City of Rockville
Mayor and Council
Agenda Item

For the meeting on:	February 11, 2008
Agenda Item Type:	Worksession
Department:	Public Works
Division:	Engineering
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Subject
Briefing on the City of Rockville Water System.

Recommendation
Staff recommends the Mayor and Council receive staff briefing on a program of proposed water treatment plant upgrades and the 15-year infrastructure renewal of the water distribution system.

Change in Law or Policy
Staff will return on a future agenda with rate schedules needed to accomplish this program. Changes to the water and sewer rate schedule will require amending the City Code, Chapter 24, "Water, Sewers and Sewage Disposal." Chapter 24 also provides for certain fees to be established by resolution. Any changes to those fees established by resolution will require the adoption of new resolutions.

Discussion
The primary purpose for public water systems is to deliver clean and safe water for human consumption, fire suppression, industrial processes and agriculture. Rockville's system primarily serves human consumption (drinking, washing, laundering, watering lawns, washing cars, heating and air conditioning), fire suppression, and limited industrial and agricultural purposes. Rockville's water system consists of a Water Treatment Plant (WTP) and Water Distribution System.

The purpose of this agenda item is to highlight several issues impacting the City's water system and infrastructure. Systems across the region and the nation are facing similar issues regarding significant upgrades to their water treatment plants and water distribution systems which are being driven by increasingly stringent federal water requirements, aging infrastructure, and pipe conditions that impact fireflow and water quality. This worksession provides an overview of the complex issues affecting the City's water treatment plant and distribution system, upgrades needed at the water plant, and a plan to replace a large portion of our water lines over the next 15 years. The financial implications will be discussed at a future Mayor and Council worksession with rates and options to pay for these essential infrastructure upgrades.

Water Treatment Plant

Initially, Rockville received water from a number of wells spread throughout the city. In the mid-1950s these wells were no longer able to keep up with the increased demand created by the booming post World War II economy and the associated development. From 1950 to 1960 Rockville's population increased by 276 percent. This surge in population and associated development overtaxed both the water and sewer systems to the point of crisis in 1953, which contributed to the formation of the Citizens for Good Government (CCG) and the election of an entirely new Mayor and Council in 1954.

In the mid-1950s, the City focused its attention on building a state-of-the-art water plant to provide a reliable water source that would withdraw "raw" water from the Potomac River, process and treat it, and then deliver "finished" water to Rockville residents. Rockville hired Gilbert Associates to design the water intake structure and high-rate, dual-media filter purification water plant with chlorine disinfection. Public Works began operating the Water Treatment Plant (WTP) in 1958; with an initial plant capacity of 4 million gallons per day (mgd). In 1969 a plant expansion was completed bringing the WTP capacity from 4 mgd to 8 mgd.

Over the years there have been process improvements to yield cleaner water to meet more stringent requirements mandated by Congress, with rules and regulations set by the Environmental Protection Agency (EPA) and Maryland Department of the Environment (MDE). Rockville initiated a Water Plant Rehabilitation Program in the mid 1990's to address EPA standards for the 1986 Safe Drinking Water Act (SDWA) Amendment.

Rockville's Water Plant Rehabilitation Program, which began with the Solids Removal project and also included Intake Upgrade, Clarifier Upgrade, Sandy Landing Road Improvements, Filter Rehabilitation, Filter Cover, and WTP Pump Upgrades, was implemented over an eleven-year period beginning in 1993. Before 1996, the silt removed from the raw water was discharged back to the Potomac River. In 1992 the MDE issued a Consent Decree ordering Rockville to stop discharging silt to the Potomac River. Accordingly, a solids handling system was implemented in 1996 to comply with the Consent Decree. Rockville invested $10 million on this Program between 1993 and 2004 to improve the water plant and intake to comply with EPA and MDE regulations.

EPA promulgated two new regulations in 2006: The Long Term 2 Enhanced Surface Water Treatment Rule (LT2 Rule) and the Stage 2 Disinfectants/Disinfection By-Products Rule (Stage 2 DBPR). Water Systems must comply with these regulations by 2013. A brief description of each follows:

- The LT2 Rule requires process improvements to reduce disease incidence associated with the presence of Cryptosporidium and other pathogenic microorganisms in drinking water. Cryptosporidium is a significant concern because it contaminates surface waters used as drinking water sources and is resistant to chlorine and other disinfectants. In addition, it has caused waterborne disease outbreaks, such as gastrointestinal illness, which may be severe in people with weakened immune systems (e.g., infants and the elderly) and sometimes fatal in people with severely compromised immune systems (e.g., cancer and AIDS patients).
- The Stage 2 DBPR requires process improvements to protect public health by limiting exposure to "disinfection by-products." Disinfection is an essential element of drinking water treatment because of the barrier it provides against waterborne disease-causing microorganisms. However, disinfection by-products (DBPs) form when disinfectants used to treat drinking water react with naturally occurring materials in the water (e.g., decomposing plant material). These by-products (Trihalomethanes (THM), Haloacetic acids (HAA), Chlorite, and Bromate), if consumed in excess of EPA's standard over many years, may lead to increased health risks for cancer, as well as possible cause of reproductive and developmental issues.

In 2006, Rockville hired a consulting firm, Hazen and Sawyer (H&S), to evaluate the WTP and its supporting facilities and prepare a comprehensive Water Treatment Plant Facility Plan to:

- Identify required process improvements that meet or exceed the SDWA amendments for LT2 and Stage 2 DBPR;
- Evaluate the plant's residuals handling process to identify ways to improve performance and reliability;
- Evaluate the plant hydraulics to meet 14 mgd; and
- Evaluate capacity of the electrical components to support recommended process changes to the plant.

Previous studies indicated that 14 mgd plant production capacity was needed to meet future demand; however, recent projections performed by H&S as part of the 2008 Water Distribution Master Plan, indicate the maximum demand will be 11 mgd. As some components have not already been sized to meet the 14 mgd output, an analysis will be done to determine the cost-effectiveness of upgrading those remaining components to 11 mgd rather than the original 14 mgd.

The WTP Facility Plan was split into two phases: Phase A and Phase B. The Phase A Study, completed in June 2007, assessed the ability of the existing plant to comply with current and projected drinking water regulations; identified unit processes that need to be upgraded to achieve the increased plant capacity; and evaluated the existing residuals handling processes to improve performance and reliability. Further, Phase A recommends performance testing of the clarification process (Clarifiers) to be accomplished during Phase B because this unit process is nearing maximum production and therefore could limit the overall WTP production capacity. Phase A of the Water Treatment Plant Systems Analysis projected a $14.6 million improvement plan, which includes:

- Solids Handling Improvements;
- Filter Improvements; and
- Chemical Feed Upgrades.

The solids handling improvements are needed to prevent the existing treatment process from being compromised during storm events on the Potomac River and to allow the plant to increase production to meet increasing demand for finished drinking water. The filter improvements and chemical feed upgrades are needed to improve plant performance relative to finished water quality goals at higher plant flow rates and bring the existing units into compliance for plant design criteria (MDE Regulations, the Ten States Standards, etc.).

What is not included in the above cost is the cost of electrical improvements, hydraulic improvements, or the cost of advanced treatment processes to achieve compliance with the Long Term 2 or Stage 2 DBP Rules. The latter could not be quantified during Phase A because:

- The 24-months of raw water *Cryptosporidium* sampling had not been initiated at the time the report was completed; therefore, a classification of where the Rockville WTP stood relative to the additional treatment requirements of the LT2 Regulation could not be ascertained. The Phase A report recommended that the City begin considering its options for complying with the worst case classification scenario under this regulation. This analysis was to occur in Phase B.

- Insufficient data was available to ascertain if the City would meet the regulatory criteria or not.

The $14.6 million cost also did not include the cost of additional filtration or clarification because the full-scale performance testing had not been performed. The full-scale testing program should cover multiple seasons (cold and warm water conditions, which can affect treatment), and should be coordinated with the Maryland Department of the Environment so that State buy-in to the testing program can be obtained.

Because of the high cost of these improvements, and because of the unknown nature of the LT2 and Stage 2 DBP Rules, H&S recommended a cost-benefit analysis be included in Phase B to include other advanced process alternatives to lay out a long-term capital improvements program for the City of Rockville WTP. Additionally, data from the component performance testing will be used to evaluate cost-effectiveness of

specific process component upgrades. Phase B of the Water Plant Study and Facility Plan, which was initiated in fall 2007 and will be completed in fall 2008, will evaluate the hydraulic capacity, electrical system capacity, as well as consider additional or alternate process changes (to those presented in the Phase A report) to meet regulatory compliance assuming a worst-case result to the additional analysis for LT2 and Stage 2 DBP Rule compliance.

When taken together, the Phase A and Phase B analyses will constitute an overall Facility Plan for the Rockville WTP. The final Facility Plan will recommend a long-term upgrade program to achieve cost-effective solutions for:

- Regulatory compliance for LT2 and DBPR;
- Hydraulic constraints;
- Hydraulic surges associated with power outages; and
- Improve the electrical components to support future plant process demands.

Water Distribution System

The water distribution system, a network of water meters, storage tanks, pumps, pipes, fire hydrants, and valves, transports the finished water from the WTP to Rockville's customers. Rockville is among many communities nationwide that are facing four issues inherent to its aging distribution system : decreased revenue caused by aging water meters; increased water main breaks; decreased water quality within the distribution system; and decreased flow rates for fire suppression.

Water Meter Replacement

Aging water meters tend to "slow down" and under-register the amount of water consumed. The Meter Replacement Program, projected to cost $5 million, began in 2006 with the commercial meters. The residential meter replacement program will begin in spring 2008. All water meters will be replaced by fall 2009. Revenues are expected to increase because water usage will be more accurately measured and billed.

Water Tank Rehabilitation

Rockville's development in the 1950s and 1960s added five water storage tanks and 93 miles of water pipe; more than quadrupling the size of the water system. The 1994 Water Distribution Study analyzed the overall system and determined two tanks (Grandin Ave and Horners Lane) were no longer needed. Accordingly, they were removed in 1998 and 2000. The remaining three water tanks (Talbott Ave, Carr Ave, and Hunting Hill) were rehabilitated between 1996 and 2000. The tanks were repaired and painted with a sealant on the interior and exterior to protect against corrosion. Additionally, cathodic protection systems were installed. Cathodic protection controls the corrosion of a metal surface by making that surface less prone to corrosion by introducing a sacrificial element (anode) that corrodes instead of the metal surface (the water tank). Rockville invested $3.5 million to remove the two tanks and rehabilitate the three other tanks.

Glen Mill Pump Station

Rockville constructed the Glen Mill Pump Station (GMPS) to allow increased water production over 8 mgd based on a recommendation from the 1992 Water System Study. GMPS is located within Montgomery County approximately halfway between the WTP and the Hunting Hill Water Tank. Construction on the station was completed and field-tested in fall, 2006; however it has not been put into routine operation because there have been problems identified by staff related to surges, valves, pumps, and air release valves. Staff received a study conducted by H&S to review these problems and they have recommended solutions that have resulted in two new CIP projects to implement these improvements: Hydraulic Surge Suppression and Air Release Valves.

Water Pipes and Breaks

The water pipes installed during this post World War II boom (1950s and 60s) represents 51% percent of our total water distribution system today (see Attachment 1 - Water System Pipes & Customers, City of Rockville). The industry standard pipe for water distribution systems at that time was cast iron pipe

without interior lining and without exterior protection. There are three primary measures for determining the need to replace/rehabilitate pipes: structural condition (leading to leaks and breaks), water quality, and water flow (tuberculation). While the age of a pipe is an indicator of its condition, the actual service life of a particular segment of cast iron pipe may vary considerably depending on the above factors. Pipe installed today (ductile iron pipe with an interior cement lining and with exterior polywrap) has a life expectancy of 100 years or more. Unlined cast iron pipe can have a life expectancy which is considerably less.

Failures in aging water mains are a problem for Rockville and many other water utilities. Water main breaks cause property damage, revenue loss, environmental damage, interruption of service, and costly repairs for water customers. Two recent water main breaks on Rockville Pike resulted in major service disruptions, took crews 29 hours to repair, interrupted traffic through several rush hours, and resulted in an estimated 1.4 million gallons of lost water ($3,750 loss of revenue). In 2007, Rockville experienced a record 65 water main breaks, costing approximately $250,000 for repairs, and much water loss.

Rockville's aging water pipes will continue to experience increased breaks unless a pro-active and systematic replacement program is initiated. Of the system's 180 miles of pipe in the distribution system, approximately 90 miles is cast iron pipe installed before the mid 1970s. Increased water main breaks in the cast iron water pipes are anticipated as the pipes age.

Water Quality

Water main breaks are not the only problem with an aging water system. Unlined cast iron pipes are subject to internal corrosion, known as "tuberculation," which degrades the quality of the water and causes flow restrictions. Water quality issues are two-fold: discoloration of the water, and decreased availability of chlorine residuals for disinfection.

Tuberculated pipes can cause water to turn a rusty brown color. A slight increase in water velocity, as may be experienced during opening of a hydrant or during a main break, can cause the rust to break loose from the interior pipe wall, resulting in discolored tap water. High water demands throughout the distribution system also increase the velocity of the water to a rate of flow which causes water discoloration.

As part of Rockville's regular maintenance program, all of the water mains in the distribution system are flushed every other year. This flushing helps to remove the internal build-up of material before it reaches homes and reduces incidents of water discoloration.

Tuberculated pipes also affect the quality of drinking water by reducing the amount of available chlorine for disinfection purposes. Utility companies throughout the nation commonly use two procedures to maintain adequate chlorine in the distribution system. The first is to add extra chlorine at the treatment plant to ensure that sufficient residual chlorine is available at the most distant point in the distribution system. However, simply adding more chlorine introduces the risk of forming additional disinfection by-products (DBPRs). As mentioned earlier in the WTP section, DBPR levels are also regulated. The second procedure to maintain chlorine levels is to flush water mains, as discussed for controlling incidents of water discoloration. Currently reduced chlorine availability occurs infrequently in Rockville's severely tuberculated pipes. Rockville takes monthly samples at 25 locations throughout the water distribution system to test for various components, including chlorine residuals. These samples consistently meet or exceed current regulatory requirements. However, continued tuberculation growth could lead to increased incidences of low chlorine residuals.

Flushing water mains is a standard industry preventive maintenance procedure to improve water quality, as well as to test the system’s fire hydrants to ensure they are in good working condition. However, flushing water mains is not enough to address discoloration and low chlorine residuals when the pipes have extensive tuberculation.

Restricted Flow

Another significant impact of tuberculation is reduced water flow. Tuberculation reduces the internal pipe diameter and causes the internal pipe surface to become rough. Both of these conditions decrease flow and pressure in the pipe. Typically, the tuberculation build-up progresses over time, steadily lowering the water flow rate. After many years of build-up, tuberculation lowers the flow to a point where it impacts the ability to meet fire flow demands.

Rockville hired H&S in 2006 to prepare Rockville's Water Distribution System Master Plan (see Attachment 2). This is the fourth Water Distribution System Study of Rockville's system during the past 40 years, but the first to use a sophisticated all-pipe computer modeling program to evaluate the entire water distribution system and develop a comprehensive improvement program to correct deficiencies. The study included field testing as well as the creation of a GIS compatible, all-pipe network computer model. A GIS compatible model will allow Rockville to integrate computer modeling with the physical data of the pipe network. Field-testing was used to calibrate the computer model and determine the flow capability of water mains. The calibrated model, along with field-testing results, revealed flow deficiencies primarily in the older sections of town with the unlined cast iron pipe within the neighborhood streets.

Because tuberculation cannot be measured directly, computer modeling is used to predict the amount of available flow at various points in the system and determine the system's ability to meet fire flow demand. Guidelines for fire flow for varying development densities are published by ISO (Insurance Service Office). Rockville has historically followed the fire flow guidelines established by ISO. For most water systems, the recommendations vary from 1,000 gpm (gallons per minute) in residential areas to 3,500 gpm for major commercial or industrial development. The study found 257 out of Rockville's 1369 fire hydrants are delivering fire flows less than 1,000 gpm. Forty-one of the 257 fire hydrants deliver fire flow less than 500 gpm.

Staff met with the Montgomery County Fire and Rescue Service (MCFRS) to review Rockville's system ability to deliver sufficient fire flow. MCFRS indicates that fire hydrants that deliver 500 gpm, though not ideal, can be used to put out a residential fire. Fire hydrants that deliver less than 500 gpm are generally considered insufficient. Rockville intends to manage these deficiencies through continued coordination with the MCFRS while the water line renewal program is implemented. For example, a fire hydrant marking program is being developed in conjunction with the MCFRS to field-identify hydrants that deliver less than 500 gpm and hydrants that deliver over 500, but less than 1,000 gpm. In the event of a fire this will allow firefighters to quickly determine which hydrant to draw water. The fire hydrant marking program is a tool to bridge the system from partial fire flow inadequacies to a system that provides adequate fire flows. Staff also plans to share GIS mapping layers of the water distribution system with MCFRS which can be used as needed. A program must be initiated to replace these deficient lines so that fire flow in these areas can be restored to an acceptable level and it must be done in a time frame that prevents this from reaching a crisis stage.

Water Line Replacement Program

To address the fire suppression and other deficiencies H&S Water Distribution Master Plan recommends replacing 32.9 miles of water pipe at a cost of $67 million over the next 15-years. The water line replacement has been prioritized into four groups. The groupings were developed to provide fire flow improvements expeditiously, minimize water service interruptions due to breaks and resulting inconvenience to Rockville residents, improve water quality to an interconnected system of pipe within each different area of Rockville, and group together projects that must be completed together in order to achieve the goals and benefits of the program. The 15-year pipe replacement program is shown in the Executive Summary (see Attachments 2 and 3 - Executive Summary and Figure ES-1, Recommended Improvements). Beyond the first two years, projects may vary according to maintenance needs, such as frequency and magnitude of breaks.

Rockville must begin implementation of a planned water line replacement program to ensure a sustainable water distribution system that will provide sufficient water flow for fire suppression and water quality that

meets or exceeds EPA and MDE regulations, while minimizing future operation and maintenance costs and service interruptions.

Staffing for the New Program

Taking together the $67 million water replacement program and the $14.6 million WTP Upgrade Program represents approximately $82 million in capital expenditures over 15 years. While most of the actual work will be accomplished through contractors, Rockville does not have sufficient resources to manage this at current staffing levels. To meet this demand staff will require approximately 4.5 additional staff positions (regular and temporary positions) in the Water Fund to manage, engineer, and execute the program.

Mayor and Council History

This is the first time this item has been brought before the Mayor and Council.

Options Considered

Water Treatment Plant

Specific options are being considered as part of the Phase B Study analysis. The plant upgrades needed for regulatory compliance must be completed by 2013. The "no-build" option is not considered, because these projects are mandated by federal and state regulations.

Water Distribution System

Staff considered two options to address concerns due to the aging water distribution system: "Clean and Line," or "Dig and Replace." Cleaning and lining water lines can be an effective means to remove tuberculation and restore the internal surface of the pipe thereby improving flow and water quality. This process uses a machine that is drawn though the pipe to scrape the tuberculated materials from the surface and then spray a cement lining onto the pipe's interior. The City has previously performed cleaning and lining on several transmission mains, based on prior recommendations to address similar issues. However, cleaning and lining does not improve the pipe's structural integrity and water main breaks will continue to occur.

A dig and replace program removes the old pipe and replaces it with new pipe that meets today's standards of lined and wrapped ductile iron pipe. Replacement also offers an opportunity to replace deteriorated valves, hydrants, service connections to the meters at the customer's property line, and upsize mains, thereby, providing a more complete renewal of the system and attaining maximum benefit for the cost of the renewal program. While initially more expensive than cleaning and lining, the life-cycle cost is lower because the pipe's service life has been dramatically increased. In addition, future water main breaks will be minimized. For these reasons staff recommended the dig and replace program.

The "no-build" option is not considered because there will be serious consequences to Rockville's distribution system if the infrastructure is not improved. Specific examples include increased fire protection problems, water quality degradation; and increasing frequency of water main breaks.

Public Notification and Engagement

Staff is planning an aggressive campaign to educate Rockville residents about the aging water system and the need to rehabilitate the various components. Staff plans to publish a two-part series in Rockville Reports in the March and April issues; broadcast a Cityline interview on TRC 11; and include a short news story in the city hall report on TRC 11 to be aired during the week of February 11. Additionally, staff will prepare a FAQ to be posted on the City Web site; place press releases on the front page of Rockville's Web site; and provide links to Mayor and Council power point presentations, staff reports from Mayor and Council meetings, and Rockville Reports articles.

Fiscal Impact

Many other utilities in this region and nationwide are faced with the need to invest in their water systems. In 2002, EPA published The Clean Water and Drinking Water Infrastructure Gap Analysis which included a funding analysis. EPA's cost projections, including financing, ranged from $178 billion to $475 billion

needed nationwide to address aging infrastructure renewal as well as regulatory compliance with tougher environmental standards. EPA's analysis suggests that a large gap will result if the challenge posed by an aging infrastructure network—a significant portion of which is beginning to reach the end of its useful life—is ignored.

The FY 2009 CIP will propose a $14.6 million WTP Upgrade Program, which appeared in the FY 2008 CIP, and a $67 million 15-year water distribution system infrastructure renewal program.

The infrastructure renewal will be an on-going program, similar to the Asphalt Pavement Maintenance and Concrete Repair programs. Both of these existing infrastructure renewal programs cycle rehabilitation work through the City on a regular schedule based on the life cycle of asphalt roadways and concrete curbs, gutters, sidewalks, and driveway aprons. Funding options will be developed to ensure the cost is equitably shared amongst the users of the entire water system.

Initially, the 15-year water infrastructure program recommended by H&S addresses the most critical and older sections of Rockville with water pipes nearing the end of their life-cycle. As future Water Distribution Master Plan Studies are conducted, and water main break information as well as water quality information are compiled, additional water pipes will be replaced. The newly installed water mains will have an anticipated life cycle of 100 years. Therefore, on average approximately 1.8 miles of water main will need to be replaced annually once the initial program addresses the critical mass of water mains installed in the 1950s and 1960s.

Staff is currently looking at different approaches for financing such significant operating and capital improvement expenses, including an approach proposed by WSSC to address similar problems. For FY 2009, WSSC is proposing an aggressive pipe replacement program and is recommending an Infrastructure Renewal Fee (ready-to-serve charge) for all customers, based on meter size, as a flat monthly fee for the next ten years. For small meters, size 5/8" to 1-1/2," the monthly fee will be $20. Staff is in the process of running different iterations of usage rates and ready-to-serve charges and will make recommendations with the principle of having the lowest rates over time for Rockville residents, while ensuring that costs are equitably distributed to all system users.

Next Steps

Staff will present funding and rate recommendations at an upcoming Mayor and Council Session and initiate public education.

Attachments


pipe & res pop served.pdf


executive-summary.pdf


Figure ES-1 - Recommended Improvements.pdf

Attachment 1: Water System Pipes and Residential Population Served


M&C_Water Briefing_Feb 11_2008.pdf

Attachment 2: Executive Summary

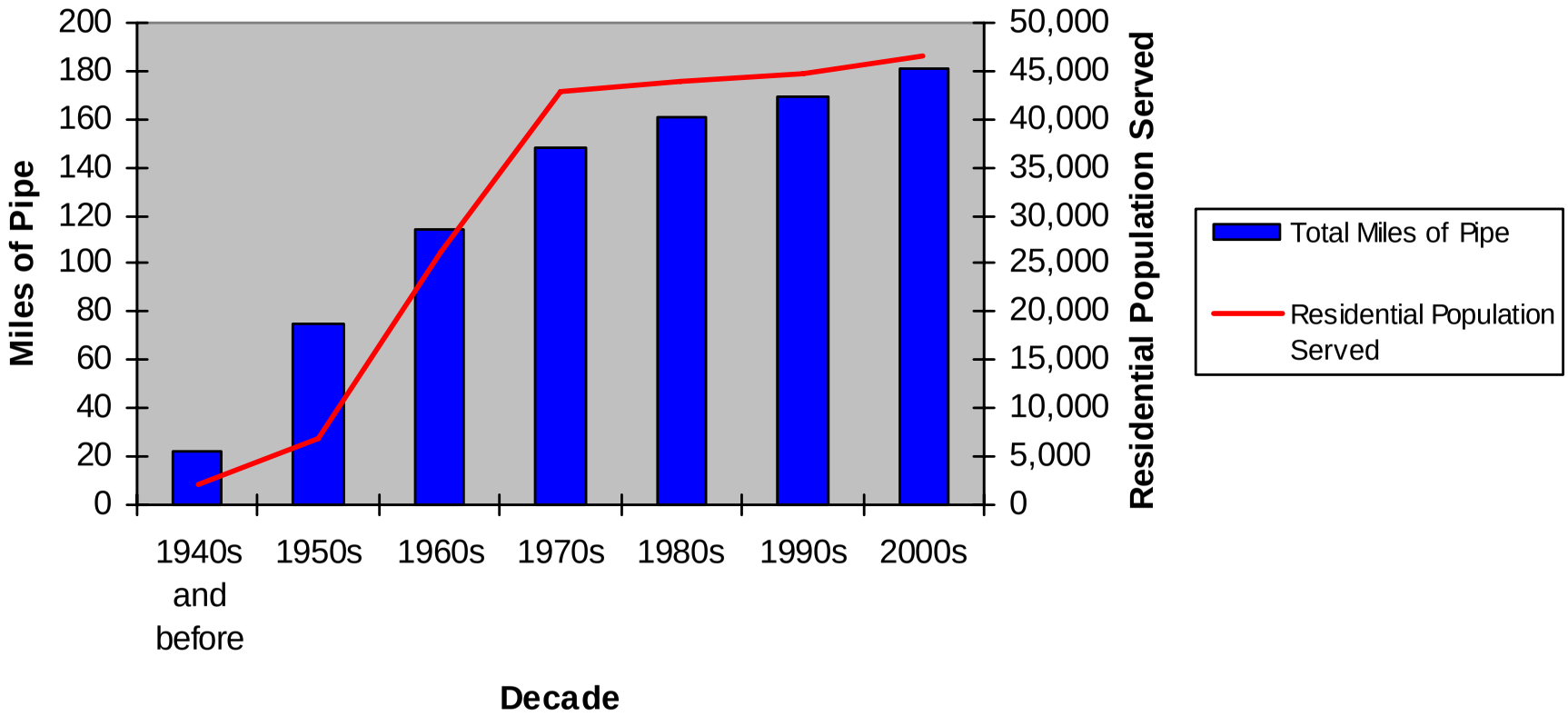
Attachment 3: Figure ES-1, Recommended Improvements

Attachment 4 Water Briefing Powerpoint

Department Head: Craig Simoneau, P.E.; , Director of Public Works
Approval Date: 02/07/2008

City Manager: Scott Ullery, City Manager
Approval Date: 02/07/2008

Attachment 3



Water System Pipes & Residential Customers Served

EXECUTIVE SUMMARY

This study presents an updated Water Distribution System Master Plan for the City of Rockville, Maryland. The purpose of this study was to evaluate the existing water distribution system and develop a program of recommended improvements to correct deficiencies found and meet future requirements. The scope of the study included the following:

- Analyze system demands based on the City's population and growth projections in order to determine future water requirements.
- Perform field tests to assess water loss within the system.
- Conduct a series of field tests to assess whether pipes are big enough and whether flow through pipes is being restricted due to factors such as whether closed valves or corrosion on the interior surface of the pipes.
- Convert the City's existing hydraulic computer model of the distribution system into a new, more detailed model which works with the City's geographic information system. Use the results of the demand analysis and the field testing program to develop and calibrate the new model.
- Utilize the new model to analyze water age and water tank storage volume, in order to identify causes of increased water age in the system.
- Evaluate the system using the new model and develop a program of recommended system improvements.

The following paragraphs describe the results of the field testing, modeling, and analyses and summarize the recommended program of improvements.

Evaluation of the Existing System

Average day demands for the system were estimated at 6.32 mgd in 2015 and 6.47 mgd in 2030, based on City Planning Department population and development projections. Using a maximum day factor of 1.7 calculated from historical trends, maximum day demands were then estimated at 10.74 mgd in 2015 and 11.00 mgd in 2030.

Based on the demand projections, the volume of water stored in tanks within the system was evaluated. It was determined that the total of 12 million gallons of storage within the distribution system's three water tanks will be sufficient through 2030, provided that the WSSC emergency interconnections remain in place; otherwise, a need for an additional 1.72 million gallons of storage is predicted for 2030.

The field testing program and modeling analysis found that the trunk mains (mains 12-inches in diameter or larger which distribute water throughout the system) were generally sufficient to serve the system with the exception of sections of mains along Lewis Avenue, Southlawn Lane, and Stonestreet Avenue where new pipes or larger replacement pipes were recommended. In the past, master plans typically focused on trunk mains, and the limitations of earlier generations of hydraulic computer models made it difficult to analyze all pipes within a system. Consequently, the trunk mains were the focus of the improvement program in the previous water distribution system master plan. The City has completed the majority of the recommended improvements from the previous master plan, and the results of the current study indicate that these efforts were successful in reinforcing the trunk main system.. However, the current study also analyzed the grid mains (mains 8-inches in diameter or smaller which serve individual streets and neighborhoods), and approximately 50 miles of grid mains (or 25% of the total length of pipe in the system) were found to have insufficient flow. Many of these pipes are approximately 50 years old or more. The leakage study portion of the field testing program concluded that only one area, in the northeast portion of the City where a portion of these older grid mains are located, showed significant signs of leakage. Thus, improvements to these grid mains would address both low flow and leakage issues.

While the City has only limited records as to the exact age and pipe material for these older pipes, based on the records that are available and the results of the field testing, it appears likely that a majority of the City's deteriorating water mains are unlined, cast iron pipes. Unlined, cast iron pipes are susceptible to tuberculation, in which a buildup of corrosion products on the interior wall of the pipe reduces the amount of flow that the pipe can carry. This would explain the low flows found during the field tests. These pipes tend to deteriorate with age more rapidly and continually as compared to more modern, lined pipes, which tend to deteriorate less overall, with the deterioration reaching a plateau and then stabilizing over time.

Therefore, it is expected that that the condition of the City's unlined, cast iron pipes will continue to degrade over time. The average life expectancy of pipes installed in the post-World War II era has been reported as 75 years[1]. Beyond the 50-year mark, it is not uncommon for these pipes to become hydraulically restricted and structurally more apt to break. With many water systems in the U.S. having been built in the 1930-40's, thousands of utilities like the City of Rockville are now facing for the first time the significant cost of replacing long-term assets such as these pipes.

The low flows found in many of these older mains may make it more difficult to fight fires in areas with the deteriorated pipes. The City has also experienced water quality issues such as red water complaints in areas with these older pipes. Also, breaks on these older pipes appear to be increasing based upon the City's water main break history, placing an added maintenance cost burden on the City and causing inconvenience to Rockville residents and the general public. The number of water main breaks in the City in 2007 was the highest on record, totaling 65 breaks. Thus, this is an infrastructure problem with multiple public health, safety, and welfare implications, as well as impacts on City operations and maintenance. If the City does not take a proactive approach to addressing these issues now, more and more reactive maintenance will be required in the future. Because these aging grid mains make up a significant percentage of the total length of pipe in the system and because pipe replacement is costly, the City needs to act now to begin the long-term process of replacing these pipes.

Cleaning and lining these pipes was considered as an alternative to replacement. Cleaning and lining involves a lower initial cost than replacement and is a widely used technique for rehabilitating aging cast iron mains; however, it has several disadvantages. For example, the standard technique of cleaning and then lining with cement mortar or epoxy does not improve the structural integrity of the pipe. In fact, the cleaning process may cause damage to the pipe; WSSC has experienced an increase in breaks following cleaning and lining and has chosen to discontinue its cleaning and lining program. If the structural integrity of the pipe has already been compromised due to internal corrosion, then cleaning and lining may result in a shorter service life and higher life cycle cost than replacement. Based on the

[1] National Research Council of the National Academies, Water Science and Technology Board, *Public Water Supply Distribution Systems: Assessing and Reducing Risks-First Report*, 2005.

insufficient flows and the recent increase in pipe breaks, it is probable that the structural condition of many of the City's cast iron pipes is poor. Even if cleaning and lining itself does not damage the pipes, if the average life expectancy of the City's cast iron pipes is 75 years and many of the pipes are already 50-60 years old, then only 15-25 years of service life remain. While replacement is 2-3 times the initial cost of cleaning and lining, it also offers an opportunity to replace deteriorated valves, hydrants, and connections to houses, as well as upsize mains, providing a more complete renewal of the system. Based on the advantages and disadvantages considered, City staff is recommending the replacement alternative.

Recommended Improvements

A water system infrastructure renewal program consisting of gradually replacing older cast iron mains and installing reinforcements in various areas throughout the system is recommended to address the issues found during the evaluation. The renewal program includes a total of 33 miles of pipe to be replaced or added within a 15-year timeframe, at a total cost of $53 million in 2008 dollars. Utilizing a historical annual average inflation rate of 3%, the total 15-year program cost for replacing 33 miles of pipe was projected at $63 million. In addition to the improvements identified in this study, City maintenance staff have also identified several mains that need to be replaced due to pipe size and material, leakage, and age. These projects include a 16-inch steel water main, air release valves, and several 2- and 4-inch pipes located throughout the City. The additional costs for this work total approximately $4 million, which brings the total cost of the water system infrastructure renewal program to $67 million.

The pipes included in the recommended improvement program are shown in Figure ES-1, and a list of the improvements with planning-level cost estimates is provided in Table ES-1. The improvements were divided into four groups and prioritized as discussed below.

The Group 1 improvements were developed with the goal of providing immediate improvements spread throughout the City by decreasing water main breaks, increasing fire flows, and improving water quality. In each area, an interconnected system of pipes was selected for replacement, as shown in Figure ES-1. An improvement schedule is listed in Table ES-1; however, timing of these projects may

vary according to maintenance needs, such as the frequency and magnitude of water main breaks. Barring any changes needed due to main breaks or maintenance issues, it is recommended that the projects be completed in the order shown. This order was developed to provide fire flow improvements expeditiously, minimize the number and frequency of interruptions to water service and resulting inconvenience to City residents, and group together projects that must be completed together in order to attain the overall improvement desired.

The Group 2 improvements are distributed across the City, continuing to replace old pipes and improve flows throughout the whole City. Groups 3 and 4 include the remaining pipe replacements needed to increase flows in low flow areas.

The City considered a 10-, 15-, and 20-year timeframe for the Group 1-4 improvements. A short-term rate of replacement averaging 2.2 miles of pipe per year (or a 15-year program for Groups 1-4) was selected as a level which would reduce the risks associated with further pipe deterioration while maintaining a fiscally responsible and practical approach to project implementation. Beyond the initial 15-year period, it is recommended that the City continue to periodically re-examine the condition of the system and identify additional pipes for replacement.

Additional recommendations include storage and pumping projects which may occur beyond the 15-year period planned for the pipe system improvements. These may address water age issues and future storage deficiencies should the City not retain its emergency interconnection agreements with WSSC. The projects are listed in Table ES-2, and include a re-pump station at the Hunting Hill Ground Storage Tank and replacement of the Carr Avenue Standpipe with an elevated tank. The total estimated cost for these projects is $11 million in 2008 dollars. Further study and water sampling is recommended in order to fully evaluate the need for these projects.

Table ES-1 – Recommended Pipe Maintenance/Replacement Projects as Identified using the Hydraulic Computer Model, FY2009 – FY2023

Group	Year	Type of Work	Size (in.)	LOCATION	Length (LF)	Unit Cost ($/LF)[1,2]	Project Cost ($)[1]
1	2009	REPLACEMENT	12	Lewis Avenue: Halpine Rd to Broadwood Dr	4,600	---	---[3]
1		REPLACEMENT	8	Crawford Drive: Broadwood Dr to Ardennes Ave	2,145	$326	$699,000
1			8	Crawford Drive: Broadwood Dr to Ardennes Ave	57	$326	$19,000
1		REPLACEMENT	8	Thornden Road: Lewis Ave to Crawford Dr	2,056	$326	$670,000
1		REPLACEMENT	8	Rockland Avenue: Lewis Ave to Thornden Rd	2,376	$326	$775,000
			8	Rockland Avenue: Lewis Ave to Thornden Rd	241	$326	$79,000
1		REPLACEMENT	8	Broadwood Drive: Lewis Ave to Veirs Mill Rd	1,730	$326	$564,000
			8	Broadwood Drive: Lewis Ave to Veirs Mill Rd	1,172	$326	$382,000
1		REPLACEMENT	8	Orchard Way S: loop south of Kersey Ln	1,619	$326	$528,000
1		REPLACEMENT	8	Kersey Lane from Falls Rd to Milboro Dr	813	$326	$265,000
						2009 Subtotal	**$3,981,000**
1	2010	REPLACEMENT	8	Vandergrift Avenue and Atlantic Avenue: Lewis Ave	4,700	$326	$1,532,000
1		REPLACEMENT	8	Broadwood Drive: Veirs Mill Rd to Baltimore Rd	2,737	$326	$892,000
1		REPLACEMENT	8	Edmonston Drive: Veirs Mill Rd to Baltimore Rd	2,019	$326	$658,000
1		REPLACEMENT	8	Lincoln Street: Horners Ln to Neal Dr	2,348	$326	$765,000
			8	Lincoln Street: Horners Ln to Neal Dr	232	$326	$76,000
1		REPLACEMENT	8	Pinewood Road: Lincoln St to Southlawn Ln	2,155	$326	$703,000
			8	Pinewood Road: Lincoln St to Southlawn Ln	299	$326	$97,000
1		REPLACEMENT	8	Lofstrand Lane and Taft Street: Pinewood Rd to 1st	1,405	$326	$458,000
1		NEW PRV	8	Southlawn PRV from WSSC	14	---	$125,000

Group	Year	Type of Work	Size (in.)	LOCATION	Length (LF)	Unit Cost ($/LF)[1,2]	Project Cost ($)[1]
1	2010	LOOP	8	Lofstrand Lane north of Taft St	235	$326	$76,000
1		LOOP	8	Lofstrand Lane south of Taft St	399	$326	$130,000
1		EXTENSION	12	Southlawn Lane to Lofstrand Ln	973	---	---[3]
						2010 Subtotal	**$5,512,000**
1	2011	REPLACEMENT	8	Charles Street: Crabb Ave to Baltimore Rd	1,719	$326	$560,000
1		REPLACEMENT	8	Park Road: S Horners Ln to Charles St	1,045	$326	$341,000
		NEW PIPE	8	Park Road: S Horners Ln to Charles St	80	$326	$26,000
1		REPLACEMENT	8	Crabb Avenue: Stonestreet Ave to 1st St	2,786	$326	$908,000
			8	Crabb Avenue: Stonestreet Ave to 1st St	842	$326	$274,000
1		NEW PIPE	12	Stonestreet Avenue: 16" in Park Rd to Frederick Ave	3,579	---	---[3]
1		REPLACEMENT	8	Stonestreet & Ashley Avenues: Frederick Ave to Westmore Ave	1,956	$326	$638,000
1		REPLACEMENT	8	Reading Avenue: Mapleton Rd to Grandin Ave	284	$326	$93,000
		CONNECT	8	Tie-in 6" to 16" at Grandin Ave and Reading Ave	74	$326	$24,000
1		REPLACEMENT	8	Mt Vernon Place: Rockville Pike to Colonist Ct	2,293	$326	$748,000
1		CONNECT	12	Research Blvd & Research Pl	28	$344	$10,000
1		CONNECT	12	Research Blvd & Research Ct	48	$344	$17,000
1		REPLACEMENT	8	Wood Lane: Adams St to Washington St	122	$326	$40,000
		REPLACEMENT	8	Wood Lane: Adams St to Washington St	453	$326	$148,000
1		REPLACEMENT	8	Washington Street: North St to Rockville Pike	1,068	$326	$348,000
1		REPLACEMENT	8	Martins Lane: Washington St to Bickford Ave	1,063	$326	$347,000
1		REPLACEMENT	8	Bickford Avenue: heading north from Martins Ln	485	$326	$158,000
1		REPLACEMENT	8	Van Buren Street: Beall Ave to North St	603	$326	$197,000

Group	Year	Type of Work	Size (in.)	LOCATION	Length (LF)	Unit Cost ($/LF)[1,2]	Project Cost ($)[1]
			8	Van Buren Street: Beall Ave to North St	686	$326	$224,000
1		REPLACEMENT	8	Beall Ave & Adams St: connect 8" to 16"	15	$326	$5,000
1		CONNECT	8	Beall Ave & Van Buren: connect 8" to 16"	30	$326	$10,000
						2011 Subtotal	**$5,116,000**
1	2012	NEW PIPE	8	Blanford Street: Mt Vernon Pl to Argyle St	245	$326	$80,000
1		REPLACEMENT	8	Blanford Street: Cabin John Pky to Argyle St	911	$326	$297,000
1		REPLACEMENT	8	Harrington Road: Edmonston Dr to Mercer Rd	1,485	$326	$484,000
1		REPLACEMENT	8	Mercer Road: Harrington Rd to Mt Vernon Pl	679	$326	$221,000
1		REPLACEMENT	8	Bowie Road: Harrington Rd to Brice Rd	1,294	$326	$422,000
1		REPLACEMENT	8	Key West Avenue: 8" pipe sections	1,690	$326	$551,000
1		REPLACEMENT	8	Orchard Way N: loop north of Kersey Ln	2,591	$326	$845,000
1		REPLACEMENT	8	Stratton Drive: Lancanshire Dr to Dunster Ln	2,367	$326	$772,000
1		REPLACEMENT	8	Mannakee Street: Montgomery Ave to Carr Ave	1,263	$326	$412,000
1		PARALLEL	12	Lewis Avenue: Edmonston Dr to Broadwood Dr	1,140	---	---[3]
1		PARALLEL	16	Lewis Avenue: Edmonston Dr to 1st St	2,191	---	---[3]
1		NEW PRV	12	PRV at Lewis Avenue and Broadwood Dr	28	---	$143,000
						2012 Subtotal	**$4,227,000**
2	2013	REPLACEMENT	8	Anderson Avenue: Nelson St to Lynch St	2,730	$326	$890,000
2		REPLACEMENT	8	Wade Avenue: Simmons Dr to Veirs Mill Rd	1,308	$326	$426,000
2		NEW PIPE	8	Falls Road: Dunster Rd to Kersey Ln	1,453	$326	$474,000
2		REPLACEMENT	8	Stanley Avenue: Thornden Rd to Rockland Ave	2,168	$326	$707,000

Group	Year	Type of Work	Size (in.)	LOCATION	Length (LF)	Unit Cost ($/LF)[1,2]	Project Cost ($)[1]
2		REPLACEMENT	8	RidgeWay Avenue: Rockland Ave to Ardennes Ave	1,171	$326	$382,000
2		REPLACEMENT	8	Lemay Road: Holland Rd to Ardennes Ave	2,472	$326	$806,000
						2013 Subtotal	$3,685,000
2	2014	REPLACEMENT	8	Wainright Avenue: Ridgeway Ave to Atlantic Ave	1,675	$326	$546,000
2		REPLACEMENT	8	Midway Avenue: Stillwell Rd to Aleutian Ave	863	$326	$281,000
2		REPLACEMENT	8	Crawford Drive: Ardennes Rd to Atlantic Ave	1,452	$326	$473,000
2		REPLACEMENT	8	Matthews Drive: Lewis Ave to Rockland Ave	696	$326	$227,000
			8	Matthews Drive: Lewis Ave to Rockland Ave	306	$326	$100,000
2		REPLACEMENT	8	Parrish Drive: Lewis Ave to Crawford Dr	1,913	$326	$624,000
2		REPLACEMENT	8	Burris Road: Broadwood Dr to Coral Sea Ave	736	$326	$240,000
2		CONNECT	8	Coral Sea Avenue: Burris Rd to Okinawa Ave	114	$326	$37,000
2		REPLACEMENT	8	Langbrook Place: Burris Rd to Coral Sea Ave	347	$326	$113,000
						2014 Subtotal	**$2,641,000**
2	2015	REPLACEMENT	8	Henry Road: Broadwood Dr to Parrish Dr	865	$326	$282,000
			8	Henry Road: Broadwood Dr to Parrish Dr	187	$326	$61,000
		NEW PIPE	8	Henry Road: Parrish Dr to Thorden Rd	350	$326	$114,000
2		REPLACEMENT	8	Highwood Road: Lewis Ave to Henry Rd	682	$326	$222,000
2		REPLACEMENT	8	Halsey Road: Henry Rd to Ardennes Ave	1,506	$326	$491,000
2		REPLACEMENT	8	Denfield Road: Midway Ave to Atlantic Ave	1,134	$326	$370,000
2		REPLACEMENT	8	Twinbrook Parkway: Rockville Pike to Rollins Ave	1,097	$326	$358,000

Group	Year	Type of Work	Size (in.)	LOCATION	Length (LF)	Unit Cost ($/LF)[1,2]	Project Cost ($)[1]
2		REPLACEMENT	8	Chapman Avenue: Thompson Ave to Twinbrook Pkwy	635	$326	$207,000
			12	Chapman Avenue: Thompson Ave to Twinbrook Pkwy	18	$344	$6,000
						2015 Subtotal	**$2,111,000**
2	2016	REPLACEMENT	8	Martha Terrace: loop off Rollins Ave	1,602	$326	$522,000
2		REPLACEMENT	8	Rollins Avenue: Evelyn Dr to easement east of Evelyn Dr	239	$326	$78,000
2		REPLACEMENT	8	Evelyn Drive: Rollins Ave to Muriel St	324	$326	$106,000
2		REPLACEMENT	8	Congressional Lane: Rollins Ave to Muriel St	64	$326	$21,000
			8	Congressional Lane: Rollins Ave to Muriel St	175	$326	$57,000
2		REPLACEMENT	8	Muriel Street: Evelyn Dr to Congressional Ln	1,105	$326	$360,000
2		REPLACEMENT	8	Lorraine Drive: Congressional Ln to Jefferson St	1,010	$326	$329,000
			8	Lorraine Drive: Congressional Ln to Jefferson St	14	$326	$5,000
2		REPLACEMENT	8	Wilmart Street-Nina Place: Muriel St to Lorre Dr	838	$326	$273,000
2		REPLACEMENT	8	Lorre Drive: Nina Pl to Lorraine Dr	605	$326	$197,000
3		REPLACEMENT	8	Paul Drive: Gail Ave to Wade Ave	922	$326	$301,000
3		REPLACEMENT	8	Grandin Avenue: Norbeck Rd to Nimitz Ave	4,324	$326	$1,410,000
			8	Grandin Avenue: Norbeck Rd to Nimitz Ave	1,070	$326	$349,000
						2016 Subtotal	**$4,008,000**
3	2017	REPLACEMENT	8	Maple Avenue and Clagett Drive: Norbeck Rd to Veirs Mill Rd	3,976	$326	$1,296,000
3		REPLACEMENT	8	Woodburn Road: Grandin Ave to Baltimore Rd	1,536	$326	$501,000
3		REPLACEMENT	8	Scott Avenue: Woodburn Rd to Gilbert Pl	1,497	$326	$488,000

Group	Year	Type of Work	Size (in.)	LOCATION	Length (LF)	Unit Cost ($/LF)[1,2]	Project Cost ($)[1]
3		REPLACEMENT	8	Gilbert Road and Place: Woodburn Rd to Scott Ave	1,673	$326	$545,000
3		REPLACEMENT	8	Dean Drive: Grandin Ave to Bradley Ave	1,565	$326	$510,000
			8	Dean Drive: Grandin Ave to Bradley Ave	24	$326	$8,000
						2017 Subtotal	**$3,348,000**
3	2018	REPLACEMENT	8	Gladstone Drive: Baltimore Rd to Dean Dr	1,839	$326	$600,000
			8	Gladstone Drive: Baltimore Rd to Dean Dr	417	$326	$136,000
3		REPLACEMENT	8	Cedar Lane: Veirs Mill Rd to Marshall Ave	1,334	$326	$435,000
3		REPLACEMENT	8	McAuliffe Drive: Cedar Ln to Bradley Ave	1,176	$326	$383,000
3		REPLACEMENT	8	Gruenther Avenue: Broadwood Dr to Linthicum St	1,553	$326	$506,000
3		REPLACEMENT	8	Marshall Avenue: Broadwood Dr to Gruenther Ave	1,678	$326	$547,000
3		REPLACEMENT	8	Mapleton Road: Reading Ave to Joseph St	696	$326	$227,000
3		REPLACEMENT	8	Stonestreet Avenue: Park Rd to Highland Ave	547	$326	$178,000
			8	Stonestreet Avenue: Park Rd to Highland Ave	28	$326	$9,000
						2018 Subtotal	**$3,021,000**
3	2019	REPLACEMENT	8	Woodland Road and MacArthur Drive: Stonestreet Ave to Charles St	2,500	$326	$815,000
3		REPLACEMENT	8	Grandin Avenue: Crabb Ave to England Ter	795	$326	$259,000
3		REPLACEMENT	8	Virginia Avenue: Crabb Ave to England Ter	799	$326	$260,000
3		REPLACEMENT	8	England Terrace & Grandin Ave: Stonestreet Ave to Highland Ave	1,509	$326	$492,000
			8	England Terrace & Grandin Ave: Stonestreet Ave to Highland Ave	33	$326	$11,000

Group	Year	Type of Work	Size (in.)	LOCATION	Length (LF)	Unit Cost ($/LF)[1,2]	Project Cost ($)[1]
3		REPLACEMENT	8	Baltimore Road: Stonestreet Ave to Charles St	1,391	$326	$453,000
3		REPLACEMENT	8	Taylor Avenue: Baltimore Rd to MacArthur Dr	1,093	$326	$356,000
3		REPLACEMENT	8	Robert Road: Taylor Ave to 1st St	482	$326	$157,000
3		REPLACEMENT	8	Lawrence Drive & Court: Taylor Ave to Robert Rd	1,055	$326	$344,000
						2019 Subtotal	**$3,147,000**
3	2020	REPLACEMENT	8	Avery Road: Baltimore Rd to Lyon Pl	1,497	$326	$488,000
3		REPLACEMENT	8	Neal Drive: Lincoln St to dead-end-north	949	$326	$309,000
3		REPLACEMENT	8	Wesley Road and Wesley Court	976	$326	$318,000
3		REPLACEMENT	8	Woodston Road: Burgundy Dr to Longwood Dr	869	$326	$283,000
3		REPLACEMENT	8	Croydon Avenue: Park Rd to MacArthur Dr	292	$326	$95,000
3		REPLACEMENT	8	Howard Avenue: Stonestreet Ave to Horners Ln	1,544	$326	$503,000
3		REPLACEMENT	8	Spring Avenue: Stonestreet Ave to Douglas Ave	788	$326	$257,000
3		REPLACEMENT	8	Lenmore Avenue: Spring Ave to Frederick Ave	521	$326	$170,000
3		REPLACEMENT	8	Douglas Avenue: from Frederick Ave to Lincoln Ave	1,066	$326	$348,000
3		REPLACEMENT	8	Elizabeth Avenue: Stonestreet Ave to Westmore Ave	951	$326	$310,000
3		REPLACEMENT	8	Westmore Avenue: Frederick Ave to Ashley Ave	892	$326	$291,000
3		REPLACEMENT	8	Moore Drive: Frederick Ave to Westmore Ave	874	$326	$285,000
						2020 Subtotal	**$3,657,000**
4	2021	REPLACEMENT	8	North Street: Washington St to McLane Ct	1,492	$326	$486,000
4		REPLACEMENT	8	Dawson Avenue: Van Buren St to Washington St	714	$326	$233,000

Group	Year	Type of Work	Size (in.)	LOCATION	Length (LF)	Unit Cost ($/LF)[1,2]	Project Cost ($)[1]
4		REPLACEMENT	8	Forest and Dawson Avenues: Carr Ave to Van Buren St	1,015	$326	$331,000
4		REPLACEMENT	8	Beall Avenue: Owens St to Lynch St	2,961	$326	$965,000
4		REPLACEMENT	8	Balmoral Drive: Dundee Rd to Glenmore Ter	737	$326	$240,000
4		REPLACEMENT	8	Glenmore Terrace: Glenmore Ln to dead-end east of Balmoral Dr	1,355	$326	$442,000
						2021 Subtotal	**$2,697,000**
4	2022	REPLACEMENT	8	Dunster Lane: Stratton Dr to Canterbury Way	1,638	$326	$534,000
4		REPLACEMENT	8	Canterbury Way: Stratton Dr to Dunster Ln	861	$326	$281,000
4		REPLACEMENT	8	Selwothy Road: Dunster Ln to Stratton Dr	874	$326	$285,000
4		REPLACEMENT	8	Monroe Street: Cabin John Pkwy to Jefferson St	2,470	$326	$805,000
4		REPLACEMENT	8	Lynfield Drive and Argyle Street: Cabin John Pkwy to Blandford St	1,299	$326	$423,000
4		REPLACEMENT	8	Waddington easement: Waddington Ln to Cabin John Pkwy	1,317	$326	$429,000
4		REPLACEMENT	8	Cabin John Parkway: Leverton Rd to Edmonston Dr	1,026	$326	$334,000
			8	Cabin John Parkway: Leverton Rd to Edmonston Dr	40	$326	$13,000
4		REPLACEMENT	8	Leverton Road: Cabin John Pkwy to Carter Rd	624	$326	$203,000
4		REPLACEMENT	8	Carter Road: Leverton Rd to Edmonston Dr	910	$326	$297,000
4		REPLACEMENT	8	Harrington Road: Leverton Rd to Edmonston Dr	922	$326	$301,000
						2022 Subtotal	**$3,905,000**
4		REPLACEMENT	8	Brice Road: Mercer Rd to Julian Pl	2,420	$326	$789,000
4		REPLACEMENT	8	Gail Avenue: Paul Dr to Veirs Mill Rd	612	$326	$200,000

Group	Year	Type of Work	Size (in.)	LOCATION	Length (LF)	Unit Cost ($/LF)[1,2]	Project Cost ($)[1]
4		REPLACEMENT	8	Crawford Drive: Gail Ave to Wade Ave	872	$326	$284,000
4		REPLACEMENT	8	Debeck Drive: Lewis Ave to Wade Ave	1,446	$326	$471,000
4		REPLACEMENT	8	Clagett Drive: Lewis Ave to Veirs Mill Rd	2,284	$326	$745,000
						2023 Subtotal	**$2,489,000**
				TOTAL	**163,459**		**$53,545,000**

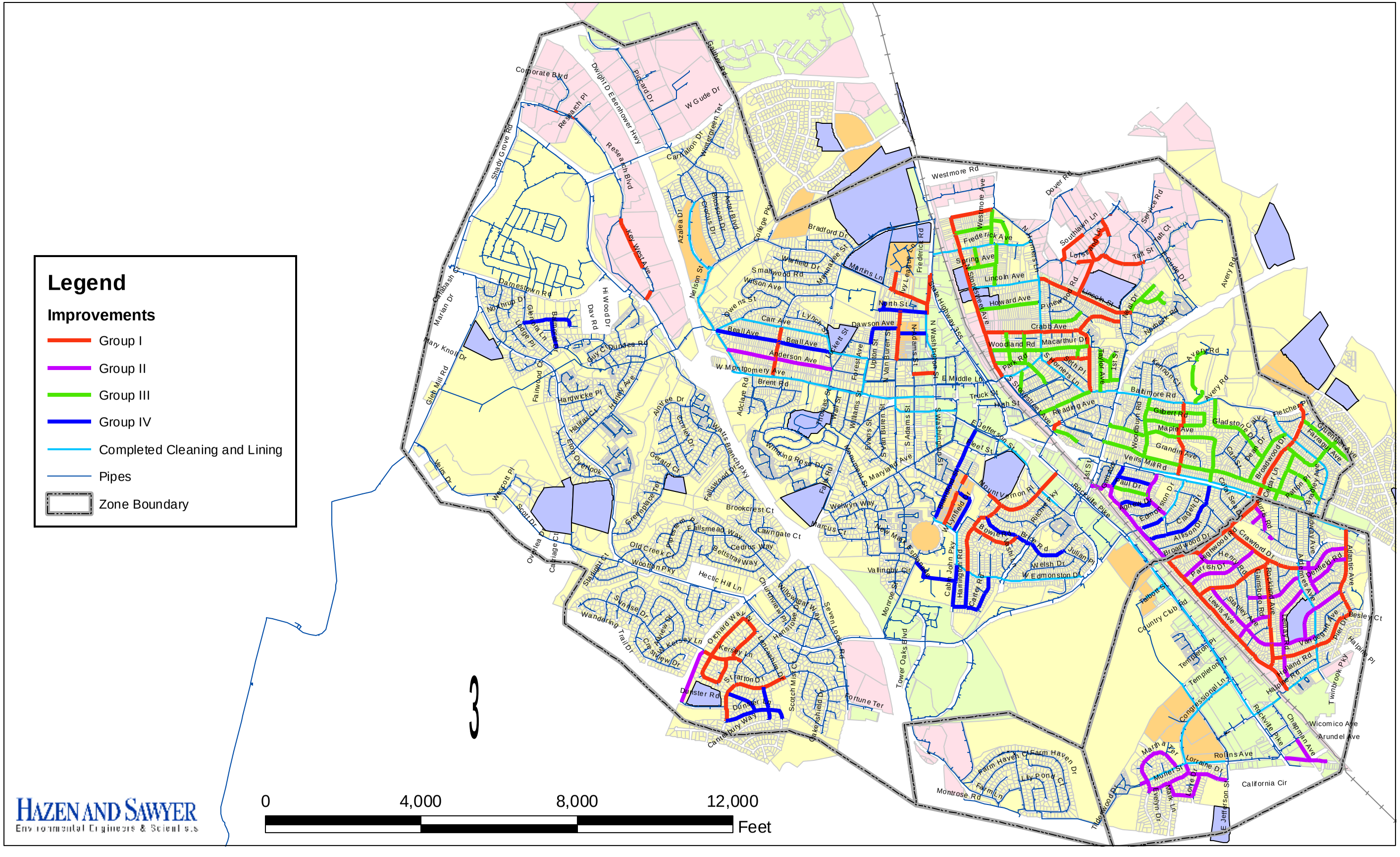
[1]Unit costs are based on recent bids for similar projects and represent project costs, including design, construction, and construction administration/inspection.
[2]Costs shown are in 2008 dollars.
[3]Cost for this project has already been incorporated into the City's CIP and is therefore not included here.

Table ES-2 – Recommended Storage and Pumping Improvements

Type of Work	Location	Project Cost ($)[1,2]
New Pump Station	Re-Pump Station at Hunting Hill Ground Storage Tank	$6,000,000
Tank Replacement	Demolish Carr Avenue Standpipe and Replace with 2 MG Carr Avenue Elevated Tank	$5,000,000
	TOTAL	**$11,000,000**

[1]Project cost, including design, construction, and construction administration/inspection.
[2]Costs shown are in 2008 dollars.

Figure ES-1 - Recommended Improvements



Attachment 3