yes / no) (when?) ____________

   (Prior location) ______________________________

   (New location) ______________________________

   b) Location of effluent's discharge point? (yes / no) (when?) __

   (Prior lat./long.) ______________________________

   (New lat./long.) ______________________________

   (Receiving water body) ______________________________

4. First date of wastewater treatment (of any level).

   (Month/year) ____________________

5. Issue date of first NPDES permit (month/year) __________

6. Who issued your first NPDES permit ?

   a) State IN
IL
WI

   b) USEPA

7. How long have you been filing DMR Forms? ______________

8. Who (what agency) receives your DMR Forms?

   a) ________________________

   b) ________________________

9. Do you keep past effluent data? ________________

   What type of data?

   Temp., pH, metals, ions, D.O., nutrients, ____________

   a) Is it in a computerized data base? ____yes/no________

   b) Is it available? ____yes/no________

   Available for what time period? __________________

c) DMRs

____

d) Prior to filing DMRs

____

10. Have you, consultants, or others done any routine special ambient water-quality monitoring of the receiving stream. (i.e. upstream/downstream sampling) ?

[yes / no]

	Type	Constituents	Location	Frequency	Dates	Type of Data
a)						
b)						
c)						
d)						
e)						
f)						
g)						
h)						

III. Current **raw** wastewater, WWTP practice, **effluent** conditions:

1) **Type of raw wastewater**

a) Domestic (municipal) WWTP ______%

b) Industrial/commercial ______%

c) other ________________ ______%

d) other ________________ ______%

2) **Strength of raw wastewater**

--> ave. conc SS ______ mg/l

--> ave. conc BOD_5 ______ mg/l

a) Weak (SS & BOD_5 = 110 mg/l)

b) Medium (SS & BOD_5 = 220 mg/l)

c) Strong (SS & BOD_5 = 400 mg/l)

e) Do you have any special raw wastewater characteristics?

____

____

3) Does your plant have an industrial pre-treatment program?

(yes / no)

4) If so, are all of the industries in compliance with their pre-treatment program?

(yes / no)

If not, give details of the violation and their compliance schedule dates.

5) Plant design capacity ______ Mgal/d

6) Actual flow rate ______ Mgal/d

7) Has design capacity changed over time? (yes / no)

If so, when:

	Capacity	Date
a)		
b)		
c)		

Is there a pronounced seasonal flow-rate trend?

____

____

____

____

8) Water quality of effluent SS ________ mg/l
BOD_5 ________ mg/l

Continuous effluent? (yes / no)
If no, explain:
____
____
____

9) Is effluent disinfection done? (yes / no)

10) All year long? (yes / no)
If no, give period when disinfection is done.

____

11) May we have a schematic of the WWTP including all components used to treat the wastewater prior to discharge?

(copy / sketch)

12) Based on results of (11) decide what classification(s) fits best:

a) Primary treatment

b) Secondary treatment (30/30 effluent quality)

c) Advanced secondary treatment (10/10)

d) Tertiary treatment

Nitrification ___

Denitrification ___

Phosphorous removal ___

____________________ ___

13) What are your current problems, concerns, violations, etc.?

a) Current sewer infiltration and bypass problems

b) Current industrial pre-treatment problems

c) Current wastewater-treatment problems

d) Current effluent problems/violations

e) Current water-quality testing problems

f) Current reporting problems to regulatory agency

14) Does your lab (or contract lab) have a <u>written</u> quality assurance plan? (yes / no)

If not, is there a plan to develop it?

(yes / no) by when: ____________

15) Does the sewer system (or treatment plant) have any (sewer) bypasses? (yes / no)

(Number,location,frequency,type of treatment)

Explain: ______________________________________

____

____

____

____

IV. Futuristic (prospective) changes

1) Is the community (company) planning any further upgrading of its sewer system and/or WWTP?

a) Sewer improvement projects

b) Elimination of bypasses

c) WWTP improvements

d) Other

2) Are any of the proceeding improvements required by regulatory agencies? If so, which ones and what are the compliance dates?

Improvement-__________________ Compliance Date-__________

3) Are there any plans to change current water quality sampling, testing, method of reporting data to EPA or state record keeping, etc.?

a) Sampling

b) Testing

c) Reporting

d) Record keeping/data files

4) Are there any plans for changes in quality assurance of the water quality or flow-monitoring information?

a) NPDES effluent water-quality data

b) NPDES effluent flow-rate data

APPENDIX B

NAMES AND ADDRESSES OF WASTEWATER-TREATMENT-PLANT OPERATORS INTERVIEWED

Upper Fox River Subbasin

John F. Budde
Fox Water Pollution Control
21225 Enterprise Avenue
Brookfield, WI 53005

Don Zacharias
Water Pollution Control Facility
300 North Pine Street
Burlington, WI 53105

Tom Rossmiller
Wastewater Treatment Facility
2104 Young Street
East Troy, WI 53120

John P. Wrzeszcz
Wastewater Treatment Facility
1st Street
Genoa City, WI 53128

Robert Walbrandt
Lyons Sanitary District #2
P.O. BOX 237
Lyons, WI 53148

Ron Olbinski
Mukwonago Wastewater Treatment
P.O. Box 96
Mukwonago, WI 53149

George Beres
New Berlin High School
4333 S. Sunny Slope Road
New Berlin, WI 53151

Robert Williams
Wastewater Treatment Facility
P.O. BOX 441
Silver Lake, WI 53170

Jim Thalke
Sussex Wastewater Plant
N59 W23551 Clover Dr.
Sussex, WI 53089

John Erickson
Twin Lakes Wastewater Treatment
108 East Main Street
Twin Lakes, WI 53181

Peter Pronold
Wastewater Treatment Facility
600 Sentry Dr.
Waukesha, WI 53186

Upper Kankakee River Subbasin

Jerry L. Becker
Town of Argos STP
119 West Walnut St.
Argos, IN 46501

Jerry J. Sheneman
Bremen Treatment Plant
Keyser Street
Bremen, IN 46506

Paul Wellman
Supt. of Bldgs. and Grounds
Ancilla Domini
Donaldson, IN 46513

Michael G. Foster
Town of Hamlet
10 S. Starke
Hamlet, IN 46532

Ron Cooper
Kingsford Heights
Municipal Sewage Treatment Plant
504 Grayton Road
Kingsford Heights, IN 46346

Steven A. Smith
Knox Waste Treatment
101 W. Washington St.
Knox, IN 46534

Alex Toth
La Porte Municipal STP
801 Michigan Ave.
LaPorte, IN 46350

Joe Toth
Kingsbury Utility Corporation
P. O. Box 119
LaPorte, IN 46350

Dan Casad
Lakeville Wastewater Treatment
P. O. Box 137
Lakeville, IN 46536

George Blackstone
New Carlisle Waste Treatment
113 S. Arch
New Carlisle, IN 46552

John Gouker
Town of North Liberty STP
118 North Main Street
P. O. Box 515
North Liberty, IN 46554

L. James Sallee
North Judson Sanitation Dept.
204 Keller Ave
North Judson, IN 46366

Donnie Davidson
Plymouth Wastewater Plant
900 Oak Hill Ave.
Plymouth, IN 46563

Arvil Boles
Yogi Bear Jellystone Park
1000 Oak Hill Ave.
Plymouth, IN 46563

Jeff Zehner
Walkerton Wastewater Facility
510 Roosevelt Road
Walkerton, IN 46574

DuPage River Subbasin

Jim Benson
Village of Bartlett
Wastewater Treatment Facility
28W007 Sterns Road
Bartlett, IL 60103

Jim Pluess
Village of Bloomingdale
Sewage Treatment Facility
299 Glen Ellyn Road
Bloomingdale, IL 60108

Cliff Evans
Citizens Utility - WS #2
1000 W. Boughton Road
Bolingbrook, IL 60439

Wade Jacobi
Royce Road Water Reclamation
151 West Royce Road
Bolingbrook, IL 60439

Bob Smith
Village of Carol Stream
Sewage Treatment Plant
500 N. Gary Ave.
Carol Stream, IL 60188

Keith Wattson
Crest Hill Waste Treatment
1610 Plainfield Road
Crest Hill, IL 60435

Lawrence C. Cox
Downers Grove Sanitary District
2710 Curtiss Street
P.O. Box 1412
Downers Grove, IL 60515-1412

Stan Rickard
Glenbard Wastewater Authority
21W551 Bemis Road
Glen Ellyn, IL 60137

Lance Blyth
Hanover Park
Sewage Treatment Facility
1200 East Sycamore
Hanover Park, IL 60103

Robbi Tanarelli
Minooka-Waterbury Wastewater
Treatment Facilities
100 Jardine Avenue
Minooka, IL 60447

Allen F. Panek
Springbrook Water Reclamation
175 West Jackson Avenue
P.O. Box 3020
Naperville, IL 60566-7020

Harrison Countryman
Village of Plainfield
Sewage Treatment Facility
1400 Division Street
Plainfield, IL 60544

Diane Fiorini
Village of Roselle-Waterbury
31 South Prospect Street
Roselle, IL 60172

James Michael Botts
City of West Chicago
Wastewater Treatment Facility
475 Main Street, Box 488
West Chicago, IL 60185

Michael Scalise
Wheaton Sanitary District
P.O. Box 626
Wheaton, IL 60189-0626

Kevin Buoy
Du Page County DPW
Field Operations
7900 S. Rt. 53
Woodridge, IL 60517

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