Portland's Water Distribution System

Maintenance Program Needs Improvement

August 2004

Office of the City Auditor
Portland, Oregon

CITY OF

PORTLAND, OREGON

OFFICE OF THE CITY AUDITOR
Audit Services Division

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August 23, 2004

TO: Vera Katz, Mayor
Jim Francesconi, Commissioner
Randy Leonard, Commissioner
Dan Saltzman, Commissioner
Erik Sten, Commissioner
Mort Anoushiravani, Administrator, Bureau of Water Works

SUBJECT: Audit of the Water Distribution System Maintenance Program, Report #299

Attached is Report #299 containing the results of our audit of the maintenance of the City of Portland's water distribution system. The audit was included in our annual audit schedule and was conducted in accordance with generally accepted government auditing standards.

As a follow-up to our recommendations, we ask that the Administrator of the Bureau of Water Works prepare a status report in one year, detailing steps taken to address the report's recommendations. This status report should be submitted to the Audit Services Division and coordinated through the Commissioner's Office.

We appreciate the cooperation and assistance we received from personnel in the Bureau of Water Works as we conducted this audit.

GARY BLACKMER
City Auditor

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A report by the Audit Services Division
Report #299

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Summary

For years, the Bureau of Water Works has provided reliable, high quality, and reasonably priced water to residential and wholesale customers in the Portland region. The Bureau's financial and operational results have compared favorably to the water utilities in the region and around the country. Recently, however, a variety of events threaten the Bureau's ability to fund and operate a high quality water system. Specifically,

- increased federal and state regulatory demands may require significant capital funding in the years to come
- declines in retail and wholesale water sales due to conservation and use of alternative sources will place upward pressure on rates
- failure of the customer billing system tarnished the Bureau's reputation for good management and required shifting of resources from maintenance activities to customer services

These challenges are also occurring at a time when the Bureau must begin addressing an aging infrastructure that will require significant resources over a number of years to replace and rehabilitate. Our review of the water distribution system indicates that Bureau maintenance efforts

are not at levels viewed as adequate by Bureau managers and fall short of industry standards in several areas. Water mains are flushed and replaced infrequently, valves receive minimal exercising and maintenance, and meters are repaired and replaced slowly. In addition, the backlog of needed repairs has grown. Although water quality and reliability have not yet been adversely affected, we believe continued decline in the maintenance of the water distribution system assets could negatively affect water service performance in the future.

We have concluded that the decline in maintenance service levels is affected by a variety of factors, including reductions in resources devoted to maintenance and a surge in retirement of experienced personnel. While addressing staffing and funding issues is essential, long-term solutions to distribution system maintenance must also include making improvements in the Bureau's maintenance management systems. Specifically, the Bureau lacks a clear and comprehensive maintenance plan, complete and reliable information on the nature and condition of its assets, and adequate methods to organize and schedule maintenance work.

Our review indicates that the Bureau has taken a number of steps to address distribution system maintenance weaknesses including the creation of special maintenance teams and implementation of a new work order system. However, we believe the Bureau needs to take a more comprehensive approach in its efforts to improve its maintenance management program.

Specifically, we recommend that the Bureau:

- prepare a comprehensive maintenance master plan
- better plan and coordinate efforts to automate water system asset information
- improve systems for organizing, scheduling, and tracking maintenance work, and strengthen current efforts to implement a maintenance management system
- develop and report improved performance measures to track the efforts and accomplishments of water system maintenance activities

We do not make specific recommendations on the level or source of additional resources needed to improve the maintenance of the water distribution system. Additional analysis of the current organization is needed to determine the most appropriate combination of rate increases, productivity enhancements, and out-sourcing strategies.

Chapter 1 Introduction

This is the Audit Services Division's first performance audit of the Bureau of Water Works. The audit was included in the City Auditor's FY 2002-03 audit schedule. We initially reviewed the Bureau's overall operations to identify potential topics to study in detail. Due to the critical nature of the water distribution system and the weaknesses we found in some of the Bureau's maintenance operations, we decided to focus our work on maintenance of the water distribution system. We conducted the audit in accordance with generally accepted government auditing standards and limited our work to those areas specified in the objectives, scope, and methodology section of this report.

City water system

The Bureau of Water constructs, maintains, and operates the City water system to ensure customers receive sufficient quantities of high-quality water now and in the future. As shown in the map on page 3, the City water system begins in the Bull Run Watershed on National Forest land east of the City. Water is delivered to the City and to wholesale customers in the metropolitan area through three large conduits that terminate at storage reservoirs at Powell Butte, Mt. Tabor, and Washington Park. From these reservoirs, water is distributed to other smaller reservoirs and tanks,

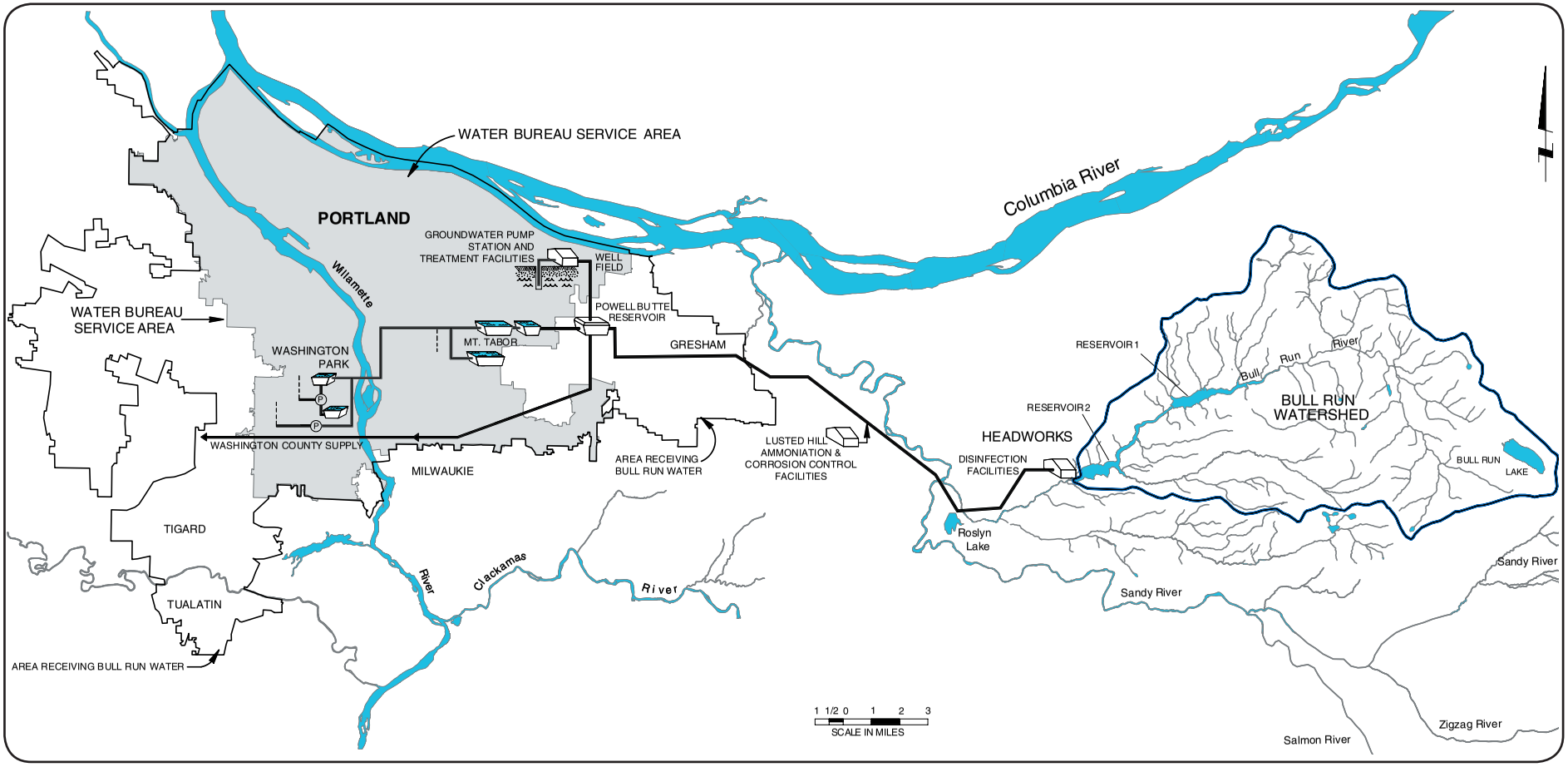
to other water districts in the region, and to customers through miles of underground pipeline. The Bureau also operates underground wells located in Columbia South Shore as a backup water supply. The shaded area on the map roughly corresponds to the distribution portion of the system, which includes water mains, fire hydrants, and service lines to customers. The supply portion of the water system begins with the Bull Run Lake and Reservoirs, and includes the conduits, in-town storage tanks and reservoirs, and the Columbia South Shore Well Field.

The City water system supplies over 35 billion gallons of water annually to nearly 800,000 people in the Portland metropolitan area. About 60 percent of the water is delivered to retail customers within Portland's city limits, while the remaining portion goes to neighboring cities and special districts on a wholesale contract basis. The Bureau works to ensure its primary water source – the Bull Run Watershed – and its backup water supply – the Columbia South Shore Well Field – are clean, safe and reliable. The Bureau tests and evaluates the quality of Portland's water at its water laboratory, and monitors and controls the supply and distribution of water using the automated Supervisory Control and Data Acquisition System (SCADA).

The Water Bureau has a FY 2003-04 Adopted Budget of $104 million, including 545 full-time positions and a $50 million capital budget. The largest portions of the budget go to Water Supply ($35.9 million), Water Distribution ($33.5 million), and Customer Services ($15.6 million), as illustrated in Figure 2. Almost half of the Bureau's total budgeted positions are assigned to the Water Distribution System.

Figure 1

Portland Water System



SOURCE: Water Bureau GIS.

Figure 2 FY 2003-04 Adopted Budget, Bureau of Water Works

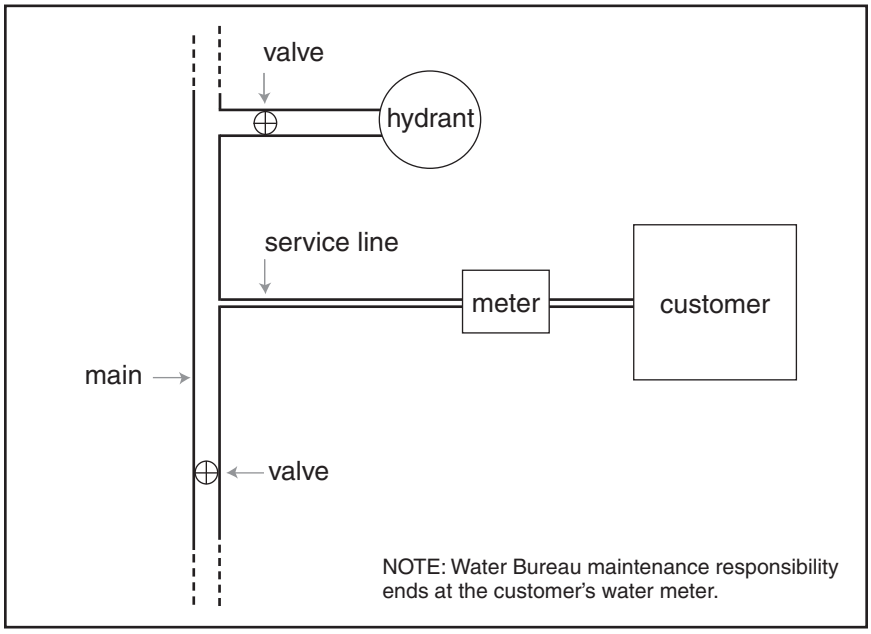
	Budget (millions)	Budgeted positions
Administration	$ 4.6	9
Finance	$ 5.0	29
Customer Services	$ 15.6	160
Water Distribution	$ 33.5	246
Water Supply	$ 35.9	57
Water Quality	$ 9.2	41
Hydroelectric	$ 0.5	3
TOTAL	$104.3	545

SOURCE: City of Portland FY 2003-04 Adopted Budget.

Maintenance of the distribution system

The Water Bureau is responsible for repairing and maintaining the City's entire water system from the Bull Run Watershed facilities to the meters that measure water flow to the customers. A majority of the assets requiring maintenance are part of the distribution system. The distribution system includes over 2,000 miles of distribution and transmission mains. Pipes range in size from 1- to 2-inch diameter services to 96-inch diameter transmission lines, and include cast iron, ductile iron, galvanized, and steel pipes with a variety of coatings and linings. The distribution system has in excess of 170,000 connections to residential, commercial, and wholesale customers, and includes 166,000 meters, 13,000 fire hydrants, and 39,000 valves. Figure 3 shows a schematic of the common elements of the distribution system requiring maintenance.

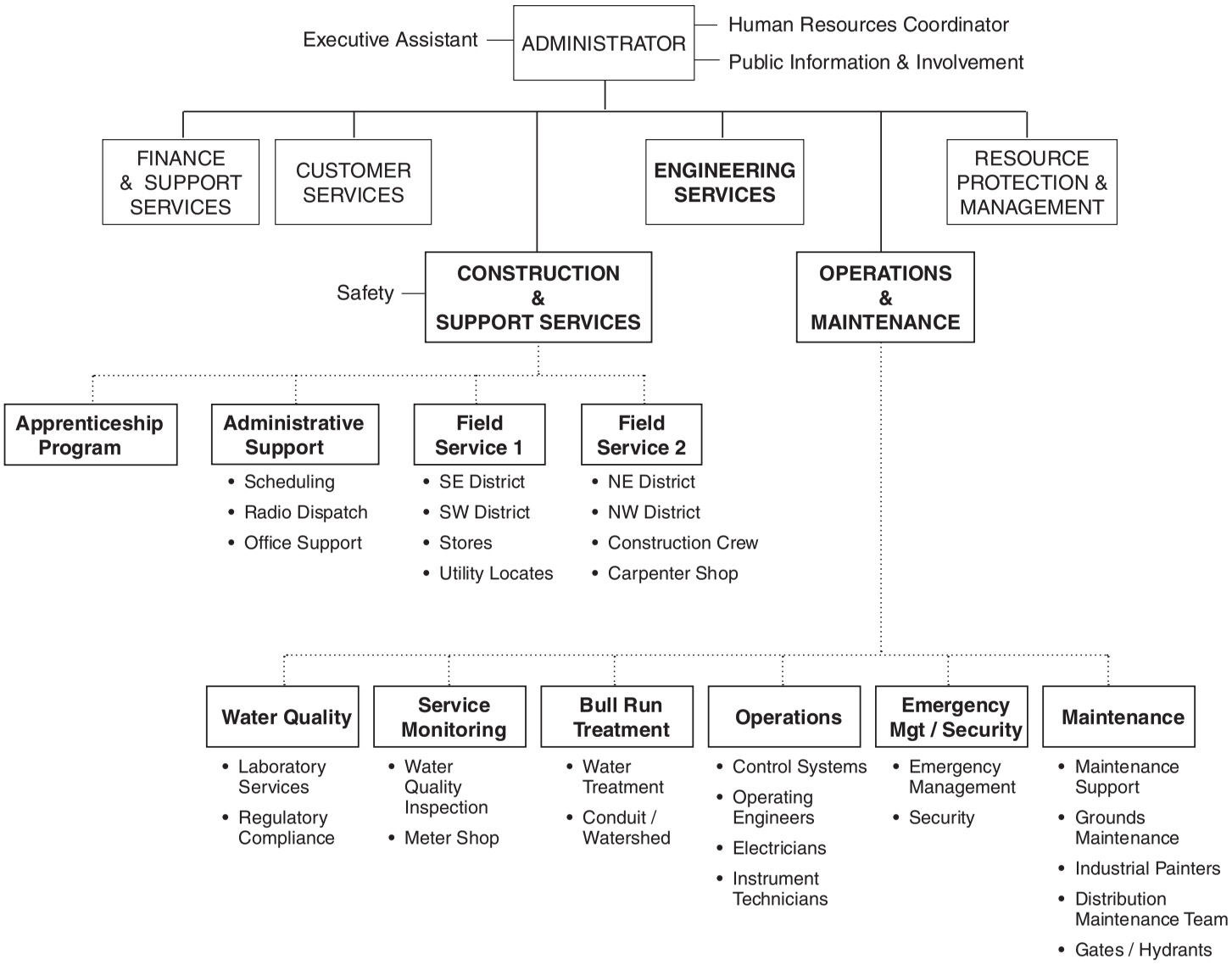
Figure 3 Schematic of common distribution system elements



SOURCE: Water Bureau records and interviews.

Maintenance and repair of distribution system assets is performed primarily by field personnel within the Bureau's Construction & Support and Maintenance & Operations Groups, which operate out of shops located on North Interstate Avenue near the Broadway Bridge. In addition, Engineering Services, with offices in the Portland Building, administers capital maintenance of the distribution system, provides design and engineering support to the Bureau's field operations, and maintains information on the water system assets. Figure 4 contains a Bureau organization chart illustrating where Construction & Support, Operations & Maintenance, and Engineering Services fit within the Bureau's overall organizational structure.

Figure 4 WATER BUREAU ORGANIZATION CHART



Construction & Support

Maintenance and repair of water distribution system assets below the ground (i.e., work requiring a backhoe) is performed by field crews within Construction & Support, as explained below:

Field Service Districts. Two to four work crews, equipped with backhoes, dump trucks, and a variety of equipment, are assigned to each of four Districts – Northwest, Southwest, Northeast, and Southeast – to carry out needed repair and construction work.

Construction Crew and Carpenter Shop. The Construction Crew installs water mains, valves, meters, and hydrants, and performs other construction related work. The Carpenter Shop performs carpentry services, although its role is diminishing because the shoring of trenches is no longer performed with lumber.

Utility Locates. Five personnel are assigned the responsibility of locating underground Water Bureau lines in response to requests from developers, builders, property owners, and other outside parties. These utility locates are required by State law.

Stores. The Stores function maintains a $1.4 million inventory of spare parts for use by Construction & Support and Operation & Maintenance crews. Stores also helps coordinate the acquisition of vehicles and equipment used by field crews.

Scheduling. Scheduling is responsible for receiving and logging work requests and preparing work orders that are given

to District Supervisors. The Scheduler processes completed work orders and sends them to Engineering Services staff who record the work in the Bureau's asset records.

Radio Dispatch. Radio Dispatch receives calls from the public, Water Bureau field crews, other City bureaus, and other utilities with emergency repair needs, and refers calls to Scheduling or gives them directly to the Field Service District Supervisors.

Operations & Maintenance

Operations & Maintenance is responsible for operating the water system, monitoring and ensuring water quality, as well as performing maintenance responsibilities. Distribution system maintenance functions within Operations & Maintenance include:

The Meter Shop. The Meter Shop is responsible for approximately 166,000 meters that register the volume of water usage for billing purposes. Meter Shop personnel test, clean, and calibrate meters to achieve customer equity, reading efficiency, and billing accuracy.

Gates / Hydrants. The Water Bureau is responsible for operating and maintaining approximately 39,000 valves, 13,000 hydrants, and 2,000 blow-offs (valves used for flushing water out of the system). Crews within the Gates/Hydrants Section perform routine maintenance, preventive maintenance, and some repair and replacement of these assets. They also provide flushing of distribution lines.

Distribution Maintenance Team. The Distribution Maintenance Team (DMT) was created in December 2002 to

perform a comprehensive review and repair of all components of the distribution system, including valves, hydrants, service lines, and meters. The DMT conducts its review one quarter section of the City at a time and limits its work to residential areas.

Water Leak Detection Crew. The Water Leak Detection Crew in Operations & Maintenance systematically tests pipes in the distribution system for leaks, and responds to requests for leak detection from Construction & Support.

Industrial Painters. Industrial Painters perform maintenance on the City's 27 decorative fountains, 130 drinking fountains, 73 water storage tanks, pump stations, reservoirs, and various buildings.

Engineering Services

The Engineering Services Group has several responsibilities that relate to the maintenance of the water distribution system. Engineering administers the Bureau's capital improvement program, which includes capital maintenance of distribution system assets. Two ongoing capital maintenance projects include the Main Replacement Program and the Large Meter Replacement Program. District crews within Construction & Support perform some work in support of these two programs; however, a significant amount of the actual construction work is performed by private contractors.

Engineering Services is also responsible for maps and other records containing the location and maintenance information on water system assets. Engineering staff responsible for GIS, maps, and other asset records are

physically located at the Water Bureau's shops on Interstate Avenue, to improve coordination with Construction & Support and Operations & Maintenance personnel.

Issues and challenges faced by the Water Bureau

The Bureau of Water currently faces several challenges that could impact its ability to address the maintenance needs of its water distribution system. We have highlighted on the following pages some of the most significant issues the Bureau is facing.

Billing system problems

The Bureau continues to address the functionality and performance of its billing system. The failure of the system implemented in February 2000 has cost millions of dollars due to increased staff requirements, foregone revenues, and other related expenses. In addition, a considerable number of maintenance positions were diverted to the Customer Services Group in order to handle the increased workload the faulty system created. The Office of Management and Finance is assisting the Water Bureau in purchasing a replacement billing system, which is expected to be implemented over the next two years.

Increasing regulatory demands

New federal regulations for surface water treatment will require modifications to the current Bull Run treatment process. It is anticipated that the Long Term 2 Enhanced Surface Water Treatment Rule may require unfiltered systems to provide treatment that inactivates or removes the microbial contaminant *Cryptosporidium*, with compliance

required by 2013. Several alternative treatment approaches are available, including ultra-violet light disinfection (UV), ozone disinfection, conventional filtration, and membrane filtration. The Bureau conducted an 18-month public decision process to evaluate and select a treatment process. The Citizens Panel on Bull Run Treatment recommended filtration with a preference for membrane filtration, but the Bureau is considering the less expensive UV over membrane filtration, which will require far less capital outlay.

Heightened water security concerns

The terrorist attack on September 11, 2001, resulted in stepped-up security measures taken by governments throughout the United States. Following the attack, the Water Bureau hired a local security company to provide 24 hour-a-day/seven days-a-week armed guard patrols of the City's reservoirs. The Bureau has since established 10 full-time security officer positions to work in conjunction with outside contractors to provide security to open reservoirs and other Bureau locations. The Bureau also completed a "Vulnerability Assessment" required by the U.S. Environmental Protection Agency (EPA) and is taking necessary water security precautions. The most significant improvements are planned for the City's five open reservoirs located at Mt. Tabor and Washington Park, which were identified as the greatest risk for intentional acts of vandalism, contamination, or terrorism. The assessment also extends to business and information systems, such as SCADA, and related hardware components. Overall, these water security improvements may have a significant financial impact on the Bureau.

Decline in water demand

Water demand for the Portland water system has fallen dramatically over the last five years, especially within the retail sector. Retail water sales peaked at 23.3 billion gallons in FY 1997-98 but fell to 21 billion gallons in FY 2002-03, a drop of over 10 percent. In addition, some wholesale customers, such as the Tualatin Valley Water District and the Powell Valley Water District, have increased their reliance on alternative water sources during the peak water season. Probably the greatest impact of the decline in water demand is the rise in water rates, especially for retail customers, which occurs because there are proportionally fewer units of water sold to cover the fixed costs of the Water Bureau.

Aging infrastructure and decline of capital financing

The Bureau estimates that the entire water system has a replacement value of over $3 billion dollars. Many of the Bureau's facilities, including dams, conduits, reservoirs, and portions of the distribution system are approaching 100 years in age and will require reinvestment due to age and condition. To facilitate decisions regarding whether to replace, rehabilitate or continue maintaining these facilities, the Bureau issued the Infrastructure Master Plan in July 2001, which focuses primarily on facilities in the supply system. The Bureau is currently seeking to hire a consultant to develop a Distribution System Master Plan to address needs of the distribution system. While water system facilities are aging, capital expenditures, along with operation and maintenance resources, have been reduced recently due to the billing system problems. The Bureau generally schedules construction bond sales every two years;

however, it postponed the bond sale that was scheduled for FY 2001-02, and finally issued two bond sales in April 2004, for $29.9 million and $61.9 million, respectively.

Water Bureau performance positive

Our review indicates the Water Bureau is continuing to provide quality services despite increasing challenges and recent setbacks. The Bureau continues to meet federal and state mandated water quality standards for regulated contaminants, including Giardia, Coliform Bacteria, Nitrate Nitrogen, E. Coli Bacteria, Trihalomethanes, and chlorine residual. The Oregon Department of Human Services (DHS) conducts a Sanitary Survey of the City's water system every five years to evaluate the system for its ability to provide safe drinking water to the public. In its last Sanitary Survey of the City's water system conducted in 1999, the DHS reported the water system was in excellent operating condition and that no "significant deficiencies" were found during the survey.

As reported in Portland's annual *Service Efforts and Accomplishments* report, the Water Bureau's operating cost per capita is less than the average of six other comparison cities. The Bureau's operating cost per capita was $62 in FY 2002-03 compared to the average cost per capita of $71 for Charlotte, North Carolina; Cincinnati, Ohio; Denver, Colorado: Kansas City; Missouri; Sacramento, California; and Seattle, Washington. In addition, the Bureau's debt coverage ratio was 3.0 in FY 2002-03, well above the Bureau's minimum goal of 1.9. The Bureau kept its debt coverage ratio above 1.9 in each of the past 10 years, with the exception of 1.8 in FY 2001-02.

Bureau water rates are relatively moderate compared to those of other jurisdictions in the Portland metropolitan area and comparably-sized cities around the country. Portland's average residential monthly water bill for 800 cubic feet of water consumed was $15.91 in 2003. This compares favorably to an average bill of $20.78 in seven other jurisdictions in the metropolitan area. In addition, Portland's bill of $14.60 for average monthly usage is lower than the average of $16.88 in six cities around the country (see Figure 5).

Figure 5 2003 residential monthly water bill: City of Portland vs. other cities and local jurisdictions

CITIES OUTSIDE OREGON (average monthly usage)	
Charlotte, NC	$13.54
Cincinnati, OH	$13.83
Denver, CO	$14.07
Sacramento, CA	$16.42
Kansas City, MO	$18.79
Seattle, WA	$24.60
Other city average	$16.88
City of Portland	**$14.60**

OTHER LOCAL JURISDICTIONS (for 800 cubic feet)	
City of Tigard	$16.81
Tualatin Valley Water Dist.	$18.40
Rockwood Water Dist.	$18.82
City of Tualatin	$19.70
City of Beaverton	$21.35
West Slope Water Dist.	$24.62
City of Gresham	$25.76
Local jurisdiction average	$20.78
City of Portland	**$15.91**

SOURCE: City Auditor's 2002-03 *Service Efforts and Accomplishments* report; Water Bureau's FY 2004-05 Preliminary Financial Plan.

As shown in Figure 6, over the last five years there has been a slight decline in the Bureau's service population (-1 percent) and operating expenditures (-4 percent). The Bureau's workload, as measured by gallons of water delivered (-9 percent), and feet of mains installed (-32 percent), declined while the number of retail accounts increased by 3 percent during the same 5-year period.

Figure 6 Change in Water Bureau workload and expenditures: FY 1998-99 through FY 2002-03

Fiscal Year	Population served	Operating expenditures	Capital expenditures	Authorized staffing	Water delivered (billions of gallons)	Number of retail accounts	Feet of new mains installed
'98-99	795,168	$51.1	$34.5	524	39.3	159,177	121,737
'99-00	773,171	$52.0	$37.6	535	39.2	160,100	107,590
'00-01	789,000	$48.8	$36.1	543	38.5	161,154	82,283
'01-02	830,834	$55.1	$21.9	531	38.2	162,631	32,781
'02-03	786,682	$49.0	$24.7	535	35.9	163,896	83,152
change	-1%	-4%	-28%	+2%	-9%	+3%	-32%

SOURCE: City Auditor's *Service Efforts and Accomplishments* report, 2002-03.

NOTE: Dollars adjusted for inflation (all years adjusted to FY 2002-03 dollars).

Audit scope, objectives, and methodology

The objectives of this audit were to evaluate the adequacy of the methods used by the Water Bureau to manage its water distribution system maintenance operations. Specifically, we analyzed the quality, reliability, and accessibility of the Bureau's asset records; the organization and scheduling of personnel resources; the inventory of parts, supplies, and vehicles used to carry out maintenance work; and the Bureau's application of automated information systems to facilitate planning and tracking of maintenance activities.

We limited the scope of our work to maintenance of distribution system assets; we excluded maintenance of supply system assets and other facilities owned by the Water Bureau. Specifically, we did not review care of pump stations, tanks, reservoirs, regulators, control valves, buildings, grounds, and decorative and drinking fountains. Although closely tied to maintenance, we also excluded operations functions performed by Operations & Maintenance personnel, including the regulating of water flow and water pressure, the monitoring of water quality, and water system modeling and analysis. While we did not examine the Bureau's capital program in detail, we performed a limited review of Engineering's capital maintenance of distribution system assets, specifically the Main Replacement Program.

We focused our efforts on maintenance management systems. We reviewed the processing of work orders in both Construction & Support and Operations & Maintenance, documented the flow of work from work request through work completion, and examined methods for recording work completed on the distribution system. We reviewed

procedures used to manage the Stores' inventory of parts and supplies, and conducted a limited assessment of the adequacy of internal controls over this inventory. We performed a limited review of the utilization of fleet vehicles assigned to Water Bureau maintenance operations and of interagency services and charges by the City's Fleet Management.

We examined records containing information on distribution system assets, including the Bureau's map boards, GIS, and various databases. We examined the Bureau's efforts to develop two automated information systems, GIS and Synergen, and assessed the time, costs, and achievements associated with these development efforts. To help evaluate Water Bureau system development efforts, we studied the development of GIS and automated maintenance management systems by Portland's Bureau of Environmental Services and Office of Transportation.

Because of their impact on Bureau maintenance operations, we identified major issues and challenges the Water Bureau is currently facing and performed a limited review of overall Water Bureau performance. We interviewed personnel from each of the Bureau's major work groups, and conducted in-depth interviews with managers, supervisors, and support staff in Construction & Support and Operations & Maintenance. We also interviewed staff in the Engineering Services Group and the Finance & Support Services Group.

We interviewed personnel from the Bureau of Fire & Rescue regarding the inspection, testing, and maintenance of City fire hydrants. In addition, we interviewed represen-

tatives from the Oregon Department of Human Services, the federal Environmental Protection Agency (EPA), and the American Water Works Association (AWWA) to obtain information on water utility standards and performance criteria.

We toured major Water Bureau facilities, including the Bull Run Watershed (dams 1 and 2 and Bull Run Lake), the Sandy River Station maintenance shop, the Columbia South Shore Groundwater facilities, the Mt. Tabor reservoirs, the Interstate Avenue shops, the water laboratory, the Water Control Center, and the Customer Services Center in the Portland Building. In addition, we reviewed a variety of management studies, reports, and planning documents.

During this audit we became aware of several opportunities for potentially increasing the efficiency of Bureau maintenance operations by contracting-out work to the private sector. However, we did not study this issue in detail; we recommend that a detailed study of contracting-out opportunities be performed in the near future.

Chapter 2 Decline in Maintenance Service Levels

The Bureau's overall efforts to maintain the water distribution system are not at levels viewed as adequate by Bureau managers and fall short of industry standards in several areas. Replacement of aging water mains has slowed in recent years while, at the same time, the backlog of needed repairs has grown. Although water quality and reliability has not yet been adversely affected, we believe continued decline in the maintenance of the water distribution system assets could negatively affect water service performance in the future.

Several factors have contributed to the decline in maintenance service levels, including a decrease in resources devoted to maintenance, a surge in retirement of experienced maintenance personnel, and an unstable organizational structure. We also believe the Bureau needs to improve the systems it uses to manage its maintenance operations to ensure it uses its resources in an efficient and effective manner. This is discussed in detail in Chapter 3.

Best practices for distribution maintenance

The American Water Works Association (AWWA) provides a variety of guidelines and services to assist water utilities in the management of their water systems. We have

utilized AWWA guidelines – particularly the Guidance for Management of Distribution System Operation and Maintenance published by the AWWA Research Foundation in 2000 – in our analysis of the Water Bureau's distribution system maintenance operations. AWWA guidelines indicate that to enhance maintenance activities, water utilities should:

- be proactive
- establish management programs geared to specific distribution system components
- develop progressive information management tools

The AWWA identifies the primary elements of a water distribution system as mains, valves, fire hydrants, and meters. The reliability of these distribution system components can be maintained through regular exercise and maintenance of valves, testing and replacement of meters, maintenance and repair of hydrants, flushing of pipes, and water main rehabilitation and replacement. The AWWA also emphasizes the importance of ensuring that maintenance personnel are provided with appropriate training. Our review indicates the Water Bureau is taking steps to become more proactive and elevate its maintenance activities in many of these areas. In addition, the Bureau is endeavoring to develop automated information systems which the AWWA emphasizes as a key ingredient in the successful operation and maintenance of a water distribution system. However, as discussed in the remainder of this report, maintenance service and staffing levels have dropped, and the Bureau's maintenance management program can be improved.

Decline in maintenance efforts

Over the past several years, efforts to maintain the Bureau's distribution assets have declined. Specifically, water mains are flushed and replaced less frequently, valves receive minimal exercising and maintenance, and meters are repaired and replaced slowly. In addition, the backlog in the number of work requests for system repairs is growing.

Water Mains

Two primary means for maintaining the reliability of water mains are (1) flushing, and (2) main rehabilitation and replacement.

Flushing. The AWWA indicates that periodic flushing of main water lines is needed to remove bacteriological growth, sediment, and corrosion, to improve flow, and to introduce fresh water with higher chlorine residual. The most effective form of flushing is unidirectional flushing, which entails comprehensive flushing of large areas of pipe in order to systematically cleanse the pipes of debris. Bureau managers state they have been unable to implement a periodic unidirectional flushing program, however, because of a shortage of staff and because of restrictions placed on flushing by Federal regulations and the City's Bureau of Environmental Services (BES). These restrictions are related to the City's combined sewer overflow and problems associated with dumping large volumes of water into the sewer system. The Bureau's ability to perform unidirectional flushing is also hampered because the Bureau does not regularly exercise and maintain valves and does not have a complete and accurate inventory of valve status and location.

Flushing that is performed in the City's water system is driven primarily by water quality complaints. In addition, Operations & Maintenance crews flush various sites on a monthly, quarterly, or annual basis, where there are recurring problems with stagnation. This flushing essentially replaces dirty water with clean water, but does not address the debris that become lodged in the walls and various components of the pipes. The AWWA recommends that mains be flushed roughly every three to four years. While some stagnant areas of the City are being flushed within this time frame, the water system as a whole is not being flushed on a periodic basis.

Main rehabilitation and replacement. The AWWA indicates that consistent repair and replacement of aging water mains is needed to increase pipe carrying capacity, reduce leaks and emergency breaks, and improve fire flow requirements and customer service. While the timing of replacement varies depending on the type of pipe and ground conditions, the AWWA recommends that mains be replaced about every 50-100 years. The Bureau's Main Replacement Program is an ongoing capital program administered by the Engineering Services Group. As shown in Figure 7, expenditures on the program decreased by more than half over the past 5-year period, while the feet of mains replaced dropped from 46,500 to 9,800 feet, a 79 percent decline. If main replacement continues at the same rate as the past five years, it will take the Bureau over 400 years to replace all the City's 2,000 miles of water mains.

Our review also indicates the Bureau does not have good information on the condition of mains and, therefore, is unable to effectively prioritize and rank mains for re-

Figure 7 **Decline in water main replacement:** FY 1998-99 through FY 2002-03

Fiscal Year	Feet of mains replaced	Expenditures* (millions)
FY 1998-99	46,500	$8.6
FY 1999-00	46,000	$5.4
FY 2000-01	12,900	$4.1
FY 2001-02	15,600	$2.7
FY 2002-03	9,800	$4.0
5-year change	-79%	-53%

SOURCE: Water Bureau records.

* Adjusted to FY 2002-03 dollars.

placement. A good portion of the mains replaced are done in order to accommodate other agencies' construction projects (e.g. Oregon Department of Transportation, Portland Office of Transportation, and the Bureau of Environmental Services).

Slower replacement of aging water mains contributes to increased main breaks that in turn result in a greater repair workload and higher costs. Bureau managers state that slowing levels of water main replacement will result in reduced reliability and increased costs in the future.

Valves

The AWWA indicates that regular exercise and maintenance of water valves is needed to replace broken elements, repair stuck valves, and locate buried or hidden valves. Proper maintenance of valves can help reduce time needed to repair main breaks and leaks, prevent water quality problems, and reduce customer service complaints. Proper function-

ing valves are also needed for meter testing, flushing, and performing other maintenance activities.

The AWWA recommends that valves be maintained and exercised once a year. If not all valves can be maintained yearly, then the AWWA recommends that critical valves be identified and maintained. The Water Bureau currently does not perform periodic maintenance of valves, nor has the Bureau developed an inventory of critical valves and attempted to maintain them. Detection of valve problems occurs as the Distribution Maintenance Team makes its way through the City and as Field Service crews work on various portions of the water system on a piecemeal basis.

In addition, because the City's distribution system includes both valves that turn left to open as well as valves that turn right to open, it is important that the Bureau maintain up-to-date records on the location and status of valves. Unfortunately, the Bureau's asset records system does not provide complete and reliable information on valves.

We were also told there is a growing problem with valves being paved over by the Office of Transportation because the Water Bureau no longer has sufficient staff to coordinate with Transportation on its paving schedule.

Meters

The AWWA indicates that meter inspection, testing, repair, and replacement is needed to help ensure accurate measurement of service provided and improve revenue collection. We were told by Meter Shop managers that the City's water meters have not received adequate care for many years, and

that the Meter Shop has experienced severe cuts in staffing, training, and equipment over the past five years. We were also told that the large meters used to be privately owned and many were beyond their useful lives when the Water Bureau assumed ownership in 1996.

As a result, the Bureau has many old water meters that under-register customer water usage and impact the collection of water fees from customers. For example, the Bureau estimates that a large meter serving the Tualatin Valley Water District, which was recently replaced, had been under-registering the flow of water to the District by as much as 20% for many years. As a result, the City received between $400,000 and $1,000,000 less per year from the District than it should have because of the faulty meter. However, it should be noted that fees not paid by an individual customer due to a faulty meter are eventually shifted to other Water Bureau customers, in effect raising their water rates.

To help replace its old water meters, the Bureau established the Large Meter Replacement Program in FY 2002-03. While large meters represent only 8,000 of the total 166,000 meters in the system, they are responsible for 60 percent of City water sales. During the first year of the program, the Bureau replaced 152 of 3,500 meters targeted for replacement. While progress has been made, at the rate of 152 meters per year, it will take the Bureau over 50 years to replace all its large meters. Our research indicates meters generally need replacement in 20-25 years. Replacement of small meters is being performed by several work groups, including crews in Operations & Maintenance

(Gates/Hydrants Section, the DMT, and the Meter Shop) and Construction & Support (Field Service crews). Nevertheless, Bureau managers recognize that progress is much slower than it needs to be.

The Meter Shop has also established a 5-year cycle for testing, cleaning, and calibrating large meters. Managers in the Meter Shop indicate they have been unable to keep up with this cycle, even though five years is longer than industry standards. Moreover, they also state that their personnel have not followed uniform procedures for testing meters for many years; however, new operating procedures were being implemented as we completed our audit work.

Fire hydrants

The AWWA indicates that regular repair and replacement of fire hydrants is needed to ensure adequate water flow in fire emergencies and recommends that hydrants be tested once a year. The Water Bureau is responsible for the operation and maintenance of approximately 13,000 fire hydrants. Hydrants are inspected yearly, consistent with the AWWA standards. Inspections were performed by the Portland Fire Bureau until July 1, 2004, when the Water Bureau assumed responsibility for inspections. The Gates/Hydrants crew in Operations & Maintenance respond to deficiency reports based on the annual inspections. However, our interviews with Bureau managers and supervisors indicate that insufficient capital dollars are being devoted to replacement of hydrants, and the maintenance of hydrants has been neglected for several years.

Work order backlog

Because Bureau maintenance personnel have been unable to keep up with the maintenance and repair needs of the City distribution system, there has been a growing backlog of repair work orders. These work orders can include leaks, customer service complaints, and non-functioning meters and hydrants. While the Bureau does not have a completely accurate count of its backlogged work orders, records indicate the volume of the backlog has grown significantly over the last four years. A recently completed analysis of outstanding work orders by Construction and Support supervisors indicates the work order backlog may currently represent in excess of 26,000 hours of needed repairs and maintenance.

Distribution Maintenance Team

To help address the growing repair needs of the water distribution system, the Bureau created the Distribution Maintenance Team (DMT) a little over a year ago. The DMT performs a comprehensive review of distribution system needs on a quarter-section by quarter-section basis. The DMT works in conjunction with the Gates/Hydrants crew to operate, inspect, repair, and replace valves, and identify other repair needs in the distribution system. DMT personnel do small maintenance and repair work but refer major repair needs to Construction & Support's Field Service crews.

In its first year of operation, the DMT completed 47 of the City's 641 quarter sections containing water facilities. At this rate it could take nearly 14 years for the DMT to complete all 641 quarter sections. Currently, there are five

personnel assigned to the DMT, and some Bureau managers indicate that the size of the DMT crew needs to be doubled or tripled if it is to complete a sweep of the City water system in a timely manner. In addition, we were told that one of the purposes of the DMT is to allow unidirectional flushing of pipes to occur in sections cleaned-up by the DMT. As noted earlier, the Bureau has performed only limited unidirectional flushing because of regulatory restrictions and staffing shortages.

Factors contributing to the decline in maintenance service levels

We have concluded that the decline in maintenance service levels has been caused by a variety of factors, including a reduction in resources devoted to maintenance, a surge in retirement of experienced maintenance personnel, and an unstable organizational structure. While addressing staffing and funding issues will help stabilize maintenance efforts, we believe long-term solutions to water distribution system maintenance can only be achieved through improving the Bureau's systems for organizing and managing its maintenance activities. We discuss these needs in detail in Chapter 3 of this report.

Reduction in personnel resources

Bureau maintenance operations have experienced a reduction in the number of positions due to the shift of maintenance positions to the Customer Services Group to address billing system problems. Since FY 1999-00, the number of personnel who carry out maintenance, construction, and operations functions within the Bureau has been reduced by 63 positions. During the same period, the number of positions in the Customer Services Group increased

by 75. Bureau managers and supervisors indicate that because of the severe reduction in the number of maintenance personnel, the work of crews is mostly reactionary. That is, workers respond to customer complaints and run from repair to repair, but have little or no time for proactive maintenance work.

Loss of experienced personnel through retirement

In addition to the reduction in the number of maintenance personnel, there has been a significant increase in retirements in recent years, resulting in the Bureau's maintenance operations losing many experienced personnel. As shown in Figure 8, the number of retirements in Construction & Support, Operations & Maintenance, and Engineering

Figure 8 Number of retirements in Bureau maintenance operations: 1994 through 2003

Year	Construction & Support	Operations & Maintenance	Engineering	TOTAL
1994	2	5	0	7
1995	6	5	0	11
1996	2	4	0	6
1997	4	3	0	7
1998	3	2	1	6
Total '94-'98	**17**	**19**	**1**	**37**
1999	13	14	3	30
2000	5	3	2	10
2001	3	4	1	8
2002	11	16	7	34
2003	11	7	4	22
Total '99-'03	**43**	**44**	**17**	**104**

SOURCE: City of Portland Human Resources and Water Bureau records.

tripled during the past five years (1999-2003) compared to the preceding 5-year period, 1994-1998. In turn, the Bureau's maintenance workforce has become less experienced and knowledgeable. For example, we were told the Bureau no longer has someone capable of repairing large gate valves.

Organizational instability

Additional strain has been placed on employees in recent years because of frequent changes in organizational work groups. Over the last four years, the Engineering & Construction Services Group was split into the Engineering Services Group and the Construction & Support Group. The Maintenance Group and Water Operations Group were combined into the Operations & Maintenance Group. Also, the Bureau's Information Technologies Group was eliminated due to the transfer of information systems positions to the Bureau of Technology Services.

In addition, individual work units have been shuffled among the various Groups. For example, in FY 2002-03 the Bureau transferred the Meter Shop and Grounds Maintenance from the Construction & Support Group to the Customer Services Group. One year later, the Meter Shop and Grounds Maintenance were moved to the Operations & Maintenance Group. In FY 2003-04 the Gates and Hydrants Crews were combined, and Gates/Hydrants and the Emergency Crew were transferred from the Construction & Support Group to the Operations & Maintenance Group.

While Bureau managers believe that organizational changes have helped improve internal coordination and efficiency, our review indicates the magnitude of changes in

recent years may have had detrimental effects on maintenance operations. We were told by a number of employees we interviewed that the many changes in organizational work units have negatively impacted their understanding of work responsibilities and the coordination of work activities within the Bureau. We believe the frequent changes in organizational work units, combined with the surge in retirements and reduction in staffing levels, have had a negative effect on the productivity of Bureau maintenance personnel.

Chapter 3 Need to Develop Stronger Management Systems

Effective management of a large maintenance operation requires the development and application of good management systems and controls. These systems include comprehensive planning, written policies and procedures, methods for organizing and scheduling work, and accurate management information. Our review of the Water Bureau's distribution maintenance program indicates that while a number of management systems are in place, several critical elements of management control are outdated, missing, or ineffective. Specifically, in order to provide a firm foundation for the management of water distribution system maintenance, we believe improvements are needed in maintenance planning, asset information, maintenance work scheduling, and performance monitoring.

Maintenance management: Essential elements of management control

Good management systems and controls can help the Water Bureau provide safe, reliable drinking water and adequate water flow for fire suppression. Our review of industry publications from the American Water Works Association and our discussions with management officials from the Water Bureau indicate that critical components of good maintenance management should include a number of elements, as follows.

Comprehensive maintenance plan

The adoption of a comprehensive maintenance plan is essential to the effective operation of a water distribution system. The plan should establish overall maintenance goals, standards for the amount and frequency of work, and maintenance priorities. By defining the amount of maintenance effort that will be conducted, resource requirements can be more precisely estimated. The plan should identify long-term capital replacement needs, estimate the life of distribution assets, and focus efforts on the most important maintenance tasks. The comprehensive plan should also provide benchmarks against which to measure the performance of the maintenance program in addressing goals and standards.

Written maintenance policies and procedures

Written maintenance policies and procedures provide specific guidance on how to carry-out the maintenance plan and perform activities such as flushing, valve management, and water main replacement. Written policies and procedures should be used to train new staff, ensure maintenance work is correctly and consistently performed, and improve productivity of work crews. Written policies and procedures also provide standards for judging the quality of maintenance work and guidance to contract work crews.

Reliable information on assets

According to the AWWA, the "collection and management of information is a key element in the successful operation of a water system. Information is the necessary link between the maintenance, operation and design aspects of water distribution system management." Reliable information on

the nature, function, location, age, and condition of system assets is needed to ensure effective communication and coordination within the organization; to plan, carry out, and manage maintenance and repair work; and to plan capital improvements and replacements. Up-to-date information in the form of maps and data must be readily accessible to all employees and is most effective when fully integrated into an electronic maintenance management system.

Methods for organizing and scheduling work

Large water systems also require efficient methods for organizing staff resources in work units and scheduling work crews. A centralized scheduling system should be used to prioritize, assign and track the status of assigned work. Managers can control job costs by monitoring the time and costs of specific job requests and reduce duplicative efforts. This system is also most effective when integrated into an electronic maintenance management system.

Performance goals and monitoring

Effective management systems should also provide information so managers can actively monitor and measure the organization's performance in meeting goals for quality and timeliness. Performance measures track the productivity of work crews, efficiency of maintenance work, and accomplishment of maintenance plans. Performance reporting provides accountability to top management and City Council and aids budget and operational decision-making. Moreover, monitoring performance trends over time provides early warning of maintenance backlogs, declining asset conditions, and need for corrective actions.

Ongoing supervision and training

Another important tool to ensure maintenance is performed efficiently and effectively is ongoing supervision and training of maintenance staff. Supervisors ensure that policies and procedures are followed and work assignments are completed as planned. Supervisors also provide assistance to work crews to solve problems and advise management on work accomplishments. Work crews and supervisors also need ongoing training to ensure skills are adequate to perform duties assigned. Some water departments have formal training and apprenticeship programs to ensure staff have the competency to perform required tasks and activities.

Adequate equipment and supply support

Maintenance crews must have adequate equipment and materials. A sufficient number of vehicles and specialized equipment is required to perform construction work and move personnel and materials. An inventory of specialized supplies including replacement parts, valves, pipes, and other fittings should be on hand when crews are ready to perform maintenance work. Effective equipment and supply support helps reduce downtime, improve turnaround time, and reduce maintenance costs.

Weaknesses in Water Bureau maintenance management

The Water Bureau has done a good job with some of the above management elements. For example, the Bureau's system for managing its inventory of parts and supplies appears to be functioning adequately. Despite cutbacks in training in recent years, the Bureau has also developed training programs for maintenance personnel, including state

certified apprenticeship programs for new Utility Workers and Water Operations Mechanics. However, although the Bureau has taken steps to improve other critical management elements, some of its actions have proven ineffective, and important management systems remain incomplete or inadequate. Additional improvements are needed in these systems to ensure that the Bureau has the ability to efficiently and effectively maintain the water distribution system.

Lack of a comprehensive maintenance plan and procedures

The Water Bureau has not developed a comprehensive maintenance plan for its distribution system, and lacks a clear set of maintenance goals, standards, and work priorities. In addition, the Bureau has not prepared a complete policies and procedures manual for maintenance personnel to follow. Although some Bureau documents refer to maintenance standards, there is not a common understanding of, or commitment to, these standards by Bureau managers and supervisors. In addition, supervisors we interviewed stated that methods used to assign work to maintenance personnel do not always result in the most important needs being addressed first.

The Bureau conducted a comprehensive Maintenance Program Review in 1987 that recommended the development of a Master Maintenance Program for all elements of the water system including the distribution system. The Review indicated that to successfully implement a Master Maintenance Program, the Bureau would need to obtain additional funding and achieve increased operational efficiencies. Specific improvement opportunities identified in

the Review include better project scheduling, a maintenance monitoring program, a maintenance replacement program, optimizing personnel utilization, life-cycle cost analysis and improved cost controls. However, the Bureau failed to achieve most of the needed improvements and has made little progress toward developing a Master Maintenance Program.

Recently, the Bureau initiated an effort to hire a consultant to develop a Distribution System Master Plan. The Bureau's project engineer estimates that the Plan will require two to three years to complete. Although part of the Plan will involve developing a maintenance program, the focus will be to identify the long-term capital needs of the distribution system.

The Water Bureau has also not adopted a clear set of maintenance work priorities. Bureau managers told us that even though the highest priorities – such as ensuring safe water and fixing main breaks and out-of-service hydrants – are not written down, maintenance personnel are still aware of them. However, supervisors we interviewed indicated that workers are frustrated because they respond to "whomever yells the loudest" rather than prioritize service requests and customer complaints. Because of reduced staffing levels, a growing portion of the work performed by Bureau maintenance personnel is reactionary in nature. When a maintenance organization spends a significant amount of time reacting to complaints and service requests, its operations will inevitably be less efficient than when it systematically addresses a prioritized list of maintenance needs.

During the course of this audit, we were told that a *Mechanics Handbook* for Construction & Support staff was being updated, and that Standard Operating Procedures for Operations & Maintenance personnel would follow. Because these manuals have not been updated or actively used for many years, employees have had to rely on institutional knowledge and guidance provided by supervisors.

Lack of reliable information on distribution system assets

We found the Bureau's existing asset and maintenance information systems to be inefficient and unreliable. Asset and maintenance information has been stored in multiple databases, has not been kept up-to-date, and is incomplete and inaccurate as a result. Moreover, efforts to implement a much-needed Geographic Information System (GIS) have been hampered by delays and implementation problems that have contributed to weaknesses in the quality of asset information. While some recent progress has been made, more effort is needed to eliminate database and mapping backlogs, to resolve known data errors, to integrate numerous databases and information systems, and to develop a bureau-wide strategy for data and information management.

Prior to the advent of electronic databases and GIS, the Bureau maintained information on its distribution system assets on hand-drawn quarter section maps ("map boards") and 3x5 index cards. With improved technology, some maps were converted to computer assisted drawings and the index card data were migrated to a database called Infrastructure. Over time, however, separate databases were developed by various work groups to track information on specific assets, such as water mains, meters, and hydrants.

In some cases, multiple databases contain information on the same asset. In 1996 the Bureau initiated a project to develop a comprehensive GIS that would integrate asset data from Infrastructure and other information sources, link to several key water management systems, and serve as the Bureau's maintenance database.

Over the past eight years, GIS implementation has experienced significant problems that have delayed completion, increased costs and have substantially limited the system's usefulness (see GIS development time line in Figure 9). To date, the Bureau estimates that it has spent approximately $3.5 million on a system that is not yet fully functional.

Major problems include:

- Extensive delays and technical problems in the original digitization of the Bureau's quarter-section maps. The five-year consultant contract was terminated early with major deliverables incomplete and the entire budget expended.
- Substantial errors in the GIS database generated from subsequent software conversions, which GIS staff are still working to correct.
- Inadequate, sometimes unusable, maintenance tools which have contributed to the ongoing difficulty of keeping the Bureau's electronic maps up-to-date.
- A long delay in shifting Infrastructure users to GIS. This meant that GIS staff have spent several years maintaining the same information in both databases.

Figure 9 History of Water Bureau GIS development: 1996 to present

1997	aug	**Roy Weston, Inc** awarded contract to build comprehensive GIS for Water Bureau, estimated at **$1.35 million**
	dec	Water Bureau expresses concern about **Weston**'s reorganization and its impact on GIS project
	jan	Budget increase of **$34,000**, **Weston** contract, for test conversion (i.e. digitize 36 quarter-section maps)
	feb	Water Bureau expresses concern to **Weston** about ability to maintain maps during conversion process
	jun	Additional **$12,000** increase for **Weston** test conversion
	jul	Water Bureau expresses concern to **Weston** about delays for maintenance tools and impact on map updates
	nov	Additional **$43,000** increase for **Weston** test conversion and **$60,000** for final conversion of all maps
1998		
	jun	**Weston** completes test conversion of 36 quarter-section maps
	sep	Water Bureau issues stop work order on **Weston** contract; **Convergent Group** paid **$15,000** to review project
	oct	**Weston** receives approval to continue work on several key tasks
1999	jan	Water Bureau confirms commitment to new software platform, **ESRI** ArcInfo 7.2
	feb	Many quarter-section maps now 1 to 2 years out-of-date due to lack of maintenance tools
	mar	Purchase orders to **ESRI**: Implementation Plan - **$70,000** (March) software migration - **$100,000**; training - **$13,000** (April) query and display applications - **$76,000** (May) data model - **$99,000** (June) installation and training - **$25,000** (October)
	sep	Budget increase of **$138,000**, **Weston** contract, for final map conversion
	oct	**Weston** contract terminated with few deliverables other than approx 680 maps converted; final cost: **$1.5 million**
2000		
	mar	Purchase order to **ESRI**: technical support - **$8,000**
	apr	**ESRI** awarded **$487,000** contract to convert Water Bureau from ArcInfo 7.2 to ArcInfo 8.0
2001	feb	Water Bureau pays Bureau of Technology Service (Corporate GIS) **$5,000** to develop rudimentary data maintenance tools
	may	**ESRI** completes conversion to ArcInfo 8.0 but system is unstable
	oct	Water Bureau determines that **ESRI** maintenance tools are corrupting their data
	nov	Water Bureau upgrades to more stable software version, ArcInfo 8.1
2002		
	aug	Water Bureau pays Corporate GIS **$13,500** to develop improved maintenance tools; Water Bureau begins replicating data to the City's central GIS server (the Hub)
	oct	Water Bureau upgrades to ArcInfo 8.2
2003		
	nov	First electronic map is fully up-to-date; Bureau implements plan to keep maps current as they are completed
	dec	Three electronic maps are now kept current
2004	mar	Total of 19 electronic maps kept current; Water Bureau staff begins switching users from Infrastructure to GIS
	may	All Infrastructure users now use GIS

Ongoing problems with GIS development have contributed to the Bureau's diminished ability to maintain reliable asset and maintenance information. The existence of numerous backlogs has been a significant problem:

- *GIS electronic mapping backlog* – The Bureau estimates that it will be five to six years before all of its GIS maps are current. This is due in part to years without proper data maintenance tools and unstable software systems. Many maps reflect the water system at the time of the first conversion.
- *Data entry and mapping backlog for big projects* – Until early June of this year, the Bureau had not updated the paper map boards or the GIS database for many large projects dating back to 1998, including Interstate MAX and the Central City Streetcar. Originally expected to require one person about two years to eliminate this backlog, GIS staff recently eliminated all but one large project.
- *Project files and microfiche backlog* – Approximately 40 boxes of engineering project files and documents need to be reviewed, microfiched, and archived. Records have not been microfiched for four years due to insufficient staffing.

The Bureau recently terminated use of the Infrastructure database and was able to switch its users over to the GIS database which is now the central source of location and maintenance information for Water Bureau assets. While this is a significant improvement, a number of duplicative databases exist in the Bureau that could be eliminated through better integration with GIS. Figure 10 describes these databases, the assets tracked, and the type of information stored.

Figure 10 Asset inventory and maintenance information for the distribution system

Information Source	Distribution System Asset	Type of Information Stored
Map boards[1]	Services, mains, valves, air valves, blow-offs, hydrants, regulators, pumps, tanks	Location and size
GIS[1]	Services, mains, valves, air valves, blow-offs, hydrants, regulators, pumps, tanks, small & large meters	Maintenance history, location, size, material, model & installation (in some cases). Mains by street and quarter section, plus by pipe segment with year, size, and material. Meters with size, location, and make
Infrastructure[2]	Services, mains, valves, air valves, blow-offs, hydrants, regulators, pumps, tanks	Maintenance history, location, size, material, model & installation (in some cases). Mains by street and quarter section
Leaks	Mains	Leak detection requests, leak detections, and leak repairs
Rank	Mains	Leak history and condition of water mains
Blow-offs	Blow-offs	Tracks scheduled water quality flushing by location
Fireslips	Hydrants	Location, maintenance, make, status, address
Large Meter	Large meters	Size, make, type, location, testing frequency & results, maintenance history
Operating Engineers Preventive Management	Regulators, pumps, tanks	Maintenance and work orders for Operating Engineers
Scanned Documents	Services, mains, valves, blow-offs, hydrants	Scanned copies of work orders (for repairs and replacement), and “as-builts” drawings

[1] Does not contain comprehensive listing of every asset that is stored on the map boards/GIS. For example, they also contain reservoirs, water bureau easements, pressure zones, and facility sites.

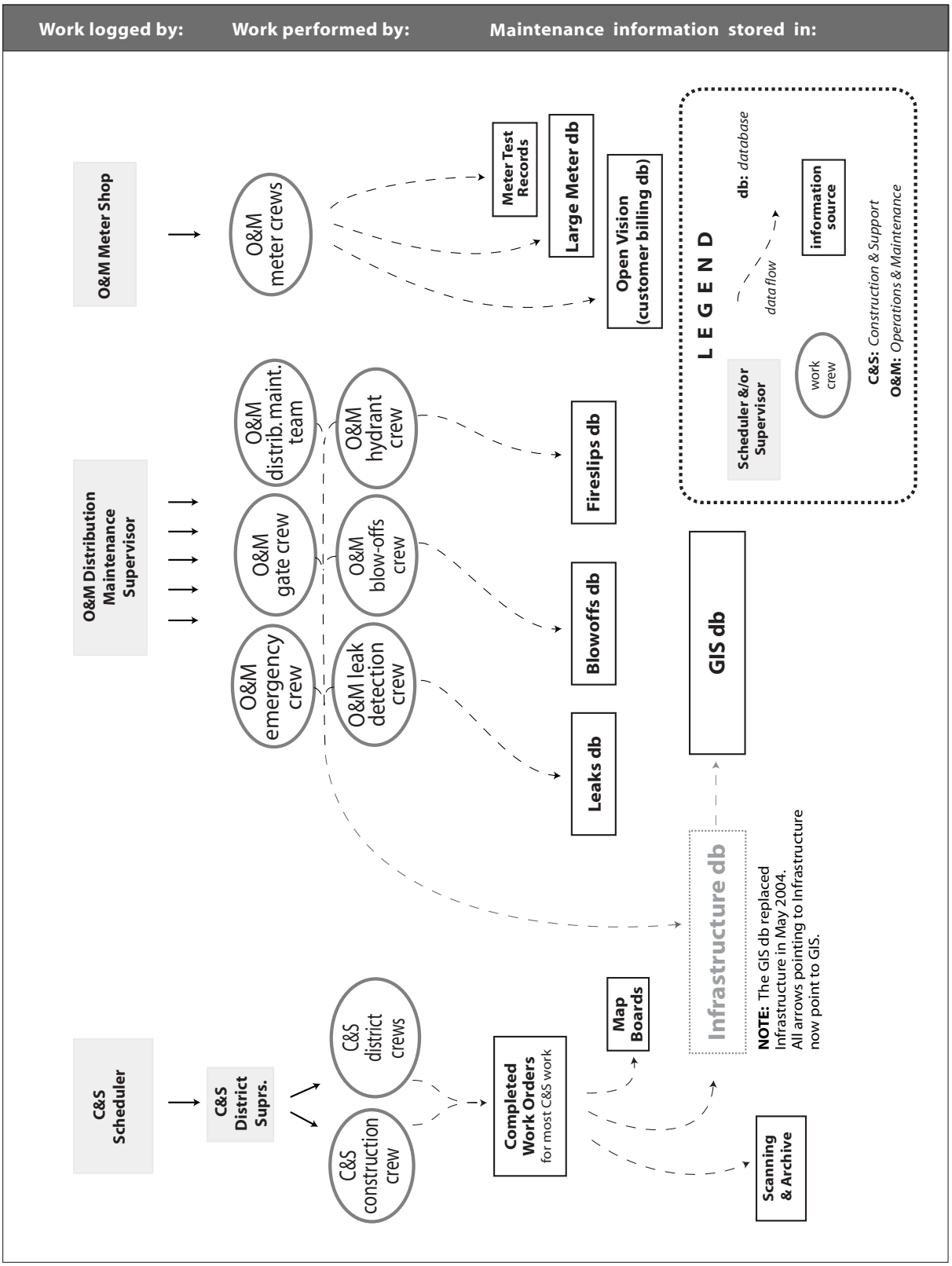
[2] As of early March 2004, this database is no longer in use. It was the primary source of information for the GIS database. Infrastructure users were switched to GIS in May 2004.

Inadequate methods for organizing, scheduling, and tracking maintenance work

The Bureau lacks an efficient and coordinated system for managing maintenance work. We found that there are multiple work order processes employed by the various work crews within the Construction & Support and Operations & Maintenance groups responsible for maintaining and repairing the distribution system. These processes have little relationship to one another, and do not comprehensively track distribution maintenance and repair. As a result, the Bureau lacks reliable and readily accessible information on what work is being performed, the amount of needed maintenance work, and the status of individual distribution assets. Because the Bureau lacks this critical information, it is difficult to schedule maintenance crews to ensure that staff resources are used efficiently to address the highest priority maintenance needs.

Figure 11 provides a simplified overview of the various work crews that perform maintenance and repair on the water distribution system, and the flow of information from work initiation to completion. As shown, work is assigned to several work crews within the Construction & Support and Operations & Maintenance groups. Some of the work is generated from requests from outside the Water Bureau (e.g. customers, builders) while most work is generated internally from Engineering Services and other departments. Figure 11 also shows that, when completed, information on work performed is entered into a variety of databases such as GIS, the Leaks database, and the Large Meter database.

Figure 11 Relationship Between Work Groups and Maintenance Information for Distribution System



Recognizing the weaknesses in current methods for generating and tracking work orders, the Water Bureau recently initiated an effort to introduce a maintenance management software tool called Synergen. Although the Synergen software has been used effectively by the Bureau for several years to support the parts and inventory function, its work scheduling and management features have never been implemented. Bureau managers believed that with a relatively small investment in updated software and consulting assistance, Synergen could replace the current work order and scheduling system and provide a more efficient and effective process for scheduling, tracking, monitoring, and recording maintenance work.

During the course of our audit, we had strong concerns regarding the level of planning and analysis that was being carried out prior to implementing the new Synergen module. Specifically we felt that there had been inadequate evaluation of existing maintenance work processes as well as Synergen's integration with other Bureau systems – especially GIS. Among individuals closest to the project, we found divergent views regarding the extent to which Synergen would be put into operation across the Bureau.

Near the completion of our audit, the Bureau was able to deploy Synergen's work order module within the Construction & Support Group. Our brief review of the system indicates that users are pleased with its functionality and it appears to be a substantial improvement over the previous scheduling system. Although synchronization with GIS is performed manually, we were told that there are plans to acquire software that will perform this process automatically. We were also told that the Bureau plans to bring the

Engineering Services Group into the system this Fall, and will coordinate closely Engineering's new Asset Management Group with both Synergen and GIS. It is not clear, however, when other maintenance activity performed by the Operations & Maintenance Group will be integrated into the system. If fully implemented across the Water Bureau, the Synergen program could vastly improve the efficiency and reliability of the Bureau's work order process, asset and maintenance management systems, as well as other financial and reporting systems.

Incomplete performance measurement and reporting

The Bureau lacks reliable information on the condition of key assets including mains, valves, and meters, as well as the level of effort needed to address maintenance requirements. This leads to an inability to create a comprehensive set of reliable performance indicators on the maintenance of its distribution system. Although the Bureau reports some valuable performance measures in the annual *Service Efforts and Accomplishments* report produced by this office, most of these measures relate to the final result of water services such as water quality, customer satisfaction, and rates. We believe some interim measures that track the effort and accomplishments of maintenance activities will provide the Bureau, Council, and the public with important information to assess the efficiency and effectiveness of maintenance work. For example, similar to Transportation infrastructure measures, the Water Bureau should develop indicators on the condition of certain major assets, progress made in addressing maintenance needs or backlogs, and the number of maintenance problems and the degree to which they are addressed.

Some water maintenance indicators could include:

- Trend in the number of major main breaks
- Trend in the maintenance work order backlog
- Number of customer service complaints and percent addressed within a certain time
- Number of out-of-service hydrants repaired or replaced within five working days
- Condition ratings/age for major groups of assets such as mains, meters, and hydrants

In addition, the Bureau should develop these new performance indicators as part of the "Managing for Results" efforts currently underway in the Bureau and in the City budget process for FY 2005-06. The Bureau should develop its program budget with sufficient performance indicators to assess progress toward Water Distribution goals, particularly as they relate to the efficiency and effectiveness of maintenance efforts.

Chapter 4 Recommendations

Effective long-term maintenance of the water distribution system requires the Bureau of Water Works to successfully address a number of challenges. Some of these challenges can be met with additional financial resources and by stabilizing the maintenance workforce. However, the source and level of funding needed to improve the maintenance of the distribution system will require a broader analysis of the current organization than was conducted in this audit. While water rate increases may be required, additional resource needs could be addressed through internal efficiencies, consolidation of functions, and out-sourcing tasks to the private sector.

We also believe that additional resources alone will not address the problems identified in this report. Fundamental changes in management practices are needed to ensure improvements in the maintenance of the water distribution system. In order to help begin these improvements, we recommend that the Bureau of Water Works:

1. Prepare a comprehensive master plan to guide the maintenance of the distribution system.

The master plan should establish 1) overall maintenance goals, 2) standards for the amount and frequency of work, and 3) priorities for maintaining the water

distribution system. The plan should also estimate the useful life of distribution assets and identify a long-term capital replacement schedule. The plan should specifically define the roles and responsibilities of Construction & Support, Operations & Maintenance, and Engineering Services, and address opportunities for functional consolidation or reorganization. The Bureau may wish to build on previous efforts to develop a master maintenance plan initiated in 1987. The master plan should serve as the basis for a revised set of policies and procedures that provide specific guidance on how to carry out routine work activities and emergency repairs.

2. Better plan and coordinate efforts to improve the reliability and accessibility of water system asset information.

The Bureau needs reliable and accessible information on the function, location, age, and condition of its assets. While some progress has been made to develop and implement a Geographic Information System, a substantial effort is needed to eliminate multiple databases, reduce backlogs, and correct data errors. In addition, in order to improve the ongoing development of GIS and other information systems, we believe the Bureau should formulate a comprehensive Bureau-wide strategy for data and information management.

3. Improve systems for organizing, scheduling and tracking maintenance work.

The Bureau should develop a centralized maintenance management system that schedules and tracks the completion of maintenance work. The Bureau should review and eliminate duplicative work order procedures, and standardize methods to track the time and costs of maintenance activities. Efforts should be taken to ensure reliable integration with GIS and other information systems so that asset condition information is updated when repair work is carried out.

4. Develop and report improved performance measures to track the efforts and accomplishments of water system maintenance activities.

Performance measures should provide information on the condition of major assets and progress made in addressing maintenance needs and reducing work backlogs.

Responses to the Audit Report

CITY OF

PORTLAND, OREGON

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August 16, 2004

Gary Blackmer
Portland City Auditor
1221 SW 4th, Room 130
Portland, OR 97204

Dear Auditor Blackmer,

Thank you for the opportunity to comment on Audit Services most recent work with the Portland Water Bureau, Portland's Water Distribution System Maintenance Program Needs Improvement. It is a very straightforward and useful tool for determining the needed priorities for the Water Bureau' distribution system.

Your auditors did an excellent job of working with staff in the Water Bureau to determine what parts of our distribution system need the most work and how staff in the Water Bureau should prioritize their efforts. It is always easy for large agencies to become complacent in their processes and having a tool such as this audit will benefit the bureau immensely. I was especially appreciative that you identified a lack of resources and the recent staff disruptions caused by the billing system as probable causes for much of the inconsistency found in the maintenance of the distribution system. The recommendations contained in the report are excellent and I know the bureau is focused on their implementation.

Thank you again for you and your staff's diligent work on this important review. We all attempt to serve our customers as best we can and work such as this audit will be helpful to all.

Sincerely,

Dan Saltzman

DS:mg

Cc: Mort Anoushiravani
Dick Tracy

CITY OF
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August 16, 2004

Memorandum

TO: Gary Blackmer, City Auditor

FROM: Mort Anoushiravani, Administrator, Portland Water Bureau

CC: Commissioner Dan Saltzman

RE: **Portland Water Bureau Response to Auditor's Report: "Portland's Water Distribution System"**

Thank you for the opportunity to respond on behalf of the Management Team of the Water Bureau to the audit report your office has just completed regarding maintenance of the City's drinking water distribution system. Ensuring adequate investment in the City's drinking water infrastructure has been an ongoing concern for the bureau and City Council, and more recently for some of our customers. I believe this report supports our concerns and provides effective guidance that will be helpful to all interested stakeholders and decision makers for the water system. It is particularly timely, as the bureau is just now beginning its preparations and planning for the FY 2005-06 budget year.

Briefly, I will address the bureau's planned actions in response to the four recommendations offered in your report. Lead staff and the corresponding implementation timelines are included.

***RECOMMENDATION #1**: Prepare a comprehensive master plan to guide the maintenance of the distribution system.*

The Water Bureau is currently performing a substantial reorganization of the Engineering Division. The new structure will include an Asset Management Group that will be responsible for an asset management plan that will develop maintenance, repair, rehabilitation and replacement programs and strategies for water system infrastructure to insure effective business management and customer service.

A key component of the asset management plan will be the development of a distinct distribution system master plan that will identify and describe deficiencies in the distribution system--both in terms of performance and condition--and establish priorities for addressing these deficiencies. The distribution master plan will also include a review of maintenance programs for key facilities and recommendations to improve asset management strategies.

Lead Staff: Dick Steinbrugge, Chief Engineer
Mark Knudson, Director of Operations and Maintenance
Michael Stuhr, Director of Construction and Support Services

Timeline: The Water Bureau anticipates completing the reorganization of the Engineering Division by January 2005. Work on the asset management plan will immediately follow with a priority focus on the distribution master plan. The bureau plans to request funding to support this work in next year's FY 2005-06 CIP budget and anticipates a completed distribution master plan and comprehensive asset management plan by December 2006.

***RECOMMENDATION #2**: Better plan and coordinate efforts to improve the reliability and accessibility of water system asset information.*

In addition to the development of an asset management plan described in the response to recommendation #1, the Water Bureau plans the following to address this recommendation.

Expedited GIS Implementation. As part of initial FY 2005-06 budget planning, the bureau is evaluating the feasibility of an expedited implementation of its Geographic Information System (GIS) by changing approach and adding staffing. Already in progress is installation of a link between the GIS and the Synergen Maintenance Management System (MMS) so that the MMS and GIS will share information directly. GIS is vital to the bureau's efforts and ability to establish a comprehensive asset information system.

Expanded Distribution Maintenance Staffing. As part of initial FY 2005-06 budget planning, the bureau is evaluating the feasibility of increasing staffing for the Distribution Maintenance Team (DMT). Expansion of DMT field staff will allow for more rapid condition assessment of assets in the distribution system, which is essential input to the maintenance work planning process, as well as verification and/or correction of asset records in GIS.

Asset Data Collection for Maintenance Management Systems. The bureau's Distribution Maintenance Team is currently collecting condition information on distribution system assets to develop complete asset descriptions. This effort includes consolidating all existing databases, updating current data and making it much more accessible throughout the bureau via the bureau's MMS described in more detail in the response to recommendation #3.

Lead Staff: Michael Stuhr, Director of Construction and Support Services

Timeline: Asset data collection is underway and anticipated to be completed by July 2005. A decision on the expedited GIS implementation will occur as part of the FY 2005-06 budget process. The expedited implementation would allow the GIS system to be implemented by October 2006, two years earlier than currently planned.

***RECOMMENDATION #3**: Improve systems for organizing, scheduling and tracking maintenance work.*

The Water Bureau plans to continue its efforts to improve systems for organizing, scheduling and tracking maintenance work. The bureau's principal tool for this effort is the Synergen Maintenance Management System (MMS).

The Water Bureau initially purchased Synergen in 1999 in response to an audit of its inventory system and in response to the City's Year 2000 efforts. Until 2003, only the inventory portion of the system was utilized. In the fall of 2003, the Water Bureau decided that full implementation of the maintenance module was essential to achieve additional efficiencies.

The bureau worked with the system manufacturer and the City's Bureau of Technology Services (BTS) to develop an incremental implementation approach that would provide system startup in the Operations and Construction Groups first, followed by Engineering, Resource Protection and Customer Service.

Synergen provides an opportunity to enhance the management of all water system assets from the road system in the Bull Run Watershed to the tens of thousands of valves, hydrants, pumps and pipes in the distribution system. Detailed data will be transferred into the system for each water system asset. The Synergen system will then function as the repository for asset history, maintenance and repair activity, replacement history, condition, and repair priority.

The Synergen system is compatible and links with the bureau's GIS system. Combined, the bureau believes the two systems will be extremely powerful tools for asset information management, comprehensive maintenance master planning, and performance management.

Lead Staff: Michael Stuhr, Director of Construction and Support Services, Water Bureau MMS Core Team

Timeline: On July 7th of this year 36 trained users in the Operations and Construction Groups began using the full maintenance module. "Go Live" in the Engineering and Resource Protection Groups is anticipated in late September and in Customer Service after the Cayenta customer information system implementation.

***RECOMMENDATION #4**: Develop and report improved performance measures to track the efforts and accomplishments of water system maintenance activities.*

The bureau is in the midst of an organization-wide development process to establish a set of relevant performance measures. The process began in December 2003 when the Water Bureau, in conjunction with Commissioner Saltzman's Office, initiated a revision of the bureau's mission, vision, and values to better serve ratepayers. Simultaneously, the bureau had examined a system called "The Balanced Scorecard"© (BSC) as a means of tying organizational strategies to performance measures. In March of 2004, the bureau adopted a revised mission, vision and values statement and committed to the development of a BSC for the organization.

BSC, which supports the City's Managing for Results Initiative, is a management tool for linking the Water Bureau's vision, mission, values to a set of strategies, targets, and performance measures organized into four balanced perspectives: Learning and Growth, Internal Business Processes, Customer, and Financial. As part of the development process, the bureau decided to add a fifth perspective, Stakeholder Perspective.

The bureau plans to use BSC to:

1. Align and prioritize work group strategies with the bureau's overall long-term initiatives,
2. Measure bureau and work group performance toward initiative and strategy achievement, and
3. Provide a framework for channeling the energies, abilities, and specific knowledge of Water Bureau employees into more effective and efficient methods for meeting customer and stakeholder expectations.

Full implementation of the BSC may take several years; however, the bureau's objective for FY 04-05 is development of an initial set of bureau and work group objectives and measures with corresponding implementation plans.

As part of this initial effort, the bureau will develop performance measures to track progress and accomplishments for water system maintenance activities. The Maintenance Management System described in the response to recommendation #3 above will provide a valuable tool in the development of appropriate performance measures.

Lead Staff: Water Bureau Management Team

Timeline: Work on developing the BSC is ongoing. Initial performance measures, objectives and implementations plans will be completed by July 2005

Thank you again for the opportunity to provide this response. The Water Bureau's lead management and I are committed to achieving the measures described here and anything else required to address the issues identified in your report completely and comprehensively. We plan to keep you updated on our progress as we move forward.

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