Rural Water Partnership Fund
NRWA White Paper
2915 S. 13th Street, Duncan, OK 73533 580-252-0629 www.nrwa.org

National Cost Estimate for Cross Connection Control in Small Water Systems

Prepared By:

Frederick W. Pontius, P.E. and William B. Evans, Ph.D.
Pontius Water Consultations, Inc.
P.O. Box 150361
Lakewood, Colorado 80215
303-986-9923
303-716-7310 fax
fred@pontiuswater.com

August 28, 2004

National Rural Water Association

1.0 EXECUTIVE SUMMARY

Cross connection control and backflow prevention are not a new concern. All states have some type of law or regulation for the control of cross connections and/or backflow prevention. The US Environmental Protection Agency (USEPA) held stakeholder meetings in 2003, where the possibility of a national regulation requiring water systems to have a cross connection control program was discussed.

A national regulation for cross connection control will impact the 49,497 Community Water Systems (CWS) and 19,668 Nontransient and Noncommunity Water Systems (NTNCWS) in the U.S. that serve 10,000 or fewer persons (USEPA 2003). This report presents a methodology to estimate the national cost for a cross connection control program for these water systems. The accuracy of any cost estimating model is determined by the quality of data available to develop the model. Unfortunately, very little reliable data is available for estimating the cost of cross-connection control programs in small water system. Because the existing underlying data are not strong, only an "order of magnitude" level estimate can be developed at this time.

Project Approach. In this study, the total national water system cost is estimated by considering the cost to a typical water system within selected public water system size categories. The total national cost is roughly estimated as the total sum of the typical system cost multiplied by the number of systems within that size category.

A computational model was developed to calculate the cost for a "typical" system in each water system size category. The cost to the typical system is then multiplied by the national water system inventory, to determine a national cost for that water system size category. Baseline conditions can be accounted for by estimating the fraction of water systems with certain baseline conditions (such as the fraction of system already having an ordinance). For this basic analysis, an assumption is made that small water systems (10,000 or fewer persons served) have minimal or no baseline cross connection control program.

For this analysis, it is assumed that any USEPA national regulation would impose requirements on the State Primacy Agency as a condition of retaining Primacy. The state would then develop appropriate laws and regulations, and pursue needed code changes to impose requirements on the public water systems and communities within the state. It is assumed that any national regulation by USEPA would include requirements for small water systems, building owners, home owners, and state regulatory agencies to develop and implement the following seven program elements and activities.

Program Element 1. Develop and Enact a Local Ordinance. It is assumed that each small water system and/or small community would be required to develop and enact a local ordinance requiring installation of an appropriate backflow device at high risk locations. The associated costs for this task consist of the labor and legal costs of writing the ordinance, obtaining support of the appropriate stakeholders and public officials, and obtaining the necessary approvals. The water system will have labor as well as legal fees associated with this task.

Program Element 2. Identification of Potential Cross-Connections. Typically, state regulations would require each small water system to survey and identify potential cross connections within the water system. The town's operator, engineer, or other official representative would perform a survey of the public water system to identify potentially hazardous cross-connections. Potential cross connections would generally be prioritized by degree of hazard. New water service installations would be inspected for compliance with backflow prevention requirements.

Water suppliers determine degrees of hazard by interviewing facility personnel as well as reviewing appropriate technical information. Connections that present a potential health hazard are required to have containment assemblies, with the most severe hazards having the highest action priority. Once inspections are completed and hazards prioritized, the water system would notify building owners, business owners, and/or home owners of the steps needed to comply with the town's backflow prevention ordinance, and what devices are required. After the devices are installed by a certified installer, the water system would inspect the installation. Any new installations would also be inspected by the water system.

Program Element 3. Public Education. The water system would have the primary responsibility for any public education about potential cross connection health risk, with particular emphasis on cross connections at or within homes and other residences.

Program Element 4. Initial Purchase & Installation of Assemblies and Devices. The cost of installation of backflow prevention assemblies and devices would typically be paid for by the building owner, business owner, or home owner. The water system would notify the building owner, business owner, or home owner of the type of device required. Each cross connection assembly or device would be commensurate with the degree of hazard posed by the cross connection. Assembly/device approval would be given by the water system operator or engineer. State regulations would specify the types of acceptable backflow prevention assemblies/devices.

Program Element 5. Testing and Repair. Typical state and local ordinances require testing by a certified backflow prevention technician. The frequency of testing is usually specified in State regulations, and may be annual, semiannual, or risk-based. The water system would only pay for the cost of testing of those backflow assemblies and devices owned by the water system. In general, the building owner, business owner, or home owner, would pay for the cost of testing and any necessary repairs for those assemblies and devices that they own.

Program Element 6. Recordkeeping. The building owner, business owner, or home owner, would be required to retain testing and maintenance records for a period of time specified in State regulations. The water system would retain records related to its backflow prevention program, and retain testing and maintenance records for devices owned by the water system. Reporting of any backflow incident would be required by the state primacy agency, and records of such incidents, as well as action taken, would be retained.

Program Element 7. Enforcement. In general, the local water system administers and enforces its own cross connection program at the local level. States typically rely on the water system to enforce the program, with little follow up or enforcement at the State level. This analysis assumes that USEPA would require State Primacy Agencies to require small water systems to enforce compliance with the local backflow prevention ordinance. The water system, therefore, would have to take action against any non-complying facility within their service area.

National Cost Estimates. The national cost estimate described in this report is highly influenced by the assumptions used in the analysis. The national capital cost of cross connection control in CWSs (Table 19) is estimated to be between $1.8 Billion and $5.15 Billion (central estimate of $2.44 Billion). First year operating costs, which include enactment of a local ordinance and an initial survey of potential cross connections, are estimated to be between $88 Million to $221 Million (central estimate of $127 Million). Ongoing operation and maintenance is estimated to be between $201 Million to $2.4 Billion (central estimate of $540 Million).

For NTNCWSs (Table 20), the total national capital cost of cross connection control is estimated to be between $113 Million and $452 Million (central estimate of $201 Million). First year operating costs, which includes an initial survey of potential cross connections, are estimated to be between $2.87 Million and $11.5 Million (central estimate $5.09 Million). Ongoing operation and maintenance is estimated to be between $11.7 Million and $46.9 Million (central estimate $20.8 Million).

Recommendations. To date, this is the only study of its kind to develop national cost estimates for cross connection control in small water systems. The following recommendations are offered to improve the estimates presented herein:

1. National and state data regarding backflow prevention practices and experiences is limited or not available. Therefore, many assumptions must be made in this analysis using professional judgment. These estimates may be improved upon by validating these assumptions, either by conducting appropriate surveys to collect needed data, or by convening a stakeholder group to develop consensus values.
2. State-specific data are needed to develop a more robust analysis on a state-by-state basis that considers baseline cross connection programs currently in existence in small water systems. Cost estimates should be developed state-by-state based on state-specific conditions, with the results summed to estimate national costs.
3. The simple approach used here is sufficient for an order of magnitude estimate given existing data. Probabilistic methods should be applied to estimate national costs if a reliable underlying database can be developed.

2.0 INTRODUCTION

The purpose of this study is to develop a national cost estimate for the implementation of a cross connection control program for small water systems and small communities. This study is sponsored by the National Rural Water Association (NRWA), its state affiliates, and the more than 23,000 small water systems it represents across the United States. The cost of cross connection control programs for small systems and small communities is especially important because the US Environmental Protection Agency's (USEPA's) has a current interest in the regulation of drinking water distribution systems.

At stakeholder meetings held by USEPA in 2003, the possibility of a national regulation requiring small water systems to have a cross connection control program was discussed. An issues paper prepared and released by USEPA (2002) reviews the health risks of cross connections, discussing backflow prevention practices, and summarizing state rules. That paper's purpose was to raise awareness of potential issues and lay out the possible need for new regulations.

Backflow prevention devices are designed to prevent backflow, which is the reversal of the normal and intended direction of water flow in a water system. Backflow is a potential problem in a water system because it can spread contaminated water back through a distribution system. A cross connection is any actual or potential connection between the public water supply and a source of contamination or pollution. Backflow at uncontrolled cross connections can allow pollutants or contaminants to enter the potable water system. More specifically, backflow from private plumbing systems, industrial areas, hospitals, and other hazardous contaminant-containing systems, into public water mains and wells poses serious public health risks and security problems. Cross-contamination from private plumbing systems can contain biological hazards (such as bacteria or viruses) or toxic substances that can contaminate and sicken an entire population in the event of backflow. The majority of historical incidences of backflow have been accidental, but growing concern that contaminants could be intentionally backfed into a system is prompting increased awareness for private homes, businesses, industries, and areas most vulnerable security-related risks.

Backflow may occur under two types of conditions (USEPA 2004): backpressure, and backsiphonage.

- Backpressure is the reverse from normal flow direction within a piping system that is the result of the downstream pressure being higher than the supply pressure. These reductions in supply pressure occur whenever the amount of water being used exceeds the amount of water being supplied, such as during water line flushing, fire fighting, or breaks in water mains.
- Backsiphonage is the reverse from normal flow direction within a piping system that is caused by negative pressure in the supply piping (i.e., the reversal of normal flow in a system caused by a vacuum or partial vacuum within the water supply piping). Backsiphonage can occur when there is a high velocity in a pipe

line; when there is a line repair or break that is lower than a service point; or when there is lowered main pressure due to high water withdrawal rate, such as during fire fighting or water main flushing.

Cross connection control and backflow prevention are not new concerns. All states have some type of law or regulation for the control of cross connections and/or backflow prevention. This is a strong argument *against* new federal regulations—all states already have such a program. However, the requirements and adequacy of state programs vary greatly, with some programs being very extensive, and others quite minimal. The inadequacy of some state programs and lack of enforcement in general is the primary argument in *favor* of new federal rules—it is thought that those states and water systems with poor programs will not improve them unless required to do so by federal regulation.

Several technical publications and standards focus on cross connection control and backflow prevention practices. The Foundation for Cross-Connection Control and Hydraulic Research (FCCCHR 1993) publishes the widely used *Manual of Cross Connection Control*. Also, AWWA has several standards and a manual (AWWA 2004). Also, USEPA (2003) has released an updated version of its *Cross-Connection Control Manual*. These documents were reviewed during this study for technical information, but that information is not repeated in this report.

The following sections will discuss key issues related to developing a national cost estimate for cross connection control as well as an overall framework for estimating national costs. Lastly, a national costs estimate is presented.

3.0 Approaches For Estimating National Cost

The simplest way to approach developing a national cost is to sum the individual cost for each state. Each state has slightly different regulatory requirements; therefore, the individual state costs will differ. A general approach to estimating costs for a single state could be developed, and then this approach could be applied to each state. The national estimate would be the sum of these individual state costs. This approach requires knowledge of the statutes and regulatory requirements for each state.

The USEPA (2002) issues paper summarizes state requirements in a general sense. This information is shown in Table A-1 (Appendix A). The American Backflow Prevention Association (ABPA) has indicated that their state surveys, conducted several years ago, are now out of date. Summaries of the ABPA survey results are available on the Internet; however, the underlying data for the USEPA issues paper and ABPA surveys are not available.

Some areas of the country use plumbing codes to set standards, as well as state cross-connection control and backflow prevention programs. Plumbing standards used by many localities can be found in the Uniform Plumbing Code, the International Plumbing Code, the Building Officials and Code Administration, and the Southern Building Code Congress International. Plumbing codes are usually enforceable only against plumbers and property owners, and not public water systems. The USEPA (2002) issue paper summarizes the plumbing codes adopted by States (Table A-2, Appendix A).

The accuracy of any cost estimating model is determined by the quality of data available to develop the model. Unfortunately, very little actual data is available for estimating the cost of cross-connection control programs in small systems and the quality of this data has not been determined. The AWWA Research Foundation (AWWARF) recently completed a study examining cross connection control programs. Their efforts focused mostly on medium and large water systems. Results of this study are not generally available, and the final report is restricted to AWWARF subscribers.

The development of a national cost estimate should consider the differences between state programs. This will require an updated assessment of state regulatory requirements and codes. Existing state program data (summarized in Table A-1, Appendix A) is useful but does not provide sufficient detail to estimate a state by state cost estimate.

In the absence of good state-specific data, the national cost estimate developed in this study was determined using available national data with reasonable assumptions based on professional judgment. *Professionals in the field may differ in judgment on these issues, and therefore it must be recognized that these estimates are necessarily uncertain.* A simple sensitivity analysis is used to evaluate the impact of differing assumptions. Future data collection efforts should focus on providing critical data needed to improve the national cost estimates presented here. A more robust model for estimating national costs can be developed should better underlying data become available.

4.0 Typical Program Elements

The typical regulatory paradigm for backflow prevention programs is for a State to enact rules requiring water systems to have a cross connection control program and then the water system develops and implements the program.

Regulations recently adopted in the State of Colorado (Appendix B) provide a typical example. Colorado has had requirements for cross connection control programs for many years, and has developed and issued a sample cross connection control program for small water systems; however, not every small water system in Colorado has enacted such a program.

For this analysis, it is assumed that any national regulation by USEPA would include requirements for small water systems, building owners, home owners, and state regulatory agencies to develop and implement the program elements and activities listed in Table 1.

Each program element is discussed in more detail below. Note that water systems would pay only the capital cost and the testing/repair cost for those backflow devices and assemblies owned by the water system. The overall cost to a small community, however, is the sum of the community water system cost, the community building owners cost, and the community home owners cost.

Program Element 0. Develop State Laws, Regulations, and Codes. *For this analysis, it is assumed that any USEPA national regulation would impose requirements on the State Primacy Agency as a condition of retaining Primacy.* The state would then develop appropriate laws and regulations, and pursue needed code changes to impose requirements on the public water systems and communities within the state. State law and regulation cost would therefore fall on the state. *This analysis assumes that this cost would be paid for out of general tax funds (i.e., the general state budget).* It is anticipated that some states would pass this cost on to the small water system and/or small community in the form of fees and assessments. In these cases, a small community would have to pay its share of the cost of having a state program for backflow prevention. At the present time, this cost is not included in the national cost estimate developed in this study.

Table 1. Assumed Direct Cost Categories for Backflow Prevention Programs

Program Element	Cost is paid by…					
	Water System	Building Owner	Home Owner	Installer or Tester	Tester Certification Agency	State Program Agency
0. Develop and implement State laws, regulations, and codes to meet any new USEPA requirements.						√
1. Develop and enact local ordinance as required by State regulations	√					
2. Identification of Potential Cross-Connections A. Survey of existing water system to identify and prioritize hazards. B. Notify building owners, business owners, and/or home owners of what they have to do, and what devices are required. C. Inspection of all new installations.	√					
3. Public education, especially for home owners.	√					
4. Initial Purchase & Installation of assemblies and devices.	√	√	√			
5. Testing and repair. A. Certification as an installer and/or tester.				√		
B. Implementation of a Certification program for installers and/or testers acceptable to States					√	
C. Testing/repair of assemblies/devices	√	√				
6. Record keeping	√		√	√	√	√
7. Enforcement	√					√

Program Element 2. Identification of Potential Cross-Connections. Typically, state regulations would require each small water system to survey and identify potential cross connections within the water system. The town's operator, engineer, or other official representative would perform a survey of the public water system to identify potentially hazardous cross connections. Potential cross connections would generally be prioritized by degree of hazard. New water service installations would be inspected for compliance with backflow prevention requirements. Inspectors would generally work from a list or template of potential cross connections, such as the following:

Potential Cross-Connection	Street Address of Potential Cross-Connection	Degree of Hazard **High** = contamination or health hazard **Low** = Pollution hazard
Elementary school fire sprinkler system		
Photo developer		
Car wash		
Apartment building boiler system		
Irrigation sprinkler system		
Ice cream dipper well		
Construction site		
Residential hose bibs		

Aging water systems, leaking sewer connections, contaminated groundwater, cross-over connections, and growing numbers of users all contribute to the potential for backflow in a system because they can lead to unintended connections between different parts of the system or leaks that can contribute contaminants to the system. Water suppliers determine degrees of hazard be interviewing facility personnel as well as reviewing appropriate technical information. Backflow preventers are typically installed at critical points in a distribution system to prevent contamination. Potential health hazards are required to have containment assemblies, with the most severe hazards having the highest action priority.

The appropriate type of backflow preventer for any given application will depend on the category of hazard which may flow into the potable water supply if backflow occurs. Municipalities define their own hazard classifications, which usually include two or three general classifications, depending on the municipality. These categories include:

- Pollutants/non-health hazards – A pollutant/non health hazard is any substance which would affect the color or odor of the water, but would not pose a health hazard.
- Contaminants/health hazards – A contaminant/health hazard is any substance that causes illness or death if ingested.

- Lethal hazards – Some communities establish a separate classification for hazards that are typically lethal. These municipalities define a lethal hazard is any substance that could/would be lethal to water users. For example, lethal hazards could include high concentrations of sewage, toxic chemicals, and radioactive materials.

Once inspections are completed and hazards prioritized, the water system would notify building owners, business owners, and/or home owners of the steps needed to comply with the town's backflow prevention ordinance, and what devices are required. After the devices are installed by a certified installer, the water system would inspect the installation. Any new installations would also be inspected by the water system.

<u>Program Element 3. Public Education</u>. The water system would have the primary responsibility for public education on potential cross connection health risks and backflow prevention practices, with particular emphasis on cross connections at or within homes and other residences and businesses. This could include special language in the water system's Consumer Confidence Report (CCR), special notices, and/or educational events.

<u>Program Element 4. Initial Purchase & Installation of Assemblies and Devices</u>. The cost of installation of backflow prevention devices would typically be paid for by the building owner, business owner, or home owner. The water system would notify the building owner, business owner, or home owner of the type of device required. Each cross connection assembly or device would be commensurate with the degree of hazard posed by the cross connection. Assembly/device approval would be given by the water system operator or engineer. State regulations would specify the types of acceptable backflow prevention assemblies/devices.

As noted above, the appropriate type of backflow preventer for any given application will depend on the category of hazard which may flow into the potable water supply if backflow occurs. The primary types of backflow preventers appropriate for use at municipalities and water utilities are:

- Air Gap Drains;
- Double Check Valves;
- Reduced Pressure Principle Assemblies; and
- Pressure Vacuum Breakers.

Each of these types of backflow preventers is manufactured to achieve certain standards. For example, the American Water Works Association (AWWA), the American Society of Sanitary Engineers (ASSE), the American Society of Mechanical Engineers (ASME), and the International Association of Plumbing and Mechanical Officials (IAPMO) have standards for the construction materials, design, workmanship, testing, and delivery of several types of backflow prevention devices.

Acceptable backflow prevention assemblies/devices have generally received approval by either the University of Southern California Foundation for Cross-Connection Control and Hydraulic Research, or the American Society of Sanitary Engineers (ASSE). Common cross connections and appropriate assemblies/devices include:

Type of Cross Connection	Backflow Prevention Device
Hose bib	Vacuum breaker
Fire sprinkler system; Solar house using potable water as heat source	Double check valve assembly on water only line. Approved reduced pressure principle backflow assembly on branch lines carrying chemicals.
Photographic processors and developers	Reduced pressure principle backflow assembly.
Hot water boilers	Reduced pressure principle backflow assembly.
Water hauler tank filling station	Air gap

Note that backflow prevention "devices" stop the reversal of flow, but are not testable once installed because they do not have inlet and outlet shut-off valves or test cocks. By contrast, backflow prevention "assemblies" include an inlet and outlet shut-off valve and test cocks to allow testing of the assembly while it is in its functional environment (in-line).

In general, backflow devices *are not* required on individual water service lines to single family homes. Dual check devices are available and approved for such use. Some water systems have used these devices but they require high maintenance; therefore, they have fallen out of favor. They require regular cleaning and maintenance to prevent problems such as low building water pressures. Dual check devices are installed within the meter pit, and would be owned by the water utility. Dual check devices cannot be tested in place and must be removed from the meter pit for testing. Typical practice involves water system personnel physically removing and testing a proportion (for example, ~10%) of the dual check devices in the distribution system each year.

If dual check devices are required nationally, then the capital and testing/repair cost would typically be born by the water system. This cost could be passed on to customers in the form of higher water rates or fees. A backflow device on a single family home service line would prevent deliberate introduction of contaminants into the distribution system by pumping through the service line.

Home owners (and some businesses) with a lawn irrigation system would be required to install a backflow assembly on the irrigation system supply line. This would be an expense for the home owner or property owner, not the water system. Existing ordinances requiring irrigation system backflow assemblies are not always enforced.

Each water system would be responsible for the purchase and installation of backflow prevention devices and assemblies for facilities owned by the water system and/or community.

Program Element 5. Testing and repair. Typical state and local ordinances require testing by a certified backflow prevention technician. The frequency of testing is usually specified in State regulations, and may be annual, semiannual, or risk-based. The water system would only pay for the cost of testing of those backflow devices owned by the water system. In general, the building owner, business owner, or home owner, would pay for the cost of testing and any necessary repairs.

Each state would need to develop or identify and approve an existing program for certification of installers and/or testers. For the purpose of this analysis, the cost to develop such a program is assumed to be paid for by general state revenues and/or user fees. The fees would be paid by the prospective installer/tester, with ongoing registration fees to maintain certification. These costs would be passed on to building owners in the price charged for device testing and repair.

Program Element 6. Recordkeeping. The building owner, business owner, or home owner, would be required to retain testing and maintenance records for a period of time specified in State regulations. The water system would retain records related to its backflow prevention program, and retain testing and maintenance records for devices owned by the water system. Reporting of any backflow incident would be required by the state primacy agency, and records of such incidents, as well as action taken, would be retained.

Program Element 7. Enforcement. In general, the local water system administers and enforces its own cross connection program at the local level. States typically rely on the water system to enforce the program, with little follow up or enforcement at the State level. Some States do not require water systems to implement or enforce the State requirements. Only 23 States require enforcement action against non-complying customers (USEPA 2002).

State oversight of water system programs vary. Thirty-two states require water systems to have a cross connection control program, but only three States conduct periodic (annual) reviews of their water system cross connection programs (USEPA 2002).

This analysis assumes that USEPA would require State Primacy Agencies to require small water systems to enforce compliance with the local backflow prevention ordinance. The water system, therefore, would have to take action against any non-complying facility within their service area.

The cost of enforcement for a water system would consist principally of the cost of labor and legal fees should legal action be required, and any recordkeeping and reporting.

5.0 Estimating Costs to Small Water Systems

Of primary interest is the incremental increase in small water system costs as a result of any future national backflow prevention regulations. In any particular state, the additional or incremental cost to a water system will be the difference between the total costs of meeting the new requirements less the current cost of meeting existing requirements.

Incremental Water System Costs = Cost to Meet New Requirements – Cost of Baseline Program

Within any particular state, water systems will likely be in differing stages of implementing current state requirements. Each system or groups of systems within a state may have different baseline conditions.

For example, if a state already requires a municipality to have a local ordinance for cross connection control, and the municipality has enacted a local ordinance, the fact that USEPA would require such a local ordinance would not increase the cost to that particular utility, except perhaps in terms of compliance reporting. If the municipality did not have a local ordinance, then the cost of developing and enacting such an ordinance would be an incremental cost to that water system, if required by USEPA.

A small water system would only pay certain costs associated with a cross connection control program. State regulatory agencies, certifying agencies, and building owners would bear much of the financial burden, with some of these costs passed on to the water systems within the State. Some costs are passed on to the water system indirectly. For example, the cost of tester certification would be passed on to the water system in the fee(s) the tester charges for testing services for those devices owned by the water system.

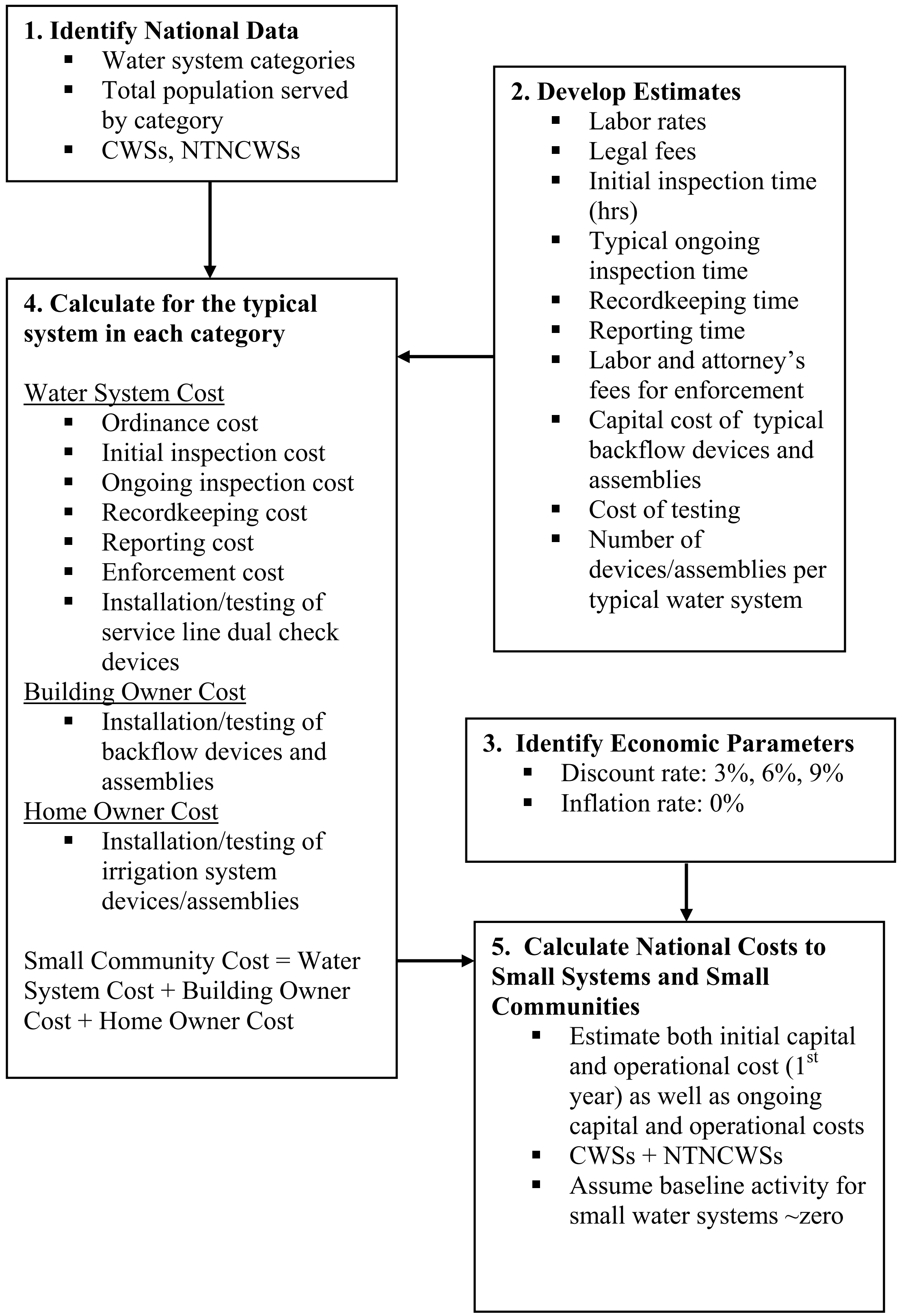
In general, water systems serving 10,000 persons or less have minimal staff with many responsibilities. The actual number of small water systems with an active backflow prevention program is unknown, even in states where such a program is required but state enforcement is lacking or non-existent. In some cases, water systems have a program "on paper," but because of practical resource limitations, the program is not active. *For the purpose of this analysis, the cost of the baseline program of the typical small water system nationally is assumed to be ~$0.* Some small water systems have cross connection control programs, but the numbers of small systems with an effective program is believed to be very small in relationship to the large number of small water systems.

The total national water system cost may also be estimated by considering the cost to a typical water system within selected public water system size categories. The total national cost would then simply be the total sum of the typical system cost multiplied by the number of systems within that size category. Because detailed state data is not available, national data will be used here applying reasonable assumptions. The resulting estimate will necessarily be rough (within an order of magnitude), but can be improved as the underlying data base regarding state requirements and baseline costs is improved.

Figure 1 summarizes the approach used in this study to develop a national cost estimate. A computational model was developed to calculate the cost for the "typical" system in each water system size category. The cost to the typical system is then multiplied by the national water system inventory, to determine a national cost. Baseline conditions would be accounted for by estimating the fraction of water systems with certain baseline conditions (such as the fraction of systems already having an ordinance). For our basic analysis, the assumption is made that small water systems (<10,000 persons served) have minimal or no baseline cross connection control program.

Because the existing underlying data are not strong, only an "order of magnitude" level estimate can be expected. More sophisticated cost estimating techniques (such as Monte Carlo techniques) can be applied, but will be misleading by implying that underlying data are more accurate and robust than they actually are. Therefore, a simple "what if" analysis is conducted to estimate reasonable maximum and minimum values.

Figure 1. General Approach for Estimating the National Costs for Cross Connection Control in Small Water Systems.



5.1 National Water System Inventory

For this analysis, the public water system inventory data presented in Table 2 was used. These data were derived from USEPA's Pivot Table of SDWISFED PWS inventory (USEPA 2003). Regulations for backflow prevention typically apply to public water systems. This analysis focuses on estimating the costs to Community Water Systems (CWSs) and Nontransient Noncommunity Water Systems (NTNCWSs) serving a population of 10,000 persons or less. NTNCWSs are typically located in rural areas, and therefore are included in this analysis. Transient Noncommunity Water Systems (TNCWSs) are not included in this cost analysis. TNCWSs differ widely and the impact of a national cross connection program on these systems is uncertain.

Because backflow prevention and cross connection control are activities that focus on the distribution system, cost estimates are not expected to be affected by source water (surface, ground, or both) nor by water system ownership (public or private). Therefore, only total numbers of water systems and total populations served in each category are of interest here.

Table 2
National Public Water System Inventory (USEPA 2003)

System Category	Population Range	Number of Systems	
		CWSs	NTNCWSs
Tiny	25-100	14,067	9,725
Very Small	101-500	16,350	7,060
Small	501-1,000	6,072	1,999
Light Medium	1,001-3,300	8,322	787
Medium	3,301-10,000	4,686	97
Total:	--	49,497	19,668

A typical water system population served within each category can be estimated by taking the total population served by water systems in that category, divided by the total number of water systems in that category. The population served by each CWS category is summarized in Table 3. Occupancy of 3.3 persons per single family home is used in this analysis.

Table 3
CWS Population Served (USEPA 2003)
And Calculated Typical System Population

System Category	Population Range	CWS	
		Total Population Served	Typical System Population*
Tiny	25-100	846,904	65
Very Small	101-500	4,163,930	255
Small	501-1,000	4,470,284	740
Light Medium	1,001-3,300	15,791,224	1,900
Medium	3,301-10,000	27,201,137	5,805
Total:	--	52,473,479	--

*Calculated by dividing the total population served (Table 3) by the total number of water systems in each category (Table 2).

A similar approach was used to calculate the population served for a typical NTNCWS, summarized in Table 4.

Table 4
NTNCWS Population Served (USEPA 2003)
And Calculated Typical System Population

System Category	Population Range	NTNCWS	
		Total Population Served	Typical System Population*
Tiny	25-100	534,642	55
Very Small	101-500	1,792,933	255
Small	501-1,000	1,448,044	725
Light Medium	1,001-3,300	1,324,290	1,685
Medium	3,301-10,000	506,124	5,220
Total:	--	5,606,033	--

*Calculated by dividing the total population served (Table 4) by the total number of water systems in each category (Table 2).

5.2 Key Assumptions

In the absence of good state-specific data, a number of assumptions must be made. Key assumptions have been made based on professional judgment, and it must be recognized that these estimates are inherently uncertain. The assumptions and estimates used here, however, are well within the range of costs currently faced by small water systems.

5.2.1 Labor rates and Legal Fees. The principal cost to the water system will be associated with labor, either provided by the water system itself or by hiring a consultant. Operator labor assumptions and legal rates used are summarized in Table 5.

Table 5. Labor Rates and Legal Fees.

Item	Tiny Systems (<100)	Very Small Systems (100-500)	Small Systems (501-1,000)	Light Medium Systems (1,001 – 3,300)	Medium Systems (3,300 – 10,000)
<u>Labor Costs</u>					
Ave. labor cost per hour*	$15.00	$15.00	29.00	$29.00	$29.00
Work day hours (no overtime)	8	8	8	8	8
<u>Legal Costs</u>					
Ave. legal cost per hour	$150.00	$150.00	$200.00	$200.00	$200.00

*Labor cost estimate based on USEPA (2000).

It is assumed that all water system activities and responsibilities are carried out by the water operator at the labor rates cited above. If consultants are used for any of the activities, then the cost of labor would likely be substantially higher.

<u>5.2.2 Develop and Enact Local a Ordinance.</u> A local ordinance is typically necessary to provide the authority needed for the water system and local community to implement and enforce a cross connection control program. It is assumed that each small water system and/or small community would be required to develop and enact a local ordinance requiring installation of an appropriate backflow device at high risk locations. The cost associated with this task consists of the labor and legal costs of writing the ordinance, obtaining support of the appropriate stakeholders and public officials, and obtaining the necessary approvals. The water system will have labor as well as legal fees associated with this task. Labor estimates would include time to attend any training for small water systems to understand state regulatory requirements and deadlines provided by the State Primacy Agency. The labor and legal costs involved would include any needed revisions in local building codes.

Key assumptions regarding labor and legal time are identified in Table 6. Larger water systems are assumed to require more time and expense because they will have more stakeholders, public officials, and politics involved in passage of a more extensive ordinance than needed for a smaller water system. For this basic analysis, it is assumed that the number of small systems with a backflow prevention ordinance that would be acceptable under new USEPA regulations is ~0. It is assumed that the cost of development and enactment of an ordinance will only be incurred in the first year of compliance with state requirements. Because NTNCWSs are typically businesses, it is assumed that they will not need to enact an ordinance, but may implement such a program directly once required to do so.

Table 6. Key Assumptions for CWS Program Element 1: Ordinance Development

Cost Category	Water System Costs					Building Owner Costs	Home Owner Costs
	Tiny (<100)	Very Small (100-500)	Small (501-1,000)	L. Med. (1,001-3,300)	Medium (3,301-10,000)		
Labor	1 day 1st year	1 day 1st year	2 days 1st year	3 days 1st year	4 days 1st year	Not applicable	Not applicable
Legal	1 day 1st year	1 day 1st year	1 day 1st year	2 days 1st year	2 days 1st year		

<u>5.2.3 Identify Potential Cross Connections.</u> The first step in implementing a cross connection program is to identify high risk sites. It is assumed that each small water system and/or small community would incur a labor cost for conducting a survey of the water system, notifying building owners of what they have to do, and inspecting all new backflow installations. Key assumptions regarding labor hours for CWSs and NTNCWSs are provided in Tables 7 and 8, respectively. The larger systems are assumed to require more labor hours because there will be a larger survey area and more sites to inspect. Labor estimates would include time to attend any training necessary to learn how to identify potential cross connections and inspect new installations.

Table 7. Key Assumptions for CWS Program
Element 2: Identification of Potential Cross Connections

Activity	Water System Costs					Building Owner Costs	Home Owner Costs
	Tiny (<100)	Very Small (100-500)	Small (501-1,000)	L. Med. (1,001-3,300)	Medium (3,301-10,000)		
2. Identification of Potential Cross-Connections A. Survey of existing water system to identify and prioritize hazards.	1 day 1st year	2 days 1st year	3 days 1st year	4 days 1st year	5 days 1st year	Not applicable	Not applicable
B. Notify building owners, business owners, and/or home owners of what they have to do, and what devices are required.	1 day 1st year	2 days 1st year	3 days 1st year	4 days 1st year	5 days 1st year		
C. Inspection of all new installations.	1 day per year	1.5 days per year	2 days per year	3 days 1st year	4 days 1st year		

Table 8. Key Assumptions for NTNCWS Program
Element 2: Identification of Potential Cross Connections

Activity	Water System Costs					Building Owner Costs	Home Owner Costs
	Tiny (<100)	Very Small (100-500)	Small (501-1,000)	L. Med. (1,001-3,300)	Medium (3,301-10,000)		
2. Identification of Potential Cross-Connections A. Survey of existing water system to identify and prioritize hazards.	1 day 1st year	2 days 1st year	3 days 1st year	4 day 1st year	5 day 1st year		
B. Notify building owners, business owners, and/or home owners of what they have to do, and what devices are required.	0	0	0	0	0	Not applicable	Not applicable
C. Inspection of all new installations.	0.5 day per year	1 days per year	1.5 days per year	2 days 1st year	2.5 days 1st year		

<u>5.2.4 Public/Employee Education.</u> It is assumed that CWSs will be required to implement a program to educate consumers about possible cross connections and backflow prevention practices. NTNCWSs would be required to educate employees and others using their facilities. For this analysis, the principle cost is assumed to be labor. However, costs for development and distribution of materials will also be incurred. Table 9 summarizes labor hour assumptions for this task.

Table 9. Key Assumptions for CWS and NTNCWS Program
Element 3: Public/Employee Education

Activity	Water System Costs					Building Owner Costs	Home Owner Costs
	Tiny (<100)	Very Small (100-500)	Small (501-1,000)	L. Med. (1,001-3,300)	Medium (3,301-10,000)		
Labor hours for public educational activities (and employee education for NTNCWSs)	1 day per year	1.5 days per year	2 days per year	3 days per year	4 days per year	Not applicable	Not applicable

5.2.5 Initial Purchase and Installation. Building owners would be required to purchase and install approved backflow assemblies/devices based on the results of the initial survey. Water systems would purchase and install assemblies/devices for the facilities that they own. Data is not available on the typical number of backflow assemblies/devices that might be expected in a small water system or small community. For this study, the average number and cost of assemblies/devices installed in the typical water system is presented in Table 10.

Table 10. Key Capital Cost Assumptions for Program Element 4: Initial Purchase and Installation

Cost	Water System Size				
	Tiny (<100)	Very Small (100-500)	Small (501-1,000)	L. Med. (1,001-3,300)	Medium (3,301-10,000)
Average Cost/Assembly (including installation)	$2,000	$2,000	$2,000	$2,000	$2,000
Ave. Number of Assemblies Installed by Building Owners in the Typical CWS	2	4	6	8	10
Ave. Number of Assemblies Installed by the CWS	1	2	3	6.91	21.1
Ave. Number of Assemblies Installed by the NTNCWS	3	6	9	12	15
Average Cost/Dual Check Device for a Service Line	$50 per dual check device $50 for fittings and/or meter pit modification per device				
Estimated Number of Service Lines Requiring Dual Check Devices	Population Served/3.3 persons per residence				
Irrigation System Backflow Prevention Assembly/Device Cost	$100 per assembly/device $200 installation 25% of homes have irrigation systems 0% of existing irrigation systems have assemblies				

The cost of purchasing and installing a backflow assembly can range from $50 to $10,000 or more, depending on the type of assembly, size, and location. Custom installations can also be expensive, depending upon the piping modifications needed. The primary factor affecting cost of a given type of backflow prevention device or assembly is the size of the pipe for which it is designed. The following factors also contribute to the total cost for installing a backflow preventer: system design (including consultation as to which products are appropriate); on-site delivery; installation and retrofit; maintenance; and inspection, testing, and surveying. Costs for individual backflow preventers or backflow preventer systems will vary depending on the product brand and vendor. USEPA (2004) notes the following capital costs for the backflow preventer, which do not include installation or service costs:

- Costs for double check assemblies range from $100 for a ¾-inch diameter unit to $2,000 for 8-inch diameter units. Larger sizes could be $10,000 or more.
- Costs for reduced pressure principle assemblies range from $180 for a ¾-inch diameter unit to $3,000 for 8-inch diameter units. Larger sizes can be $12,000 or more.
- Costs for vacuum breakers range from $10 for a hose bib to $400 dollars for a 2-inch pressure vacuum breaker.
- Costs for air gap drains will be site-specific, and will depend on the size of the pipe and the area in which it is located. If re-pumping is required, the capital and operating costs will most likely be higher than for all other devices.

For this analysis, a small assembly with installation is assumed for the typical system, which is believed to be conservative (low). Some backflow prevention approaches, such as use of an air gap, are relatively inexpensive. But others may be very costly. For example, a 10" diameter backflow assembly that would be needed on the service line to a high-risk manufacturing facility could cost $12,000, with installation between $2,000 to $10,000, depending upon the degree of piping modification needed. A $2,000 cost is used in this analysis to represent a typical average capital and installation cost across all water system sizes and all facilities that would require an assembly or device.

For this analysis, professional judgment was used to estimate the number of assemblies that would be installed by building owners (businesses) in a typical CWS, and in a typical NTNCWS.

A more rigorous framework was developed for the number backflow assemblies/devices to be installed by the typical CWS. The number of backflow assemblies and devices needed varies with the facility and type of hazard. Some facilities, such as a hospital, may have many assemblies or devices (i.e., 30 or more). Table 11 lists the types of buildings and facilities that might be present in a CWS that could require one or more backflow assemblies or devices. Not every community will contain every type of building or facility listed in Table 11. However, by estimating the prevalence per unit of population, and the number of devices per typical facility, the overall number of devices that might be required could be estimated. A minimum number of devices are expected for the three smallest water system size categories. The number of devices was calculated for the two largest water system size categories using the estimates provided in Table 11.

Table 11
Buildings and Facilities in CWSs
Potentially Requiring Backflow Prevention Assemblies

Service Area Type	Entity Bearing the Expense	Assumed Prevalence (# per 1000 population)	Estimated Average Assemblies per Category
Agricultural processing facilities	Business	0.25	1.00
Airparks	Community	0.01	1.00
Amusement Parks	Business	0.01	0.50
Campgrounds/RV Parks	Business	0.25	1.00
Churches	Business	1.00	0.25
City Parks	Community	0.25	0.25
Construction Sites	Business	0.01	1.00
Daycare Center	Business	0.25	0.25
Fire Department	Community	1.00	1.00
Golf and Country Club	Business	0.10	0.25
Hotels/Motels	Business	1.00	0.25
Landfills	Community	0.25	0.25
Manufacturing: Food	Business	0.10	1.00
Manufacturing: Non-food	Business	0.10	0.25
Medical Facilities-Private	Business	1.00	2.00
Medical Facilities-Public Local	Community	0.50	2.00
Medical Facilities-Public State	State	0.25	2.00
Mining Facilities	Business	0.01	1.00
Mobile Home Parks	Business	0.50	0.25
Nursing Homes-Private	Business	0.25	1.00
Nursing Homes-Public	Community	0.25	1.00
Office Parks	Business	0.10	1.00
Prisons/Jails	Community	0.25	1.00
Recreation Centers/Pools	Community	0.25	1.00
Restaurants	Business	1.00	1.00
Retailers (Food related)	Business	1.00	1.00
Retailers (Non-Food related)	Business	2.00	0.10
Schools-Private	Business	0.50	1.00
Schools-Public	Community	0.50	1.00
Service Stations	Business	1.00	1.00
State Parks	State	0.01	1.00
Summer Camps	Business	0.01	1.00
Wastewater Facilities	Community	0.25	1.00

5.2.6 Testing and repair. Backflow prevention devices must be tested on a periodic basis. Testing must be conducted by a trained and certified technician. Testing time for an individual backflow prevention device will vary with the size of the device and its accessibility. Typically, testing time can range from half an hour for a small, easily accessible device to several hours for larger units located in areas that are not easily accessible. When these requirements are extrapolated to include testing for each backflow prevention device within a system, costs for a backflow prevention testing program can be considerable.

Typically, testing and repair of backflow assemblies is required annually. In some cases, high hazard assemblies may be tested every six months or more frequently. The cost of testing can vary widely, depending upon the type and size of the assembly, the time of travel to the location of testing, and hourly rates charged by the tester. Testing charges have been quoted at $50 to $200 per assembly. For this analysis, it is assumed that an average of 4 hours labor is needed per device for testing and repair. The cost of any repair parts has not been included. This corresponds to a testing cost per assembly of $60 for Tiny and Very Small Systems, and $116 for the Small, Light Medium, and Medium sized systems (at the assumed labor rates). Note that labor costs associated with travel time is not included, and may be charged by the technician if the backflow assembly is located in a remote area or a long distance from the technician's normal service area.

For dual check devices on service lines, the typical practice is to remove and test a portion of the devices in the distribution system each year. Of the devices tested, a certain proportion would be require replacement. For this analysis, it is assumed that 10% of the devices are tested each year and that 10% of the devices tested fail and must be repaired or replaced each year.

5.2.7 Recordkeeping. The time required for recordkeeping and reporting will very depending upon the number of devices, and state reporting requirements. The water system would retain records related to its backflow prevention program, and retain testing and maintenance records for devices owned by the water system. Reporting of any backflow incident would be required by the state primacy agency, and records of such incidents, as well as action taken, would be retained. For this analysis, it is assumed that the minimum labor needed each year for recordkeeping and reporting would be 1 day, 2 days, 3 days, 4 days, and 5 days for Tiny, Very Small, Small, Light Medium, and Medium sized systems, respectively, at the assumed labor rates. Building owners would also be required to maintain records on testing and repair of assemblies, and similar labor hours are assumed.

5.2.8 Enforcement. In general, the local water system administers and enforces its own cross connection program. For this analysis, it is assumed that the minimum labor needed each year for enforcement would be 1 day, 2 days, 3 days, 4 days, and 5 days for Tiny, Very Small, Small, Light Medium, and Medium sized systems, respectively, at the assumed labor rates.

5.2.9 Economic Assumptions. Economic assumptions used in this analysis are summarized in Table 12. We assume that identification of potential cross connections and initial purchase and installation occurs within year 1. Purchase and installation may necessarily extend into the second or third year depending upon the number of required assemblies and devices, the financial and labor resources available to the water system, and the responsiveness of the supplier. We assumed no inflation for this initial analysis.

The useful life of backflow assemblies depends on water quality, where the unit is located (environment), and the quality of the unit. A useful life of 10 years or more is expected, however, manufacturer's warranties typically do not extend this long. For this analysis, a useful life of 10 years is assumed.

Table 12. Key Economic Assumptions

Projected Discount Rate: 3%, 6%, 9%
Projected Inflation Rates: 0%
All capital purchases and initial installation occurs in year 1
Useful life of assemblies and devices: 10 years

6.0 CWS and NTNCWS Cost Estimates

The initial capital cost, first year operating expenses, and continuing operating expenses for CWSs and NTNCWSs are summarized in Tables 13 through 18. CWS costs include the costs to the water system, building owners within the water system, and homeowners served by the water system. The 1st year operating expense includes the cost of development of a local ordinance, as well as the initial survey for potential cross connections within the community. Annualized costs are presented in Table 19. (Note: Estimates rounded to $Millions. Columns may not add because of rounding.)

Central estimates are defined as those calculated based on the assumed values presented above. To assess the overall sensitivity of these estimates, Lower and Upper values are calculated and presented in Tables 14 through 20. Lower values are based on calculations using 75% of the assumed values used to calculate the central estimates. In other words, the Lower values represent the situation whereby our original assumptions are over estimated by 33%.

Upper values are calculated using 150% of the assumed values used to calculate the central estimates. In other words, the Upper values represent the situation whereby our original assumptions are underestimated by 50%. The span between the Lower and Upper estimates represents the likely range of costs for cross connection control in small water systems, given existing data.

Table 13. Overall "Central" Estimate of CWS and NTNCWS Costs

Category	Central Cost Estimates ($Millions)					
	CWS			NTNCWS		
	Initial Capital Cost	1st Year Operating Cost	Continuing Operating Cost	Initial Capital Cost	1st Year Operating Cost	Continuing Operating Cost
Water System Cost	$448	$127	$120	$201	$5.1	$20.9
Building & Business Owner Cost	$799	$0	$420	$0	$0	$0
Home Owner Cost	$1,197	$0	$0	$0	$0	$0
Totals:	$2,443	$127	$540	$201	$5.1	$20.9

Table 14. Tiny System Costs

Estimate	Tiny Systems (<100 persons, $Millions)					
	CWS			NTNCWS		
	Initial Capital Cost	1st Year Operating Cost	Continuing Operating Cost	Initial Capital Cost	1st Year Operating Cost	Continuing Operating Cost
Lower	$64.3	$14.6	$6.29	$32.8	$0.656	$3.28
Central	$78.8	$20.2	$11.2	$58.4	$1.17	$5.84
Upper	$111	$32.9	$26.1	$131	$2.63	$13.1

Table 15. Very Small System Costs

Estimate	Very Small Systems (101-500 persons, $Millions)					
	CWS			NTNCWS		
	Initial Capital Cost	1st Year Operating Cost	Continuing Operating Cost	Initial Capital Cost	1st Year Operating Cost	Continuing Operating Cost
Lower	$195	$18.0	$15.9	$47.7	$0.953	$3.81
Central	$228	$25.5	$28.7	$84.7	$1.69	$6.77
Upper	$409	$42.7	$91.0	$191	$3.81	$15.2

Table 16. Small System Costs

Estimate	Small Systems (501-1,000 persons, $Millions)					
	CWS			NTNCWS		
	Initial Capital Cost	1st Year Operating Cost	Continuing Operating Cost	Initial Capital Cost	1st Year Operating Cost	Continuing Operating Cost
Lower	$158	$11.2	$19.4	$20.2	$0.782	$2.87
Central	$206	$16.7	$46.7	$35.9	$1.39	$5.10
Upper	$439	$30.4	$183	$80.9	$3.13	$11.5

Table 17. Light Medium System Costs

Estimate	Light Medium Systems (1,001-3,300 persons, $Millions)					
	CWS			NTNCWS		
	Initial Capital Cost	1st Year Operating Cost	Continuing Operating Cost	Initial Capital Cost	1st Year Operating Cost	Continuing Operating Cost
Lower	$509	$27.6	$60.3	$10.6	$0.411	$1.54
Central	$710	$40.1	$162	$18.8	$0.730	$2.74
Upper	$1,541	$70.3	$714	$42.5	$1.64	$6.16

Table 18. Medium System Costs

Estimate	Medium Systems (3,300-10,000 persons, $Millions)					
	CWS			NTNCWS		
	Initial Capital Cost	1st Year Operating Cost	Continuing Operating Cost	Initial Capital Cost	1st Year Operating Cost	Continuing Operating Cost
Lower	$873	$16.8	$99.1	$1.64	$0.063	$0.240
Central	$1,221	$24.8	$290.9	$2.91	$0.112	$0.428
Upper	$2,650	$44.5	$1,388	$6.55	$0.253	$0.962

Table 19. Annualized Capital and Operating Costs for CWSs

Estimate	Capital Costs ($Millions)				Operating Costs ($Millions)	
	Total Capital	Annualized @ 3%	Annualized @ 6%	Annualized @9%	1st Year	Ongoing
Lower	$1,800	$211	$244	$280	$88	$201
Central	$2,440	$286	$332	$381	$127	$540
Upper	$5,150	$604	$700	$802	$221	$2,400

Table 20. Annualized Capital and Operating Costs for NTNCWSs

Estimate	Capital Costs ($Millions)				Operating Costs ($Millions)	
	Total Capital	Annualized @ 3%	Annualized @ 6%	Annualized @9%	1st Year	Ongoing
Lower	$113	$13.2	$15.3	$17.6	$2.87	$11.7
Central	$201	$23.5	$27.3	$31.3	$5.09	$20.8
Upper	$452	$52.9	$61.4	$70.4	$11.5	$46.9

Figures 2 through 6 present the proportion of the various cost categories to the total cost for each water system size category. For each water system size category, the capital and installation expense contributes the greatest fraction of the total cost.

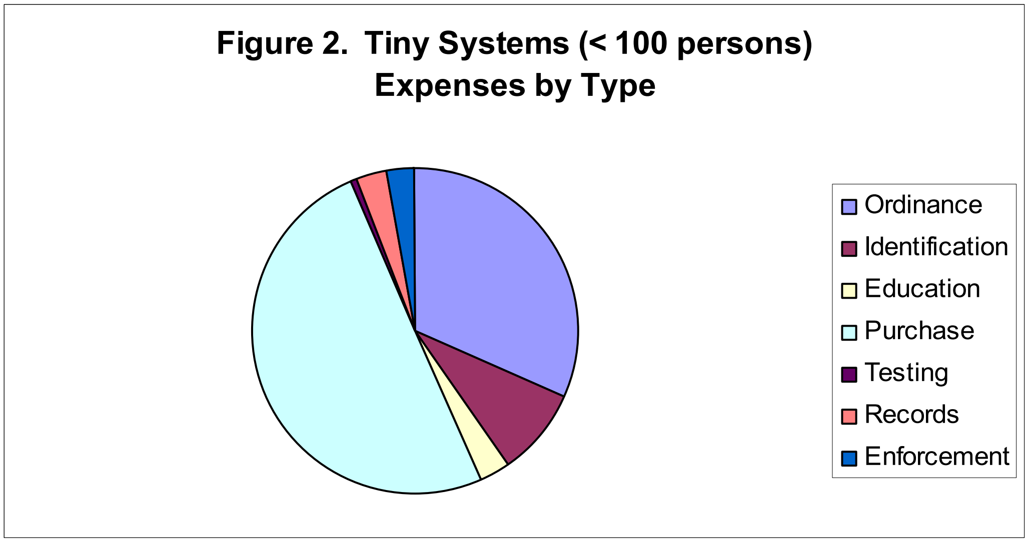


Figure 2. Tiny Systems (< 100 persons) Expenses by Type

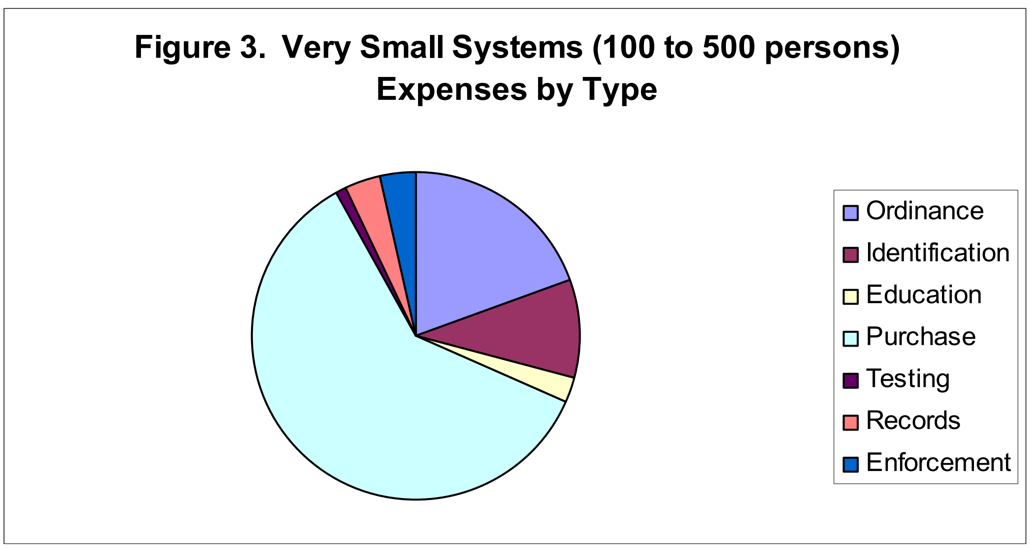


Figure 3. Very Small Systems (100 to 500 persons) Expenses by Type

Figure 4. Small Systems (501 to 1,000 persons) Expenses by Type

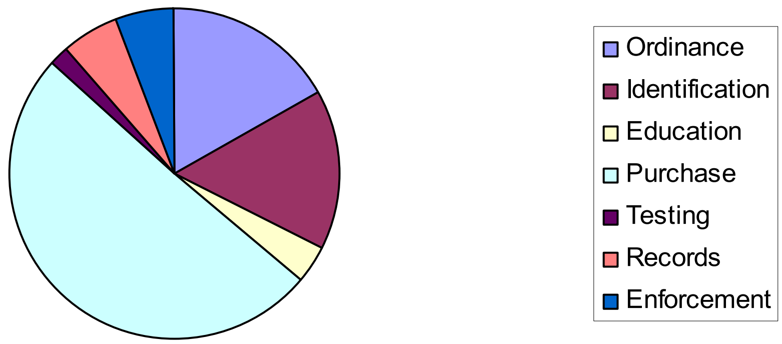


Figure 5. Light Medium Systems (1,001 to 3,000 persons) Expenses by Type

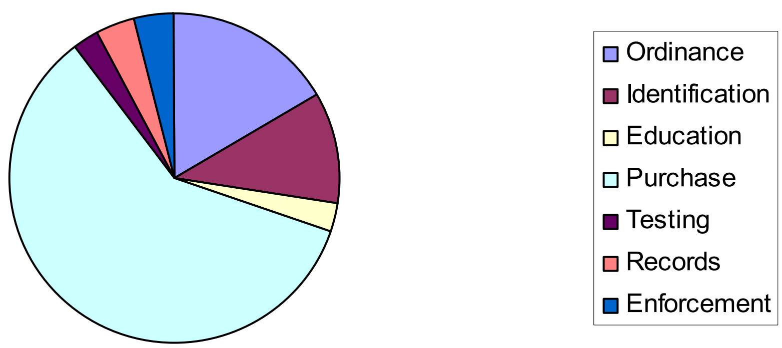
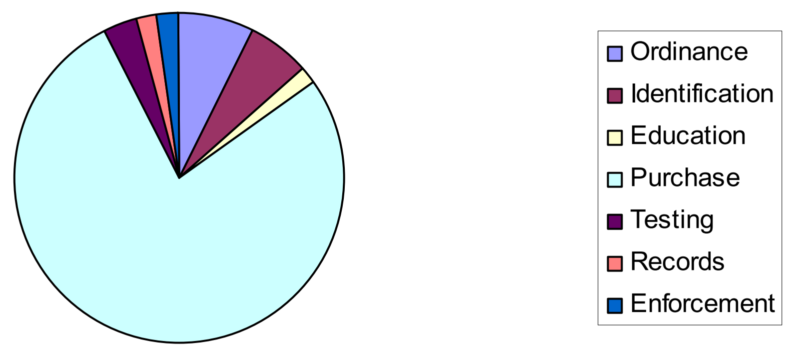
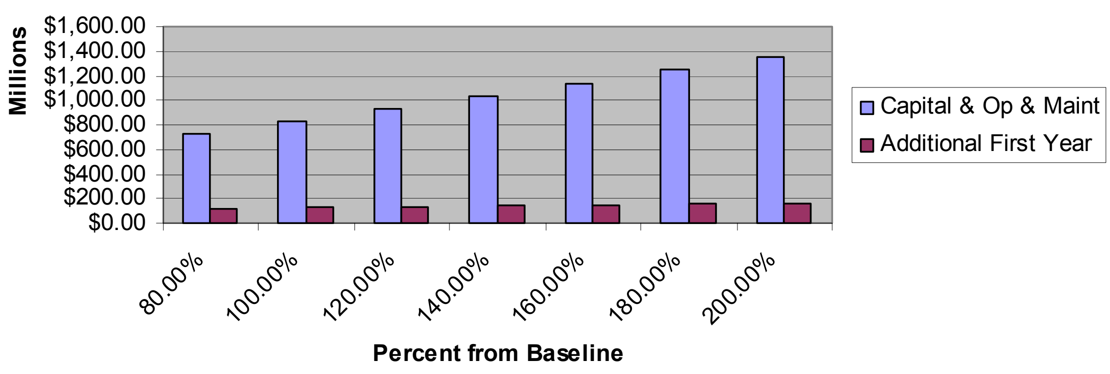


Figure 6. Medium Systems (3,001 to 10,000 persons) Expenses by Type



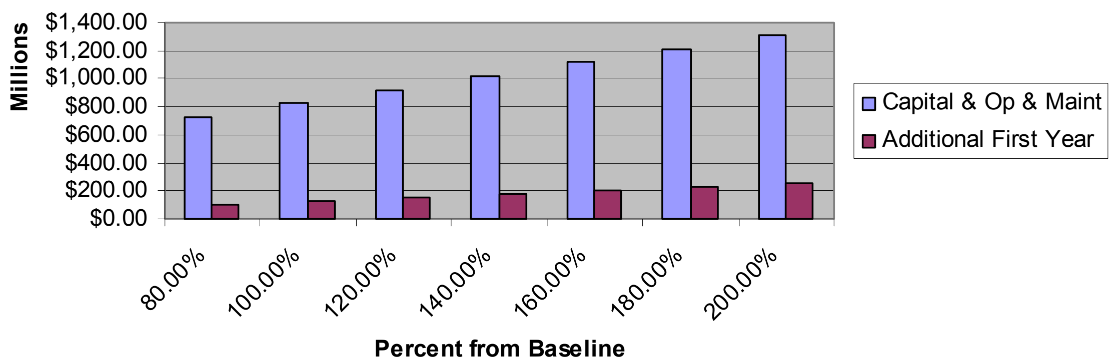
A simple sensitivity analysis was performed to evaluate the affect on CWSs of differing labor rates. The baseline labor costs were summarized above in Table 5. Should the baseline labor cost be higher than assumed, the overall cost to CWSs would increase proportionally as shown in Figure 7. (Note that the 100% baseline given in Figure 7 represent the rates given in Table 5.) For this analysis, costs were annualized at a 3% discount rate.

Figure 7. Impact on CWSs of Varying Baseline Labor Cost



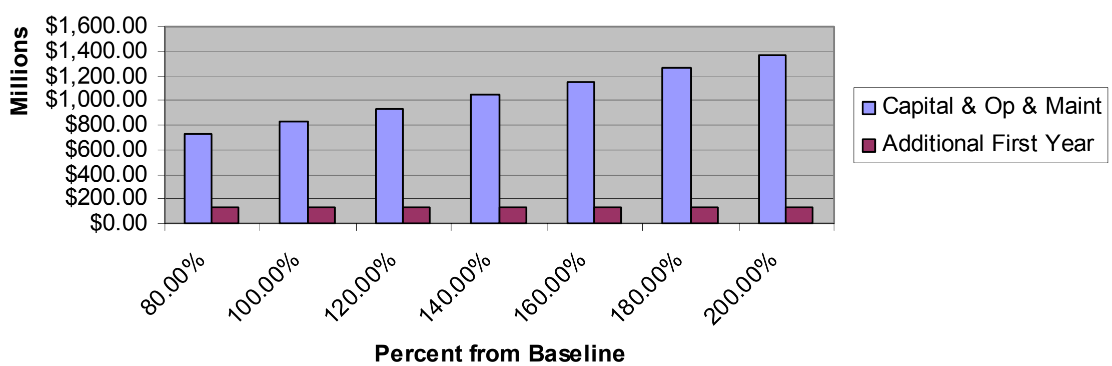
The affect on CWSs of differing labor hours is presented in Figure 8. The baseline labor hours were summarized above for various elements of a cross connection control program. Should the baseline labor hours actually be higher than assumed, the overall cost to CWSs would increase proportionally as shown in Figure 8. For this analysis, costs were annualized at a 3% discount rate.

Figure 8. Impact on CWSs of Varying Baseline Labor Hours



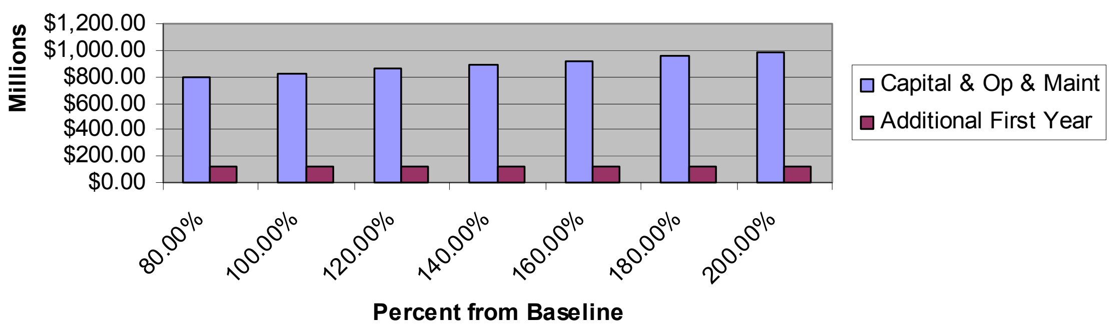
The affect on CWSs of differing backflow prevention device and assembly count is presented in Figure 9. The baseline device count was estimated as describe above based on prevalence factors presented in Table 11. Should the device count be higher than that estimated above, the overall cost to CWSs would increase proportionally as shown in Figure 9. For this analysis, costs were annualized at a 3% discount rate.

Fgiure 9. Impact on CWSs of Varying Baseline Device Count



The affect on CWSs of differing backflow prevention device and assembly purchase price is presented in Figure 10. The baseline device and assembly purchase price was estimated as presented above in Table 10. Should the device or assembly purchase price be higher than that estimated above, the overall cost to CWSs would increase proportionally as shown in Figure 10. For this analysis, costs were annualized at a 3% discount rate.

Figure 10. Impact on CWSs of Varying Baseline Device Purchase Price



7.0 Conclusions and Recommendations

The national costs estimated using the methodology described in this report is highly dependent upon the assumptions used in the analysis. The national capital cost of cross connection control in CWSs (Table 19) is estimated to be between $1.8 Billion and $5.15 Billion (central estimate of $2.44 Billion). First year operating costs, which includes enactment of a local ordinance and an initial survey of potential cross connections, are estimated to be between $88 Million to $221 Million (central estimate of $127 Million). Ongoing operation and maintenance is estimated to be between $201 Million to $2.4 Billion (central estimate of $540 Million).

For NTNCWSs (Table 20), the national capital cost of cross connection control is estimated to be between $113 Million and $452 Million (central estimate of $201 Million). First year operating costs, which includes an initial survey of potential cross connections, are estimated to be between $2.87 Million and $11.5 Million (central estimate $5.09 Million). Ongoing operation and maintenance is estimated to be between $11.7 Million and $46.9 Million (central estimate $20.8 Million).

To date, this is the only study of its kind to develop national cost estimates for cross connection control in small water systems. The following recommendations are offered to improve the estimates presented herein:

1. National and state data regarding backflow prevention practices and experiences necessary to prepare a national cost estimate based on a state-specific analysis is limited or not available. Therefore, many assumptions were made in this analysis using professional judgment. These estimates may be improved upon by validating these assumptions, either by conducting appropriate surveys to collect needed data, or by convening a stakeholder group to develop consensus values.
2. State-specific data are needed to develop a more robust analysis that considers baseline cross connection programs currently in existence in small water systems. Cost estimates should be developed state-by-state based on state-specific conditions, with the results summed to estimate national costs.
3. The simple approach used here is sufficient for an order of magnitude estimate given existing data. Probabilistic methods should be applied to estimate national costs if a reliable underlying database can be developed.

8.0 References

AWWA 2004. *Recommended Practice for Backflow Prevention and Cross-Connection Control* M14. Denver, Colo.

FCCCHR 1993. *Manual of Cross Connection Control*. University of Southern California, Los Angeles.

USEPA. 2004. Backflow Prevention Devices. August 25, 2004. http://www.epa.gov/watersecurity/guide/backflowpreventiondevices.html

USEPA. 2003. Pivot Table SDWISFED PWS inventory, FY2003.xls

USEPA. 2003. *Cross-Connection Control Manual*. Office of Water. EPA 816-R-03-002.

USEPA 2002. Potential Contamination Due to Cross-Connections and Backflow and the Associated Health Risks. OGWDW, Washington, D.C. Aug. 13, 2002.

USEPA 2000. Arsenic in Drinking Water Rule Economic Analysis. OGWDW, Washington, D.C. Dec. 2000.

Appendix A

Table A-1. State Cross-Connection Control Requirements (as reported by USEPA 2002)

Requirement	Number of States with Requirement
1. Does the State have a requirement for the control of cross-connections and/or backflow prevention?	50
2. Is it specified in the requirement that the system must implement or develop a cross-connection control and/or backflow prevention program?	32
3. Does that State require authority to implement a local ordinance or rule for cross-connection control and/or backflow prevention?	33
a. Must the authority cover testing of backflow prevention assemblies?	27
b. Must the authority cover the use of only licensed or certified backflow assembly testers?	16
c. Must the authority cover the entry of the premises for the sake of inspecting the premises?	14
d. Must the authority cover entry of the premises for the sake of inspecting and/or installing backflow prevention assemblies?	15
4. Does the State require training, licensing, or certification of backflow prevention assembly testers?	26
5. Does the State require training, licensing, or certification of backflow prevention assembly and/or device installers?	6
6. Does the State require training, licensing, or certification of backflow prevention assembly and/or device repairers?	10
7. Does the State require training, licensing, or certification of cross-connection control inspectors?	19
8. Does the State require inspection of backflow prevention devices and/or testing of backflow prevention assemblies?	37
9. Does the State require the system to include record keeping as part of cross-connection control?	34
10. Does the requirement include keeping records of hazard assessment surveys?	11
11. Does the State require the system to notify the public following the occurrence of a backflow event?	3
12. Does the State require the local rule or ordinance to allow the system to take enforcement action against customers that do not comply with the cross-connection control and backflow prevention requirements?	23
13. Does the State conduct periodic reviews of cross-connection control programs?	3
14. Does the State regulation or plumbing code require public education regarding cross-connection control and/or backflow prevention?	7

Table A-2. Plumbing Codes Adopted by States (as reported by USEPA 2002)

Plumbing Code	**Number of States Adopting**
Statewide Code	47
No Statewide Code	3
Statewide Codes Adopted	
Uniform Plumbing Code	14
State Code	7
International Plumbing Code	5
National Standard Plumbing Code	4
Southern Building Code Congress International	4
Other	13

Appendix B

Article 12 of the Colorado Primary Drinking Water Regulations (CPDWRs) has been revised to read as follows:

Article 12 Hazardous Cross-Connection

12.1 Control of Hazardous Cross-Connections

(a) A public water system or a consecutive distribution system of a public water system shall have no uncontrolled cross-connections to a pipe, fixture, or supply, any of which contain water not meeting all applicable provisions of the *Colorado Primary Drinking Water Regulations*.

(b) A supplier of water shall protect the public water system from contamination in the following manner:

(1) Identify potentially uncontrolled hazardous service cross connections.

(2) Require system users to install and maintain containment devices on any uncontrolled hazardous service cross connections, provided the Department has determined that the device is consistent with the degree of hazard posed by the uncontrolled cross connection.

(3) Installation of containment devices shall be approved by the public water system upon installation.

(4) All containment devices shall be tested and maintained as necessary on installation and at least annually thereafter, by a Certified Cross-Connection Control Technician.

(c) Public water systems shall retain maintenance records of all containment devices. Section 1.7 requires these records shall be available for inspection by Department personnel. All maintenance records shall be kept for three years.

(d) A public water system shall notify the Department of any cross-connections, as defined in section 1.5.2, within 10 calendar days of its discovery. The cross-connection shall be corrected within 10 days of being ordered in writing by the Department to correct the problem. Failure to do so may result in an enforcement order.

(e) Violations shall be subject to the provisions and penalties prescribed by sections 25.1.114 and 25.1.114.1, Colorado Revised Statutes, and to such other actions as provided by law.

12.2 Cross-Connection Control Technician Certification

(a) A Certified Cross-Connection Control Technician must possess a valid certification from the American Society of Sanitary Engineering (ASSE), the American Backflow Prevention Association (ABPA), or the Association of Boards of Certification (ABC). The process for certification must include successful completion of an examination administered by one of the approved organizations. Certifications that are not renewed on or before their expiration date shall not be valid after such date.

(b) Cross-Connection Control Technicians certified prior to January 1, 2003 under the program administered by the Colorado Water and Wastewater Collection Systems Certification Council, Inc. shall be considered compliant with the certification requirements of this provision through the scheduled expiration date of their certification except as noted below. Individuals whose certification would otherwise expire between January 1, 2003, and December 31, 2004, will have until December 31, 2004, to obtain certification from one of the organizations approved in 12.1(a) or the certification will lapse as of January 1, 2005.

(c) The Department shall, no less often than once every two years, conduct an evaluation of the certification process of each organization referenced in section 12.2(a) and report the results to the Colorado State Board of Health. The Department shall ensure that the certification processes, including the examination requirement, are adequate to protect public water systems as referenced in section 12.1(b). If the Department concludes, based upon the available facts, that an organization's certification process no longer meets the standards necessary for the purposes of this article, it may request that the Colorado State Board of Health, after notice and comment rulemaking, revoke the organization's standing under Article 12.