The Infrastructure Investment Gap Facing Drinking Water and Wastewater Systems

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Speech to the Association of Metropolitan Water Agencies
St. Pete Beach, Florida – October 24, 2000

1.0 Introduction

The nation's drinking water and wastewater systems are at critical points in their life cycles. While significant parts of the systems are approaching the end of their useful life, infrastructure spending is far short of the amount needed to replace aging and failing pipes and meet the objectives of the Safe Drinking Water Act (SDWA) and the Clean Water Act (CWA). The resulting gap between spending levels and investment needs is expected to reach $23 billion a year over the next 20 years: $11 billion a year for drinking water systems, and $12 billion a year for wastewater systems.[1]

If the present situation persists, the financial solvency of many drinking and wastewater systems will be in doubt, and the environmental, public health, and economic gains these systems have provided over the past 30 years are in jeopardy. Clearly, action must be taken to overcome what threatens to be a ruinous shortfall in drinking water and wastewater investments.

Discussions about what needs to be done have started, but consensus on the best way to proceed on all aspects of the problem will not be reached for some time. It is clear, however, that there is little chance of seriously affecting the fate of this vital infrastructure without upgrading the partnerships between federal, state, and local governments. In particular, the federal government, which has been a significant force and vital investor in the evolution of the nation's water and

[1]The estimates in the Gap Analysis and the Water Infrastructure Network report, *Clean & Safe Water for the 21st Century,* April 2000, use the same approach to quantify the order of magnitude of the Gap.

wastewater services, can play a more significant role in financing improvements to renew today's systems and to meet future public health and environmental objectives.

2.0 The Challenges Facing Drinking Water and Wastewater Systems

Seventy-five percent of the nation's capital investment in drinking water and wastewater infrastructure is buried under ground. Much of this pipe was laid during the 1950s and 1960s, as suburban areas developed rapidly following World War II. Now 40-50 years old, this "new" pipe is connected to drinking water and wastewater pipes that date back to the early 1900s and late 1800s.

The useful life of these pipes depends on the material the pipes are made of, the conditions of the soil in which they are buried, the character of the drinking water or wastewater that flows through them, and numerous other factors. It is important to note that pipes do not deteriorate at a constant rate; during the initial period, which may last several decades, the rate is likely to be slow and repair and upkeep expenses low. Later, further along the life cycle curve, the pipes deteriorate much more rapidly. Frequently, system operators do not have a clear understanding of the overall condition of their piping networks.

In addition to providing new connections, much emphasis has been placed over the last 30 years on improving drinking water and wastewater treatment plants. These plants have shorter useful lives than do the networks of pipes attached to them and so require more frequent investments in repair and renewal.

To a large degree, the aging of pipes and plants will seriously stress the financial capacity of many, if not most, service providers. Even in systems that are financially sound, doubling current capital investments will not be easy. Acquiring the necessary capital will be even more of a challenge in communities where keeping water and wastewater services affordable is already difficult.

The economics of pipe renewal pose especially difficult problems in older urban areas. Systems installed to service larger populations are now candidates for renewal, but the service populations may have declined greatly in the decades since the pipes were installed.

The level of spending on drinking water and wastewater projects indicates that needed capital investments are already being deferred. Deferring investments beyond the optimal points for system repair and renewal will eventually lead to even greater increases in the cost of providing service.

2.1 The "Gap Analysis[2]"

To characterize the shortfall in infrastructure investments by drinking water and wastewater systems over the next 30 years, the U.S. Environmental Protection Agency (EPA) has undertaken the "Gap Analysis." Begun in 1999, the study was spurred by increasing calls from stakeholder associations and Congress for a strategic approach to wastewater financing.

The "Gap Analysis" forecast about $ 1 trillion in total spending in capital, maintenance and operations of water and wastewater systems between 2010 and 2020 to meet current mandates. This spending is called for to operate and maintain, repair and renew the current systems, retire existing debt and make essential high priority new service investments.

This year, a little over $18 billion will be spent on capital investment in water and wastewater. At the more detailed level, annual public spending on capital for wastewater alone from all sources has declined from about $11 billion in 1990 to a little over $9 billion today. Current annual needs for new wastewater infrastructure investment and replacement are about $15 billion. The difference of $6 Billion is the current projected gap and it is projected to grow over the next 20 years to about $12 Billion a year as cited in the introductory paragraph. Preliminary estimates indicate similar capital shortfalls are likely for investments in drinking water systems.

By 2010, on an aggregate basis and considering all potential funding sources, the Funding Gap Study estimates the annual amount needed for new investments in and replacement of existing systems' infrastructure will be about twice that of current spending levels.

In addition to providing such facts, the Gap Analysis will serve as one point of departure in exploring the options for reform and

[2] U.S. Environmental Protection Agency, *Funding Gap Study for Water Programs*, typewritten, undated. A significant portion of the historic data was derived from a Congressional Budget Office Study *Trends in Pubic Spending, May 1999.*

change management initiatives to lower the costs of achieving sustainable infrastructure systems.

2.2 The Impact of Public Investment in Infrastructure

In the period between 1956 and 1992, about $1 trillion of the public's money was spent on capital expenditures and on the operation and maintenance (O&M) of the nation's drinking water and wastewater systems. Most of the capital expenditures were to upgrade and expand systems to improve plant performance and extend services to previously unserved households.

The impact of these capital investments has been significant. Effluent discharges are half of what they were 30 years ago, despite the fact that waste loads grew by more than a third, keeping pace with growth in the population and the economy. Plants also treat waste more efficiently today than they did 30 years ago. The national aggregate removal efficiencies for BOD_5 and BOD_U in 1968, for example, were about 63 percent and 39 percent, respectively. In the intervening years, they have risen to nearly 85 percent and 65 percent.

These hard-won gains are not irreversible. Without continued improvements in wastewater treatment infrastructure to increase pollutant removal, population growth will erode the achievements gained in effluent loading reduction. By the year 2016, BOD loading rates could be similar to the rates of the mid-1970s.[3]

2.2.1 More Remains to be Done

Although significant progress has been made in cleaning up the nation's polluted waters over the past 30 years, much remains to be done to address point source and non point source pollution. States, tribes, territories, and interstate commissions report that, in 1998, about 40 percent of the 32 percent of U.S. waters assessed for the section 305(b) national inventory were not clean enough to support uses such as fishing and swimming.[4] The major pollutants in impaired waters include siltation, bacteria, nutrients, and metals—all the result primarily of runoff from urban and agricultural lands.

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[3]U.S. EPA, *Progress in Water Quality - An evaluation of the National Investment in Municipal Wastewater Treatment, June 2000*.

[4]In their 1998 305(b) reports, States assessed 840,000 miles of rivers and 17.4 million acres of lakes—150,000 more miles of rivers and 600,000 more acres of lakes than in 1996.

In addition, more than 291,000 miles of assessed rivers and streams do not meet water quality standards. States, territories, tribes, and other jurisdictions report that poor water quality in all types of waters affects aquatic life, fish consumption, swimming, and drinking water.

States also assessed 5 percent of the nation's ocean shoreline miles and found that 12 percent of the assessed shoreline was impaired primarily by bacteria, turbidity, and excess nutrients. Urban runoff, storm sewers, and land disposal of wastes were reported to be the major sources of these pollutants.

Returning to system assets, in many case, the information on where these assets are located is sketchy. Frequently, there is little sense of the overall condition. A significant amount of pipe isn't even in the public picture. The small line connections to households, the onsite lines, are likely to be even more condition suspect then the trunk lines, collectors and interceptors. In addition, Onsite/decentralized wastewater treatment systems serve approximately 25 percent of U.S. households and almost 40 percent of new development. More than half of the existing systems are over 30 years old, and homeowners indicate that at least 10 percent of all systems are not working at all at any given time. Other data has shown that at least 25 percent of systems are malfunctioning to some degree.[5]

2.3 Sources of Capital Investments

In the area of wastewater, more funds for capital expenditures between 1956 and 1992 came from the federal government, than from State and local sources. Over the last decade, local government has become the primary source of capital for wastewater investment. Of course there is a history behind this transition. In the 1970s, the federal government expanded its financial support for wastewater infrastructure improvements, but in less than a decade it became apparent that the investments required were far larger than the willingness to commit federal funds. While federal grants initially covered 75 percent or more of a capital project's costs, grant funding was later reduced to 55 percent, then to less than 55 percent, and finally replaced by loans offered at very favorable terms because they are subsidized by federal dollars.[6]

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[5] U.S. EPA, *DRAFT - EPA Guidelines for Management of Onsite/decentralized Wastewater Systems.-- October 6, 2000*

[6] Although federal contributions to infrastructure investments of all types have remained flat since about 1970,

Federal financial support for capital expenditures by drinking water systems has been relatively modest during much of the past 30 years. This assistance tended to be targeted at small rural communities. Changes in tax policy, however, dampened capital investments in water systems, as they had in wastewater systems. The policy changes reduced the incentive value of tax-exempt benefits of debt issued by State and local entities for a range of public projects.

It was widely believed that the Construction Grants Program, the State Revolving Fund Program, and a series of specialty programs for economically disadvantaged communities would lead systems to a self-sufficient financial future. Initial federal support for capital projects, the reasoning went, would help service providers to gain solid financial footing, after which fees would be sufficient to cover costs. However, that has not come to pass, and current conditions suggest that the objective of financial self-sufficiency is far from a reality. Some form of financial support appears essential for the foreseeable future.

In the meantime, communities have taken to working directly with their representatives in Congress to obtain support for line-item funding of their projects in the federal budget. However, few would argue that this project by project, Congressional add-on approach would lead to long-term success in addressing the nation's water and wastewater needs. For every community that finds a successful path to preferential treatment, numerous communities with equally valid projects do not get funding.

The decline in federal outlays for water and wastewater during the past decade accounts for a corresponding decline in the overall level of capital investment in these systems. The result of this relatively flat investment level and growing needs is that the financial gap is increasing and must be closed or systems will fail.

2.3.1 The Local Contribution to Capital Investment

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over the past 20 years federal investment in highway and aviation trust accounts has increased, offset by declines in water- and wastewater-related federal outlays.

About 95 percent of total expenditures in drinking water and wastewater come from local sources. Overall, the amount of money invested annually in these systems is at an all-time high.[7] Since 1970, spending on water doubled and spending on wastewater tripled, while spending on all areas of the nation's municipal related infrastructure grew by about 60 percent during the same period. The result is that water and wastewater systems represent an increasing share of the total infrastructure spending and they are capital intensive, so they will represent and even larger demand for future capital dollars.

[7]U.S. EPA, *Funding Gap Study for Water Programs and CBO, Trends in Public Spending.*

The spending increase appears to have been prompted, however, not by increased capital expenditures, but by the growing costs of operating and maintaining aging systems: O&M expenditures have increased 5 to 6 percent a year for more than 40 years. Of the $53 billion currently spent on drinking water and wastewater, 63 percent goes to O&M.[8] However, it would be misleading to draw a bright distinction between capital and O&M spending when a significant portion of the latter funds extensive repairs to and incremental replacement of deteriorating /aging systems.

At the same time, it appears that water, wastewater and drainage systems, which account for 30 to 35 percent of the total projected demand for capital infrastructure dollars, are not receiving their share of debt-supported capital. During the past 15 years, the publically issued State and local debt for drinking water and wastewater projects has remained at around the same level on an annual basis, while cumulative local debt for all purposes has doubled.

It is safe to forecast that as drinking water and wastewater replacement investments grow, there will be a commensurate need to increase the capital funds directed toward renewal and a similar increase in the funds need to maintain the aging existing infrastructure (see Appendix A).

2.3.2 The Affordability of User Fees

When capital funding is supported by debt—even low-interest loans made available at favorable terms by federal subsidies—debt payment must be made with local revenues usually generated by fees. The affordability of such fees is a growing concern.

Four percent of median household income is generally used as a "bright line" for determining whether fees for drinking water or wastewater services are affordable. In 1985, about 14 percent of U.S. households crossed that line and paid more than 4 percent of the median household income in their areas for these services. By 1997, their ranks grew to 18 percent of households, and almost 25 percent of households are expected to cross the line within the decade.

The implications of this trend for capital formation are ominous. The use of traditional user fees to fund capital improvements to

[8]Ibid.

replace aging infrastructure and meet additional treatment requirements will be severely constrained.

3.0 Introduction to the Policy Dialogue of Reform

The cost of drinking water and wastewater services is set to grow dramatically in a relatively short span of time. As the costs associated with system renewal and higher service levels grow, the need for broad reform on the way these systems are managed and funded will also grow, and local officials will be faced with some very fundamental choices. Some will conclude that the challenges are insurmountable and will seek regulatory or fiscal relief. The Gap Analysis advances the view that the challenge of reform can be met, but not without substantial and concerted efforts toward changing the current operating and financing paradigm.

Managing reform in a thoughtful and deliberate manner will return significant public health, environmental, and economic dividends. Other countries that have come to terms with large-scale institutional, financial, and managerial reforms show that some future costs can be avoided if efficiency and optimal choices are promoted (see Appendix B).

A convincing case can be made that the current service arrangements are not sustainable and a shift toward a more efficient, business-like approach is inevitable. In selected segments of the industry this shift is already well documented. As costs increase, arguments that drinking water and wastewater systems are exempted from typical efficiency pressures are unlikely to resonate with ratepayers or taxpayers. Simply waiting for systems to fail before implementing changes will lose the economic dividends associated with managing and investing in the shift to a more business-like arrangement.

The broad implementation of reforms will require the actions of thousands of independent decision makers, many of whom must overcome philosophical biases and concerns that they could be harmed by some reforms. But the current literature on reforming the drinking water and wastewater services suggest that serious change will not be a solely bottom-up phenomenon. Those experienced with reform, advocate national leadership and have strategically invested significant resources in advancing reform.

The Gap Analysis advocates a role for the federal government in facilitating significant reform in the drinking water and wastewater services and bringing to bear the government’s support, resources and technical capacity in pursuit of change.

In addition to funding and financing approaches, there is a need to explore a more comprehensive agenda of options to “reform” the water and wastewater industry. Background assessments have already been prepared. Besides the Gap Analysis, a report called *Clean and Safe Water for the 21st Century* has been issued by the Water Infrastructure Network (WIN), a coalition of stakeholder groups. Both reports begin to identify target areas for possible improvements.

4.0 A Strategic Approach to Reform

Finance and funding are not the only issues that require attention. A long-term approach to asset management needs to be formulated; greater investment must be targeted to research, development, innovation, and the role of competition; and best management practices (BMPs) must be developed and improved. A strategy to achieve efficient and affordable management of drinking water and wastewater assets over the long term is at least as important as a strategy to provide adequate capital formation.

4.1 The Immediate Issues: Increasing Investment, Asset Management, and Change Management.

This section presents immediate issues that could be used to set the long-term agenda for achieving a sustainable approach to water and wastewater infrastructure.

4.1.1 Increasing Investment

It appears that, in the short run, continuing an intergovernmental fiscal partnership is an essential part of the policy response needed to increase capital investment. The dialogue on financing and funding is well underway. WIN has been working through a facilitated process involving major stakeholder organizations to sort out financing and funding issues.

Because creating entirely new mechanisms and institutional arrangements is very difficult in the short run, changes in funding likely will be tied to existing mechanisms. Never-the-less, even in the short term current mechanisms should be altered to permit more flexible and optimal uses of the funds, and some special funding could be targeted at areas where water quality standards are not being met.

A dialogue on funding, by definition, requires discussions on how much money, who gets it, by what mechanism and who are the lead decision makers on priorities and uses of the funds. Achieving service objectives can readily be defined in either public or private terms and funding should not distinguish between the models of ownership, if the service is to meet a generally defined public purpose. The challenge in working out immediate funding decisions is to derive a framework where the short term funding arrangements do not conflict with the full exploration of the policy direction over the long term. A discussion that leads to new investment while leaving open the opportunity to set a course toward reform is certainly possible. The idea of additional Federal funds ought to be framed in a manner where the investment produces a value added to the investment by State and local government. It is important to avoid the substitution of financial efforts or delays in making needed investment decisions that have accompanied previous periods of legislative activity.

It is also important that the way funds are provided does not distort using the most optimal approach to lower the long term costs of meeting service, environmental and public health objectives. For example, if the best way to lower long term service cost is to invest in life extension approaches to address failing pipes, then funding approaches that limit funding solely to pipe replacement may bias the incentives against efficiently attacking the problem. When renewal is a big part of the investment requirement, then optimization between capital and operating expenses is a key to being efficient.

The Political Process

A bi-partisan Congressional caucus, the Water Infrastructure Caucus, is ready to lead the consensus-building process. Key leaders have framed the debate and indicated their interest in addressing the problem. Within 6 months, some 75 representatives have joined the caucus. Its breadth and bi-partisan membership are seen as indications that the next Congress may well be in a strong position to reach toward consensus on legislative solutions to closing the funding gap.

A Potential Model

Congress recently addressed a set of infrastructure issues in the 1998 Transportation Equity Act for the 21st Century (TEC-21). Since the dialogue on TEC-21 is still fresh in the minds of representatives and staff, considering TEC-21 as a model for dealing with drinking water and wastewater infrastructure may be useful.

Many of the issues are similar. In each case, systems are aging and a greater portion of overall spending is projected to be used for maintenance, repair, and renewal. And just as some areas of the country unable to meet air quality standards were addressed by TEC-21, areas where water quality standards have not been achieved might benefit from special investments.

An infrastructure investment strategy also ought to consider how current activities can be done more efficiently, more effectively, and with the aid of innovation and process improvements. Although this last category does not involve a great deal of money compared to other facets of an investment strategy, failing to address this area over the long term will result in an unnecessarily expensive program.

The Relationship to Current Programs: Looking for Added Value
While the State Revolving Fund (SRF) will be important, it should not be the only vehicle for federal support of improvements to drinking water and wastewater infrastructure. Other potential solutions should be evaluated, and the problems some communities may have with acquiring debt should be considered. The federal commitment needs to be a companion to a new, sizeable investment from State and local governments. The financial help that results from this federal, State, and local partnership should allow for non-traditional approaches to provide States and communities with sufficient flexibility to address their infrastructure needs. Obviously, it is important to assure essential coordination between existing and newly envisioned funding arrangements.

4.1.2 Asset Management

In addition to addressing the issue of funding, a more comprehensive approach to improving the efficient and affordable management of current assets should be explored. A strategic plan for asset management will improve the process for building, maintaining, and renewing infrastructure. Work has already begun with utilities to define the elements of an asset management plan which, in its final form, must be tailored to meet their needs.

The asset management process insists that sufficient funds be allocated over the life of an asset to ensure its optimal value. Getting the most service out of existing assets, through life extension strategies and other means, is one component. Another is to challenge aggressively the demand for new assets by ensuring that their life cycle costs are known and to consider solutions which do not call for new assets as options for achieving objectives. It is also important that new facilities incorporate a value management process at the early stage of project development. Seventy five percent of the decisions affecting life cycle cost and seventy five percent of the life cycle cost reduction opportunities are fixed halfway through the planning process. If we are going to reduce costs, we need to get on the right track in the early stages of attacking the problem.

Whether asset management becomes a best management practice or a requirement that must be undertaken in order to receive additional project funding remains to be decided. Avoiding or eliminating unproductive requirements is important, while adding requirements that provide value is warranted. The central point is that an asset management process is crucial to quality decision making, whether it is a requirement or a best practice. As the costs of drinking water and wastewater services grow, the demand for accountability in the stewardship of funds and the efficient use of resources is likely to increase. Adopting state-of-the-art practices in the planning and management of infrastructure and efficient life cycle maintenance programs has the potential to save billions of dollars and demonstrate acceptable stewardship over the use of funds. Providing financial support for asset management activities will prove to be a good investment because the activities can return savings without compromising service. We should be exploring how Federal financial resources can assist in encouraging broad adoption of state of the art strategies that encourage efficient practices in minimizing the life cycle cost of essential assets.

4.1.3 Investing in Change Management

Investing in and facilitating a process for determining how over the long term drinking water and wastewater systems could be sustained is an important item for the immediate agenda. A recent EPA report contained information on public and private water pollution related R&D expenditure. Both public and private spending shows a general decline from as much as $300 million for the public sector and $231 million for the private sector in 1973 to less than $150 million and $100 million, respectively, in the mid-1990s.[9] It is generally understood that investments in innovation, R&D and the like are an essential precursor to becoming more efficient and effective in accomplishing a task.

Various approaches are available to sort out the vital information which is essential to high-quality, long-term decision making. In general, any of these approaches will involve change management becoming a higher investment priority in order to stimulate more comprehensive strategic thinking and to provide opportunities for more informed choices. No level of government, no profession, no single organization or individual has the whole

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[9] U.S. EPA, *A Retrospective Assessment of the Costs of the Clean Water Act: 1972 to 1997, October 2000*

package of tools, information, skills, and resources necessary to advance a credible and rational plan of action. The idea of a change management initiative is to move beyond the traditional R&D investment categories toward a broader framework for doing the analytic and technical assistance tasks of reform.

Although the water and wastewater industry, as a whole, can set forth a new paradigm, current efforts appear much too limited. Good ideas and definite steps toward more efficient and effective management abound, but the changes are piecemeal, unsystematic, and not all that widespread. In the short term, a framework and financial commitment should be put in place to undertake comprehensively the long-term strategic work necessary to define avenues for continuous improvement.

5.0 Quality Decision Making on Fundamental Choices

Some issues, such as increasing investment and asset management cannot await a period of delay in decision making. But for other issues, much more needs to be done to provide a sustainable vision of the future. The hard, long-term questions demand quality information and a thorough analytic framework. The work that will lead to reform, needs to be subjected to the scrutiny and evaluation of experts.

Very fundamental choices remain to be made. An approach can be devised to move toward full cost recovery from users, in which case drinking water and wastewater services should be treated as commercial enterprises. Or, a permanent revenue structure similar to the highway or airport trust funds could be developed to provide a defined, permanent source of revenue for future subsidies. Over the long term, any vision of a future course must be mapped with a clear sense of our chosen path or it will be impossible to navigate toward a sustainable future.

But before such choices can be made, the information available on which to base decisions needs to be improved. Improvements to the current situation are unlikely if that situation cannot be characterized fully and accurately, and the future situation cannot be envisioned predictably. Right now, there are categories of planned activities, the costs of which are not well understood. Little is known about the life cycle implications of these activities. Decision support tools such as asset management plans, integrated resource management planning, and life cycle projection evaluation processes will become more important if this missing information is to be provided(see Appendix C).

6.0 A National Water Infrastructure Reform Project

If the answers to all of the critical issues were known, discussions of change and reform would be at a different stage. The stakes involved in reform are impressive: Achieving 20 percent savings by improving performance, for example, could reduce future costs by hundreds of billions of dollars.

There are potentially many options for aggressively working on setting a long term framework for reform. The most obvious way is to charge the federal government, in broad consultation with State and local governments, to establish a National Water Infrastructure Reform Project. A serious undertaking will demand a significant financial commitment over 10 years and a lesser commitment is unlikely to gain the desired improvements.

Such an effort should be independent, but its work should be performed in concert with organizations currently involved with the topic. A list of issues similar to those presented in Appendix C could be developed for expert evaluation in a broadly participatory and transparent manner. Tasks would be undertaken and reports issued under an adequate, clearly defined timetable.

To manage this project, an organization like a National Center of Excellence for Water Utility Management could be established, either through a competitive process or by creating some special form of public-private partnership. Details of the Center concept need to be worked out, but the basic idea sets a tone toward creativity and innovation by recognizing the shortfall in current arrangements and declaring the importance of bringing new thinking to bear in attacking the root causes of our current situation.

The Center could be vested with broad analysis and advisory assignments to encourage the maximum use of partnerships with federal, State, and local governments and with private parties. A primary objective will be to bring the best expertise to bear on defining long-term solutions to achieving sustainable systems. To gain the flexibility necessary to acquire the needed expertise, arrangements could be made for inter-governmental personnel assignments, grants, contracts, and other mechanisms to involve the most experience people in government and industry.

During its tenure, the Center would be given sufficient resources to undertake a wide range of activities associated with reform, such as promoting BMPs in infrastructure management, facilitating the transition to asset management, and providing technical assistance, technology transfer, demonstration projects, and pilot projects. Again, the idea is to add to the existing efforts and institutions, not replace these efforts. And focus this new work on change management and reform.

The Center also would be encouraged to consult with its international counterparts and to work toward establishing the United States' leadership in this important area of international commerce. (About 1.4 billion people around the world do not have adequate drinking water or sanitation.) A tremendous amount of work in this area is going on internationally, but much of it is going to service providers and consultants in other countries. Over time, the Center could help forge partnerships that could help the United States compete in the emerging international marketplace for these services.

7.0 Conclusion

The gap between infrastructure spending and infrastructure needs is an enormous problem and it is growing. But it can be addressed. The capacity exists to rethink how these essential systems operate and are financed. Actions can be taken in the near term that will lead in a new direction. Those actions ought to be taken. We have a responsibility to future generations to make some hard decisions about the long-term direction, and we ought to set a course toward a future in which infrastructure is sustainable.

Appendix A
The Nessie Curve Case Studies
of Columbus, Georgia and Gloucester, Massachusetts

The Nessie Curve is a method for modeling the replacement funding echo wave that results from the original demographic waves that drive development within a region. There were a number of major waves of development in the last century and the composite of the data for several areas starts to suggests a general profile.

The wave of replacement needs will be smoothed out by the fact that assets do not wear out uniformly. This smooths the replacement wave. The bulk of the assets put in place in the last century have very long lives. They have not needed to be replaced until now and hence the funding of replacement needs on a large scale is new to our experience.

Using the Nessie approach to examine a couple of communities is very instructive. The Nessie approach looks at the original investment profile and uses the replacement values of the assets installed in each year in year 2000 dollars.

Columbus, Georgia is one of the case studies. Columbus is a somewhat newer city with development in three waves: pre-1920; 1920 to 1960; and 1960 to present. The development pattern is smooth suggesting an even smoother echo wave of replacement needs. In the early period the expenses are predominantly pipe assets being installed every year as population grows. The treatment investments appear as investment spikes and are primarily in the more recent periods.

One of the first things you notice is how much larger the treatment expenditure spikes are. The treatment assets need to be replaced on a much shorter cycle than pipe assets. The different components within treatment plants may need replacement on 5, 10, 20, 40 or 50 year cycles. Columbus may have already replaced some of the shortest life cycle equipment, but not as yet, the structural elements.

The case study developed a first approximation "Nessie Curve" projections of replacement expenses over the next 75 years of the new century in today's dollars, making no adjustments for inflation. If you look at the portion of the curve covering the next 20 years, it shows that the increase in replacement needs in Columbus over the initial 20 years is pretty modest. This pattern reflects the fact that Columbus is a relatively young city where the growth patterns were relatively smooth and, some extensive work has already been done on the system.
At first cut, it is clear that the water and sewer mains present a gradually increasing expenditure ramp that will be sustained throughout most of the century. Future expenditures for plant assets are more variable (lumpy), reflecting their more intensive investment demands.

It is especially noteworthy that the Nessie Curve shows how replacement is not a short term rise, but rather a sustained rise that will be with us throughout the century. Converting the Nessie Curve values into percentages of the total for each year gives a clear impression of which components are relatively stable and which components are more variable. It also shows the increasing impact of the ramp that is presented by mains replacement.

Whatever we want to do in the way of treatment replacement or advanced treatment, will have to come on top of the increasing ramp up of replacement costs for mains. The data projects only the replacement of existing treatment facilities. There is nothing added to simulate any additional treatment required to meet any prospective new compliance requirements. The case study data suggest that just holding our own is going to get relentlessly more and more expensive.

But that's only half of the story. The other Nessie Curve is a projection of increased maintenance costs. Old assets are just like old cars, it costs more to keep them in service. As pipes age, there are more breaks. As pumps age, they are less efficient and require more servicing. The increased maintenance costs that are forecast for Columbus assumed that increased replacement is also taking place at the same time.

Because of the shape of the demographic wave that is behind us -- building to a climax at the end of the last century -- we will have a lot of aging assets that will continue to be in service for some time yet into the new century. Thus, these maintenance costs will continue to rise.

It is most meaningful to look at the next 20 years or so as the time horizon that we are trying to manage in the near term. At an order of magnitude level, the total replacement investment for Columbus over this 20-year period will have to increase to about two and a half times the current rate of replacement expenditure. This is at the lower end of the scale for U.S. utilities that have been studied with the Nessie Curve technique. Again, this is because Columbus is younger and because some work has already been done.

When you add the increased maintenance costs, the preliminary findings suggest these will have to increase to a level of four times the current annual maintenance cost over the 20-year time period. This is about on par with the average for U.S. utilities that have been studied with the Nessie Curve technique. When you put the increased replacement funding needs together with the increased maintenance funding needs, this gives you a comprehensive understanding of replacement, maintenance and repair spending requirements.

The investment objective should be to minimize the present value of the total cash outlays by varying the proportions of replacement versus repair versus life-extending rehabilitation work that a utility undertakes. This is what “Asset Management” really is -- managing assets to minimize the total costs of owning and operating them while delivering the desired service levels or outcomes. It is essential that utilities optimize these cost ramps because deviations from least cost asset management will make any treatment investments needed on top of the ramp a greater challenge to providing affordable service.

Columbus is a growing community and the chart shows that this ratio has stabilized. Many cities have lost population and are facing a more challenging picture. The per capita and per household costs projected for Columbus is at the lower end of the range of utilities studied with the Nessie Curve technique. Yet the annual outlays are still projected to increase by a factor of two-and-a-half times by the year 2020.

The long-lived pipe assets have not required this replacement expenditure until now. So as we consider the next 20 years, we observe there is a ramp rising up under our feet that was not there before. It was not in revenue requirements. It was not in customer bills.

Taking the water and wastewater mains apart confirms that they are both gradual increasing ramps. The water and wastewater plants have the shorter replacement cycles and are the inherently lumpier patterns. One part of explaining why the Columbus example illustrates replacement cost at the bottom end of the range of US utilities, stems from the fact that Columbus has been undertaking a successful program of water main replacement via pipe bursting technology. The Nessie analysis was also used to perform a retrospective analysis of this effort. By comparing the actual Nessie Curve with a "what-if" Nessie Curve based on the assumption of normal replacement instead of pipe bursting, we have estimated that Columbus is saving 25 percent of the cost of replacement through the use of this technology.

Another one of the compelling findings from applying the Nessie Curve technique and recognizing the need for a life cycle cost approach to managing assets is the revelation that we should be placing a high priority on innovations in trenchless replacement technologies and life-extending rehabilitation technologies.

The other case study is Gloucester, Massachusetts. Every utility has a set of challenges in asset management stemming from the unique demographic and historical factors that shaped their infrastructure in the beginning.

Gloucester is facing great variability in their wastewater treatment assets. The other replacement needs are primarily water and wastewater mains which exhibit the familiar gradual ramp over the first part of the Century.

A few years ago Gloucester was faced with the need to opt for a decentralized treatment technology -- the STEP system -- in part of its service area in order to satisfy a compliance order. Unfortunately, the system does not have a very long useful life, requiring replacement about every 10 years. It is this expense that will remain the major affordability issue in Gloucester for some time.

The implications of the Gloucester story may be that we should consider compliance solutions in the full context of the life cycle cost management of all of a utility's assets. The cost of the STEP investment would look differently if you were looking at it in isolation. But, going forward, we have to recognize that these lumpy treatment costs are going to be sitting on top of a ramp -- a ramp that was not part of our experience just a short while ago because the long-lived assets have never had to be replaced on a broad scale before.

The addition of the STEP system has brought Gloucester up to a much higher level of assets per capita than previously. The short-term affordability is revealed in the projected annual outlays for replacement divided by the resident population. Gloucester has a stable population. The current and peak populations are the same.

The short-cycle replacement interval of the chosen technology impacts per capita and per household costs. There is, of course, another side to the story. Water resources and water quality are quite critical amenities to a city by the sea like Gloucester. So there are more than the normal benefits to match against costs. Never-the-less, the short-cycle replacement needs present a troublesome picture of the affordable challenges associated with meeting long term objectives for the area.
A final point on affordable systems can be drawn from using the Nessie technique on a rust belt example. In many older Northeastern and Midwestern cities, there has been a decline in population since the peak. Many cities have lost a significant portion of the population that they once had. That means they are left with an infrastructure replacement burden that is falling very heavily on those who remain, adding to affordability concerns. The set of future outlay estimates for renewal and replacement in these communities, greatly informs the discussions about the value of aggressively pursuing in fill strategies and other approaches that promote redevelopment and optimization of existing system capacity in an effort to lower the per capita burden of asset renewal.

Appendix B
The Drinking Water and Wastewater Industries Are Going Global

Water mains and sewer lines are still local, but the drinking water and wastewater industries have become international. The equipment, techniques, and other factors that affect each industry cross international boundaries all over the world. It is common for a U.S. firm to be affiliated with a French firm advancing technology developed in the United Kingdom and tested in Australia.

Although frequently characterized as natural monopolies, the drinking water and wastewater services are not immune to new and potentially better ways of being organized to provide and manage basic services.

Understanding the reform experiences of other countries is important to envisioning the organizational, institutional, and economic changes that are possible in this country. Changes in the ways these countries have affected their industries provide alternative approaches to efficient service that are practical, tested, and available for consideration and adoption here. U.S. communities already are exploring dialogues and signing contracts with international experts. As a result, ideas common throughout the world are being explored in this country as well.

Several nations have viewed the competitive global marketplace as driving their need to demand reform of the drinking water and wastewater industries. Some have introduced market reforms in these industries as a consideration in developing trade agreements. The services remain local, but the issues have a global context.

The Record on Reform

The reforms undertaken in other countries have focused on competition and competitive neutrality between public and private owners, outsourcing models, organizational and structural amalgamations, new approaches to overseeing and managing price regulation, and moving toward the definition of clear commercial objectives for water and wastewater services.

The drinking water and wastewater industries in some countries have moved from numerous small service providers to fewer, but larger, providers.[1] These large service providers compete internationally as consultants, planners, engineers, designers, builders, and operators. They can be public or private.

Such mega-service providers have the capacity to foster efficiencies, streamline work processes, and modernize management controls. They tend to have Boards of Directors composed of industry experts and to operate under the same laws as private companies.

The organization necessary to provide services efficiently may challenge the current structure of drinking water and wastewater service providers in this country. In the international arena, water and wastewater services tend to be integrated. Functions from the point of water source acquisition, through treatment and distribution and collection and cleanup are vertically integrated. The perception is that this vertical integration provides for a more comprehensive approach to resource management and a broader construct under which to pursue more optimal approaches to meeting service objectives.

In the scheme of organizational structures, we are on the far side of highly decentralized models of service delivery. In drinking water systems, we refer to 55,000 to 59,000 service providers. In wastewater we estimate almost 20,000 providers. The services are frequently not integrated. We have a very mixed

[1]For example, the Australian State of Victoria has gone from about 400 systems in 1982 to 18 systems today. The Australian State of New South Wales has about 20 systems to serve 6 million people. And the United Kingdom has 10 systems, including 3 in Wales.

bag, some providers have water and wastewater functions, others provide only one or the other service.

In other countries, water and wastewater services tend to be integrated. Functions from water source acquisition through treatment and distribution to collection and cleanup are vertically integrated. The rationale for this vertical integration is that it permits a more comprehensive approach to resource management and provides opportunities to pursue more efficient approaches to providing services.

Even in countries whose drinking water and wastewater systems are comparatively decentralized, the trend in ownership is toward system consolidation. For example, France has a very decentralized system of some 33,000 owners, but only 3 firms that provide all the operating services. And in Australia, entities that are basically rural districts provide impressive levels of service to hundreds of small communities across hundreds of miles. In each example, service providers are structured to capture management and technical efficiencies regardless of whether facilities are consolidated physically.

Drinking water and wastewater professionals must consider cost-saving initiatives as part of the package of options available in addressing the shortfall between actual and needed infrastructure investments in this country. A review of how other countries have addressed similar issues suggests that the structural, organizational, and service arrangements for water and wastewater services in the United States may be made to be more efficient.

It is very clear from the ongoing dialogue that a significant amount of similar thinking is underway in the U.S. water and wastewater industry. The AWWA project on developing Nessie curves - - an Australian approach for minimizing the whole life costs of replacement and repairs by starting with the data you have and continually improving it -- shows much promise.

The projects that have been undertaken by the national associations such as the Association of Metropolitan Sewerage Agencies and the Association of Metropolitan Water Agencies on bench marking and best management practices provide insight into the direction of the U.S. industry. These U.S. initiatives look very similar to initiatives that were undertaken in the international arena by some of the countries that have appeared in the forefront of seeking a more efficient, business-like approach to water and wastewater services.

Appendix C
Examples of Key Issues
That Would Benefit from an Emphasis on Improved Information

There is a need to attack the underlying informational, organizational and process problems. The lack of a serious coordinated national strategy results in addressing challenges through disconnected initiatives and piecemeal incremental steps, not in concert with any long term vision.

A variety of issues must be decided that involve philosophical dimensions about the role of government. But just as important, making these decisions will require adequate information. New models for getting the job done need to be explored and tested. Some key decisions, should be deferred until a better basis for addressing these difficult decisions is established.

Over the long run, additional analysis needs to be undertaken on how incentives can be structured to promote sustainable systems. The flow of funds to the most optimal uses in the context of a particular local situation should be in the context of strategies that strive toward reaching the lowest life cycle costs for the water and wastewater service under conditions particular to that given environmental and public health situation.

A broader view of how public health, environmental, and economic objectives can be achieved efficiently is needed. For example, some goals can be best addressed with local funds, while others may need additional funding from outside sources. And some projects primarily benefit service users, while others provide benefits beyond the service population. There may be a case to be made that projects which offer so-called "spillover" benefits beyond a system's service area ought to be subsidized to gain those benefits.

A new approach to organizing and quantifying needs should be explored. There are categories of planned activity where the cost of doing something isn't well understood. There is little known about the life cycle implications. Decision support tools, such as asset management plans, integrated resource management planning tools or life cycle project evaluation processes need to take on a new level of importance in decision making. Asset registers and condition assessments could provide a much better basis for thinking about needs in a more comprehensive manner.

If it is decided to have someday fully integrated drinking water and wastewater services, either public or private, dramatic changes in current thinking will be necessary. To be efficient, should these systems be subject to competitive ownership and service delivery pressures? When pressures led to consolidations, should government policies and investment strategies promote and facilitate these actions?

Many issues will have to be addressed if it is decided that there should be competitive neutrality between public and private ownership. They include access to capital, taxation, regulation, and accounting. The current situation impedes the flow of ownership between public and private parties.

If it is decided to treat drinking water and wastewater as economic goods, the services must be priced to recover at least the costs of supply, storage, treatment, distribution, and the subsequent collection and treatment of the waste stream. Adequate provisions for price transparency and necessary structures to oversee prices would need reform. Should prices be sufficient to encourage efficient use, continue the availability of the service, and improve and expand the system while avoiding adverse impacts to the natural environment? Do we know what the resulting price would be? Do we have a vision of how to sustain the service with adequate guarantees to public health and social equity?

As the costs of drinking water and wastewater services go up, more consideration will be given to risk. Risk management is the process of identifying and controlling risk to contain its cost. Risk can never be eliminated. What role should risk management have in making decisions? Regulation may take a decidedly new look. Perhaps the regulators should be subject to greater public scrutiny if their decisions cause services to become more expensive. Such scrutiny might lead to more accountability and more concern about efficiency. Such considerations demand serious analytic evaluation and testing, not quick fixes. The common concern that should cross Federal, State and local interest is to achieve the best value in the provision of services and assets while protecting the public heath and environment. Decision making can improve with better facts.