Management of Aging Wastewater Infrastructure
-- Challenges and Strategies --

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Overview of the Aging Situation

For many years, water and sewer systems in core cities in the U.S. have suffered from deferred and under-funded programs for upkeep and improvements. Many systems, especially in the eastern U.S., date from the middle 1800s, and an acute backlog of needs to maintain basic services and meet new regulatory mandates has developed.

The U.S. Environmental Protection Agency (EPA) has estimated that water and sewer systems in the U.S. will require funding upwards of $500 billion above current spending levels over the next 20 years to improve the aging infrastructure. Core cities in the U.S. cannot, on their own, finance these needs from existing revenues based on rates and taxes.

Lawmakers, on the other hand, seem to have not recognized the urgent situation facing the core cities and instead have focused on programs that provide federal financial assistance to the more visible public projects in the areas of roads, bridges and airports. Moreover, lawmakers and regulators continue to mandate more stringent environmental controls which require massive water and sewer projects to achieve compliance. When these mandates are added to the already severely strained financial structures of core cities, the burden becomes critical and in some cases results in population and industry moving out of the cities to avoid high utility costs among other factors. This leaves these municipalities with a smaller revenue base to fund a fast-growing investment need.

U.S. cities need to marshal their resources to educate elected officials and the general public to the situation and the need for a comprehensive national program that reinvests in critical infrastructure. Washington, D.C. is typical of a core city having to deal with an aged water and sewer infrastructure, and the problems of deferred upkeep and new environmental mandates. The following discussion shows how the D.C. Water and Sewer Authority is addressing the funding needs and existing infrastructure conditions, and highlights our efforts to shift from past practices and meet new demands.

A population shift and shrinking rate base

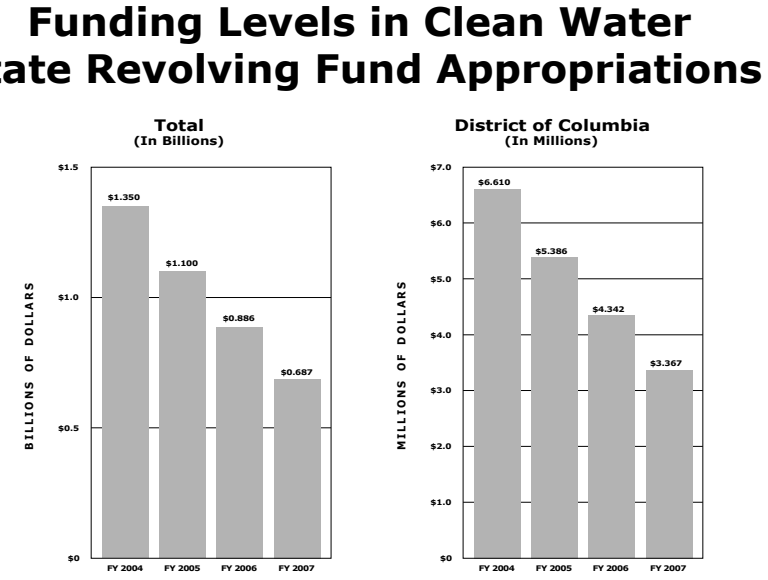
Infrastructure systems in this country have followed population growth in cities across the nation. Over the years, populations continue to increase in numbers and shift in location. For example, the U.S. Census Bureau projects its 2000 population count of 231 million to increase to 325 million by 2020. Moreover, this growth continues to move outward from the core cities, leaving many older cities with a declining population, a shrinking rate base and the costly maintenance of an aging and failing infrastructure. The problems are not just financial; they are also managerial and technical.

Federal funding support continues to decline

Since 1987, the Clean Water State Revolving Fund (CWSRF) has been the primary source of federal funding for wastewater infrastructure – including the repair and replacement of pipes, pumps and treatment plants. However, federal support for clean water projects such as these has continued a steady decline.

Total federal funds for the CWSRF have declined from $1.35 billion in fiscal year 2004 to $687.6 million in fiscal year 2007 or 50%.

Over the same period, the CWSRF funding allocation for the District of Columbia has declined 50% from $6.6 million to $3.4 million.



Long-term, dedicated funding needed

Studies by U.S. Environmental Protection Agency (EPA), Congress and the General Accounting Office (GAO) have estimated a water and wastewater funding gap of $300 – $500 billion over the next 20 years between the nation's needs and what is actually spent on aging infrastructure. The District of Columbia Water and Sewer Authority has joined elected officials, wastewater service providers, state environmental and health administrators, engineers and environmentalists in advocating the establishment of a trust fund to guarantee basic services and compliance with environmental standards over the long-term. (Similar trust funds have been formed to dedicate revenue sources for other critical infrastructure such as highways and airports.)

Wastewater infrastructure in the nation's capital

An examination of the financing and management of America's wastewater utilities shows major trends toward (1) addressing wet weather issues, driven by regulations, and (2) undertaking major replacements, driven by aging infrastructure. Facing these challenges in the nation's capital is the District of Columbia Water and Sewer Authority (WASA), one of the largest such utilities on the East Coast – with a 725 square mile service area. Incorporated in 1996 as a regional utility, WASA distributes drinking water to a population of 500,000 in the District of Columbia and provides wastewater treatment

for more than two one half million persons in the District and for suburban counties in Maryland and Virginia.

WASA operates and maintains 1300 miles of sanitary and combined sewers, 500 miles of storm sewers, nine sanitary pumping stations, 15 stormwater pumping stations, and 53 outfalls. The collection system includes more than 900 flow control structures such as diversion and overflow facilities, weirs, siphons, inflatable dams, and tide gates. Sewage flows mainly by gravity, however, there are some pressurized forced mains and pumping stations. The pumping stations were constructed from 1905 through around 1960. Parts of the sewer system date back to the 1800's and are comprised of various materials including vitrified clay pipe, reinforced concrete, ductile iron, brick arch, and some PVC pipe.

The District's wastewater treatment facility, originally constructed in 1938, sits on a 150-acre site on the Potomac River. Blue Plains is the largest advanced wastewater treatment facility of its type with a rated annual average capacity of 370 million gallons per day and a peak wet weather capacity of 1.076 billion gallons per day. While other metropolitan areas have facilities with larger capacities, none of these provide the high level of treatment that Blue Plains does with its nitrification, de-nitrification and filtration processes. Consistent with the high level of treatment provided, the plant's operating permit contains the most stringent effluent discharge requirements of any plant of its size. However, all of this comes at a cost and since 1997, WASA has invested more than $300 million in a critical overhaul of the plant – targeting the repair and replacement of every process unit, from grit chambers and screening to nitrogen removal and final filtration. As a result, Blue Plains has evolved from a facility with significant reliability and odor issues ten years ago, to one that is nationally recognized for its high quality effluent and biosolids management program.

Financing the District's aging wastewater infrastructure

WASA has implemented a 10-year, $2.1 billion Capital Improvement Program (CIP) to address the needs of its aging water and sewer infrastructure that had been deferred for decades. In the last 10 years, WASA has invested more than $1.2 billion in capital improvements for sanitary and stormwater projects, combined sewer overflow control, and wastewater treatment plant upgrades. These investments, along with prudent financial policies implemented by its Board of Directors, have earned WASA a double-A category bond rating, resulting in reducing debt service costs associated with financing the CIP. Rate revenue, with steady, predictable annual increases, continues to be the major source of funding for maintaining and improving the water and sewer infrastructure.

Regulatory challenges

Wet weather discharges A third of the District is served by a combined sewer system. Built in the 1870s, this system carries both sanitary sewage and stormwater in a single pipe. During wet weather, or rainstorms, the capacity of these sewers is overwhelmed and a mixture of untreated wastewater and stormwater will overflow into local rivers and streams. Combined sewer overflows (CSOs) impact nearly 1100 cities in this country. Federal "wet weather" policies require combined-sewer communities to

reduce these overflows to meet water quality standards through a combination of short-term control measures and the implementation of long-term control plans. This mandate represents a $2.1 billion cost burden for WASA customers, who must fund a federal court-ordered short-term plan to reduce CSOs by 40 percent and a Long-Term Control Plan to obtain an overall 96 percent reduction over the next 20 years. Compliance with "wet weather" mandates has created a severe financial plight for urban areas and the federal government must come forward with increased financial assistance to construct these massive CSO control projects. Without greater federal participation, the burden of these mandates falls unfairly on ratepayers in older core cities, like the District, where costs sometime far exceed the affordability index of the community. Moreover, a recent federal court ruling redefining discharges from CSOs may substantially impact WASA's ability and the cost to move forward on its mandated long-term plan to control CSOs.

Nitrogen reduction Blue Plains is the single, largest point source of discharge entering the Chesapeake Bay. As a condition of its federal discharge permit, WASA operates under the limitations of the Chesapeake Bay Agreement goal of a 40 percent reduction in nitrogen discharges. The District was the only one of five Agreement signatories (EPA and Bay states) to reach the 2000 goal. In 2004, the nitrogen load was reduced by 56 percent, far exceeding the goal. However, EPA is modifying WASA's discharge permit with new limits for "enhanced" nitrogen removal, requiring WASA to spend upwards of $800 million to $1 billion to meet these limits.

Strategies for managing aging wastewater infrastructure

Sewer Assessment Program Management challenges for the District's sewers relate largely to the age of the system. It is extensive and will take many years to assess its condition. To begin the process, WASA has commissioned a five-year Sewer System Assessment Program with multiple contracts and plans for internal inspections over the next decade. The assessment begins with high priority sewers, such as outfalls, siphons, stream crossings, major interceptors and sewers under buildings.

Products of the assessment program include hydraulic modeling, capacity analyses, location mapping integrating GIS, condition assessment and a facilities plan and schedule for improvements and ongoing inspections. Meanwhile, WASA is addressing immediate sewer problems and failures with TV/video inspections, cleaning and lining and other technologies that includes trenchless repair.

Asset management In America, the wastewater industry has embraced the concept of asset management as a major tool in managing the operations and costs associated with aging infrastructure. At WASA, the implementation of its Asset Management Program represents a significant leap in automation and business process improvements for infrastructure management and maintenance lifecycles. From receiving a customer complaint to its ultimate resolution, the system supports work orders, job planning, operating condition monitoring, proactive and scheduled maintenance activities, and is integrated with WASA's inventory system. Among the benefits of an Asset Management System, is its impact on changing the operating culture from "break down" maintenance to predictive and planned maintenance. Eventually the system will tie into WASA's purchasing and financial systems for capital replacement and associated cost management.

Human resource management WASA, like most utilities, is faced with a critical shortage of personnel in positions that require a unique skill set, and there are at least three other utilities within 30 miles with which WASA has to compete for employees. The average age of workers in the U.S. wastewater utility industry is 45; the average age at WASA is 47 years old, with an average of 14 years service. More than half of the middle management staff has been with WASA since its inception in 1996, and in some cases for more than 20 years. Many of WASA's employees are eligible to retire and that will cause a significant loss of operational and managerial knowledge. WASA is preparing for this type of turnover in two ways. WASA is using a Knowledge Capture concept for key processes to gather and document the tacit institutional knowledge that exists with individual employees rather than in the standard operating manuals. Succession Planning focuses on the senior and executive levels in the organization and ensures that the right people with the right competencies, experience and training are positioned for operations and business continuity. Additional strategies employed by WASA include "double-filling" certain key positions, rotating engineering and internship programs, and entry level training opportunities.

Summary

The District of Columbia is one of many core cities in America burdened with the need, cost and requirements to maintain, replace and upgrade aging plant and underground wastewater infrastructure. Aging systems, costly upgrades, regulatory demands and shifting populations are a challenge for communities across the country. Thirty years ago, the federal share for wastewater infrastructure construction was 75 percent. Today it has fallen below five percent. EPA estimates that, if the nation's infrastructure needs are not addressed in the next 10 years, 35 years of water quality gains will be lost. The experience in the nation's capital reflects conditions and challenges in like communities across America. As the District and other core city stakeholders advocate the establishment of a federal clean water trust fund, annual rate increases continue. In the meantime, long term facility planning, the use of strategies and tools such as legislative advocacy, asset management systems, succession planning and public education are keys to meeting the service, regulatory, and financial challenges facing America's aging water and sewer infrastructure.

4th Japan-U.S. Governmental Conference on Drinking Water Quality Management and Wastewater Control

Management of Aging Wastewater Infrastructure

Challenges and Strategies

January 22-25, 2007

Bankoku Shinryokan, Okinawa

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District of Columbia
Water and Sewer Authority

Serving the Public ✱ Protecting the Environment

America's Systems Are Aging

- Our pipes and plants are aging
- Many have passed their life expectancy—costly repairs, replacement
- Wastewater plants—useful life of 20 years before required expansion or rehabilitation
- Sewer pipe life-cycle—50 to >100 years (some East Coast cities ~200 yrs. Old)

Populations Are Increasing and Shifting

- U.S. population (2000)—231 million to 325 million (2020)
- U.S. populations are shifting away from older, core cities leaving the responsibility of costly maintenance of aging systems to a declining population and rate base

Aging Infrastructure is a National Challenge

"Sewer System Wasting Away"
Modesto Bee (CA), June 2006

"Sewer Plant Calls in Plumber"
Daily Press (CA), June 2006

"Sewer Line Costs are Exploding"
The Honolulu Advertiser (HI), July 2006

"Sewers Use Outdated Technology"
Gotham Gazette (NY), October 2003

America's Wastewater Infrastructure Needs

- Collection and pumping infrastructure
- Plants and advanced treatment
- Reclamation and reuse facilities
- Biosolids management

Funding for Aging Infrastructure

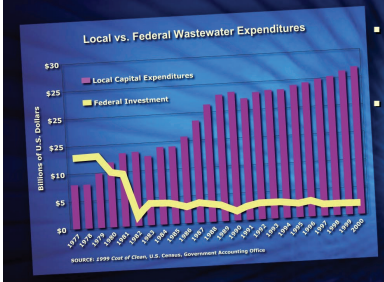
Clean Water State Revolving Fund

- America's largest water quality funding source since 1987—Federal Clean Water State Revolving Fund (CWSRF)
- Eligible projects include wastewater collection and treatment, non-point source pollution control and watershed management

Federal Funds for Wastewater Projects Continues to Decline

- Total funds have declined 50%—from $1.35 billion in 2004 to $687 million in 2007
- Washington, DC's share declined 50% from $6.6 million in 2004 to $3.4 million in 2007

Cities are Funding a Growing Share of the Cost



- Infrastructure needs have grown—funding has declined
- This challenges core cities with a declining rate base to meet needs/ regulations

Proposed Clean Water Trust Act

- Long-term, sustainable funding needed

- Proposed Clean Water Trust Act—a dedicated funding source
- Similar to federal highway and airport trust funds

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Major Challenges for Wastewater Industry

- Wet weather issues
  - ✓ Sewer overflows
  - ✓ Stormwater
  - ✓ Non-point source pollution
- Aging infrastructure
  - ✓ Sewer failures
  - ✓ New discharge limits
  - ✓ Biosolids management

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District of Columbia Water and Sewer Authority (WASA)

- One of the largest water/sewer utilities on East Coast
- Regional utility with 725-mile service area
- Water distribution to 500,000 in District of Columbia
- Wastewater treatment for over 2 million in District and suburban MD and VA counties

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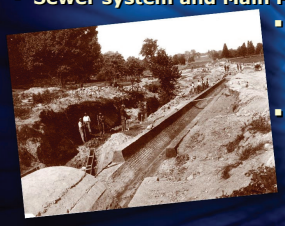
Age of District's Wastewater Infrastructure

- Oldest sewer—1850's (42" pipe leading from Capitol—1859)
- Sewer system and Main Pumping Station—1908



- Sewer materials— clay, reinforced concrete, ductile iron, brick arch, PVC
- Blue Plains wastewater (primary) treatment plant—1938

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Sewer Collection System

- Sanitary and combined sewers—1,300 miles
- Storm sewers—500 miles
- Pumping stations—9 sanitary 15 stormwater
- Outfalls—53

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Blue Plains Advanced Wastewater Treatment Plant

- Largest such facility in the world
- 150 acres on Potomac River
- Capacity 370 MGD; over 1 billion gallons a day peak
- Tertiary treatment (nitrification/de-nitrification, filtration)
- Completed $300 million critical, comprehensive renovation—from grit chambers through filtration

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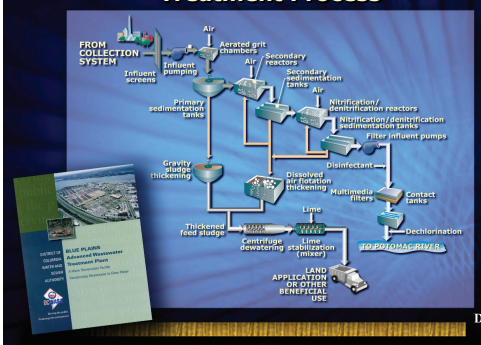
Blue Plains Advanced Wastewater Treatment Process



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Infrastructure Financing Strategies

- Approved a 42 percent rate increase
- Since 1996, WASA has invested >$1.2 billion in capital improvements
  - ✓ Sanitary and stormwater projects
  - ✓ Combined sewer overflow control
  - ✓ Wastewater treatment plant upgrades
- Established 10-year, $2.1 billion Capital Improvement Program and Financing Plan
- Secured bond financing authority and bond rating upgrade to AA-
- Gradual and predictable rate increases

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Regulatory Challenges—Combined Sewer Overflow (CSO) Control

- CSO's impact 1,100 U.S. cities
- Built in 1870s—1/3 of DC system is combined sewers
- Federal mandate to control overflows to meet water quality standards
- WASA Long-Term Control Plan—20-year, $1.9 billion
- 8 miles of underground tunnels; plant and pumping station upgrades

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Regulatory Challenges—Combined Sewer Overflow Control

- Ruling on TMDL definition
- Fed. "affordability index" does not reflect true cost burden to older, core cities like D.C.
- Impact on rate increases—double digit

($90 million in federal funding assistance to date)

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Regulatory Challenges—Nitrogen Removal

- Chesapeake Bay Agreement Goal—40% reduction by 2000
- WASA only one of five partner states to reach goal
- WASA nitrogen load reduction 56% in 2004
- New permit limits could cost WASA $700 million to $1 billion for plant improvements

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Strategies—Identify and Assess Condition of Assets

- Five-year Sewer Assessment Program, using multiple inspection contracts
- Sewers selected based on priority
- Addressing immediate problems with TV inspections, cleaning and lining, other repair technologies

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Sewer System Assessment Program Products

- GIS layer for mapping, database
- Sewer system hydraulic model
- Capacity analysis—Flow meters installed to assess capacity, inflow, infiltration
- Sewer system facility plan
  - ✓ Identify system improvements
  - ✓ Plan ongoing inspections

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Managerial Strategies

- Completed privatization study
- Implemented Best Engineering Practices
- Expanded staff capability and capacity with consultants; joint venture, project and construction management teams

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Asset Management System

Major tool in managing operations and costs associated with aging infrastructure—integrated with GIS to view assets and locations graphically

- Electronic Work Management
  - ✓ Processes Work orders, routes assignments
  - ✓ Prioritizes work—criticality of asset, severity of problem
- Electronic Asset Management
  - ✓ Job planning, operating condition monitoring
  - ✓ Predictive maintenance (predict failure)
- Integrate with GIS, Financial, and Procurement systems

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Human Resources—Challenges

WASA faces critical shortage of personnel in skilled areas

- National study—utilities will lose 30% or more staff within five years
- WASA competes with other utilities (three in 30-mile radius in region)
- Average age in wastewater industry is 45
- Average at WASA is 47; many eligible to retire at 55
- Retirements could result in significant loss of institutional knowledge

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Human Resources—Strategies

Knowledge Management

- Knowledge capture workshops for key processes—to capture information not in manuals

Succession Planning

- Focus mainly on senior and executive levels
- Position those with the right competencies, experience and training in operations for business continuity

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Human Infrastructure—Strategies

- Double-fill certain key positions
- "Rotating Engineering" program
- Internship program
- Entry-level Operator program

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Summary—Challenges

- Aging wastewater systems
- Costly upgrades
- Regulatory demands
- Continuing reduction in federal funding assistance
- Shifting populations and impact of cost burden

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Summary—Strategies

- Implement asset management system
- Implement knowledge capture program
- Request federal impact studies and cost-benefit analysis of regulatory requirements
- Lobby for Federal Clean Water Trust Fund
- Establish local rate stabilization fund
- Educate community about aging infrastructure costs

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