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TREATABILITY MANUAL

VOLUME V. Summary

OFFICE OF RESEARCH AND DEVELOPMENT  
U.S. ENVIRONMENTAL PROTECTION AGENCY  
WASHINGTON, D.C. 20460

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INSTRUCTIONS FOR UPDATE OF VOLUME V, TREATABILITY MANUAL  
CHANGE 1 AND CHANGE 2 (1/24/83)

| <u>Section</u>                  | <u>Instruction</u>  | <u>Sheets (front/back)</u>                        | <u>Revision Status</u>                                   |
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| Table of Contents               | <u>Replace</u> the following sheets with revised sheets provided: | v   | Change 2   |
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|                                 | <u>Add</u> the following new sheet                                |   |  |
| V.6 MB/DAK and Cross References | <u>Replace</u> the Bibliography with the following new section:   | V.6   | Change 2   |
| V.7 Data Interpretation         | <u>Replace</u> the following sheets with revised sheets provided: | V.7-3/4<br>V.7-23/24<br>V.7-25/26                 | Change 2<br>Change 2<br>Change 2                         |
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## PREFACE

In January, 1979, USEPA's Office of Enforcement and Office of Water and Waste Management requested help from the Office of Research and Development in compiling wastewater treatment performance data into a "Treatability Manual."

A planning group was set up to manage this activity under the chairmanship of William Cawley, Deputy Director, Industrial Environmental Research Laboratory - Cincinnati. The group includes participants from: 1) the Industrial Environmental Research Laboratory - Cincinnati; 2) Effluent Guidelines Division; 3) Office of Water Enforcement and Permits; 4) Municipal Environmental Research Laboratory - Cincinnati; 5) R.S. Kerr, Environmental Research Laboratory - Ada; 6 Industrial Environmental Research Laboratory - Research Triangle Park; 7) WAPORA, Incorporated; and 8) Burke-Hennessy Associates, Incorporated.

The objectives of this program are :

- to provide readily accessible data and information on treatability of industrial waste streams;
- to provide a basis for research planning by identifying gaps in knowledge of the treatability of certain pollutants and waste streams.

The primary output from this program is a five volume Treatability Manual. This was first published in June 1980, with revisions made in September 1981 and August 1982. This publication replaces Volume I in its entirety, and updates Volumes II, III, IV, and V. The individual volumes are named as follows:

- Volume I - Treatability Data
- Volume II - Industrial Descriptions
- Volume III - Technologies
- Volume IV - Cost Estimating (In the process of revision for later publication)
- Volume V - Summary

## ACKNOWLEDGEMENT

The development of this revision to the Treatability Manual has resulted from efforts of a large number of people. It is the collection of contributions from throughout the Environmental Protection Agency, particularly from the Office of Water Enforcement, Office of Water and Waste Management, and the Office of Research and Development. Equally important to its success were the efforts of the employees of WAPORA, Inc., and Burke-Hennessy Associates, Inc., who participated in this operation.

A list of names of contributors would not adequately acknowledge the effort expended in the development of the manual. This document exists because of the major contributions of numerous individuals within EPA and the EPA contractors, including:

Effluent Guidelines Division  
Office of Water Regulations and Standards, Office of  
Water

Permits Division  
Office of Water Enforcement and Permits, Office of  
Water

National Enforcement Investigation Center  
Office of Enforcement

Office of Research and Development

Center for Environmental Research Information

Municipal Environmental Research Laboratory

Robert S. Kerr Environmental Research Laboratory

Industrial Environmental Research Laboratory  
Research Triangle Park, NC

Industrial Environmental Research Laboratory  
Cincinnati, OH

As Committee Chairman, I would like to express my sincere appreciation to the Committee Members and others who contributed to the success of this effort.

---

William A. Cawley, Deputy Director,  
IERL-Ci  
Chairman, Treatability Coordination  
Committee

Date: 1/24/83

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\*Indicates an update of reference.

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| 3-27           | 0170      | 3-63           | 0252      | 3-99           | 0258      | 3-135          | 0507      |
| 3-28           | 0018      | 3-64           | 0253      | 3-100          | 0259      | 3-136          | 0508      |
| 3-29           | 0184      | 3-65           | 0254      | 3-101          | 0260      | 3-137          | 0509      |
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| 3-32           | 0177      | 3-68           | 0005      | 3-104          | 0261      | 3-140          | 0417      |
| 3-33           | 0229      | 3-69           | 0021      | 3-105          | 0262      | 3-141          | 0600      |
| 3-34           | 0294      | 3-70           | 0010      | 3-106          | 0039      | 3-142          | 0601      |
| 3-35           | 0192      | 3-71           | 0006      | 3-107          | 0038      | 3-143          | 0450      |
| 3-36           | 0034      | 3-72           | 0060      | 3-108          | 0004      | 3-144          | 0290      |

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| 5-11                     | 0172      | 5-41         | 0153      |           |
| 5-12                     | 0173      | 5-42         | 0157      |           |
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| 5-17                     | 0180      | 5-47         | 0159      |           |
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| 5-19                     | 0025      | 5-49         | 0002      |           |
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| 5-21                     | 0184      | 5-51         | 0254      |           |
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| 5-25                     | 0150      | 5-55         | 0198      |           |
| 5-26                     | 0149      | 5-56         | 0266      |           |
| 5-27                     | 0139      | 5-57         | 0281      |           |
| 5-28                     | 0059      | 5-58         | 0282      |           |
| 5-29                     | 0189      | 5-59         | 0268      |           |
| 5-30                     | 0018      | 5-60         | 0200      |           |

preparation of field spikes. Sample splitting represents a division of the sample into two or more portions for parallel analysis by independent laboratories. Splits may be developed for duplicate analysis (e.g., by EPA and the facility) or analysis of specific fractions (e.g., metals, organics). Field blanks represent water samples of known composition that are prepared in the field and handled in a manner similar to the other samples. These are used as a means of characterizing the contamination that occurs during the sample handling. Field spikes represent the addition of a known quantity of material to the sample in the field. The subsequent analysis of a field spike will identify the changes which occur due to the effect of sample instability as well as the effects due to the analytic method used in the laboratory. The stability effects can be determined by comparing the results of a field spike to the results of a laboratory spike (the laboratory spike characterizes the method effects only).

#### V.7.2.2 Analysis - General

The basic premise in the development of analytical chemistry techniques is that by establishing a rigorous protocol for the handling and analysis of the sample, the test results will be representative of the true concentration of the tested species within certain, well-defined statistical limits. The chemist may report the value measured in terms of a range, but it is common to present only one value.

The analysis of toxic pollutants in industrial wastewaters is complicated because the chemical nature of the sample may not be known and there usually are a large number of pollutants present. The relative levels and types of priority pollutants may vary at a plant from day-to-day, or even from one shift to another. An analytical method perfectly suited to one wastewater matrix may be less effective in a different matrix, despite the fact that the same priority pollutants, or a similar combination, are being analyzed. However, an industrial category where a relatively invariant wastewater is characteristic may not present this problem.

Quality assurance and quality control (QA/QC) during the analysis of toxic pollutants is required to ensure that all results have been developed using accepted methods and that the quality of the resulting measurements can be estimated. The quality of a particular method is characterized by estimates of the precision of the measurement and the accuracy of any such measurement. (Precision refers to the refinement with which a measurement can be determined. Accuracy refers to the degree to which the measurement conforms to the true concentration within the sample at the time of analysis). Validation of a measurement requires validation of the method by determining both the multiple laboratory operational precision and the pooled single operator precision. Also required is self-validation of the particular method in a given laboratory.

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TABLE 7.2-5. SUMMARY OF OVERALL ANALYTICAL RECOVERIES FOR VARIOUS CLASSES OF PRIORITY POLLUTANTS [5-57]

| Compounds<br>Class/Number | Method Standard Analysis |            | Matrix Spiked Analysis |            |
|---------------------------|--------------------------|------------|------------------------|------------|
|                           | P $\pm$ Sp/N(a)          | Range/L(b) | P $\pm$ Sp/N(a)        | Range/L(b) |
| Purgeables/30             | 90 $\pm$ 20/785          | 59-106/4   | 92 $\pm$ 27/2161       | 32-111/4   |
| Acids/11                  | 84 $\pm$ 23/360          | 61-96/4    | 76 $\pm$ 26/862        | 54-102/5   |
| Base/Neutrals/43          | 84 $\pm$ 30/1415         | 56-142/3   | 68 $\pm$ 29/2762       | 27-105/5   |
| Pesticides/18             | 78 $\pm$ 16/505          | 65-85/3    | 59 $\pm$ 15/960        | 42-76/4    |
| Metals/13                 | 108 $\pm$ 34/385         | 83-136/2   | 96 $\pm$ 26/1638       | 79-106/3   |
| Cyanide                   | 103 $\pm$ 7/65           | 103-103/2  | 96 $\pm$ 14/70         | 93-101/2   |
| Total Phenols             | 101 $\pm$ 8/58           | 97-107/3   | 96 $\pm$ 11/85         | 93-98/3    |
| All Organics/102          | 85 $\pm$ 25/3065         | 56-142/5   | 73 $\pm$ 26/6745       | 32-111/5   |

(a)N is the total number of measurements used to compute the cited average recovery (P) and standard deviation (Sp).

(b)The range of average recoveries for the compounds in a class and the number of contributing laboratories (L) is given in this column.



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Table 7.2-6. Interlaboratory comparison of percent recovery data for priority pollutant fractions analyzed using the April 1977 EPA protocol (a) [5-57]

| Priority Pollutant Fraction(b) | Lab I  | Lab II | Lab III | Lab IV | Lab V | Lab VII | Average |
|--------------------------------|--------|--------|---------|--------|-------|---------|---------|
| Volatile (MS)                  | 88±21  | 95±5   |         | 100±8  |       |         | 90±13   |
| Volatile Sample Spike          | 82±24  | 101±9  | 93±13   | 107±9  |       |         | 92±15   |
| Acid (MS)                      | 90±18  | 89±5   |         | 67±14  | 82±16 |         | 84±13   |
| Acid Sample Blank              | 92±34  | 72±10  | 62±12   | 60±15  | 84±17 |         | 76±19   |
| B/N-(MS)                       | 95±25  | 78±41  |         | 77±15  |       |         | 84±25   |
| B/N Sample Spike               | 84±18  | 61±22  | 55±24   | 68±16  |       | 63±13   | 68±21   |
| Pesticide (MS)                 | 73±8   | 74±19  |         | 88±8   |       |         | 78±11   |
| Pesticide Sample Spike         | 69±7   | 51±18  | 33±10   | 93±5   |       |         | 59±11   |
| Metals (MS)                    | 113±37 |        |         | 103±8  |       |         | 108±22  |
| Metals Sample Spike            | 100±20 | 103±14 |         | 92±7   |       |         | 96±11   |
| Cyanide (MS)                   | 103±14 |        |         | 103±8  |       |         | 103±7   |
| Cyanide Sample Spike           | 101±12 |        |         | 93±16  |       |         | 96±14   |
| Phenolics (MS)                 | 10±13  | 97±6   |         | 100±7  |       |         | 101±8   |
| Phenolics Sample Spike         | 93±15  | 98±10  |         | 97±9   |       |         | 96±11   |

(a) The values are in units of percent recovery plus or minus (±) one standard deviation. Percent recovery and standard deviation are weighted averages based on the number of data points contributed by each laboratory.

(b) MS refers to the method standard or the standard addition to blank water. Sample spike refers to the standard addition to a sample.

This indicates that most data are probably reported at concentration lower than actually existed.

#### June 1977 EPA Protocol

The June 1977 EPA protocol included a QA/QC requirement similar to that required for the April 1977 protocol. The precision and accuracy of the data developed using this protocol have not been defined by the sources used in preparing this manual.

#### December 1979 EPA Protocol

This protocol includes as a fundamental requirement the validation of the analytic methods prior to their use for routine analysis of a wastewater matrix. EPA is sponsoring validation studies that are to establish the accuracy and precision of the methods. However, these studies have not been completed.

The protocol also includes a requirement that each laboratory establish control limits for evaluating the reliability of the methods during routine analysis. The sources of data used in this manual have not reported any results of these laboratory-specific validation and QA/QC programs.

An evaluation of the precision, bias and comparability of the inductively coupled plasma method ICP with that of flame atomic adsorption AA was made by the EPA Effluent Guidelines Division in 1980 for total metals (iron, chromium, copper, nickel, lead and zinc) in mine effluents. This study, while limited in scope, was an inter-laboratory round-robin conducted in accordance with ASTM D2777-77, "Standard Practice for Determination of the Precision and Bias of Methods of Committee D-19 on Water." The limits of detection and of determination in mine effluents based on inter-laboratory precision for the ICP method were several times higher than those for flame AA in the 0-1 mg/L range for all of the above mentioned elements except chromium.

### 3. RBC Pilot Scale Study

Sampling: Swanson - Oswald Assc.

Analysis: Swanson - Oswald Assc.

Reference: 5-62

Date: November 1977 - March 1978

Procedures: Data Set 3 - RBC Pilot Scale Study

A pilot scale study of rotating biological contactors was conducted at a gum and wood chemicals manufacturing plant. Sampling and analysis followed standard methodology, outlined in Standard Methods for the Analysis of Water and Wastewater, 14th edition, American Public Health Organization, with a few modifications.

Sampling consisted of, at the minimum, bi-weekly grab samples. Collected samples were preserved on ice until arrival at the laboratory. Pollutant analysis consisted of standard method procedures from the above mentioned protocol as well as parallel and additional analysis using other established methods. The purpose of multiple analysis was to quantify the accuracy of methods chosen when presenting data as well as to further develop the data base. Data are a representation of these analytical methods without analysis specific designation.



Procedures: Data Set 2 - Additional Sampling (Screening)

The additional screening study was conducted in 1979. The April 1977 EPA protocol was followed for all sampling and analysis work performed during this study. Nine of the thirteen subcategories were included in the study. The survey was initiated in order to determine the concentration of toxic compounds in the industry's raw wastewater.

Procedures: Data Set 3 - Pilot Plant Study

This study was initiated in order to determine the effectiveness of the rotating biological contactor in pollutant removability. The sampling method was unspecified.

Analysis of organics utilized a gas chromatograph with a flame ionization detector, using methods defined by American Society for Testing Materials, Methods D-3328-#aT and D-3257-73, USA. Atomic absorption was used for metals analyses. The organics QA/QC program included the spiking of raw wastewater samples with the organic species to confirm detectability by the method used.

V.7.3.31 Steam Electric Power Plants

Volume II Reference: Section II.19

Data Sets:

1. Initial BAT Survey (Screening Phase)  
Sampling: Hittman Associates, NUS Corporation  
Analysis: Carborundum  
Reference: 5-31  
Date: 1977
2. BAT Survey (Verification Phase)  
Sampling: Hittman Associates  
Analysis: Richardson Associates, EPA  
Reference: 5-31  
Date: 1977
3. Surveillance and Analysis  
Sampling: EPA Regional Teams  
Analysis: EPA  
Reference: 5-31  
Date: Unspecified

Procedures: Data Set 1 - Initial BAT Survey (Screening Phase)

The program included analysis at eight plants. The EPA study was paralleled by the electric power industry, including the separate sampling and analysis by industry-contracted laboratories.

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Sampling involved the collection of grab samples and 24-hour composite samples using automatic equipment. The April 1977 EPA protocol was used for sampling.

Analysis used analytical procedures that included the GC/MS for organic pollutants and the AA for metals.

Procedures: Data Set 2 - BAT Survey (Verification Phase)

Sixteen plants were included in this program initially with two plants added later to the data base by EPA, since the data were collected by similar methods and format.

Sampling was performed using the April 1977 EPA protocol. The collected samples were split with the power industry for their parallel analysis. The analytic methods used included the GC/MS or GC for the organic priority pollutants. The inorganics were analyzed by AA or inductively coupled plasma ICP. Mercury was analyzed by cold-vapor AA, selenium by fluorometry, and cyanide by a colorimetric procedure.

Procedures: Data Set 3 - Surveillance and Analysis

The EPA regional Surveillance and Analysis program included periodic visits to power plants to determine compliance with NPDES permits. Priority pollutant sampling was conducted at eight plants. The sampling and analysis procedures were similar to those used in the screening and verification programs. Analytical methods included GC/MS for organics and ICAP for inorganics.

V.7.3.32 Textile Mills

Volume II Reference: Section II.20

Data Sets:

1. Comprehensive Field Sampling Program (Screening and Verification Survey, Four Phases)
  - a. Phase 1 - Joint ATMI/EPA Mobile Plant Project  
Sampling: ATMI; Monsanto Research Corporation (MRC)  
Analysis: ATMI; MRC  
Reference: 5-32  
Date: March - May 1977
  - b. Phase 2 - Untreated and Treated Wastewater  
plus Pilot Plant Advanced Treatment  
Sampling: Sverdrup and Parcel; EPA  
Analysis: MRC

4. Pilot Plant Study

Sampling: CARRE, Inc.

Analysis: Clemson University, Texidyne

Reference: 5-61

Date: Sept. 23, 1977 - Sept. 22, 1978

Procedures: Data Set 4 - Pilot Plant Study

This data set is comprised of pilot plant data generated in the 1978 hyperfiltration study conducted at a La France Industries textile mill. Sample analysis followed standard procedure.

Sampling consisted of one gallon plastic bottle samples collected periodically and sent to the lab for analysis.

Analysis of membrane flux, color and conductivity rejections were monitored on site. Color comparisons were determined through the use of a Bausch and Lomb Spectronic 20 while conductivity measurements were made using a Balsbaugh conductivity bridge and dip cell. All other samples were collected and delivered to the laboratory where analysis was done in accordance with quality assurance procedures approved for this project.





APPENDIX A  
NUMBER OF SOURCE/TREATMENT  
TECHNOLOGY DATA SETS

Date: 9/25/81

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TABLE A-1. NUMBER OF SOURCE/TREATMENT TECHNOLOGY DATA SETS

| Industry/control technology          | Data Sets  |             |             |
|--------------------------------------|------------|-------------|-------------|
|                                      | Full scale | Pilot scale | Bench scale |
| Adhesives and sealants               |            |             |             |
| Chemical oxidation                   |            | 1           |             |
| Reverse osmosis                      |            | 1           |             |
| Sedimentation                        |            | 1           |             |
| Auto and other laundries             |            |             |             |
| Activated carbon adsorption-granular | 1          | 1           |             |
| Chemical precipitation               | 1          |             |             |
| Filtration                           | 3          |             |             |
| Flotation                            | 10         |             |             |
| Ultrafiltration                      |            | 5           |             |
| Coal mining                          |            |             |             |
| Sedimentation                        | 7          |             |             |
| Rotating biological contactors       |            | 1           |             |
| Coil coating                         |            |             |             |
| Chemical precipitation               | 6          |             |             |
| Filtration                           | 1          |             |             |
| Sedimentation                        | 2          |             |             |
| Inorganic chemicals manufacturing    |            |             |             |
| Chemical oxidation                   | 2          |             |             |
| Chemical precipitation               | 5          |             |             |
| Chemical reduction                   | 1          |             |             |
| Filtration                           | 4          |             |             |
| Sedimentation                        | 3          |             |             |
| Stripping-air                        | 1          |             |             |
| Iron and steel manufacturing         |            |             |             |
| Chemical precipitation               | 1          |             |             |
| Coagulation and flocculation         | 5          |             |             |
| Filtration                           | 4          |             |             |
| Neutralization                       | 1          |             |             |
| Oil separation                       | 1          |             |             |
| Sedimentation                        | 8          |             |             |
| Solvent extraction                   | 1          |             |             |
| Ultrafiltration                      | 1          |             |             |
| Activated sludge                     | 1          |             |             |
| Leather tanning and finishing        |            |             |             |
| Sedimentation                        | 1          |             |             |
| Activated sludge                     | 8          |             |             |
| Lagoon                               | 2          | 1           |             |
| Trickling filters                    | 1          |             |             |

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TABLE A-1. NUMBER OF SOURCE/TREATMENT TECHNOLOGY DATA SETS (CONTINUED)

| Industry/control technology          | Data Sets     |                |                |
|--------------------------------------|---------------|----------------|----------------|
|                                      | Full<br>scale | Pilot<br>scale | Bench<br>scale |
| Battery manufacturing                |               |                |                |
| Chemical precipitation               | 1             |                |                |
| Electrical and electronic components |               |                |                |
| Activated carbon adsorption-granular | 1             |                |                |
| Chemical precipitation               | 1             |                |                |
| Chemical reduction                   | 1             |                |                |
| Coagulation and flocculation         | 1             |                |                |
| Filtration                           | 3             |                |                |
| Oil separation                       | 1             |                |                |
| Foundries                            |               |                |                |
| Chemical precipitation               | 1             |                |                |
| Filtration                           | 1             |                |                |
| Sedimentation                        | 9             |                |                |
| Metal finishing                      |               |                |                |
| Chemical precipitation               | 28            |                |                |
| Chemical reduction                   | 5             |                |                |
| Reverse osmosis                      |               | 1              |                |
| Sedimentation                        | 2             |                |                |
| Aluminum forming                     |               |                |                |
| Chemical precipitation               | 1             |                |                |
| Chemical reduction                   | 1             |                |                |
| Coagulation and flocculation         | 2             |                |                |
| Oil separation                       | 2             |                |                |
| Sedimentation                        | 1             |                |                |
| Ultrafiltration                      | 1             |                |                |
| Copper forming                       |               |                |                |
| Chemical precipitation               | 3             |                |                |
| Filtration                           | 1             |                |                |
| Plastics processing                  |               |                |                |
| Activated sludge                     | 1             |                |                |
| Porcelain enameling                  |               |                |                |
| Chemical precipitation               | 1             |                |                |
| Gum and wood chemicals               |               |                |                |
| Activated carbon adsorption-granular | 1             |                |                |
| Sedimentation                        | 1             |                |                |
| Lagoon                               | 3             |                |                |
| Rotating biological contactor        |               | 2              |                |

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TABLE A-1. NUMBER OF SOURCE/TREATMENT TECHNOLOGY DATA SETS (CONTINUED)

| Industry/control technology            | Data sets     |                |                |
|--|---------------|----------------|----------------|
|  | Full<br>scale | Pilot<br>scale | Bench<br>scale |
| Pesticide manufacturing                |               |                |                |
| Activated carbon adsorption-granular   | 1             |                |                |
| Pharmaceutical manufacturing           |               |                |                |
| Activated sludge                       | 3             |                |                |
| Lagoon-aerated                         | 2             |                |                |
| Nonferrous metals manufacturing        |               |                |                |
| Chemical precipitation                 | 2             |                |                |
| Ore mining and dressing                |               |                |                |
| Activated carbon adsorption-granular   |               | 1              |                |
| Chemical oxidation                     | 1             | 2              |                |
| Chemical precipitation                 | 6             | 4              |                |
| Filtration                             |               | 5              |                |
| Ion exchange                           | 1             | 1              |                |
| Sedimentation                          | 14            | 2              |                |
| Organic chemicals                      |               |                |                |
| Activated carbon adsorption-granular   |               | 14             |                |
| Chemical oxidation                     |               | 3              |                |
| Ion exchange                           | 1             |                |                |
| Stripping-steam                        |               | 6              |                |
| Solvent extraction                     |               | 13             |                |
| Paint and ink formulation              |               |                |                |
| Chemical precipitation                 | 11            |                |                |
| Filtration                             | 2             |                |                |
| Sedimentation                          | 3             |                |                |
| Lagoon                                 | 1             |                |                |
| Petroleum refining                     |               |                |                |
| Activated carbon adsorption - powdered | 1             | 4              |                |
| Activated carbon adsorption - granular |               | 6              | 2              |
| Filtration                             |               | 6              |                |
| Flotation                              | 1             |                |                |
| Solvent extraction                     |               | 4              |                |

TABLE A-1. NUMBER OF SOURCE/TREATMENT TECHNOLOGY DATA SETS (CONTINUED)

| Industry/control technology      | Data Sets     |                |                |
|----------------------------------|---------------|----------------|----------------|
|                                  | Full<br>scale | Pilot<br>scale | Bench<br>scale |
| Pulp and paperboard mills        |               |                |                |
| Activated carbon adsorption      |               |                |                |
| - Powdered                       | 1             |                |                |
| - Granular                       |               | 1              |                |
| Filtration                       | 1             |                |                |
| Flotation                        | 1             |                |                |
| Activated sludge                 | 2             |                |                |
| Trickling filter                 | 1             |                |                |
| Rubber processing                |               |                |                |
| Ultrafiltration                  |               | 2              |                |
| Activated sludge                 | 1             |                |                |
| Soap and detergent manufacturing |               |                |                |
| Rotating biological contactor    |               | 1              |                |
| Steam electric power plants      |               |                |                |
| Chemical precipitation           | 1             |                | 7              |
| Reverse osmosis                  |               |                | 6              |
| Sedimentation                    | 2             |                |                |
| Textile mills                    |               |                |                |
| Activated carbon adsorption      |               |                |                |
| - Powdered                       | 1             |                | 10             |
| - Granular                       |               | 12             |                |
| Chemical oxidation               |               | 2              |                |
| Chemical precipitation           | 1             | 3              | 2              |
| Coagulation and flocculation     |               | 2              |                |
| Filtration                       | 1             | 12             |                |
| Flotation                        | 1             |                |                |
| Reverse osmosis                  |               | 11             |                |
| Ultrafiltration                  |               | 3              |                |
| Activated sludge                 | 33            |                |                |
| Lagoon                           | 4             |                |                |
| Sedimentation                    |               | 1              |                |
| Timber products processing       |               |                |                |
| Reverse osmosis                  |               | 1              |                |
| Ultrafiltration                  |               | 1              |                |
| Activated sludge                 | 1             |                | 2              |
| Lagoon                           | 1             |                |                |
| Trickling filter                 |               | 2              |                |

TABLE A-1. NUMBER OF SOURCE/TREATMENT TECHNOLOGY DATA SETS (CONCLUDED)

| Industry/control technology          | Data sets     |                |                |
|--------------------------------------|---------------|----------------|----------------|
|                                      | Full<br>scale | Pilot<br>scale | Bench<br>scale |
| Miscellaneous and Unspecified        |               |                |                |
| Activated carbon adsorption-granular |               | 1              |                |
| Solvent extraction                   |               | 2              |                |
| Activated sludge                     | 1             | 1              |                |
| Organic and inorganic                |               |                |                |
| Chemical oxidation                   |               |                | 1              |
| Chemical precipitation               |               | 1              |                |
| Filtration                           |               | 1              |                |
| Activated sludge                     | 2             |                |                |
| Totals                               | 248           | 133            | 30             |