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**DISTRIBUTION OF COMMUNITY WATER SYSTEMS
ACROSS THE UNITED STATES WITH EMPHASIS ON
SIZE, WATER PRODUCTION, OWNERSHIP, AND
TREATMENT**

by

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DISTRIBUTION OF COMMUNITY WATER SYSTEMS ACROSS THE UNITED STATES WITH EMPHASIS ON SIZE, WATER PRODUCTION, OWNERSHIP, AND TREATMENT

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ABSTRACT*

An understanding of the diversity of community water systems (CWS) in the United States is essential when evaluating the financial implications of the 1986 and subsequent amendments to the Safe Drinking Water Act (SDWA). This diversity, in terms of size, primary water source, ownership, and existing levels of treatment, shape the nature of the technical, institutional, and financial issues that must be confronted in moving these systems toward compliance with SDWA regulations. This report provides a descriptive summary of these operating and design characteristics of CWS's across the country.

The data are organized to help provide a typology of representative public water systems that can be examined to better understand the regional effects of policy implementation. The focus of the analysis is on small water systems, those most burdened by the expanded monitoring and treatment regulations; much of the data are also provided for larger systems for purposes of comparison and completeness.

Emphasis is directed towards current water treatment objectives being pursued by CWS's and the treatment processes already in place. It is for those smaller systems that may require the addition of multiple water treatment processes that the financial implications are likely to be most severe.

As would be expected, there is a shortfall between the number of systems serving fewer than 10,000 people employing multiple treatment processes and the estimated number required. There are systems, however, that have demonstrated success with a number of multiple treatment processes, particularly in the small and medium-size categories. The experience gained by these systems would seem invaluable in efforts to accelerate the process of field testing and approval of technologies applicable to systems serving lower population levels.

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INTRODUCTION

As part of a comprehensive examination of the status of our nation's community water systems (CWS) and the financial implications of the 1986 Amendments to the Safe Drinking Water Act (SDWA), one must have a clear picture of the number and diversity of these systems both nationally and at the regional level. This diversity, particularly in terms of size, primary water source, ownership, and existing levels of treatment, shape the nature of the technical, institutional, and financial issues that must be confronted in moving the nation's many community water systems toward compliance with SDWA regulations.¹

The purpose of this report is to provide a descriptive summary of these various operating and design characteristics of CWS's across the country. As such, the manuscript is one of the first in a series designed to provide a comprehensive look at the implications of the 1986 amendments. The objectives are modest relative to the scope of the overall research effort, but they are a necessary first step. Emphasis is focused on the policy implications that can be drawn from a careful analysis of the data. These data are also organized to help provide a typology of representative public water systems that can be examined to better understand the regional effects of policy implementation. The focus of the analysis is on small water systems, but much of the data is also provided for larger systems primarily for purposes of comparison and completeness.

Brief summaries of the size distribution of public water systems are already contained in two previous reports designed to assess the benefits and costs of the 1986 SDWA amendments, and the technical and economic capacity of states and public water systems for implementation of the 1986 amendments (Wade Miller Associates, 1990, and EPA, 1993). However, the assessments in these reports focused primarily at the national level, and there was little need to articulate differences in the distribution of systems regionally or by characteristics such as ownership, system capacity, and nature of the population served. At the time at least one of these studies was completed, many of the rules associated with various provisions of the 1986 amendments were at best in the early stages of development; few systems had yet to be confronted with the reality of compliance, so there was little need to focus on existing monitoring and treatment experience.

¹ Passage of the 1996 amendments to the SDWA (PL-104-182) occurred during the development of this report. As such, the predominant focus of the report is directed towards the 1986 amendments, application is made to the 1996 amendments where appropriate. Given the descriptive nature of this report, this should be of little concern.

The issues surrounding the implementation of the 1986 amendments go well beyond those related to aggregate benefits and costs to society, which are the primary bases for justifying the regulations from a national perspective. Knowledge of the diversity of systems at a more disaggregate level is essential for the examination of these broader issues. For example, detailed information about public water systems at the regional level should be of interest in the design and location of regional centers for technical assistance as authorized in the 1996 amendments to the Safe Drinking Water Act. To the extent that the distribution of systems by type differs regionally, the cost of compliance relative to the benefits will differ as well. This could alter the financial implications for local governments, and in regions where the perceived benefit-cost ratios are lowest, the incentives for seeking exemptions could be quite high. The potential for viable restructuring could also be affected. Information concerning the proportion of systems owned privately and their size may be important to understand the effects of new legislative initiatives such as the unfunded mandate legislation passed recently by both the Senate and the House. This could be particularly true if, as some suspect, the availability of exemptions from full compliance would differ between public and private providers. Information about the type of population served by community water systems should enable one to make educated guesses about the income distribution in order to study the financial effects of amendments on individuals by income class.

The remainder of the report is divided into several sections. To provide a clear picture of what the data represent, we begin by reiterating the definition of a public water system. Since the data described in this report come primarily from the *FRDS-II Data Base*, we also discuss briefly how the data were organized to complete the analysis, and how potential problems associated with missing data in this large data base were handled. The focus then shifts to a discussion of the characteristics of water systems at the national level and their policy implications. The policy significance of the regional diversity of water systems is also highlighted.² Perhaps the most important section relates to the current treatment objectives and levels of treatment. This discussion helps to delineate the treatment needs, but it also provides a good indication of what financially feasible treatment strategies are being used currently by large and small systems. It should be invaluable in establishing priorities for further research. The final section summarizes the conclusions and implications for policy. Before proceeding, it is also important to emphasize that the nature of the analysis requires the presentation of a lot of data, particularly relating to the treatment strategies. This makes for

² To facilitate this discussion of the regional data without adding unduly to the length of the text of the report, a detailed description of the regional diversity of water systems and the supporting data is included in an appendix. Its primary purpose is as a source document for those interested in the specific regional data.

some rather tedious reading at times, but we offer few apologies because this is very much a working document; much of the descriptive analysis is designed to help set priorities for further research.

PUBLIC WATER SYSTEMS DEFINED

A public water system (PWS), according to the definition used by the Federal government for policy purposes, is one that pipes water to the public for human consumption (EPA, 1993). To qualify as a PWS, a system must have at least 15 service connections, or regularly serve at least 25 individuals for two months or more during the year. By federal definition, PWS's are further divided into two groups: community water systems and non-community water systems. Non-community water systems are either transient or non-transient.

Of the more than 200 thousand PWS's across the nation, nearly 30% are community water systems (CWS), just over 10% are non-transient, non-community systems (NTNC), and the remaining systems, nearly 60%, are transient, non-community systems (TNC).

In addition to being descriptive of the types of customers they serve, these classifications are important because the extent to which they must comply with the 1986 amendments differs. Historically, for example, all non-community water systems were required to meet only those standards designed to prevent short-term health problems such as bacteria, nitrates, and turbidity. This remains true for most transient, non-community systems (such as campgrounds, motels, and gas stations) which cater to transient customers in non-residential areas. The estimated 3% of these systems that rely on surface water supplies are also required to meet standards for filtration and disinfection (EPA, 1993).

On the other hand, non-transient non-community water systems must serve at least 25 people at least six months of the year and include schools, factories, hospitals and other institutions with their own water supplies. Subsequent to their passage, NTNC's are required to comply with the 1986 SDWA amendments. This is also true for community water systems (CWS), defined as public water systems which serve at least 15 service connections used by year-round residents or regularly serve at least 25 year-round residents. CWS's range from smaller units such as trailer parks and housing complexes to larger systems serving rural and suburban communities and large cities. Since the majority of systems which are potentially affected most seriously by the passage of the 1986 SDWA amendments are community water systems, the analysis here focuses on this group. This is consistent with the analysis in EPA's recent report to Congress on the technical and economic capacity of states and public water systems to implement drinking water regulations (EPA, 1993).

THE FEDERAL REPORTING DATA SYSTEM

The data on CWS's analyzed in this report come primarily from EPA's *FRDS-II Data Base* as of July 1, 1994. The data base is designed specifically to support the EPA's Office of Groundwater and Drinking Water (OGWDW) in monitoring compliance with the Safe Drinking Water Act of 1974. Water systems across the country are required to report information about their systems on an annual basis to their respective state agencies, who, in turn, forward it to the *FRDS* system maintained at EPA's computing center in North Carolina.

The *FRDS-II Data Base* is a complex data structure for public water systems arranged hierarchically in four levels and containing information relating to the operation, design, and treatment. There is detailed information on: population served, daily water production and design capacity, ownership, primary water sources, treatment objectives, treatment processes employed, the geographic areas served, on site visits and water sampling, violation and enforcement actions, and variance/exemption actions. As one moves deeper into the hierarchy of the system, it is necessary to maintain numerous records for each system. For example, the source/entry file in Level 2 contains individual records for each water source utilized by a particular CWS listed in the Level 1 file. The treatment data file, located in Level 3, contains separate records for each treatment process that is linked to each source record from Level 2. The location of the treatment (i.e., at the source, treatment plant, or entry point) is also attached to these records.³

This type of data structure lends itself well to retrieving complete data for one or a handful of systems. However, the structure presents a real challenge to anyone attempting to use such a data base for research purposes where detailed data on all systems must be summarized and analyzed. To our knowledge, no one has attempted such an analysis, and to this extent, much of the information in this report is not widely known.

This report relies primarily on the first-and second-level descriptive features of CWS's across the country relating to operation characteristics, production requirements, and treatment processes and objectives. Subsequent reports will concentrate more on types and frequencies of violation and enforcement actions and/or variances related to those violations.

³ Other data files exhibit a similar "branching" structure, such as the non-compliance file at Level 2 which branches first into the violation file at Level 3, and second into the file on enforcement action at Level 4. Put differently, a CWS listed in Level 1 may be flagged as being non-compliant at Level 2, with the one or more individual violations associated with non-compliance delineated at Level 3. Each of these records is finally linked to the one or more enforcement actions in Level 4 associated with the corresponding violation contained in Level 3 records.

In any data base of this size and where reporting is ultimately the responsibility of individuals at the system level, there are always some problems with the data. To facilitate the identification of these problems and the manipulation of the data, we converted the entire *FRDS-II Data Base* into SAS data files. For this analysis, we focused attention on systems located in the 50 states, ignoring, at least for the time being, about 700 systems in the several territories of the United States.

To obtain a usable data set for this analysis, it was also necessary to eliminate observations in which important pieces of data were either missing or obviously in error. To begin, we eliminated observations where some of the most basic information on population served, ownership, and treatment classification was missing. We also eliminated systems where the information was provided, but was obviously erroneous because of inconsistencies between population served, average daily production and design capacity. The result was a data set including information on about 45,600 community water systems.

Although this is a significant subset of the data (containing 80% of the community water systems around the country), we were concerned that inferences drawn from it may be biased if the subset turned out not to be representative of the population. To obtain some notion of the nature of any bias, we performed a number of statistical tests between the distribution of the subset of systems by size category and the entire population of water systems by size category as reported in the EPA's report to Congress on the technical and economic capacity of states and public water systems to implement drinking water regulations (EPA, 1993). The test for the similarity of distributions is the Kolmogorov-Smirnov test, and the results are reported in detail in appendix A.

Based on this test, there is reason to believe that the size distribution of the systems in the subset is representative of that for the entire population of combined ground and surface water systems. The same is true for ground water systems examined separately. For surface water systems, the size distributions appear identical, with the exception of those in the smallest size category. Here, there seemed to be a slightly higher proportion of small systems eliminated because of missing or inconsistent data. On this basis, it seems unlikely that the steps required to develop a useable set of data for the analysis lead to any serious bias in the results, particularly if one believes that the general characteristics of very small systems are likely to be more homogeneous than those of systems with retail service populations greater than 500.

A NATIONAL AND REGIONAL PERSPECTIVE

To obtain a picture of the diversity of community water systems from a national perspective, it is convenient to begin by examining the distribution of systems by size. Size, however, can be defined in a variety of ways, ranging from the size of the population served, to some measure of the average (or peak) daily flow or the system's design capacity. Measures of average daily flow or design capacity are most important for decisions regarding water system construction and water treatment, and are related to the population served, but not completely so. The demand for water also depends among other things on climate, the demographic makeup of the population, as well as the nature of the retail, industrial, and residential development in the service area.

For policy purposes and to facilitate the development of regulations, the EPA groups public water systems into 12 categories by size of population served if the information necessary to formulate the regulation is available at that level of detail (EPA, 1993). Where information is limited, the systems are recombined into five size categories which are simple aggregations of the initial 12. These categories are defined according to the population served, and are presented in table 1.

Classifying systems in this way for policy purposes is one way to focus attention on the potential resources that can be drawn on to meet the costs of compliance with the SDWA regulations. For example, it is generally believed that systems serving populations of 10,000 or more are large enough to take advantage of economies of size in production and management and sufficient resources to finance increased monitoring and treatment at a reasonable cost to customers. For systems serving fewer people, the possibilities for realizing economies of size in production, distribution, or planning are limited, and the ability to finance needed treatment and monitoring to comply with SDWA regulations is more problematic. Other characteristics such as ownership of the system and the primary water source affect the cost, as well as the resources available to comply with the regulations.

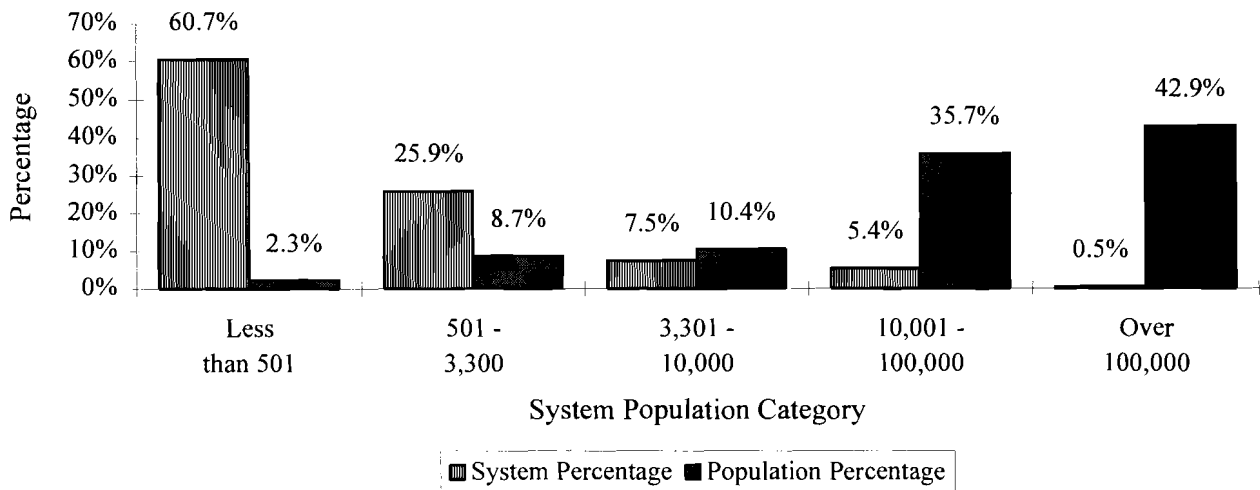
Distribution of CWS's by Population Served

Of the more than 57,000 community water systems nationwide, just over 18% of them rely on surface water as their primary water source, with the remaining 82% relying primarily on ground water. The data in table 1 provide a clear picture of the distribution of CWS's by population size category for all systems, as well as for groups differentiated by whether the system's primary water source is from ground or surface water. These data are easier to

Table 1. Distribution of Community Water Systems and Population Served by Ground and Surface Water Sources.

| Population Category | Population Range | Population Classification | Ground and Surface Water Systems | | Ground Water Systems | | Surface Water Systems | |
|---------------------|-------------------|---------------------------|----------------------------------|-------------------|----------------------|-------------------|-----------------------|-------------------|
| | | | Number | Population Served | Number | Population Served | Number | Population Served |
| ----- % ----- | | | | | | | | |
| A | < 101 | → Very Small | 29.6 | 0.4 | 34.6 | 1.0 | 7.5 | 0.0 |
| B | 101 to 500 | | 31.0 | 1.9 | 33.6 | 4.1 | 19.6 | 0.4 |
| C | 501 to 1,000 | → Small | 10.8 | 1.9 | 10.6 | 3.8 | 11.5 | 0.7 |
| D | 1,001 to 2,500 | | 12.0 | 4.6 | 10.4 | 8.3 | 19.0 | 2.3 |
| E | 2,501 to 3,300 | | 3.1 | 2.2 | 2.4 | 3.4 | 6.3 | 1.3 |
| F | 3,301 to 5,000 | → Medium | 3.3 | 3.2 | 2.3 | 4.6 | 7.6 | 2.2 |
| G | 5,001 to 10,000 | | 4.2 | 7.3 | 2.8 | 9.9 | 10.6 | 5.4 |
| H | 10,001 to 50,000 | → Large | 4.7 | 24.7 | 2.8 | 29.3 | 13.6 | 21.6 |
| I | 50,001 to 75,000 | | 0.5 | 6.8 | 0.2 | 6.9 | 1.5 | 6.8 |
| J | 75,001 to 100,000 | | 0.2 | 4.2 | 0.1 | 4.5 | 0.7 | 4.0 |
| K | > 100,000 | → Very Large | 0.5 | 42.9 | 0.2 | 24.1 | 2.1 | 55.2 |

Figure 1. CWS Distribution by System and Population Served by Size Category.



visualize in figure 1. Very small systems, those serving retail populations of less than 500 people, account for the lion's share (over 60%) of all CWS's nationwide. Given their size, it is not surprising that they serve only an estimated 2% of the population. Small systems, those serving between 501 and 3,300 people, account for an additional 26% of all systems and serve just under 9% of the retail population. Medium-sized systems, serving retail populations between 3,301 and 10,000 people, constitute slightly more than 7% of all CWS's, and serve an additional 10% of the retail population. The remaining 80% of the population is served by only 6% of the CWS's, all of which have a service population of more than 10,000; within this group, over 40% of the population is served by the one-half of one percent of the CWS's with a service population over 100,000.

The fact that such a large percentage of the population is served by large systems with sufficient resources to take advantage of economies of size in water treatment and system administration tends to disguise the magnitude of the problems in achieving greater compliance with the 1986 amendments to the Safe Drinking Water Act. While only 10% of the population is affected, the unique problems facing small systems potentially affect about 50,000 CWS's and/or units of local government distributed across the country, somewhat differentially by region as is seen in the data from appendix B.

For example, the proportion of small and very small systems exceeds the national average significantly in New England and in the three EPA regions served by Dallas, Denver, and Seattle. The proportion of the population served by these systems in the Dallas region is more than double the national average. With the exception of the metropolitan areas

surrounding the regional offices in these latter two regions, the small systems are scattered across the sparsely populated areas of the northern plains where population densities are among the lowest in the country. In New England, the rural populations served by these small systems are much more evenly distributed across the landscape. Thus, the problems facing small systems in these two diverse areas, and the potential for restructuring in terms of physical consolidation or administrative cooperation can be expected to be markedly different.

Perhaps one of the few bright spots about the nature of small water systems affecting their effort to expand water treatment is their relatively large reliance on ground water as the primary source of water. Nearly 92% of all ground water systems are in the small and very small categories, and they serve over 20% percent of the population receiving water from ground water sources (table 1). Part of the explanation lies in the fact that many of the areas served by these small systems have no proximity to a surface water source, and, in other cases, the source development costs could have been lower than that for surface water or the quality of the raw water could have been higher.⁴

Regardless of the reasons for this pattern, there are important implications for compliance with the SDWA regulations and modifications in them that might be anticipated in future reauthorization efforts. The most direct implication relates to the Surface Water Treatment Rule (SWTR). This rule was promulgated in June of 1989 and requires surface water sources to apply disinfection and may require filtration unless specific criteria are met. These requirements are designed to protect against the adverse health effects associated with various viruses, heterotrophic bacteria, and other pathogenic organisms (54 FR 27486).

With the exception of those ground water sources under the direct influence of surface water, none of these rules apply to small or very small systems whose primary source is ground water. Fortunately, according to the data in *FRDS-II*, fewer than two-tenths of one percent of the ground water systems are under the direct influence of surface water.

In addition, the Information Collection Rule (ICR) defines specific monitoring requirements based on a system's size. Systems subject to the SWTR and serving populations of more than 10,000 or ground water systems serving more than 50,000 are all affected by the ICR. All utilities serving more than 100,000 people must develop a formal sampling plan, including monthly monitoring requirements for coliphage viruses and *Clostridium perfringens*, as well as traditional coliforms, *Giardia*, and *Cryptosporidium*. The smaller systems will be

⁴ Although small surface water systems serve less than 5% of the population receiving water from surface water sources, they still represent nearly 65% of all surface water systems.

required to monitor every two months; all subject to change relative to microbes to be tested and testing schedules. It is expected that monitoring for disinfection by-products (DBP) will proceed in a parallel fashion, with EPA looking for chemicals of concern related to chloramine, chlorine, dioxide, and ozone disinfection.

In addition to a more relaxed standard setting process from the 1996 amendments to the SDWA, small water system monitoring requirements will be limited to those contaminants likely to be detected in their drinking water. EPA must issue regulations for a monitoring program regarding unregulated contaminants. These regulations ensure that only a representative sample of small water systems will be required to monitor for all regulated contaminants. States with primacy may provide interim monitoring relief for PWS's serving under 10,000 people. However, systems must provide to customers annual reports on existing contaminant levels and potential health effects.

Furthermore, where the raw water from a ground water source is of high quality, small water systems may benefit from a growing recognition that the list of potentially effective strategies for insuring the safety of our drinking water extend well beyond conventional treatment solutions, including a greater emphasis on watershed planning and the identification of methods for adequate source protection.

System Size as Measured by Flow or Design Capacity

Although for many purposes it makes sense to classify CWS's by the population served, measures of size that are more directly related to the actual volume of water produced are also important for planning purposes and projecting system costs. Classifying systems by these measures is less important for policy purposes, but given the availability of data on average daily flow and design capacity, it is useful to relate these three measures of size directly in a formal mathematical way. In so doing, we essentially are able to estimate two equations econometrically that provide estimates of conditional demands for water at the system level.⁵ Demands can easily be put on a per capita basis.

⁵ We refer to conditional demand models in much the same way energy economists have used multivariate regression models with demographic characteristics, weather, and the stock of household appliances to estimate electricity consumption or appliance utilization rates (EPRI EA-3410, 1984, and Parti and Parti, 1980). In this case, however, the regression models are used to estimate average daily flow or design capacity as functions of population served, weather, and geographic location. These consumption estimates are conditional in the sense that the effect of price cannot be determined because of the lack of data. To the extent that there are systematic differences in price by region or in rural vs. urban areas, the dummy variables in the regression may reflect some of the price differentials.

These relationships will prove extremely useful in further research, but it should be pointed out that in working with the *FDRS-II Data Base* the quality of the data on a system's average daily flow and system design capacity was perhaps the most problematic. In many cases, only one of the two variables was reported, and in other cases both were missing. Therefore, in addition to their being useful in other research, these equations were necessary to estimate missing values for many systems in order to develop size distributions of CWS's using these variables as measures of size. To estimate the conditional demand relations, we used data from over 11,000 systems for which there was reliable data on these variables. The estimated equations are given in appendix C, along with a detailed discussion of the interpretation of the estimated coefficients.

As one would expect, both the average daily flow and the design capacity of water systems are positively related to the population served as well as the number of hookups. The design capacity is also positively related to the average daily flow, requiring that the two equations be estimated in a two-stage fashion. These equations are used to estimate the average daily flow and the design capacity for all the systems in the data set for which data were missing.

Based on these estimates, the mean average daily flow (production) (ADF) is about 700,000 gallons per day; the design capacity is just under 1.9 million gallons per day. This is about 2.7 times the average daily production, and the excess capacity is there partly to accommodate peak flows and to anticipate growth in demand or system expansion.

On a per capita basis, average daily flow is estimated at about 126 gallons per day (table 2). This figure is understandably larger than the per capita consumption implied by the 300-gallon per day estimate of household indoor use for a typical family of four (EPA, 1991). On a per capita basis, these estimated average daily flows are remarkably consistent across systems by population category. The many additional demands placed on a water system in urban areas for industrial, commercial, institutional, and emergency purposes certainly explains why per capita demands placed on the very large systems are nearly 40% higher than for the very small systems. The 138 gallon average daily flow per person for the smallest group is larger than for systems serving populations between 101 and 10,000, probably because of some need for systems to be of some minimum size to operate properly. Water needs for emergencies, etc. also constitute a disproportionate share of total production for these very small systems.

Table 2. Per Capita Average Daily Flow and Design Capacity by Population Category.

| Population Category | Population Range | Average Daily Flow Per Capita | | Design Capacity Per Capita | |
|---------------------|-------------------|-------------------------------|-----------|----------------------------|-----------|
| | | Mean | Std. Dev. | Mean | Std. Dev. |
| All Categories | A - K | 126 | 113 | 789 | 692 |
| A | < 101 | 138 | 111 | 1,232 | 786 |
| B | 101 to 500 | 118 | 123 | 774 | 652 |
| C | 501 to 1,000 | 113 | 114 | 551 | 486 |
| D | 1,001 to 2,500 | 119 | 112 | 480 | 411 |
| E | 2,501 to 3,300 | 123 | 104 | 440 | 403 |
| F | 3,301 to 5,000 | 127 | 107 | 408 | 339 |
| G | 5,001 to 10,000 | 130 | 108 | 391 | 310 |
| H | 10,001 to 50,000 | 139 | 76 | 379 | 292 |
| I | 50,001 to 75,000 | 155 | 62 | 385 | 250 |
| J | 75,001 to 100,000 | 164 | 62 | 431 | 288 |
| K | > 100,000 | 181 | 77 | 431 | 277 |

Note: Average flow and capacity values are given in gallons per day per capita.

The variation around the mean in average daily flow is substantial for all systems, but is higher for the small and medium-size systems. The same pattern is evident in the variation in design capacity. This variation is certainly due in large measure to the socioeconomic and demographic characteristics of the service areas, and without detailed data on the demographic structure of the population and the diversity of the economic systems it is impossible to sort the differences out precisely.

However, by examining the coefficients on the dummy variables in the regression equations in appendix C, we do see part of the explanation. All else equal, the design capacity tends to be higher in the hot and semi-arid areas in the South and the West, and in urban areas. Compared with systems that serve non-residential areas, systems that serve residential and semi-residential areas design systems with smaller capacities for a given service population. Design capacities of private systems tend to be smaller than for those owned by the government. The capacity also tends to be smaller for systems that purchase water from other systems or rely primarily on surface rather than ground water. The story is about the same for the equation used to predict average daily flow. The two exceptions are: the average daily flow is higher for surface water systems than for ground water systems (table 3), and average daily flow is also higher if the system serves a semi-residential area. These trends are certainly evident in the regional data reported in appendix B.

Table 3. Per Capita Average Daily Flow and Design Capacity Distributions by Water Source and Population Classification.

| Population Classification | Ground Water Systems | | | | Surface Water Systems | | | |
|------------------------------|----------------------|-----------|-----------------|-----------|-----------------------|-----------|-----------------|-----------|
| | Average Daily Flow | | Design Capacity | | Average Daily Flow | | Design Capacity | |
| | Mean | Std. Dev. | Mean | Std. Dev. | Mean | Std. Dev. | Mean | Std. Dev. |
| All Populations | 125 | 112 | 863 | 717 | 131 | 121 | 434 | 431 |
| Very Small | 128 | 116 | 1027 | 763 | 127 | 133 | 669 | 588 |
| Small | 115 | 109 | 542 | 471 | 122 | 121 | 398 | 337 |
| Medium | 124 | 86 | 437 | 326 | 134 | 130 | 349 | 312 |
| Large | 132 | 57 | 421 | 278 | 150 | 86 | 346 | 294 |
| Very Large | 171 | 73 | 506 | 318 | 185 | 79 | 399 | 252 |

Note: Average flow and capacity mean values are expressed in gallons per day per capita.

The explanation for why the design capacities of ground water systems tend to have larger design capacities but smaller average daily flows than for surface water systems is straightforward if viewed in terms of the financial and other requirements to expand or otherwise change the two types of systems. Increasing production for a given surface water system may, in many instances, require modest changes such as increasing intake flow rates from an established reservoir or impoundment. The situation, however, may be much more complicated for a ground water system. The physical and technical changes could very well include the drilling of additional wells, the installation of additional transmission mains, or increased storage capacity. Therefore, to allow for possible growth in demand and avoid the additional costs of increasing capacity in the future, it may be more cost effective to "oversize" the systems to some degree in the initial construction phase.

System Ownership

During the debate over re-authorization, it was clear that members of both Houses of Congress were keenly aware of the financial burden facing the owners of small water systems throughout the country as they make changes to comply with the SDWA, and it is their hope that this financial burden can be eased by careful relaxation of some requirements without seriously compromising water quality or health risk. The 1996 amendments to the SDWA provide additional federal funding for drinking water system improvements in the form of a state revolving loan fund (SRF), similar in form to the current SRF available in the Clean Water Act for waste water treatment improvements. The fund provides \$9.6 billion in grant and loan funding, capitalized over the years of 1994 through 2003, for local water system facility improvements. To ease the burden further, the 1996 amendments provide to states up to 15% of annual funding for PWS's serving less than 10,000 people. In addition, states may use up to 30% of their fund allocation for special assistance to small, disadvantaged systems.

The appropriateness of the size of this set aside turns not only on the size distribution of water systems across the country, but on the distribution of ownership as well. The importance of the size distribution is perhaps the most obvious. While 15% of the funds are earmarked for systems serving populations below 10,000, we know from the data above, that these community water systems constitute over 90% of the total and provide water to about 20% of the population (table 1). Clearly, funds are not being set aside in proportion to the number of systems or population served. It is unclear at this time whether the cost savings provided by the relief from some of the regulations are sufficient to offset the higher costs of compliance with the remaining provisions. It is well known that these small systems are

unable to take advantage of the substantial economies of size in water supply and treatment (Boisvert and Tsao, 1995).

If it turns out that funds are insufficient, then the effects will be largest in EPA regions where the proportions of population served by systems of less than 10,000 are well above the national average (See table B2). These include regions whose regional offices are located in Dallas, Kansas City, Denver, and Seattle. The situation could well be exacerbated in these regions, as well as throughout the country if, as is suspected by many, the infrastructure of many small systems has been allowed to deteriorate. In such cases, EPA estimates that for every dollar spent on treatment there would be need for an additional dollar spent on rehabilitation and repair (EPA, 1993).

The implications of system ownership for the requirements for allocating money from the revolving funds are less clear until one remembers that money from these funds are earmarked primarily for public/governmental water systems, with some provisions for investor-owned (private) water systems. Public water systems not owned by a governmental or inter-governmental agency, a non-profit organization, an Indian tribe, or any combination thereof, may receive assistance from a state revolving fund; however it will be designated only to those systems having the greatest public health and financial needs. Granted, the specification here is vague and determining those systems with the "greatest" need may be obligatory, but, it is also clear that owners of private systems may be at a competitive disadvantage in applying for these loan funds.

This is unlikely to be a trivial problem because only 41% of all CWS's are owned by local governments, including authorities, commissions, districts, municipalities, cities, towns, and counties, while 53% are owned privately by various entities such as subdivisions, investors, trusts, cooperatives, and water associations (table 4).⁶

These ownership patterns are not overly surprising, based on the high proportion of small systems, most of which are located in smaller communities or mobile home parks and housing complexes. Over 96% of the systems serve primary residential areas, of which 17% of them serve mobile home parks. This is certainly reflected as well in the distribution of ownership by system size. About 73% of the very small systems are owned privately,

⁶ Ownership of the remaining CWS's is in the hands of the Federal government (1%), the state governments (1%), mixed public and private ownership (4%), and Native Americans (less than one-half of 1%). The Native American classification includes Indian tribes and reservations and Alaskan remote villages.

Table 4. Ownership Type Percentage Distributions by Water Source and Population Classification.

| Population Classification | Ground and Surface Water Systems | | Ground Water Systems | | Surface Water Systems | |
|------------------------------|----------------------------------|---------------------|----------------------|---------------------|-----------------------|---------------------|
| | Private | Local Government | Private | Local Government | Private | Local Government |
| | - - - - - % - - - - - | | | | | |
| All Populations | 52.6 | 41.2 | 59.7 | 33.9 | 20.3 | 66.4 |
| Very Small | 72.9 | 20.9 | 75.9 | 17.9 | 39.3 | 55.7 |
| Small | 25.4 | 67.7 | 28.5 | 64.6 | 16.4 | 76.6 |
| Medium | 12.5 | 81.7 | 15.4 | 78.1 | 8.7 | 86.3 |
| Large | 13.3 | 82.5 | 16.9 | 77.0 | 10.2 | 87.3 |
| Very Large | 20.1 | 78.3 | 21.6 | 73.0 | 19.4 | 80.6 |

Note: The percentage of systems not accounted for are owned by Federal and state governments, mixed public and private entities, and Native American villages.

dropping to just over 25% in the small system category. From a regional perspective, the proportion of private ownership is much higher than the national average in New England and in the EPA regions served by regional offices in New York, Philadelphia, and Atlanta (table B4). The predominance of private ownership in these regions is explained in part by the fact that they were the oldest developed areas of the country and by the fact that the desire for local control is as strong in New England and the Northeast as any where in the country. The nature of the retirement communities in Florida may also partially explain this trend in the Atlanta region.

One can only speculate on the average income levels of the people living in areas served by these small private water systems. In some cases where the systems serve exclusive developments and upper middle income multi-family housing developments, we know the answer. We probably also know the answer for those that serve mobile home parks and similar developments, and it is here where low-income people and others on fixed incomes will have the most difficulty absorbing the additional costs of treatment passed on by the owners of the private systems. The incomes of rural residents is generally lower than those of their suburban and urban counterparts as well (EPA, 1988; Boisvert and Ranney, 1991). How these considerations are factored into plans for allocating money from revolving funds have important implications for equity.

Again, the only bright spot in this scenario is that nearly 60% of the ground water systems are privately owned. In contrast, local governments own nearly 75% of the surface water systems, and to the extent that the treatment needs of these systems are likely to be more extensive than for ground water systems, there may be some justification for a disproportionate share of revolving fund loans to go to these systems.

Treatment Objectives

In attempting to deal with the particular problems facing smaller community water systems, the 1996 amendments to the SDWA also contain provisions for making the regulations more flexible and less costly for states and local governments, including relaxing the schedules for testing and monitoring for contaminants. Specifically, the amendments contain provisions for communities serving fewer than 10,000 people to use alternative, more affordable technologies to meet current and anticipated drinking water regulations. These alternatives, referred to as Best Available Affordable Technologies (BAAT), are to be designed by EPA and may include public education and notification. The BAAT's may not reduce

contaminant levels to regulated MCL's, but the level of treatment is to be sufficient so as not to result in an unreasonable health risk.

An important step in understanding the effects of legislation is to know the treatment practices and treatment objectives currently in place in the Nation's medium-sized and small community water systems. This will provide a perspective of the seriousness of the remaining problems and also lend perspective on treatment practices that seem to be working for a selected number of systems. This will be a solid foundation for examining the economic feasibility of adapting these successful treatment scenarios to other systems.

Dealing with treatment objectives and the individual processes used to meet the various objectives is undoubtedly the most complex aspect of the *FRDS-II Data Base*. Exhibit 1 provides some perspective on the long list of the most relevant treatment processes and the corresponding treatment objectives that can be met by each. A comprehensive examination of these data is complicated by at least two factors. The first is rather mechanical, and relates to those systems for which treatment information is from the previous FRDS's data file (FRDS1.5). This indicates that treatment for these systems has not changed recently. It appears that the earlier version of *FRDS's* did not differentiate between treatment processes and objectives, and while one can infer treatment objectives from the process file, there is no way to obtain this information from the treatment objective file. Therefore, for our purposes these records are eliminated from initial consideration. As is seen below, this causes few problems.

The second complexity is a direct result of the fact that some water systems have more than one water source and/or plant. Since treatments can differ by source and plant, the treatment file can contain multiple records for an individual system. Developing a strategy for summarizing the data under these conditions was a challenge. It was extremely difficult to avoid double counting etc.

We were assisted in our efforts by a variable in *FRDS-II* that is generated by the program which classifies CWS's as treated, mixed, or untreated. A "treated" classification implies that all of a particular system's water sources are subjected to treatment; an "untreated" classification implies that none of a particular system's water sources are subjected to treatment. Obviously, a system is assigned a "mixed" treatment classification when systems with multiple water sources provide treatment for water from at least one source, but no treatment for water from at least one other source. Regardless of whether the system is classified as "treated" or "mixed", the treatment objectives for water at each source may well differ. Water can be treated at the source, at the treatment plant, or at the point of entry.

Exhibit 1. Combined Treatment Objective & Process Codes

| Treatment Process | Treatment Objectives | | | | | | | | | | | |
|----------------------------|----------------------|-------------------|---------------|-----------------|------|-------------|------------|----------|--------------|----------------|--------|-------------|
| | DBP Control | Corrosion Control | Dis-infection | De-Chlorination | Iron | In-organics | Man-ganese | Organics | Par-ticulate | Radio-nuclides | Soften | Taste/Ordor |
| Activated Alumina | | | | | | X | | | | X | | |
| Activated Carbon, Granular | X | | | X | | X | | X | | X | | X |
| Activated Carbon, Powder | X | | | | | | | X | | | | X |
| Aeration, Cascade | X | | | X | X | | | X | | X | | X |
| Aeration, Diffused | X | | | X | X | | | X | | X | | X |
| Aeration, Packed Tower | X | | | X | X | | | X | | X | | X |
| Aeration, Slat Tray | X | | | X | X | | | X | | X | | X |
| Aeration, Spray | X | | | X | X | | | X | | X | | X |
| Chlorine Dioxide | X | | X | | | | | | | | | |
| Coagulation | X | | | | | X | | X | X | X | X | |
| Distillation | | | | | X | X | X | X | X | X | X | |
| Electrodialysis | | | | | | X | | | | X | | |
| Filtration, Cartridge | | | | | | | | | X | | | |
| Diatomaceous Earth | | | | | | | | | X | | | |
| Greensand | | | | | X | | X | | | | | |
| Pressure Sand | X | | | | X | X | | | X | X | X | |
| Rapid Sand | X | | | | X | X | | X | X | X | X | |
| Slow Sand | | | X | | | | | | X | | | |
| Ultrafiltration | | | | | | | | | X | | | |
| Gas. Chlorination, Post | | | X | | | | | | | | | |
| Gas. Chlorination, Pre | | | X | | X | | X | X | | | | X |
| Hypochlorination, Post | | | X | | | | | | | | | |
| Hypochlorination, Pre | | | X | | X | | X | X | | | | X |
| Inhibitor | | X | | | | | | | | | | |
| Iodine | | | X | | | | | | | | | |
| Ion Exchange | | | | | | X | | | | X | X | |
| Lime - Soda Ash | X | | | | | X | | | | X | X | |
| Microscreening | | | | | | | | | X | | | |
| Ozonation, Post | X | | X | | | | | | | | | |
| Ozonation, Pre | X | | X | | X | | X | X | | | | X |
| Permanganate | | | | | X | | | X | | | | X |
| Peroxide | | | | | X | | | X | | | | X |
| Reducing Agents | | | | X | | | | X | | | | |
| Reverse Osmosis | X | | | | X | X | X | X | | X | X | |
| Ultraviolet Radiation | X | | X | | | | | | | | | |
| pH Adjustment | X | X | | | X | X | | X | X | X | X | |

According to this variable, over 60% of CWS's nationwide are classified as "treated" and, therefore, meet at least one treatment objective for each source. Of the remaining CWS's, 32% are classified as "untreated", while 7% are "mixed" (table B5 of appendix B). Put differently, nearly 70% of CWS's provide at least some treatment for their sources of water, and, irrespective of system size, more systems provide treatment than do not. For systems serving larger retail populations, there is a larger proportion of them in the "mixed" treatment category. This seems only logical, since as systems increase in size, the average number of water sources used increases, providing greater flexibility in treatment options. The fact that treatment may differ by source could reflect incremental investment in new sources of water to accommodate growth in demand.

As one would expect, the proportions of systems treating at least one of its water sources increases with system size: 97% of the very large systems are classified as "treated" or "mixed", while 91% and 87%, respectively, of the large and medium-size systems fall into these two categories. Given the heightened concern over the implications for smaller systems of the 1986 amendments to the SDWA it is perhaps somewhat surprising to see that over 50% of the small and very small systems are doing some type of treatment. It remains to be seen, the extent to which these treatment objectives are consistent with the requirements under the 1986 amendments. This can only be done by moving deeper into the details of the treatment files. In this way, we eventually hope to match treatment objectives with treatment processes as a way of identifying appropriate treatment technologies for meeting various combinations of treatment objectives.

The extent to which systems are currently treating water differs by primary water source as well. About 65% of ground water systems apply at least some treatment; this is significantly below the 80% of all surface water systems that treat at least some portion of their raw water. Although smaller ground water well systems are likely to apply no treatment, as systems serve larger populations, storage with at least some disinfection requirements may be needed; this is certainly one explanation of why this gap narrows between ground water and surface water systems as size increases. To provide further insight into the differences in current treatment practices, we need to examine specific treatment objectives and/or processes in use and delineate situations where systems are meeting more than one treatment objective. Multiple treatment objectives and/or treatment processes which address multiple contaminant regulations will have significant impacts on system and national cost-benefit analyses.

Treatment Objectives. Through the four panels of data in table 5, we obtain a first glimpse of the detailed information in the *FRDS-II Data Base*. Since there are some major differences in the level of treatment between ground water and surface water systems, we focus on these two subsets immediately. There are about 6,600 systems in the surface water subset and nearly 34,500 ground water systems.

The total of the two, about 41,100 systems, is about 4,500 fewer than our original sample for two reasons. First, about half of the removed observations had to be eliminated because of missing information. The other half of these systems are not in the data because they purchase water and the water is treated by the seller. Thus, this treatment is reflected in the data, but it is in the records for systems selling water.

For purposes of the analysis, it is also necessary to ignore systems whose treatment classification is still in terms of the old FRDS's system. We have no way to know what treatment is being applied to these systems. This leaves us with about 6,100 surface water systems and 30,600 ground water systems in the data set.

With these preliminaries out of the way, we can begin to examine the data. The first panel in table 5 contains those surface water systems that list a single treatment objective. There are 25% of these systems that have no treatment at all sources and water plants. Just over 14% of the systems only disinfect, while processes needed to remove particulates only are in use by about 3% of the systems.

For the ground water systems, nearly 39% have no treatment at any plant or source, while about 34% only disinfect, and less than 1% soften water, remove particulates and iron, and operate corrosion control indirectly. There are just a handful of systems that have other single treatment objectives.

While the data on single treatments are useful to gain perspective on the extent of treatment, the panels in table 5 containing data on multiple treatments are potentially more important for identifying the range of treatment options being used already by small systems. These data, however, need some explanation. To begin, the sum in the systems column is much greater than the total number of systems, because every individual water source and plant where a particular treatment objective is met is reported separately and individual sources or plants may contain more than one treatment objective. Thus, for example, the "no treatment" row contains all systems (61% of the total) which have at least one source or plant doing no treatment. Where these systems have other water sources or plants at which there is treatment,

Table 5. General Treatment Objectives of All Community Water Systems^a

| Treatment Objective | Obj. Code | Single Treatment | | Multiple Treatments | |
|--|-----------|------------------|------------|---------------------|------------|
| | | Systems | Percentage | Systems | Percentage |
| Surface Water Systems^c | | | | | |
| Additional Treatment Elsewhere | A | 0 | 0.0 | 7 | 0.1 |
| Disinfection By-Product Control | B | 1 | 0.0 | 272 | 4.5 |
| Corrosion Control | C | 7 | 0.1 | 1,432 | 23.5 |
| Disinfection | D | 876 | 14.4 | 3,970 | 65.3 |
| Dechlorination | E | 0 | 0.0 | 11 | 0.2 |
| Iron Removal | F | 4 | 0.1 | 519 | 8.5 |
| Inorganics Removal | I | 0 | 0.0 | 224 | 3.7 |
| Manganese Removal | M | 0 | 0.0 | 152 | 2.5 |
| No Treatment ^b | N | 1,516 | 24.9 | 3,718 | 61.1 |
| Organics Removal | O | 1 | 0.0 | 384 | 6.3 |
| Particulate Removal | P | 153 | 2.5 | 3,137 | 51.6 |
| Radionuclides Removal | R | 0 | 0.0 | 60 | 1.0 |
| Softening | S | 7 | 0.1 | 597 | 9.8 |
| Taste/Odor Control | T | 1 | 0.0 | 916 | 15.1 |
| Other (Process Fluoridation) | Z | 5 | 0.1 | 1,068 | 17.6 |
| Ground Water Systems^d | | | | | |
| Additional Treatment Elsewhere | A | 0 | 0.0 | 0 | 0.0 |
| Disinfection By-Product Control | B | 4 | 0.0 | 50 | 0.2 |
| Corrosion Control | C | 65 | 0.2 | 1,996 | 6.5 |
| Disinfection | D | 10,543 | 34.4 | 16,769 | 54.8 |
| Dechlorination | E | 1 | 0.0 | 14 | 0.0 |
| Iron Removal | F | 109 | 0.4 | 2,600 | 8.5 |
| Inorganics Removal | I | 13 | 0.0 | 221 | 0.7 |
| Manganese Removal | M | 7 | 0.0 | 667 | 2.2 |
| No Treatment ^b | N | 11,790 | 38.5 | 21,007 | 68.6 |
| Organics Removal | O | 7 | 0.0 | 423 | 1.4 |
| Particulate Removal | P | 79 | 0.3 | 887 | 2.9 |
| Radionuclides Removal | R | 7 | 0.0 | 65 | 0.2 |
| Softening | S | 124 | 0.4 | 1,183 | 3.9 |
| Taste/Odor Control | T | 40 | 0.1 | 1,146 | 3.7 |
| Other (Process Fluoridation) | Z | 85 | 0.3 | 2,212 | 7.2 |

^a Frequencies exclude those system which apply no treatment themselves, but purchase treated water, since unable to tie specific treatment objective to water utilized; i.e. systems with treatment objective=N (no treatment) and treatment process = 996 (treatment applied by seller).

^b For sole treatments, no treatment implies no treatment at all source or plant locations. For the general multiple classification, no treatment implies that the system applies no treatment to at least one source or plant location and may be in addition to other treatments.

^c total systems = 6,083

^d total systems = 30,624

they are reported separately under that particular objective. A system with two sources of water employing different objectives at each would be counted in both objective categories. The same result would occur for a system meeting two treatment objectives at a single source.

According to this interpretation of the data in table 5, there are just over 60% of the surface water systems around the country in which at least one water source or plant apply no water treatment whatsoever; the percentage (69%) is only slightly higher for ground water systems.⁷ Similarly, about 65% of the surface water systems disinfect their water, while 52% remove particulates, and nearly a quarter control for corrosion. Another 10% soften their water; about 15% treat for taste and odor problems; and about 9% remove iron. Fewer than 5% of the surface water systems have processes in place that meet any of the other treatment objectives listed in the table. Although the percentage of ground water systems that have no treatment processes in place somewhere in the system is not substantially higher than for surface water systems, the multiple treatment strategies used seem to be less complex and focus mainly around disinfection (55%), iron removal (9%), and corrosion control (7%). Just under 4% of the systems soften their water and treat for taste and odor problems. Similar data for community water systems by size category are given in appendix D for completeness, but there is no need to discuss the data in detail.

To gain some perspective on what multiple treatment strategies can be used effectively and at affordable costs, it is helpful to look behind these numbers and delineate the number of these systems that meet more than one treatment objective. These objectives may or may not be accomplished through a single treatment process, and it is in the data in the treatment process files that we can shed some light on which combinations of processes seem to be working currently for small and very small systems. We examine the various combinations of treatment processes used by the community water systems in a subsequent section.

For completeness, we include a detailed list of the number of systems in EPA's five aggregate size categories that are meeting any possible combination of treatment objectives as an attachment to this report. However, as is evident from the attachment, there are an extremely large number of treatment objective combinations, many of which are given by fewer than 5 water systems. Therefore, to facilitate discussion, we limit our attention to those combinations of treatments given by at least 5 systems. (The percentages given in the tables are based on the whole sample, including systems where the combined treatment objectives are

⁷Although this "no treatment" percentage is not overly meaningful, the percentages under the various treatment objectives do provide a benchmark measure for the extent to which various treatment objectives are met.

given by fewer than 5 systems.) The data for very small and small systems are in tables 6 and 7, because systems in these two groups are of primary interest to this analysis. Tables E1 through E3 in appendix E contain data for medium, large, and very large systems.

Somewhat surprisingly, the data in table 6 suggest that a significant number of very small systems are treating to meet a wide combination of treatment objectives, but as one would expect, the majority of the systems treat for a single objective. Nearly 73% of the ground water systems only disinfect, while 30% of the surface water systems do likewise. Another third of the surface water systems disinfect and treat for particulate removal, and about 3% combine some type of corrosion control. Nearly 12% of the surface water systems only treat for removal of particulates. Nearly 5% of the very small ground water systems disinfect and only apply some type of corrosion control, with an additional 1.3% adding an additional objective to disinfection and corrosion control. About 4% disinfect and remove iron. About 4% combine disinfection with either water softening or taste and odor control. Each of the many remaining combinations of treatment objectives in place are in at most 1% of the systems, and for most in much less than 1% of the systems.

The story is not terribly different for the small community water systems (table 7). The number of treatment objective combinations is somewhat higher primarily because a smaller proportion of systems do no treatment at all. In addition, there are fewer small surface and ground water systems that treat for only a single objective such as disinfection. Only 60% of these ground water systems solely disinfect, while this is true for only 26% of the surface water systems. An additional 34% of the ground water systems and 50% of the surface water systems combine disinfection with one or more additional treatment objectives.

Treatment Processes. In trying to understand the nature of current treatment strategies being used by CWS's across the country, we must look at the various treatment processes as well. Appendix F contains estimates of the percentages of systems by size category currently treating water through a variety of treatment processes. While it is important to include the information at this level of detail in this report, further discussion of it is probably unnecessary. What is needed is some way to relate the treatment objectives to treatment processes.

Perhaps the best way to do this is to compare these data with estimates of the proportions of CWS's that would need particular combinations of water treatment technologies to meet the 1986 amendments. These proportions were estimated by Miller (1990) and are based on probabilities of co-occurrence of various contaminants, and the ability of different processes to deal with the contaminants. The joint probabilities on which the estimates are

| Table 6. Multiple Treatment Objectives Found in Very Small Community Water Systems | | | | |
|--|----------------------|---------|-----------------------|---------|
| Treatment Objectives ^a | Ground Water Systems | | Surface Water Systems | |
| | Number | Percent | Number | Percent |
| BD | 10 | 0.10 | | |
| C | 47 | 0.46 | | |
| CD | 495 | 4.79 | 8 | 1.00 |
| CDF | 51 | 0.49 | | |
| CDFM | 30 | 0.29 | | |
| CDFP | 7 | 0.07 | | |
| CDFS | 5 | 0.05 | | |
| CDI | 9 | 0.09 | | |
| CDO | 19 | 0.18 | | |
| CDP | 6 | 0.06 | 26 | 3.25 |
| CDPS | | | 12 | 1.50 |
| CDPT | | | 8 | 1.00 |
| CDS | 14 | 0.14 | | |
| CDST | 5 | 0.05 | | |
| CDT | 5 | 0.05 | | |
| CF | 6 | 0.06 | | |
| CPS | | | 5 | 0.63 |
| D | 7506 | 72.70 | 237 | 29.66 |
| DF | 380 | 3.68 | 6 | 0.75 |
| DFM | 189 | 1.83 | | |
| DFMP | 6 | 0.06 | | |
| DFMS | 6 | 0.06 | | |
| DFP | 33 | 0.32 | | |
| DFPS | 6 | 0.06 | | |
| DFPT | 14 | 0.14 | | |
| DFS | 56 | 0.54 | | |
| DFT | 20 | 0.19 | | |
| DI | 25 | 0.24 | | |
| DIM | 10 | 0.10 | | |
| DIS | 5 | 0.05 | | |
| DM | 64 | 0.62 | | |
| DO | 16 | 0.16 | | |
| DOP | | | 10 | 1.25 |
| DOT | 49 | 0.47 | 5 | 0.63 |
| DP | 109 | 1.06 | 262 | 32.79 |
| DPS | 14 | 0.14 | 23 | 2.88 |
| DPT | 10 | 0.10 | 10 | 1.25 |
| DS | 224 | 2.17 | | |
| DST | 15 | 0.15 | | |
| DT | 239 | 2.31 | 7 | 0.88 |
| F | 130 | 1.26 | | |
| FM | 21 | 0.20 | | |
| FP | 9 | 0.09 | | |
| FS | 9 | 0.09 | | |
| I | 15 | 0.15 | | |
| IRS | 5 | 0.05 | | |
| M | 19 | 0.18 | | |
| O | 6 | 0.06 | | |
| P | 81 | 0.78 | 93 | 11.64 |
| R | 7 | 0.07 | | |
| S | 116 | 1.12 | | |
| T | 32 | 0.31 | | |

^aEach letter in this column represents a particular treatment objective from table 5, e.g. CD is corrosion control combined with disinfection.

| Treatment Objectives ^a | Ground Water Systems | | Surface Water Systems | |
|-----------------------------------|----------------------|---------|-----------------------|---------|
| | Number | Percent | Number | Percent |
| BDIOPRS | | | 7 | 0.46 |
| BDPS | | | 15 | 0.99 |
| C | 25 | 0.48 | 10 | 0.66 |
| CD | 343 | 6.65 | 31 | 2.04 |
| CDF | 102 | 1.98 | | |
| CDFM | 26 | 0.50 | | |
| CDFO | 27 | 0.52 | | |
| CDFP | 17 | 0.33 | 7 | 0.46 |
| CDFPS | 8 | 0.16 | | |
| CDFPT | 7 | 0.14 | 11 | 0.72 |
| CDFS | 11 | 0.21 | | |
| CDFT | 5 | 0.10 | | |
| CDI | 7 | 0.14 | | |
| CDO | 72 | 1.40 | | |
| CDP | 6 | 0.12 | 130 | 8.55 |
| CDPS | 7 | 0.14 | 64 | 4.21 |
| CDPST | 10 | 0.19 | 10 | 0.66 |
| CDS | 14 | 0.27 | 5 | 0.33 |
| CDST | 5 | 0.10 | | |
| CDT | 13 | 0.25 | | |
| D | 3114 | 60.38 | 402 | 26.43 |
| DF | 375 | 7.27 | 9 | 0.59 |
| DFI | 5 | 0.10 | | |
| DFM | 90 | 1.75 | 5 | 0.33 |
| DFMP | 5 | 0.10 | | |
| DFMS | 5 | 0.10 | | |
| DFO | 6 | 0.12 | | |
| DFP | 39 | 0.76 | 12 | 0.79 |
| DFPS | 13 | 0.25 | 10 | 0.66 |
| DFPT | 11 | 0.21 | 26 | 1.71 |
| DFS | 110 | 2.13 | | |
| DFST | 10 | 0.19 | | |
| DFT | 24 | 0.47 | | |
| DIP | 5 | 0.10 | 5 | 0.33 |
| DM | 15 | 0.29 | | |
| DO | 16 | 0.31 | | |
| DOPT | | | 11 | 0.72 |
| DOT | 11 | 0.21 | | |
| DP | 35 | 0.68 | 298 | 19.59 |
| DPS | 8 | 0.16 | 50 | 3.29 |
| DPST | 13 | 0.25 | 7 | 0.46 |
| DPT | 15 | 0.29 | 47 | 3.09 |
| DS | 48 | 0.93 | 9 | 0.59 |
| DST | 14 | 0.27 | | |
| DT | 189 | 3.66 | 12 | 0.79 |
| F | 65 | 1.26 | | |
| FM | 8 | 0.16 | | |
| FS | 7 | 0.14 | | |
| M | 9 | 0.17 | | |
| P | 6 | 0.12 | 123 | 8.09 |
| S | 44 | 0.85 | 7 | 0.46 |
| T | 8 | 0.16 | | |

^aEach letter in this column represents a particular treatment objective from table 5, e.g. CD is corrosion control combined with disinfection.

| Treatment Objectives ^a | Ground Water Systems | | Surface Water Systems | |
|-----------------------------------|----------------------|---------|-----------------------|---------|
| | Number | Percent | Number | Percent |
| BD | 10 | 0.10 | | |
| C | 47 | 0.46 | | |
| CD | 495 | 4.79 | 8 | 1.00 |
| CDF | 51 | 0.49 | | |
| CDFM | 30 | 0.29 | | |
| CDFP | 7 | 0.07 | | |
| CDFS | 5 | 0.05 | | |
| CDI | 9 | 0.09 | | |
| CDO | 19 | 0.18 | | |
| CDP | 6 | 0.06 | 26 | 3.25 |
| CDPS | | | 12 | 1.50 |
| CDPT | | | 8 | 1.00 |
| CDS | 14 | 0.14 | | |
| CDST | 5 | 0.05 | | |
| CDT | 5 | 0.05 | | |
| CF | 6 | 0.06 | | |
| CPS | | | 5 | 0.63 |
| D | 7506 | 72.70 | 237 | 29.66 |
| DF | 380 | 3.68 | 6 | 0.75 |
| DFM | 189 | 1.83 | | |
| DFMP | 6 | 0.06 | | |
| DFMS | 6 | 0.06 | | |
| DFP | 33 | 0.32 | | |
| DFPS | 6 | 0.06 | | |
| DFPT | 14 | 0.14 | | |
| DFS | 56 | 0.54 | | |
| DFT | 20 | 0.19 | | |
| DI | 25 | 0.24 | | |
| DIM | 10 | 0.10 | | |
| DIS | 5 | 0.05 | | |
| DM | 64 | 0.62 | | |
| DO | 16 | 0.16 | | |
| DOP | | | 10 | 1.25 |
| DOT | 49 | 0.47 | 5 | 0.63 |
| DP | 109 | 1.06 | 262 | 32.79 |
| DPS | 14 | 0.14 | 23 | 2.88 |
| DPT | 10 | 0.10 | 10 | 1.25 |
| DS | 224 | 2.17 | | |
| DST | 15 | 0.15 | | |
| DT | 239 | 2.31 | 7 | 0.88 |
| F | 130 | 1.26 | | |
| FM | 21 | 0.20 | | |
| FP | 9 | 0.09 | | |
| FS | 9 | 0.09 | | |
| I | 15 | 0.15 | | |
| IRS | 5 | 0.05 | | |
| M | 19 | 0.18 | | |
| O | 6 | 0.06 | | |
| P | 81 | 0.78 | 93 | 11.64 |
| R | 7 | 0.07 | | |
| S | 116 | 1.12 | | |
| T | 32 | 0.31 | | |

^aEach letter in this column represents a particular treatment objective from table 5, e.g. CD is corrosion control combined with disinfection.

| Treatment Objectives ^a | Ground Water Systems | | Surface Water Systems | |
|-----------------------------------|----------------------|---------|-----------------------|---------|
| | Number | Percent | Number | Percent |
| BDIOPRS | | | 7 | 0.46 |
| BDPS | | | 15 | 0.99 |
| C | 25 | 0.48 | 10 | 0.66 |
| CD | 343 | 6.65 | 31 | 2.04 |
| CDF | 102 | 1.98 | | |
| CDFM | 26 | 0.50 | | |
| CDFO | 27 | 0.52 | | |
| CDFP | 17 | 0.33 | 7 | 0.46 |
| CDFPS | 8 | 0.16 | | |
| CDFPT | 7 | 0.14 | 11 | 0.72 |
| CDFS | 11 | 0.21 | | |
| CDFT | 5 | 0.10 | | |
| CDI | 7 | 0.14 | | |
| CDO | 72 | 1.40 | | |
| CDP | 6 | 0.12 | 130 | 8.55 |
| CDPS | 7 | 0.14 | 64 | 4.21 |
| CDPST | 10 | 0.19 | 10 | 0.66 |
| CDS | 14 | 0.27 | 5 | 0.33 |
| CDST | 5 | 0.10 | | |
| CDT | 13 | 0.25 | | |
| D | 3114 | 60.38 | 402 | 26.43 |
| DF | 375 | 7.27 | 9 | 0.59 |
| DFI | 5 | 0.10 | | |
| DFM | 90 | 1.75 | 5 | 0.33 |
| DFMP | 5 | 0.10 | | |
| DFMS | 5 | 0.10 | | |
| DFO | 6 | 0.12 | | |
| DFP | 39 | 0.76 | 12 | 0.79 |
| DFPS | 13 | 0.25 | 10 | 0.66 |
| DFPT | 11 | 0.21 | 26 | 1.71 |
| DFS | 110 | 2.13 | | |
| DFST | 10 | 0.19 | | |
| DFT | 24 | 0.47 | | |
| DIP | 5 | 0.10 | 5 | 0.33 |
| DM | 15 | 0.29 | | |
| DO | 16 | 0.31 | | |
| DOPT | | | 11 | 0.72 |
| DOT | 11 | 0.21 | | |
| DP | 35 | 0.68 | 298 | 19.59 |
| DPS | 8 | 0.16 | 50 | 3.29 |
| DPST | 13 | 0.25 | 7 | 0.46 |
| DPT | 15 | 0.29 | 47 | 3.09 |
| DS | 48 | 0.93 | 9 | 0.59 |
| DST | 14 | 0.27 | | |
| DT | 189 | 3.66 | 12 | 0.79 |
| F | 65 | 1.26 | | |
| FM | 8 | 0.16 | | |
| FS | 7 | 0.14 | | |
| M | 9 | 0.17 | | |
| P | 6 | 0.12 | 123 | 8.09 |
| S | 44 | 0.85 | 7 | 0.46 |
| T | 8 | 0.16 | | |

^aEach letter in this column represents a particular treatment objective from table 5, e.g. CD is corrosion control combined with disinfection.

based are first approximations. They are based on the best available data, and they were used in EPA's assessment of the technical and economic capacity of public water systems to comply with the 1986 SDWA amendments.⁸

To understand how these comparisons are made, we can look at the summary data in table 8. For example, Miller estimates that to comply with the 1986 amendments, 46% of the very small ground water systems would need to install multiple treatment processes, while 40% would need only a single process. About 14% would need no treatment at all. Based on the *FRDS's* data, however, 48% of the very small ground water systems currently treat none of their water, while 42% use a single treatment technology, and only 8% currently employ more than one treatment process.

Perhaps the most striking features of this table are the rather high estimates of the systems that require no treatment at all to meet the 1986 amendments to the SDWA, particularly for the medium to very large systems. This means that the proportion of systems that will need multiple treatments is correspondingly low. Miller (1990) comments on the relative size of these proportions and suggests that the probability of needing multiple treatments, particularly for the larger systems is too low. He argues that the results are driven by the underlying assumptions about contaminant occurrence, the decision trees built into the analysis, and the numbers of systems in the various size categories. Unfortunately, he provides too little information about the procedure for us to unravel the mystery, although we suspect much of the explanation for the underestimates has to do with the assumption of independence of co-occurrence of all contaminants. This assumption is hard to rationalize in built up areas served by large and very large water systems. The independence assumption is probably easier to justify in areas served by smaller systems. The magnitude of the underestimates of the need for multiple treatment in these cases is probably smaller. For this reason, one might regard Miller's (1990) estimates as lower bounds on the proportion of systems needing single or multiple treatments. The estimates provided by Miller may also be more appropriate for smaller systems since the recent 1996 amendments to the SDWA allow for more relaxed monitoring and treatment schedules by systems serving fewer than 10,000 people.

Detailed information about the particular combinations of processes on which table 8 was constructed is given in appendix G. In discussing these data, however, we are less interested in the percentages themselves than we are the short fall between what is needed and what is in place at the present time. This can be seen best by examining the relative

⁸ As data from EPA's on-going needs survey of the Nation's public water systems becomes available, it will certainly be possible to refine these probability estimates.

Table 8. Estimated and Actual Treatment Combinations Used by Community Water Systems

| Treatment Combination | No. of Treatments | Very Small | | Small | | Medium | | Large | | Very Large | |
|-----------------------|-------------------|------------------------|---------------------|-----------|--------|-----------|--------|-----------|--------|------------|--------|
| | | Estimated ^a | Actual ^b | Estimated | Actual | Estimated | Actual | Estimated | Actual | Estimated | Actual |
| ----- % ----- | | | | | | | | | | | |
| Ground Water: | | | | | | | | | | | |
| No Treatment | 0 | 14 | 48 | 22 | 21 | 24 | 14 | 25 | 7 | 33 | 1 |
| Single Treatment | 1 | 40 | 42 | 47 | 53 | 47 | 49 | 47 | 33 | 49 | 18 |
| Multiple Treatment | 2+ | 46 | 8 | 30 | 19 | 30 | 28 | 28 | 39 | 19 | 44 |
| Surface Water: | | | | | | | | | | | |
| No Treatment | 0 | 12 | 49 | 12 | 22 | 15 | 13 | 15 | 12 | 22 | 4 |
| Single Treatment | 1 | 45 | 25 | 45 | 27 | 46 | 27 | 47 | 23 | 50 | 28 |
| Multiple Treatment | 2+ | 41 | 25 | 42 | 48 | 39 | 58 | 38 | 63 | 28 | 67 |

Note: These data were calculated from Tables G1. and G2. by summing up the number of systems using no treatment, single treatment, and multiple treatments.

^aEstimated percentages were calculated from EPA document, Benefits and Costs of the 1986 Amendments to the SDWA (Wade Miller, 1989).

^bActual percentages were obtained from FRDS multiple treatment data search results.

based are first approximations. They are based on the best available data, and they were used in EPA's assessment of the technical and economic capacity of public water systems to comply with the 1986 SDWA amendments.⁸

To understand how these comparisons are made, we can look at the summary data in table 8. For example, Miller estimates that to comply with the 1986 amendments, 46% of the very small ground water systems would need to install multiple treatment processes, while 40% would need only a single process. About 14% would need no treatment at all. Based on the *FRDS's* data, however, 48% of the very small ground water systems currently treat none of their water, while 42% use a single treatment technology, and only 8% currently employ more than one treatment process.

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Detailed information about the particular combinations of processes on which table 8 was constructed is given in appendix G. In discussing these data, however, we are less interested in the percentages themselves than we are the short fall between what is needed and what is in place at the present time. This can be seen best by examining the relative

⁸ As data from EPA's on-going needs survey of the Nation's public water systems becomes available, it will certainly be possible to refine these probability estimates.

Table 8. Estimated and Actual Treatment Combinations Used by Community Water Systems

| Treatment Combination | No. of Treatments | Very Small | | Small | | Medium | | Large | | Very Large | |
|-----------------------|-------------------|------------------------|---------------------|-----------|--------|-----------|--------|-----------|--------|------------|--------|
| | | Estimated ^a | Actual ^b | Estimated | Actual | Estimated | Actual | Estimated | Actual | Estimated | Actual |
| ----- % ----- | | | | | | | | | | | |
| Ground Water: | | | | | | | | | | | |
| No Treatment | 0 | 14 | 48 | 22 | 21 | 24 | 14 | 25 | 7 | 33 | 1 |
| Single Treatment | 1 | 40 | 42 | 47 | 53 | 47 | 49 | 47 | 33 | 49 | 18 |
| Multiple Treatment | 2+ | 46 | 8 | 30 | 19 | 30 | 28 | 28 | 39 | 19 | 44 |
| Surface Water: | | | | | | | | | | | |
| No Treatment | 0 | 12 | 49 | 12 | 22 | 15 | 13 | 15 | 12 | 22 | 4 |
| Single Treatment | 1 | 45 | 25 | 45 | 27 | 46 | 27 | 47 | 23 | 50 | 28 |
| Multiple Treatment | 2+ | 41 | 25 | 42 | 48 | 39 | 58 | 38 | 63 | 28 | 67 |

Note: These data were calculated from Tables G1. and G2. by summing up the number of systems using no treatment, single treatment, and multiple treatments.

^aEstimated percentages were calculated from EPA document, Benefits and Costs of the 1986 Amendments to the SDWA (Wade Miller, 1989).

^bActual percentages were obtained from FRDS multiple treatment data search results.

differences between the actual and the estimated percentages of single and multiple treatment needs (tables 9 and 10), although the conclusions drawn from the sign on these differences is somewhat ambiguous. For example, if this difference is positive, as is the case for the "no treatment" percentages, then a move toward more complete compliance would require a reduction in the actual percentage of systems not treating, while the percentage of systems employing single or multiple treatments could both rise. In this instance, the interpretation of the positive difference is straightforward. On the other hand, if the difference is positive for the single treatment case, it could mean that many of the systems are in compliance, but it could also imply that many of the systems now using a single treatment actually belong in multiple treatment category and, therefore, need to install additional treatment processes to be in compliance with the SDWA amendments.

Despite this ambiguity, when the difference between the actual and estimated percentage is negative, more systems belong in that category. Thus, we have a criterion for setting priorities for study of the economic and institutional feasibility of various combinations of treatments. Beginning in the multiple treatment category, we can place some priority on those combinations of processes where the short fall is negative. Highest priority should perhaps be given where the absolute value of this short fall is the largest. Next on the list of priorities would be an examination of the single treatments where the negative short fall is highest.

Although the data in tables 9 and 10 provide, in theory, a good criterion by which to set priorities for the development and evaluation of multiple treatment options, the data themselves are a bit disappointing. That is, in order to establish clear priorities, one would have hoped for more variation in the estimated short falls, across treatment combinations and system size categories. Most of the estimated short falls for the multiple treatment combinations for the three smallest size groups range between -1.0 and -0.8. A value of -1.0 is important because even though it was estimated earlier that there would be need for systems to employ these combinations, none have done so to date. A value between -1.0 and 0.0 means that some systems are employing the treatment combination, but not in proportion to the projected need.

We do, however, see some important patterns in the data. For example, there is complete consistency across ground water systems with respect to the exclusive use of corrosion control: no systems currently control corrosion as their only treatment strategy, but it is an integral part of many of the treatment combinations currently in use. The same is true for activated carbon processes, although only a few systems are now using the multiple technologies for which this process is an integral part of the projected needs.

Table 9. Relative Short Fall Between Estimated Treatment Needs and Actual Treatment Combinations Used by CWS's with a Ground Water Source

| Treatment Combination | No. of Treatments | Very Small Relative Short Fall | Small Relative Short Fall | Medium Relative Short Fall | Large Relative Short Fall | Very Large Relative Short Fall |
|--------------------------------------|-------------------|-----------------------------------|------------------------------|-------------------------------|------------------------------|-----------------------------------|
| No Treatment | 0 | 2.4 | -0.1 | -0.4 | -0.7 | -1.0 |
| Alt. Treatment ^c | 1 | 5.0 | 12.2 | * | * | * |
| Disinfection (DSF) ^d | 1 | 2.9 | 6.7 | 8.7 | 11.1 | * |
| Corrosion Control (CC) ^e | 1 | -1.0 | -1.0 | -1.0 | -1.0 | -1.0 |
| Ion Exchange (IE) ^f | 1 | -0.2 | -0.9 | -1.0 | -1.0 | -1.0 |
| Aeration (PTA) ^g | 1 | -0.9 | -0.7 | -0.7 | -0.6 | -1.0 |
| Gran. Act. Carbon (GAC) ^h | 1 | -1.0 | -1.0 | -1.0 | -1.0 | * |
| DSF / CC | 2 | -0.8 | -0.2 | 0.4 | 2.2 | * |
| DSF / IE | 2 | 1.5 | 1.3 | 1.5 | 1.3 | * |
| DSF / PTA | 2 | -0.6 | 3.9 | 10.6 | 37.5 | * |
| DSF / GAC | 2 | -0.9 | -0.7 | -0.5 | * | * |
| CC / IE | 2 | -1.0 | -1.0 | -1.0 | -1.0 | -1.0 |
| CC / PTA | 2 | -1.0 | -0.9 | -0.9 | -0.9 | -1.0 |
| CC / GAC | 2 | -1.0 | -1.0 | -0.9 | -0.9 | * |
| IE / PTA | 2 | -1.0 | -0.8 | -0.8 | -1.0 | * |
| IE / GAC | 2 | -0.9 | -1.0 | -1.0 | * | * |
| PTA / GAC | 2 | -1.0 | -1.0 | -1.0 | * | * |
| DSF / CC / IE | 3 | -0.8 | -0.6 | 0.1 | 0.2 | * |
| DSF / CC / PTA | 3 | -0.9 | 0.9 | 4.9 | 26.8 | * |
| DSF / CC / GAC | 3 | -0.9 | -0.7 | 0.0 | 7.2 | * |
| DSF / IE / GAC | 3 | * | * | * | * | * |
| DSF / IE / PTA | 3 | * | * | * | * | * |
| DSF / PTA / GAC | 3 | -1.0 | -0.4 | * | * | * |
| DSF / PTA / IE | 3 | * | * | * | * | * |
| CC / IE / PTA | 3 | -1.0 | -0.9 | -1.0 | -1.0 | * |
| CC / IE / GAC | 3 | -1.0 | -1.0 | -1.0 | * | * |
| CC / PTA / GAC | 3 | -1.0 | -1.0 | -1.0 | -1.0 | * |
| IE / PTA / GAC | 3 | * | * | * | * | * |
| DSF / CC / IE / PTA | 4 | -0.9 | 0.8 | 5.1 | * | * |
| DSF / CC / IE / GAC | 4 | -0.8 | -0.5 | * | * | * |
| DSF / CC / PTA / GAC | 4 | * | * | * | * | * |
| Other Combinations ⁱ | | -0.8 | -0.9 | -1.0 | -1.0 | -0.6 |

Note: These data were calculated from Table G1 by subtracting the actual proportion of systems using a specific combination of treatment options by the estimated proportion of systems needing that combination. This result is divided by the estimated proportion.

^aEstimated percentages were calculated from EPA document, Benefits and Costs of the 1986 Amendments to the SDWA (Wade Miller, 1989).

^bActual percentages were obtained from FRDS multiple treatment data search results.

^cThe number of systems using alternative treatments includes those that do not directly affect SDWA treatment requirements, (e.g. fluoride treatment).

^dDisinfection (DSF) includes treatment process codes C, O, and U. (See Exhibit F1.)

^eCorrosion (CC) control includes treatment process codes I, H, L. (See Exhibit F1.)

^fIon exchange (IE) relates to code E, and includes activated both alumina, and anion and cation exchange.

^gAeration (PTA) includes all aeration processes: Cascade, diffused, packed tower, slat spray, and spray aeration.

^hGAC includes both powdered and granulated activated carbon processes.

ⁱThis category includes treatment combinations that are not considered feasible and combinations estimated to affect less than one percent of all systems.

^jAn '*' occurs wherever the estimated value was zero, in which case there would have been a division by zero.

Table 10. Relative Short Fall Between Estimated Treatment Needs and Actual Treatment Combinations Used by CWS's with a Surface Water Source

| Treatment Combination | No. of Treatments | Very Small Relative Short Fall | Small Relative Short Fall | Medium Relative Short Fall | Large Relative Short Fall | Very Large Relative Short Fall |
|--------------------------------------|-------------------|-----------------------------------|------------------------------|-------------------------------|------------------------------|-----------------------------------|
| No Treatment | 0 | 3.2 | 0.8 | -0.1 | -0.2 | -0.8 |
| Alt. Treatment ^c | 1 | -0.4 | 3.8 | * | * | * |
| Filtration (FILT) ^d | 1 | 0.0 | -0.1 | -0.2 | -0.3 | 0.4 |
| Corrosion Control (CC) ^e | 1 | -1.0 | -0.8 | -0.7 | -0.8 | -0.9 |
| Ion Exchange (IE) ^f | 1 | * | * | * | * | * |
| Aeration (PTA) ^g | 1 | * | * | * | * | * |
| Gran. Act. Carbon (GAC) ^h | 1 | -0.5 | -0.5 | -0.6 | -0.3 | * |
| FILT / CC | 2 | -0.9 | -0.6 | -0.4 | -0.5 | -0.2 |
| FILT / IE | 2 | 0.3 | 5.2 | * | * | * |
| FILT / PTA | 2 | * | * | * | * | * |
| FILT / GAC | 2 | 0.4 | 1.8 | 3.0 | 3.6 | * |
| CC / IE | 2 | -0.5 | * | * | * | * |
| CC / PTA | 2 | * | * | * | * | * |
| CC / GAC | 2 | -0.9 | -0.9 | -0.1 | 0.2 | * |
| IE / PTA | 2 | * | * | * | * | * |
| IE / GAC | 2 | * | * | * | * | * |
| PTA / GAC | 2 | * | * | * | * | * |
| FILT / CC / IE | 3 | -1.0 | 0.2 | * | * | * |
| FILT / CC / PTA | 3 | * | * | * | * | * |
| FILT / CC / GAC | 3 | 0.3 | 4.0 | 6.1 | 9.3 | 45.3 |
| FILT / IE / GAC | 3 | * | * | * | * | * |
| FILT / PTA / GAC | 3 | * | * | * | * | * |
| FILT / PTA / IE | 3 | * | * | * | * | * |
| CC / IE / PTA | 3 | * | * | * | * | * |
| CC / IE / GAC | 3 | * | * | * | * | * |
| CC / PTA / GAC | 3 | * | * | * | * | * |
| FILT / CC / IE / PTA | 4 | * | * | * | * | * |
| FILT / CC / IE / GAC | 4 | * | * | * | * | * |
| FILT / CC / PTA / GAC | 4 | * | * | * | * | * |
| Other Combinations ⁱ | | 8.0 | 13.0 | 15.2 | 17.2 | 1.3 |

Note: These data were calculated from Table G2 by subtracting the actual proportion of systems using a specific combination of treatment options by the estimated proportion of systems needing that combination. This result is divided by the estimated proportion.

^aEstimated percentages were calculated from EPA document, Benefits and Costs of the 1986 Amendments to the SDWA (Wade Miller, 1989).

^bActual percentages were obtained from FRDS multiple treatment data search results.

^cThe number of systems using alternative treatments includes those that do not directly affect SDWA treatment requirements, (e.g. fluoride treatment).

^dFiltration includes all filtration processes: Cartridge, greensand, DE, rapid sand, slow sand, ultrafiltration and direct filtration.

^eCorrosion (CC) control includes treatment process codes I, H, L. (See Exhibit F1.)

^fIon exchange (IE) relates to code E, and includes activated both alumina, and anion and cation exchange.

^gAeration (PTA) includes all aeration processes: Cascade, diffused, packed tower, slat spray, and spray aeration.

^hGAC includes both powdered and granulated activated carbon processes.

ⁱThis category includes treatment combinations that are not considered feasible and combinations estimated to affect less than one percent of all systems.

^jAn '*' occurs wherever the estimated value was zero, in which case there would have been a division by zero.

The situation is quite different for disinfection. Here, many more systems employ methods for disinfection as their only method of treatment than is estimated to be acceptable under widespread compliance with the 1986 amendments. Furthermore, three of the dual treatment strategies involving disinfection are "over subscribed" as well. This means that many of these systems are likely to install additional treatment technologies as they are faced with decisions regarding full compliance with the regulations. And, according to the predictions of need, these strategies will involve at least three distinct treatment processes. Since these are being used by only a few, if any, systems currently, this is obviously a top priority for technology development, testing, and evaluation.

One of the most encouraging aspects of this analysis is that the short falls relative to most treatment combinations decrease as one moves to categories for larger systems. This pattern is most evident for the treatment combinations involving two technologies. Accordingly, many of these treatment combinations are being used by small and medium sized systems, but not by the very small ones. These very small systems will undoubtedly be among the last to install elaborate treatment technologies, both because they are more likely to receive exemptions from treatment and because costs may be prohibitive. This is strong evidence that these treatment combinations can be used by systems at the smaller end of the size range. It should be possible to obtain first-hand information about these operations as part of a strategy for adapting them for use by the very small systems.

One can find similar patterns relative to surface water systems in table 10, but there is less that needs to be described in detail. There are fewer multiple treatment combinations applicable to surface water quality problems, and there are also fewer very small and small systems that rely on surface water.

POLICY IMPLICATIONS AND CONCLUSIONS

As stated above, the purpose of this report is to provide a descriptive summary of these various operating and design characteristics of CWS's across the country. The manuscript is one of the first in a series designed to provide a comprehensive look at the implications of the 1986 amendments. The objectives are modest relative to the scope of the overall research effort, but they are a necessary first step. Emphasis is focused on the policy implications that can be drawn from a careful analysis of the data. These data are also organized to help provide a typology of representative public water systems that can be examined to better understand the regional effects of policy implementation.

Emphasis has also been on the current water treatment objectives being pursued by CWS's and the treatment processes that are already in place. This latter information is used in conjunction with prior estimates of the probability that systems will need certain combinations of treatment processes to set priorities for further research. It is for those smaller systems that may require the addition of multiple water treatment processes that the financial implications are likely to be the most severe. Finding economically feasible treatment strategies for these systems is most challenging as well.

Much of the descriptive information about the characteristics of the CWS's across the country serves to reinforce what we may have suspected already. About 80% of the population is served by only 6% of the Nation's community water systems, but these are the largest systems. While the implementation of the 1986 amendments to the SDWA may pose some problems for these systems, the fact remains that a large percentage of the population is served by systems having the technical and financial resources to accommodate additional monitoring and treatment requirements.

The fact that only 20% of the population are served by community water systems serving fewer than 10,000 people tends to disguise the magnitude of the problems facing systems of this size. However, the problems can be put into proper perspective by recognizing that over 90% of the Nation's community water systems are involved in meeting the drinking water needs of this 20% of the population. Most would agree that even the logistics of dealing with well over 50,000 community water systems is problematic. Furthermore, since most of these community water systems are scattered across the rural landscape throughout the country, the problems are exacerbated by the widening gap between average incomes of rural vs. urban residents and the declining economic base in some rural areas as well.

The proportion of small and very small water systems exceeds the national average in New England and in EPA's three western regions. It is here where the problems facing small and very small systems are likely to have a disproportionately large effect. Given the wide variations in population density and other socio-economic differences between New England, for example, and the sparsely populated states in the West, the opportunities for restructuring either through physical consolidation or administrative or institutional cooperation, are dramatically different. This only serves to underscore the need to think about solutions that accommodate the important features of our Nation's regional diversity. Without a doubt, the inherent problems in dealing with this country's regional diversity is always one of the major challenges to implementing national policy. It is certainly true in this case, and this recognition

is perhaps in large measure responsible for provisions in the 1996 amendments to establish regional centers for technical support.

We also learn from the data that systems dependent primarily on surface water tend to be the larger ones. Thus, the vast majority of small and very small systems rely primarily on ground water. This is perhaps the only bright spot in this whole picture because the level of treatment necessary for these systems is often below what is needed to guarantee acceptable levels of water quality for systems relying on surface water.

The data also suggest that issues surrounding the financing of treatment for systems under 10,000 are compounded by the patterns of system ownership. With more than one-half of the community water systems serving fewer than 10,000 people being privately owned, it is difficult to understand why provisions for credit to water systems through a revolving fund are earmarked primarily for publicly owned water systems. As written, the legislation provides assistance from a state revolving fund only to those private systems having the greatest public health and financial need. Clearly, without some well-established guidelines for allocating these funds, private systems and the people they serve could well be at a competitive disadvantage in gaining access to these funds.

There is also growing recognition that one major barrier facing small water systems is obtaining government approval for innovative, small scale technology for monitoring and treating drinking water. The problems seem to evolve around the amount of field-scale testing required and the conflicting requirements among states. While this suggests the need for a clear statement of the requirements for testing, a clear indication of the combinations of treatment processes needed by these small community water systems would help establish priorities for development and testing of new technology. The recent SDWA amendments do, however, provide treatment and monitoring flexibility, as dictated by the states, to address these issues.

On the basis of our analysis, there is, as would be expected, a short fall between the number of systems serving fewer than 10,000 employing multiple treatment processes and the estimated number required. Assuming that the data are reported accurately, there are systems that have demonstrated success with a number of multiple treatment processes, particularly in the small and medium-size categories. The experience gained by these systems would seem invaluable in efforts to accelerate the process of field testing and approval of new technology. Priorities for such analysis for ground water systems would be processes anchored by disinfection and corrosion control, combined with either an activated carbon process or

aeration. For surface water systems, priorities would include multiple treatment strategies involving filtration and corrosion control, combined with ion exchange or activated carbon.

As part of EPA's efforts to develop Best Available Technologies for very small systems and on-going research as part of this cooperative agreement, much is already known about the costs of single treatment technologies and the differences in the economies of size across treatment processes. However, much of this information is based on engineering estimates, and there have been few actual installations on which to verify the cost estimates. The effects on treatment costs as these processes are operated jointly is also not well understood, and this is an additional priority for our ongoing research.

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APPENDIX A

Testing for Identical Distributions Using the Kolmogorov-Smirnov Test

To develop a clear perspective on the number and diversity of community water systems (CWS) across the United States, the FRDS-II data base is used to obtain information on various system characteristics, such as primary water source, population served, ownership, water treatment objectives and processes in place, and two other important measures of system size, average daily flow and design capacity. The *FRDS-II Data Base* as of July 1, 1994, contains records for over 57,000 CWS's nationally. However, in any data set of this size and complexity, the degree to which the information is accurate and up to date for individual systems varies, and depends on the care taken by the system personnel responsible for supplying the information to EPA. Consequently, our descriptive analysis of the data is based on a subset of the data after observations with missing or obviously erroneous data for various characteristics of the systems are removed.

As emphasized in the text, we eliminate observations where some of the most basic information on population served, ownership, and treatment classification is missing. We also eliminate systems where the information was provided, but was obviously in error because of inconsistencies between population served, average daily production, and design capacity. Over 45,600 community water systems (about 80% of the total) remain in the "sample". The purpose of this appendix is to report the results of some statistical tests regarding the similarity of the distribution of water systems by size, compared with the size distribution for the entire 57,000 systems. To the extent that they are similar, we can be confident that inferences about the population drawn from an analysis of the sample will not be biased in any way. We are obviously most concerned about small system categories. One might expect the quality of the information for these systems to be more variable than for larger systems because of the lack of personnel to do the reporting. On this basis, one might expect a larger proportion of these systems to be eliminated from the data set initially.

The statistical test is designed to test the similarity of the two distributions of CWS's according to the population served. This is essentially a test of the similarity in the size distributions of the CWS's in the two respective data sets. It would have been advisable to test the similarity of the distributions of other system characteristics as well. This, however, was not possible because of the missing or erroneous data in some of the observations which made it necessary to eliminate them in the first place. More importantly, if more than one test were conducted in sequence, the validity of each would be conditional on the results of the previous

tests, and it would be difficult to have any confidence in the "levels of significance" of any of these subsequent tests. The only effective way to conduct a test on more than one characteristic would be to base it on a test of the similarity of the joint distributions. While theoretically possible, we know of no such test that could be applied empirically in this case.

There are two commonly used statistical procedures to test the null hypothesis that two distributions are the same. The first is a Chi-square test (Snedecor and Cochran, 1989), and the second is the Kolmogorov-Smirnov test (Siegel, 1956). For our purposes, the Kolmogorov-Smirnov test is used rather than the Chi-squared test because it evaluates the similarity of the distributions at all sample points. On the other hand, the Chi-squared test, evaluates the similarity of the two distributions over intervals, and the outcome depends explicitly on how these intervals are specified. The Chi-square test is certainly the more subjective of the two.

The testing procedure for the Kolmogorov-Smirnov test involves specifying the cumulative frequency distribution for the theoretical distribution and comparing it with the observed cumulative frequency distribution (Siegel, 1956). In many instances, the test is used to compare a sample with some known continuous probability distribution, but, in the case here, we have two empirical distributions to compare.

In particular, we compare the size distribution (as measured by population served) of the "sample" data set with the size distribution of the original population of CWS's found in EPA's report to Congress "Technical and Economic Capacity of States..." (EPA, 1993). The data from the EPA report include the 57,500 CWS's in the FRDS-II data system of a year earlier than the FRDS-II data from which our sample is drawn. It includes all systems, regardless of the quality of the data. In testing our "sample" against this population of systems, we are implicitly assuming that the data on retail population served is accurate. More is said about this below. Since the distribution of systems in the EPA report distinguishes between ground water and surface water systems, we test both distributions, as well as the distributions for the combined systems.

The CWS's are categorized into nine size categories which are arranged in ascending order. The data for all systems are in table A1, whereas the data for ground and surface water systems are in tables A2 and A3, respectively.

To conduct the test and develop the test statistic, let $F_{\theta}(X)$ be the specified cumulative frequency distribution function for the size distribution of CWS's in the entire population of water systems. That is, for any value of X (population category), the value of $F_{\theta}(X)$ is the

Table A1. Data for Kolmogorov-Smirnov Test of Size Distributions of all Community Water Systems

| Population Category | CWS Population Distribution ¹ | | | CWS Sample Distribution ² | | | Deviations in Cumulative Proportion ³ |
|---------------------|--|------------|-----------------------|--------------------------------------|------------|-----------------------|--|
| | Frequency | Proportion | Cumulative Proportion | Frequency | Proportion | Cumulative Proportion | |
| < 101 | 17,300 | 0.301 | 0.301 | 13,528 | 0.297 | 0.297 | 0.004 |
| 101-500 | 18,211 | 0.317 | 0.618 | 14,165 | 0.310 | 0.607 | 0.011 |
| 501-1,000 | 6,207 | 0.108 | 0.726 | 4,917 | 0.108 | 0.715 | 0.011 |
| 1,001-3,300 | 8,318 | 0.145 | 0.871 | 6,897 | 0.151 | 0.866 | 0.005 |
| 3,301-10,000 | 4,085 | 0.071 | 0.942 | 3,414 | 0.075 | 0.941 | 0.001 |
| 10,001-50,000 | 2,660 | 0.046 | 0.988 | 2,152 | 0.047 | 0.988 | 0.000 |
| 50,001-75,000 | 260 | 0.004 | 0.992 | 215 | 0.005 | 0.993 | 0.000 |
| 75,001-100,000 | 121 | 0.002 | 0.994 | 94 | 0.002 | 0.995 | 0.000 |
| > 100,000 | 315 | 0.005 | 1.000 | 249 | 0.006 | 1.000 | 0.000 |

¹ CWS's distribution by system size from "Technical and Economic Capacity of States and Public Water Systems to Implement Drinking Water Regulations" (EPA, 1993).

² "Sample" CWS's distribution by system size constructed from FRDS-II data files for cooperative research agreement between EPA and Cornell University (1995).

³ Cumulative deviations are in absolute value terms.

Table A2. Data for Kolmogorov-Smirnov Test Size Distributions for Ground Water Systems

| Population Category | CWS Population Distribution ¹ | | | CWS Sample Distribution ² | | | Deviations in Cumulative Proportion ³ |
|---------------------|--|------------|-----------------------|--------------------------------------|------------|-----------------------|--|
| | Frequency | Proportion | Cumulative Proportion | Frequency | Proportion | Cumulative Proportion | |
| < 101 | 16,140 | 0.345 | 0.345 | 12,910 | 0.346 | 0.346 | 0.001 |
| 101-500 | 15,950 | 0.341 | 0.686 | 12,545 | 0.336 | 0.681 | 0.005 |
| 501-1,000 | 4,980 | 0.107 | 0.793 | 3,967 | 0.106 | 0.787 | 0.005 |
| 1,001-3,300 | 5,814 | 0.124 | 0.917 | 4,804 | 0.129 | 0.916 | 0.001 |
| 3,301-10,000 | 2,374 | 0.051 | 0.968 | 1,912 | 0.051 | 0.967 | 0.001 |
| 10,001-50,000 | 1,275 | 0.027 | 0.995 | 1,028 | 0.028 | 0.995 | 0.000 |
| 50,001-75,000 | 99 | 0.002 | 0.997 | 87 | 0.002 | 0.997 | 0.000 |
| 75,001-100,000 | 45 | 0.001 | 0.998 | 39 | 0.001 | 0.998 | 0.000 |
| > 100,000 | 89 | 0.002 | 1.000 | 74 | 0.002 | 1.000 | 0.000 |

¹ CWS's distribution by system size from "Technical and Economic Capacity of States and Public Water Systems to Implement Drinking Water Regulations" (EPA, 1993).

² "Sample" CWS's distribution by system size constructed from FRDS-II data files for cooperative research agreement between EPA and Cornell University (1995).

³ Cumulative deviations are in absolute value terms.

Table A3. Data for Kolmogorov-Smirnov Test Size Distributions for Surface Water Systems

| Population Category | CWS Population Distribution ¹ | | | CWS Sample Distribution ² | | | Deviations in Cumulative Proportion ³ |
|---------------------|--|------------|-----------------------|--------------------------------------|------------|-----------------------|--|
| | Frequency | Proportion | Cumulative Proportion | Frequency | Proportion | Cumulative Proportion | |
| < 101 | 1,160 | 0.108 | 0.108 | 618 | 0.075 | 0.075 | 0.033 |
| 101-500 | 2,261 | 0.211 | 0.319 | 1,620 | 0.196 | 0.271 | 0.049 |
| 501-1,000 | 1,227 | 0.115 | 0.434 | 950 | 0.115 | 0.386 | 0.048 |
| 1,001-3,300 | 2,504 | 0.234 | 0.668 | 2,093 | 0.253 | 0.639 | 0.029 |
| 3,301-10,000 | 1,711 | 0.160 | 0.828 | 1,502 | 0.182 | 0.821 | 0.007 |
| 10,001-50,000 | 1,385 | 0.129 | 0.957 | 1,124 | 0.136 | 0.957 | 0.000 |
| 50,001-75,000 | 161 | 0.015 | 0.972 | 128 | 0.016 | 0.972 | 0.000 |
| 75,001-100,000 | 76 | 0.001 | 0.979 | 55 | 0.007 | 0.979 | 0.000 |
| > 100,000 | 226 | 0.021 | 1.000 | 175 | 0.021 | 1.000 | 0.000 |

¹ CWS's distribution by system size from "Technical and Economic Capacity of States and Public Water Systems to Implement Drinking Water Regulations" (EPA, 1993).

² "Sample" CWS's distribution by system size constructed from FRDS-II data files for cooperative research agreement between EPA and Cornell University (1995).

³ Cumulative deviations are in absolute value terms.

proportion of CWS's expected to have retail service populations equal to or less than X . Furthermore, let $S_n(X)$ be the observed cumulative frequency distribution for the size distribution of CWS's in our "sample" of n observations; $S_n(X)=k/n$, and k is the number of observations whose retail service population is equal to or less than X . Therefore, under the null hypothesis that the "sample" has been drawn from the specified distribution $F_0(X)$, $S_n(X)$ should be fairly close to $F_0(X)$ for every value of X . The Kolmogorov-Smirnov test concentrates on the largest of these deviations, where the test statistic given by:

$$(1) \quad D = \max |S_n(X) - F_0(X)| ,$$

where D is the greatest absolute difference in height between the two empiric distribution functions, S and F . If an appropriately large value of D is observed, one rejects the null hypothesis that both distributions are the same in favor of the alternative hypothesis that they are not. The asymptotic sampling distribution of D is given by:

$$(2) \quad Pr \{ D \leq zN^{-1/2} \} \rightarrow L(z) \text{ as } n_1, n_2 \rightarrow \infty$$

$$(3) \quad N = n_1 n_2 / (n_1 + n_2) ,$$

where n_1 and n_2 are the numbers of observations in the original and "sample" data sets, respectively; and

$$(4) \quad L(z) = 1 - 2 \sum_{j=1}^{\infty} (-1)^{j-1} e^{-2j^2 z^2}$$

$$(5) \quad = \frac{\sqrt{2\pi}}{z} \sum_{j=1}^{\infty} e^{-(2j-1)^2 \pi^2 / 8z^2} \text{ for } z > 0,$$

$$(6) \quad L(z) = 0 \text{ for } z \leq 0$$

The sampling distribution of D under H_0 is known, and the significance of a given critical value of D depends on N . The critical values are found on page 251 in Siegel (1956).

In addition to containing the cumulative frequencies for the two distributions, tables A1 through A3 contain the differences in the cumulative frequencies for all CWS's, and for when they are separated into the two groups by primary water source. The test statistics and results for each set of CWS's are in table A4. As can be seen from table A4, we fail to reject H_0 for

Table A4. Kolmogorov Test Statistics and Results of Hypothesis Tests

| Test Statistic | Both Ground and | | |
|-----------------------------|--------------------------|-------------------------|--------------------------|
| | Surface Water Systems | Ground Water Systems | Surface Water Systems |
| N | 25,437 | 20,770 | 4,665 |
| Critical Value ¹ | 0.01 | 0.01 | 0.02 |
| max D | 0.01 | 0.005 | 0.05 |
| Test Result | Fail to Reject H_0 | Fail to Reject H_0 | Reject H_0 |

¹ Critical value based on Type I error level of 0.01, It is calculated as $1.63/N^{0.5}$. See Siegel (1956), page 251.

both the full sample of CWS's and the subset of ground water systems. That is, we conclude that the cumulative distributions are equivalent. In the case of the ground water systems, the result, seems fairly robust with a maximum absolute deviation over all population categories of only 0.005. The results are different for the test of the size distributions for surface water systems. Because the critical value of 0.02 is below the calculated value of D , we reject H_0 and conclude that the distributions are different.

Given that these tests turned out differently for the two types of systems, a closer examination of the distributions is warranted here, both to validate the results and discuss the implications for our analysis. Our primary concern in having to rely on this 80% sample in the first place has to do with retaining a representative number of small CWS's. It was reasonable to expect that owners of smaller systems, such as trailer parks and housing complexes, would find it more difficult to complete the FRDS's data requirements, and would also be less likely to see any value in spending the time to complete the necessary forms. This would naturally result in a proportionately higher reduction in the observations in these small size ranges compared with the number eliminated in the larger size categories.

Somewhat surprisingly, the results indicate that the proportion of smaller systems retained is very close to the proportions in the entire population of ground water systems. For small surface water systems, those serving under 500 people, the effects of eliminating some observations is somewhat more serious if viewed strictly in terms of the results of the statistical tests. However, for surface water systems serving under 500 people, the percentage of systems in the sample fell by only 3 percentage points between the total population surface water

CWS's and the "sample", falling from 11% to 8%. Since there are still a significant number of systems of this size category remaining in the "sample" the only real concern is the extent to which these systems eliminated are sufficiently different than those retained to "bias" any inferences drawn from the sample.

It is impossible to know the answer to this question, but given the size of the systems, they might be expected to be quite homogenous as a group, at least in terms of the several general descriptive characteristics of the systems being examined in this report. It is also true that in "cleaning" the FRDS's data for our purposes, there were many systems where the population served was set at 25, the lowest value possible by federal PWS definition, and either average daily flow or design capacity was set much higher than reasonably expected for that population size. It is impossible to know whether these systems were actually large or small ones. There is every reason to believe that this problem existed in the data in EPA's report to Congress which is used as the base of comparison for the hypothesis tests. If this is true, it is likely that these data slightly over estimate the proportion of small systems. On the strength of these arguments, we are not overly concerned about the possibility of systematic bias in the analysis of small systems as a result of our necessary "sampling" procedure.

A more serious concern would certainly be in the effects of our "sampling" on medium and large systems because of the potential diversity of these CWS's. However, if the small-system categories are removed from the test procedure, all tests fail to reject H_0 . Thus, there seems to be little concern over systematic bias in the analysis of these larger systems.

Some comments regarding the Kolmogorov-Smirnov test procedure also support our contention that the analysis based on our sample lead to reasonable results. Since the critical values of the Kolmogorov-Smirnov test depend on N , the large number of observations in the data sets being examined here reduce critical values substantially over what they would be in most tests which involve much smaller samples. Under these conditions, failure to reject the null hypothesis is difficult using the Kolmogorov-Smirnov test, and the similarity in magnitudes of the test statistic and the critical value for the tests of surface water systems is encouraging. The results of the tests could also have been influenced by disaggregating the categories further for a given N . We chose not to do this because we thought it important to keep the categories consistent with EPA's delineation used for policy purposes.

In conclusion, the testing procedure provides optimistic results concerning the validity and representative nature of the "sample" constructed for the descriptive analysis in this report. Test procedures failed to reject H_0 for the entire "sample" of CWS's and for the subset of

ground water systems. But, the test led to a rejection H_0 in favor of the alternative hypothesis for the subset of surface water systems, in large measure due to the number of small systems that had to be eliminated from the analysis. However, because it is expected that this group may be quite homogenous in terms of system characteristics and operation procedures, it is unlikely that our strategy would lead to any systematic bias in the results. Therefore, further analyses based on the 80% "sample" described here should, to the best of our knowledge, provide representative results for all CWS's across the country and lead to applicable and reliable implications regarding the characteristics of water systems across the country and compliance with the 1986 amendments to EPA's Safe Drinking Water Act.

APPENDIX B

Characteristics of Community Water Systems by EPA Region

The purpose of this appendix is to provide a self-contained description of the regional diversity of community water systems throughout the United States. The data reported here are used in the text to support or highlight the regional significance of various provisions of the 1986 amendments to the Safe Drinking Water Act and changes brought about by the recent 1996 amendments to the SDWA.

As in any regional analysis, it is important to define regions that highlight the diversity that is important for the policy analysis at hand. Almost without exception, the practice of delineating regions on the basis of state, or even local political boundaries is in many respects inappropriate for the task. However, there is also rarely any choice because its on the basis of these boundaries that most data are available. In this case, we do have data at the state level, and some consideration was given to defining our own regions based primarily on geographic proximity, climate, and to some extent on urban orientation. This strategy was abandoned, primarily because the benefits in terms of being able to group similar areas seemed small relative to those associated with doing the analysis based on the EPA's 10 administrative regions. Given that we would still have been limited to regions defined on the basis of state boundaries, there seemed to be little point in merely moving four or five states from one region to another.

For administrative purposes, the Environmental Protection Agency has established 10 regional offices, each serving several of the surrounding states and territories of the United States, such as American Samoa and/or freely associated states, such as the Marshall Islands. For the purpose of this report and future research, we include in these regions only the 50 United States and the District of Columbia (DC). As stated in the earlier text, this excludes about 700 systems. The 10 regions are named for the locations of their regional offices; the states associated with each region are shown in exhibit B1.

A Regional Overview

Through tables B1 and B2, one can begin to understand the regional distribution of the community water systems and the proportion of the populations served by them. The distribution of systems by size across regions in general is consistent with that for the Nation. One could hardly expect any difference given that 87% of the systems nationwide are either

Exhibit B1. EPA Regions, Regional Office Location, and States included.

| EPA Region | Regional Office | States in Region |
|------------|-----------------|--------------------------------|
| 1 | Boston | CT, ME, NH, RI, VT |
| 2 | New York | NJ, NY |
| 3 | Philadelphia | DC, DE, MD, PA, VA, WV |
| 4 | Atlanta | AL, FL, GA, KY, MS, NC, SC, TN |
| 5 | Chicago | IL, IN, MI, MN, OH, WI |
| 6 | Dallas | AR, LA, NM, OK, TX |
| 7 | Kansas City | IA, KS, MO, NE |
| 8 | Denver | CO, MT, ND, SD, UT, WY |
| 9 | San Francisco | AZ, CA, HI, NV |
| 10 | Seattle | AK, ID, OR, WA |

small or very small. However, in three regions (Atlanta, Chicago, and San Francisco), the proportions of small and very small systems are lower than the national average; in the San Francisco Region the proportion is significantly lower. The proportions of the populations served by these small systems in the regions are lower as well.

In contrast, the proportion of small and very small systems exceeds the national average significantly in New England and in the three EPA regions served by Dallas, Denver, and Seattle. The proportion of the population served by these systems in the Dallas region is more than double the national average.

Average Daily Production and Design Capacity

From table 3 in the text, it is clear that while there is some consistency in water production, as measured by average daily flow, and design capacity on a per capita basis across system size categories, the variation both within and between groups is substantial. The same is true at the regional level (table B3). In six of the EPA regions, average daily water production per capita is below the national average. As would be predicted by the regression equations in appendix C, the four regions where per capita production is the lowest are in the Midwest and the East: the Chicago, Boston, New York, and Philadelphia regions. Per capita production in both the Kansas City and Atlanta regions is just slightly below the national average and is explained in large measure by large proportion of the population living in rural areas. In the case of the Atlanta region, this rural orientation more than offsets the fact that

Table B1. Percentage Distribution of Community Water Systems by System Size

| Population Category | EPA Region Number with Regional Headquarters | | | | | | | | | | |
|---------------------|--|-------------|---------------|-------------|--------------|--------------|-------------|-------------|-----------------|----------------|---------------|
| | Nation | 1 Boston | 2 New York | 3 Phila. | 4 Atlanta | 5 Chicago | 6 Dallas | 7 Denver | 8 Kans. City | 9 San Fran. | 10 Seattle |
| | ----- % ----- | | | | | | | | | | |
| <i>Very Small</i> | | | | | | | | | | | |
| < 101 | 29.6 | 41.4 | 38.7 | 31.6 | 26.9 | 21.8 | 24.7 | 20.0 | 34.7 | 27.1 | 48.0 |
| 101 to 500 | 31.0 | 35.8 | 29.3 | 33.4 | 29.7 | 28.8 | 31.2 | 37.4 | 33.0 | 22.8 | 32.2 |
| <i>Small</i> | | | | | | | | | | | |
| 510 to 1,001 | 10.8 | 5.5 | 8.4 | 9.9 | 10.7 | 14.5 | 12.4 | 14.7 | 10.6 | 9.2 | 5.7 |
| 1,001 to 2,500 | 12.0 | 6.7 | 7.8 | 10.5 | 12.4 | 15.5 | 15.1 | 15.9 | 10.5 | 10.9 | 6.0 |
| 2,501 to 3,300 | 3.1 | 1.8 | 2.2 | 3.1 | 4.1 | 3.2 | 4.0 | 2.8 | 2.0 | 3.2 | 1.7 |
| <i>Medium</i> | | | | | | | | | | | |
| 3,301 to 5,000 | 3.3 | 1.4 | 2.8 | 3.0 | 4.0 | 3.9 | 4.1 | 2.9 | 2.3 | 3.8 | 1.2 |
| 5,001 to 10,000 | 4.2 | 2.9 | 3.8 | 3.4 | 5.6 | 4.9 | 4.3 | 3.3 | 2.9 | 6.9 | 2.0 |
| <i>Large</i> | | | | | | | | | | | |
| 10,001 to 50,000 | 4.7 | 3.2 | 5.8 | 3.9 | 5.5 | 6.2 | 3.5 | 2.4 | 3.2 | 10.7 | 2.9 |
| 50,001 to 75,000 | 0.5 | 0.5 | 0.5 | 0.3 | 0.5 | 0.6 | 0.3 | 0.2 | 0.3 | 2.1 | 0.1 |
| 75,001 to 100,000 | 0.2 | 0.3 | 0.0 | 0.2 | 0.2 | 0.2 | 0.1 | 0.1 | 0.2 | 1.1 | 0.1 |
| <i>Very Large</i> | | | | | | | | | | | |
| > 100,000 | 0.5 | 0.5 | 0.7 | 0.7 | 0.5 | 0.4 | 0.4 | 0.4 | 0.3 | 2.1 | 0.2 |

Table B2. Percentage of Population Served by Community Water Systems by System Size

| Population Category | EPA Region Number with Regional Headquarters | | | | | | | | | | |
|---------------------|--|-------------|---------------|-------------|--------------|--------------|-------------|-------------|-----------------|----------------|---------------|
| | Nation | 1 Boston | 2 New York | 3 Phila. | 4 Atlanta | 5 Chicago | 6 Dallas | 7 Denver | 8 Kans. City | 9 San Fran. | 10 Seattle |
| | ----- % ----- | | | | | | | | | | |
| <i>Very Small</i> | | | | | | | | | | | |
| < 101 | 0.4 | 0.8 | 0.3 | 0.4 | 0.4 | 0.3 | 0.5 | 0.4 | 0.8 | 0.1 | 1.6 |
| 101 to 500 | 1.9 | 2.7 | 1.3 | 1.8 | 1.8 | 1.8 | 2.5 | 3.8 | 3.0 | 0.4 | 4.2 |
| <i>Small</i> | | | | | | | | | | | |
| 510 to 1,001 | 1.9 | 1.3 | 1.1 | 1.7 | 1.9 | 2.5 | 2.8 | 4.0 | 2.9 | 0.6 | 2.4 |
| 1,001 to 2,500 | 4.6 | 3.8 | 2.2 | 3.9 | 4.9 | 5.7 | 7.7 | 9.5 | 6.1 | 1.5 | 5.7 |
| 2,501 to 3,300 | 2.2 | 1.7 | 1.1 | 2.0 | 2.8 | 2.1 | 3.6 | 3.0 | 2.1 | 0.7 | 3.0 |
| <i>Medium</i> | | | | | | | | | | | |
| 3,301 to 5,000 | 3.2 | 1.8 | 1.9 | 2.8 | 3.9 | 3.7 | 5.3 | 4.5 | 3.4 | 1.3 | 2.9 |
| 5,001 to 10,000 | 7.3 | 6.9 | 4.7 | 5.4 | 9.6 | 8.3 | 9.5 | 8.7 | 7.7 | 4.1 | 8.4 |
| <i>Large</i> | | | | | | | | | | | |
| 10,001 to 50,000 | 24.7 | 26.4 | 22.0 | 19.2 | 27.9 | 30.9 | 22.3 | 19.1 | 23.5 | 21.8 | 37.7 |
| 50,001 to 75,000 | 6.8 | 8.4 | 5.7 | 4.2 | 6.7 | 8.8 | 5.3 | 4.6 | 7.2 | 10.4 | 2.5 |
| 75,001 to 100,000 | 4.2 | 8.9 | 0.3 | 2.8 | 3.7 | 4.8 | 4.1 | 1.5 | 7.6 | 7.5 | 4.9 |
| <i>Very Large</i> | | | | | | | | | | | |
| > 100,000 | 42.9 | 37.4 | 59.3 | 55.7 | 36.5 | 31.2 | 36.4 | 40.7 | 35.7 | 51.5 | 26.7 |

Table B3. Average Water Production^a and Design Capacity of Community Water Systems

| Water Source | EPA Region Number with Regional Headquarters | | | | | | | | | | |
|-------------------------------|--|-------------|---------------|-------------|--------------|--------------|-------------|-------------|-----------------|----------------|---------------|
| | Nation | 1 Boston | 2 New York | 3 Phila. | 4 Atlanta | 5 Chicago | 6 Dallas | 7 Denver | 8 Kans. City | 9 San Fran. | 10 Seattle |
| | | | | | | % | | | | | |
| Daily Production (1,000 gal.) | 714 | 444 | 1,005 | 562 | 610 | 621 | 565 | 381 | 428 | 3,147 | 325 |
| Design Capacity (1,000 gal.) | 1,875 | 1,107 | 1,916 | 1,304 | 1,267 | 1,342 | 1,745 | 1,250 | 1,110 | 10,143 | 1,075 |
| Retail Population | 4,214 | 3,088 | 5,945 | 4,483 | 4,204 | 4,309 | 3,183 | 2,637 | 2,772 | 12,468 | 1,722 |
| Hookups | 1,246 | 803 | 1,362 | 1,262 | 1,420 | 1,339 | 1,018 | 946 | 803 | 3,123 | 560 |
| Retail Population/Hookup | 5 | 5 | 7 | 7 | 4 | 5 | 4 | 4 | 4 | 5 | 7 |
| Daily Production/Capita | 126 | 114 | 114 | 105 | 120 | 102 | 142 | 124 | 135 | 166 | 154 |
| Daily Production/Hookup | 510 | 483 | 564 | 596 | 441 | 424 | 465 | 386 | 492 | 718 | 729 |
| Design Capacity/Capita | 789 | 722 | 641 | 530 | 659 | 545 | 901 | 868 | 982 | 1,192 | 1,233 |
| Design Capacity/Hookup | 2,832 | 2,791 | 2,481 | 2,583 | 2,256 | 2,050 | 2,919 | 2,619 | 3,416 | 4,359 | 4,609 |

^a Water production is equivalent to average daily flow.

water systems in the South tend to have higher water production rates. A similar pattern is evident in design capacity per capita, with the exception of the Kansas City region where design capacity per capita is above the national average.

System Ownership

As is highlighted in the text, ownership of the nation's community water systems is primarily in the hands of the private sector which controls 53% of the systems) and the many local governments across which own a 41% share. The remaining systems are either owned jointly by public and private interests, the Federal and state governments, or Native Americans. All regions, likewise are dominated by the private and local government, and, for the most part are consistent with the pattern at the national level (table B4). However, in the Midwest regions, those whose regional offices are in Chicago and in Kansas City, local government ownership is substantially higher than the national average, 60 and 73%, respectively. In the Dallas and Seattle regions there are substantially higher proportions of systems owned jointly by public and private interests, 11 and 18%, respectively.

Water Treatment

As is seen in table B5, the distribution of systems in the three broad treatment classifications, "treated", "mixed", and "untreated", differs substantially by EPA region. Nationally, 60% of CWS's apply treatment to at least one of their water sources; while one-third do no treatment at all. For water systems in the Boston region, these percentages are nearly reversed, with two-thirds of the systems indicating that their water is "untreated". This region's higher proportions of ground water systems and systems of smaller size may explain most of this difference. At the other end of the spectrum, it is in the New York and Atlanta regions where the lowest proportions of untreated systems are found, 11 and 19% respectively.

Distribution of CWS's by Primary Water Source

Both the distributions of the number of CWS's by primary water source and the percentage of the water supplied differ substantially by EPA region (tables B6 and B7). The percentage of ground water systems ranges from a low of 72% in the New York region to a high of 89% in the Seattle region. This variation is to be expected, and it has implications for the cost of compliance with EPA regulations, assuming that the level of treatment required for ground water will, in general, always be less than for surface water.

Table B4. Percentage Distribution of Community Water Systems by Ownership

| Ownership Category | EPA Region Number with Regional Headquarters | | | | | | | | | | |
|----------------------|--|-------------|---------------|-------------|--------------|--------------|-------------|-------------|-----------------|----------------|---------------|
| | Nation | 1 Boston | 2 New York | 3 Phila. | 4 Atlanta | 5 Chicago | 6 Dallas | 7 Denver | 8 Kans. City | 9 San Fran. | 10 Seattle |
| | ----- % ----- | | | | | | | | | | |
| Federal Government | 1.0 | 0.1 | 0.4 | 0.9 | 0.7 | 0.3 | 0.7 | 0.3 | 0.7 | 6.0 | 1.5 |
| Private | 52.6 | 76.1 | 55.1 | 62.7 | 62.0 | 38.1 | 56.8 | 26.1 | 48.8 | 53.2 | 48.5 |
| State Government | 1.0 | 0.5 | 1.0 | 0.8 | 0.9 | 1.3 | 0.8 | 0.4 | 0.5 | 4.7 | 0.7 |
| Local Government | 41.2 | 23.3 | 41.8 | 35.5 | 35.9 | 59.5 | 30.2 | 73.1 | 50.0 | 32.9 | 29.7 |
| Mixed public/private | 3.9 | 0.1 | 1.6 | 0.0 | 0.3 | 0.1 | 11.4 | 0.1 | 0.0 | 3.1 | 18.2 |
| Native American | 0.3 | 0.0 | 0.2 | 0.0 | 0.1 | 0.7 | 0.0 | 0.0 | 0.0 | 0.0 | 1.4 |

Table B5. Percentage Distribution of Community Water Systems by Treatment Classification

| Treatment Classification | EPA Region Number with Regional Headquarters | | | | | | | | | | |
|--------------------------|--|-------------|---------------|-------------|--------------|--------------|-------------|-------------|-----------------|----------------|---------------|
| | Nation | 1 Boston | 2 New York | 3 Phila. | 4 Atlanta | 5 Chicago | 6 Dallas | 7 Denver | 8 Kans. City | 9 San Fran. | 10 Seattle |
| | ----- % ----- | | | | | | | | | | |
| Treated | 60.8 | 24.4 | 78.3 | 56.4 | 76.4 | 46.0 | 71.4 | 52.7 | 51.9 | 25.1 | 63.0 |
| Untreated | 32.0 | 65.6 | 10.8 | 35.9 | 19.5 | 46.9 | 27.3 | 41.4 | 39.6 | 38.2 | 34.9 |
| Mixed | 7.2 | 9.9 | 10.8 | 7.7 | 4.2 | 7.1 | 1.3 | 5.9 | 8.5 | 36.7 | 2.1 |

Note: Treated Systems imply that the water from all of a system's sources is subjected to treatment. Untreated systems apply no treatment for any of its water sources. For the system in the mixed treatment classification, water from some sources is treated, while water from others is not.

Table B6. Percentage Distribution of the Number of Community Water Systems by Water Source

| Water Source | EPA Region Number with Regional Headquarters | | | | | | | | | | |
|---------------------------------------|--|-------------|---------------|-------------|--------------|--------------|-------------|-------------|-----------------|----------------|---------------|
| | Nation | 1 Boston | 2 New York | 3 Phila. | 4 Atlanta | 5 Chicago | 6 Dallas | 7 Denver | 8 Kans. City | 9 San Fran. | 10 Seattle |
| | % | | | | | | | | | | |
| Ground, nonpurchased | 78.7 | 85.9 | 71.3 | 77.0 | 79.7 | 81.6 | 74.9 | 78.1 | 75.8 | 83.2 | 85.4 |
| Ground, purchased | 3.2 | 0.4 | 1.0 | 1.4 | 3.8 | 2.6 | 4.0 | 6.1 | 4.5 | 0.6 | 3.9 |
| Surface, nonpurchased | 8.2 | 9.7 | 8.5 | 13.1 | 7.2 | 4.3 | 7.7 | 6.1 | 10.9 | 13.0 | 8.4 |
| Surface, purchased | 9.7 | 3.9 | 19.2 | 8.4 | 8.9 | 11.4 | 13.5 | 9.7 | 8.6 | 2.9 | 2.1 |
| Ground UDI, nonpurchased ^a | 0.1 | 0.0 | 0.0 | 0.1 | 0.4 | 0.0 | 0.0 | 0.0 | 0.2 | 0.2 | 0.1 |
| Ground UDI, purchased ^a | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 |
| Totals | | | | | | | | | | | |
| Ground Water Systems | 81.9 | 86.3 | 72.3 | 78.4 | 83.5 | 84.3 | 78.8 | 84.2 | 80.3 | 83.7 | 89.3 |
| Surface Water Systems ^a | 18.1 | 13.7 | 27.7 | 21.6 | 16.5 | 15.7 | 21.2 | 15.8 | 19.7 | 16.3 | 10.7 |

^aUDI means that the ground water is under the direct influence of surface water. Thus, they are subject to the same regulations as surface water and are included in the surface water system's total.

Table B7. Percentage Distribution of the Water Production by Community Water Systems by Water Source

| Water Source | EPA Region Number with Regional Headquarters | | | | | | | | | | |
|---------------------------------------|--|-------------|---------------|-------------|--------------|--------------|-------------|-------------|-----------------|----------------|---------------|
| | Nation | 1 Boston | 2 New York | 3 Phila. | 4 Atlanta | 5 Chicago | 6 Dallas | 7 Denver | 8 Kans. City | 9 San Fran. | 10 Seattle |
| | % | | | | | | | | | | |
| Ground, nonpurchased | 32.4 | 11.2 | 20.3 | 12.7 | 44.3 | 23.8 | 31.7 | 39.6 | 18.8 | 41.4 | 39.5 |
| Ground, purchased | 0.9 | 0.1 | 0.2 | 0.5 | 1.5 | 0.6 | 0.8 | 1.4 | 0.3 | 0.1 | 6.8 |
| Surface, nonpurchased | 58.4 | 80.6 | 71.4 | 74.4 | 47.2 | 55.2 | 54.6 | 55.0 | 70.1 | 56.9 | 50.1 |
| Surface, purchased | 8.2 | 8.0 | 8.2 | 12.4 | 6.8 | 20.5 | 12.9 | 4.1 | 10.7 | 1.4 | 3.6 |
| Ground UDI, nonpurchased ^a | 0.1 | 0.0 | 0.0 | 0.1 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 |
| Ground UDI, purchased ^a | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Totals | | | | | | | | | | | |
| Ground Water Systems | 33.3 | 11.3 | 20.4 | 13.2 | 45.7 | 24.4 | 32.4 | 41.0 | 19.2 | 41.5 | 46.2 |
| Surface Water Systems ^a | 66.7 | 88.7 | 79.6 | 86.8 | 54.3 | 75.6 | 67.6 | 59.0 | 80.8 | 58.5 | 53.8 |

^aUDI means that the ground water is under the direct influence of surface water. Thus, they are subject to the same regulations as surface water and are included in the surface water system's total.

Perhaps a more surprising result is that in the West, (regions 7, 8, and 9), over 40% of the total water production is from ground water sources. This is substantially above the 33% figure nationally, and it is nearly four times the percentage of water from ground water sources in New England and the Philadelphia region.

APPENDIX C

Relationship Between Population Served and System Flow and Design Capacity

Everyone would agree that there is a high correlation between the population served by a community water system and its average daily flow and design capacity. In an attempt to establish these relationships in a formal way, we use a sample of over 11,000 systems in the *FRDS-II Data Base* to estimate two separate equations, one for average daily flow and one for design capacity. Summary data on the variables used in the estimation appear in table C1. Even though the focus of this study is on small water systems, the 11,000 observations used to estimate the equations include observations from all systems in *FRDS-II* for which measures of output and design capacity are reported, be they large or small. Having this added variability in the data helped to estimate the coefficients in the model with greater precision, and helped improve the ability of the model to provide more accurate predictions of both average design capacity and average daily flow.

Table C1. Variables for Regressions on Average Daily Flow and Design Capacity

| Variable Name | Mean | Standard Deviation | Minimum | Maximum |
|--|-----------|-----------------------|---------|---------------|
| Average Daily Flow (gal./day) | 999,103 | 9,861,350 | 500 | 780,000,000 |
| Design Capacity (gal./day) | 2,551,726 | 21,519,384 | 1,000 | 1,440,000,000 |
| Retail Population | 6,194 | 46,333 | 8 | 3,000,000 |
| Number of Hookups | 1,902 | 11,513 | 1 | 500,000 |
| Dummy Variables: ^a | | | | |
| WSSURF: Surface water=1 | 0.181 | 0.385 | 0 | 1 |
| WSPURCH: Purchase water=1 | 0.074 | 0.262 | 0 | 1 |
| OWNF: Federal government owned=1 | 0.007 | 0.493 | 0 | 1 |
| OWNS: State government owned=1 | 0.008 | 0.090 | 0 | 1 |
| OWNL: Local government owned=1 | 0.481 | 0.500 | 0 | 1 |
| SRVRES: Residential service area=1 | 0.974 | 0.159 | 0 | 1 |
| SRVSRES: Semi-residential service area=1 | 0.017 | 0.128 | 0 | 1 |
| URBAN: Located in MSA=1 | 0.507 | 0.500 | 0 | 1 |
| EPASOUTH: EPA Region 4, 6, or 9=1 | 0.512 | 0.500 | 0 | 1 |
| EPAWEST: EPA Region 5, 6, 7, 8, 9, or 10=1 | 0.471 | 0.500 | 0 | 1 |

^a The means of the dummy variables are the proportions of observations with a value of 1.

For this reason, it is not surprising that the average retail population in the sample is about 6,200, while the number of retail hookups averaged about 1,900. Average design capacity was about 2.6 million gallons per day, supporting an average flow of just under a million gallons per day. The primary water source for about 18% of the water systems in the data set is surface water, and only 7% purchase any water from other systems. Nearly half are owned by local governments, whereas about 97% serve residential areas. About half are in Metropolitan Statistical Areas (MSA), and about half are in EPA regions in the South or the West, but these regional delineations are not mutually exclusive.

The first equation that is estimated is the one for average daily flow, in gallons per day. This measure of output is regressed against the size of the retail population and the number of commercial hookups, as well as a number of dummy variables to control for differences in the primary water source, whether or not the system purchases water from another system, whether or not the system serves residential or semi-residential areas, and whether or not the system is located in a Metropolitan Statistical Area. Dummy variables also account for any differences due to whether or not the system is private, or publicly owned. Finally, differences in average daily flow due to regional location are accounted for by dummy variables for the South and the West.

The second equation that is estimated is for design capacity, again measured in gallons per day. This is regressed on the same variables as in the equation for average daily flow, except that average daily flow is also included as a regressor. The hypothesis here is that expectations about the required average daily flow affect decisions about design capacity, but not *vice versa*.⁹

For estimation purposes, the continuous variables are transformed into their logarithmic form, and the results of the estimation are in table C2. In general, the estimated equations perform quite well, with an R^2 of 0.80 and 0.92 for the equations for design capacity and average daily flow, respectively. The signs on the coefficients of the variables are also as expected, and the t-ratios are high as well.

⁹ Because average daily flow itself is estimated and it also appears as a regressor in the equation for design capacity, it was necessary to purge the variable for average daily flow of any unexplained random component before using it as an explanatory variable in the second regression. This was accomplished by using the predicted values from the average daily flow equation as the regressor in the design flow equation. This is equivalent to an instrumental variable procedure (Judge *et al.*, 1988).

Table C2. Regression Equations for Average Daily Flow and Design Capacity

| Variable | Average Daily Flow | | | Design Capacity | | |
|-----------------------|--------------------|----------------------|---------|-----------------|----------------------|---------|
| | Coefficient | Std Error | t-ratio | Coefficient | Std Error | t-ratio |
| | | R ² =0.92 | | | R ² =0.80 | |
| INTERCEPT | 5.20 | 0.08 | 63.26 | 7.55 | 0.10 | 77.65 |
| PPRODSQ ^a | | | | 0.01 | 0.00 | 12.18 |
| LOGPOP ^a | 0.69 | 0.02 | 41.91 | 0.29 | 0.03 | 9.59 |
| LOGHOOK ^a | 0.10 | 0.02 | 6.07 | 0.23 | 0.02 | 11.41 |
| WSSURF | 0.20 | 0.02 | 11.03 | -0.11 | 0.03 | -3.92 |
| WSPURCH | -0.23 | 0.02 | -9.25 | -0.22 | 0.04 | -6.01 |
| OWNF | 0.54 | 0.07 | 7.95 | 0.41 | 0.10 | 4.19 |
| OWNS | 0.48 | 0.07 | 7.19 | 0.56 | 0.10 | 5.85 |
| OWNL | 0.25 | 0.01 | 16.92 | 0.13 | 0.02 | 6.53 |
| SRVRES | -0.12 | 0.06 | -2.07 | -0.20 | 0.09 | -2.39 |
| SRVSRES | 0.21 | 0.08 | 2.74 | -0.27 | 0.11 | -2.54 |
| URBAN | 0.03 | 0.01 | 2.46 | 0.12 | 0.02 | 7.26 |
| EPASOUTH | 0.07 | 0.01 | 5.93 | 0.06 | 0.02 | 3.70 |
| EPAWEST | 0.17 | 0.01 | 14.70 | 0.40 | 0.02 | 23.44 |
| LPOPHOOK ^a | 0.02 | 0.00 | 13.68 | | | |

^a The variables used in the regressions are all defined in Table1, except for:

PPRODSQ = $[\log(\text{average daily flow})]^2$

LOGPOP = $\log(\text{retail population})$

LOGHOOK = $\log(\text{number of hookups})$

LPOPHOOK = $\log(\text{retail population}) \times \log(\text{number of hookups})$.

Because the continuous variables in the equations are specified in logarithmic form, the coefficients on these variables can be interpreted as elasticities -- that is, they reflect the percentage change in the dependent variable as the independent variable changes by one percent. For example, as the retail population increases by one percent, design capacity increases by 0.29 percent. Similarly, for a one percent increase in the number of hookups, design capacity increases by 0.23 percent. The situation is not quite that simple for the effect of average daily flow on design capacity, because it is the square of the logarithm of average daily flow that appears in this equation. Thus, the elasticity of design capacity with respect to average daily production is not constant. It is twice the value of the coefficient times the logarithm of the variable, $0.02 * \ln(\text{average daily flow})$, in this case. By examining the coefficients on the dummy variables, it is not surprising that the design capacity is higher for

systems in the South and the West and for those in urban areas. Compared with systems that serve non-residential areas, systems that serve residential and semi-residential areas have smaller design capacities. The design capacities of private systems are generally smaller than systems owned by the government, and are smaller for systems that purchase water and rely primarily on surface rather than ground water.

In terms of the effects of the dummy variables, the story is about the same for the equation to predict average daily flow as it is for design capacity. The two exceptions are: the average daily flow is higher for surface water systems than for ground water systems, and average daily flow is also higher if the system serves a semi-residential area. Similarly, as both retail population and the number of hookups increase, the average daily flow rises as well. Because of the cross product term (the product of the logarithm of population and the logarithm of hookups), the elasticities of the average daily flow are again not constant. For each variable, they depend on the level of the other variable in the cross product term. That is, the elasticity of average daily flow with respect to retail population is $0.69 + 0.02 * \ln(\text{number of hookups})$. For the number of hookups, the elasticity of average daily production is $0.10 + 0.02 * \ln(\text{retail population})$.¹⁰

¹⁰ These elasticities are essentially the logarithmic derivatives of a function of the general form $\ln y = \ln a + b \ln x + c (\ln x)^2 + d [(\ln x) (\ln z)] + e (\ln z)^2 + f \ln z$. For this function we have $\partial \ln y / \partial \ln x = b + 2 c (\ln x) + d (\ln z)$, and $\partial \ln y / \partial \ln z = f + 2 e (\ln z) + d (\ln x)$. In the estimated functions above, not all the terms in this general expression are present.

APPENDIX D

Summary Tables for General Water Treatment Objectives of Community Water Systems

Table D1. General Treatment Objectives of Very Small Community Water Systems^a

| Treatment Objective | Obj. Code | Single Treatment | | Multiple Treatments | |
|--|-----------|------------------|------------|---------------------|------------|
| | | Systems | Percentage | Systems | Percentage |
| Surface Water Systems^c | | | | | |
| Additional Treatment Elsewhere | A | 0 | 0.0 | 0 | 0.0 |
| Disinfection By-Product Control | B | 0 | 0.0 | 14 | 0.9 |
| Corrosion Control | C | 1 | 0.1 | 91 | 5.7 |
| Disinfection | D | 218 | 13.7 | 688 | 43.2 |
| Dechlorination | E | 0 | 0.0 | 3 | 0.2 |
| Iron Removal | F | 4 | 0.3 | 44 | 2.8 |
| Inorganics Removal | I | 0 | 0.0 | 24 | 1.5 |
| Manganese Removal | M | 0 | 0.0 | 8 | 0.5 |
| No Treatment ^b | N | 777 | 48.8 | 1,159 | 72.8 |
| Organics Removal | O | 0 | 0.0 | 44 | 2.8 |
| Particulate Removal | P | 57 | 3.6 | 512 | 32.2 |
| Radionuclides Removal | R | 0 | 0.0 | 15 | 0.9 |
| Softening | S | 1 | 0.1 | 62 | 3.9 |
| Taste/Odor Control | T | 1 | 0.1 | 59 | 3.7 |
| Other (Process Fluoridation) | Z | 1 | 0.1 | 41 | 2.6 |
| Ground Water Systems^d | | | | | |
| Additional Treatment Elsewhere | A | 0 | 0.0 | 0 | 0.0 |
| Disinfection By-Product Control | B | 4 | 0.0 | 27 | 0.1 |
| Corrosion Control | C | 40 | 0.2 | 748 | 3.6 |
| Disinfection | D | 7,196 | 34.7 | 9,777 | 47.2 |
| Dechlorination | E | 1 | 0.0 | 12 | 0.1 |
| Iron Removal | F | 84 | 0.4 | 1,057 | 5.1 |
| Inorganics Removal | I | 13 | 0.1 | 120 | 0.6 |
| Manganese Removal | M | 6 | 0.0 | 388 | 1.9 |
| No Treatment ^b | N | 9,984 | 48.2 | 15,553 | 75.1 |
| Organics Removal | O | 6 | 0.0 | 130 | 0.6 |
| Particulate Removal | P | 75 | 0.4 | 361 | 1.7 |
| Radionuclides Removal | R | 7 | 0.0 | 45 | 0.2 |
| Softening | S | 100 | 0.5 | 549 | 2.7 |
| Taste/Odor Control | T | 29 | 0.1 | 447 | 2.2 |
| Other (Process Fluoridation) | Z | 32 | 0.2 | 514 | 2.5 |

^a Frequencies exclude those system which apply no treatment themselves, but purchase treated water, since unable to tie specific treatment objective to water utilized; i.e. systems with treatment objective=N (no treatment) and treatment process = 996 (treatment applied by seller).

^b For sole treatments, no treatment implies no treatment at all source or plant locations. For the general multiple classification, no treatment implies that the system applies no treatment to at least one source or plant location and may be in addition to other treatments.

^c total systems = 1,591

^d total systems = 20,708

Table D2. General Treatment Objectives of Small Community Water Systems^a

| Treatment Objective | Obj. Code | Single Treatment | | Multiple Treatments | |
|------------------------------------|-----------|------------------|------------|---------------------|------------|
| | | Systems | Percentage | Systems | Percentage |
| Surface Water Systems ^c | | | | | |
| Additional Treatment Elsewhere | A | 0 | 0.0 | 2 | 0.1 |
| Disinfection By-Product Control | B | 0 | 0.0 | 61 | 3.0 |
| Corrosion Control | C | 4 | 0.2 | 400 | 19.9 |
| Disinfection | D | 356 | 17.7 | 1,364 | 67.9 |
| Dechlorination | E | 0 | 0.0 | 0 | 0.0 |
| Iron Removal | F | 0 | 0.0 | 148 | 7.4 |
| Inorganics Removal | I | 0 | 0.0 | 62 | 3.1 |
| Manganese Removal | M | 0 | 0.0 | 32 | 1.6 |
| No Treatment ^b | N | 443 | 22.0 | 1,248 | 62.1 |
| Organics Removal | O | 0 | 0.0 | 98 | 4.9 |
| Particulate Removal | P | 35 | 1.7 | 1,008 | 50.1 |
| Radionuclides Removal | R | 0 | 0.0 | 18 | 0.9 |
| Softening | S | 5 | 0.2 | 236 | 11.7 |
| Taste/Odor Control | T | 0 | 0.0 | 231 | 11.5 |
| Other (Process Fluoridation) | Z | 1 | 0.0 | 1,068 | 53.1 |
| Ground Water Systems ^d | | | | | |
| Additional Treatment Elsewhere | A | 0 | 0.0 | 0 | 0.0 |
| Disinfection By-Product Control | B | 0 | 0.0 | 10 | 0.1 |
| Corrosion Control | C | 18 | 0.3 | 760 | 10.7 |
| Disinfection | D | 2,630 | 36.9 | 4,956 | 69.6 |
| Dechlorination | E | 0 | 0.0 | 1 | 0.0 |
| Iron Removal | F | 22 | 0.3 | 1,043 | 14.6 |
| Inorganics Removal | I | 0 | 0.0 | 58 | 0.8 |
| Manganese Removal | M | 1 | 0.0 | 196 | 2.8 |
| No Treatment ^b | N | 1,499 | 21.0 | 3,818 | 53.6 |
| Organics Removal | O | 0 | 0.0 | 161 | 2.3 |
| Particulate Removal | P | 3 | 0.0 | 259 | 3.6 |
| Radionuclides Removal | R | 0 | 0.0 | 12 | 0.2 |
| Softening | S | 22 | 0.3 | 376 | 5.3 |
| Taste/Odor Control | T | 5 | 0.1 | 389 | 5.5 |
| Other (Process Fluoridation) | Z | 38 | 0.5 | 1,017 | 14.3 |

^a Frequencies exclude those system which apply no treatment themselves, but purchase treated water, since unable to tie specific treatment objective to water utilized; i.e. systems with treatment objective=N (no treatment) and treatment process = 996 (treatment applied by seller).

^b For sole treatments, no treatment implies no treatment at all source or plant locations. For the general multiple classification, no treatment implies that the system applies no treatment to at least one source or plant location and may be in addition to other treatments.

^c total systems = 2,010

^d total systems = 7,124

Table D3. General Treatment Objectives of Medium Community Water Systems^a

| Treatment Objective | Obj. Code | Single Treatment | | Multiple Treatments | |
|--|-----------|------------------|------------|---------------------|------------|
| | | Systems | Percentage | Systems | Percentage |
| Surface Water Systems^c | | | | | |
| Additional Treatment Elsewhere | A | 0 | 0.0 | 1 | 0.1 |
| Disinfection By-Product Control | B | 0 | 0.0 | 55 | 4.8 |
| Corrosion Control | C | 1 | 0.1 | 392 | 33.9 |
| Disinfection | D | 155 | 13.4 | 882 | 76.4 |
| Dechlorination | E | 0 | 0.0 | 2 | 0.2 |
| Iron Removal | F | 0 | 0.0 | 128 | 11.1 |
| Inorganics Removal | I | 0 | 0.0 | 67 | 5.8 |
| Manganese Removal | M | 0 | 0.0 | 42 | 3.6 |
| No Treatment ^b | N | 151 | 13.1 | 592 | 51.3 |
| Organics Removal | O | 0 | 0.0 | 104 | 9.0 |
| Particulate Removal | P | 27 | 2.3 | 728 | 63.0 |
| Radionuclides Removal | R | 0 | 0.0 | 16 | 1.4 |
| Softening | S | 1 | 0.1 | 133 | 11.5 |
| Taste/Odor Control | T | 0 | 0.0 | 244 | 21.1 |
| Other (Process Fluoridation) | Z | 1 | 0.1 | 318 | 27.5 |
| Ground Water Systems^d | | | | | |
| Additional Treatment Elsewhere | A | 0 | 0.0 | 0 | 0.0 |
| Disinfection By-Product Control | B | 0 | 0.0 | 7 | 0.4 |
| Corrosion Control | C | 5 | 0.3 | 248 | 14.6 |
| Disinfection | D | 516 | 30.4 | 1,274 | 74.9 |
| Dechlorination | E | 0 | 0.0 | 0 | 0.0 |
| Iron Removal | F | 3 | 0.2 | 308 | 18.1 |
| Inorganics Removal | I | 0 | 0.0 | 19 | 1.1 |
| Manganese Removal | M | 0 | 0.0 | 56 | 3.3 |
| No Treatment ^b | N | 230 | 13.5 | 889 | 52.3 |
| Organics Removal | O | 0 | 0.0 | 57 | 3.4 |
| Particulate Removal | P | 1 | 0.1 | 124 | 7.3 |
| Radionuclides Removal | R | 0 | 0.0 | 5 | 0.3 |
| Softening | S | 2 | 0.1 | 125 | 7.4 |
| Taste/Odor Control | T | 5 | 0.3 | 145 | 8.5 |
| Other (Process Fluoridation) | Z | 12 | 0.7 | 383 | 22.5 |

^a Frequencies exclude those system which apply no treatment themselves, but purchase treated water, since unable to tie specific treatment objective to water utilized; i.e. systems with treatment objective=N (no treatment) and treatment process = 996 (treatment applied by seller).

^b For sole treatments, no treatment implies no treatment at all source or plant locations. For the general multiple classification, no treatment implies that the system applies no treatment to at least one source or plant location and may be in addition to other treatments.

^c total systems = 1,155

^d total systems = 1,700

Table D4. General Treatment Objectives of Large Community Water Systems^a

| Treatment Objective | Obj. Code | Single Treatment | | Multiple Treatments | |
|--|-----------|------------------|------------|---------------------|------------|
| | | Systems | Percentage | Systems | Percentage |
| Surface Water Systems^c | | | | | |
| Additional Treatment Elsewhere | A | 0 | 0.0 | 4 | 0.3 |
| Disinfection By-Product Control | B | 1 | 0.1 | 121 | 10.4 |
| Corrosion Control | C | 1 | 0.1 | 465 | 40.1 |
| Disinfection | D | 142 | 12.2 | 896 | 77.2 |
| Dechlorination | E | 0 | 0.0 | 4 | 0.3 |
| Iron Removal | F | 0 | 0.0 | 174 | 15.0 |
| Inorganics Removal | I | 0 | 0.0 | 59 | 5.1 |
| Manganese Removal | M | 0 | 0.0 | 63 | 5.4 |
| No Treatment ^b | N | 139 | 12.0 | 619 | 53.3 |
| Organics Removal | O | 1 | 0.1 | 110 | 9.5 |
| Particulate Removal | P | 28 | 2.4 | 749 | 64.5 |
| Radionuclides Removal | R | 0 | 0.0 | 9 | 0.8 |
| Softening | S | 0 | 0.0 | 141 | 12.1 |
| Taste/Odor Control | T | 0 | 0.0 | 312 | 26.9 |
| Other (Process Fluoridation) | Z | 2 | 0.2 | 378 | 32.6 |
| Ground Water Systems^d | | | | | |
| Additional Treatment Elsewhere | A | 0 | 0.0 | 0 | 0.0 |
| Disinfection By-Product Control | B | 0 | 0.0 | 6 | 0.6 |
| Corrosion Control | C | 2 | 0.2 | 221 | 21.6 |
| Disinfection | D | 193 | 18.8 | 723 | 70.6 |
| Dechlorination | E | 0 | 0.0 | 1 | 0.1 |
| Iron Removal | F | 0 | 0.0 | 185 | 18.1 |
| Inorganics Removal | I | 0 | 0.0 | 24 | 2.3 |
| Manganese Removal | M | 0 | 0.0 | 27 | 2.6 |
| No Treatment ^b | N | 76 | 7.4 | 689 | 67.3 |
| Organics Removal | O | 1 | 0.1 | 70 | 6.8 |
| Particulate Removal | P | 0 | 0.0 | 128 | 12.5 |
| Radionuclides Removal | R | 0 | 0.0 | 3 | 0.3 |
| Softening | S | 0 | 0.0 | 122 | 11.9 |
| Taste/Odor Control | T | 1 | 0.1 | 153 | 14.9 |
| Other (Process Fluoridation) | Z | 3 | 0.3 | 281 | 27.4 |

^a Frequencies exclude those system which apply no treatment themselves, but purchase treated water, since unable to tie specific treatment objective to water utilized; i.e. systems with treatment objective=N (no treatment) and treatment process = 996 (treatment applied by seller).

^b For sole treatments, no treatment implies no treatment at all source or plant locations. For the general multiple classification, no treatment implies that the system applies no treatment to at least one source or plant location and may be in addition to other treatments.

^c total systems = 1,161

^d total systems = 1,024

Table D5. General Treatment Objectives of Very Large Community Water Systems^a

| Treatment Objective | Obj. Code | Single Treatment | | Multiple Treatments | |
|------------------------------------|-----------|------------------|------------|---------------------|------------|
| | | Systems | Percentage | Systems | Percentage |
| Surface Water Systems ^c | | | | | |
| Additional Treatment Elsewhere | A | 0 | 0.0 | 0 | 0.0 |
| Disinfection By-Product Control | B | 0 | 0.0 | 21 | 12.7 |
| Corrosion Control | C | 0 | 0.0 | 84 | 50.6 |
| Disinfection | D | 5 | 3.0 | 140 | 84.3 |
| Dechlorination | E | 0 | 0.0 | 2 | 1.2 |
| Iron Removal | F | 0 | 0.0 | 25 | 15.1 |
| Inorganics Removal | I | 0 | 0.0 | 12 | 7.2 |
| Manganese Removal | M | 0 | 0.0 | 7 | 4.2 |
| No Treatment ^b | N | 6 | 3.6 | 100 | 60.2 |
| Organics Removal | O | 0 | 0.0 | 28 | 16.9 |
| Particulate Removal | P | 6 | 3.6 | 140 | 84.3 |
| Radionuclides Removal | R | 0 | 0.0 | 2 | 1.2 |
| Softening | S | 0 | 0.0 | 25 | 15.1 |
| Taste/Odor Control | T | 0 | 0.0 | 70 | 42.2 |
| Other (Process Fluoridation) | Z | 0 | 0.0 | 80 | 48.2 |
| Ground Water Systems ^d | | | | | |
| Additional Treatment Elsewhere | A | 0 | 0.0 | 0 | 0.0 |
| Disinfection By-Product Control | B | 0 | 0.0 | 0 | 0.0 |
| Corrosion Control | C | 0 | 0.0 | 19 | 27.9 |
| Disinfection | D | 8 | 11.8 | 39 | 57.4 |
| Dechlorination | E | 0 | 0.0 | 0 | 0.0 |
| Iron Removal | F | 0 | 0.0 | 7 | 10.3 |
| Inorganics Removal | I | 0 | 0.0 | 0 | 0.0 |
| Manganese Removal | M | 0 | 0.0 | 0 | 0.0 |
| No Treatment ^b | N | 1 | 1.5 | 58 | 85.3 |
| Organics Removal | O | 0 | 0.0 | 5 | 7.4 |
| Particulate Removal | P | 0 | 0.0 | 15 | 22.1 |
| Radionuclides Removal | R | 0 | 0.0 | 0 | 0.0 |
| Softening | S | 0 | 0.0 | 11 | 16.2 |
| Taste/Odor Control | T | 0 | 0.0 | 12 | 17.6 |
| Other (Process Fluoridation) | Z | 0 | 0.0 | 17 | 25.0 |

^a Frequencies exclude those system which apply no treatment themselves, but purchase treated water, since unable to tie specific treatment objective to water utilized; i.e. systems with treatment objective=N (no treatment) and treatment process = 996 (treatment applied by seller).

^b For sole treatments, no treatment implies no treatment at all source or plant locations. For the general multiple classification, no treatment implies that the system applies no treatment to at least one source or plant location and may be in addition to other treatments.

^c total systems = 166

^d total systems = 68

APPENDIX E

Summary Tables for CWS's Multiple Water Treatment Objectives

| Table E1. Multiple Treatment Objectives Found in Medium Community Water Systems | | | | |
|---|----------------------|---------|-----------------------|---------|
| Treatment Objectives ^a | Ground Water Systems | | Surface Water Systems | |
| | Number | Percent | Number | Percent |
| BCDFIMOP | | | 9 | 0.92 |
| BCDFPT | | | 6 | 0.61 |
| C | 5 | 0.38 | | |
| CD | 80 | 6.11 | 30 | 3.06 |
| CDF | 39 | 2.98 | | |
| CDFIMOPT | | | 6 | 0.61 |
| CDFM | 9 | 0.69 | | |
| CDFMOP | 5 | 0.38 | | |
| CDFO | 6 | 0.46 | | |
| CDFP | 6 | 0.46 | 8 | 0.81 |
| CDFPST | | | 8 | 0.81 |
| CDFTP | | | 16 | 1.63 |
| CDFS | 9 | 0.69 | | |
| CDO | 20 | 1.53 | | |
| CDOPT | | | 11 | 1.12 |
| CDP | 6 | 0.46 | 124 | 12.63 |
| CDPS | 7 | 0.53 | 31 | 3.16 |
| CDPST | | | 12 | 1.22 |
| CDPT | | | 66 | 6.72 |
| CDT | 7 | 0.53 | | |
| D | 676 | 51.60 | 187 | 19.04 |
| DF | 108 | 8.24 | | |
| DFM | 7 | 0.53 | | |
| DFP | 16 | 1.22 | 6 | 0.61 |
| DFPS | 8 | 0.61 | | |
| DFPT | | | 10 | 1.02 |
| DFS | 19 | 1.45 | | |
| DFT | 11 | 0.84 | | |
| DM | 9 | 0.69 | | |
| DO | 10 | 0.76 | | |
| DOP | | | 13 | 1.32 |
| DOPT | | | 8 | 0.81 |
| DP | 25 | 1.91 | 153 | 15.58 |
| DPS | 7 | 0.53 | 29 | 2.95 |
| DPST | | | 5 | 0.51 |
| DPT | 6 | 0.46 | 39 | 3.97 |
| DS | 24 | 1.83 | | |
| DST | 7 | 0.53 | | |
| DT | 63 | 4.81 | | |
| F | 9 | 0.69 | | |
| FIMOPT | | | 5 | 0.51 |
| P | | | 64 | 6.52 |
| PT | | | 5 | 0.51 |
| S | 6 | 0.46 | | |
| T | 8 | 0.61 | | |

^aEach letter in this column represents a particular treatment objective from table 5, e.g. CD is corrosion control combined with disinfection.

| Treatment Objectives ^a | Ground Water Systems | | Surface Water Systems | |
|-----------------------------------|----------------------|---------|-----------------------|---------|
| | Number | Percent | Number | Percent |
| BCDFIMO | | | 5 | 0.50 |
| BCDFIMOP | | | 15 | 1.50 |
| BCDP | | | 8 | 0.80 |
| BCDPT | | | 12 | 1.20 |
| BCFPST | | | 6 | 0.60 |
| BDPS | | | 5 | 0.50 |
| BDPT | | | 16 | 1.60 |
| CD | 56 | 7.58 | 20 | 2.01 |
| CDF | 30 | 4.06 | | |
| CDFMP | | | 7 | 0.70 |
| CDFO | 8 | 1.08 | | |
| CDFP | 10 | 1.35 | 12 | 1.20 |
| CDFPST | | | 18 | 1.81 |
| CDFPT | | | 20 | 2.01 |
| CDFS | 5 | 0.68 | | |
| CDIPST | 5 | 0.68 | | |
| CDO | 9 | 1.22 | | |
| CDOP | | | 10 | 1.00 |
| CDOPT | | | 13 | 1.30 |
| CDP | | | 110 | 11.03 |
| CDPS | 8 | 1.08 | 24 | 2.41 |
| CDPST | 6 | 0.81 | 17 | 1.71 |
| CDPT | | | 79 | 7.92 |
| CDT | 15 | 2.03 | | |
| D | 273 | 36.94 | 167 | 16.75 |
| DF | 40 | 5.41 | 6 | 0.60 |
| DFP | | | 6 | 0.60 |
| DFPT | | | 9 | 0.90 |
| DFS | 17 | 2.30 | | |
| DFT | 6 | 0.81 | | |
| DO | 18 | 2.44 | | |
| DP | 11 | 1.49 | 99 | 9.93 |
| DPS | 15 | 2.03 | 21 | 2.11 |
| DPST | 10 | 1.35 | 7 | 0.70 |
| DPT | | | 44 | 4.41 |
| DS | 16 | 2.17 | | |
| DT | 55 | 7.44 | | |
| P | | | 85 | 8.53 |

^aEach letter in this column represents a particular treatment objective from table 5, e.g. CD is corrosion control combined with disinfection.

| Treatment Objectives ^a | Ground Water Systems | | Surface Water Systems | |
|-----------------------------------|----------------------|---------|-----------------------|---------|
| | Number | Percent | Number | Percent |
| CDOPT | | | 6 | 3.80 |
| CDP | | | 22 | 13.92 |
| CDPT | | | 15 | 9.49 |
| D | 12 | 28.57 | 7 | 4.43 |
| DP | | | 16 | 10.13 |
| DPT | | | 11 | 6.96 |
| P | | | 18 | 11.39 |

^aEach letter in this column represents a particular treatment objective from table 5, e.g. CD is corrosion control combined with disinfection.

APPENDIX F

Summary Tables for CWS's Multiple Treatment Processes

Exhibit F1. Codes for Water Treatment Processes

| Treatment Code | Process Name | Types Included |
|----------------|-----------------------|---|
| A | Aeration | Cascade Diffused Packed Tower Slat Tray Spray |
| C | Chlorination | Chloramines Chlorine Dioxide Pre- and Post-Gaseous Chlorination Pre- and Post-Hypochlorination |
| E | Ion Exchange | Activated Alumina Ion Exchange |
| F | Filtration | Cartridge Diatomaceous Earth Greensand Pressure Sand Rapid Sand Slow Sand Ultrafiltration |
| H | pH Adjustment | Pre-and Post-pH Adjustment |
| I | Inhibitors | Bimetallic Phosphate Hexametaphosphate Orthophosphate Polyphosphate Silicate |
| L | Lime-Soda Ash | |
| N | Activated Carbon | Granular Powered |
| O | Ozonation | Pre-and Post-Ozonation |
| P | Permanganate | |
| R | Reverse Osmosis | |
| U | Ultraviolet Radiation | |

| Processes | Ground Water Systems | | Surface Water Systems | |
|-----------|----------------------|---------|-----------------------|---------|
| | Number | Percent | Number | Percent |
| AC | 233 | 2.27 | | |
| ACE | 5 | 0.05 | | |
| ACEF | 7 | 0.07 | | |
| ACEP | 24 | 0.23 | | |
| ACF | 56 | 0.55 | | |
| ACFH | 13 | 0.13 | | |
| ACFHINOP | 5 | 0.05 | | |
| ACFL | 5 | 0.05 | | |
| ACH | 24 | 0.23 | | |
| ACHR | 12 | 0.12 | | |
| AF | 13 | 0.13 | | |
| AFHP | 9 | 0.09 | | |
| AFP | 57 | 0.56 | 8 | 1.01 |
| AP | 46 | 0.45 | | |
| C | 7984 | 77.89 | 251 | 31.57 |
| CE | 246 | 2.40 | | |
| CEF | 36 | 0.35 | | |
| CEH | 10 | 0.10 | | |
| CEI | 9 | 0.09 | | |
| CF | 267 | 2.60 | 278 | 34.97 |
| CFH | 30 | 0.29 | 41 | 5.16 |
| CFHL | | | 5 | 0.63 |
| CFHN | | | 9 | 1.13 |
| CFHNO | 40 | 0.39 | | |
| CFHP | 5 | 0.05 | | |
| CFI | 5 | 0.05 | 5 | 0.63 |
| CFL | 11 | 0.11 | 14 | 1.76 |
| CFN | 5 | 0.05 | 10 | 1.26 |
| CFP | 12 | 0.12 | | |
| CH | 374 | 3.65 | 7 | 0.88 |
| CHI | 26 | 0.25 | | |
| CI | 142 | 1.39 | | |
| CL | 19 | 0.19 | | |
| CN | 19 | 0.19 | | |
| CR | 8 | 0.08 | | |
| E | 110 | 1.07 | | |
| EF | 8 | 0.08 | | |
| EFP | 10 | 0.10 | | |
| EP | 8 | 0.08 | | |
| F | 108 | 1.05 | 94 | 11.82 |
| FH | | | 5 | 0.63 |
| H | 41 | 0.40 | | |
| HP | 9 | 0.09 | | |
| I | 10 | 0.10 | | |
| L | 25 | 0.24 | | |
| N | 9 | 0.09 | | |
| O | 5 | 0.05 | | |
| R | 5 | 0.05 | | |
| U | 18 | 0.18 | | |

^aThe letters refer to combinations of treatment processes given in Exhibit F1.

| Processes | Ground Water Systems | | Surface Water Systems | |
|-----------|----------------------|---------|-----------------------|---------|
| | Number | Percent | Number | Percent |
| AC | | | 7 | 0.46 |
| ACEFI | 5 | 0.10 | | |
| ACEFIP | | | 7 | 0.46 |
| ACF | 122 | 2.38 | 12 | 0.79 |
| ACFH | 53 | 1.04 | 9 | 0.59 |
| ACFHL | 9 | 0.18 | | |
| ACFI | 12 | 0.23 | | |
| ACFL | 19 | 0.37 | | |
| ACH | 81 | 1.58 | | |
| ACHR | 11 | 0.21 | | |
| ACI | 11 | 0.21 | | |
| ACL | 6 | 0.12 | | |
| AF | 28 | 0.55 | | |
| AFHP | 24 | 0.47 | 29 | 1.91 |
| AFP | 47 | 0.92 | 16 | 1.05 |
| AP | 15 | 0.29 | | |
| C | 3394 | 66.32 | 423 | 27.85 |
| CE | 23 | 0.45 | | |
| CEF | 43 | 0.84 | 7 | 0.46 |
| CEH | 8 | 0.16 | | |
| CEI | 5 | 0.10 | | |
| CF | 165 | 3.22 | 332 | 21.86 |
| CFH | 47 | 0.92 | 152 | 10.01 |
| CFHI | | | 18 | 1.19 |
| CFHIN | | | 5 | 0.33 |
| CFHL | 8 | 0.16 | 27 | 1.78 |
| CFHLN | | | 9 | 0.59 |
| CFHN | | | 36 | 2.37 |
| CFHNO | 6 | 0.12 | | |
| CFHP | 17 | 0.33 | | |
| CFI | 11 | 0.21 | 40 | 2.63 |
| CFIL | | | 10 | 0.66 |
| CFIN | | | 6 | 0.40 |
| CFL | 42 | 0.82 | 39 | 2.57 |
| CFLN | | | 20 | 1.32 |
| CFN | | | 29 | 1.91 |
| CFP | 18 | 0.35 | | |
| CH | 215 | 4.20 | 20 | 1.32 |
| CHI | 24 | 0.47 | 5 | 0.33 |
| CHL | | | 5 | 0.33 |
| CI | 132 | 2.58 | 11 | 0.72 |
| CL | 43 | 0.84 | 9 | 0.59 |
| CR | 5 | 0.10 | | |
| ECAP | 11 | 0.21 | | |
| EFP | 5 | 0.10 | | |
| F | 12 | 0.23 | 124 | 8.16 |
| FHNP | | | 11 | 0.72 |
| FNP | | | 5 | 0.33 |
| H | 13 | 0.25 | 11 | 0.72 |
| I | 17 | 0.33 | | |
| L | 39 | 0.76 | 5 | 0.33 |

^aThe letters refer to combinations of treatment processes given in Exhibit F1.

| Processes | Ground Water Systems | | Surface Water Systems | |
|-----------|----------------------|---------|-----------------------|---------|
| | Number | Percent | Number | Percent |
| AC | 83 | 6.36 | | |
| ACE | 5 | 0.38 | | |
| ACEFIP | | | 10 | 1.02 |
| ACF | 46 | 3.52 | 7 | 0.71 |
| ACFH | 26 | 1.99 | 11 | 1.12 |
| ACFI | 14 | 1.07 | | |
| ACFL | 11 | 0.84 | | |
| ACH | 28 | 2.14 | | |
| AFHP | | | 21 | 2.14 |
| AFP | 8 | 0.61 | 7 | 0.71 |
| C | 752 | 57.58 | 194 | 19.80 |
| CE | 12 | 0.92 | | |
| CEF | 6 | 0.46 | | |
| CF | 48 | 3.68 | 168 | 17.14 |
| CFH | 17 | 1.30 | 128 | 13.06 |
| CFHI | | | 25 | 2.55 |
| CFHIN | | | 13 | 1.33 |
| CFHL | 6 | 0.46 | 14 | 1.43 |
| CFHLN | | | 6 | 0.61 |
| CFHN | | | 35 | 3.57 |
| CFI | | | 33 | 3.37 |
| CFIN | | | 9 | 0.92 |
| CFL | 13 | 1.00 | 17 | 1.73 |
| CFLN | | | 8 | 0.82 |
| CFN | | | 31 | 3.16 |
| CFP | 7 | 0.54 | | |
| CH | 45 | 3.45 | 23 | 2.35 |
| CHI | 8 | 0.61 | 6 | 0.61 |
| CI | 43 | 3.29 | 9 | 0.92 |
| CL | 18 | 1.38 | 9 | 0.92 |
| F | | | 63 | 6.43 |
| FHNP | | | 17 | 1.73 |
| FNP | | | 5 | 0.51 |
| H | | | 6 | 0.61 |
| L | 5 | 0.38 | | |

^aThe letters refer to combinations of treatment processes given in Exhibit F1.

| Processes | Ground Water Systems | | Surface Water Systems | |
|-----------|----------------------|---------|-----------------------|---------|
| | Number | Percent | Number | Percent |
| AC | 76 | 10.30 | 6 | 0.60 |
| ACEFIP | | | 11 | 1.11 |
| ACF | 19 | 2.57 | 19 | 1.91 |
| ACFH | 29 | 3.93 | 12 | 1.21 |
| ACFHI | 6 | 0.81 | | |
| ACFHN | | | 9 | 0.91 |
| ACFI | 9 | 1.22 | | |
| ACFL | 21 | 2.85 | | |
| ACH | 25 | 3.39 | | |
| ACI | 5 | 0.68 | | |
| AFHP | | | 14 | 1.41 |
| AFP | 8 | 1.08 | 6 | 0.60 |
| C | 300 | 40.65 | 178 | 17.91 |
| CE | 5 | 0.68 | | |
| CEFINP | | | 21 | 2.11 |
| CEFLNP | | | 8 | 0.80 |
| CF | 17 | 2.30 | 114 | 11.47 |
| CFH | 11 | 1.49 | 113 | 11.37 |
| CFHI | | | 38 | 3.82 |
| CFHIN | | | 25 | 2.52 |
| CFHL | | | 11 | 1.11 |
| CFHN | | | 45 | 4.53 |
| CFI | | | 23 | 2.31 |
| CFILN | | | 5 | 0.50 |
| CFIN | | | 17 | 1.71 |
| CFL | 19 | 2.57 | 6 | 0.60 |
| CFLN | | | 10 | 1.01 |
| CFN | | | 29 | 2.92 |
| CH | 33 | 4.47 | 13 | 1.31 |
| CI | 21 | 2.85 | 9 | 0.91 |
| CL | 18 | 2.44 | 17 | 1.71 |
| ECAP | | | 6 | 0.60 |
| F | | | 84 | 8.45 |
| FHLP | | | 6 | 0.60 |
| FHNP | | | 22 | 2.21 |
| FNP | | | 8 | 0.80 |

^aThe letters refer to combinations of treatment processes given in Exhibit F1.

| Table F5. Multiple Treatment Processes Found in Very Large Community Water Systems ^a | | | | |
|---|----------------------|---------|-----------------------|---------|
| Processes | Ground Water Systems | | Surface Water Systems | |
| | Number | Percent | Number | Percent |
| ACFH | | | 5 | 3.16 |
| C | 12 | 28.57 | 10 | 6.33 |
| CF | | | 21 | 13.29 |
| CFH | | | 20 | 12.66 |
| CFHI | | | 5 | 3.16 |
| CFHN | | | 11 | 6.96 |
| CFN | | | 7 | 4.43 |
| F | | | 18 | 11.39 |
| FHNP | | | 7 | 4.43 |

^aThe letters refer to combinations of treatment processes given in Exhibit F1.

APPENDIX G

Summary Tables for CWS's Estimated and Actual Treatment Combinations

Table G1. Estimated Treatment Needs and Actual Treatment Combinations Used by Community Water Systems with a Ground Water Source

| Treatment Combination | No. of Treatments | Very Small | | Small | | Medium | | Large | | Very Large | |
|-------------------------------------|-------------------|------------------------|---------------------|-----------|--------|-----------|--------|-----------|--------|------------|--------|
| | | Estimated ^a | Actual ^a | Estimated | Actual | Estimated | Actual | Estimated | Actual | Estimated | Actual |
| No Treatment | 0 | 14.313 | 48.213 | 22.477 | 21.042 | 23.840 | 13.529 | 25.000 | 7.422 | 32.558 | 1.471 |
| Alt. Treatment ^c | 1 | 0.379 | 2.284 | 0.538 | 7.117 | 0.000 | 9.647 | 0.000 | 20.508 | 0.000 | 36.765 |
| Disinfection (DSF) ^d | 1 | 10.363 | 40.125 | 6.543 | 50.379 | 4.941 | 47.706 | 2.592 | 31.445 | 0.000 | 17.647 |
| Corrosion Control (CC) ^e | 1 | 21.784 | 0.449 | 34.135 | 1.081 | 35.414 | 0.706 | 37.207 | 0.586 | 44.186 | 0.000 |
| Ion Exchange (IE) ^f | 1 | 0.792 | 0.666 | 1.536 | 0.154 | 2.341 | 0.000 | 3.763 | 0.000 | 2.326 | 0.000 |
| Aeration (PTA) ^g | 1 | 5.020 | 0.642 | 3.883 | 1.319 | 3.251 | 0.824 | 2.926 | 1.074 | 2.326 | 0.000 |
| Gran. Act. Carbon (GAC) | 1 | 1.640 | 0.058 | 1.174 | 0.000 | 0.607 | 0.000 | 0.502 | 0.000 | 0.000 | 0.000 |
| DSF / CC | 2 | 15.364 | 3.018 | 9.712 | 7.875 | 7.326 | 9.941 | 3.930 | 12.598 | 0.000 | 16.176 |
| DSF / IE | 2 | 0.558 | 1.415 | 0.430 | 0.997 | 0.477 | 1.176 | 0.334 | 0.781 | 0.000 | 0.000 |
| DSF / PTA | 2 | 3.540 | 1.473 | 1.095 | 5.348 | 0.694 | 8.059 | 0.251 | 9.668 | 0.000 | 5.882 |
| DSF / GAC | 2 | 1.159 | 0.121 | 0.323 | 0.098 | 0.130 | 0.059 | 0.000 | 0.293 | 0.000 | 1.471 |
| CC / IE | 2 | 1.178 | 0.019 | 2.279 | 0.028 | 3.511 | 0.000 | 5.518 | 0.000 | 4.651 | 0.000 |
| CC / PTA | 2 | 7.443 | 0.048 | 5.771 | 0.365 | 4.855 | 0.294 | 4.264 | 0.391 | 2.326 | 0.000 |
| CC / GAC | 2 | 2.430 | 0.005 | 1.731 | 0.000 | 0.867 | 0.059 | 0.669 | 0.098 | 0.000 | 0.000 |
| IE / PTA | 2 | 0.271 | 0.010 | 0.254 | 0.056 | 0.303 | 0.059 | 0.334 | 0.000 | 0.000 | 0.000 |
| IE / GAC | 2 | 0.086 | 0.010 | 0.078 | 0.000 | 0.043 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| PTA / GAC | 2 | 0.558 | 0.000 | 0.196 | 0.000 | 0.087 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| DSF / CC / IE | 3 | 0.829 | 0.135 | 0.646 | 0.239 | 0.737 | 0.824 | 0.585 | 0.684 | 0.000 | 0.000 |
| DSF / CC / PTA | 3 | 5.248 | 0.309 | 1.633 | 3.046 | 0.997 | 5.882 | 0.418 | 11.621 | 0.000 | 14.706 |
| DSF / CC / GAC | 3 | 1.717 | 0.212 | 0.489 | 0.140 | 0.173 | 0.176 | 0.084 | 0.684 | 0.000 | 0.000 |
| DSF / IE / GAC | 3 | 0.000 | 0.034 | 0.000 | 0.154 | 0.000 | 0.118 | 0.000 | 0.098 | 0.000 | 0.000 |
| DSF / IE / PTA | 3 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| DSF / PTA / GAC | 3 | 0.395 | 0.014 | 0.049 | 0.028 | 0.000 | 0.118 | 0.000 | 0.488 | 0.000 | 0.000 |
| DSF / PTA / IE | 3 | 0.000 | 0.116 | 0.000 | 0.056 | 0.000 | 0.000 | 0.000 | 0.195 | 0.000 | 0.000 |
| CC / IE / PTA | 3 | 0.401 | 0.000 | 0.381 | 0.028 | 0.477 | 0.000 | 0.585 | 0.000 | 0.000 | 0.000 |
| CC / IE / GAC | 3 | 0.126 | 0.000 | 0.117 | 0.000 | 0.087 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| CC / PTA / GAC | 3 | 0.829 | 0.000 | 0.284 | 0.000 | 0.130 | 0.000 | 0.084 | 0.000 | 0.000 | 0.000 |
| IE / PTA / GAC | 3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| DSF / CC / IE / PTA | 4 | 0.28 | 0.02 | 0.12 | 0.21 | 0.09 | 0.53 | 0.00 | 0.68 | 0.00 | 0.00 |
| DSF / CC / IE / GAC | 4 | 0.09 | 0.02 | 0.03 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| DSF / CC / PTA / GAC | 4 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 | 0.06 | 0.00 | 0.39 | 0.00 | 1.47 |
| Other Combinations ⁱ | | 3.20 | 0.55 | 4.10 | 0.22 | 8.63 | 0.24 | 10.95 | 0.29 | 11.63 | 4.41 |

^aEstimated percentages were calculated from EPA document, Benefits and Costs of the 1986 Amendments to the SDWA (Wade Miller, 1989).

^bActual percentages were obtained from FRDS multiple treatment data search results.

^cThe number of systems using alternative treatments includes those that do not directly affect SDWA treatment requirements, (e.g. fluoride treatment).

^dDisinfection (DSF) includes treatment process codes C, O, and U. (See Exhibit F1.)

^eCorrosion (CC) control includes treatment process codes I, H, L. (See Exhibit F1.)

^fIon exchange (IE) relates to code E, and includes activated both alumina, and anion and cation exchange.

^gAeration (PTA) includes all aeration processes: Cascade, diffused, packed tower, slat spray, and spray aeration.

^hGAC includes both powdered and granulated activated carbon processes.

ⁱThis category includes treatment combinations that are not considered feasible and combinations estimated to affect less than one percent of all systems.

Table G2. Estimated Treatment Needs and Actual Treatment Combinations Used by Community Water Systems with a Surface Water Source

| Treatment Combination | No. of Treatments | Very Small | | Small | | Medium | | Large | | Very Large | |
|-------------------------------------|-------------------|------------------------|---------------------|-----------|--------|-----------|--------|-----------|--------|------------|--------|
| | | Estimated ^a | Actual ^b | Estimated | Actual | Estimated | Actual | Estimated | Actual | Estimated | Actual |
| No Treatment | 0 | 11.615 | 48.837 | 12.486 | 22.040 | 14.965 | 13.074 | 15.107 | 11.972 | 22.318 | 3.614 |
| Alt. Treatment ^c | 1 | 1.988 | 1.194 | 0.502 | 2.388 | 0.000 | 2.078 | 0.000 | 2.412 | 0.000 | 1.205 |
| Filtration (FILT) ^d | 1 | 24.907 | 23.759 | 25.585 | 22.736 | 23.702 | 20.087 | 23.605 | 17.227 | 16.738 | 24.096 |
| Corrosion Control (CC) ^e | 1 | 20.186 | 0.880 | 19.398 | 3.831 | 22.145 | 5.714 | 22.403 | 4.393 | 33.047 | 3.614 |
| Ion Exchange (IE) ^f | 1 | 0.000 | 0.126 | 0.000 | 0.199 | 0.000 | 0.260 | 0.000 | 0.086 | 0.000 | 0.000 |
| Aeration (PTA) ^g | 1 | 0.000 | 0.314 | 0.000 | 0.398 | 0.000 | 0.346 | 0.000 | 0.603 | 0.000 | 0.602 |
| Gran. Act. Carbon (GAC) | 1 | 0.248 | 0.126 | 0.279 | 0.149 | 0.433 | 0.173 | 0.515 | 0.345 | 0.000 | 0.000 |
| FILT / CC | 2 | 36.894 | 5.091 | 38.071 | 15.025 | 35.121 | 20.173 | 34.936 | 18.949 | 24.893 | 19.277 |
| FILT / IE | 2 | 0.186 | 0.251 | 0.056 | 0.348 | 0.000 | 0.260 | 0.000 | 0.000 | 0.000 | 0.000 |
| FILT / PTA | 2 | 0.000 | 0.629 | 0.000 | 1.393 | 0.000 | 1.212 | 0.000 | 2.153 | 0.000 | 3.012 |
| FILT / GAC | 2 | 0.497 | 0.691 | 0.613 | 1.741 | 0.779 | 3.117 | 0.687 | 3.187 | 0.000 | 4.819 |
| CC / IE | 2 | 0.124 | 0.063 | 0.000 | 0.050 | 0.000 | 0.173 | 0.000 | 0.086 | 0.000 | 0.000 |
| CC / PTA | 2 | 0.000 | 0.063 | 0.000 | 0.100 | 0.000 | 0.260 | 0.000 | 0.345 | 0.000 | 0.602 |
| CC / GAC | 2 | 0.435 | 0.063 | 0.446 | 0.050 | 0.692 | 0.606 | 0.773 | 0.947 | 0.000 | 0.602 |
| IE / PTA | 2 | 0.000 | 0.000 | 0.000 | 0.149 | 0.000 | 0.519 | 0.000 | 0.689 | 0.000 | 0.000 |
| IE / GAC | 2 | 0.000 | 0.126 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| PTA / GAC | 2 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| FILT / CC / IE | 3 | 0.248 | 0.000 | 0.167 | 0.199 | 0.000 | 0.606 | 0.000 | 1.981 | 0.000 | 1.205 |
| FILT / CC / PTA | 3 | 0.000 | 0.189 | 0.000 | 2.388 | 0.000 | 3.636 | 0.000 | 3.101 | 0.000 | 4.217 |
| FILT / CC / GAC | 3 | 0.870 | 1.131 | 0.892 | 4.478 | 1.125 | 7.965 | 1.116 | 11.456 | 0.429 | 19.880 |
| FILT / IE / GAC | 3 | 0.000 | 0.063 | 0.000 | 0.100 | 0.000 | 0.000 | 0.000 | 0.172 | 0.000 | 0.602 |
| FILT / PTA / GAC | 3 | 0.000 | 0.063 | 0.000 | 0.100 | 0.000 | 0.173 | 0.000 | 0.258 | 0.000 | 0.602 |
| FILT / PTA / IE | 3 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.086 | 0.000 | 0.000 |
| CC / IE / PTA | 3 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.086 | 0.000 | 0.000 |
| CC / IE / GAC | 3 | 0.000 | 0.000 | 0.000 | 0.100 | 0.000 | 0.000 | 0.000 | 0.086 | 0.000 | 0.000 |
| CC / PTA / GAC | 3 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.086 | 0.000 | 0.000 |
| FILT / CC / IE / PTA | 4 | 0.000 | 0.063 | 0.000 | 0.398 | 0.000 | 1.039 | 0.000 | 1.034 | 0.000 | 0.000 |
| FILT / CC / IE / GAC | 4 | 0.000 | 0.063 | 0.000 | 0.249 | 0.000 | 0.779 | 0.000 | 0.947 | 0.000 | 3.012 |
| FILT / CC / PTA / GAC | 4 | 0.000 | 0.000 | 0.000 | 0.299 | 0.000 | 0.952 | 0.000 | 1.723 | 0.000 | 3.012 |
| Other Combinations ⁱ | | 1.801 | 16.216 | 1.505 | 21.095 | 1.038 | 16.797 | 0.858 | 15.590 | 2.575 | 6.024 |

^aEstimated percentages were calculated from EPA document, Benefits and Costs of the 1986 Amendments to the SDWA (Wade Miller, 1989).

^bActual percentages were obtained from FRDS multiple treatment data search results.

^cThe number of systems using alternative treatments includes those that do not directly affect SDWA treatment requirements, (e.g. fluoride treatment).

^dFiltration includes all filtration processes: Cartridge, greensand, DE, rapid sand, slow sand, ultrafiltration and direct filtration.

^eCorrosion (CC) control includes treatment process codes I, H, L. (See Exhibit F1.)

^fIon exchange (IE) relates to code E, and includes activated both alumina, and anion and cation exchange.

^gAeration (PTA) includes all aeration processes: Cascade, diffused, packed tower, slat spray, and spray aeration.

^hGAC includes both powdered and granulated activated carbon processes.

ⁱThis category includes treatment combinations that are not considered feasible and combinations estimated to affect less than one percent of all systems.

ATTACHMENT 1

CWS Multiple Objective Combinations by Population Category and Water Source

| Treatment Objectives | <u>Very Small Ground Water Systems</u> | | Cumulative Frequency | Cumulative Percent |
|----------------------|--|---------|----------------------|--------------------|
| | Frequency | Percent | | |
| B | 4 | 0.0 | 4 | 0.0 |
| BCD | 2 | 0.0 | 6 | 0.1 |
| BCR | 1 | 0.0 | 7 | 0.1 |
| BD | 10 | 0.1 | 17 | 0.2 |
| BDEFIMOPRST | 1 | 0.0 | 18 | 0.2 |
| BDEIOPRST | 1 | 0.0 | 19 | 0.2 |
| BDEORT | 1 | 0.0 | 20 | 0.2 |
| BDI | 1 | 0.0 | 21 | 0.2 |
| BDIMOPRST | 1 | 0.0 | 22 | 0.2 |
| BDIOPRS | 1 | 0.0 | 23 | 0.2 |
| BDIPRS | 1 | 0.0 | 24 | 0.2 |
| BDOT | 1 | 0.0 | 25 | 0.2 |
| BEIORST | 1 | 0.0 | 26 | 0.3 |
| BIRS | 1 | 0.0 | 27 | 0.3 |
| C | 47 | 0.5 | 74 | 0.7 |
| CD | 495 | 4.8 | 569 | 5.5 |
| CDEI | 1 | 0.0 | 570 | 5.5 |
| CDF | 51 | 0.5 | 621 | 6.0 |
| CDFI | 2 | 0.0 | 623 | 6.0 |
| CDFIMPT | 1 | 0.0 | 624 | 6.0 |
| CDFM | 30 | 0.3 | 654 | 6.3 |
| CDFMP | 2 | 0.0 | 656 | 6.4 |
| CDFMR | 1 | 0.0 | 657 | 6.4 |
| CDFMS | 1 | 0.0 | 658 | 6.4 |
| CDFO | 2 | 0.0 | 660 | 6.4 |
| CDFOP | 1 | 0.0 | 661 | 6.4 |
| CDFP | 7 | 0.1 | 668 | 6.5 |
| CDFPS | 1 | 0.0 | 669 | 6.5 |
| CDFS | 5 | 0.0 | 674 | 6.5 |
| CDFT | 1 | 0.0 | 675 | 6.5 |
| CDI | 9 | 0.1 | 684 | 6.6 |
| CDIPT | 1 | 0.0 | 685 | 6.6 |
| CDIST | 3 | 0.0 | 688 | 6.7 |
| CDM | 4 | 0.0 | 692 | 6.7 |
| CDMS | 1 | 0.0 | 693 | 6.7 |
| CDO | 19 | 0.2 | 712 | 6.9 |
| CDOP | 1 | 0.0 | 713 | 6.9 |
| CDOT | 3 | 0.0 | 716 | 6.9 |
| CDP | 6 | 0.1 | 722 | 7.0 |
| CDPS | 3 | 0.0 | 725 | 7.0 |
| CDPST | 4 | 0.0 | 729 | 7.1 |
| CDPT | 1 | 0.0 | 730 | 7.1 |
| CDR | 3 | 0.0 | 733 | 7.1 |
| CDS | 14 | 0.1 | 747 | 7.2 |
| CDST | 5 | 0.0 | 752 | 7.3 |
| CDT | 5 | 0.0 | 757 | 7.3 |
| CF | 6 | 0.1 | 763 | 7.4 |
| CFM | 1 | 0.0 | 764 | 7.4 |
| CFMS | 1 | 0.0 | 765 | 7.4 |
| CFR | 1 | 0.0 | 766 | 7.4 |
| CM | 1 | 0.0 | 767 | 7.4 |
| CO | 1 | 0.0 | 768 | 7.4 |
| CPS | 1 | 0.0 | 769 | 7.4 |
| CS | 3 | 0.0 | 772 | 7.5 |
| D | 7506 | 72.7 | 8278 | 80.2 |
| DEF | 1 | 0.0 | 8279 | 80.2 |

Very Small Ground Water Systems (continued)

| Treatment Objectives | Frequency | Percent | Cumulative Frequency | Cumulative Percent |
|----------------------|-----------|---------|----------------------|--------------------|
| DEFMT | 1 | 0.0 | 8280 | 80.2 |
| DEIS | 1 | 0.0 | 8281 | 80.2 |
| DET | 1 | 0.0 | 8282 | 80.2 |
| DF | 380 | 3.7 | 8662 | 83.9 |
| DFI | 4 | 0.0 | 8666 | 83.9 |
| DFIM | 4 | 0.0 | 8670 | 84.0 |
| DFIMST | 1 | 0.0 | 8671 | 84.0 |
| DFIP | 1 | 0.0 | 8672 | 84.0 |
| DFIPR | 1 | 0.0 | 8673 | 84.0 |
| DFIRS | 1 | 0.0 | 8674 | 84.0 |
| DFIS | 1 | 0.0 | 8675 | 84.0 |
| DFM | 189 | 1.8 | 8864 | 85.8 |
| DFMO | 1 | 0.0 | 8865 | 85.9 |
| DFMOT | 2 | 0.0 | 8867 | 85.9 |
| DFMP | 6 | 0.1 | 8873 | 85.9 |
| DFMPS | 2 | 0.0 | 8875 | 86.0 |
| DFMPT | 1 | 0.0 | 8876 | 86.0 |
| DFMS | 6 | 0.1 | 8882 | 86.0 |
| DFMT | 4 | 0.0 | 8886 | 86.1 |
| DFO | 4 | 0.0 | 8890 | 86.1 |
| DFOP | 3 | 0.0 | 8893 | 86.1 |
| DFOST | 1 | 0.0 | 8894 | 86.1 |
| DFOT | 1 | 0.0 | 8895 | 86.2 |
| DFP | 33 | 0.3 | 8928 | 86.5 |
| DFPR | 4 | 0.0 | 8932 | 86.5 |
| DFPS | 6 | 0.1 | 8938 | 86.6 |
| DFPST | 3 | 0.0 | 8941 | 86.6 |
| DFPT | 14 | 0.1 | 8955 | 86.7 |
| DFRS | 1 | 0.0 | 8956 | 86.7 |
| DFS | 56 | 0.5 | 9012 | 87.3 |
| DFST | 3 | 0.0 | 9015 | 87.3 |
| DFT | 20 | 0.2 | 9035 | 87.5 |
| DI | 25 | 0.2 | 9060 | 87.7 |
| DIM | 10 | 0.1 | 9070 | 87.8 |
| DIO | 1 | 0.0 | 9071 | 87.9 |
| DIORST | 2 | 0.0 | 9073 | 87.9 |
| DIP | 3 | 0.0 | 9076 | 87.9 |
| DIPS | 4 | 0.0 | 9080 | 87.9 |
| DIPT | 2 | 0.0 | 9082 | 88.0 |
| DIRS | 2 | 0.0 | 9084 | 88.0 |
| DIS | 5 | 0.0 | 9089 | 88.0 |
| DIST | 1 | 0.0 | 9090 | 88.0 |
| DM | 64 | 0.6 | 9154 | 88.7 |
| DMPS | 1 | 0.0 | 9155 | 88.7 |
| DMT | 1 | 0.0 | 9156 | 88.7 |
| DO | 16 | 0.2 | 9172 | 88.8 |
| DOP | 3 | 0.0 | 9175 | 88.9 |
| DOS | 1 | 0.0 | 9176 | 88.9 |
| DOST | 1 | 0.0 | 9177 | 88.9 |
| DOT | 49 | 0.5 | 9226 | 89.4 |
| DP | 109 | 1.1 | 9335 | 90.4 |
| DPR | 1 | 0.0 | 9336 | 90.4 |
| DPS | 14 | 0.1 | 9350 | 90.6 |
| DPST | 4 | 0.0 | 9354 | 90.6 |
| DPT | 10 | 0.1 | 9364 | 90.7 |
| DR | 2 | 0.0 | 9366 | 90.7 |
| DRS | 2 | 0.0 | 9368 | 90.7 |
| DS | 224 | 2.2 | 9592 | 92.9 |
| DST | 15 | 0.1 | 9607 | 93.0 |
| DT | 239 | 2.3 | 9846 | 95.4 |
| E | 1 | 0.0 | 9847 | 95.4 |

Very Small Ground Water Systems (continued)

| Treatment Objectives | Frequency | Percent | Cumulative Frequency | Cumulative Percent |
|----------------------|-----------|---------|----------------------|--------------------|
| EFM | 2 | 0.0 | 9849 | 95.4 |
| F | 130 | 1.3 | 9979 | 96.6 |
| FI | 1 | 0.0 | 9980 | 96.7 |
| FIM | 2 | 0.0 | 9982 | 96.7 |
| FM | 21 | 0.2 | 10003 | 96.9 |
| FMO | 1 | 0.0 | 10004 | 96.9 |
| FMP | 1 | 0.0 | 10005 | 96.9 |
| FMPST | 1 | 0.0 | 10006 | 96.9 |
| FMR | 1 | 0.0 | 10007 | 96.9 |
| FMS | 1 | 0.0 | 10008 | 96.9 |
| FMT | 1 | 0.0 | 10009 | 96.9 |
| FOP | 2 | 0.0 | 10011 | 97.0 |
| FOST | 1 | 0.0 | 10012 | 97.0 |
| FP | 9 | 0.1 | 10021 | 97.1 |
| FPS | 2 | 0.0 | 10023 | 97.1 |
| FR | 1 | 0.0 | 10024 | 97.1 |
| FS | 9 | 0.1 | 10033 | 97.2 |
| FT | 1 | 0.0 | 10034 | 97.2 |
| I | 15 | 0.1 | 10049 | 97.3 |
| IP | 1 | 0.0 | 10050 | 97.3 |
| IRS | 5 | 0.0 | 10055 | 97.4 |
| IS | 1 | 0.0 | 10056 | 97.4 |
| IST | 1 | 0.0 | 10057 | 97.4 |
| M | 19 | 0.2 | 10076 | 97.6 |
| O | 6 | 0.1 | 10082 | 97.6 |
| OPST | 1 | 0.0 | 10083 | 97.7 |
| P | 81 | 0.8 | 10164 | 98.4 |
| PS | 3 | 0.0 | 10167 | 98.5 |
| PT | 1 | 0.0 | 10168 | 98.5 |
| R | 7 | 0.1 | 10175 | 98.5 |
| RT | 1 | 0.0 | 10176 | 98.6 |
| S | 116 | 1.1 | 10292 | 99.7 |
| ST | 1 | 0.0 | 10293 | 99.7 |
| T | 32 | 0.3 | 10325 | 100.0 |

Very Small Surface Water Systems

| Treatment Objectives | Frequency | Percent | Cumulative Frequency | Cumulative Percent |
|----------------------|-----------|---------|----------------------|--------------------|
| BCDFIMOP | 1 | 0.1 | 1 | 0.1 |
| BCDIOPRS | 1 | 0.1 | 2 | 0.3 |
| BCOP | 1 | 0.1 | 3 | 0.4 |
| BDEFIMOS | 1 | 0.1 | 4 | 0.5 |
| BDFIOP | 1 | 0.1 | 5 | 0.6 |
| BDFIOPST | 1 | 0.1 | 6 | 0.8 |
| BDFIPT | 1 | 0.1 | 7 | 0.9 |
| BDFPT | 1 | 0.1 | 8 | 1.0 |
| BDIOPRS | 3 | 0.4 | 11 | 1.4 |
| BDOPT | 1 | 0.1 | 12 | 1.5 |
| BDP | 2 | 0.3 | 14 | 1.8 |
| C | 1 | 0.1 | 15 | 1.9 |
| CD | 8 | 1.0 | 23 | 2.9 |
| CDF | 1 | 0.1 | 24 | 3.0 |
| CDFIOPT | 1 | 0.1 | 25 | 3.1 |
| CDFMP | 2 | 0.3 | 27 | 3.4 |
| CDFOPT | 2 | 0.3 | 29 | 3.6 |
| CDFP | 2 | 0.3 | 31 | 3.9 |
| CDFPR | 2 | 0.3 | 33 | 4.1 |
| CDFPST | 1 | 0.1 | 34 | 4.3 |

Very Small Surface Water Systems (continued)

| Treatment Objectives | Frequency | Percent | Cumulative Frequency | Cumulative Percent |
|----------------------|-----------|---------|----------------------|--------------------|
| CDIOPT | 1 | 0.1 | 35 | 4.4 |
| CDIP | 2 | 0.3 | 37 | 4.6 |
| CDOP | 2 | 0.3 | 39 | 4.9 |
| CDOPT | 4 | 0.5 | 43 | 5.4 |
| CDP | 26 | 3.3 | 69 | 8.6 |
| CDPS | 12 | 1.5 | 81 | 10.1 |
| CDPST | 1 | 0.1 | 82 | 10.3 |
| CDPT | 8 | 1.0 | 90 | 11.3 |
| CDS | 2 | 0.3 | 92 | 11.5 |
| CMP | 1 | 0.1 | 93 | 11.6 |
| CP | 1 | 0.1 | 94 | 11.8 |
| CPR | 1 | 0.1 | 95 | 11.9 |
| CPS | 5 | 0.6 | 100 | 12.5 |
| CRT | 1 | 0.1 | 101 | 12.6 |
| CS | 1 | 0.1 | 102 | 12.8 |
| D | 237 | 29.7 | 339 | 42.4 |
| DEI | 1 | 0.1 | 340 | 42.6 |
| DEPST | 1 | 0.1 | 341 | 42.7 |
| DF | 6 | 0.8 | 347 | 43.4 |
| DFIMOPS | 1 | 0.1 | 348 | 43.6 |
| DFM | 2 | 0.3 | 350 | 43.8 |
| DFOPT | 2 | 0.3 | 352 | 44.1 |
| DFP | 3 | 0.4 | 355 | 44.4 |
| DFPR | 4 | 0.5 | 359 | 44.9 |
| DFPS | 2 | 0.3 | 361 | 45.2 |
| DFPT | 1 | 0.1 | 362 | 45.3 |
| DFS | 1 | 0.1 | 363 | 45.4 |
| DFT | 1 | 0.1 | 364 | 45.6 |
| DI | 2 | 0.3 | 366 | 45.8 |
| DIO | 1 | 0.1 | 367 | 45.9 |
| DIOPT | 2 | 0.3 | 369 | 46.2 |
| DIP | 2 | 0.3 | 371 | 46.4 |
| DIPT | 1 | 0.1 | 372 | 46.6 |
| DIS | 1 | 0.1 | 373 | 46.7 |
| DOP | 10 | 1.3 | 383 | 47.9 |
| DOPT | 3 | 0.4 | 386 | 48.3 |
| DOT | 5 | 0.6 | 391 | 48.9 |
| DP | 262 | 32.8 | 653 | 81.7 |
| DPR | 3 | 0.4 | 656 | 82.1 |
| DPS | 23 | 2.9 | 679 | 85.0 |
| DPST | 2 | 0.3 | 681 | 85.2 |
| DPT | 10 | 1.3 | 691 | 86.5 |
| DS | 2 | 0.3 | 693 | 86.7 |
| DT | 7 | 0.9 | 700 | 87.6 |
| F | 4 | 0.5 | 704 | 88.1 |
| P | 93 | 11.6 | 797 | 99.7 |
| S | 1 | 0.1 | 798 | 99.9 |
| T | 1 | 0.1 | 799 | 100.0 |

Small Ground Water Systems

| Treatment Objectives | Frequency | Percent | Cumulative Frequency | Cumulative Percent |
|----------------------|-----------|---------|----------------------|--------------------|
| BCD | 3 | 0.1 | 3 | 0.1 |
| BCFPST | 1 | 0.0 | 4 | 0.1 |
| BD | 1 | 0.0 | 5 | 0.1 |
| BDF | 1 | 0.0 | 6 | 0.1 |
| BDFMST | 1 | 0.0 | 7 | 0.1 |
| BDIOPRST | 1 | 0.0 | 8 | 0.2 |

Small Ground Water Systems (continued)

| Treatment Objectives | Frequency | Percent | Cumulative Frequency | Cumulative Percent |
|----------------------|-----------|---------|----------------------|--------------------|
| BDIPRS | 2 | 0.0 | 10 | 0.2 |
| C | 25 | 0.5 | 35 | 0.7 |
| CD | 343 | 6.7 | 378 | 7.3 |
| CDF | 102 | 2.0 | 480 | 9.3 |
| CDFIOS | 1 | 0.0 | 481 | 9.3 |
| CDFIP | 1 | 0.0 | 482 | 9.3 |
| CDFIPS | 1 | 0.0 | 483 | 9.4 |
| CDFM | 26 | 0.5 | 509 | 9.9 |
| CDFMOP | 2 | 0.0 | 511 | 9.9 |
| CDFMOT | 1 | 0.0 | 512 | 9.9 |
| CDFMPT | 2 | 0.0 | 514 | 10.0 |
| CDFMS | 1 | 0.0 | 515 | 10.0 |
| CDFMT | 1 | 0.0 | 516 | 10.0 |
| CDFO | 27 | 0.5 | 543 | 10.5 |
| CDFOP | 2 | 0.0 | 545 | 10.6 |
| CDFP | 17 | 0.3 | 562 | 10.9 |
| CDFPS | 8 | 0.2 | 570 | 11.1 |
| CDFPST | 2 | 0.0 | 572 | 11.1 |
| CDFPT | 7 | 0.1 | 579 | 11.2 |
| CDFR | 1 | 0.0 | 580 | 11.2 |
| CDFRST | 1 | 0.0 | 581 | 11.3 |
| CDFS | 11 | 0.2 | 592 | 11.5 |
| CDFST | 1 | 0.0 | 593 | 11.5 |
| CDFT | 5 | 0.1 | 598 | 11.6 |
| CDI | 7 | 0.1 | 605 | 11.7 |
| CDIPST | 1 | 0.0 | 606 | 11.8 |
| CDIPT | 2 | 0.0 | 608 | 11.8 |
| CDIS | 1 | 0.0 | 609 | 11.8 |
| CDIST | 3 | 0.1 | 612 | 11.9 |
| CDIT | 2 | 0.0 | 614 | 11.9 |
| CDM | 2 | 0.0 | 616 | 11.9 |
| CDMO | 1 | 0.0 | 617 | 12.0 |
| CDMS | 1 | 0.0 | 618 | 12.0 |
| CDO | 72 | 1.4 | 690 | 13.4 |
| CDOPT | 1 | 0.0 | 691 | 13.4 |
| CDOT | 1 | 0.0 | 692 | 13.4 |
| CDP | 6 | 0.1 | 698 | 13.5 |
| CDPRST | 1 | 0.0 | 699 | 13.6 |
| CDPS | 7 | 0.1 | 706 | 13.7 |
| CDPST | 10 | 0.2 | 716 | 13.9 |
| CDPT | 1 | 0.0 | 717 | 13.9 |
| CDRT | 2 | 0.0 | 719 | 13.9 |
| CDS | 14 | 0.3 | 733 | 14.2 |
| CDST | 5 | 0.1 | 738 | 14.3 |
| CDT | 13 | 0.3 | 751 | 14.6 |
| CF | 3 | 0.1 | 754 | 14.6 |
| CFIPS | 1 | 0.0 | 755 | 14.6 |
| CFM | 3 | 0.1 | 758 | 14.7 |
| CFMP | 1 | 0.0 | 759 | 14.7 |
| CFMPST | 1 | 0.0 | 760 | 14.7 |
| CFS | 1 | 0.0 | 761 | 14.8 |
| CIM | 1 | 0.0 | 762 | 14.8 |
| CM | 1 | 0.0 | 763 | 14.8 |
| CS | 3 | 0.1 | 766 | 14.9 |
| D | 3114 | 60.4 | 3880 | 75.2 |
| DEFP | 1 | 0.0 | 3881 | 75.3 |
| DF | 375 | 7.3 | 4256 | 82.5 |
| DFI | 5 | 0.1 | 4261 | 82.6 |
| DFIMO | 1 | 0.0 | 4262 | 82.6 |
| DFIMP | 2 | 0.0 | 4264 | 82.7 |
| DFIMS | 1 | 0.0 | 4265 | 82.7 |

Small Ground Water Systems (continued)

| Treatment Objectives | Frequency | Percent | Cumulative Frequency | Cumulative Percent |
|----------------------|-----------|---------|----------------------|--------------------|
| DFIO | 1 | 0.0 | 4266 | 82.7 |
| DFIP | 1 | 0.0 | 4267 | 82.7 |
| DFIPS | 1 | 0.0 | 4268 | 82.8 |
| DFIPST | 1 | 0.0 | 4269 | 82.8 |
| DFIS | 4 | 0.1 | 4273 | 82.9 |
| DFIST | 1 | 0.0 | 4274 | 82.9 |
| DFM | 90 | 1.7 | 4364 | 84.6 |
| DFMOP | 1 | 0.0 | 4365 | 84.6 |
| DFMP | 5 | 0.1 | 4370 | 84.7 |
| DFMS | 5 | 0.1 | 4375 | 84.8 |
| DFMST | 1 | 0.0 | 4376 | 84.9 |
| DFMT | 2 | 0.0 | 4378 | 84.9 |
| DFO | 6 | 0.1 | 4384 | 85.0 |
| DFOP | 2 | 0.0 | 4386 | 85.0 |
| DFOT | 1 | 0.0 | 4387 | 85.1 |
| DFP | 39 | 0.8 | 4426 | 85.8 |
| DFPS | 13 | 0.3 | 4439 | 86.1 |
| DFPST | 4 | 0.1 | 4443 | 86.2 |
| DFPT | 11 | 0.2 | 4454 | 86.4 |
| DFRST | 2 | 0.0 | 4456 | 86.4 |
| DFRT | 1 | 0.0 | 4457 | 86.4 |
| DFS | 110 | 2.1 | 4567 | 88.6 |
| DFST | 10 | 0.2 | 4577 | 88.8 |
| DFT | 24 | 0.5 | 4601 | 89.2 |
| DI | 3 | 0.1 | 4604 | 89.3 |
| DIM | 1 | 0.0 | 4605 | 89.3 |
| DIP | 5 | 0.1 | 4610 | 89.4 |
| DIPS | 1 | 0.0 | 4611 | 89.4 |
| DIPT | 2 | 0.0 | 4613 | 89.5 |
| DIS | 1 | 0.0 | 4614 | 89.5 |
| DIT | 3 | 0.1 | 4617 | 89.5 |
| DM | 15 | 0.3 | 4632 | 89.8 |
| DMO | 1 | 0.0 | 4633 | 89.8 |
| DMOT | 1 | 0.0 | 4634 | 89.9 |
| DMP | 2 | 0.0 | 4636 | 89.9 |
| DMS | 1 | 0.0 | 4637 | 89.9 |
| DMT | 2 | 0.0 | 4639 | 90.0 |
| DO | 16 | 0.3 | 4655 | 90.3 |
| DOP | 3 | 0.1 | 4658 | 90.3 |
| DOPS | 1 | 0.0 | 4659 | 90.3 |
| DOS | 2 | 0.0 | 4661 | 90.4 |
| DOST | 1 | 0.0 | 4662 | 90.4 |
| DOT | 11 | 0.2 | 4673 | 90.6 |
| DP | 35 | 0.7 | 4708 | 91.3 |
| DPS | 8 | 0.2 | 4716 | 91.4 |
| DPST | 13 | 0.3 | 4729 | 91.7 |
| DPT | 15 | 0.3 | 4744 | 92.0 |
| DR | 1 | 0.0 | 4745 | 92.0 |
| DS | 48 | 0.9 | 4793 | 92.9 |
| DST | 14 | 0.3 | 4807 | 93.2 |
| DT | 189 | 3.7 | 4996 | 96.9 |
| F | 65 | 1.3 | 5061 | 98.1 |
| FM | 8 | 0.2 | 5069 | 98.3 |
| FMP | 1 | 0.0 | 5070 | 98.3 |
| FOP | 2 | 0.0 | 5072 | 98.4 |
| FP | 3 | 0.1 | 5075 | 98.4 |
| FPS | 1 | 0.0 | 5076 | 98.4 |
| FS | 7 | 0.1 | 5083 | 98.6 |
| FT | 2 | 0.0 | 5085 | 98.6 |
| M | 9 | 0.2 | 5094 | 98.8 |
| MT | 2 | 0.0 | 5096 | 98.8 |

Small Ground Water Systems (continued)

| Treatment Objectives | Frequency | Percent | Cumulative Frequency | Cumulative Percent |
|----------------------|-----------|---------|----------------------|--------------------|
| O | 1 | 0.0 | 5097 | 98.8 |
| OPT | 1 | 0.0 | 5098 | 98.9 |
| P | 6 | 0.1 | 5104 | 99.0 |
| PST | 1 | 0.0 | 5105 | 99.0 |
| S | 44 | 0.9 | 5149 | 99.8 |
| T | 8 | 0.2 | 5157 | 100.0 |

Small Surface Water Systems

| Treatment Objectives | Frequency | Percent | Cumulative Frequency | Cumulative Percent |
|----------------------|-----------|---------|----------------------|--------------------|
| BCDFIMO | 2 | 0.1 | 2 | 0.1 |
| BCDFIMOP | 6 | 0.4 | 8 | 0.5 |
| BCDFIMOPR | 3 | 0.2 | 11 | 0.7 |
| BCDFIOP | 1 | 0.1 | 12 | 0.8 |
| BCDFP | 1 | 0.1 | 13 | 0.9 |
| BCDIMOPT | 1 | 0.1 | 14 | 0.9 |
| BCDIOPRS | 3 | 0.2 | 17 | 1.1 |
| BCDIOPRST | 1 | 0.1 | 18 | 1.2 |
| BCDIOPT | 1 | 0.1 | 19 | 1.2 |
| BCDOPT | 1 | 0.1 | 20 | 1.3 |
| BCDP | 1 | 0.1 | 21 | 1.4 |
| BCDPT | 1 | 0.1 | 22 | 1.4 |
| BCFMOPT | 1 | 0.1 | 23 | 1.5 |
| BDFIPT | 1 | 0.1 | 24 | 1.6 |
| BDFPS | 1 | 0.1 | 25 | 1.6 |
| BDFPT | 1 | 0.1 | 26 | 1.7 |
| BDFS | 1 | 0.1 | 27 | 1.8 |
| BDIOPRS | 7 | 0.5 | 34 | 2.2 |
| BDIOPRST | 1 | 0.1 | 35 | 2.3 |
| BDIOPST | 1 | 0.1 | 36 | 2.4 |
| BDP | 7 | 0.5 | 43 | 2.8 |
| BDPS | 15 | 1.0 | 58 | 3.8 |
| BDPT | 1 | 0.1 | 59 | 3.9 |
| BDS | 2 | 0.1 | 61 | 4.0 |
| C | 10 | 0.7 | 71 | 4.7 |
| CD | 31 | 2.0 | 102 | 6.7 |
| CDFIMOP | 1 | 0.1 | 103 | 6.8 |
| CDFIMOPT | 3 | 0.2 | 106 | 7.0 |
| CDFIMPST | 1 | 0.1 | 107 | 7.0 |
| CDFIOPT | 1 | 0.1 | 108 | 7.1 |
| CDFIP | 1 | 0.1 | 109 | 7.2 |
| CDFIPT | 2 | 0.1 | 111 | 7.3 |
| CDFM | 1 | 0.1 | 112 | 7.4 |
| CDFMO | 1 | 0.1 | 113 | 7.4 |
| CDFMOP | 1 | 0.1 | 114 | 7.5 |
| CDFMP | 2 | 0.1 | 116 | 7.6 |
| CDFOP | 3 | 0.2 | 119 | 7.8 |
| CDFP | 7 | 0.5 | 126 | 8.3 |
| CDFPS | 2 | 0.1 | 128 | 8.4 |
| CDFPST | 14 | 0.9 | 142 | 9.3 |
| CDFPT | 11 | 0.7 | 153 | 10.1 |
| CDIMPT | 1 | 0.1 | 156 | 10.3 |
| CDIOPS | 1 | 0.1 | 157 | 10.3 |
| CDIOPT | 2 | 0.1 | 159 | 10.5 |
| CDOP | 4 | 0.3 | 163 | 10.7 |
| CDOPST | 2 | 0.1 | 165 | 10.8 |
| CDOPT | 7 | 0.5 | 172 | 11.3 |
| CDFST | 1 | 0.1 | 154 | 10.1 |

Small Surface Water Systems (continued)

| Treatment Objectives | Frequency | Percent | Cumulative Frequency | Cumulative Percent |
|----------------------|-----------|---------|----------------------|--------------------|
| CDIM | 1 | 0.1 | 155 | 10.2 |
| CDP | 130 | 8.5 | 302 | 19.9 |
| CDPR | 1 | 0.1 | 303 | 19.9 |
| CDPRT | 1 | 0.1 | 304 | 20.0 |
| CDPS | 64 | 4.2 | 368 | 24.2 |
| CDPST | 10 | 0.7 | 378 | 24.9 |
| CDPT | 39 | 2.6 | 417 | 27.4 |
| CDS | 5 | 0.3 | 422 | 27.7 |
| CDT | 4 | 0.3 | 426 | 28.0 |
| CF | 1 | 0.1 | 427 | 28.1 |
| CFPST | 1 | 0.1 | 428 | 28.1 |
| CFPT | 1 | 0.1 | 429 | 28.2 |
| CP | 3 | 0.2 | 432 | 28.4 |
| CPS | 4 | 0.3 | 436 | 28.7 |
| CPST | 1 | 0.1 | 437 | 28.7 |
| CT | 1 | 0.1 | 438 | 28.8 |
| D | 402 | 26.4 | 840 | 55.2 |
| DF | 9 | 0.6 | 849 | 55.8 |
| DFIMPST | 1 | 0.1 | 850 | 55.9 |
| DFIOP | 1 | 0.1 | 851 | 56.0 |
| DFIOPT | 1 | 0.1 | 852 | 56.0 |
| DFM | 5 | 0.3 | 857 | 56.3 |
| DFOP | 2 | 0.1 | 859 | 56.5 |
| DFOPT | 1 | 0.1 | 860 | 56.5 |
| DFP | 12 | 0.8 | 872 | 57.3 |
| DFPS | 10 | 0.7 | 882 | 58.0 |
| DFPST | 2 | 0.1 | 884 | 58.1 |
| DFPT | 26 | 1.7 | 910 | 59.8 |
| DFRS | 1 | 0.1 | 911 | 59.9 |
| DFS | 2 | 0.1 | 913 | 60.0 |
| DI | 1 | 0.1 | 914 | 60.1 |
| DIOP | 1 | 0.1 | 915 | 60.2 |
| DIOPS | 1 | 0.1 | 916 | 60.2 |
| DIP | 5 | 0.3 | 921 | 60.6 |
| DIPS | 4 | 0.3 | 925 | 60.8 |
| DIPST | 1 | 0.1 | 926 | 60.9 |
| DIPT | 3 | 0.2 | 929 | 61.1 |
| DM | 1 | 0.1 | 930 | 61.1 |
| DOP | 17 | 1.1 | 947 | 62.3 |
| DOPS | 2 | 0.1 | 949 | 62.4 |
| DOPST | 1 | 0.1 | 950 | 62.5 |
| DOPT | 11 | 0.7 | 961 | 63.2 |
| DOT | 2 | 0.1 | 963 | 63.3 |
| DP | 298 | 19.6 | 1261 | 82.9 |
| DPS | 50 | 3.3 | 1311 | 86.2 |
| DPST | 7 | 0.5 | 1318 | 86.7 |
| DPT | 47 | 3.1 | 1365 | 89.7 |
| DS | 9 | 0.6 | 1374 | 90.3 |
| DT | 12 | 0.8 | 1386 | 91.1 |
| FOPT | 1 | 0.1 | 1387 | 91.2 |
| FP | 1 | 0.1 | 1388 | 91.3 |
| IOP | 1 | 0.1 | 1389 | 91.3 |
| OP | 1 | 0.1 | 1390 | 91.4 |
| P | 123 | 8.1 | 1513 | 99.5 |
| S | 7 | 0.5 | 1520 | 99.9 |
| T | 1 | 0.1 | 1521 | 100.0 |

| <u>Medium Ground Water Systems</u> | | | | |
|------------------------------------|-----------|---------|----------------------|--------------------|
| Treatment Objectives | Frequency | Percent | Cumulative Frequency | Cumulative Percent |
| BCD | 1 | 0.1 | 1 | 0.1 |
| BCDFIPST | 1 | 0.1 | 2 | 0.2 |
| BCDFMS | 1 | 0.1 | 3 | 0.2 |
| BCFMOPT | 1 | 0.1 | 4 | 0.3 |
| BDFIMOPRST | 1 | 0.1 | 5 | 0.4 |
| BDFMST | 1 | 0.1 | 6 | 0.5 |
| BDS | 1 | 0.1 | 7 | 0.5 |
| C | 5 | 0.4 | 12 | 0.9 |
| CD | 80 | 6.1 | 92 | 7.0 |
| CDF | 39 | 3.0 | 131 | 10.0 |
| CDFI | 4 | 0.3 | 135 | 10.3 |
| CDFIM | 1 | 0.1 | 136 | 10.4 |
| CDFM | 9 | 0.7 | 145 | 11.1 |
| CDFMO | 1 | 0.1 | 146 | 11.1 |
| CDFMOP | 5 | 0.4 | 151 | 11.5 |
| CDFMOS | 1 | 0.1 | 152 | 11.6 |
| CDFMPT | 1 | 0.1 | 153 | 11.7 |
| CDFMS | 3 | 0.2 | 156 | 11.9 |
| CDFMT | 1 | 0.1 | 157 | 12.0 |
| CDFO | 6 | 0.5 | 163 | 12.4 |
| CDFOP | 1 | 0.1 | 164 | 12.5 |
| CDFP | 6 | 0.5 | 170 | 13.0 |
| CDFPRST | 1 | 0.1 | 171 | 13.1 |
| CDFPS | 4 | 0.3 | 175 | 13.4 |
| CDFPST | 3 | 0.2 | 178 | 13.6 |
| CDFPT | 2 | 0.2 | 180 | 13.7 |
| CDFS | 9 | 0.7 | 189 | 14.4 |
| CDFST | 2 | 0.2 | 191 | 14.6 |
| CDFT | 4 | 0.3 | 195 | 14.9 |
| CDI | 1 | 0.1 | 196 | 15.0 |
| CDIP | 1 | 0.1 | 197 | 15.0 |
| CDIPT | 1 | 0.1 | 198 | 15.1 |
| CDM | 2 | 0.2 | 200 | 15.3 |
| CDO | 20 | 1.5 | 220 | 16.8 |
| CDOP | 1 | 0.1 | 221 | 16.9 |
| CDOS | 1 | 0.1 | 222 | 16.9 |
| CDP | 6 | 0.5 | 228 | 17.4 |
| CDPS | 7 | 0.5 | 235 | 17.9 |
| CDPST | 2 | 0.2 | 237 | 18.1 |
| CDPT | 3 | 0.2 | 240 | 18.3 |
| CDS | 1 | 0.1 | 241 | 18.4 |
| CDST | 1 | 0.1 | 242 | 18.5 |
| CDT | 7 | 0.5 | 249 | 19.0 |
| CF | 1 | 0.1 | 250 | 19.1 |
| CT | 1 | 0.1 | 251 | 19.2 |
| D | 676 | 51.6 | 927 | 70.8 |
| DF | 108 | 8.2 | 1035 | 79.0 |
| DFI | 2 | 0.2 | 1037 | 79.2 |
| DFIM | 1 | 0.1 | 1038 | 79.2 |
| DFIMPT | 1 | 0.1 | 1039 | 79.3 |
| DFIP | 1 | 0.1 | 1040 | 79.4 |
| DFM | 7 | 0.5 | 1047 | 79.9 |
| DFMOP | 1 | 0.1 | 1048 | 80.0 |
| DFMP | 2 | 0.2 | 1050 | 80.2 |
| DFMS | 1 | 0.1 | 1051 | 80.2 |
| DFMST | 1 | 0.1 | 1052 | 80.3 |
| DFMT | 2 | 0.2 | 1054 | 80.5 |
| DFO | 2 | 0.2 | 1056 | 80.6 |
| DFP | 16 | 1.2 | 1072 | 81.8 |
| DFPS | 8 | 0.6 | 1080 | 82.4 |
| DFPST | 1 | 0.1 | 1081 | 82.5 |

Medium Ground Water Systems (continued)

| Treatment Objectives | Frequency | Percent | Cumulative Frequency | Cumulative Percent |
|----------------------|-----------|---------|----------------------|--------------------|
| DFPT | 1 | 0.1 | 1082 | 82.6 |
| DFR | 1 | 0.1 | 1083 | 82.7 |
| DFS | 19 | 1.5 | 1102 | 84.1 |
| DFST | 1 | 0.1 | 1103 | 84.2 |
| DFT | 11 | 0.8 | 1114 | 85.0 |
| DI | 2 | 0.2 | 1116 | 85.2 |
| DIPS | 1 | 0.1 | 1117 | 85.3 |
| DIS | 1 | 0.1 | 1118 | 85.3 |
| DM | 9 | 0.7 | 1127 | 86.0 |
| DO | 10 | 0.8 | 1137 | 86.8 |
| DOPST | 1 | 0.1 | 1138 | 86.9 |
| DOS | 1 | 0.1 | 1139 | 86.9 |
| DOT | 4 | 0.3 | 1143 | 87.3 |
| DP | 25 | 1.9 | 1168 | 89.2 |
| DPS | 7 | 0.5 | 1175 | 89.7 |
| DPST | 4 | 0.3 | 1179 | 90.0 |
| DPT | 6 | 0.5 | 1185 | 90.5 |
| DR | 1 | 0.1 | 1186 | 90.5 |
| DRT | 1 | 0.1 | 1187 | 90.6 |
| DS | 24 | 1.8 | 1211 | 92.4 |
| DST | 7 | 0.5 | 1218 | 93.0 |
| DT | 63 | 4.8 | 1281 | 97.8 |
| F | 9 | 0.7 | 1290 | 98.5 |
| FM | 1 | 0.1 | 1291 | 98.5 |
| FMS | 1 | 0.1 | 1292 | 98.6 |
| FS | 1 | 0.1 | 1293 | 98.7 |
| M | 1 | 0.1 | 1294 | 98.8 |
| P | 2 | 0.2 | 1296 | 98.9 |
| S | 6 | 0.5 | 1302 | 99.4 |
| T | 8 | 0.6 | 1310 | 100.0 |

Medium Surface Water Systems

| Treatment Objectives | Frequency | Percent | Cumulative Frequency | Cumulative Percent |
|----------------------|-----------|---------|----------------------|--------------------|
| BCDFIMO | 1 | 0.1 | 1 | 0.1 |
| BCDFIMOP | 9 | 0.9 | 10 | 1.0 |
| BCDFIMOPR | 1 | 0.1 | 11 | 1.1 |
| BCDFIMOPRT | 1 | 0.1 | 12 | 1.2 |
| BCDFIMOPT | 1 | 0.1 | 13 | 1.3 |
| BCDFIOPR | 3 | 0.3 | 16 | 1.6 |
| BCDFIOPRST | 1 | 0.1 | 17 | 1.7 |
| BCDFIOPT | 1 | 0.1 | 18 | 1.8 |
| BCDFPPT | 6 | 0.6 | 24 | 2.4 |
| BCDFT | 1 | 0.1 | 25 | 2.5 |
| BCDIOP | 1 | 0.1 | 26 | 2.6 |
| BCDIOPRST | 1 | 0.1 | 27 | 2.7 |
| BCDIOPST | 1 | 0.1 | 28 | 2.9 |
| BCDP | 2 | 0.2 | 30 | 3.1 |
| BCDPT | 1 | 0.1 | 31 | 3.2 |
| BCFP | 1 | 0.1 | 32 | 3.3 |
| BCFPST | 1 | 0.1 | 33 | 3.4 |
| BCIOPRS | 3 | 0.3 | 36 | 3.7 |
| BD | 1 | 0.1 | 37 | 3.8 |
| BDFIMOPRS | 2 | 0.2 | 39 | 4.0 |
| BDFIOP | 1 | 0.1 | 40 | 4.1 |
| BDFIOPRS | 2 | 0.2 | 42 | 4.3 |
| BDFP | 1 | 0.1 | 43 | 4.4 |
| BDFPT | 1 | 0.1 | 44 | 4.5 |

| <u>Medium Surface Water Systems (continued)</u> | | | | |
|---|-----------|---------|----------------------|--------------------|
| Treatment Objectives | Frequency | Percent | Cumulative Frequency | Cumulative Percent |
| BDIOPRS | 1 | 0.1 | 45 | 4.6 |
| BDIOPRST | 1 | 0.1 | 46 | 4.7 |
| BDOPT | 1 | 0.1 | 47 | 4.8 |
| BDPS | 4 | 0.4 | 51 | 5.2 |
| BDPST | 2 | 0.2 | 53 | 5.4 |
| BDPT | 1 | 0.1 | 54 | 5.5 |
| BF | 1 | 0.1 | 55 | 5.6 |
| C | 4 | 0.4 | 59 | 6.0 |
| CD | 30 | 3.1 | 89 | 9.1 |
| CDEPS | 1 | 0.1 | 90 | 9.2 |
| CDF | 3 | 0.3 | 93 | 9.5 |
| CDFIMOPST | 1 | 0.1 | 94 | 9.6 |
| CDFIMOPT | 6 | 0.6 | 100 | 10.2 |
| CDFIP | 1 | 0.1 | 101 | 10.3 |
| CDFM | 2 | 0.2 | 103 | 10.5 |
| CDFMOP | 1 | 0.1 | 104 | 10.6 |
| CDFMP | 1 | 0.1 | 105 | 10.7 |
| CDFOP | 1 | 0.1 | 106 | 10.8 |
| CDFOPT | 3 | 0.3 | 109 | 11.1 |
| CDFP | 8 | 0.8 | 117 | 11.9 |
| CDFPS | 1 | 0.1 | 118 | 12.0 |
| CDFPST | 8 | 0.8 | 126 | 12.8 |
| CDFPT | 16 | 1.6 | 142 | 14.5 |
| CDFS | 1 | 0.1 | 143 | 14.6 |
| CDIOP | 2 | 0.2 | 145 | 14.8 |
| CDIOPS | 1 | 0.1 | 146 | 14.9 |
| CDIP | 1 | 0.1 | 147 | 15.0 |
| CDIPS | 1 | 0.1 | 148 | 15.1 |
| CDIPT | 1 | 0.1 | 149 | 15.2 |
| CDMOPT | 1 | 0.1 | 150 | 15.3 |
| CDMP | 2 | 0.2 | 152 | 15.5 |
| CDOP | 4 | 0.4 | 156 | 15.9 |
| CDOPT | 11 | 1.1 | 167 | 17.0 |
| CDOS | 1 | 0.1 | 168 | 17.1 |
| CDP | 124 | 12.6 | 292 | 29.7 |
| CDPS | 31 | 3.2 | 323 | 32.9 |
| CDPST | 12 | 1.2 | 335 | 34.1 |
| CDPT | 66 | 6.7 | 401 | 40.8 |
| CDS | 2 | 0.2 | 403 | 41.0 |
| CDT | 4 | 0.4 | 407 | 41.4 |
| CIMOPT | 1 | 0.1 | 408 | 41.5 |
| CPS | 2 | 0.2 | 410 | 41.8 |
| CPST | 1 | 0.1 | 411 | 41.9 |
| D | 187 | 19.0 | 598 | 60.9 |
| DE | 1 | 0.1 | 599 | 61.0 |
| DF | 2 | 0.2 | 601 | 61.2 |
| DFIMOP | 1 | 0.1 | 602 | 61.3 |
| DFIOPT | 2 | 0.2 | 604 | 61.5 |
| DFM | 1 | 0.1 | 605 | 61.6 |
| DFMP | 1 | 0.1 | 606 | 61.7 |
| DFOPT | 2 | 0.2 | 608 | 61.9 |
| DFP | 6 | 0.6 | 614 | 62.5 |
| DFPS | 4 | 0.4 | 618 | 62.9 |
| DFPST | 2 | 0.2 | 620 | 63.1 |
| DFPT | 10 | 1.0 | 630 | 64.2 |
| DI | 1 | 0.1 | 631 | 64.3 |
| DIMOP | 1 | 0.1 | 632 | 64.4 |
| DIOPT | 1 | 0.1 | 633 | 64.5 |
| DIP | 2 | 0.2 | 635 | 64.7 |
| DIPS | 1 | 0.1 | 636 | 64.8 |
| DIPT | 2 | 0.2 | 638 | 65.0 |

Medium Surface Water Systems (continued)

| Treatment Objectives | Frequency | Percent | Cumulative Frequency | Cumulative Percent |
|----------------------|-----------|---------|----------------------|--------------------|
| DMP | 1 | 0.1 | 639 | 65.1 |
| DMPT | 1 | 0.1 | 640 | 65.2 |
| DOP | 13 | 1.3 | 653 | 66.5 |
| DOPST | 1 | 0.1 | 654 | 66.6 |
| DOPT | 8 | 0.8 | 662 | 67.4 |
| DOT | 1 | 0.1 | 663 | 67.5 |
| DP | 153 | 15.6 | 816 | 83.1 |
| DPS | 29 | 3.0 | 845 | 86.0 |
| DPST | 5 | 0.5 | 850 | 86.6 |
| DPT | 39 | 4.0 | 889 | 90.5 |
| DS | 2 | 0.2 | 891 | 90.7 |
| DST | 1 | 0.1 | 892 | 90.8 |
| DT | 3 | 0.3 | 895 | 91.1 |
| FIMOPT | 5 | 0.5 | 900 | 91.6 |
| FIOPS | 1 | 0.1 | 901 | 91.8 |
| FIT | 1 | 0.1 | 902 | 91.9 |
| FP | 1 | 0.1 | 903 | 92.0 |
| FPT | 1 | 0.1 | 904 | 92.1 |
| I | 1 | 0.1 | 905 | 92.2 |
| IMOPT | 1 | 0.1 | 906 | 92.3 |
| IOP | 1 | 0.1 | 907 | 92.4 |
| OP | 1 | 0.1 | 908 | 92.5 |
| P | 64 | 6.5 | 972 | 99.0 |
| PS | 2 | 0.2 | 974 | 99.2 |
| PST | 1 | 0.1 | 975 | 99.3 |
| PT | 5 | 0.5 | 980 | 99.8 |
| S | 2 | 0.2 | 982 | 100.0 |

Large Ground Water Systems

| Treatment Objectives | Frequency | Percent | Cumulative Frequency | Cumulative Percent |
|----------------------|-----------|---------|----------------------|--------------------|
| BCDF | 3 | 0.4 | 3 | 0.4 |
| BCDFIOPS | 1 | 0.1 | 4 | 0.5 |
| BCDFO | 1 | 0.1 | 5 | 0.7 |
| BDIOPT | 1 | 0.1 | 6 | 0.8 |
| C | 3 | 0.4 | 9 | 1.2 |
| CD | 56 | 7.6 | 65 | 8.8 |
| CDF | 30 | 4.1 | 95 | 12.9 |
| CDFI | 2 | 0.3 | 97 | 13.1 |
| CDFIMP | 1 | 0.1 | 98 | 13.3 |
| CDFIP | 1 | 0.1 | 99 | 13.4 |
| CDFIPT | 1 | 0.1 | 100 | 13.5 |
| CDFMO | 4 | 0.5 | 104 | 14.1 |
| CDFMOP | 2 | 0.3 | 106 | 14.3 |
| CDFMOPT | 1 | 0.1 | 107 | 14.5 |
| CDFMPS | 1 | 0.1 | 108 | 14.6 |
| CDFMS | 1 | 0.1 | 109 | 14.7 |
| CDFMT | 1 | 0.1 | 110 | 14.9 |
| CDFO | 8 | 1.1 | 118 | 16.0 |
| CDFOP | 1 | 0.1 | 119 | 16.1 |
| CDFOPS | 1 | 0.1 | 120 | 16.2 |
| CDFOPT | 1 | 0.1 | 121 | 16.4 |
| CDFOT | 1 | 0.1 | 122 | 16.5 |
| CDFP | 10 | 1.4 | 132 | 17.9 |
| CDFPS | 4 | 0.5 | 136 | 18.4 |
| CDFPST | 4 | 0.5 | 140 | 18.9 |
| CDFPT | 3 | 0.4 | 143 | 19.4 |
| CDFS | 5 | 0.7 | 148 | 20.0 |

Large Ground Water Systems (continued)

| Treatment Objectives | Frequency | Percent | Cumulative Frequency | Cumulative Percent |
|----------------------|-----------|---------|----------------------|--------------------|
| CDFST | 1 | 0.1 | 149 | 20.2 |
| CDFT | 4 | 0.5 | 153 | 20.7 |
| CDIO | 1 | 0.1 | 154 | 20.8 |
| CDIP | 1 | 0.1 | 155 | 21.0 |
| CDIPST | 5 | 0.7 | 160 | 21.7 |
| CDIT | 1 | 0.1 | 161 | 21.8 |
| CDO | 9 | 1.2 | 170 | 23.0 |
| CDOP | 1 | 0.1 | 171 | 23.1 |
| CDOPRS | 1 | 0.1 | 172 | 23.3 |
| CDOPT | 4 | 0.5 | 176 | 23.8 |
| CDOS | 1 | 0.1 | 177 | 24.0 |
| CDOST | 1 | 0.1 | 178 | 24.1 |
| CDOT | 1 | 0.1 | 179 | 24.2 |
| CDP | 1 | 0.1 | 180 | 24.4 |
| CDPS | 8 | 1.1 | 188 | 25.4 |
| CDPST | 6 | 0.8 | 194 | 26.3 |
| CDPT | 3 | 0.4 | 197 | 26.7 |
| CDR | 1 | 0.1 | 198 | 26.8 |
| CDS | 3 | 0.4 | 201 | 27.2 |
| CDST | 3 | 0.4 | 204 | 27.6 |
| CDT | 15 | 2.0 | 219 | 29.6 |
| CIPST | 1 | 0.1 | 220 | 29.8 |
| CP | 1 | 0.1 | 221 | 29.9 |
| CT | 1 | 0.1 | 222 | 30.0 |
| D | 273 | 36.9 | 495 | 67.0 |
| DEFP | 1 | 0.1 | 496 | 67.1 |
| DF | 40 | 5.4 | 536 | 72.5 |
| DFIS | 1 | 0.1 | 537 | 72.7 |
| DFM | 3 | 0.4 | 540 | 73.1 |
| DFMP | 1 | 0.1 | 541 | 73.2 |
| DFMPS | 1 | 0.1 | 542 | 73.3 |
| DFMPT | 2 | 0.3 | 544 | 73.6 |
| DFMS | 1 | 0.1 | 545 | 73.7 |
| DFMT | 1 | 0.1 | 546 | 73.9 |
| DFO | 1 | 0.1 | 547 | 74.0 |
| DFP | 4 | 0.5 | 551 | 74.6 |
| DFPS | 4 | 0.5 | 555 | 75.1 |
| DFPST | 1 | 0.1 | 556 | 75.2 |
| DFPT | 3 | 0.4 | 559 | 75.6 |
| DFS | 17 | 2.3 | 576 | 77.9 |
| DFST | 1 | 0.1 | 577 | 78.1 |
| DFT | 6 | 0.8 | 583 | 78.9 |
| DI | 1 | 0.1 | 584 | 79.0 |
| DIM | 1 | 0.1 | 585 | 79.2 |
| DIOS | 1 | 0.1 | 586 | 79.3 |
| DIPT | 2 | 0.3 | 588 | 79.6 |
| DIT | 1 | 0.1 | 589 | 79.7 |
| DM | 3 | 0.4 | 592 | 80.1 |
| DMT | 1 | 0.1 | 593 | 80.2 |
| DO | 18 | 2.4 | 611 | 82.7 |
| DOPS | 1 | 0.1 | 612 | 82.8 |
| DOPST | 2 | 0.3 | 614 | 83.1 |
| DOPT | 1 | 0.1 | 615 | 83.2 |
| DOS | 1 | 0.1 | 616 | 83.4 |
| DOST | 1 | 0.1 | 617 | 83.5 |
| DOT | 2 | 0.3 | 619 | 83.8 |
| DP | 11 | 1.5 | 630 | 85.3 |
| DPS | 15 | 2.0 | 645 | 87.3 |
| DPST | 10 | 1.4 | 655 | 88.6 |
| DPT | 1 | 0.1 | 656 | 88.8 |
| DRT | 1 | 0.1 | 657 | 88.9 |

Large Ground Water Systems (continued)

| Treatment Objectives | Frequency | Percent | Cumulative Frequency | Cumulative Percent |
|----------------------|-----------|---------|----------------------|--------------------|
| DS | 16 | 2.2 | 673 | 91.1 |
| DST | 1 | 0.1 | 674 | 91.2 |
| DT | 55 | 7.4 | 729 | 98.6 |
| F | 3 | 0.4 | 732 | 99.1 |
| FMP | 1 | 0.1 | 733 | 99.2 |
| IMT | 1 | 0.1 | 734 | 99.3 |
| O | 1 | 0.1 | 735 | 99.5 |
| P | 2 | 0.3 | 737 | 99.7 |
| S | 1 | 0.1 | 738 | 99.9 |
| T | 1 | 0.1 | 739 | 100.0 |

Large Surface Water Systems

| Treatment Objectives | Frequency | Percent | Cumulative Frequency | Cumulative Percent |
|----------------------|-----------|---------|----------------------|--------------------|
| B | 3 | 0.3 | 3 | 0.3 |
| BCDEFIOPT | 1 | 0.1 | 4 | 0.4 |
| BCDEOPT | 1 | 0.1 | 5 | 0.5 |
| BCDEP | 1 | 0.1 | 6 | 0.6 |
| BCDFIM | 1 | 0.1 | 7 | 0.7 |
| BCDFIMO | 5 | 0.5 | 12 | 1.2 |
| BCDFIMOP | 15 | 1.5 | 27 | 2.7 |
| BCDFIMOPR | 2 | 0.2 | 29 | 2.9 |
| BCDFIMOPRST | 1 | 0.1 | 30 | 3.0 |
| BCDFIMOPST | 1 | 0.1 | 31 | 3.1 |
| BCDFIMOPT | 1 | 0.1 | 32 | 3.2 |
| BCDFIMPT | 1 | 0.1 | 33 | 3.3 |
| BCDFOP | 1 | 0.1 | 34 | 3.4 |
| BCDFOPT | 1 | 0.1 | 35 | 3.5 |
| BCDFP | 2 | 0.2 | 37 | 3.7 |
| BCDFPS | 2 | 0.2 | 39 | 3.9 |
| BCDFPT | 3 | 0.3 | 42 | 4.2 |
| BCDIMOPT | 1 | 0.1 | 43 | 4.3 |
| BCDIOP | 1 | 0.1 | 44 | 4.4 |
| BCDIOPRS | 1 | 0.1 | 45 | 4.5 |
| BCDIOPRST | 2 | 0.2 | 47 | 4.7 |
| BCDOP | 1 | 0.1 | 48 | 4.8 |
| BCDOPST | 1 | 0.1 | 49 | 4.9 |
| BCDOPT | 2 | 0.2 | 51 | 5.1 |
| BCDP | 8 | 0.8 | 59 | 5.9 |
| BCDPS | 2 | 0.2 | 61 | 6.1 |
| BCDPST | 2 | 0.2 | 63 | 6.3 |
| BCDPT | 12 | 1.2 | 75 | 7.5 |
| BCFPST | 6 | 0.6 | 81 | 8.1 |
| BD | 2 | 0.2 | 83 | 8.3 |
| BDFPS | 1 | 0.1 | 84 | 8.4 |
| BDFPT | 2 | 0.2 | 86 | 8.6 |
| BDOPS | 1 | 0.1 | 87 | 8.7 |
| BDOPT | 2 | 0.2 | 89 | 8.9 |
| BDOST | 1 | 0.1 | 90 | 9.0 |
| BDP | 3 | 0.3 | 93 | 9.3 |
| BDPS | 5 | 0.5 | 98 | 9.8 |
| BDPST | 2 | 0.2 | 100 | 10.0 |
| BDPT | 16 | 1.6 | 116 | 11.6 |
| BDS | 2 | 0.2 | 118 | 11.8 |
| BDT | 2 | 0.2 | 120 | 12.0 |
| BP | 1 | 0.1 | 121 | 12.1 |
| C | 2 | 0.2 | 123 | 12.3 |
| CD | 20 | 2.0 | 143 | 14.3 |

Large Surface Water Systems (continued)

| Treatment Objectives | Frequency | Percent | Cumulative Frequency | Cumulative Percent |
|----------------------|-----------|---------|----------------------|--------------------|
| CDF | 2 | 0.2 | 145 | 14.5 |
| CDFI | 1 | 0.1 | 146 | 14.6 |
| CDFIM | 1 | 0.1 | 147 | 14.7 |
| CDFIMOP | 1 | 0.1 | 148 | 14.8 |
| CDFIMOPR | 1 | 0.1 | 149 | 14.9 |
| CDFIMOPT | 2 | 0.2 | 151 | 15.1 |
| CDFIMS | 1 | 0.1 | 152 | 15.2 |
| CDFIOP | 1 | 0.1 | 153 | 15.3 |
| CDFIOPRT | 1 | 0.1 | 154 | 15.4 |
| CDFIOPT | 1 | 0.1 | 155 | 15.5 |
| CDFIP | 1 | 0.1 | 156 | 15.6 |
| CDFIPT | 1 | 0.1 | 157 | 15.7 |
| CDFMOP | 3 | 0.3 | 160 | 16.0 |
| CDFMOPR | 2 | 0.2 | 162 | 16.2 |
| CDFMPT | 7 | 0.7 | 169 | 17.0 |
| CDFOP | 1 | 0.1 | 170 | 17.1 |
| CDFOPR | 3 | 0.3 | 173 | 17.4 |
| CDFOPS | 1 | 0.1 | 174 | 17.5 |
| CDFOPT | 3 | 0.3 | 177 | 17.8 |
| CDFP | 12 | 1.2 | 189 | 19.0 |
| CDFPS | 2 | 0.2 | 191 | 19.2 |
| CDFPST | 18 | 1.8 | 209 | 21.0 |
| CDFPT | 20 | 2.0 | 229 | 23.0 |
| CDIOPST | 1 | 0.1 | 230 | 23.1 |
| CDIP | 2 | 0.2 | 232 | 23.3 |
| CDIPRS | 1 | 0.1 | 233 | 23.4 |
| CDIPS | 1 | 0.1 | 234 | 23.5 |
| CDIPT | 2 | 0.2 | 236 | 23.7 |
| CDIT | 1 | 0.1 | 237 | 23.8 |
| CDM | 2 | 0.2 | 239 | 24.0 |
| CDMP | 3 | 0.3 | 242 | 24.3 |
| CDMPT | 2 | 0.2 | 244 | 24.5 |
| CDMT | 1 | 0.1 | 245 | 24.6 |
| CDO | 1 | 0.1 | 246 | 24.7 |
| CDOP | 10 | 1.0 | 256 | 25.7 |
| CDOPS | 2 | 0.2 | 258 | 25.9 |
| CDOPT | 13 | 1.3 | 271 | 27.2 |
| CDOT | 2 | 0.2 | 273 | 27.4 |
| CDP | 110 | 11.0 | 383 | 38.4 |
| CDPS | 24 | 2.4 | 407 | 40.8 |
| CDPST | 17 | 1.7 | 424 | 42.5 |
| CDPT | 79 | 7.9 | 503 | 50.5 |
| CDT | 1 | 0.1 | 504 | 50.6 |
| CFMT | 1 | 0.1 | 505 | 50.7 |
| CP | 1 | 0.1 | 506 | 50.8 |
| CPT | 1 | 0.1 | 507 | 50.9 |
| CT | 1 | 0.1 | 508 | 51.0 |
| D | 167 | 16.8 | 675 | 67.7 |
| DEPT | 1 | 0.1 | 676 | 67.8 |
| DF | 6 | 0.6 | 682 | 68.4 |
| DFI | 1 | 0.1 | 683 | 68.5 |
| DFIMOPST | 1 | 0.1 | 684 | 68.6 |
| DFIMPT | 1 | 0.1 | 685 | 68.7 |
| DFIOP | 1 | 0.1 | 686 | 68.8 |
| DFIPS | 1 | 0.1 | 687 | 68.9 |
| DFIPT | 1 | 0.1 | 688 | 69.0 |
| DFM | 1 | 0.1 | 689 | 69.1 |
| DFMP | 1 | 0.1 | 690 | 69.2 |
| DFOS | 2 | 0.2 | 694 | 69.6 |
| DFP | 6 | 0.6 | 700 | 70.2 |

Large Surface Water Systems (continued)

| Treatment Objectives | Frequency | Percent | Cumulative Frequency | Cumulative Percent |
|----------------------|-----------|---------|----------------------|--------------------|
| DFPS | 2 | 0.2 | 702 | 70.4 |
| DFPST | 1 | 0.1 | 703 | 70.5 |
| DFPT | 9 | 0.9 | 712 | 71.4 |
| DFS | 2 | 0.2 | 714 | 71.6 |
| DFT | 1 | 0.1 | 715 | 71.7 |
| DM | 1 | 0.1 | 716 | 71.8 |
| DO | 3 | 0.3 | 719 | 72.1 |
| DOP | 3 | 0.3 | 722 | 72.4 |
| DOPST | 2 | 0.2 | 724 | 72.6 |
| DOPT | 4 | 0.4 | 728 | 73.0 |
| DOT | 1 | 0.1 | 729 | 73.1 |
| DP | 99 | 9.9 | 828 | 83.0 |
| DPS | 21 | 2.1 | 849 | 85.2 |
| DPST | 7 | 0.7 | 856 | 85.9 |
| DPT | 44 | 4.4 | 900 | 90.3 |
| DS | 4 | 0.4 | 904 | 90.7 |
| DT | 2 | 0.2 | 906 | 90.9 |
| F | 1 | 0.1 | 907 | 91.0 |
| FOPT | 1 | 0.1 | 908 | 91.1 |
| MT | 1 | 0.1 | 909 | 91.2 |
| O | 1 | 0.1 | 910 | 91.3 |
| P | 85 | 8.5 | 995 | 99.8 |
| PT | 1 | 0.1 | 996 | 99.9 |
| T | 1 | 0.1 | 997 | 100.0 |

Very Large Ground Water Systems

| Treatment Objectives | Frequency | Percent | Cumulative Frequency | Cumulative Percent |
|----------------------|-----------|---------|----------------------|--------------------|
| CDF | 3 | 7.1 | 3 | 7.1 |
| CDFP | 1 | 2.4 | 4 | 9.5 |
| CDFPS | 1 | 2.4 | 5 | 11.9 |
| CDFPT | 1 | 2.4 | 6 | 14.3 |
| CDFS | 1 | 2.4 | 7 | 16.7 |
| CDOPS | 1 | 2.4 | 8 | 19.0 |
| CDOPT | 1 | 2.4 | 9 | 21.4 |
| CDOT | 1 | 2.4 | 10 | 23.8 |
| CDPS | 3 | 7.1 | 13 | 31.0 |
| CDPT | 1 | 2.4 | 14 | 33.3 |
| CDS | 1 | 2.4 | 15 | 35.7 |
| CDT | 4 | 9.5 | 19 | 45.2 |
| D | 12 | 28.6 | 31 | 73.8 |
| DO | 2 | 4.8 | 33 | 78.6 |
| DPS | 1 | 2.4 | 34 | 81.0 |
| DPST | 2 | 4.8 | 36 | 85.7 |
| DS | 1 | 2.4 | 37 | 88.1 |
| DT | 2 | 4.8 | 39 | 92.9 |
| P | 3 | 7.1 | 42 | 100.0 |

Very Large Surface Water Systems

| Treatment Objectives | Frequency | Percent | Cumulative Frequency | Cumulative Percent |
|----------------------|-----------|---------|----------------------|--------------------|
| BCDEFMOPT | 1 | 0.6 | 1 | 0.6 |
| BCDFIMO | 2 | 1.3 | 3 | 1.9 |
| BCDFIMOPRT | 1 | 0.6 | 4 | 2.5 |
| BCDFIMOPST | 1 | 0.6 | 5 | 3.2 |

Very Large Surface Water Systems (continued)

| Treatment Objectives | Frequency | Percent | Cumulative Frequency | Cumulative Percent |
|----------------------|-----------|---------|----------------------|--------------------|
| BCDFIOPST | 1 | 0.6 | 6 | 3.8 |
| BCDFP | 1 | 0.6 | 7 | 4.4 |
| BCDOPT | 1 | 0.6 | 8 | 5.1 |
| BCDPST | 2 | 1.3 | 10 | 6.3 |
| BCDPT | 3 | 1.9 | 13 | 8.2 |
| BCFPST | 1 | 0.6 | 14 | 8.9 |
| BD | 1 | 0.6 | 15 | 9.5 |
| BDFOPT | 1 | 0.6 | 16 | 10.1 |
| BDPS | 1 | 0.6 | 17 | 10.8 |
| BDPT | 4 | 2.5 | 21 | 13.3 |
| CD | 2 | 1.3 | 23 | 14.6 |
| CDEP | 1 | 0.6 | 24 | 15.2 |
| CDFIMOPST | 1 | 0.6 | 25 | 15.8 |
| CDFIOPT | 1 | 0.6 | 26 | 16.5 |
| CDFIPT | 2 | 1.3 | 28 | 17.7 |
| CDFMOPST | 1 | 0.6 | 29 | 18.4 |
| CDFOPT | 2 | 1.3 | 31 | 19.6 |
| CDFPS | 1 | 0.6 | 32 | 20.3 |
| CDFPST | 3 | 1.9 | 35 | 22.2 |
| CDFPT | 2 | 1.3 | 37 | 23.4 |
| CDIOPT | 1 | 0.6 | 38 | 24.1 |
| CDO | 1 | 0.6 | 39 | 24.7 |
| CDOP | 2 | 1.3 | 41 | 25.9 |
| CDOPT | 6 | 3.8 | 47 | 29.7 |
| CDP | 22 | 13.9 | 69 | 43.7 |
| CDPRST | 1 | 0.6 | 70 | 44.3 |
| CDPS | 1 | 0.6 | 71 | 44.9 |
| CDPST | 3 | 1.9 | 74 | 46.8 |
| CDPT | 15 | 9.5 | 89 | 56.3 |
| CDS | 1 | 0.6 | 90 | 57.0 |
| CDT | 1 | 0.6 | 91 | 57.6 |
| D | 7 | 4.4 | 98 | 62.0 |
| DF | 1 | 0.6 | 99 | 62.7 |
| DFO | 1 | 0.6 | 100 | 63.3 |
| DFP | 1 | 0.6 | 101 | 63.9 |
| DIPS | 2 | 1.3 | 103 | 65.2 |
| DOP | 2 | 1.3 | 105 | 66.5 |
| DOPT | 2 | 1.3 | 107 | 67.7 |
| DP | 16 | 10.1 | 123 | 77.8 |
| DPS | 4 | 2.5 | 127 | 80.4 |
| DPST | 1 | 0.6 | 128 | 81.0 |
| DPT | 11 | 7.0 | 139 | 88.0 |
| DT | 1 | 0.6 | 140 | 88.6 |
| P | 18 | 11.4 | 158 | 100.0 |

ATTACHMENT 2

CWS Multiple Treatment Combinations by Population Category and Water Source

| <u>Very Small Ground Water Systems</u> | | | | |
|--|-----------|---------|----------------------|--------------------|
| Treatment Combination | Frequency | Percent | Cumulative Frequency | Cumulative Percent |
| A | 17 | 0.2 | 17 | 0.2 |
| AC | 233 | 2.3 | 250 | 2.4 |
| ACE | 5 | 0.0 | 255 | 2.5 |
| ACEF | 7 | 0.1 | 262 | 2.6 |
| ACEFIP | 2 | 0.0 | 264 | 2.6 |
| ACEH | 3 | 0.0 | 267 | 2.6 |
| ACEN | 1 | 0.0 | 268 | 2.6 |
| ACEP | 24 | 0.2 | 292 | 2.8 |
| ACF | 56 | 0.5 | 348 | 3.4 |
| ACFH | 13 | 0.1 | 361 | 3.5 |
| ACFHI | 1 | 0.0 | 362 | 3.5 |
| ACFHINOP | 5 | 0.0 | 367 | 3.6 |
| ACFHR | 1 | 0.0 | 368 | 3.6 |
| ACFI | 4 | 0.0 | 372 | 3.6 |
| ACFL | 5 | 0.0 | 377 | 3.7 |
| ACFNPR | 1 | 0.0 | 378 | 3.7 |
| ACFP | 1 | 0.0 | 379 | 3.7 |
| ACFR | 2 | 0.0 | 381 | 3.7 |
| ACH | 24 | 0.2 | 405 | 4.0 |
| ACHR | 12 | 0.1 | 417 | 4.1 |
| ACI | 2 | 0.0 | 419 | 4.1 |
| ACIP | 1 | 0.0 | 420 | 4.1 |
| ACL | 1 | 0.0 | 421 | 4.1 |
| ACN | 1 | 0.0 | 422 | 4.1 |
| ACP | 1 | 0.0 | 423 | 4.1 |
| AE | 2 | 0.0 | 425 | 4.1 |
| AEFN | 1 | 0.0 | 426 | 4.2 |
| AF | 13 | 0.1 | 439 | 4.3 |
| AFHP | 9 | 0.1 | 448 | 4.4 |
| AFI | 1 | 0.0 | 449 | 4.4 |
| AFP | 57 | 0.6 | 506 | 4.9 |
| AP | 46 | 0.4 | 552 | 5.4 |
| C | 7984 | 77.9 | 8536 | 83.3 |
| CE | 246 | 2.4 | 8782 | 85.7 |
| CEF | 36 | 0.4 | 8818 | 86.0 |
| CEFH | 4 | 0.0 | 8822 | 86.1 |
| CEFHILNP | 2 | 0.0 | 8824 | 86.1 |
| CEFHL | 1 | 0.0 | 8825 | 86.1 |
| CEFHLP | 1 | 0.0 | 8826 | 86.1 |
| CEFI | 1 | 0.0 | 8827 | 86.1 |
| CEFO | 1 | 0.0 | 8828 | 86.1 |
| CEFP | 1 | 0.0 | 8829 | 86.1 |
| CEFR | 4 | 0.0 | 8833 | 86.2 |
| CEH | 10 | 0.1 | 8843 | 86.3 |
| CEHP | 1 | 0.0 | 8844 | 86.3 |
| CEI | 9 | 0.1 | 8853 | 86.4 |
| CEINU | 1 | 0.0 | 8854 | 86.4 |
| CELN | 1 | 0.0 | 8855 | 86.4 |
| CEN | 2 | 0.0 | 8857 | 86.4 |
| CENP | 2 | 0.0 | 8859 | 86.4 |
| CER | 1 | 0.0 | 8860 | 86.4 |
| CEU | 2 | 0.0 | 8862 | 86.5 |
| CF | 267 | 2.6 | 9129 | 89.1 |
| CFH | 30 | 0.3 | 9159 | 89.3 |

Very Small Ground Water Systems (continued)

| Treatment Combination | Frequency | Percent | Cumulative Frequency | Cumulative Percent |
|--------------------------|-----------|---------|-------------------------|-----------------------|
| CFHI | 3 | 0.0 | 9162 | 89.4 |
| CFHL | 1 | 0.0 | 9163 | 89.4 |
| CFHLO | 1 | 0.0 | 9164 | 89.4 |
| CFHN | 2 | 0.0 | 9166 | 89.4 |
| CFHNO | 40 | 0.4 | 9206 | 89.8 |
| CFHP | 5 | 0.0 | 9211 | 89.9 |
| CFI | 5 | 0.0 | 9216 | 89.9 |
| CFIL | 1 | 0.0 | 9217 | 89.9 |
| CFL | 11 | 0.1 | 9228 | 90.0 |
| CFLNR | 1 | 0.0 | 9229 | 90.0 |
| CFN | 5 | 0.0 | 9234 | 90.1 |
| CFNR | 1 | 0.0 | 9235 | 90.1 |
| CFO | 4 | 0.0 | 9239 | 90.1 |
| CFP | 12 | 0.1 | 9251 | 90.2 |
| CFR | 1 | 0.0 | 9252 | 90.3 |
| CFU | 3 | 0.0 | 9255 | 90.3 |
| CH | 374 | 3.6 | 9629 | 93.9 |
| CHI | 26 | 0.3 | 9655 | 94.2 |
| CHIL | 1 | 0.0 | 9656 | 94.2 |
| CHL | 2 | 0.0 | 9658 | 94.2 |
| CHN | 1 | 0.0 | 9659 | 94.2 |
| CHP | 1 | 0.0 | 9660 | 94.2 |
| CHR | 1 | 0.0 | 9661 | 94.2 |
| CI | 142 | 1.4 | 9803 | 95.6 |
| CIL | 1 | 0.0 | 9804 | 95.6 |
| CL | 19 | 0.2 | 9823 | 95.8 |
| CLP | 1 | 0.0 | 9824 | 95.8 |
| CN | 19 | 0.2 | 9843 | 96.0 |
| CP | 1 | 0.0 | 9844 | 96.0 |
| CR | 8 | 0.1 | 9852 | 96.1 |
| CU | 3 | 0.0 | 9855 | 96.1 |
| E | 110 | 1.1 | 9965 | 97.2 |
| ECAP | 3 | 0.0 | 9968 | 97.2 |
| EF | 8 | 0.1 | 9976 | 97.3 |
| EFP | 10 | 0.1 | 9986 | 97.4 |
| EH | 2 | 0.0 | 9988 | 97.4 |
| EHU | 1 | 0.0 | 9989 | 97.4 |
| EI | 2 | 0.0 | 9991 | 97.5 |
| EN | 2 | 0.0 | 9993 | 97.5 |
| EP | 8 | 0.1 | 10001 | 97.6 |
| ER | 2 | 0.0 | 10003 | 97.6 |
| EU | 2 | 0.0 | 10005 | 97.6 |
| F | 108 | 1.1 | 10113 | 98.7 |
| FH | 3 | 0.0 | 10116 | 98.7 |
| FHL | 1 | 0.0 | 10117 | 98.7 |
| FHP | 1 | 0.0 | 10118 | 98.7 |
| FL | 3 | 0.0 | 10121 | 98.7 |
| FN | 1 | 0.0 | 10122 | 98.7 |
| FP | 1 | 0.0 | 10123 | 98.8 |
| FU | 2 | 0.0 | 10125 | 98.8 |
| H | 41 | 0.4 | 10166 | 99.2 |
| HN | 1 | 0.0 | 10167 | 99.2 |
| HP | 9 | 0.1 | 10176 | 99.3 |
| I | 10 | 0.1 | 10186 | 99.4 |
| L | 25 | 0.2 | 10211 | 99.6 |
| N | 9 | 0.1 | 10220 | 99.7 |
| NP | 2 | 0.0 | 10222 | 99.7 |
| O | 5 | 0.0 | 10227 | 99.8 |
| OU | 1 | 0.0 | 10228 | 99.8 |
| R | 5 | 0.0 | 10233 | 99.8 |
| U | 18 | 0.2 | 10251 | 100.0 |

| <u>Very Small Surface Water Systems</u> | | | | |
|---|-----------|---------|-------------------------|-----------------------|
| Treatment Combination | Frequency | Percent | Cumulative Frequency | Cumulative Percent |
| AC | 3 | 0.4 | 3 | 0.4 |
| ACEFIP | 1 | 0.1 | 4 | 0.5 |
| ACF | 2 | 0.3 | 6 | 0.8 |
| ACFLP | 1 | 0.1 | 7 | 0.9 |
| ACFN | 1 | 0.1 | 8 | 1.0 |
| ACH | 1 | 0.1 | 9 | 1.1 |
| AFHP | 2 | 0.3 | 11 | 1.4 |
| AFP | 8 | 1.0 | 19 | 2.4 |
| AP | 2 | 0.3 | 21 | 2.6 |
| C | 251 | 31.6 | 272 | 34.2 |
| CE | 2 | 0.3 | 274 | 34.5 |
| CEF | 3 | 0.4 | 277 | 34.8 |
| CEFLNP | 1 | 0.1 | 278 | 35.0 |
| CEHP | 1 | 0.1 | 279 | 35.1 |
| CENO | 1 | 0.1 | 280 | 35.2 |
| CF | 278 | 35.0 | 558 | 70.2 |
| CFH | 41 | 5.2 | 599 | 75.3 |
| CFHI | 1 | 0.1 | 600 | 75.5 |
| CFHIN | 2 | 0.3 | 602 | 75.7 |
| CFHIR | 1 | 0.1 | 603 | 75.8 |
| CFHL | 5 | 0.6 | 608 | 76.5 |
| CFHN | 9 | 1.1 | 617 | 77.6 |
| CFHNO | 1 | 0.1 | 618 | 77.7 |
| CFHNP | 1 | 0.1 | 619 | 77.9 |
| CFHO | 1 | 0.1 | 620 | 78.0 |
| CFI | 5 | 0.6 | 625 | 78.6 |
| CFIL | 1 | 0.1 | 626 | 78.7 |
| CFIN | 1 | 0.1 | 627 | 78.9 |
| CFL | 14 | 1.8 | 641 | 80.6 |
| CFLN | 1 | 0.1 | 642 | 80.8 |
| CFN | 10 | 1.3 | 652 | 82.0 |
| CFNO | 1 | 0.1 | 653 | 82.1 |
| CFO | 1 | 0.1 | 654 | 82.3 |
| CFR | 1 | 0.1 | 655 | 82.4 |
| CFU | 1 | 0.1 | 656 | 82.5 |
| CH | 7 | 0.9 | 663 | 83.4 |
| CHLN | 1 | 0.1 | 664 | 83.5 |
| CI | 4 | 0.5 | 668 | 84.0 |
| CL | 1 | 0.1 | 669 | 84.2 |
| CU | 1 | 0.1 | 670 | 84.3 |
| EFNORU | 1 | 0.1 | 671 | 84.4 |
| EFRU | 1 | 0.1 | 672 | 84.5 |
| ENOR | 1 | 0.1 | 673 | 84.7 |
| F | 94 | 11.8 | 767 | 96.5 |
| FH | 5 | 0.6 | 772 | 97.1 |
| FHL | 3 | 0.4 | 775 | 97.5 |
| FHLP | 1 | 0.1 | 776 | 97.6 |
| FHNP | 3 | 0.4 | 779 | 98.0 |
| FI | 2 | 0.3 | 781 | 98.2 |
| FIU | 1 | 0.1 | 782 | 98.4 |
| FU | 3 | 0.4 | 785 | 98.7 |
| H | 1 | 0.1 | 786 | 98.9 |
| L | 1 | 0.1 | 787 | 99.0 |
| N | 1 | 0.1 | 788 | 99.1 |
| NOR | 1 | 0.1 | 789 | 99.2 |
| O | 2 | 0.3 | 791 | 99.5 |
| RU | 2 | 0.3 | 793 | 99.7 |
| U | 2 | 0.3 | 795 | 100.0 |

| <u>Small Ground Water Systems</u> | | | | |
|-----------------------------------|-----------|---------|-------------------------|-----------------------|
| Treatment Combination | Frequency | Percent | Cumulative Frequency | Cumulative Percent |
| A | 4 | 0.1 | 4 | 0.1 |
| AC | 227 | 4.4 | 231 | 4.5 |
| ACE | 8 | 0.2 | 239 | 4.7 |
| ACEF | 21 | 0.4 | 260 | 5.1 |
| ACEFH | 3 | 0.1 | 263 | 5.1 |
| ACEFHL | 1 | 0.0 | 264 | 5.2 |
| ACEFHP | 1 | 0.0 | 265 | 5.2 |
| ACEFI | 5 | 0.1 | 270 | 5.3 |
| ACEFIP | 2 | 0.0 | 272 | 5.3 |
| ACEFL | 1 | 0.0 | 273 | 5.3 |
| ACEH | 1 | 0.0 | 274 | 5.4 |
| ACEHI | 1 | 0.0 | 275 | 5.4 |
| ACEN | 1 | 0.0 | 276 | 5.4 |
| ACEP | 4 | 0.1 | 280 | 5.5 |
| ACF | 122 | 2.4 | 402 | 7.9 |
| ACFH | 53 | 1.0 | 455 | 8.9 |
| ACFHI | 2 | 0.0 | 457 | 8.9 |
| ACFHIL | 1 | 0.0 | 458 | 8.9 |
| ACFHL | 9 | 0.2 | 467 | 9.1 |
| ACFHP | 1 | 0.0 | 468 | 9.1 |
| ACFHR | 3 | 0.1 | 471 | 9.2 |
| ACFI | 12 | 0.2 | 483 | 9.4 |
| ACFIL | 1 | 0.0 | 484 | 9.5 |
| ACFL | 19 | 0.4 | 503 | 9.8 |
| ACFLR | 1 | 0.0 | 504 | 9.8 |
| ACFR | 3 | 0.1 | 507 | 9.9 |
| ACH | 81 | 1.6 | 588 | 11.5 |
| ACHI | 2 | 0.0 | 590 | 11.5 |
| ACHLR | 1 | 0.0 | 591 | 11.5 |
| ACHN | 1 | 0.0 | 592 | 11.6 |
| ACHR | 11 | 0.2 | 603 | 11.8 |
| ACI | 11 | 0.2 | 614 | 12.0 |
| ACIL | 2 | 0.0 | 616 | 12.0 |
| ACL | 6 | 0.1 | 622 | 12.2 |
| ACN | 1 | 0.0 | 623 | 12.2 |
| AEF | 4 | 0.1 | 627 | 12.3 |
| AEFI | 1 | 0.0 | 628 | 12.3 |
| AEFL | 1 | 0.0 | 629 | 12.3 |
| AF | 28 | 0.5 | 657 | 12.8 |
| AFH | 1 | 0.0 | 658 | 12.9 |
| AFHP | 24 | 0.5 | 682 | 13.3 |
| AFP | 47 | 0.9 | 729 | 14.2 |
| AL | 1 | 0.0 | 730 | 14.3 |
| AP | 15 | 0.3 | 745 | 14.6 |
| C | 3394 | 66.3 | 4139 | 80.9 |
| CE | 23 | 0.4 | 4162 | 81.3 |
| CEF | 43 | 0.8 | 4205 | 82.2 |
| CEFHP | 1 | 0.0 | 4206 | 82.2 |
| CEFI | 1 | 0.0 | 4207 | 82.2 |
| CEFL | 2 | 0.0 | 4209 | 82.2 |
| CEFO | 1 | 0.0 | 4210 | 82.3 |
| CEFP | 3 | 0.1 | 4213 | 82.3 |
| CEH | 8 | 0.2 | 4221 | 82.5 |
| CEHIN | 1 | 0.0 | 4222 | 82.5 |
| CEI | 5 | 0.1 | 4227 | 82.6 |
| CEP | 1 | 0.0 | 4228 | 82.6 |
| CF | 165 | 3.2 | 4393 | 85.8 |
| CFH | 47 | 0.9 | 4440 | 86.8 |
| CFHI | 1 | 0.0 | 4441 | 86.8 |
| CFHIL | 3 | 0.1 | 4444 | 86.8 |

Small Ground Water Systems (continued)

| Treatment Combination | Frequency | Percent | Cumulative Frequency | Cumulative Percent |
|-----------------------|-----------|---------|----------------------|--------------------|
| CFHIP | 1 | 0.0 | 4445 | 86.9 |
| CFHL | 8 | 0.2 | 4453 | 87.0 |
| CFHLN | 1 | 0.0 | 4454 | 87.0 |
| CFHLP | 1 | 0.0 | 4455 | 87.0 |
| CFHNO | 6 | 0.1 | 4461 | 87.2 |
| CFHP | 17 | 0.3 | 4478 | 87.5 |
| CFHR | 1 | 0.0 | 4479 | 87.5 |
| CFI | 11 | 0.2 | 4490 | 87.7 |
| CFIL | 4 | 0.1 | 4494 | 87.8 |
| CFIP | 3 | 0.1 | 4497 | 87.9 |
| CFL | 42 | 0.8 | 4539 | 88.7 |
| CFLN | 1 | 0.0 | 4540 | 88.7 |
| CFN | 3 | 0.1 | 4543 | 88.8 |
| CFP | 18 | 0.4 | 4561 | 89.1 |
| CFR | 3 | 0.1 | 4564 | 89.2 |
| CH | 215 | 4.2 | 4779 | 93.4 |
| CHI | 24 | 0.5 | 4803 | 93.8 |
| CHL | 3 | 0.1 | 4806 | 93.9 |
| CHN | 1 | 0.0 | 4807 | 93.9 |
| CHR | 1 | 0.0 | 4808 | 93.9 |
| CI | 132 | 2.6 | 4940 | 96.5 |
| CIL | 1 | 0.0 | 4941 | 96.5 |
| CIN | 1 | 0.0 | 4942 | 96.6 |
| CIP | 1 | 0.0 | 4943 | 96.6 |
| CL | 43 | 0.8 | 4986 | 97.4 |
| CLP | 2 | 0.0 | 4988 | 97.5 |
| CN | 3 | 0.1 | 4991 | 97.5 |
| CNP | 1 | 0.0 | 4992 | 97.5 |
| CO | 1 | 0.0 | 4993 | 97.6 |
| CP | 1 | 0.0 | 4994 | 97.6 |
| CR | 5 | 0.1 | 4999 | 97.7 |
| E | 3 | 0.1 | 5002 | 97.7 |
| ECAP | 11 | 0.2 | 5013 | 97.9 |
| EFP | 5 | 0.1 | 5018 | 98.0 |
| EI | 1 | 0.0 | 5019 | 98.1 |
| EP | 3 | 0.1 | 5022 | 98.1 |
| F | 12 | 0.2 | 5034 | 98.4 |
| FH | 2 | 0.0 | 5036 | 98.4 |
| FHI | 1 | 0.0 | 5037 | 98.4 |
| FL | 2 | 0.0 | 5039 | 98.5 |
| FP | 1 | 0.0 | 5040 | 98.5 |
| H | 13 | 0.3 | 5053 | 98.7 |
| HL | 1 | 0.0 | 5054 | 98.7 |
| HP | 1 | 0.0 | 5055 | 98.8 |
| I | 17 | 0.3 | 5072 | 99.1 |
| IL | 1 | 0.0 | 5073 | 99.1 |
| L | 39 | 0.8 | 5112 | 99.9 |
| LP | 1 | 0.0 | 5113 | 99.9 |
| O | 2 | 0.0 | 5115 | 99.9 |
| R | 3 | 0.1 | 5118 | 100.0 |

Small Surface Water Systems

| Treatment Combination | Frequency | Percent | Cumulative Frequency | Cumulative Percent |
|-----------------------|-----------|---------|----------------------|--------------------|
| AC | 7 | 0.5 | 7 | 0.5 |
| ACEFIP | 7 | 0.5 | 14 | 0.9 |
| ACEFLP | 1 | 0.1 | 15 | 1.0 |
| ACF | 12 | 0.8 | 27 | 1.8 |

Small Surface Water Systems (continued)

| Treatment Combination | Frequency | Percent | Cumulative Frequency | Cumulative Percent |
|--------------------------|-----------|---------|-------------------------|-----------------------|
| ACFH | 9 | 0.6 | 36 | 2.4 |
| ACFHI | 1 | 0.1 | 37 | 2.4 |
| ACFHL | 4 | 0.3 | 41 | 2.7 |
| ACFHN | 3 | 0.2 | 44 | 2.9 |
| ACFHNP | 2 | 0.1 | 46 | 3.0 |
| ACFI | 1 | 0.1 | 47 | 3.1 |
| ACFILNP | 2 | 0.1 | 49 | 3.2 |
| ACFIN | 1 | 0.1 | 50 | 3.3 |
| ACFL | 2 | 0.1 | 52 | 3.4 |
| ACFN | 2 | 0.1 | 54 | 3.6 |
| ACH | 1 | 0.1 | 55 | 3.6 |
| ACI | 1 | 0.1 | 56 | 3.7 |
| AFHP | 29 | 1.9 | 85 | 5.6 |
| AFP | 16 | 1.1 | 101 | 6.6 |
| AP | 1 | 0.1 | 102 | 6.7 |
| C | 423 | 27.8 | 525 | 34.6 |
| CE | 4 | 0.3 | 529 | 34.8 |
| CEF | 7 | 0.5 | 536 | 35.3 |
| CEFH | 1 | 0.1 | 537 | 35.4 |
| CEFHN | 1 | 0.1 | 538 | 35.4 |
| CEFINP | 1 | 0.1 | 539 | 35.5 |
| CEFL | 1 | 0.1 | 540 | 35.5 |
| CEFLNP | 4 | 0.3 | 544 | 35.8 |
| CEFLP | 1 | 0.1 | 545 | 35.9 |
| CEFN | 2 | 0.1 | 547 | 36.0 |
| CEI | 1 | 0.1 | 548 | 36.1 |
| CELN | 2 | 0.1 | 550 | 36.2 |
| CF | 332 | 21.9 | 882 | 58.1 |
| CFH | 152 | 10.0 | 1034 | 68.1 |
| CFHI | 18 | 1.2 | 1052 | 69.3 |
| CFHILP | 1 | 0.1 | 1053 | 69.3 |
| CFHIN | 5 | 0.3 | 1058 | 69.7 |
| CFHL | 27 | 1.8 | 1085 | 71.4 |
| CFHLN | 9 | 0.6 | 1094 | 72.0 |
| CFHLP | 1 | 0.1 | 1095 | 72.1 |
| CFHN | 36 | 2.4 | 1131 | 74.5 |
| CFHNP | 1 | 0.1 | 1132 | 74.5 |
| CFHP | 2 | 0.1 | 1134 | 74.7 |
| CFI | 40 | 2.6 | 1174 | 77.3 |
| CFIL | 10 | 0.7 | 1184 | 77.9 |
| CFILN | 2 | 0.1 | 1186 | 78.1 |
| CFIN | 6 | 0.4 | 1192 | 78.5 |
| CFL | 39 | 2.6 | 1231 | 81.0 |
| CFLN | 20 | 1.3 | 1251 | 82.4 |
| CFN | 29 | 1.9 | 1280 | 84.3 |
| CFNP | 1 | 0.1 | 1281 | 84.3 |
| CFU | 1 | 0.1 | 1282 | 84.4 |
| CH | 20 | 1.3 | 1302 | 85.7 |
| CHI | 5 | 0.3 | 1307 | 86.0 |
| CHL | 5 | 0.3 | 1312 | 86.4 |
| CHLP | 2 | 0.1 | 1314 | 86.5 |
| CHNP | 1 | 0.1 | 1315 | 86.6 |
| CI | 11 | 0.7 | 1326 | 87.3 |
| CIL | 1 | 0.1 | 1327 | 87.4 |
| CL | 9 | 0.6 | 1336 | 88.0 |
| CLP | 4 | 0.3 | 1340 | 88.2 |
| CN | 3 | 0.2 | 1343 | 88.4 |
| CO | 1 | 0.1 | 1344 | 88.5 |
| ECAP | 3 | 0.2 | 1347 | 88.7 |
| F | 124 | 8.2 | 1471 | 96.8 |
| FH | 4 | 0.3 | 1475 | 97.1 |

Small Surface Water Systems (continued)

| Treatment Combination | Frequency | Percent | Cumulative Frequency | Cumulative Percent |
|-----------------------|-----------|---------|----------------------|--------------------|
| FHL | 2 | 0.1 | 1477 | 97.2 |
| FHLP | 4 | 0.3 | 1481 | 97.5 |
| FHNP | 11 | 0.7 | 1492 | 98.2 |
| FL | 2 | 0.1 | 1494 | 98.4 |
| FNP | 5 | 0.3 | 1499 | 98.7 |
| H | 11 | 0.7 | 1510 | 99.4 |
| HI | 2 | 0.1 | 1512 | 99.5 |
| HP | 1 | 0.1 | 1513 | 99.6 |
| I | 1 | 0.1 | 1514 | 99.7 |
| L | 5 | 0.3 | 1519 | 100.0 |

Medium Ground Water Systems

| Treatment Combination | Frequency | Percent | Cumulative Frequency | Cumulative Percent |
|-----------------------|-----------|---------|----------------------|--------------------|
| A | 2 | 0.2 | 2 | 0.2 |
| AC | 83 | 6.4 | 85 | 6.5 |
| ACE | 5 | 0.4 | 90 | 6.9 |
| ACEF | 2 | 0.2 | 92 | 7.0 |
| ACEFH | 2 | 0.2 | 94 | 7.2 |
| ACEFI | 2 | 0.2 | 96 | 7.4 |
| ACEFIP | 1 | 0.1 | 97 | 7.4 |
| ACEFIPR | 1 | 0.1 | 98 | 7.5 |
| ACEFLP | 1 | 0.1 | 99 | 7.6 |
| ACEI | 2 | 0.2 | 101 | 7.7 |
| ACF | 46 | 3.5 | 147 | 11.3 |
| ACFH | 26 | 2.0 | 173 | 13.2 |
| ACFHIL | 1 | 0.1 | 174 | 13.3 |
| ACFHL | 3 | 0.2 | 177 | 13.6 |
| ACFHLR | 1 | 0.1 | 178 | 13.6 |
| ACFHN | 1 | 0.1 | 179 | 13.7 |
| ACFHP | 3 | 0.2 | 182 | 13.9 |
| ACFHR | 1 | 0.1 | 183 | 14.0 |
| ACFI | 14 | 1.1 | 197 | 15.1 |
| ACFL | 11 | 0.8 | 208 | 15.9 |
| ACFR | 1 | 0.1 | 209 | 16.0 |
| ACH | 28 | 2.1 | 237 | 18.1 |
| ACHI | 4 | 0.3 | 241 | 18.5 |
| ACHL | 1 | 0.1 | 242 | 18.5 |
| ACI | 3 | 0.2 | 245 | 18.8 |
| ACL | 4 | 0.3 | 249 | 19.1 |
| ACN | 2 | 0.2 | 251 | 19.2 |
| AEF | 1 | 0.1 | 252 | 19.3 |
| AF | 2 | 0.2 | 254 | 19.4 |
| AFHP | 4 | 0.3 | 258 | 19.8 |
| AFI | 1 | 0.1 | 259 | 19.8 |
| AFP | 8 | 0.6 | 267 | 20.4 |
| AP | 2 | 0.2 | 269 | 20.6 |
| C | 752 | 57.6 | 1021 | 78.2 |
| CE | 12 | 0.9 | 1033 | 79.1 |
| CEF | 6 | 0.5 | 1039 | 79.6 |
| CEFH | 3 | 0.2 | 1042 | 79.8 |
| CEFHL | 1 | 0.1 | 1043 | 79.9 |
| CEFHP | 2 | 0.2 | 1045 | 80.0 |
| CEFI | 1 | 0.1 | 1046 | 80.1 |
| CEFIP | 3 | 0.2 | 1049 | 80.3 |
| CEFP | 2 | 0.2 | 1051 | 80.5 |
| CEH | 3 | 0.2 | 1054 | 80.7 |
| CEHP | 1 | 0.1 | 1055 | 80.8 |

Medium Ground Water Systems (continued)

| Treatment Combination | Frequency | Percent | Cumulative Frequency | Cumulative Percent |
|-----------------------|-----------|---------|----------------------|--------------------|
| CF | 48 | 3.7 | 1103 | 84.5 |
| CFH | 17 | 1.3 | 1120 | 85.8 |
| CFHI | 4 | 0.3 | 1124 | 86.1 |
| CFHIL | 2 | 0.2 | 1126 | 86.2 |
| CFHIP | 2 | 0.2 | 1128 | 86.4 |
| CFHL | 6 | 0.5 | 1134 | 86.8 |
| CFHNO | 1 | 0.1 | 1135 | 86.9 |
| CFHP | 4 | 0.3 | 1139 | 87.2 |
| CFI | 2 | 0.2 | 1141 | 87.4 |
| CFIP | 1 | 0.1 | 1142 | 87.4 |
| CFL | 13 | 1.0 | 1155 | 88.4 |
| CFLN | 1 | 0.1 | 1156 | 88.5 |
| CFLP | 1 | 0.1 | 1157 | 88.6 |
| CFN | 1 | 0.1 | 1158 | 88.7 |
| CFO | 2 | 0.2 | 1160 | 88.8 |
| CFP | 7 | 0.5 | 1167 | 89.4 |
| CFR | 1 | 0.1 | 1168 | 89.4 |
| CH | 45 | 3.4 | 1213 | 92.9 |
| CHI | 8 | 0.6 | 1221 | 93.5 |
| CHIL | 1 | 0.1 | 1222 | 93.6 |
| CHN | 1 | 0.1 | 1223 | 93.6 |
| CI | 43 | 3.3 | 1266 | 96.9 |
| CIL | 2 | 0.2 | 1268 | 97.1 |
| CL | 18 | 1.4 | 1286 | 98.5 |
| CP | 1 | 0.1 | 1287 | 98.5 |
| ECAP | 2 | 0.2 | 1289 | 98.7 |
| F | 4 | 0.3 | 1293 | 99.0 |
| FHNP | 1 | 0.1 | 1294 | 99.1 |
| H | 3 | 0.2 | 1297 | 99.3 |
| HI | 2 | 0.2 | 1299 | 99.5 |
| I | 1 | 0.1 | 1300 | 99.5 |
| L | 5 | 0.4 | 1305 | 99.9 |
| LP | 1 | 0.1 | 1306 | 100.0 |

Medium Surface Water Systems

| Treatment Combination | Frequency | Percent | Cumulative Frequency | Cumulative Percent |
|-----------------------|-----------|---------|----------------------|--------------------|
| AC | 4 | 0.4 | 4 | 0.4 |
| ACE | 1 | 0.1 | 5 | 0.5 |
| ACEFH | 1 | 0.1 | 6 | 0.6 |
| ACEFHINP | 2 | 0.2 | 8 | 0.8 |
| ACEFIP | 10 | 1.0 | 18 | 1.8 |
| ACEFLP | 1 | 0.1 | 19 | 1.9 |
| ACEP | 1 | 0.1 | 20 | 2.0 |
| ACF | 7 | 0.7 | 27 | 2.8 |
| ACFH | 11 | 1.1 | 38 | 3.9 |
| ACFHI | 2 | 0.2 | 40 | 4.1 |
| ACFHIL | 1 | 0.1 | 41 | 4.2 |
| ACFHIP | 1 | 0.1 | 42 | 4.3 |
| ACFHL | 1 | 0.1 | 43 | 4.4 |
| ACFHLN | 3 | 0.3 | 46 | 4.7 |
| ACFHP | 1 | 0.1 | 54 | 5.5 |
| ACFI | 1 | 0.1 | 55 | 5.6 |
| ACFIN | 3 | 0.3 | 58 | 5.9 |
| ACFL | 1 | 0.1 | 59 | 6.0 |
| ACFN | 2 | 0.2 | 61 | 6.2 |
| ACHI | 3 | 0.3 | 64 | 6.5 |
| AFHP | 21 | 2.1 | 85 | 8.7 |

Medium Surface Water Systems (continued)

| Treatment Combination | Frequency | Percent | Cumulative Frequency | Cumulative Percent |
|--------------------------|-----------|---------|-------------------------|-----------------------|
| ACFHLP | 2 | 0.2 | 48 | 4.9 |
| ACFHN | 4 | 0.4 | 52 | 5.3 |
| ACFHNP | 1 | 0.1 | 53 | 5.4 |
| AFP | 7 | 0.7 | 92 | 9.4 |
| C | 194 | 19.8 | 286 | 29.2 |
| CE | 2 | 0.2 | 288 | 29.4 |
| CEF | 3 | 0.3 | 291 | 29.7 |
| CEFH | 1 | 0.1 | 292 | 29.8 |
| CEFHL | 3 | 0.3 | 295 | 30.1 |
| CEFHLN | 2 | 0.2 | 297 | 30.3 |
| CEFILN | 1 | 0.1 | 298 | 30.4 |
| CEFINP | 2 | 0.2 | 300 | 30.6 |
| CEFL | 1 | 0.1 | 301 | 30.7 |
| CEFLNP | 4 | 0.4 | 305 | 31.1 |
| CEH | 1 | 0.1 | 306 | 31.2 |
| CEHP | 1 | 0.1 | 307 | 31.3 |
| CF | 168 | 17.1 | 475 | 48.5 |
| CFH | 128 | 13.1 | 603 | 61.5 |
| CFHI | 25 | 2.6 | 628 | 64.1 |
| CFHIL | 2 | 0.2 | 630 | 64.3 |
| CFHIN | 13 | 1.3 | 643 | 65.6 |
| CFHL | 14 | 1.4 | 657 | 67.0 |
| CFHLN | 6 | 0.6 | 663 | 67.7 |
| CFHN | 35 | 3.6 | 698 | 71.2 |
| CFHNP | 1 | 0.1 | 699 | 71.3 |
| CFHP | 2 | 0.2 | 701 | 71.5 |
| CFHR | 1 | 0.1 | 702 | 71.6 |
| CFI | 33 | 3.4 | 735 | 75.0 |
| CFIL | 3 | 0.3 | 738 | 75.3 |
| CFILN | 1 | 0.1 | 739 | 75.4 |
| CFIN | 9 | 0.9 | 748 | 76.3 |
| CFINP | 1 | 0.1 | 749 | 76.4 |
| CFL | 17 | 1.7 | 766 | 78.2 |
| CFLN | 8 | 0.8 | 774 | 79.0 |
| CFN | 31 | 3.2 | 805 | 82.1 |
| CFO | 1 | 0.1 | 806 | 82.2 |
| CH | 23 | 2.3 | 829 | 84.6 |
| CHI | 6 | 0.6 | 835 | 85.2 |
| CHL | 4 | 0.4 | 839 | 85.6 |
| CHN | 1 | 0.1 | 840 | 85.7 |
| CHNP | 1 | 0.1 | 841 | 85.8 |
| CI | 9 | 0.9 | 850 | 86.7 |
| CIL | 2 | 0.2 | 852 | 86.9 |
| CILP | 1 | 0.1 | 853 | 87.0 |
| CIN | 1 | 0.1 | 854 | 87.1 |
| CINP | 1 | 0.1 | 855 | 87.2 |
| CL | 9 | 0.9 | 864 | 88.2 |
| CLP | 2 | 0.2 | 866 | 88.4 |
| CN | 2 | 0.2 | 868 | 88.6 |
| E | 1 | 0.1 | 869 | 88.7 |
| ECAP | 4 | 0.4 | 873 | 89.1 |
| F | 63 | 6.4 | 936 | 95.5 |
| FH | 4 | 0.4 | 940 | 95.9 |
| FHL | 1 | 0.1 | 941 | 96.0 |
| FHN | 1 | 0.1 | 942 | 96.1 |
| FHNP | 17 | 1.7 | 959 | 97.9 |
| FI | 2 | 0.2 | 961 | 98.1 |
| FL | 1 | 0.1 | 962 | 98.2 |
| FNP | 5 | 0.5 | 967 | 98.7 |
| H | 6 | 0.6 | 973 | 99.3 |
| HN | 3 | 0.3 | 976 | 99.6 |

Medium Surface Water Systems (continued)

| Treatment Combination | Frequency | Percent | Cumulative Frequency | Cumulative Percent |
|--------------------------|-----------|---------|-------------------------|-----------------------|
| HP | 2 | 0.2 | 978 | 99.8 |
| I | 1 | 0.1 | 979 | 99.9 |
| L | 1 | 0.1 | 980 | 100.0 |

Large Ground Water Systems

| Treatment Combination | Frequency | Percent | Cumulative Frequency | Cumulative Percent |
|--------------------------|-----------|---------|-------------------------|-----------------------|
| A | 1 | 0.1 | 1 | 0.1 |
| AC | 76 | 10.3 | 77 | 10.4 |
| ACE | 2 | 0.3 | 79 | 10.7 |
| ACEF | 2 | 0.3 | 81 | 11.0 |
| ACEFH | 1 | 0.1 | 82 | 11.1 |
| ACEFIP | 3 | 0.4 | 85 | 11.5 |
| ACEFL | 1 | 0.1 | 86 | 11.7 |
| ACEH | 2 | 0.3 | 88 | 11.9 |
| ACEP | 1 | 0.1 | 89 | 12.1 |
| ACER | 1 | 0.1 | 90 | 12.2 |
| ACF | 19 | 2.6 | 109 | 14.8 |
| ACFH | 29 | 3.9 | 138 | 18.7 |
| ACFHI | 6 | 0.8 | 144 | 19.5 |
| ACFHIN | 1 | 0.1 | 145 | 19.6 |
| ACFHL | 4 | 0.5 | 149 | 20.2 |
| ACFHLR | 4 | 0.5 | 153 | 20.7 |
| ACFHP | 1 | 0.1 | 154 | 20.9 |
| ACFHR | 1 | 0.1 | 155 | 21.0 |
| ACFI | 9 | 1.2 | 164 | 22.2 |
| ACFIL | 1 | 0.1 | 165 | 22.4 |
| ACFILN | 1 | 0.1 | 166 | 22.5 |
| ACFIN | 1 | 0.1 | 167 | 22.6 |
| ACFIP | 1 | 0.1 | 168 | 22.8 |
| ACFL | 21 | 2.8 | 189 | 25.6 |
| ACFN | 1 | 0.1 | 190 | 25.7 |
| ACH | 25 | 3.4 | 215 | 29.1 |
| ACHI | 2 | 0.3 | 217 | 29.4 |
| ACHL | 1 | 0.1 | 218 | 29.5 |
| ACHN | 1 | 0.1 | 219 | 29.7 |
| ACHR | 4 | 0.5 | 223 | 30.2 |
| ACI | 5 | 0.7 | 228 | 30.9 |
| ACIL | 1 | 0.1 | 229 | 31.0 |
| ACIN | 1 | 0.1 | 230 | 31.2 |
| ACL | 3 | 0.4 | 233 | 31.6 |
| ACN | 4 | 0.5 | 237 | 32.1 |
| AF | 1 | 0.1 | 238 | 32.2 |
| AFHLR | 1 | 0.1 | 239 | 32.4 |
| AFHP | 2 | 0.3 | 241 | 32.7 |
| AFP | 8 | 1.1 | 249 | 33.7 |
| AH | 1 | 0.1 | 250 | 33.9 |
| AP | 1 | 0.1 | 251 | 34.0 |
| C | 300 | 40.7 | 551 | 74.7 |
| CE | 5 | 0.7 | 556 | 75.3 |
| CEF | 3 | 0.4 | 559 | 75.7 |
| CEFH | 2 | 0.3 | 561 | 76.0 |
| CEFHI | 1 | 0.1 | 562 | 76.2 |
| CEFI | 2 | 0.3 | 564 | 76.4 |
| CEFIR | 1 | 0.1 | 565 | 76.6 |
| CEHI | 1 | 0.1 | 566 | 76.7 |
| CF | 17 | 2.3 | 583 | 79.0 |
| CFH | 11 | 1.5 | 594 | 80.5 |

Large Ground Water Systems (continued)

| Treatment Combination | Frequency | Percent | Cumulative Frequency | Cumulative Percent |
|--------------------------|-----------|---------|-------------------------|-----------------------|
| CFHI | 3 | 0.4 | 597 | 80.9 |
| CFHIL | 2 | 0.3 | 599 | 81.2 |
| CFHIO | 1 | 0.1 | 600 | 81.3 |
| CFHIP | 2 | 0.3 | 602 | 81.6 |
| CFHL | 4 | 0.5 | 606 | 82.1 |
| CFHN | 4 | 0.5 | 610 | 82.7 |
| CFHP | 3 | 0.4 | 613 | 83.1 |
| CFI | 1 | 0.1 | 614 | 83.2 |
| CFILNP | 1 | 0.1 | 615 | 83.3 |
| CFL | 19 | 2.6 | 634 | 85.9 |
| CFLN | 2 | 0.3 | 636 | 86.2 |
| CFN | 1 | 0.1 | 637 | 86.3 |
| CFO | 1 | 0.1 | 638 | 86.4 |
| CFP | 2 | 0.3 | 640 | 86.7 |
| CH | 33 | 4.5 | 673 | 91.2 |
| CHI | 4 | 0.5 | 677 | 91.7 |
| CHL | 1 | 0.1 | 678 | 91.9 |
| CI | 21 | 2.8 | 699 | 94.7 |
| CIL | 3 | 0.4 | 702 | 95.1 |
| CL | 18 | 2.4 | 720 | 97.6 |
| CLO | 1 | 0.1 | 721 | 97.7 |
| CLR | 2 | 0.3 | 723 | 98.0 |
| CN | 2 | 0.3 | 725 | 98.2 |
| CP | 1 | 0.1 | 726 | 98.4 |
| CR | 1 | 0.1 | 727 | 98.5 |
| ECAP | 1 | 0.1 | 728 | 98.6 |
| F | 2 | 0.3 | 730 | 98.9 |
| FH | 1 | 0.1 | 731 | 99.1 |
| FHNP | 1 | 0.1 | 732 | 99.2 |
| H | 1 | 0.1 | 733 | 99.3 |
| HI | 1 | 0.1 | 734 | 99.5 |
| HP | 1 | 0.1 | 735 | 99.6 |
| I | 1 | 0.1 | 736 | 99.7 |
| L | 1 | 0.1 | 737 | 99.9 |
| R | 1 | 0.1 | 738 | 100.0 |

Large Surface Water Systems

| Treatment Combination | Frequency | Percent | Cumulative Frequency | Cumulative Percent |
|--------------------------|-----------|---------|-------------------------|-----------------------|
| AC | 6 | 0.6 | 6 | 0.6 |
| ACE | 1 | 0.1 | 7 | 0.7 |
| ACEFH | 1 | 0.1 | 8 | 0.8 |
| ACEFIP | 11 | 1.1 | 19 | 1.9 |
| ACEFN | 1 | 0.1 | 20 | 2.0 |
| ACEFP | 1 | 0.1 | 21 | 2.1 |
| ACEH | 1 | 0.1 | 22 | 2.2 |
| ACF | 19 | 1.9 | 41 | 4.1 |
| ACFH | 12 | 1.2 | 53 | 5.3 |
| ACFHI | 1 | 0.1 | 54 | 5.4 |
| ACFHILN | 1 | 0.1 | 55 | 5.5 |
| ACFHIN | 3 | 0.3 | 58 | 5.8 |
| ACFHIO | 1 | 0.1 | 59 | 5.9 |
| ACFHL | 1 | 0.1 | 60 | 6.0 |
| ACFHLNP | 3 | 0.3 | 63 | 6.3 |
| ACFHN | 9 | 0.9 | 72 | 7.2 |
| ACFHOP | 1 | 0.1 | 73 | 7.3 |
| ACFHP | 1 | 0.1 | 74 | 7.4 |
| ACFI | 2 | 0.2 | 76 | 7.6 |

| <u>Large Surface Water Systems (continued)</u> | | | | |
|--|-----------|---------|-------------------------|-----------------------|
| Treatment Combination | Frequency | Percent | Cumulative Frequency | Cumulative Percent |
| ACFILNP | 1 | 0.1 | 77 | 7.7 |
| ACFIN | 2 | 0.2 | 79 | 7.9 |
| ACFL | 1 | 0.1 | 80 | 8.0 |
| ACFLN | 2 | 0.2 | 82 | 8.2 |
| ACFLO | 1 | 0.1 | 83 | 8.4 |
| ACFN | 2 | 0.2 | 85 | 8.6 |
| ACH | 2 | 0.2 | 87 | 8.8 |
| ACHI | 2 | 0.2 | 89 | 9.0 |
| ACHN | 1 | 0.1 | 90 | 9.1 |
| AFHP | 14 | 1.4 | 104 | 10.5 |
| AFP | 6 | 0.6 | 110 | 11.1 |
| AI | 1 | 0.1 | 111 | 11.2 |
| AP | 1 | 0.1 | 112 | 11.3 |
| C | 178 | 17.9 | 290 | 29.2 |
| CE | 1 | 0.1 | 291 | 29.3 |
| CEFH | 1 | 0.1 | 292 | 29.4 |
| CEFHLP | 1 | 0.1 | 293 | 29.5 |
| CEFHN | 2 | 0.2 | 295 | 29.7 |
| CEFHNP | 1 | 0.1 | 296 | 29.8 |
| CEFINP | 21 | 2.1 | 317 | 31.9 |
| CEFLNP | 8 | 0.8 | 325 | 32.7 |
| CEFN | 2 | 0.2 | 327 | 32.9 |
| CEHI | 1 | 0.1 | 328 | 33.0 |
| CELN | 1 | 0.1 | 329 | 33.1 |
| CF | 114 | 11.5 | 443 | 44.6 |
| CFH | 113 | 11.4 | 556 | 55.9 |
| CFHI | 38 | 3.8 | 594 | 59.8 |
| CFHIL | 3 | 0.3 | 597 | 60.1 |
| CFHILN | 3 | 0.3 | 600 | 60.4 |
| CFHIN | 25 | 2.5 | 625 | 62.9 |
| CFHIP | 1 | 0.1 | 626 | 63.0 |
| CFHL | 11 | 1.1 | 637 | 64.1 |
| CFHLN | 3 | 0.3 | 640 | 64.4 |
| CFHLP | 1 | 0.1 | 641 | 64.5 |
| CFHLR | 1 | 0.1 | 642 | 64.6 |
| CFHN | 45 | 4.5 | 687 | 69.1 |
| CFHNP | 1 | 0.1 | 688 | 69.2 |
| CFHO | 3 | 0.3 | 691 | 69.5 |
| CFHP | 4 | 0.4 | 695 | 69.9 |
| CFHR | 1 | 0.1 | 696 | 70.0 |
| CFI | 23 | 2.3 | 719 | 72.3 |
| CFIL | 4 | 0.4 | 723 | 72.7 |
| CFILN | 5 | 0.5 | 728 | 73.2 |
| CFILNP | 1 | 0.1 | 729 | 73.3 |
| CFILP | 3 | 0.3 | 732 | 73.6 |
| CFIN | 17 | 1.7 | 749 | 75.4 |
| CFIP | 1 | 0.1 | 750 | 75.5 |
| CFL | 6 | 0.6 | 756 | 76.1 |
| CFLN | 10 | 1.0 | 766 | 77.1 |
| CFLNP | 1 | 0.1 | 767 | 77.2 |
| CFN | 29 | 2.9 | 796 | 80.1 |
| CFO | 1 | 0.1 | 797 | 80.2 |
| CH | 13 | 1.3 | 810 | 81.5 |
| CHI | 4 | 0.4 | 814 | 81.9 |
| CHL | 2 | 0.2 | 816 | 82.1 |
| CHN | 1 | 0.1 | 817 | 82.2 |
| CI | 9 | 0.9 | 826 | 83.1 |
| CIL | 1 | 0.1 | 827 | 83.2 |
| CILN | 1 | 0.1 | 828 | 83.3 |
| CIN | 3 | 0.3 | 831 | 83.6 |
| CINP | 3 | 0.3 | 834 | 83.9 |

Large Surface Water Systems (continued)

| Treatment Combination | Frequency | Percent | Cumulative Frequency | Cumulative Percent |
|-----------------------|-----------|---------|----------------------|--------------------|
| CL | 17 | 1.7 | 851 | 85.6 |
| CLN | 2 | 0.2 | 853 | 85.8 |
| CLP | 1 | 0.1 | 854 | 85.9 |
| CN | 1 | 0.1 | 855 | 86.0 |
| ECAP | 6 | 0.6 | 861 | 86.6 |
| F | 84 | 8.5 | 945 | 95.1 |
| FH | 1 | 0.1 | 946 | 95.2 |
| FHLP | 6 | 0.6 | 952 | 95.8 |
| FHNP | 22 | 2.2 | 974 | 98.0 |
| FNP | 8 | 0.8 | 982 | 98.8 |
| FO | 1 | 0.1 | 983 | 98.9 |
| H | 3 | 0.3 | 986 | 99.2 |
| HN | 1 | 0.1 | 987 | 99.3 |
| I | 1 | 0.1 | 988 | 99.4 |
| N | 2 | 0.2 | 990 | 99.6 |
| NP | 1 | 0.1 | 991 | 99.7 |
| O | 1 | 0.1 | 992 | 99.8 |
| OP | 1 | 0.1 | 993 | 99.9 |
| P | 1 | 0.1 | 994 | 100.0 |

Very Large Ground Water Systems

| Treatment Combination | Frequency | Percent | Cumulative Frequency | Cumulative Percent |
|-----------------------|-----------|---------|----------------------|--------------------|
| AC | 4 | 9.5 | 4 | 9.5 |
| ACFH | 1 | 2.4 | 5 | 11.9 |
| ACFHI | 1 | 2.4 | 6 | 14.3 |
| ACFHL | 1 | 2.4 | 7 | 16.7 |
| ACFHN | 1 | 2.4 | 8 | 19.0 |
| ACFI | 1 | 2.4 | 9 | 21.4 |
| ACFL | 2 | 4.8 | 11 | 26.2 |
| ACH | 3 | 7.1 | 14 | 33.3 |
| ACHN | 1 | 2.4 | 15 | 35.7 |
| C | 12 | 28.6 | 27 | 64.3 |
| CFH | 2 | 4.8 | 29 | 69.0 |
| CFHI | 1 | 2.4 | 30 | 71.4 |
| CFHL | 1 | 2.4 | 31 | 73.8 |
| CFL | 4 | 9.5 | 35 | 83.3 |
| CH | 1 | 2.4 | 36 | 85.7 |
| CIL | 1 | 2.4 | 37 | 88.1 |
| CL | 1 | 2.4 | 38 | 90.5 |
| CN | 1 | 2.4 | 39 | 92.9 |
| F | 3 | 7.1 | 42 | 100.0 |

Very Large Surface Water Systems

| Treatment Combination | Frequency | Percent | Cumulative Frequency | Cumulative Percent |
|-----------------------|-----------|---------|----------------------|--------------------|
| AC | 1 | 0.6 | 1 | 0.6 |
| ACF | 4 | 2.5 | 5 | 3.2 |
| ACFH | 5 | 3.2 | 10 | 6.3 |
| ACFHI | 1 | 0.6 | 11 | 7.0 |
| ACFHIN | 2 | 1.3 | 13 | 8.2 |
| ACFHINP | 1 | 0.6 | 14 | 8.9 |
| ACFHN | 1 | 0.6 | 15 | 9.5 |
| ACFLN | 1 | 0.6 | 16 | 10.1 |
| ACFN | 1 | 0.6 | 17 | 10.8 |

Very Large Surface Water Systems (continued)

| Treatment Combination | Frequency | Percent | Cumulative Frequency | Cumulative Percent |
|--------------------------|-----------|---------|-------------------------|-----------------------|
| ACFO | 1 | 0.6 | 18 | 11.4 |
| ACHI | 1 | 0.6 | 19 | 12.0 |
| AFHP | 1 | 0.6 | 20 | 12.7 |
| C | 10 | 6.3 | 30 | 19.0 |
| CEFHIN | 1 | 0.6 | 31 | 19.6 |
| CEFINP | 2 | 1.3 | 33 | 20.9 |
| CEFLN | 1 | 0.6 | 34 | 21.5 |
| CEFLNP | 3 | 1.9 | 37 | 23.4 |
| CF | 21 | 13.3 | 58 | 36.7 |
| CFH | 20 | 12.7 | 78 | 49.4 |
| CFHI | 5 | 3.2 | 83 | 52.5 |
| CFHILNP | 1 | 0.6 | 84 | 53.2 |
| CFHIN | 4 | 2.5 | 88 | 55.7 |
| CFHINP | 2 | 1.3 | 90 | 57.0 |
| CFHLN | 2 | 1.3 | 92 | 58.2 |
| CFHLNP | 1 | 0.6 | 93 | 58.9 |
| CFHN | 11 | 7.0 | 104 | 65.8 |
| CFHP | 1 | 0.6 | 105 | 66.5 |
| CFI | 1 | 0.6 | 106 | 67.1 |
| CFILN | 1 | 0.6 | 107 | 67.7 |
| CFIN | 4 | 2.5 | 111 | 70.3 |
| CFL | 3 | 1.9 | 114 | 72.2 |
| CFN | 7 | 4.4 | 121 | 76.6 |
| CFO | 1 | 0.6 | 122 | 77.2 |
| CH | 3 | 1.9 | 125 | 79.1 |
| CIL | 1 | 0.6 | 126 | 79.7 |
| CIN | 1 | 0.6 | 127 | 80.4 |
| CL | 2 | 1.3 | 129 | 81.6 |
| EFNO | 1 | 0.6 | 130 | 82.3 |
| F | 18 | 11.4 | 148 | 93.7 |
| FHLP | 1 | 0.6 | 149 | 94.3 |
| FHNP | 7 | 4.4 | 156 | 98.7 |
| FILP | 1 | 0.6 | 157 | 99.4 |
| FNP | 1 | 0.6 | 158 | 100.0 |

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