Small Rural Communities' Quest for Safe Drinking Water

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The overwhelming majority of drinking water systems are small and in small rural communities, serving primarily residential customers with few, if any, commercial or industrial customers. Because they are unable to achieve economies of scale available to larger systems serving urban populations, small water systems face high investment, operational, maintenance, and compliance costs, and charge relatively high water rates. Meanwhile, most of their customers have relatively low per capita income. This creates a dilemma for small water systems—how to provide water at an affordable rate while charging a price that will cover all costs.

Congress passed the Safe Drinking Water Act (SDWA) in 1974 and amended it in 1986 and 1996. Safe drinking water is important for all 180,364 public water systems, but the rules and regulations of the SDWA and subsequent amendments apply only to community drinking water systems.

This article examines some of the challenges facing the approximately 50,000 community water systems, which constitute only 28 percent of all public systems but serve 92.5 percent of the population served by all public water systems (see "Types of Public Water Systems"). The smaller systems typical of rural communities must combat high per unit costs. These same diseconomies of scale hinder the ability of rural communities to comply with regulations to improve the quality of drinking water. To indicate the severity of these challenges, this article presents financial data provided by the Environmental Protection Agency (USEPA), broken down by size of water system.

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Small Water Systems Primarily in Small Rural Communities

The problems associated with small systems are of greatest concern to rural areas because small rural communities are typically served by such systems. According to the 1990 census, two-thirds of all incorporated communities with populations below 10,000 were in rural areas, as were three-fourths below 2,500, and four-fifths under 1,000 (Bagi). More than 70 percent of all community water systems serve fewer than 1,000 residents and 93 percent serve communities with 10,000 or fewer residents (USEPA, 1997b). Highly rural counties are particularly prevalent in the Great Plains, the South, and Appalachia, so water systems there may be particularly stretched.

Characteristics of Community Drinking Water Systems

The size of the population served by any water system determines important operating ratios. The capacity-to-daily-production ratio shows that water production is well below full capacity at systems of every size, but it is more pronounced among smaller systems (table 1). The inverse relationship between the ratio of peak daily water production to average daily production shows that smaller systems experience higher fluctuations in water production during different times of the day. Since smaller systems more often lack storage facilities for their treated water, they have to meet any increases in demand by increasing the amount of treated water at that time. With larger systems, storage facilities can meet increased demand by releasing treated water, helping such systems regulate and manage their daily production of treated water more efficiently.

The length of distribution and transmission pipes per connection generally increases as the system size decreases. The median pipe length per connection for the smallest water systems, serving 25-100 persons, is more than double that for the largest systems (serving over 10,000 persons) which have

the lowest median pipe length per connection. The median number of persons served per mile of pipe directly increases with (publicly owned) water system size (table 1). Consequently, smaller systems have to spend more, per connection, on installing, maintaining, and repairing the transmission and distribution pipe.

The smallest water systems produce water almost exclusively for residential customers. Eighty-seven percent of all community water system connections are residential connections, but only 47 percent of total water is delivered to residential customers. Annual median water sales per connection to residential and nonresidential customers are $218 and $1,177. Each nonresidential connection delivers 7.4 times more water and earns 5.4 times more revenue than a residential connection.

The share of revenue earned from residential customers declines rapidly, while that from nonresidential customers rises rapidly with the increasing size of the community water system.

For the smallest size systems, the share of revenue from nonresidential customers is only 5.5 percent, while it is nearly half (46.4 percent) for systems serving populations larger than 10,000. The share of water connections fitted

Table 1

Profile of community drinking water systems

Small community water systems dominate in numbers, serve more dispersed populations, and are less able to operate close to their maximum design

Item	System size (Number of persons served per system)					
	25-100	101-500	501-1,000	1,001-3,300	3,301-10,000	Over 10,000
Percent of all community water systems[1]	27.4	30.7	13.0	13.9	8.2	6.8
Average water delivery connections per system[1]	28.4	114	310	732	2145	32295
Median number of persons served per system[2]	58	225	726	1,775	5,474	23,000
Daily water production per connection (gallons)	250	304	296	361	393	1,200
Mean daily water produced (million gallons)[1]	0.012	0.034	0.093	0.314	0.933	16.939
Density or dispersal of population served:						
Median miles of pipe per connection	0.030	0.026	0.026	0.033	0.023	0.014
Persons served per mile of existing pipe:[3]						
Publicly owned systems	100	117	172	122	161	347
Privately owned systems	151	160	101	102	97	236
				Percent		
Design capacity and daily production:						
Design capacity to average daily production ratio[1]	6.3	6.3	5.0	4.5	2.7	2.4
Design capacity to peak daily production ratio[1]	2.5	2.4	2.2	2.0	1.6	1.4
Peak daily to average daily production ratio[1]	2.0	2.0	2.2	1.9	1.7	1.5
Percent of systems without treated water storage	59	36	19	16	9	3
Source of raw water:						
Ground water	95.7	85.2	76.6	68.2	57.6	47.4
Surface and purchased water	4.3	14.8	23.4	31.8	42.4	52.6
Treatment and system operator profile:						
Participating in source water protection[1]	27.5	31.2	38.5	35.0	40.1	50.3
Percent of systems without water treatment[1]	30.5	15.7	10.7	11.8	4.7	0.6
Average number of water treatment operators[1]	0.6	1.2	1.6	2.2	3.2	9.4

[1]Adapted by ERS from EPA, *1995 Community Water System Survey: Volume II: Detailed Survey Result Tables and Methodology Report*, January 1997c.
[2]Adapted by ERS from EPA, *National Characteristics of Drinking Water Systems Serving Population Under 10,000*, July 1999.
[3]Adapted by ERS from EPA, *1995 Community Water System Survey, Volume I: Overview*, January 1997b.

Table 2
Violations of SDWA rules and regulations
Smaller community water systems account for a greater share of total violations

Systems violations	System size (Population served per system) <500	501-3,300	3,301-10,000	>10,000
	Percent			
Maximum contaminant limit (MCL) rule[1]	65.2	21.3	7.3	7.4
Treatment technology (TT) rule[2]	45.1	32.5	11.6	10.8
Monitoring and reporting (M/R) rule[3]	71.4	19.2	5.2	4.2
Other rule and regulation violations[4]	66.7	21.2	6.3	5.7

[1]Under the Safe Drinking Water Act of 1974 and subsequent amendments of 1986 and 1996, U.S. Environmental Protection Agency has set the maximum limit for about 90 contaminants. MCL is the highest level of a contaminant permitted in drinking water, consistent with a level safe for human consumption, the best available treatment technology, and at affordable cost.
[2]Specifies the best available technology for all systems and also affordable for small systems serving 3,300 or fewer persons.
[3]Schedule prescribed to the operators of water systems, for monitoring and reporting any violations to the designated local or regional office of the Environmental Protection Agency.
[4]All rules and regulations, other than the above three, prescribed and enforced by the Environmental Protection Agency.
Source: Adapted by ERS, from the EPA, *National Characteristics of Drinking Water Systems Serving Populations Under 10,000*, July 1999.

with water meters also increases rapidly with the increasing size of the community water system. Less than 37 percent of the smallest systems have metered connections, versus 97 percent of the large systems. Without metered connections, small systems must charge a flat rate per connection, which discourages an efficient use of water.

Small Systems Account for Most SDWA Violations

The overriding objective of the Safe Drinking Water Act (SDWA) and subsequent amendments is to protect human health from waterborne diseases and contaminants.

Protecting source water and wellheads can reduce contamination, decrease the incidence of waterborne diseases, and reduce outlays for treatment facilities and technology. Community water systems that monitor and prevent contaminants can reduce water rates charged to customers. But data show that the smaller the system, the fewer participate in programs designed to protect source water or wellheads. Some systems pump out groundwater and deliver it to their customers without treating it. But as system size increases, more systems install filtration for removing iron and manganese, softening hard water, and filtering out organic matter.

In 1998 (latest data available), only a fraction of community water systems in each size group violated important SDWA rules or regulations. However, the share of total violations of any given SDWA rule was inversely related with the size of the community water system. Systems serving 25-500 persons, which account for only 27 percent of community water systems, incurred 65 percent of all violations of the maximum contaminant limit (MCL), 45 percent of all treatment technology violations, and 71 percent of all of monitoring/reporting violations (table 2).

Such high incidence of SDWA rule violations may be caused, at least in part, by the lack of full-time, trained, and State-certified operators. In 1998, 62 percent of all community water systems did not hire any operators. The average number of water system operators is directly related to the size of the water system (table 1).

Financial Health of Small Community Water Systems

The basic indicator of financial difficulty is either a deficit (for a public system) or a loss (for a private system). Recent (1995) EPA data showed that small systems had a higher incidence of deficits and losses than larger systems (table 3). Smaller systems undoubtedly have greater difficulty borrowing funds, because of their smaller cash flow relative to debt.

To determine the source of the financial problem, the *operating ratio* is calculated by dividing a water system's operating revenues by its operating and maintenance expenses. An operating ratio equal to 1.0 implies that a water system's operating revenues exactly cover its operating and maintenance expenses. A ratio less than 1.0 indicates that the system's revenues are insufficient to cover its expenses. Operating ratios indicate how common it is (one out of every three of the smallest size systems) for small systems to fail to pay for their own current operating costs.

In addition to operating costs, water systems must pay for the cost of borrowing—*debt service cost*. The debt service ratio is calculated by dividing net available revenue by

annual principal and interest (debt service) charges, where net available revenue is measured by subtracting operating and maintenance expenses from total revenues. The smaller the size of the water system, the larger the share of systems with a debt service ratio less than 1.0, and thus unable to service debt using available system revenues.

Another useful financial indicator is the *net takedown ratio*, calculated by dividing net available revenue (as defined above) by total gross revenue (which includes both operating and nonoperating revenues). The net takedown ratio is an indicator of a water system's profitability. Lenders prefer a ratio greater than 20 percent. The smaller the water system (in 1995), the less likely it was to have a takedown ratio greater than 20 percent (table 3).

The ratio of total debt to total annual revenue measures a water system's ability to support additional debt: the lower the ratio, the greater the ability to service additional debt. This ratio, in general, is inversely related with system size (table 4)—the smaller the system, the lesser its ability to service additional debt.

The higher the total-assets-to-total-revenue ratio, the lower the return on assets. This ratio is quite high for all systems, but it is almost twice as high for the smallest size systems—more than 250 percent higher for systems serving 101-500 persons and, on average, 150 to 400 percent higher for all water systems than for investor-owned electric and gas utilities. This is inherent in water treatment technology, and is aggravated by the inadequate water storage capacity of small systems.

In sum, smaller systems are more likely than large systems to have deficit or loss, lower operating ratios, lower debt service ratios, and lower takedown ratios, but higher assets-to-revenue ratio. All of these financial measures reinforce each other and clearly show that the smaller the water system, the weaker its financial health is likely to be.

Table 3
Financial ratios of drinking water systems
Smaller community water systems have less favorable financial performance measures

Financial performance measure	System size (population served per system)			
	<500	501-3,300	3,301-50,000	>50,000
	Percent of systems			
Operating ratio:				
Public—				
<1.0	34.8	19.0	14.4	8.3
1.0 - 1.2	17.8	23.5	10.8	9.5
>1.2	47.4	57.4	74.8	82.2
Private—				
<1.0	32.3	17.2	6.0	6.4
2.0 - 1.2	19.6	18.7	16.8	5.1
>1.2	48.1	64.1	77.2	88.5
Debt service coverage ratio:				
Public—				
<1.0	52.1	41.5	25.7	15.7
1.0 - 1.5	19.3	16.5	21.0	21.2
>1.5	28.6	42.0	53.3	63.1
Private—				
<1.0	46.7	28.5	15.4	7.7
1.0 - 1.5	12.6	11.4	14.8	3.1
1.5	40.7	60.1	68.8	89.2
Net takedown ratio:				
Public—				
<0.0%	29.6	13.0	10.0	8.0
0.0 % - 20%	11.2	22.9	13.5	8.0
>20%	59.2	64.1	76.5	84.0
Private—				
<0.0%	19.7	10.2	5.6	7.7
1.0 % - 20%	9.6	18.6	14.0	3.0
>20%	70.7	71.2	80.4	89.3
Systems with deficit or loss:				
Public systems	42.5	34.3	25.3	16.4
Privately owned systems	39.6	35.0	19.2	6.1

Source: Adapted by ERS from the EPA, *1995 Community Water System Survey, Volume I: Overview*, January 1997b.

Small Systems Charge Higher Water Rates and Increase Them More Frequently

The smallest systems had higher water rates than other systems and increased their rates more frequently. Their rate increases were also the highest of all system sizes; annualized rate increases from 1986 to 1995 were higher than all other system sizes (table 4).

Table 4

Financial profile of community drinking water systems

Smaller community water systems have higher per capita total expenses, charge higher water rates, and raise water rates more frequently and by higher margins

Item	System size (number of persons served per system)					
	25-100	101-500	501-1,000	1,001-3,300	3,301-10,000	Over 10,000
Percent of revenue from residential customers[1]	94.5	81.9	73.5	62.6	58.3	53.6
Metered customer connections (percent)[1]	36.6	71.8	87.4	93.7	92.0	97.0
Water rates and revenue:						
Water rates (cents/1,000 gallons)[1]	321	306	312	255	252	190
Years since last residential rate increase[1]	2.5	3.8	2.9	3.8	3.3	2.5
Last rate increase (percent)[1]	37.2	22.2	24.7	28.4	16.3	14.5
Average of last two rate increases (percent)[1]	25.6	17.7	20.7	24.5	16.5	12.2
Annualized rate increase 1986-1995 (percent)[2]	14.8	5.8	8.6	7.4	4.9	6.0
			Dollars			
Total expenses per capita[1]	205	100	112	107	99	96
Total assets to total revenue ratio	12.8	17.1	6.7	6.5	6.4	6.9
Total assets per connection[1]	1,081	3,013	1,702	1,733	1,803	2,297
Total liabilities per connection[1]	1,201	1,791	925	1,000	866	1,154
Total net assets per connection	-120	1,222	777	733	937	1,143
Per connection investment from 1987 to 1995[1]	859	1,412	1,242	705	766	656
			Ratio			
Total debt to total revenue:[1]						
Public systems	3.34	2.38	1.82	2.47	2.02	1.42
Privately owned systems	2.23	1.76	1.94	1.89	1.85	1.39

[1]Adapted by ERS from EPA, 1*995 Community Water System Survey: Volume II: Detailed Survey Result Tables and Methodology Report*, January 1997c.
[2]Adapted by ERS from EPA, *1995 Community Water System Survey, Volume I: Overview*, January 1997b.

Small systems have few, if any, wholesale, commercial, and industrial customers, for whom water expenses are business costs, which they can pass on to customers. As such, commercial and industrial customers may be better able to absorb water rate increases. For very small systems serving 25-1,000 persons, residential share is over three-quarters of total water revenue (table 4). For residential customers, water rate increases are quite unpopular because they must cut spending elsewhere to pay for increased water bills.

Revenue earned from residential customers has generally been increasing since 1975 for all system sizes. Systems serving fewer than 10,000 persons have been charging higher rates than those serving larger populations due to diseconomies of scale and the smaller customer base over which to spread investment costs and operating/maintenance costs.

Water Infrastructure Needs Through 2015

Eighty-five percent of all community drinking water systems serve 3,300 or fewer persons. Capital investment needs of these small systems, which account for only about 10 percent of the service population, amount to $37.2 billion (27 percent of the estimated total investment capital needed for all community drinking water systems) over the 1995-2015 period. These capital needs, however, are underestimated because some small systems either did not identify every need or did not document it as specified by the Environmental Protection Agency (1997a). (These estimates include neither the infrastructure needs of non-community water systems nor those of some 56 million Americans living in

unincorporated areas not connected to public water systems.)

The investment need per household over 1995-2015 rapidly decreases with increasing system size: $3,300 for systems serving 25-3,300 persons, $1,200 for systems serving 3,301-50,000 persons, and $970 for systems serving 50,000 or more persons (USEPA, 1997a). Other sources show that about 58 percent of all community water systems serve 500 or fewer persons, and their capital needs per household are likely to be much higher than $3,300.

The largest investment need for community water systems is the installation and repair of transmission and distribution pipes. For systems serving 3,300 or fewer persons, this category accounts for $23.8 billion of their total capital investment need of $37.2 billion. Any breakdown in transmission lines can interrupt water treatment and raise water treatment costs. Deteriorating distribution pipes can contaminate water and interrupt water delivery to customers. Most of the need in this category is for replacing deteriorated or severely undersized pipes. The smallest systems also have a greater share of capital investment need for water storage capacity (USEPA, 1997a).

1996 Amendments Begin To Reduce Small System Problems

In 1994, 85 percent of community water systems served 3,300 or fewer persons. All of these are technically eligible for all special assistance provisions of the 1996 amendments to the SDWA. Another 7 percent—systems serving 3,301 to 10,000 persons—are also eligible for nearly all of the provisions.

These special provisions for the small systems can reduce: (1) the costs of monitoring and testing for contaminants not likely to be present in a water systems, (2) the cost of printing and mailing consumer confidence reports to all customers, and (3) the cost of operator training and certification. The provision that the EPA should identify feasible and affordable technology for small systems is limited to technologies necessary for meeting the requirements of the new rules.

Although these provisions can reduce some of the costs to small systems of new regulations, most costs would still be borne by the communities. For example, with regard to the hiring of water system operators (required by SDWA amendments), only expenses incurred in the training and State certification of hired operators would be reimbursed. Systems would still have to pay compensation to the newly hired operators. Then, after training and State certification, operators might leave for better paying jobs at larger systems. In 1998, 62 percent of community water systems had no regular operators. This requirement will substantially increase the operating expenses of these systems.

According to the 1996 amendments to the SDWA, small water systems will not be required to test for contaminants that are known to be absent from their water system. This is a helpful rule in that it lowers costs, but it makes it difficult to discover any new pollutants entering the source water.

Another provision allows States to exempt a water system from mailing consumer confidence reports to every customer. This would reduce printing and mailing costs, but would customers be promptly informed about any harmful violations at such a system? Is it a benefit to the water system at the expense of its customers' health?

SDWA provisions reduce neither the capital investment need for 1995-2015 nor current maintenance/replacement costs. Amendments do not help pay off any

Types of Public Drinking Water Systems

A public water system is either a community or a non-community water system. It has at least 15 service connections or regularly provides water for human consumption to at least 25 persons daily, for at least 60 days out of the year. A public water system is called a community water system (CWS) if it has at least 15 service connections used by year-round residents or if it regularly serves at least 25 year-round residents (USEPA, January 1997b). The remaining public water systems, which do not meet the above condition, are called non-community water system (NCWS).

There were 180,364 public water systems as of 1995. Out of them, 50,289 were community water systems, which served 243 million people; the remaining 130,075 were NCWSs, serving about 20 million people (USEPA, January 1997b). Three out of ten NCWSs are restaurants or hotels/motels, and two out of five are other sites that include highway rest stops, factories, office/industrial parks, and large shopping malls. The remainder were churches (9.8 percent), schools (7.8 percent), recreation places—ummer camps, campgrounds, and RV parks—(10.8 percent), and medical facilities and nursing homes (1 percent) (USEPA, July 1999).

existing debt, except in the case of some "disadvantaged communities" plagued by very high unemployment and poverty, low personal income, and limited credit. Such disadvantaged communities are eligible for additional financial assistance for loan subsidies and forgiveness of principal, but the State must decide how much of such assistance to provide.

Conclusions

Smaller community water systems face a number of challenges. They are less able to operate near capacity, experience greater fluctuations in daily water production, and more frequently fail to meet SDWA rules. They deliver much less water, install more miles of pipe, spend more on maintenance and replacement of water pipes, and are often unable to achieve economies of scale. Thus, smaller community water systems have higher total per capita expenses, charge higher water rates, raise water rates more frequently and by larger margins, and suffer weaker financial position.

Smaller water systems are located primarily in small rural communities and serve primarily residential customers. Small rural communities typically have a greater share of retired and older residents, higher rates of unemployment and underemployment, and lower per capita income (Reeder). Thus, the share of rural household income spent on the capital needs of drinking water systems (and all other environmental protection programs and utilities) are higher than for urban residents, even those living in small metro areas. RA

For Further Reading . . .

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